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Summary Report for the Corrective Measures Implementation at Consolidated Unit 16-021(c)-99

Los Alamos
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Responsible project leader:

John McCann	[signature]	Project Leader	Environmental Programs	2-25-10
Printed Name	Signature	Title	Organization	Date

Responsible LANS representative:

Michael J. Graham	[signature] for MJG	Associate Director	Environmental Programs	2-26-10
Printed Name	Signature	Title	Organization	Date

Responsible DOE representative:

David R. Gregory	[signature] for	Project Director	DOE-LASO	3/01/10
Printed Name	Signature	Title	Organization	Date

EXECUTIVE SUMMARY

This summary report presents the results from the 2009–2010 corrective measures implementation (CMI) at Consolidated Unit 16-021(c)-99 within Technical Area 16 (TA-16), Los Alamos National Laboratory (LANL or the Laboratory). Consolidated Unit 16-021(c)-99 consists of two solid waste management units (SWMUs): 16-003(k) and 16-021(c). SWMU 16-003(k) comprises 13 sumps and approximately 1200 ft of associated drainlines and troughs that lead from the high explosives (HE) machining building (building 16-260) to the 260 Outfall drainage channel. HE-contaminated water flowed from the sumps into the concrete trough and ultimately to the 260 Outfall. SWMU 16-021(c) consists of three portions: an upper drainage channel fed directly by the 260 Outfall, a former settling pond, and a lower drainage channel leading to Cañon de Valle. The drainage channel runs approximately 600 ft northeast from the 260 Outfall to the bottom of Cañon de Valle. A 15-ft near-vertical cliff is located approximately 400 ft from the 260 Outfall and marks the break between the upper and lower drainage channels.

The 2009–2010 CMI characterization and remediation 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 Sanitary Wastewater Systems Consolidation (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 permeable reactive barrier (PRB) for treatment of HE and barium in Cañon de Valle.

The objective of the CMI was to remediate HE and other contaminants at the 260 Outfall channel (the concrete trough, former settling pond, and outfall drainage channel) and in the alluvial systems (SWSC, Burning Ground, Martin Springs, SWSC Cut, and Cañon de Valle). All treatments, as specified in the CMI plan, included installing the PRB, installing two carbon filter treatment systems, removing the concrete trough, injecting grouting, removing soil, replacing the cap, and sampling sediment. This summary report includes as-built diagrams for the PRB and carbon filter treatment systems.

Additional soil removal in the lower drainage not required in the CMI plan was initiated but was not completed because of heavy snow and limited access. Field-screening samples collected from the base of the excavation indicated RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) concentrations remained above the cleanup level. Additional excavation will be required at this location. The removal activities and final confirmation sampling will be conducted in the spring of 2010 when access is possible. The results will be reported in an addendum to this summary report to be submitted to NMED on August 31, 2010. The addendum will also include a revised risk-screening assessment for the 260 Outfall drainage channel.

Per the CMI plan, the target cleanup levels at the 260 Outfall channel were based on a target risk of 10^{-5} for carcinogens and a hazard index of 1 for noncarcinogens for the on-site worker. Three chemicals of potential concern are RDX, TNT (2,4,6-trinitrotoluene), and barium. The prescribed cleanup levels are site-specific screening action levels of 36.9 mg/kg for RDX and 135.0 mg/kg for TNT. The CMI plan did not stipulate a soil cleanup level for barium because HE is the primary driver of risk. The New Mexico Environment Department (NMED) residential soil screening level (SSL) of 15,600 mg/kg was used as the target cleanup level for barium.

The target cleanup levels for RDX, TNT, and barium have been met at all but one location within the 260 Outfall channel. One former settling pond location contained RDX at a concentration of 44.1 mg/kg, which exceeds the cleanup level of 36.9 mg/kg. However the RDX concentration at this location is below NMED residential and industrial SSLs.

The five SWSC Cut sediment samples had silver concentrations above the background value. In accordance with the CMI plan, the location with the highest silver concentration will be resampled and the sample submitted for sediment toxicity testing of chironomus. Confirmation sampling will be conducted in March 2010 when access is possible. If the new sample is found to contain elevated concentrations of silver and fails toxicity testing, NMED will be consulted and further removal actions may be required. The results of the sediment sampling will be reported in an addendum to this summary report and submitted to NMED on August 31, 2010.

In addition, a long-term monitoring and maintenance plan for the CMI will be submitted to NMED by April 30, 2010.

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Acronyms and Abbreviations

AOC	area of concern
ASTM	American Society for Testing and Materials
bgs	below ground surface
BH	borehole
CMI	corrective measures implementation
CMS	corrective measures study
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency
FD	field duplicate
HI	hazard index
HQ	hazard quotient
HE	high explosives
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazocine
IDW	investigation-derived waste
IM	interim measure
Ks	saturated hydraulic conductivity
LANL	Los Alamos National Laboratory
NMED	New Mexico Environmental Department
NPDES	National Pollutant Discharge Elimination System
PRB	permeable reactive barrier
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RFA	RCRA facility assessment
RFI	RCRA facility iInvestigation
SCL	sample collection logs
SMO	Sample Management Office
SOP	standard operating procedure
SSAL	site-specific screening action level
SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TA	technical area

TAL	target analyte list
TATB	triaminotrinitrobenzene
TD	total depth
TNT	2,4,6-trinitrotoluene
VOC	volatile organic compound
wt%	weight percent
XRF	x-ray fluorescence
ZVI	zero valent iron

1.0 INTRODUCTION

This summary report discusses the 2009–2010 corrective measures implementation (CMI) at Consolidated Unit 16-021(c)-99 within Technical Area 16 (TA-16), Los Alamos National Laboratory (LANL or the Laboratory) (Figure 1.0-1). The report describes characterization and remediation activities including (1) removing the concrete trough outfall next to building 16-260 at the 260 Outfall channel; (2) removing soil and sediment at 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 Sanitary Wastewater Systems Consolidation (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 permeable reactive barrier (PRB) for treatment of high explosives (HE) and barium in Cañon de Valle.

The objective of the 2009–2010 CMI was to remediate HE and other contaminants present in the 260 Outfall channel (including a concrete trough, former settling pond, and outfall drainage channel) and in the alluvial systems of Cañon de Valle and Martin Spring Canyon. The CMI was conducted in accordance with the CMI work plan (LANL 2007, 098192) and the New Mexico Environment Department (NMED) approval with modifications (NMED 2009, 107307). Corrective actions at the Laboratory are subject to the March 1, 2005, Compliance Order on Consent (the Consent Order).

This summary report is organized into seven sections, including this introduction, and multiple supporting appendixes. Section 2 presents an overview of the site operational history, the results of previous investigations, and details on additional investigation data requirements. Section 3 discusses the scope of investigation activities, and section 4 presents field investigation activities and results. Section 5 describes waste management, and section 6 summarizes deviations from the approved CMI work plan. Section 7 presents conclusions. Section 8 lists the references cited in this report and the map data sources. Appendixes A through C (on CD included with this document) present field documentation, including field logbooks, sample collections logs (SCLs) and chain-of-custody forms, and photographs, respectively. Appendixes D and E present summaries of air-permeability testing and surge bed cap specifications. Appendix F details as-built diagrams for the PRB, and Appendix G presents the alluvial monitoring well construction diagrams and lithologic logs.

2.0 BACKGROUND

2.1 Site Description and Operational History

Consolidated Unit 16-021(c)-99 consists of two solid waste management units (SWMUs): 16-003(k) and 16-021(c).

SWMU 16-003(k) consists of 13 sumps and approximately 1200 ft of associated drainlines and troughs that lead from the HE-machining building (16-260) to the 260 Outfall drainage channel (Figure 2.1-1). HE-contaminated water flowed from the sumps into the concrete trough and ultimately to the 260 Outfall, located approximately 200 ft east of building 16-260.

Building 16-260 has been used since 1951 to process and machine HE. Water was used to machine HE (which is slightly water-soluble); wastewater from machining operations contained dissolved HE and possible entrained HE cuttings. Wastewater treatment consisted of routing the water to 13 settling sumps to recover entrained HE cuttings. From 1951 to 1996, the water from these sumps was discharged to the

260 Outfall. In 1994, outfall discharge volumes were measured at several million gallons per year. The discharge volumes were likely higher during the 1950s when HE production output from building 16-260 was substantially greater than it was in the 1990s (LANL 1994, 076858). In the past, barium had been a constituent of certain HE formulations, and thus barium is also present in the outfall wastewater from building 16-260.

From the late 1970s to 1996, the 260 Outfall was permitted by the U.S. Environmental Protection Agency (EPA) to operate as EPA Outfall No. 05A056 under the Laboratory's National Pollutant Discharge Elimination System (NPDES) permit (EPA 1990, 012454). The last NPDES permitting effort for the 260 Outfall occurred in 1994. The NPDES-permitted 260 Outfall was deactivated in November 1996 and removed from the permit in January 1998.

SWMU 16-021(c) consists of three portions: an upper drainage channel fed directly by the 260 Outfall, a former settling pond, and a lower drainage channel leading to Cañon de Valle (Figure 2.1-1). The former settling pond was approximately 50 ft long and 20 ft wide and was located in the upper drainage channel, approximately 45 ft below the 260 Outfall. The drainage channel runs approximately 600 ft northeast from the 260 Outfall to the bottom of Cañon de Valle. A 15-ft near-vertical cliff is located approximately 400 ft from the 260 Outfall and marks the break between the upper and lower drainage channels.

A 2000–2001 interim measure (IM) cleanup (LANL 2002, 073706) removed more than 1300 yd^3 of contaminated soil from the former settling pond and channel. Approximately 90% of the HE in the Consolidated Unit 16-021(c)-99 source area was removed (LANL 2002, 073706). A low-permeability cap was installed on top of the former settling pond during the IM. The cap consists of crushed tuff/bentonite mixture and is approximately 20 in. thick.

HE-contaminated water from the building 16-260 outfall entered the former settling pond and drained into the 260 Outfall drainage channel. This was a significant pathway for contamination identified in downgradient components of Consolidated Unit 16-021(c)-99 hydrogeologic system, including three springs (SWSC, Burning Ground, and Martin Springs) and SWSC Cut and the area is next to SWSC Spring and SWSC pipeline and derived its name because it is a roadcut for the SWSC pipeline.

The CMI addressed contaminants associated with Consolidated Unit 16-021(c)-99 present in shallow soil, springs, and shallow groundwater at several locations at TA-16. These contaminants include RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), TNT (2,4,6-trinitrotoluene), and barium. Another explosive compound (although not as prevalent) is HMX (1,3,5,7-tetranitro-1,3,5,7-tetrazocine).

