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APR 2010
Hazardous Waste Bureau

Date: APR 23 2010
Refer To: EP2010-0156

James Bearzi, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

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

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the Long-Term Monitoring and Maintenance Plan for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99. This plan fulfills the requirements of the CMI work plan and the New Mexico Environment Department Notice of Approval dated August 17, 2007.

If you have any questions, please contact John McCann at (505) 665-1091 (jmccann@lanl.gov) or Woody Woodworth at (505) 665-5820 (lwoodworth@doeal.gov).

Sincerely,

M. J. Graham

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Sincerely,

David R. Gregory

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Enclosures: Two hard copies with electronic files – Long-Term Monitoring and Maintenance Plan for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99 (LA-UR-10-2196)

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LA-UR-10-2196
April 2010
EP2010-0156

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

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Prepared by the Environmental Programs Directorate

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LA-UR-10-2196
EP2010-0156

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

April 2010

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David R. Gregory	David R. Gregory	Project Director	DOE-LASO	22 April 2010

EXECUTIVE SUMMARY

This document presents the long-term monitoring and maintenance plan for the corrective measures implementation (CMI) at Consolidated Unit 16-021(c)-99 within Technical Area 16 at Los Alamos National Laboratory (the Laboratory). The plan fulfills the requirements of the CMI work plan and the New Mexico Environment Department (NMED) approvals with modifications.

Consolidated Unit 16-021(c)-99 consists of the high explosives (HE) machining building (16-260) and associated sumps, drainlines, and troughs that lead to the 260 Outfall drainage channel. The drainage channel consists of the outfall, a former settling pond, and the lower portion of the drainage channel leading to Cañon de Valle. HE-contaminated water from the 260 Outfall entered the former settling pond and drained into the drainage channel. This is a pathway for contamination identified in downgradient components of the Consolidated Unit 16-021(c)-99 hydrogeologic system, including the 260 Outfall drainage channel and Sanitation Wastewater Systems Consolidation (SWSC), Burning Ground, and Martin Springs.

The CMI at Consolidated Unit 16-021(c)-99 included installing four remedial 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.

The plan describes monitoring activities that will be conducted to assess the performance of the CMI treatment systems. One alluvial well installed in the vicinity of the former settling pond will monitor the performance of surge bed injection grouting within the former settling pond area. Treated spring water discharged from the carbon filter systems will be monitored to assess the performance of the carbon filter systems at SWSC, Burning Ground, and Martin Springs. Multiple upgradient and downgradient alluvial wells and vessel test ports will be monitored to test the effectiveness of the pilot PRB system and the effects of the system on the alluvial water in Cañon de Valle.

The pilot PRB project will be evaluated following 1 yr of operation, after which NMED will be consulted regarding possible upgrades or alterations. If data indicate that the PRB is not an effective technology for remediating alluvial groundwater in Cañon de Valle, other alternatives (summarized in a corrective measures study) will be further examined.

The plan also describes maintenance activities that will be completed to ensure the performance and longevity of the treatment systems. The structural integrity of the low-permeability cap and surrounding stormwater control structures will be maintained. The components of the carbon filter systems and PRB system will be inspected, and parts and materials will be upgraded and replaced as needed.

Monitoring and maintenance activities, analytical parameters, and methods are presented in the plan. Performance criteria for each monitoring and maintenance activity have been established as a means of evaluating the effectiveness of the approach.

Data generated from the monitoring activities will assist the Laboratory and NMED in determining whether the goal of the CMI, to remediate HE and barium in the former settling pond within the 260 Outfall drainage channel and in the alluvial systems of Cañon de Valle and Martin Spring Canyon, has been met.

The plan will be updated to incorporate new information from data obtained following a 1-yr operational period. Locations, analytical parameters, and sampling frequencies will be evaluated to ensure the most appropriate monitoring of the treatment systems. The Laboratory will provide recommendations to NMED regarding potential changes or refinements to future monitoring and maintenance activities.

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Acronyms and Abbreviations

AO	administrative order
bgs	below ground surface
CMI	corrective measures implementation
CMS	corrective measures study
CWA	Clean Water Act
DO	dissolved oxygen
DOE	Department of Energy (U.S.)
DOT	Department of Transportation (U.S.)
EPA	Environmental Protection Agency (U.S.)
FFCA	Federal Facility Compliance Agreement
HE	high explosives
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazocine
IM	interim measure
LANL	Los Alamos National Laboratory
µS/cm	microsiemens per centimeter
mV	millivolt
NMED	New Mexico Environmental Department
NMSA	New Mexico Statutes Annotated
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
PRB	permeable reactive barrier
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RFI	RCRA facility investigation
SOP	standard operating procedure
SWSC	Sanitation Wastewater Systems Consolidation
TA	technical area
TAL	target analyte list
TDS	total dissolved solids
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TSS	total suspended solids
ZVI	zero-valent iron

1.0 INTRODUCTION

This document presents the long-term monitoring and maintenance plan (the plan) 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). The plan fulfills the requirements of the CMI work plan and the New Mexico Environment Department (NMED) approvals with modifications (LANL 2007, 098192; NMED 2009, 107307; NMED 2009, 108099). NMED provided to the Laboratory letters of approval with modification to best evaluate the ongoing effectiveness of the remedial systems installed during the CMI. Corrective actions and monitoring and maintenance at the Laboratory are subject to the Compliance Order on Consent (the Consent Order).

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 1.0-2). HE-contaminated water from the outfall entered the former settling pond and drained into the 260 Outfall drainage channel. This is a pathway for contamination identified in downgradient components of the Consolidated Unit 16-021(c)-99 hydrogeologic system, including the 260 Outfall drainage channel and the Sanitation Wastewater Systems Consolidation (SWSC) Spring, Burning Ground Spring, and Martin Spring (LANL 2003, 077965). Contaminants associated with Consolidated Unit 16-021(c)-99, particularly HE and barium, are present in shallow soil, springs, and shallow groundwater at several locations at TA-16 (LANL 2003, 077965).

The near-surface 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 (Figure 1.0-2). The plan discusses the monitoring and maintenance activities for these treatment systems.

The document is organized in six sections, including this introduction. Section 2 describes the objectives of the CMI monitoring and maintenance program and the general approach for determining the effectiveness of the remedial systems. Sections 3 through 5 provide details for each of the treatment systems and their monitoring strategies. Section 6 presents the references cited in this document.

1.1 Purpose

The plan describes monitoring activities that will be conducted to assess the performance and effectiveness of the CMI treatment systems for Consolidated Unit 16-021(c)-99. The monitoring activities are derived from the approved CMI work plan (LANL 2007, 098192). One alluvial well installed in the vicinity of the former settling pond will monitor the effectiveness of injection grouting of the surge bed underlying the former pond within the 260 Outfall drainage channel. Spring water treated from the carbon filter systems will be monitored to assess the effectiveness of the carbon filter systems at SWSC, Burning Ground, and Martin Springs. Multiple upgradient and downgradient alluvial wells and PRB vessel test ports will be monitored to test the effectiveness of the pilot PRB system and effects of the system on the alluvial water in Cañon de Valle.

Data generated from the monitoring activities will assist the Laboratory and NMED in determining whether the objective of the CMI, to remediate HE and barium in the former settling pond within the 260 Outfall drainage channel and in the alluvial systems of Cañon de Valle and Martin Spring Canyon, has been met.

The plan also describes maintenance activities that will be completed to secure the performance and longevity of the treatment systems. The maintenance activities are derived from the approved CMI work plan (LANL 2007, 098192). The structural integrity of the low-permeability cap and surrounding stormwater control structures will be maintained. The components of the carbon filter systems and PRB system will be inspected, and parts and materials will be upgraded and replaced as needed.

1.2 Reporting

The Laboratory will submit a monitoring and maintenance summary report to NMED after a 1-yr operational period. The report will present operations and maintenance results (including data tables and graphs), discuss groundwater and spring water quality and quantity data attributable to the treatment systems, and present successes and problems with the monitoring and maintenance activities.

The plan will be updated to incorporate new information from data obtained following the initial 1-yr operational period. Locations, analytes, and sampling frequencies will be evaluated to ensure the most appropriate monitoring of the treatment systems. The Laboratory will provide recommendations to NMED regarding potential changes or refinements to future monitoring and maintenance activities.

1.3 Regulatory Context

The plan activities fulfill the requirements of the approved Consolidated Unit 16-021(c)-99 CMI plan, revision 1, and the NMED approvals with modifications (LANL 2007, 098192; NMED 2009, 107307; NMED 2009, 108099). The CMI activities are subject to the Consent Order. Monitoring and maintenance activities will also comply with U.S. Department of Energy (DOE) orders, Environmental Programs Directorate requirements, and the Laboratory's quality and integrated work document processes.

The plan complements and integrates with other regulatory requirements for groundwater and surface water monitoring at the Laboratory, including the following:

1. The Interim Facility-Wide Groundwater Monitoring Program, groundwater monitoring requirement IV.A.3.b of the Consent Order.

   Long-term monitoring of groundwater from springs (including SWSC, Burning Ground, and Martin Springs), alluvial wells (including CdV-16-2656, -2657, -2658, and -2659), and intermediate and regional wells (including CdV-16-1i and R-25) in the vicinity and downgradient of the CMI treatment sites is performed as part of the Water Canyon/Cañon de Valle watershed monitoring conducted under the Interim Facility-Wide Groundwater Monitoring Plan. Data are reported in the periodic monitoring reports for Water Canyon/Cañon de Valle Watershed.

2. Storm runoff and snowmelt, monitored by the Laboratory under the auspices of the 2005 Federal Facility Compliance Agreement (FFCA) (Administrative Order [AO] Docket No. Clean Water Act [CWA] 06-2005-1701) entered into between the U.S. Environmental Protection Agency (EPA) and DOE on February 3, 2005, and the AO (Docket No. CWA-06-2005-1734) entered into between EPA and the University of California on March 14, 2005. The FFCA/AO is being replaced by a National Pollution Discharge Elimination System (NPDES) permit expected to become effective in 2010.

   Surface runoff, including storm runoff and snowmelt, in the vicinity and downgradient of the CMI treatment systems is monitored as part of the FFCA/AO. Data are reported in the Laboratory's annual Storm Water Pollution Prevention Plan.

2.0 MONITORING AND MAINTENANCE OBJECTIVES AND APPROACH

The plan is designed to assess the performance of the CMI treatment systems for Consolidated Unit 16-021(c)-99, to determine whether the objectives of the treatment systems have been met, and to repair and/or adjust the treatment systems as necessary to ensure maximum effectiveness. The monitoring effectiveness will be evaluated following a 1-yr period of activities (refer to section 1.2).

The objective of the treatment systems is to reduce HE and barium concentrations in groundwater and spring water in Cañon de Valle and Martin Spring Canyon to below their respective performance standards or screening levels, which in turn will reduce the concentrations infiltrating into intermediate and regional groundwater zones. Specific monitoring and maintenance objectives for the treatment systems are presented in sections 3 through 5.

The alluvial well in the vicinity of the former settling pond will be monitored for the presence of water. If present, the water will be analyzed for explosive compounds. The monitoring approach is designed to test the success of the surge bed injection grouting underlying the former settling pond. One measure of the success of the injection grouting is that no water should be detected in the alluvial well (LANL 2007, 098192, p. 16).

The carbon filter systems at SWSC, Burning Ground, and Martin Springs are designed for spring water to be conveyed through activated carbon (where HE contamination is adsorbed). The treated water is then discharged to the surface downgradient of the filter system. Treated water will be monitored, and if concentrations of RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) exceed the performance standard of 6.1 µg/L, the filters will be replaced (LANL 2007, 098192, p. 19).

The pilot PRB is designed to remove HE and barium from the Cañon de Valle alluvial groundwater. The monitoring for HE, HE-breakdown products, and barium at upgradient and downgradient sampling ports will provide direct performance results. Secondarily, field parameter and geochemical screening results from the upgradient, interior, and downgradient sampling ports will be used to diagnose the PRB treatment processes. Zero-valent iron (ZVI) media will be replaced or modified if the treated water concentration of RDX exceeds the 6.1-µg/L performance standard. Zeolite media will be replaced or modified if the treated water concentration of barium exceeds the 1000-µg/L performance standard (LANL 2007, 098192, p. 20). The water level measurements in upgradient and downgradient monitoring wells will provide a groundwater potentiometric surface above and below the PRB cutoff wall. The monitoring for HE, HE-breakdown products, and barium in upgradient and downgradient monitoring wells will indicate potential effects of the PRB system on the alluvial water in Cañon de Valle.

3.0 260 OUTFALL FORMER SETTLING POND AND SURGE BED

The 260 Outfall drainage channel consists of a drainage channel formally fed directly by the 260 Outfall, a former settling pond, and a lower portion of the drainage channel that leads to Cañon de Valle (Figure 1.0-2). The former settling pond was approximately 50 ft long and 20 ft wide and was located in the upper portion of the drainage channel, approximately 45 ft below the outfall. An interim measure (IM) cleanup removed more than 1300 yd^3 of contaminated soil from the former settling pond and the 260 Outfall channel (LANL 2002, 073706). Approximately 90% of the HE in the Consolidated Unit 16-021(c)-99 source area was removed (LANL 2002, 073706). In addition, a low-permeability cap (20-in.-thick crushed tuff/bentonite mixture) was installed on top of the former settling pond during the IM to serve as a barrier and to prevent water from infiltrating the source area (Figure 3.0-1).

Previous investigations at TA-16 indicated the presence of HE contamination within the surge beds underlying the area of the former settling pond in the 260 Outfall drainage channel (LANL 2003, 077965). As part of a Phase II Resource Conservation and Recovery Act (RCRA) facility investigation (RFI), several boreholes were advanced into the tuff next to the former settling pond to determine the vertical extent of HE (LANL 1998, 059891). Many of the boreholes indicated the presence of surge beds underlying the former settling pond area and adjacent areas. Surge beds are geological features that are highly discontinuous and porous. They are typically present on the Pajarito Plateau, and if present, they can vary in thickness and permeability over short distances (WoldeGabriel et al. 2001, 092523). Samples from the surge bed at approximately 17 ft below ground surface (bgs) beneath the former settling pond contained RDX at 4500 mg/kg, HMX (1,3,5,7-tetranitro-1,3,5,7-tetrazocine) at 1700 mg/kg, and TNT (2,4,6-trinitrotoluene) at 3500 mg/kg.

The following sections discuss the monitoring and maintenance activities for the low-permeability cap on the former settling pond and the groundwater monitoring well that was installed to monitor the effectiveness of the injection grouting.

3.1 Low-Permeability Cap on the Former Settling Pond

Soil removal activities conducted during the CMI disturbed a portion of the cap that had been installed on the former settling pond during the IM. The disturbed section of the cap was replaced as part of CMI activities and is schematically shown in Figure 3.0-1. Construction and installation details for the low-permeability cap are provided in the CMI field summary report (LANL 2010, 108868, p. 11). Stormwater control measures, consisting of straw wattles, were placed upgradient of the former settling pond to prevent run-on from entering the former settling pond area (Figure 3.0-1). Photographs are presented in Appendix A.

3.1.1 Cap Maintenance Objectives

The objective of installing and maintaining the low-permeability cap on top of the former settling pond is to prevent surface water from infiltrating and contacting the potentially contaminated underlying tuff. The objective of the run-on/runoff controls is to prevent stormwater run-on from eroding the cap and to prevent runoff and sediment from moving farther down the 260 Outfall drainage channel.

3.1.2 Cap Maintenance Schedule and Frequency

The low-permeability cap will be inspected for the following parameters: settlement or cracking of the cap, erosion of the cap, evidence of water ponding, animal intrusions, straw wattle integrity, and stormwater control sediment accumulation. Inspections will be documented on the Former Settling Pond Cap and Stormwater Controls Inspection checklist (Appendix B). The completed inspection checklists will be submitted to NMED as part of the annual report.

Per the approved CMI work plan inspections are to be completed in March/April and August (LANL 2007, 098192, p. 12). The intent of performing inspections during these 2 mo is to monitor for possible damage from spring runoff and monsoonal rains. To meet this intent, inspections will be completed following spring snowmelt and at the conclusion of the summer rain season. A summary of maintenance parameters and frequency of cap and stormwater control maintenance activities is presented in Table 3.1-1. All monitoring data will be reported to NMED in the annual report.

3.1.3 Cap Performance Criteria

The low-permeability cap replacement was installed and determined to meet moisture and compaction density requirements (LANL 2010, 108868). The sole performance criterion for long-term maintenance activities is the continued sound structural integrity of the cap. In addition, the criterion for the stormwater controls is to prevent water from running on to the cap and potentially eroding the cap.

3.2 Groundwater Monitoring Well at the Surge Bed Injection Grouting Area

CMI activities included injecting grout into the subsurface surge bed material underlying the former settling pond (where contamination was previously identified). Grout was injected into 16 injection boreholes, which were installed within the former settling pond area in the 260 Outfall drainage channel (Figure 3.0-1). The injection boreholes were drilled to depths ranging from 22 ft to 33 ft bgs. A total of 9080 gal. of grout was injected into the subsurface to stabilize the surge bed (LANL 2010, 108868).

In accordance with the approved CMI plan, one alluvial groundwater well was installed adjacent to the former settling pond to monitor the amount of saturation in the surge bed and to evaluate the effectiveness of the injection grouting (Figure 3.0-1) (LANL 2007, 098192, p. 16). The monitoring well was drilled to 25 ft bgs and screened across the projected surge bed horizon. No water was encountered during drilling and construction of the well. Per the approved CMI plan the in situ injection grouting system requires no maintenance (LANL 2007, 098192, p. 16).

3.2.1 Groundwater Monitoring Objectives

The objective of the alluvial monitoring well, installed next to the former settling pond and injection boreholes, is to monitor for water to assess the effectiveness of in situ injection grouting of the surge bed.

3.2.2 Groundwater Monitoring Schedule and Frequency

The alluvial monitoring well will be monitored on a quarterly basis. If water is present in the well, a sample will be collected and submitted for off-site analysis for explosive compounds. A summary of monitoring parameters and frequency of alluvial groundwater monitoring activities at the former settling pond is presented in Table 3.1-1. All monitoring data will be reported to NMED in the annual report.

3.2.3 Groundwater Performance Criteria

The sole performance criterion for monitoring groundwater is to evaluate the performance of the in situ injection grouting system by monitoring for the presence of water. Assuming the in situ injection grouting successfully filled the fractures and interstitial pore space of the surge bed underlying the former settling pond, no water is anticipated to be present in the well. The presence of water indicates that all of the fractures and interstitial pore space were not grouted.

4.0 SPRING CARBON FILTERS AT SWSC, BURNING GROUND, AND MARTIN SPRINGS

Spring carbon filter systems were identified in the corrective measures study (CMS) report as the preferred option for cleanup of SWSC and Burning Ground Springs in Cañon de Valle and Martin Spring in Martin Spring Canyon (LANL 2003, 085531). 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 also upgraded during the CMI by installing a second spring collection box at a seep adjacent to the original spring outlet (LANL 2010, 108868).

The carbon filter systems consist of a collection box to collect the spring water, subgrade piping to convey the water to the carbon filter, and piping to convey the treated water to the discharge point (Figure 4.0-1). The spring collection boxes consist of a weir and a reservoir. The carbon filters consist of a subgrade vault containing two activated carbon canisters. Flow through the two canisters is in parallel and is activated by a float valve within each canister. The system was designed to ensure a minimum hydraulic head of 1.5 ft is provided across the units. Photographs are presented in Appendix A.