2.2 Current and Future Land Use

Current and future land use of TA-16 is industrial and specifically designated for HE research, development, and testing (LANL 2000, 076100; LANL 2001, 070210). Most areas within TA-16 are active sites for the former Engineering Science and Application Division of the Laboratory. Construction of new buildings and other facilities in the area is possible. As shown in Figure 2.1-1, numerous roads and utilities are present in the vicinity of Consolidated Unit 16-021(c)-99.

2.3 Results of Historical Investigations

Five investigations of Consolidated Unit 16-021(c)-99 have been conducted, including a postremediation investigation of the outfall drainage channel implemented after the removal of drainage channel soils, sediment, and tuff during IM activities. The investigations and results are summarized below chronologically.

A Resource Conservation and Recovery Act (RCRA) facility assessment (RFA) (LANL 1990, 007512) summarized soil and water sampling results from the 1970s for the outfall area. The RFA data collected for the 260 Outfall showed substantially elevated HE contamination in the sediment, outfall, and sump water. Levels up to 27 wt% (270,000 mg/kg) of HMX and RDX were documented in the area of the former settling pond. The data showed HE contamination extending from the discharge point to Cañon de Valle (Baytos 1971, 005913; Baytos 1976, 005920).

The Phase I RCRA facility investigation (RFI) (April 1995–November 1995) (LANL 1996, 055077) concentrated on characterizing contamination at the drainage channel and its intersection with Cañon de Valle, including alluvial sediment, surface water, and groundwater. NMED approved the report in 1998 (NMED 1998, 093664).

The Phase II RFI (November 1996–November 1997) (LANL 1998, 059891) further delineated contamination in tuff surge beds beneath the drainage channel and in Cañon de Valle sediment and waters. The Phase II RFI included the sampling of surface and near-surface material within the drainage and the sampling of 13 boreholes drilled to depths between 17 and 115 ft in and near the drainage. The Phase II RFI also included extensive field screening for RDX and TNT using immunoassay methods as well as sampling for other chemicals. A risk characterization was also performed. NMED approved the report in September 1999 (NMED 1999, 093666).

An IM remedial excavation was conducted in the outfall drainage channel and settling basin in 2000 and 2001. More than 1300 yd^3 of contaminated material containing approximately 8500 kg of HE was removed from these areas. The investigation results are presented in the IM report (LANL 2002, 073706), which was approved by NMED on January 13, 2003 (NMED 2003, 076174).

The Phase III RFI (October 1998–March 2002) (LANL 2003, 077965) included analyses of water and sediment data collected since the Phase II RFI (post-1998), a study of spring dynamics, a geomorphic alluvial sediment study, geophysical studies, and baseline risk assessments for the outfall source area and for selected reaches of Cañon de Valle and Martin Spring Canyon. In addition, a baseline ecological risk assessment was performed for Cañon de Valle. NMED approved the Phase III RFI report in June 2004 (NMED 2004, 093248).

An alluvial corrective measures study (CMS) conducted in November 2003 addressed the contaminants remaining in the unsaturated subsurface and the alluvial system in Cañon de Valle. The intermediate and regional groundwater CMS report (LANL 2003, 085531) focused on the extent of contaminants in the deep-perched zone and the regional aquifer. Remedial alternatives and long-term monitoring requirements were addressed.

3.0 GENERAL FIELD PROCEDURES

3.1 Preliminary Activities and Approach

Preliminary activities completed before the CMI field activities began included obtaining Laboratory-required permits and access agreements, identifying and marking potential utilities within the work zones, and conducting a geodetic survey to identify site locations. Mobilization activities included bringing all equipment, personnel, and materials on-site. Heavy equipment was inspected by TA-16 operations and safe work permits were issued for equipment before it was brought to the secured area.

All activities were conducted under the approved “Environmental Safety and Health Plan (ES&H Plan) for Corrective Measures Implementation of Consolidated Unit 16-021(c)-99 and Supplemental Investigative Work Plan for Consolidated Units 16-007(a)-99 and 16-008(a)-99 in Technical Area 16 (CMI and IWP [investigation work plan] at TA-16).” In addition, since TA-16 is a high-security area, site-specific training and a site security plan (TA-16 Site Security Plan EFOD 06-005, Revision 0) were also required. All fieldwork was implemented in accordance with RCRA Hazardous Waste Operations and Emergency Response guidelines, in addition to the security guidelines already established for the area.

3.2 Field Screening

Field screening was conducted for health and safety/U.S. Department of Transportation (DOT) purposes as well as for environmental screening.

Health and safety/DOT screening was conducted at all sites and included (1) HE spot testing using a Laboratory-supplied HE spot test kit and (2) monitoring for gross alpha/beta activity using an Eberline E-600 radiation meter with an SHP-380AB alpha/beta scintillation detector, or equivalent. The radiological screening was conducted by a Laboratory radiation control technician. Environmental samples were screened before they were transported to off-site laboratories. Equipment was screened before it was demobilized from the sites.

Environmental field screening was conducted as part of the 260 Outfall drainage channel activities. Following excavation at the concrete trough, former settling pond and drainage channel, samples were field-screened for RDX and TNT. Field screening methods included (1) HE spot test (detection limit 100 mg/kg]) and (2) RDX and TNT using Strategic Diagnostics, Inc. field screening EnSys test kit (detection limits approximately 1 mg/kg). In addition to field screening for HE at the concrete trough, the field investigation and removal action at this area also included screening for barium using an Innov-X Alpha Series x-ray fluorescence spectroscopy (XRF) instrument.

Field screening was implemented to meet remedial objectives proposed in the approved CMI plan (LANL 2007, 098192) using site-specific screening action levels (SSALs) of 36.9 mg/kg for RDX and 135.0 mg/kg for TNT. The CMI plan (LANL 2007, 098192) did not stipulate a soil field screening action level for barium because RDX and TNT were the primary contaminants for risk. As a conservative measure, NMED residential soil screening level (SSL) of 15,600 mg/kg was used as the target cleanup level for barium (NMED 2009, 108070). These levels for RDX, TNT, and barium were used for cleanup goals. Field screening for barium was required only for removal of the concrete trough.

If screening samples were found to contain RDX, TNT, or barium levels above their respective cleanup level, additional material was removed until concentrations were below these levels. Field screening results were recorded in the field logbook and/or SCLs, presented in Appendixes A and B (on CD).

3.3 Cleanup Goals

The levels at the 260 Outfall channel were based on a target risk of 10^{-5} for carcinogens and a hazard index (HI) of 1 for noncarcinogens for the on-site worker (LANL 2003, 085531; LANL 2007, 098192). Elevated risks from the baseline risk assessment (LANL 2003, 077965) were primarily from RDX, TNT, and barium. The same levels (36.9 mg/kg for RDX; 135.0 mg/kg for TNT; and 15,600 mg/kg for barium) were used for the cleanup goals at the 260 Outfall channel.

4.0 FIELD INVESTIGATION ACTIVITIES

This section summarizes the completed CMI activities and briefly describes the procedures and methods used during the execution of the 2009–2010 characterization and remedial activities. Photographs taken during field activities are presented in Appendix C (on CD).

4.1 260 Outfall Drainage Channel Remediation

Per the approved CMI plan (LANL 2007, 098192), the remedial objectives 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. The activities conducted to meet these four objectives are discussed below.

4.1.1 Concrete Trough Removal

Concrete trough removal began on October 10, 2009, and was completed on November 20, 2009. The east-west concrete trough (from the building 16-260 sumps at the roadway to the 260 Outfall) and sampling locations are shown in Figure 4.1-1. Appendix C presents photographs of the removal activities.

The steel plate cover and 6- to 8-in. layer of soil overlying the steel plate cover of the east-west concrete trough were removed. After the concrete trough was uncovered, stormwater was observed in the trough, and water from the trough was discharging from the polyvinyl chloride (PVC) outfall pipe into the drainage channel.

It was necessary to pump out the water remaining in the concrete trough before the trough was removed. A total of 5000 gal. of water was pumped from the trough and stored in water tanks for waste containment and later disposal (section 5 summarizes waste management at the site). After the trough was pumped dry, additional water was observed flowing from beneath one of the building 16-260 sumps (at the junction of the east-west trough) (Figure 4.1-1). As a result, a concrete plug (5 ft tall and 1 ft thick) was placed at the building sump at the junction of the east-west trough (on the west end) to prevent stormwater run-off from entering the 260 Outfall drainage channel. Additional stormwater runoff control measures were implemented and included placing straw wattles and native seed mix at various locations in the vicinity of building 16-260, the concrete trough, and the drainage channel.

The east-west concrete trough was excavated after all of the water was removed from the trough and the plug was installed. Approximately 40 yd^3 of concrete debris and approximately 9 yd^3 of soil were removed during the excavation. The soil was excavated as a result of elevated field-screening results at three locations (section 4.1.1.1). (An additional 3.0 yd^3 of soil was removed from 0 ft from the trough terminus, 2.0 yd^3 of soil was removed from 12 ft from the trough terminus, and 4.0 yd^3 of soil was removed from 132 ft from the trough terminus.)

Excavation and removal of the concrete trough and underlying soil at the concrete trough was conducted using a Komatsu PC200 Excavator. After the concrete trough was excavated, field-screening samples were collected from the base of the excavation (section 4.1.1.1), confirmation sampling was conducted (section 4.1.1.2), and the trench was backfilled using site material in 1-ft lifts, compacted, and regraded.

4.1.1.1 Field-Screening Results

HE field-screening results were used to guide the excavation activities. Field-screening samples were collected from beneath the base of the excavated trough. The excavated concrete trough was 150 ft in length; the 150-ft screening sample was collected at the junction of the sump at building 16-260 (the west end of the excavated concrete trough) (Figure 4.1-1). The 0-ft sample was collected at the trough terminus (the east end of the excavated concrete trough). Screening samples were collected at 6-ft intervals from 0 to 150 ft. Twenty-nine screening samples were field screened for HE and barium. No cracks or leaks points were noted in the trough. Screening results were logged in the field notebook and/or SCLs

(Appendixes A and B). The field-screening results of sampling at the base of the excavated concrete trough are presented in Table 4.1-1.

Elevated HE screening results using the EnSys kits were detected at three locations: at the 0-ft terminus of the former trough (66.9 mg/kg RDX and 0.5 mg/kg TNT); 12 ft from the trough terminus (12.5 mg/kg RDX and 138 mg/kg TNT); and 132 ft from the trough terminus (49.5 mg/kg RDX and 0.0 mg/kg TNT). Elevated barium screening results using the XRF were also indicated at the 0-ft terminus location (3590 mg/kg barium); 12 ft from trough terminus (1034 mg/kg barium); and 132 ft from the trough terminus (411 mg/kg barium). Field-screening results obtained at these three locations after the additional excavation indicated RDX and TNT were below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively. Although the screening concentration of barium increased slightly following additional excavation at the132-ft location, the concentrations were well below the residential SSL of 15,600 mg/kg (Table 4.1-1).

The EnSys field screening for the other 26 sample locations resulted in RDX concentrations ranging from 0.1 mg/kg to 19.6 mg/kg and TNT concentrations ranging from 0.0 mg/kg to 1.0 mg/k, all below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively (Table 4.1-1). The barium field-screening results ranged from 273 mg/kg to 3590 mg/kg, all below the residential SSL of 15,600 mg/kg (Table 4.1-1).

4.1.1.2 Confirmation Sampling

After field screening confirmed concentrations of HE and barium were below cleanup levels, confirmation samples were collected along the base of the trough (Figure 4.1-1). Three confirmatory samples and one field duplicate (FD) sample were collected. The samples collected during the confirmation sampling at the concrete trough and the requested analyses are presented in Table 4.1-2.

Two locations (16-608207 and 16-611358) were selected for confirmatory sampling from field screening locations where elevated RDX levels were detected, at 12 ft and 132 ft from the trough terminus. A third confirmation sample (location 16-611357) was collected from 72 ft from the trough terminus and is representative of the midpoint of the trough.

Another confirmation sample at location 16-608211 (Figure 4.1-1) was collected as an extra sample during the outfall drainage channel removal and sampling activities (section 4.1.3). This sample serves as a confirmation sample at the trough terminus of 0 ft. The location was not directly beneath the trough; however, it was within 4 ft of the 0-ft trough terminus.

All samples were screened on-site for radiological activity using an Eberline E-600 radiation meter with an SHP-380AB alpha/beta scintillation detector before the samples were transported to the Sample Management Office (SMO). All samples were submitted to an off-site contract laboratory for the analysis of HE, target analyte list (TAL) metals, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). The FD sample was submitted for the same suite of analyses as the confirmatory samples for quality assurance (QA)/quality control (QC) purposes.

Evaluation of analytical results for the confirmatory samples from the base of the excavated concrete trough identified six metals with detected concentrations or detection limits above background values (BVs): antimony, barium, cadmium, copper, lead, and manganese. Seven HE analytes [amino-2,6-dinitrotoluene(4-), amino-2,6-dinitrotoluene(2-), HMX, RDX, triaminotrinitrobenzene (TATB), trinitrobenzene(1,3,5-), and TNT] were detected. One VOC, acetone, was detected. No SVOCs were detected in the confirmation samples. Tables 4.1-3 and 4.1-4 provide summaries of inorganic chemicals above BVs and organic chemicals, respectively, detected at the concrete trough.

Data from the confirmation samples indicated concentrations of RDX, TNT and barium were below the cleanup levels. In addition, the concentrations were below the NMED industrial and residential SSLs, which are based on a 10^{-5} target risk for carcinogens or a hazard quotient (HQ) of 1 for noncarcinogens.

4.1.2 Former Settling Pond Soil Removal

Previous investigations indicated isolated pockets of soil exceeded the cleanup levels, primarily for RDX and TNT, following removal actions at the former settling pond (LANL 2003, 077965). Removal activities were conducted at three former settling pond locations from October 11 to October 19*,* 2009. The former settling pond and soil removal locations are shown in Figure 4.1-1.

A 5-ft radius was marked around former settling pond removal location 16-608212 (Figure 4.1-1). A pit was excavated to a depth of approximately 2.5 ft on the channel side and approximately 4 ft on the southeastern corner. A portion of the low-permeability pond cap that had been installed in 2001 was approximately 6 to 8 in. below the surface and mixed with soil. The cap was not continuous and could not be saved. After the area was excavated, screening samples were collected.

A 5-ft radius was marked around former settling pond removal location 16-608213 (Figure 4.1-1). The pit was excavated to a depth of approximately 2.6 ft on the channel side and approximately 4.4 ft on the north side. The pond cap was not present at this location. After the area was excavated, screening samples were collected.

Per the approved CMI plan (LANL 2007, 098192), the prescribed protocol for the third former settling pond location 16-06403 was first to hand auger to the 1-ft depth to determine whether the RDX screening concentrations exceeded the cleanup level. If screening results were found to be above the cleanup level, then a minimum of 5-ft radius was to be excavated. This protocol was followed because previous RDX field-screening results at location16-06403 exceeded the cleanup level; however, the associated off-site analytical data results at the location were below the cleanup level. Since the 2009 field-screening result at location 16-06403 exceeded the RDX cleanup level, the excavation area was enlarged to 10 ft by 10 ft by 2 ft deep. A small portion of the low-permeability cap was encountered approximately 1 ft below the surface, and the area consisted of moist fill and cobbles. The cap was not continuous and could not be saved. After the area was excavated, screening samples were collected.

Excavation of the three locations at the former settling pond was conducted using *a* Komatsu excavator or a Caterpiller 420D backhoe. Approximately 40 yd^3 of soil was removed from the former settling pond area. Upon completion of the excavations and sampling, field-screening samples were collected from the base of each excavation (section 4.1.2.1), confirmation sampling was conducted (section 4.1.2.2), and the pits were backfilled using site material in 1-ft lifts, compacted, and regraded. Because the low-permeability cap was not continuous and could not be maintained, per the CMI work plan a new low-permeability cap was installed (section 4.1.4).

4.1.2.1 Field-Screening Results

HE field-screening results were used to guide the excavation activities. Screening samples were collected at three locations within the former settling pond and field screened for HE using the EnSys test kits (Figure 4.1-1). The screening results were logged in the field notebook and/or SCLs (Appendixes A and B). A summary of the HE field-screening results obtained during the removal and sampling at the former settling pond is presented in Table 4.1-5.

Following excavation at location 16-608212, the field-screening results using the HE spot test kit were negative. The EnSys field screening resulted in RDX concentrations ranging from 1.6 mg/kg to 2.7 mg/kg and TNT concentrations ranging from 0.402 mg/kg to 3.077 mg/kg, all below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively.

Following excavation at location 16-608213, field-screening results using the HE spot test kit were negative. The EnSys field screening resulted in RDX concentrations ranging from 2.6 mg/kg to 5.8 mg/kg and TNT concentrations ranging from 0.341 mg/kg to 0.526 mg/kg, all below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively.

Following excavation at location 16-06403, field-screening results using the HE spot test kit were negative. The EnSys field screening resulted in RDX concentrations ranging from 10.9 mg/kg to 15.7 mg/kg, all below the cleanup level of 36.9 mg/kg. Samples were not field screened for TNT because RDX was driving the removal.

4.1.2.2 Confirmation Sampling

After field screening confirmed concentrations of HE were below cleanup levels, confirmation samples were collected from the base of each of the three excavated areas at the former settling pond (Figure 4.1-1). Three confirmatory samples and one FD were collected. The samples were selected from screening locations that resulted in the highest RDX concentrations at each excavation area. The samples collected during the confirmation sampling at the former settling pond and the requested analyses are presented in Table 4.1-2.

All samples were screened on-site for radiological activity using an Eberline E-600 radiation meter with an SHP-380AB alpha/beta scintillation detector before the samples were transported to the SMO. All samples were submitted to an off-site contract laboratory for analysis of HE, TAL metals, VOCs, and SVOCs. The FD sample was submitted for the same suite of analyses as the confirmatory samples for QA/QC purposes.

Evaluation of analytical results for these confirmatory samples from the base of the former settling pond excavations identified four metals with detected concentrations or detection limits above BVs: antimony, barium, cadmium, and selenium were detected. Seven HE analytes [amino-2,6-dinitrotoluene(4-), amino-2,6-dinitrotoluene(2-), HMX, RDX, TATB, trinitrobenzene(1,3,5-), and TNT] were detected. No VOCs or SVOCs were detected in the confirmation samples. Tables 4.1-6 and 4.1-7 present the inorganic chemicals above BVs and organic chemicals, respectively, detected at the former settling pond.

Concentrations of RDX and TNT in confirmation samples from locations 16-608212 and 16-06403 were below cleanup levels. The RDX concentration (44.1 mg/kg) in the confirmation sample from location 16-608213 exceeded the cleanup level of 36.9 mg/kg; however, it is below NMED industrial and residential SSLs.

4.1.3 Removal of 260 Outfall Drainage Channel Soil and Tuff

Based on previous investigations, RDX and TNT concentration exceeded cleanup levels in soil in the 260 Outfall drainage channel after the IM (LANL 2003, 077965). Removal activities were conducted at five outfall channel locations from October 17 to December 7, 2009. The 260 Outfall drainage channel and soil removal locations are shown in Figure 4.1-1.

Three of the outfall drainage channel removal locations (16-608208, 16-608209, and 16-608210) are in the upper outfall drainage channel, down-drainage from the former settling pond and above the cliff

(Figure 4.1-1). The area of excavation at outfall channel location 16-608208 was approximately 5 ft by 5 ft by 2.5 ft deep, and three screening samples were collected from the base of the excavation. The area of excavation at location 16-608209 was approximately 5 ft by 5 ft by 1.5 ft deep, and three screening samples were collected from the base of the excavation. The area of excavation at location 16-608210 was approximately 5 ft by 5 ft by 1.5 ft deep, and three screening samples were collected from the base of the excavation.

A fourth outfall drainage area encompassing locations 16-608211 and 16-06404 (Figure 4.1-1) was a combined removal from both locations. Location 16-608211 is at the former terminus of the concrete trough. Location 16-06404 is 4 ft east of the terminus. Soil and tuff were removed from an area 10 ft by 5 ft by 3 ft deep, which included both the area at the trough terminus and a 5-ft section around location 16-06404. Screening samples were collected from the base of the excavation. The coordinates for location 16-06404 were incorrectly identified in the CMI plan (LANL 2007, 098192). The correct coordinates for 16-06404 (northing 1764489.51, easting 1613296.19) place the location 4 ft below outfall rather than below the cliff. This location is in agreement with the 260 Outfall IM report (LANL 2002, 073706) and the RFI Phase III report (LANL 2003, 077965). The soil beneath the cliff was screened for RDX and was found to contain concentrations of RDX that exceeded the cleanup level, thus prompting removing soil from the fifth location.