4.1 Spring Carbon Filter Monitoring and Maintenance Objectives

The objective of the carbon filter systems within SWSC, Burning Ground, and Martin Springs is to treat RDX present in the spring waters to levels below 6.1 µg/L, which is NMED's tap water screening level (NMED 2009, 108070).

4.2 Spring Carbon Filter Monitoring and Maintenance Activities

Monitoring activities will include visual inspections of the carbon filter system piping and hardware and maintenance of these items as needed, measuring spring water flow rates and other field parameters, and collecting samples for off-site analysis for explosive compounds.

4.2.1 Spring Carbon Filter Inspections

Visual inspections of the carbon filter systems will be conducted each time data are collected from SWSC, Burning Ground, and Martin Springs (refer to section 4.3 for the schedule). The filter system piping and hardware will be inspected to ensure the integrity of aboveground piping and U-joints and to ensure debris does not accumulate in the weir box. At Martin Spring, observation and monitoring of the seep discharge (outside of the current weir) and the repositioning of the auxiliary collection system will be required, especially during the spring snowmelt period. Inspections will be documented on the Carbon Filter System Inspection Checklist (Appendix C). The completed inspection checklists will be submitted to NMED as part of the annual report. Equipment and hardware will be maintained as needed.

4.2.2 Spring Flow Rate Measurements

The Laboratory continuously measures spring flow rates at SWSC, Burning Ground, and Martin Springs with ultrasonic flow detectors. These data are available once they are downloaded and quality assured. Manual measurements will be made at each spring outlet and filter unit outlet each time a sample is collected (Figure 4.0-1). Flow rates will be measured using a graduated measuring device and stopwatch in accordance with Standard Operating Procedure (SOP) 5224, Spring and Surface Water Sampling. Based on the flow rate measurements and the analytical results of influent and treated water sampling (section 4.2.4), the mass of HE removed will be calculated and reported to NMED in the annual report.

4.2.3 Spring Field Parameter Measurements

Field parameters will be measured at each spring outlet and downgradient from the sampling U-tube at SWSC, Burning Ground, and Martin Springs (Figure 4.0-1). Field parameters (in addition to flow rates discussed above) will be measured using a YSI multiparameter water quality probe, or equivalent, and will include pH, temperature, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen (DO), and turbidity (Table 4.2-1).

4.2.4 Spring Sampling for Off-Site Analyses

Water samples will be collected upgradient at each spring outlet and downgradient of the sampling U-tube at SWSC, Burning Ground, and Martin Springs (Figure 4.0-1). The access ports are either 2-in. or 4-in. polyvinyl chloride (PVC); therefore, it will be necessary to measure parameters using a flow-through cell and low-flow purging techniques. Off-site analytical samples will be submitted for explosive compound analysis (Table 4.2-2).

4.3 Spring Monitoring and Maintenance Schedule and Frequency

The SWSC and Burning Ground Springs carbon filter systems will consist of weekly sampling of the influent and treated water for the first month. The remainder of the first quarter will be sampled monthly. Subsequently, quarterly sampling will be performed for the remaining three quarters of the year. Monitoring will commence upon receipt of the NPDES permit. Monitoring will include measurements of field parameters and collection of water samples for off-site analysis of explosive compounds.

The Martin Springs carbon filter system will consist of monthly monitoring of the influent and treated water to the carbon filter for the first quarter, followed by quarterly monitoring thereafter. Monitoring will include measurements of field parameters and collection of water samples for off-site analysis of explosive compounds.

Spring flow rates will be measured manually on a quarterly basis at SWSC, Burning Ground, and Martin Springs.

A summary of monitoring and maintenance parameters and frequencies at SWSC, Burning Ground, and Martin Springs is presented in Table 4.3-1. All monitoring data will be reported to NMED in the annual report.

4.4 Spring Carbon Filter Performance Criteria

Performance criteria of the carbon filter systems include the ability to treat explosive compounds (particularly RDX) to groundwater standards and to maintain proper flow through the unit. The performance will be measured using flow rates, other field parameters, and analytical data.

4.5 Spring Carbon Filter Contingency

Because the carbon filter system at Martin Springs has been operating successfully since 2001, major problems with the spring carbon filters at the three springs are not anticipated (LANL 2007, 098192, p. 19). If maintenance issues occur (such as fouling with silt or premature contaminant breakthrough), the carbon media will be replaced. In addition, media will be replaced when RDX concentrations exceed the performance standard. The media is anticipated to last approximately 18 mo, based on the Martin Spring pilot carbon filter system. If other problems persist, a different particle size of carbon may be required.

5.0 PERMEABLE REACTIVE BARRIER IN CAÑON DE VALLE

Installation of the pilot PRB was identified in the CMS as the preferred remedial alternative for the Cañon de Valle alluvial system (LANL 2003, 085531). The remedial goal for the PRB is to reduce explosive compounds (particularly RDX) and barium concentrations in alluvial groundwater to below their respective groundwater standards, which in turn will reduce the concentrations infiltrating into the intermediate and

regional groundwater zones. The pilot PRB location in Cañon de Valle was selected because it is upgradient of a potential recharge area for deeper groundwater.

The PRB includes a cutoff wall to divert groundwater into a downgradient reactive cell. The groundwater diversion wall consists of PVC sheet-piling. The reactive cell is a baffled polypropylene vessel containing four chambers for the reactive media. Granular ZVI and clinoptilolite zeolite were determined to be the most effective and cost efficient means of treating RDX and barium, respectively (LANL 2010, 108648). The system is baffled to allow water to flow into four cells sequentially as follows: (1) into a cell containing 3/8-in. pea gravel, (2) into a cell containing ZVI/sand mixture, (3) into a cell containing 3/8-in. pea gravel, and (4) into a cell containing clinoptilolite zeolite. After treatment through the four-stage reactive cell, the groundwater is directed to an infiltration gallery (Figure 5.0-1). Photographs are presented in Appendix A.

5.1 PRB Vessel

5.1.1 PRB Vessel Monitoring and Maintenance Objectives

There are seven PRB vessel monitoring points: two upgradient points (MP1 and MP2), three points within the vessel (MP3, MP4, and MP5), and two downgradient points (MP6 and MP7) (Figure 5.0-1 and Table 5.1-1). The objective of the PRB vessel monitoring of the upgradient and downgradient monitoring points (MP1 and MP7) is to assess the performance of the PRB system using field parameter measurements, geochemical samples, and analytical data. These two points serve as the primary criteria monitoring points for assessing the effectiveness of the PRB system.

The objective of monitoring the inside vessel ports (MP3, MP4, and MP5) is to assess the performance of the ZVI and zeolite media.

5.1.2 PRB Vessel Monitoring and Maintenance Activities

Sequential monitoring at the seven points will facilitate evaluation of contaminant removal, degradation of the ZVI and zeolite media, and media longevity. Once groundwater is observed flowing at monitoring point MP1, the vessel will be bypassed using the by-pass line for one week to clear the lines (Figure 5.0-1). After 1 wk, captured water will be routed to the vessel. After the vessel is filled with water, monitoring will be conducted in accordance with the schedule discussed in section 5.1.3.

5.1.2.1 PRB Vessel Hydrology and Field Parameter Measurements

The PRB vessel access ports are either 1-in. or 2-in. PVC; therefore, it will be necessary to measure field parameters using a flow-through cell and purging techniques in accordance with SOP-5232, Groundwater Sampling. Flow rates will be measured from monitoring points MP2 and MP6.

Water levels will be measured from monitoring points MP1, MP3, MP4, MP5, and MP7; these monitoring points will also be used to measure field parameters. Water will be pumped into the cells using a peristaltic pump, and field parameters will be measured using a YSI multiparameter water quality probe, or equivalent. Other field parameter measurements include pH, temperature, ORP, specific conductance, DO, and turbidity (Table 5.1-2).

5.1.2.2 PRB Vessel Geochemical Sampling

Water will be collected from monitoring points MP1, MP3, MP4, MP5, and MP7 for geochemical analyses using a flow-through cell and low-flow purging techniques. Per the approved CMI work plan, geochemical

sampling and testing will consist of analysis for alkalinity, major cations and anions, nitrogen species, and stable isotopes of carbon and nitrogen (LANL 2007, 098192, p. 26) (Table 5.1-3).

A secondary level of analysis will be to field screen for sulfide and/or ferrous iron. This screening will be required only if the vessel is not working properly (Table 5.1-3). Sulfide and ferrous iron will be measured in the field using a HACH, or equivalent, field test kit. This approach of using field test kits avoids problems with the very short holding times for these analytes. Care will be taken to perform the sulfide and ferrous iron field tests quickly while minimizing contact with air, which rapidly oxidizes these analytes.

5.1.2.3 PRB Vessel Sampling for Off-Site Analyses

Water will be collected from monitoring points MP1, MP3, MP4, MP5, and MP7 for off-site analyses using the method described in section 5.1.2.2. Off-site analytical samples will be submitted for explosive compounds, HE-breakdown products, and metals (Table 5.1-4).

If the vessel is not working properly, samples may also be collected for total dissolved solids (TDS), total suspended solids (TSS), total organic carbon (TOC), and dissolved gases (headspace gas) (Table 5.1-4). Low-flow collection methods will be used to collect TDS, TSS, and TOC from the sampling ports. Dissolved gas samples will be screened from the vessel interior headspace and analyzed for methane, carbon dioxide, hydrogen, and nitrogen in accordance with SOP-5074, Sampling for Sub-Atmospheric Air, or using screening instruments such as a LANDTEC carbon dioxide and methane analyzer or HACH ORBISPHERE 3654 portable hydrogen and nitrogen analyzer.