The fifth drainage channel removal location (16-06405 in Figure 4.1-1) was an extra soil removal not required in the CMI plan (LANL 2007, 098192). This removal was initiated as a good stewardship measure. Location 16-06405 is 5 ft below cliff in the lower outfall drainage channel. Soil and tuff were excavated from an area 5 ft by 5 ft by 1.5 ft deep. Hand tools were used to excavate because the steep terrain prevented heavy equipment from accessing this location. The excavated material was hauled out on foot using 5-gal. buckets. Field-screening samples collected from the base of the excavation indicated RDX concentrations above the cleanup level (section 4.1.3.1). Additional excavation will be required at this location; however, the snow cover has made access not feasible until the spring. The removal activities and final confirmation sampling will resume as soon as access is possible. The results will be reported in an addendum to this summary report.

Excavation and removal of soil and tuff at the four upper drainage channel locations was conducted using a Komatsu excavator. The lower outfall channel excavation was conducted using a pick and shovels. Approximately 10 yd^3 of soil and tuff was excavated from the five locations. Certified clean fill material was provided by SG Western and used to backfill the four upper drainage channel excavation areas, after which the areas were compacted and regraded.

4.1.3.1 Field-Screening Results

HE field-screening results were used to guide the excavation activities. Screening samples were collected along the drainage channel and field screened for RDX and TNT using EnSys test kits. The screening results were logged in the field notebook and/or SCLs (Appendixes A and B). The field-screening results obtained during the removal and sampling at the drainage channel are presented in Table 4.1-8. Locations are shown in Figure 4.1-1.

Following excavation at location 16-608208, field-screening results using the HE spot test kit were negative for all samples. The EnSys field screening resulted in RDX concentrations ranging from 2.2 mg/kg to 3.3 mg/kg, and TNT concentrations ranging from 0.03 mg/kg to 0.43 mg/kg; all below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively.

Following excavation at location 16-608209, field-screening results using the HE spot test kit were negative for two of the three samples, and one sample was positive. The EnSys field screening resulted in RDX concentrations ranging from 1.8 mg/kg to 16.8 mg/kg, and TNT concentrations were 0.0 mg/kg, all below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively.

Following excavation at location 16-608210, field-screening results using the HE spot test kit were negative for two of the three samples, and one sample was positive. The EnSys field screening resulted in RDX concentrations ranging from 0.133 mg/kg to 0.80 mg/kg and TNT concentrations ranging from 0.37 mg/kg to 0.50 mg/k, all below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively.

Following excavation at location 16-06404, field-screening results using the HE spot test kit were negative for all samples. The EnSys field screening resulted in RDX concentrations ranging from 0.9 mg/kg to 16.5 mg/kg and TNT concentrations ranging from 0.4 mg/kg to 1.2 mg/kg, all below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively. Following excavation at location 16-608211, the EnSys field-screening results showed the RDX concentration was 2.9 mg/kg and the TNT concentration was 10 mg/kg, both below the cleanup levels of 36.9 mg/kg and 135 mg/kg, respectively.

Location 16-06405 at the base of the cliff (Figure 4.1-1) was screened for HE at three depths: 0–0.5 ft, 1.0–1.2 ft, and 3.0–3.6 ft. The RDX EnSys field screening result for the surface sample was 127 mg/kg. Soil was removed to a depth of 1.2 ft and RDX concentrations were 63 mg/kg and 164 mg/kg, both above the cleanup levels of 36.9 mg/kg. TNT screening was not performed on these samples because the samples had already failed for RDX screening. A third screening sample, collected at a depth of 3.6 ft using a hand auger, contained RDX at 0.005 mg/kg and TNT at 0.005 mg/kg, both below the cleanup levels. Although the one sample was below the cleanup level, further excavation will be required at the location to remove an estimated 5-ft by 5-ft by 2.4-ft volume of soil and tuff. Work will be completed in the spring of 2010 when the area is accessible.

4.1.3.2 Confirmation Sampling

After field screening confirmed concentrations of HE below cleanup levels, four confirmation samples and one FD sample were collected at drainage channel locations (Figure 4.1-1). The samples were selected from screening locations that resulted in the highest concentrations of RDX. A summary of the samples collected during the confirmation sampling at the drainage channel and the requested analyses are presented in Table 4.1-2.

All samples were screened on-site for radiological activity using an Eberline E-600 radiation meter with an SHP-380AB alpha/beta scintillation detector before they were transported to the SMO. All samples were submitted to an off-site contract laboratory for the analysis of HE, TAL metals, VOCs, and SVOCs. The FD sample was submitted for the same suite of analyses as the confirmation samples for QA/QC purposes.

Evaluation of analytical results for the samples from the drainage channel identified six metals with detected concentrations or detection limits above BVs: antimony, barium, beryllium, cadmium, iron, and selenium. Seven HE constituents [amino-2,6-dinitrotoluene(4-), amino-2,6-dinitrotoluene(2-), HMX, RDX, TATB, trinitrobenzene(1,3,5-), and TNT] were detected. One VOC, acetone, was detected, and no SVOCs were detected. Tables 4.1-9 and 4.1-10 provide summaries of inorganic chemicals detected above BVs and organic chemicals detected, respectively, at the drainage channel.

Concentrations of RDX and TNT in confirmation samples from locations 16-608208, 16-608209, 16-608210, and 16-608610 were below cleanup levels and below NMED industrial and residential SSLs.

4.1.4 Replacement of Low-Permeability Cap

The low-permeability cap was replaced over the former settling pond to prevent surface and groundwater from infiltrating and contacting potentially contaminated underlying tuff. The cap that had been installed over the former settling pond in 2001 was not continuous and could not be maintained. Field activities were completed on January 30 and 31, 2010, following the injection grouting in the former settling pond area (section 4.3). Appendix C presents photographs of the pond cap installation activities. Appendix E presents engineering details of the cap construction and installation.

The performance standards for the low-permeability soil-bentonite cap were 1×10^{-7} cm/s for saturated hydraulic conductivity (Ks), a thickness of 1 ft placed to achieve a maximum thickness of 6 in. per compacted lift, and compacted to a minimum 95% of maximum density from American Society for Testing and Materials (ASTM) D-698 (standard proctor) with moisture content 0% to 3% of optimum. The specification recommended using soil collected from the former cap soil stockpile for the cap. The settling pond stockpiled soil was unacceptable to use as a cap soil/material because of the large percentage of rock over ¾-in. diameter. An acceptable soil was located in Española, New Mexico, and supplied by Española Transit. The bentonite specification calls for a free flowing, high swelling, and granular sodium bentonite.

Moisture-density compaction and permeability testing was performed by an approved testing agency in accordance with the listed ASTM standards. Both soil-bentonite ratios (10% and 20% by weight) resulted in Ks values below the specified 1×10^{-7} cm/s; therefore, the 10% bentonite ratio was chosen for developing a proctor curve and for the field mixture. The lower bentonite content will result in less desiccation cracking.

During the soil-bentonite low-permeability cap installation, on-site field tests were conducted to verify the materials (e.g., water) and soil-bentonite backfill mixture met the requirements (e.g., moisture, compaction density). The soil-bentonite (90:10 by weight) was mixed at Española Transit using a conveyor belt system. With a conveyor belt system, soil is placed in one hopper and bentonite in a second hopper. Material was dispensed onto the conveyor belt at the prescribed ratios using variable speed motors controlling the feed rates from each hopper. The soil-bentonite mixture was compacted in 6-in. lifts. In-place soil density and moisture content was determined in accordance with ASTM D 1556-82 (Sand Cone Method). Three representative samples from each 6-in. lift were collected. All samples exceeded the minimum 95% of laboratory dry bulk density from the standard proctor test. Complete details and records are provided in Appendix E.

Per the CMI plan (LANL 2007, 098192), the new low-permeability cap will be inspected and run-on/runoff controls will be measured. Details will be provided in a long-term monitoring and maintenance plan.

4.2 SWSC Cut Soil Investigation

Previous investigations indicated soil in a road cut in the vicinity of the SWSC sewer pipeline (referred to as the SWSC Cut) contained elevated concentrations of silver and failed sediment toxicity testing (chironomus testing) (LANL 2003, 077965). The CMI plan called for further sampling at five locations at SWSC Cut. All samples are to be analyzed for TAL metals, and the location with the highest silver concentrations will be tested for toxicity to the chironomid.

Five investigation samples and one FD sample were collected on December 5, 2009 (Figures 4.1-1 and 4.2-1). The surface samples were collected from 0.0–0.3 ft depth and field screened for HE using the HE spot test kit; the samples screened negative. Appendix C presents photographs of sampling activities at the SWSC Cut.

All samples were screened on-site for radiological activity using an Eberline E-600 radiation meter with an SHP-380AB alpha/beta scintillation detector before the samples were transported to the SMO. The samples were submitted to an off-site contract laboratory for the analysis of TAL metals. The FD sample was submitted for the same suite of analyses as the investigation samples for QA/QC purposes. A summary of the samples collected during the sampling at the SWSC Cut and the requested analyses are presented in Table 4.2-1.

Evaluation of analytical results of these samples from the SWSC Cut identified nine metals with detected concentrations or detection limits above BVs: antimony, barium, cadmium, copper, manganese, nickel, selenium, silver, and thallium. Table 4.2-2 provides a summary of inorganic chemicals above BVs at SWSC Cut.

Silver concentrations range from 11.9 mg/kg to 38.5 mg/kg. Location 16-608204 had the highest silver concentration (38.5 mg/kg) and will be resampled in March 2010. The new sample will be submitted to an off-site laboratory for sediment toxicity testing of chironomus. The objective of this test is to determine whether inorganic chemicals, silver in particular, in sediment are harmful to the biota. If the new sample is found to contain elevated concentrations of silver and fails toxicity testing, NMED will be consulted and further removal actions may be required.

4.3 Remediation of Former Settling Pond Surge Bed

Previous investigations at TA-16 indicated the presence of HE contamination within surge beds beneath the footprint of the former settling pond (LANL 2003, 077965). As part of the Phase II RFI (LANL 1998, 059891) several boreholes were advanced into tuff next to the former settling pond to determine the vertical extent of HE. Many of the boreholes indicated the presence of surge beds underlying the former settling pond area. Surge beds are typically highly discontinuous features on the Pajarito Plateau; if they are present, they can vary in thickness and permeability over short distances (WoldeGabriel et al. 2001, 092523). Samples from the upper surge bed at approximately 17 ft below ground surface (bgs) beneath the former settling pond contained RDX (4500 mg/kg), HMX (1700 mg/kg), and TNT (3500 mg/kg).