5.1.2.4 PRB Vessel Interpretation of Results

Previous studies using ZVI to treat water with organic compounds (including HE) have shown general field parameter, chemistry, and biological trends in the ZVI media and downgradient water (ITRC 2005, 109019). Table 5.1-5 summarizes the general trends that may be expected as the PRB remedial process progresses using ZVI (ITRC 2005, 109019). These general ZVI trends may be used to interpret effects of the PRB system. For example, if field parameter measurements show an increase in pH or a decrease in TOC, these trends may be indicative of increased microbial or bacteria activity (as presented in Table 5.1-5).

5.1.2.5 PRB Vessel Maintenance Inspections

Visual inspections will be conducted during the monthly or quarterly monitoring activities at the PRB system (refer to section 5.1.3 for the schedule). The PRB piping and hardware will be inspected for the following parameters to ensure the system is functioning correctly: integrity of aboveground piping and U-joints; integrity of access ports; integrity of vent tubes, the bypass line, manholes, and valves; and channel erosion. Inspections will be documented on the Permeable Reactive Barrier Inspection Checklist (Appendix D). The completed inspection checklists will be submitted to NMED as part of the annual report. Equipment and hardware will be maintained as needed.

5.1.3 PRB Vessel Monitoring and Maintenance Schedule and Frequency

Water levels at the PRB vessel monitoring points will be measured monthly for the first quarter and quarterly thereafter.

Flow rates, other field parameters, and off-site analytical results will be obtained monthly for the first three months and quarterly thereafter. A summary of maintenance parameters and frequency of water level

measurements at the PRB vessel monitoring points is presented in Table 5.1-6. All monitoring data will be reported to NMED in the annual report.

5.1.4 PRB Vessel Performance Criteria

Monitoring and maintenance of the pilot PRB will focus on the collection of hydrological and geochemical data so the effectiveness of the system can be evaluated. The performance criteria for effectiveness include the system's ability to treat explosive compounds and barium to groundwater standards, maintenance of sufficient flow rates through the system, durability of the PRB system, and the life of the PRB media. General trends presented in Table 5.1-5 will be used to assess the performance of the PRB system.

ZVI media will be replaced or modified if the effluent RDX concentration exceeds the 6.1 µg/L performance standard (LANL 2007, 098192). Zeolite media will be replaced or modified if the effluent barium concentration exceeds the 1000-µg/L performance standard (LANL 2007, 098192). Spent media will be removed and characterized for disposal in accordance with Laboratory waste management procedures.

5.2 PRB Cutoff Wall

5.2.1 PRB Cutoff Wall Monitoring and Maintenance Objectives

The objective of the PRB cutoff wall monitoring is to assess the hydraulic capture performance of the wall by measuring water level trends.

5.2.2 PRB Cutoff Wall Monitoring and Maintenance Activities

Seventeen monitoring points will be used to monitor groundwater levels in the vicinity of the PRB cutoff wall. These monitoring points include four upgradient piezometers, five upgradient alluvial wells, and eight downgradient alluvial wells (Figure 5.2-1). The water levels and locations of the wells and piezometers will provide a potentiometric surface of the groundwater above and below the PRB cutoff wall. Alluvial wells MW-2, -3, -4, -5, and -12 and piezometers PZ-13, -14, -15, and -16 will be used to monitor water levels upgradient of the cutoff wall. Alluvial wells MW-6, -7, -8, -9, -10, -11, -17, and -18 will be used to monitor water levels downgradient of the cutoff wall (Figure 5.2-1 and Table 5.1-6).

Depths of the wells range from 7 to 16 ft bgs. The well casings are 2-in.-diameter PVC and are screened across the alluvium. The well diameter is sufficient to accommodate sampling equipment but small enough to minimize purge volume and disruption of the groundwater flow field. The four piezometers are 2-in.-diameter PVC and are seated in the gravel collection gallery upgradient of the cutoff wall.

5.2.2.1 PRB Cutoff Wall Water Level Measurements

Water level measurements will include both manual and automated readings. Three wells upstream and three wells downstream of the cutoff wall will be instrumented with pressure transducers to collect water level data on 1-h intervals. The selection of the wells to be instrumented will be determined after review of the manually collected well data discussed in section 5.2.2.

5.2.3 PRB Cutoff Wall Monitoring and Maintenance Schedule and Frequency

Manual water level measurements will be collected at all 17 locations on a weekly basis for the first quarter following installation of the wall and semimonthly for the second quarter. Thereafter, measurements will be collected monthly for the first year. Automated water level data will be downloaded quarterly or more frequently if problems are encountered. A summary of maintenance parameters and frequency of field parameter sampling at the PRB cutoff wall monitoring wells is presented in Table 5.1-6. All monitoring data will be reported to NMED in the annual report.

5.2.4 PRB Cutoff Wall Performance Criteria

Water level data will be analyzed to determine if the cutoff wall is effectively intercepting and routing the alluvial groundwater to the PRB vessel. If water elevation data indicate a possible leak or bypass then maintenance or repair will be initiated at the cutoff wall.

5.3 Cañon de Valle Groundwater

5.3.1 Cañon de Valle Groundwater Monitoring Objectives

The objective of monitoring the upgradient and downgradient wells for explosive compounds, HE-breakdown products, and barium concentrations is to evaluate trends in concentrations that may have been affected by the PRB treatment system.

5.3.2 Cañon de Valle Groundwater Monitoring Activities

A total of 20 alluvial groundwater monitoring wells were installed in strategic locations to provide data for HE and barium contamination above and below the cutoff wall, within the wall, and below the PRB vessel (LANL 2010, 108868). Seventeen of these 20 wells are discussed in section 5.2.2. Groundwater samples will be collected from three upgradient alluvial wells (MW-5, -12, and -18) and three downgradient alluvial wells (MW-1, -19, and -20) to assess effects of the PRB system on the alluvial water in Cañon de Valle (Figure 5.2-1).

5.3.2.1 Cañon de Valle Groundwater Field Parameter Measurements

Standard field parameters will be collected from the six monitoring wells to ensure a representative groundwater sample is collected per SOP-5232, Groundwater Sampling. Field parameter measurements include water level, pH, temperature, ORP, specific conductance, DO, and turbidity. Field parameters will be measured using a YSI multiparameter water quality probe, or equivalent, and industry-standard water level tape (Table 5.3-1).

5.3.2.2 Cañon de Valle Groundwater Sampling for Off-Site Analyses

Samples will be collected from the six monitoring wells in accordance with SOP-5232, Groundwater Sampling. Analytical samples will be submitted for explosive compounds, HE-breakdown products, metals, cations, and anions (Table 5.3-2).

5.3.3 Cañon de Valle Groundwater Monitoring Schedule and Frequency

Field parameters will be measured and off-site chemistry analyses will be conducted on a monthly basis during the first quarter; subsequently, quarterly sampling will be performed. A summary of maintenance

parameters and frequency of off-site chemistry sampling at the alluvial monitoring wells is presented in Table 5.1-6. All monitoring data will be reported to NMED in the annual report.

5.3.4 Cañon de Valle Groundwater Performance Criteria

HE and barium results will be analyzed within the context of the other PRB vessel results to evaluate the overall effectiveness of the PRB.

5.4 Contingency Plan for the Pilot PRB

The pilot PRB will provide operational data to determine the effectiveness of the PRB for remediation of alluvial groundwater. A 1-yr operational period is proposed. If the PRB media is determined to not be effective, the media will be replaced with an alternative. Consultation with NMED will precede any corrective actions concerning the PRB.

6.0 REFERENCES

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

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

ITRC (Interstate Technology and Regulatory Council), February 2005. "Technical/Regulatory Guidelines, Permeable Reactive Barriers: Lessons Learned/New Directions," Interstate Technology and Regulatory Council, Permeable Reactive Barriers Team, Washington, D.C. (ITRC 2005, 109019)

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LANL (Los Alamos National Laboratory), September 2003. "Phase III RFI Report for Solid Waste Management Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-03-5248, Los Alamos, New Mexico. (LANL 2003, 077965)

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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), March 2010. "Column Study Results for the Permeable Reactive Barrier," Los Alamos National Laboratory document LA-UR-10-1107, Los Alamos, New Mexico. (LANL 2010, 108648)

NMED (New Mexico Environment Department), September 16, 2009. "Approval for 'Contained-In' Determination for Spring and Alluvial Groundwater for Implemented Corrective Measures Consolidated Unit 16-021(c)-99," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2009, 107307)

NMED (New Mexico Environment Department), December 2009. "Technical Background Document for Development of Soil Screening Levels, Revision 5.0," with revised Table A-1, New Mexico Environment Department, Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, Santa Fe, New Mexico. (NMED 2009, 108070)

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WoldeGabriel, G., R.G. Warren, D. Broxton, D. Vaniman, M.T. Heizler, E.C. Kluk, and L. Peters, 2001. "Episodic Volcanism, Petrology, and Lithostratigraphy of the Pajarito Plateau and Adjacent Areas of the Española Basin and the Jemez Mountains," *Volcanology in the New Mexico, NM Natural History and Science Bulletin,* Vol. 18, pp. 97-129. (WoldeGabriel et al. 2001, 092523)