Injection wells were installed around the former settling pond during the 2009–2010 characterization and remediation activities to grout the surge beds. A grouting plan (LANL 2009, 107452) was submitted to NMED before the work was conducted. These activities were designed to prevent the contaminated upper surge bed within the former settling pond area from making contact with groundwater by isolating the contaminated horizon and preventing contaminants from leaching into groundwater, migrating off-site, and threatening groundwater quality. The decision to treat the surge bed using in situ injection grouting was based on the areal extent, depth, and volume of contamination, type and concentration of contaminants present, soil characteristics, and site hydrogeology (LANL 2009, 107452). Injection grouting activities began on November 3, 2009, and were completed on January 31, 2010. The injection well locations within the former settling pond are shown in Figure 4.3-1.

4.3.1 Injection Grouting Design

Because of the general capabilities of grouting and the anticipated surge bed permeability, a performance goal of 5.0×10^{-5} cm/s, representing 1 to 2 orders of magnitude reduction in permeability, was set as the performance standard for grouting. To avoid potential hydraulic fracturing of the subsurface formation in and around the surge bed, low pressure grouting was used. Low-pressure grouting, otherwise known as permeation or area grouting, is a technique where a low-viscosity grout is injected in a formation filling pores and fissures, thereby decreasing formation permeability (LANL 2009, 107452).

The grout material and injection technique are dictated by the site conditions. The surge bed site is a relatively small area (approximately 1250 ft^2). The contaminant levels are moderate to high and are primarily HE contamination with RDX concentrations up to 4500 mg/kg. The contamination is believed to reside within the surge bed material primarily to a depth of approximately 17 ft bgs. The overburden consists of very densely welded unsaturated tuff, which cannot be easily excavated. Normally, such a small volume of contaminated material would be excavated; however, treatment by grout injection is the appropriate method because the depth to the surge bed is approximately 17 ft bgs and the volume of contaminated soil versus the overburden volume is relatively small. The selection was described in the CMI plan (LANL 2007, 098192) and approved by NMED (2007, 098449).

The choice of grout material was determined by the grain size, porosity, and density of the formation (LANL 2009, 107452). These characteristics of the surge bed material and tuff were determined from borehole logs and archived core from the former settling pond. The grain size of the surge bed material is similar to a fine-grained soil ranging in particle-size diameter from 0.001 to 2 mm (Freeze and Cherry 1979, 088742). The porosity and bulk density of the surge material have not been measured; however, laboratory results of core samples collected from surge beds in two nearby borings indicate porosities of 47% and 51%, and bulk densities of 1.30 g/cm^{-3} and 1.42 g/cm^{-3} (Newman et al. 2007, 095632).

4.3.2 Injection Grouting Activities

Eleven primary injection boreholes (P-1 through P-11) were drilled to depths ranging from 22 ft to 33 ft bgs. The boreholes are spaced approximately 10 ft around the bottom of the drainage channel and encompass the perimeter of the surge bed (Figure 4.3-1). Five secondary injection wells (S-1 through S-5) were drilled to depths of 23 ft and were located equidistant from the primary boreholes (Figure 4.3-1). The purpose of the secondary injection wells was to infill between the primary injection boreholes. Appendix C presents photographs of the injection grouting activities.

The 16 boreholes were drilled using a TEI Rock Drills, Drillall Geo model rig. Water-injection tests were first conducted in each of the injection wells until steady-state was reached and flow and water uptake could be measured to determine the correct grout mixtures for infiltration into the formation at the various boreholes. Injection pressures were measured using an RST Instruments, Ltd., permeation grout monitor, and the pressures were maintained at 20 pounds per square inch (psi) or less. This was considered sufficient for using a low-viscosity grout to fill the pores and fissures and decrease formation permeability.

Different mixtures of grout-cement and water were used in the boreholes effectively grout subsurface voids. Grout-cement included Type I, Type II, Type III, and microfine cement. Grout ratios (water to grout-cement) are 4:1, 3:1, 2:1, and 1:1, respectively. Testing indicated that coarser cement such as Type III cement worked better in the boreholes that advanced into more conductive part of the formation. In general, the approach was to begin grouting with finer-grained grout and incrementally increasing the grain size and reducing the water content of the grout until the refusal criterion was met. The refusal criterion was an injection rate of less than 1 gal./min for a 5-min period. Microfine cement was used in the boreholes that advanced into the less conductive part of the formation. Table 4.3-1 presents the final grout ratios and volumes of grout used.

Five of the injection wells (P-10, P-11, S-2, S-3, and S-4) were found to take over 800 gal. of grout each. Over 6000 gal. of grout was injected into these five boreholes, and the refusal criterion was met for each borehole. The volume of grout injected indicated the presence and dominance of subsurface fractures in the upper part of the drainage beneath the former settling pond in the area of the contaminated surge bed. Grout probably filled the fractures and secondarily filled the interstitial pore space of the surge bed. The air-permeability test holes were also installed in this region as discussed in section 4.3.3.

A groundwater monitoring well was installed to monitor the long-term effectiveness of grouting**.** The borehole for the down-drainage monitoring well was drilled to 25 ft, and no water was encountered during drilling and construction of the well. The well was cased and was screened at 15 to19 ft to target the 17-ft-deep surge layer. The sand pack, bentonite seal and concrete plug were installed. Details of the monitoring will be reported in the long-term monitoring and maintenance plan.

4.3.3 Air-Permeability Testing Activities

To assess the effectiveness of injection grouting, an air-permeability test of the grouted area was conducted. The intrinsic permeability determined from this air-permeability test was then compared to a performance goal to evaluate the efficacy of injection grouting. The performance goal was set to a saturated hydraulic conductivity value of 5×10^{-5} cm/s. The intrinsic permeability calculated from this saturated hydraulic conductivity is 6×10^{-10} cm^2.

On November 12, 2009, two air-permeability test boreholes (AP-1 and AP-2) were drilled to approximately 25 ft bgs and placed approximately 8 ft apart (Figure 4.3.1). The boreholes were located within the grouted area but did not receive any grout before testing.

On January 16, 2010, the air-permeability test was performed. Borehole AP-1 was monitored as an observation borehole, while vacuum was placed on extraction borehole AP-2. Inflatable packers were used to seal and isolate the lower portions of each borehole during the test. The packers were placed at a depth of approximately 12 ft bgs and inflated to 120 psi; accordingly, the test interval was from 12 ft bgs to 25 ft bgs. This interval is presumably the same one that received grout and where the surge bed is located.

Air was extracted at an average rate of 41 ft^3/min from AP-2 using a 3-amp GAST regenerative blower. Vacuum was monitored at the blower and at both the extraction and observation boreholes using standard vacuum gauges. In addition, an in situ pressure transducer (Bare-Troll) was placed in the observation borehole, and pressure recorded at 1-min intervals. The extraction period was approximately 168 min (2.8 hr). A vacuum response was observed at borehole AP-1 (the observation borehole) after about 80 min of extraction at borehole AP-2. Total vacuum at borehole AP-1 stabilized to approximately 1.7 in. of water after approximately 120 min of extraction.

Vacuum data measured at borehole AP-1 were analyzed to determine the intrinsic permeability of the test interval (Appendix D). The intrinsic permeability determined from the test is 6.3×10^{-7} cm^2, which is comparable to the intrinsic permeability values of permeable basalt or clean sand (Freeze and Cherry, 1979, 088742). The intrinsic permeability determined from the test is 3 orders of magnitude greater than the performance goal of 6×10^{-10} cm^2, which is comparable to a sandstone or silty sand (Freeze and Cherry 1979, 088742). It is likely that the test borehole flow paths were connected to the highly fractured zone encountered by injection wells P-10, P-11, S-2, S-3, and S-4.

4.4 Installation of Spring Carbon Filters at SWSC and Burning Ground Springs and Modification of Existing Carbon Filter at Martin Spring

Carbon filters were installed at SWSC and Burning Ground Springs between November 20 and December 5, 2009. The spring carbon filters are designed to optimize hydraulic head difference across the filter and to preserve any existing wetlands associated with the spring, both during and after construction for cleanup of SWSC and Burning Ground Springs in Cañon de Valle and Martin Spring in Martin Spring Canyon. As-built diagrams of the SWSC Spring and Burning Ground Spring carbon filter systems are presented in Figures 4.4-1 and 4.4-2. Appendix C presents photographs of storm filter installation activities.

4.4.1 Carbon Filter Design

The carbon filter design consists 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. To preserve the small wetland area associated with SWSC and Burning Ground Springs, the treated spring water was designed to discharge to the surface within the existing wetland areas.

The carbon filters (manufactured by Contech, based in Portland, Oregon) consist of a subgrade vault containing two activated carbon canisters, each with approximately 45 lb of activated carbon. A similar unit was installed in 2001 as a pilot and is operating at Martin Spring. 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. The spring collection boxes consist of a weir and a reservoir and are fabricated from aluminum by a machine shop.

4.4.2 Installation of Carbon Filter

SWSC Spring

Storm filters (weighing approximately 1300 lb) and other supplies were transported to the SWSC Spring site using a Caterpillar 420D backhoe. One load of pea gravel (1 yd^3) was used to backfill and seat the SWSC Spring carbon filter.

SWSC Spring was diverted before excavation and installation of the carbon filter system were conducted. A 30-ft long trench was dug and a 6-ft by 4-ft by 4-ft area was excavated using a Caterpillar 420D backhoe to lay the piping and the spring box. The piping to the box, sampling port, and discharge line to the channel were installed. The weir box, which was specially fabricated with plumbing to the subsurface, was installed. During excavation of the spring box, the alluvial groundwater table was reached at approximately 4 ft bgs and water readily filled the highly productive zone in the excavation.

After the subsurface system was installed, the excavations were backfilled with the native soil. Native seed mix was applied to the bare soil, and erosion blankets were rolled out over the disturbed area. Straw wattles were installed at the downgradient edge of the disturbed area at SWSC Spring to prevent sediment and runoff from entering Cañon de Valle.

Burning Ground Spring

Storm filters and other supplies were transported to the Burning Ground Spring site using a Caterpillar 420D backhoe. Two loads of pea gravel (2 yd^3) were delivered and used to backfill and seat the carbon filter unit.

Water from Burning Ground Spring was flowing at a rate of approximately 0.2 L/s. Therefore water was diverted from the upper slope installation site for 1 wk before excavation. A 15-ft-long trench and a 6-ft by 4-ft by 4-ft excavation were dug using a Caterpillar 420D backhoe to lay the piping and the spring box. The piping to the box, sampling port, and discharge line to the channel were installed. The weir box, which was specially fabricated with plumbing to the subsurface, was installed.

After the subsurface system was installed, the excavations were backfilled with native soil. Native seed mix was applied to the bare soil and erosion blankets were rolled out over the disturbed area. Straw wattles were installed at the downgradient edge of the disturbed area at Burning Ground Spring to prevent sediment and runoff from entering Cañon de Valle. Appendix C presents photographs of the restoration activities.

Martin Spring

A weir adapter box was installed at Martin Spring to capture the seep next to the weir box. Because the soil was frozen in the area, the box will be adjusted and seated firmly after the ground has thawed.

4.5 Installation of Pilot PRB in Cañon de Valle

Installation of PRBs was identified in the CMS as the preferred remedial alternative for the Cañon de Valle alluvial system (LANL 2003, 085531). Three PRBs were proposed for Cañon de Valle and one was proposed for Martin Spring Canyon. The primary remedial objective for the PRB is to reduce RDX and barium concentrations in alluvial groundwater to below their respective groundwater standards, which in turn will reduce the concentrations of contaminants infiltrating intermediate and regional groundwater zones. The chosen location of the PRB (Figure 4.5-1) was identified by previous investigations (LANL 2003, 077965) to be an area recharge potential to the deeper groundwater is high. 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.

In the CMS (LANL 2003, 085531) the Laboratory proposed installing a PRB in Cañon de Valle as a pilot project to investigate the effectiveness of the barrier before other PRBs are installed. The pilot PRB is located next to alluvial monitoring well 16-02658 and intermediate well CdV-16-1i, which is located in a potential recharge area for deeper groundwater (Figure 4.5-1). Because this remedy is a pilot project and concentrations of RDX in alluvial groundwater have decreased during recent years, a key goal is to demonstrate a significant decrease (>90%) in RDX concentration. The PRB installation activities began on December 14, 2009, and were completed on January 19, 2010. As-built diagrams of the PRB are presented in Appendix F.

4.5.1 PRB Design

The PRB consists of a cutoff wall to divert groundwater into a downgradient reactive cell. The reactive cell is a baffled polypropylene vessel containing four chambers for the reactive media (Figure 5.5-1). The groundwater diversion wall consists of PVC sheet-piling. The PVC wall is placed in a 2-ft-wide linear trench (the bottom of which is tuff). The wall is sealed and secured into the underlying tuff using bentonite-soil mixture, and then overlain with geotextile and 3/8-in. pea gravel. Two penetrations in the wall direct water through a 2-in. pipe to the four-stage reactive cell system.

As part of the first phase of the PRB, laboratory tests were completed to determine the best reactive media for treating RDX and barium (LANL 2010, 108648). The results indicated that granular zero valent iron (ZVI) and clinoptilolite zeolite are the most effective and cost efficient means of treating RDX and barium, respectively. Based on the study, ZVI and clinoptilolite zeolite are used in the four-stage reactive cell system. The system is baffled to allow water to flow into four cells sequentially as follows: water first flows into cell 1 (containing 3/8-in. pea gravel) to cell 2 (containing ZVI/sand mixture) to cell 3 (containing 3/8-in. pea gravel) and to cell 4 (containing clinoptilolite zeolite). After treatment through the four-stage reactive cell, the groundwater is directed to an infiltration gallery (LANL 2010, 108648). Appendix C presents photographs of the PRB system, including the four-stage reactive cell. Appendix F presents as-built diagrams of the PRB system.

4.5.2 PRB Installation

To prevent sediment and stormwater from entering channel before excavation and installation activities were conducted, straw wattles were placed alongside the stream channel. The infiltration gallery and reactive cell of the PRB system were installed first. A 3-ft by 10-ft by 3-ft-deep area was excavated for the infiltration gallery using a Caterpillar 420D backhoe. Competent bedrock was reached at 2.7 ft bgs. The infiltration gallery consists of a 12-ft section of infiltrators, which were buried 3 ft bgs and covered with 1 ft of soil. A 15-ft by 5-ft by 4-ft-deep area was excavated for the PRB and valve access. Appendix C presents photographs of the PRB installation activities.

The PRB four-stage reactive cell was installed just upstream of the infiltration gallery. The prefabricated vessel was installed within an excavated area approximately 20 ft long by 6 ft wide by 5 ft deep. The reactive cell is offset from the perennial stream to minimize erosion effects around the reactive cell. The vessel was filled with approximately 8700 lb of ZVI, zeolite, and pea-gravel mixture. Although the PRB is installed belowground, the PRB cells can be accessed through a removable cover to replace the media, if necessary. Three 1-in.-diameter sampling tubes were installed within the media and penetrate the cell, allowing groundwater gauging and sampling and other data gathering within the cells. Three vent tubes were installed within the lid to vent air that is displaced by rising or falling groundwater levels and also to allow the venting of any generated gas. A 2-in. bypass line was also installed to allow water to flow around the reactive cell. The valves for the bypass line can be accessed from manholes installed upstream and downstream of the reactive cell. Sampling ports are also plumbed upstream and downstream of the vessel so water samples can be collected above and below the vessel. As-built diagrams of the PRB are presented in Appendix F.

The cutoff wall and groundwater transfer line of the PRB system was installed next. A 103-ft by 3-ft by 10-ft-deep trench was excavated, and a minimum of 2-ft soil-bentonite mixture was placed in the bottom of the trench. The plastic sheet piling is fabricated in 2-ft-wide sections with tongue-and-groove connecting slots. The slots were filled with a hydroswelling caulk, and the sheets were assembled on-site to form the wall 2 ft at a time. The sheet piling was seated into the soil-bentonite for the entire length of the trench. After the PVC sheet pilings were installed, geotextile was placed over the soil-bentonite mixture. A 4-in. slotted flexible pipe was placed at the base of the geotextile and overlain with a 1-ft to 3-ft layer of pea gravel. This layer served as a groundwater collection gallery. The geotextile/gravel layer was secured and native soil was backfilled to the existing grade. Before the trench and diversion wall were backfilled, two penetrations were drilled in the wall. The penetrations are connected by Y-piping to a flexible corrugated plastic pipe that connects the upgradient cutoff wall to the downgradient reactive cell of the PRB system. The corrugated pipe was placed in a 120-ft by 2-ft by 3-ft-deep trench that was later backfilled and graded. The entire site was regraded and seeded. Five rolls of erosion blankets (100 ft by 8 ft each) were used to cover the areas impacted from construction.

4.5.3 Alluvial Monitoring Wells

Sixteen alluvial groundwater-monitoring wells were drilled using a CME-55 hollow-stem auger rig and 8-in.-outer diameter to monitor the performance of the PRB (Figure 4.5-1). The wells were installed in strategic locations to provide a potentiometric surface of the groundwater above and below the cutoff wall, within the wall, and below the vessel. Five of these wells were installed 30 ft upgradient of the PRB, and 11 wells were installed downgradient. In addition, four 2-in. piezometers were installed upgradient of and next to the diversion wall. All four piezometers are seated in the pea gravel and will be used to monitor water levels and water chemistry upgradient of the cutoff wall. From January 26 to January 31, 2010, 20 monitoring points (16 alluvial wells and 4 piezometers) for water level and water chemistry were installed.

Depths of the wells ranged from 7 to 16 ft bgs. The well casing is 2-in.-diameter PVC and is screened across the alluvium. The filter pack between the screen and well bore consists of clean silica sand. Bentonite chips or pellets were used for the annular seal. All drilling activities were conducted in accordance with appropriate Laboratory guidance documents and protocols. Appendix G presents the lithologic logs and well construction diagrams for the 16 monitoring wells.

5.0 WASTE MANAGEMENT

The investigation-derived waste (IDW) generated as a result of investigation and remediation activities includes concrete, steel plates, excavated soil and tuff, waste water, municipal solid waste, contact waste, and spent solvent/soil from the HE spot test kits. The IDW was containerized, characterized, and managed as specified in the project's waste characterization strategy form, which was prepared in accordance with Standard Operating Procedure 5023, Characterization and Management of Environmental Program Waste. The IDW is currently being managed as nonhazardous waste within the consolidated unit. Waste profile forms and manifests will be prepared for these wastes, and the waste will be disposed at the appropriate facilities.

6.0 DEVIATION

One deviation from the approved CMI plan for Consolidated Unit 16-021(c)-99 occurred during the field implementation. The geodetic coordinates for location 16-06404 were incorrectly presented in the CMI plan (LANL 2007, 098192). The coordinates have been corrected and are consistent with the location as presented in the 260 Outfall IM report (LANL 2002, 073706). Additional soil removal in the lower drainage not required in the CMI plan was initiated but not completed because of heavy snow and limited access. The location was identified through field screening of an incorrectly located sample. Additional excavation will be required at this location.

7.0 CONCLUSIONS

This report describes the completion of the following eight activities conducted in 2009–2010 at Consolidated Unit 16-021(c)-99: removing the concrete trough at the 260 Outfall; removing soil from beneath the former settling pond within the 260 Outfall drainage channel; removing soil from the four required 260 Outfall drainage channel locations; replacing the low-permeability cap on the former settling pond; sampling soil for silver in the SWSC Cut of Cañon de Valle; installing surge bed injection grouting within the former settling pond at the 260 Outfall drainage channel; 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 installing a PRB in Cañon de Valle for treatment of HE and barium.

Additional soil removal in the lower drainage not required in the CMI plan was initiated but not completed because of heavy show and limited access. The location in the lower drainage was identified through field screening of an incorrectly located sample. Additional excavation will be required at this location. The removal activities and final confirmation sampling will be conducted in the spring of 2010 when access is possible. The results will be reported in an addendum to this summary report to be submitted to NMED on August 31, 2010.

The five SWSC Cut sediment samples had silver concentrations above the background value. In accordance with the CMI plan, the location with the highest silver concentration will be resampled and submitted for sediment toxicity testing of chironomus. The confirmation sampling will be conducted in March 2010 when access is possible. The results will be reported in an addendum to this summary report and submitted to NMED on August 31, 2010. If the new sample is found to contain elevated concentrations of silver and fails toxicity testing, NMED will be consulted and further removal actions may be required.

In addition, to confirm the effectiveness of the CMI characterization and remediation activities, and per NMED requirements, a long-term monitoring and maintenance plan will be submitted to NMED on April 30, 2010.

8.0 REFERENCES AND MAP DATA SOURCES

8.1 References

The following list includes all documents cited in this report. 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.