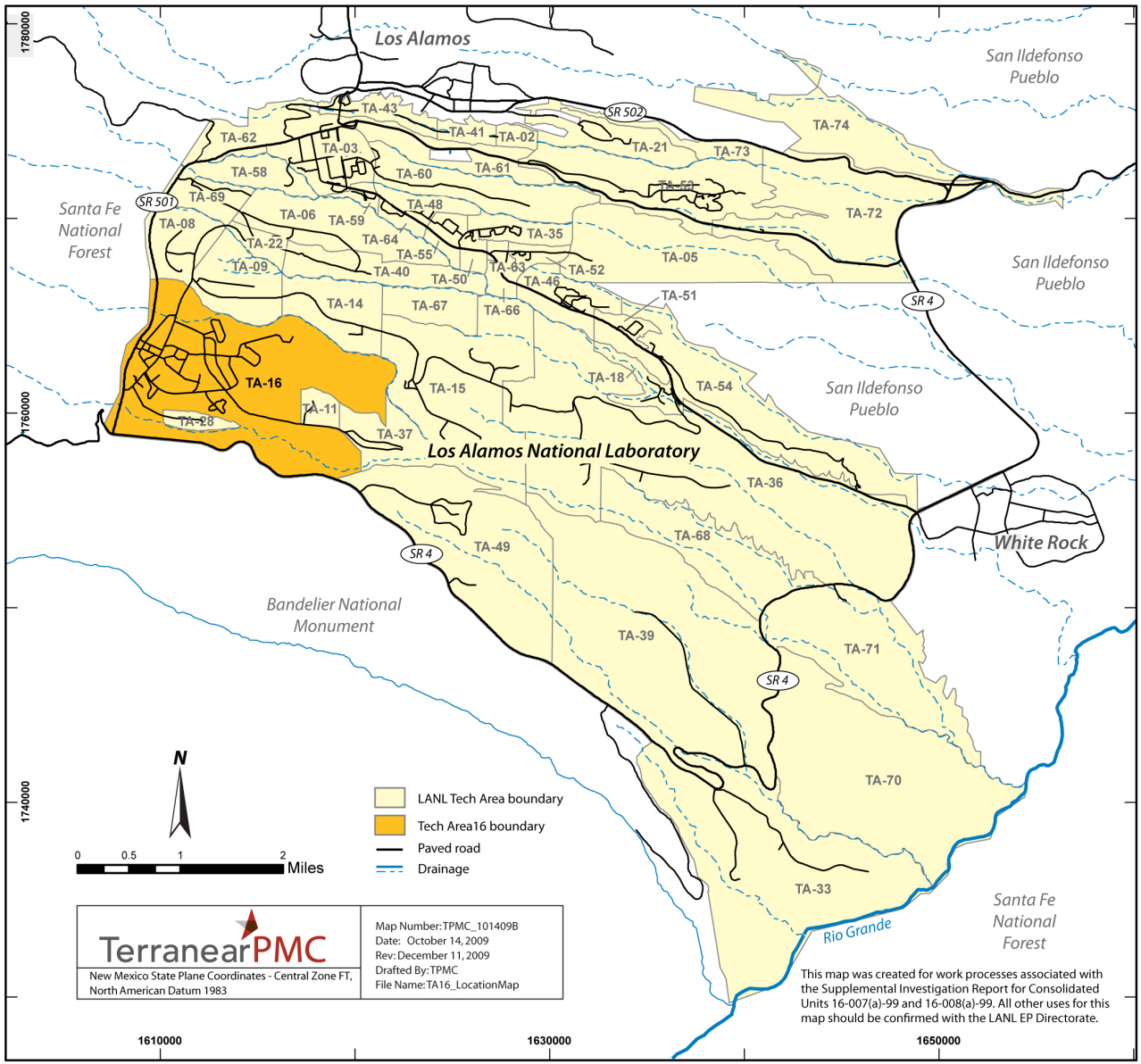

Figure 1.0-1 Location of TA-16 with respect to Laboratory TAs and surrounding areas

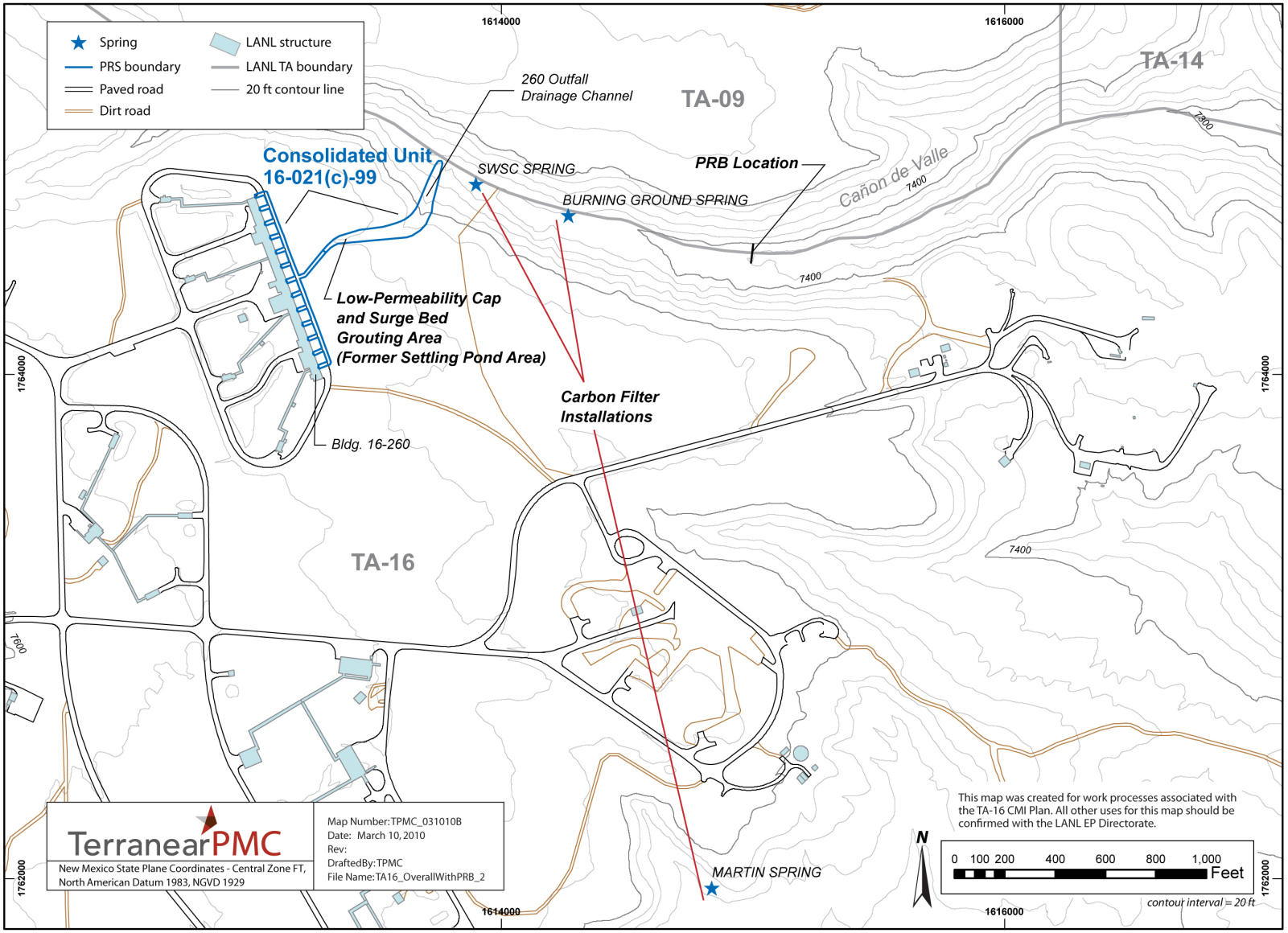

Figure 1.0-2 **Location of Consolidated Unit 16-021(c)-99 including 260 Outfall drainage; former settling pond area; SWSC, Burning Ground, and Martin Springs; PRB location; and carbon filter system locations**

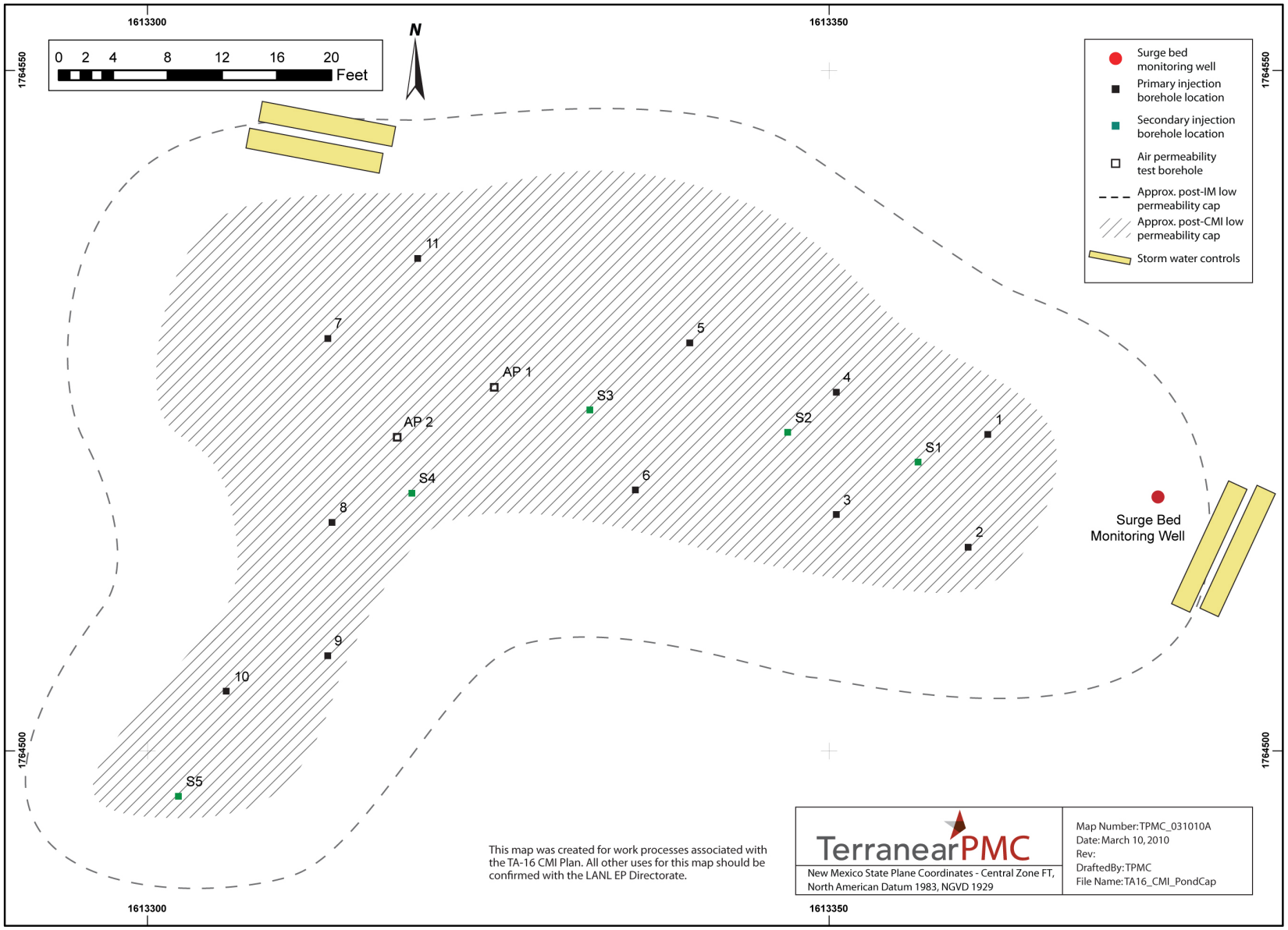

Figure 3.0-1 Locations of the former settling pond low-permeability cap, surge bed monitoring well, and boreholes