Baytos, J.F., December 9, 1971. "Analysis of Soil Samples for Residual Explosives from Drainage Ditches at Sump Effluent Outlets," Los Alamos Scientific Laboratory memorandum to H.E. Ballance from J.F. Baytos, Los Alamos, New Mexico. (Baytos 1971, 005913)

Baytos, J.F., December 16, 1976. "Analysis of Soil Samples for Residual Explosives from Drainage Ditches at Sump Effluent Outlets," Los Alamos Scientific Laboratory memorandum to H.E. Ballance from J.F. Baytos, Los Alamos, New Mexico. (Baytos 1976, 005920)

EPA (U.S. Environmental Protection Agency), 1990. "NPDES Authorization to Discharge Waters of the United States," Water Management Division, EPA Region 6, Dallas, Texas. (EPA 1990, 012454)

Freeze, R.A., and J.A. Cherry, January 1979. *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey. (Freeze and Cherry 1979, 088742)

LANL (Los Alamos National Laboratory), November 1990. "Solid Waste Management Units Report," Vol. II of IV (TA-10 through TA-25), Los Alamos National Laboratory document LA-UR-90-3400, Los Alamos, New Mexico. (LANL 1990, 007512)

LANL (Los Alamos National Laboratory), May 9, 1994. "Process Flow Reductions from Waste Minimization for Value Engineering Study," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 1994, 076858)

LANL (Los Alamos National Laboratory), September 1996. "RFI Report for Potential Release Sites in TA-16: 16-003(k), 16-021(c)," Los Alamos National Laboratory document LA-UR-96-3191, Los Alamos, New Mexico. (LANL 1996, 055077)

LANL (Los Alamos National Laboratory), September 1998. "RFI Report for Potential Release Site 16-021(c)," Los Alamos National Laboratory document LA-UR-98-4101, Los Alamos, New Mexico. (LANL 1998, 059891)

LANL (Los Alamos National Laboratory), September 22, 1998. "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-98-4847, Los Alamos, New Mexico. (LANL 1998, 059730)

LANL (Los Alamos National Laboratory), 2000. "Comprehensive Site Plan 2000," Los Alamos National Laboratory document LA-UR-99-6704, Los Alamos, New Mexico. (LANL 2000, 076100)

LANL (Los Alamos National Laboratory), 2001. "Comprehensive Site Plan 2001," Los Alamos National Laboratory document LA-UR-01-1838, Los Alamos, New Mexico. (LANL 2001, 070210)

LANL (Los Alamos National Laboratory), July 2002. "Interim Measure Report for Potential Release Site 16-021(c)-99," Los Alamos National Laboratory document LA-UR-02-4229, Los Alamos, New Mexico. (LANL 2002, 073706)

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)

LANL (Los Alamos National Laboratory), November 2003. "Corrective Measures Study Report for Solid Waste Management Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-03-7627, Los Alamos, New Mexico. (LANL 2003, 085531)

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), October 2009. "Grouting Plan for the Corrective Measures Implementation for Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-09-6807, Los Alamos, New Mexico. (LANL 2009, 107452)

LANL (Los Alamos National Laboratory), March 2010. "Column Study Results for the Permeable Reactive Barrier," Los Alamos National Laboratory, Los Alamos, New Mexico. (LANL 2010, 108648)

Newman, B.D., D.D. Hickmott, and P. Gram, 2007. "Flow and High Explosives Transport in a Semiarid Mesa in New Mexico, USA," unpublished manuscript. (Newman et al. 2007, 095632)

NMED (New Mexico Environment Department), January 20, 1998. "Approval Upon Modification, 16-003(k) and 16-021(c), RCRA Facility Investigation Report (EM/ER:96-502) and Response to Supplemental Information (EM/ER:97-476)," New Mexico Environment Department letter to T. Taylor (DOE-LAAO) and J. Browne (LANL Director) from B. Garcia (NMED-HRMB), Santa Fe, New Mexico. (NMED 1998, 093664)

NMED (New Mexico Environment Department), September 8, 1999. "Approval, 16-021(c) RFI Report and CMS Plan," New Mexico Environment Department letter to T. Taylor (DOE-LAAO) and J. Browne (LANL Director) from J.E. Kieling (NMED-HRMB), Santa Fe, New Mexico. (NMED 1999, 093666)

NMED (New Mexico Environment Department), January 13, 2003. "Approval of the Interim Measure Report for Potential Release Site 16-021(c)-99," New Mexico Environment Department letter to E. Trollinger (DOE-OLASO) and J.C. Browne (LANL Director) from J.E. Young (NMED-HWB), Santa Fe, New Mexico. (NMED 2003, 076174)

NMED (New Mexico Environment Department), June 21, 2004. "Approval as Modified, Phase III RFI Report for Solid Waste Management Unit (SWMU) 16-021(c)-99," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and G.P. Nanos (LANL Director) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2004, 093248)

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)

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)

8.2 Map Data Sources

Data sources used in original figures created for this report are described below and identified by legend title.

Legend Item/Type	Data Source
LANL Technical Areas	Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 04 December 2008.
Paved roads	Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.
Dirt roads	Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.
Drainages	WQH Drainage_arc; Los Alamos National Laboratory, ENV Water Quality and Hydrology Group; 1:24,000 Scale Data; 03 June 2003.
LANL structures	Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 28 May 2009.
LANL PRS boundaries	Potential Release Sites; Los Alamos National Laboratory, Waste and Environmental Services Division, Environmental Data and Analysis Group, EP2009-0137; 1:2,500 Scale Data; 13 March 2009.
LANL historical sample locations	Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2009-0283; 04 June 2009.

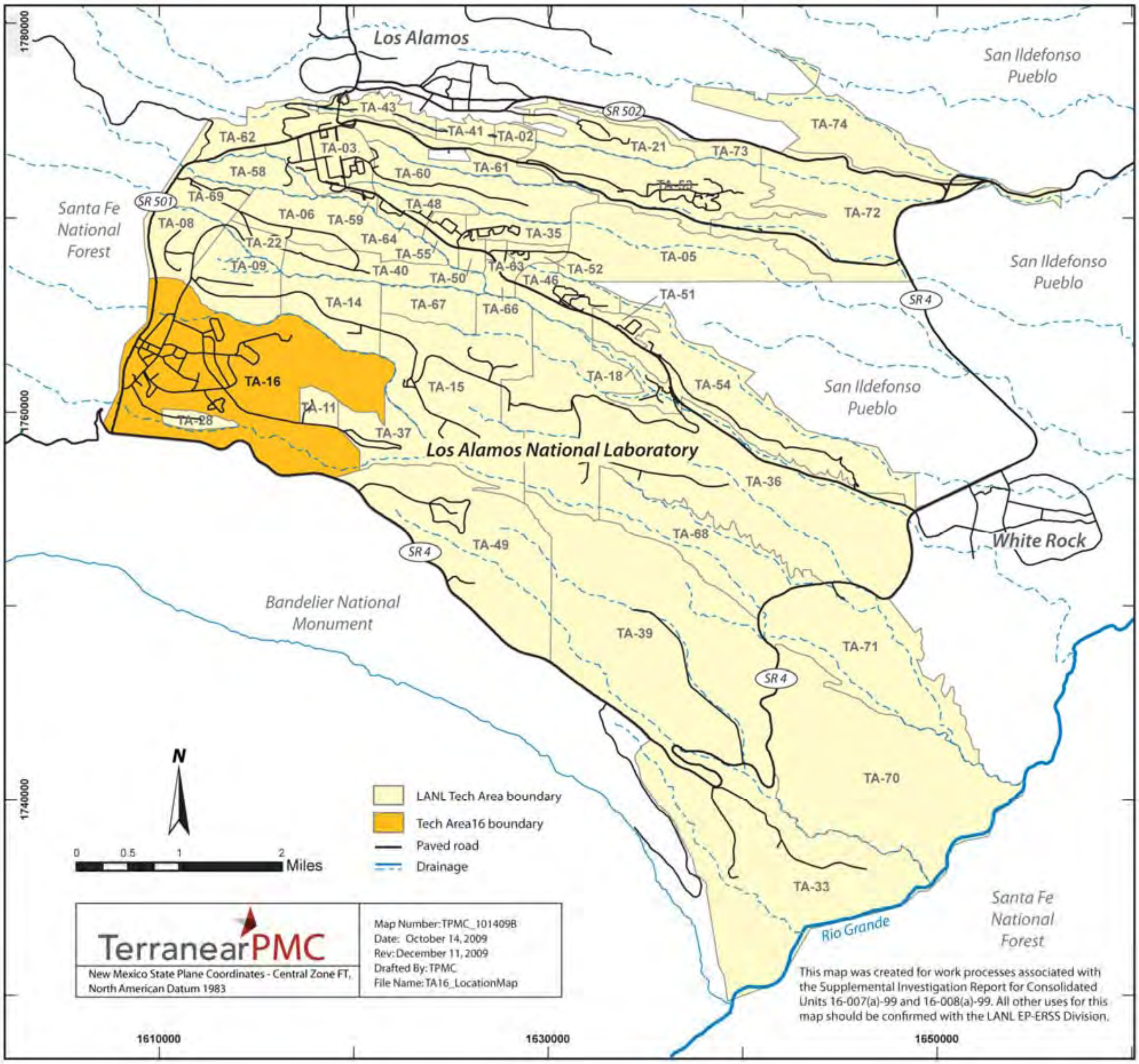


Figure 1.0-1 Location of TA-16 with respect to Laboratory TAs and surrounding areas