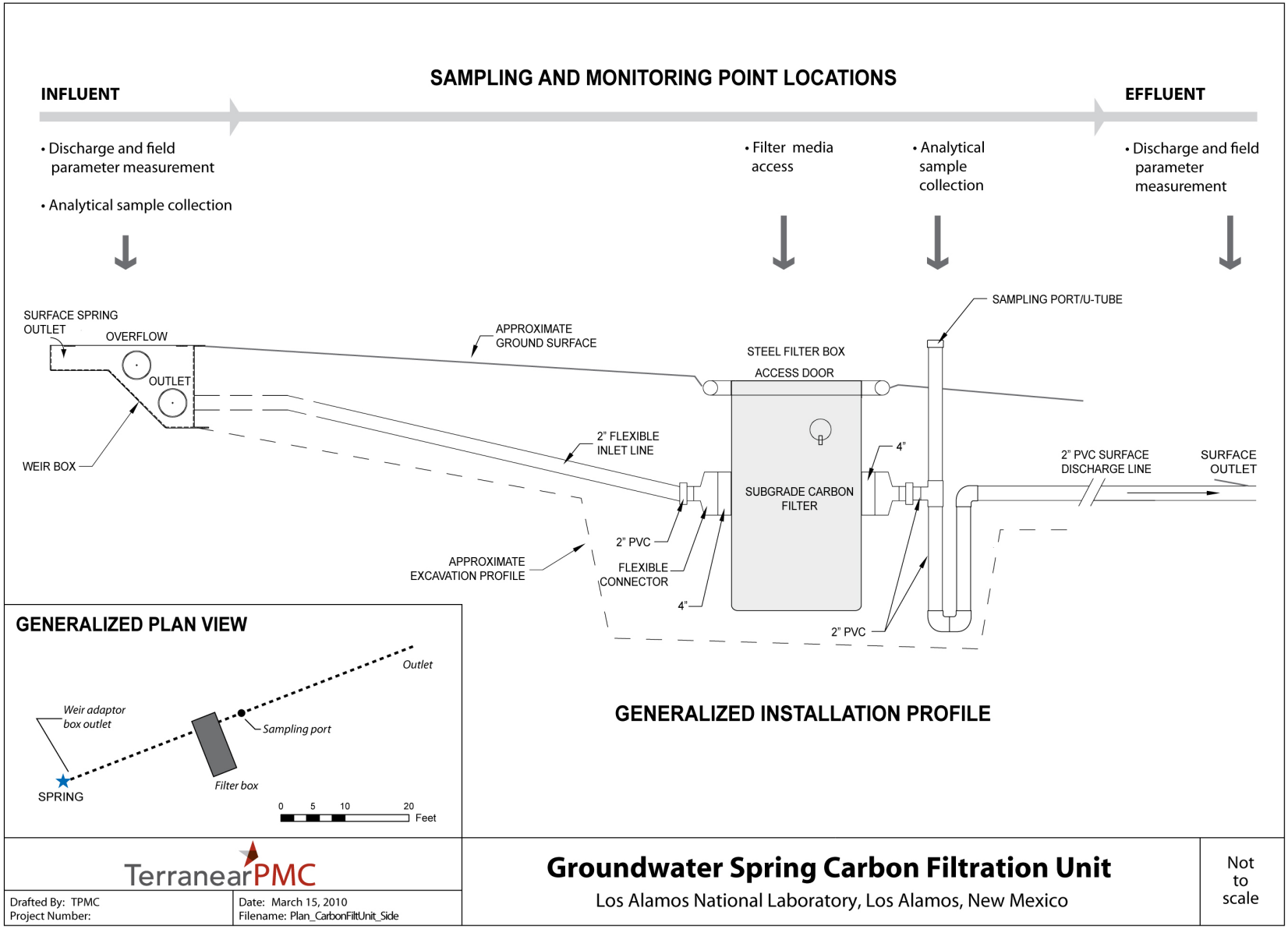

Figure 4.0-1 Locations of the SWSC, Burning Ground, and Martin Springs carbon filter system monitoring points

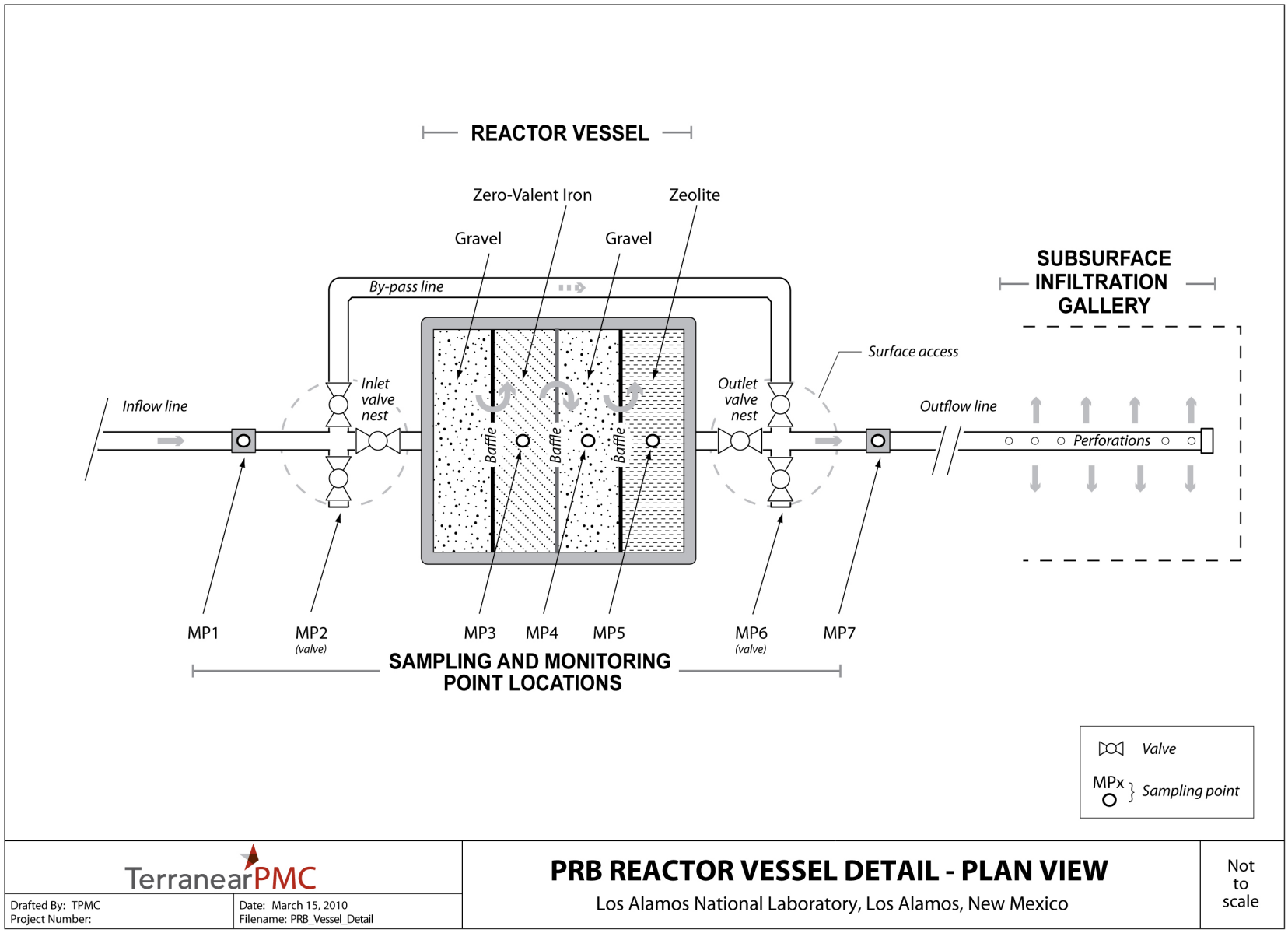

Figure 5.0-1 Locations of the PRB vessel monitoring points in Cañon de Valle

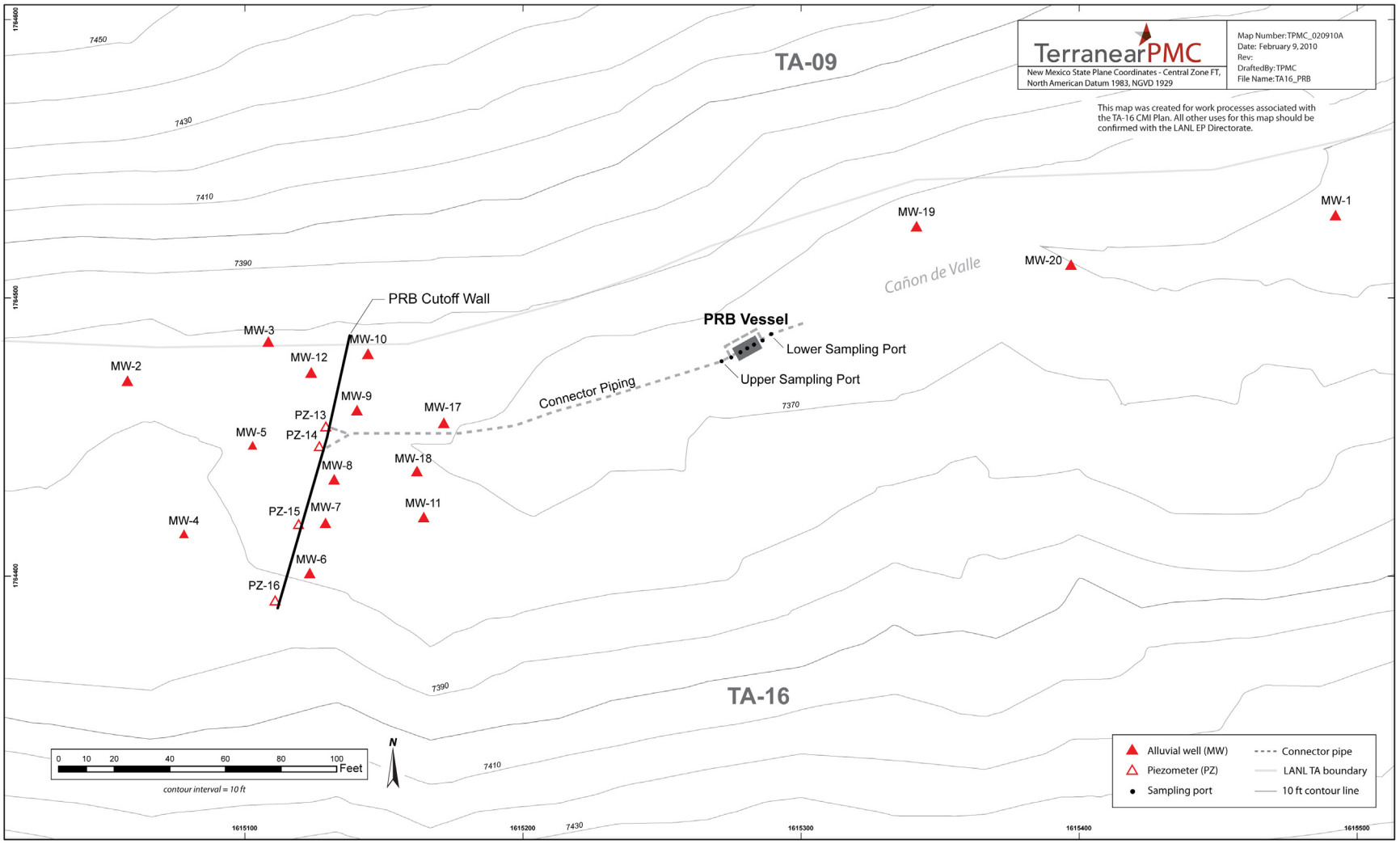

Figure 5.2-1 Locations of the PRB monitoring wells and piezometers in Cañon de Valle

Table 3.1-1
Summary of Monitoring and
Maintenance Parameters and Frequencies at the Former Settling Pond

Sampling Media	Monitoring/ Maintenance Parameter	Sampling Point/ Location	Monitoring Event Frequency	Number of Maintenance Events in 1 yr	Explosive Compounds (EPA SW-846:8330)	Comments
Low-Permeability Cap						
Cap	Stability	n/a[a]	March/April August	1 1	—[b]	Inspections will follow spring snowmelt and summer rains. Any problems with cap integrity will be repaired in a timely manner.
Run-on/ runoff controls	Stability	n/a	March/April August	1 1	—	Inspections will follow spring snowmelt and summer rains. Any problems with run-on/runoff controls integrity will be repaired in a timely manner.
Groundwater Well						
Groundwater	Chemical analysis	Well	Year 1 – Quarterly	4	X[c]	Groundwater, if present, will be sampled and analyzed for explosive compounds. One event will coincide with the summer monsoon.

[a] n/a = Not applicable.

[b] — = Analysis will not be requested.

[c] X = Analysis will be requested.

Table 4.2-1
Summary of Field Parameter Measurements at SWSC, Burning Ground, and Martin Springs

Location and Monitoring Point	Flow Rate (L/s)	pH (standard units)	Temp (deg C)	ORP (mV[a])	Specific Conductance (µS/cm[b])	DO (mg/L)	Turbidity (NTU[c])
Martin Spring Outlet	X[d]	X	X	X	X	X	X
Martin Spring Sampling Port	X	X	X	X	X	X	X
SWSC Spring Outlet	X	X	X	X	X	X	X
SWSC Spring Sampling Port	X	X	X	X	X	X	X
Burning Ground Spring Outlet	X	X	X	X	X	X	X
Burning Ground Spring Sampling Port	X	X	X	X	X	X	X

[a] mV = Millivolt.

[b] µS/cm = Microsiemens per centimeter.

[c] NTU = Nephelometric turbidity unit.

[d] X = Parameter will be measured.

Table 4.2-2
Summary of Analyses Requested at SWSC, Burning Ground, and Martin Springs

Location and Monitoring Point	Explosive Compounds (EPA SW-846:8330)
SWSC Spring Outlet	X*
SWSC Spring Sampling Port	X
Martin Spring Outlet	X
Martin Spring Sampling Port	X
Burning Ground Spring Outlet	X
Burning Ground Spring Sampling Port	X

*X = Analysis will be requested.

Table 4.3-1
Summary of Monitoring and Maintenance Parameters and Frequencies at SWSC, Burning Ground, and Martin Springs

Sampling Media	Monitoring Parameter	Sampling Point/ Location	Monitoring Event Frequency	Number of Samples Collected in 1 yr per Event	Explosive Compounds (EPA SW-846:8330)
SWSC and Burning Ground Springs[a]					
Spring water	Field parameters and off-site chemical analysis	Influent	Month 1 – Weekly Rest of Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	4 2 1 1 1	X[b]
Spring water	Field parameters and off-site chemical analysis	Effluent	Month 1 – Weekly Rest of Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	4 2 1 1 1	X
Spring water	Flow rate	Influent/Effluent	Year 1 – Quarterly	4	—[c]
Martin Spring[a]					
Spring water	Field parameters and off-site chemical analysis	Influent	Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	3 1 1 1	X
Spring water	Field parameters and off-site chemical analysis	Effluent	Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	3 1 1 1	X
Spring water	Flow rate	Influent/Effluent	Year 1 – Quarterly	4	—

[a] Carbon filters will be replaced if the effluent concentrations exceed 6.1 µg/L.

[b] X = Analysis will be requested.

[c] — = Parameter will not be measured.

Table 5.1-1
Summary of PRB Vessel Monitoring Points

Monitoring Point	Location	Goal/Feature
MP1	Upgradient sampling tube	Pretreatment water chemistry
MP2	Upgradient valve	Influent flow rate measurement
MP3	Vessel ZVI port	ZVI performance
MP4	Vessel gravel port	Prezeolite/post-ZVI chemistry
MP5	Vessel zeolite port	Zeolite performance
MP6	Downgradient valve	Effluent flow rate measurement
MP7	Downgradient sampling tube	Posttreatment water chemistry; PRB performance

Table 5.1-2
Summary of Field Parameter Measurements at the PRB Vessel Monitoring Points

Monitoring Point	Water Level	Flow Rate (L/s)	pH (standard units)	Temp (deg C)	Oxidation Reduction Potential (mV[a])	Specific Conductance (µS/cm[b])	Dissolved Oxygen (mg/L)	Turbidity (NTU[c])
MP1	X[d]	—[e]	X	X	X	X	X	X
MP2	—	X	—	—	—	—	—	—
MP3	X	—	X	X	X	X	X	X
MP4	X	—	X	X	X	X	X	X
MP5	X	—	X	X	X	X	X	X
MP6	—	X	—	—	—	—	—	—
MP7	X	—	X	X	X	X	X	X

[a] mV = Millivolt.
[b] µS/cm = Microsiemens per centimeter.
[c] NTU = Nephelometric turbidity unit.
[d] X = Parameter will be measured.
[e] — = Parameter will not be measured.

Table 5.1-3
Summary of Geochemical Analyses at the PRB Vessel Monitoring Points

Monitoring Point	Alkalinity	Cations (filtered and unfiltered)	Anions	Nitrogen Species	Carbon and Nitrogen Isotopes	Optional Sulfide by Test Kit	Optional Ferrous Iron by Test Kit
MP1	X[a]	X	X	X	X	X	X
MP2	—[b]	—	—	—	—	—	—
MP3	X	X	X	X	X	X	—
MP4	X	X	X	X	X	X	—
MP5	X	X	X	X	X	X	—
MP6	—	—	—	—	—	—	—
MP7	X	X	X	X	X	X	X

[a] X = Analysis will be requested.
[b] — = Analysis will not be requested.

Table 5.1-4
Summary of Analyses Requested at the PRB Vessel Monitoring Points

Monitoring Point	Explosive Compounds (EPA SW-846:8330)	HE-Breakdown Products (EPA SW-846:8321A_MOD)	Target Analyte List (TAL) Metals (EPA SW-846:6010B/6020) (filtered/unfiltered)	Optional TDS	Optional TSS	Optional TOC	Optional Dissolved Gases (methane, carbon dioxide, hydrogen, nitrogen)
MP1	X[a]	X	X	X	X	X	—[b]
MP2	—	—	—	—	—	—	—
MP3	X	X	X	X	X	X	X
MP4	X	X	X	X	X	X	X
MP5	X	X	X	X	X	X	X
MP6	—	—	—	—	—	—	—
MP7	X	X	X	X	X	X	—

[a] X = Analysis will be requested.
[b] — = Analysis will not be requested.

Table 5.1-5
General Field Parameter, Chemistry, and Biological Trends in the ZVI Media

Parameter	ZVI Media Effect	Downgradient Change
pH	Generally increases signaling groundwater is contacting ZVI	Can indicate microbial activity
DO	Declines, should be totally removed	Electron acceptor for biodegradation of organic contaminants (<10 ppm)
Alkalinity	Declines as minerals precipitate	Indicates buffering capacity of groundwater and CO_2 amount
Temperature	Affects degradation rates, slower at lower temperatures	Slower microbial metabolism at lower temperatures
Redox potential	Declines (typically to below 200 mV)	Measure of oxidation/reduction potential (ranges from +500 mV to -300 mV)
Sulfate	Generally declines due to sulfate reducing bacteria	Electron acceptor in biodegradation of organic constituents
Sulfide	Occurs as precipitate	Reduced form of sulfate. If present indicates reducing conditions in PRB
Methane gas	Appears as result of biodegradation within ZVI	Indicator of anaerobic conditions and methanogenic bacteria. Produced by microbial reduction of CO_2. Solubility limit 25–40 ppm
Hydrogen gas	Byproduct of Fe^o (ZVI) anaerobic corrosion	Indicator of iron corrosion
Carbon dioxide	Increase indicates RDX breakdown	Product of mineralization of RDX
TOC	May decline as it is consumed as carbon source for bacteria	Measure of TOC in water possibly available for biological degradation
RDX daughter products	Persistence of degradation byproducts of RDX may indicate insufficient residence time	Provides insight into mass balance of RDX degradation
Iron (total dissolved)	Product of bacterial iron reduction	May go up initially downgradient of barrier (shows up as reduced form Fe^{2+} ferrous), some iron is released, will stabilize over time
Nitrogen	Further RDX breakdown byproduct	Nutrient of microbial degradation, indicates degradation of RDX and daughter products
Nitrate	Further RDX breakdown byproduct	Indicates degradation of RDX and daughter products
Nitrite	Further RDX breakdown byproduct	Indicates degradation of RDX and daughter products
Ammonia/ammonium	Byproduct of reduction of nitrate and nitrite	Indicates reduction of nitrate and nitrite

Note: Modified from Table 6-1 of Permeable Reactive Barriers: Lessons Learned/New Directions (ITRC 2005, 109019, p. 77–78).

Table 5.1-6
Summary of Monitoring and Maintenance Parameters and Frequencies at the PRB Vessel Monitoring Points, Cutoff Wall Monitoring Wells, and Alluvial Groundwater Monitoring Wells

Monitoring Locations	Monitoring Parameter	Monitoring Event Frequency	Number of Samples Collected in 1 yr per Event	Water Level	Flow Rate	Explosive Compounds and Breakdown Compounds (EPA SW-846:8321A_MOD)	TAL Metals (EPA SW-846:6010B/6020)	Cations (calcium, magnesium, iron, manganese)	Anions (sulfate, chloride, nitrate, alkalinity)	General Chemistry[a] (stable isotopes)	Field Chemistry[b] (pH, temperature, ORP, specific conductivity, DO, turbidity)
PRB Vessel Hydrology											
MP1, MP3, MP4, MP5, MP7	Water level	Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	3 1 1 1	X[c]	—[d]	—	—	—	—	—	—
MP2, MP6	Flow rate	Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	3 1 1 1	—	X	—	—	—	—	—	—
PRB Vessel Field Parameters											
MP1, MP3, MP4, MP5, MP7	Field parameter analysis	Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	3 1 1 1	—	—	—	—	—	—	—	X
PRB Vessel Off-Site Analytical Laboratory											
MP1, MP3, MP4, MP5, MP7	Chemical analysis	Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	3 1 1 1	—	—	X	X	X	X	X	—
Cutoff Wall Hydrology											
Upgradient: MW-2, -3, -4, -5, and -12; PZ-13, -14, -15, and -16; Downgradient: MW-6, -7, -8, -9, -10, -11, -17, and -18	Water level[e]	Quarter 1 – Weekly Quarter 2 – Semimonthly Quarter 3 – Monthly Quarter 4 – Monthly	12 6 4 4	X	—	—	—	—	—	—	—

Table 5.1-6 (continued)

Monitoring Locations	Monitoring Parameter	Monitoring Event Frequency	Number of Samples Collected in 1 yr per Event	Water Level	Flow Rate	Explosive Compounds and Breakdown Compounds (EPA SW-846:8321A_MOD)	TAL Metals (EPA SW-846:6010B/6020)	Cations (calcium, magnesium, iron, manganese)	Anions (sulfate, chloride, nitrate, alkalinity)	General Chemistry[a] (stable isotopes)	Field Chemistry[b] (pH, temperature, ORP, specific conductivity, DO, turbidity)
Cañon de Valle Groundwater Field Parameters											
MW-1, -5, -12, -18, -19, -20	Field parameter analysis	Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	3 1 1 1	—	—	—	—	—	—	—	X
Cañon de Valle Off-Site Analytical Laboratory											
MW-1, -5, -12, -18, -19, -20	Chemical analysis	Quarter 1 – Monthly Quarter 2 – Quarterly Quarter 3 – Quarterly Quarter 4 – Quarterly	3 1 1 1	—	—	X	X	X	X	—	X

[a] TDS, TSS, TOC, and dissolved gases will be analyzed for if the PRB vessel is not working properly.

[b] Sulfide and ferrous iron will be analyzed for if the PRB vessel is not working properly.

[c] X = Analysis will be requested or parameter will be measured.

[d] — = Analysis will not be requested or parameter will not be measured.

[e] Water levels will be measured manually. Three upgradient and three downgradient wells will be instrumented with pressure transducers for automated monitoring (which will be downloaded on a quarterly basis).

Table 5.3-1
Summary of Field Parameter Measurements at the PRB Groundwater Alluvial Wells

Monitoring Well	Water Level	pH (standard units)	Temp (deg C)	Oxidation Reduction Potential (mV)	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)
MW-1	X*	X	X	X	X	X	X
MW-5	X	X	X	X	X	X	X
MW-12	X	X	X	X	X	X	X
MW-18	X	X	X	X	X	X	X
MW-19	X	X	X	X	X	X	X
MW-20	X	X	X	X	X	X	X

*X = Parameter will be measured.

Table 5.3-2
Summary of Off-Site Analyses at the PRB Groundwater Alluvial Wells

Monitoring Well	Explosive Compounds and Breakdown Compounds (EPA SW-846:8321A_MOD)	TAL Metals (EPA SW-846:6010B/6020) (filtered/unfiltered)	Cations (calcium, magnesium, iron, manganese)	Anions (sulfate, chloride, nitrate, alkalinity)
MP-1	X*	X	X	X
MW-5	X	X	X	X
MW-12	X	X	X	X
MW-18	X	X	X	X
MW-19	X	X	X	X
MW-20	X	X	X	X

*X = Analysis will be requested.

Appendix A

Photographs

Photographs showing low-permeability cap installed on the former settling pond in the 260 Outfall drainage

Photographs showing the carbon filter system installed at Burning Ground Spring

Photograph showing the upgradient sampling tube (MP1), valve access point, and MP2 valve to measure flow upgradient of vessel

Photograph of permeable reactive barrier (PRB) vessel showing the different reactive chambers. From left to right: gravel, zero-valent iron (ZVI), gravel, and zeolite. The grey 1-in. polyvinyl chloride (PVC) pipes from left to right are MP3, ZVI; MP4, gravel; and MP4, zeolite.

Photograph showing the downgradient sampling tube (MP5) and vessel cover. The three PVC pipes in the middle of the vessel cover are vent tubes.

Photograph looking downgradient of PRB vessel

Photograph showing the Sanitation Wastewater Systems Consolidation (SWSC) Spring carbon storm filter installation and spring outlet

Photograph showing the SWSC Spring carbon storm filter sampling tube outlet and granular activated carbon cartridges

Appendix B

Former Settling Pond Cap
and Stormwater Controls Inspection Checklist

Former Settling Pond Cap and Stormwater Controls Inspection Checklist

Date of Inspection_____

Time of Inspection_____

Name of Inspector_____

Inspection Parameters	Parameter Inspected (Yes or No)	Action Required (Yes or No)	Comments
Low-Permeability Cap			
Visible settlement or cracking of the cap			
Erosion of the cap			
Evidence of water ponding			
Animal intrusions and burrows			
Stormwater Control Structures			
Straw wattle control measure integrity			
Stormwater control sediment accumulation			

Appendix C

Carbon Filter System Inspection Checklist

Carbon Filter System Inspection Checklist

Date of Inspection_____

Time of Inspection_____

Name of Inspector_____

Inspection Parameters	Parameter Inspected (Yes or No)	Action Required (Yes or No)	Comments
SWSC, Burning Ground, and Martin Springs			
Integrity of aboveground piping and U-joints			
Evidence of debris in the weir box			
Martin Spring			
Monitor the seep discharge (outside of the current weir)			

Appendix D

Permeable Reactive Barrier Inspection Checklist

Permeable Reactive Barrier Inspection Checklist

Date of Inspection_____

Time of Inspection_____

Name of Inspector_____

Inspection Parameters	Parameter Inspected (Yes or No)	Action Required (Yes or No)	Comments
Integrity of aboveground piping and U-joints			
Integrity of access ports			
Integrity of the vent tubes, bypass line, manholes, and valves			
Observe channel for incisions at cutoff wall or buried piping			