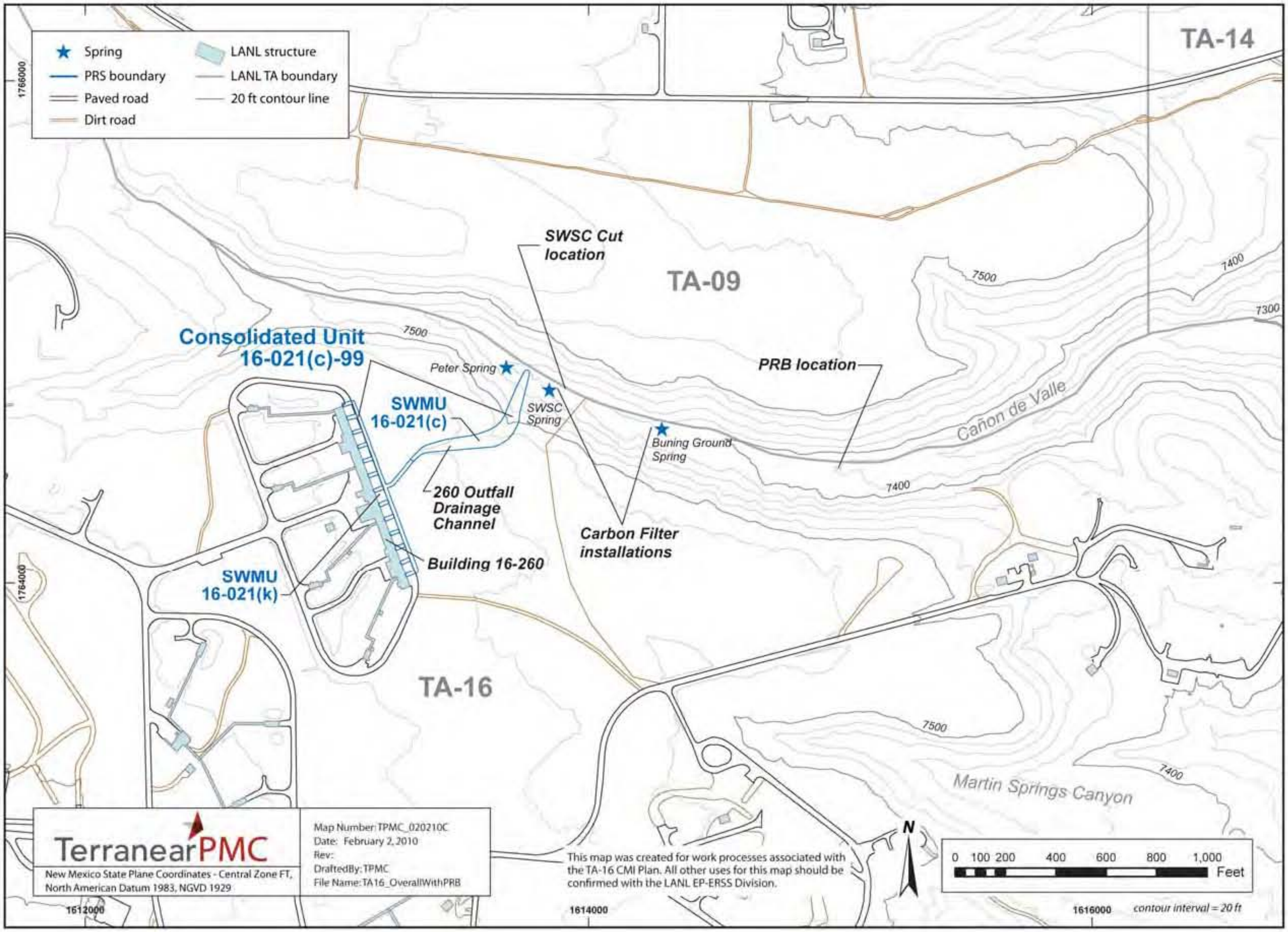


Figure 2.1-1 Location of Consolidated Unit 16-021(c)-99 and associated features

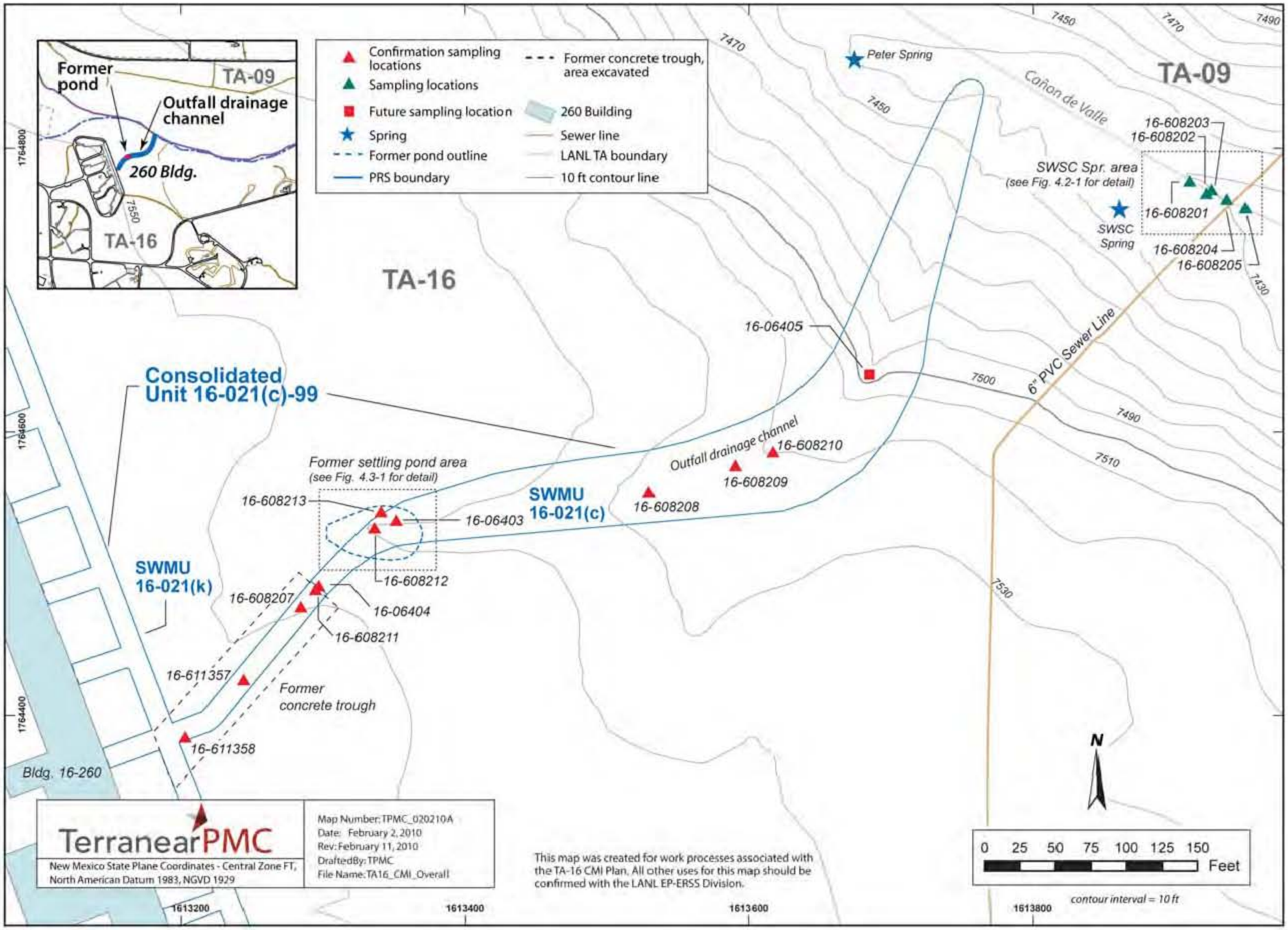


Figure 4.1-1 Location of 260 Outfall concrete trough, former settling pond, and drainage channel

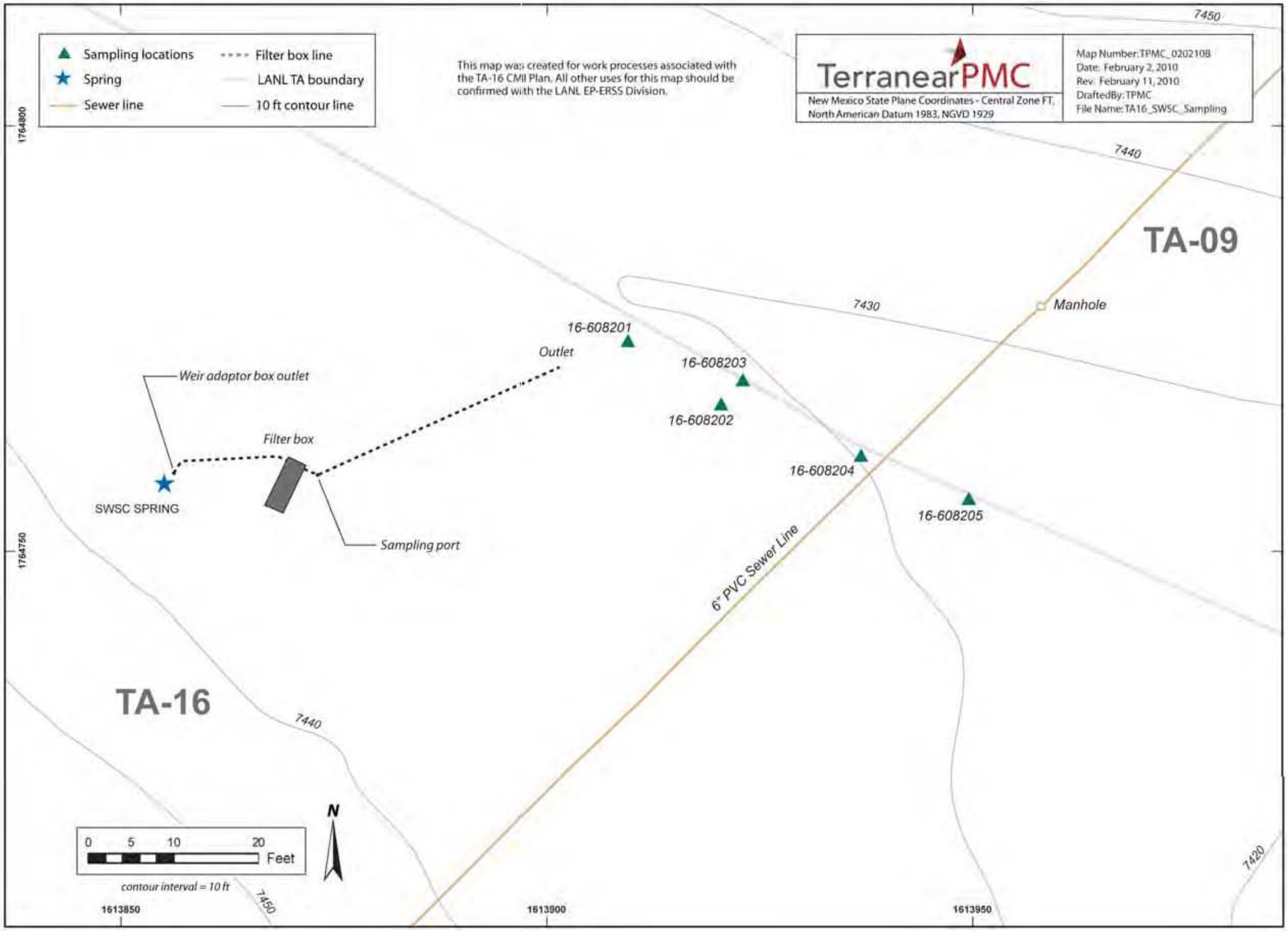


Figure 4.2-1 SWSC Cut sampling locations

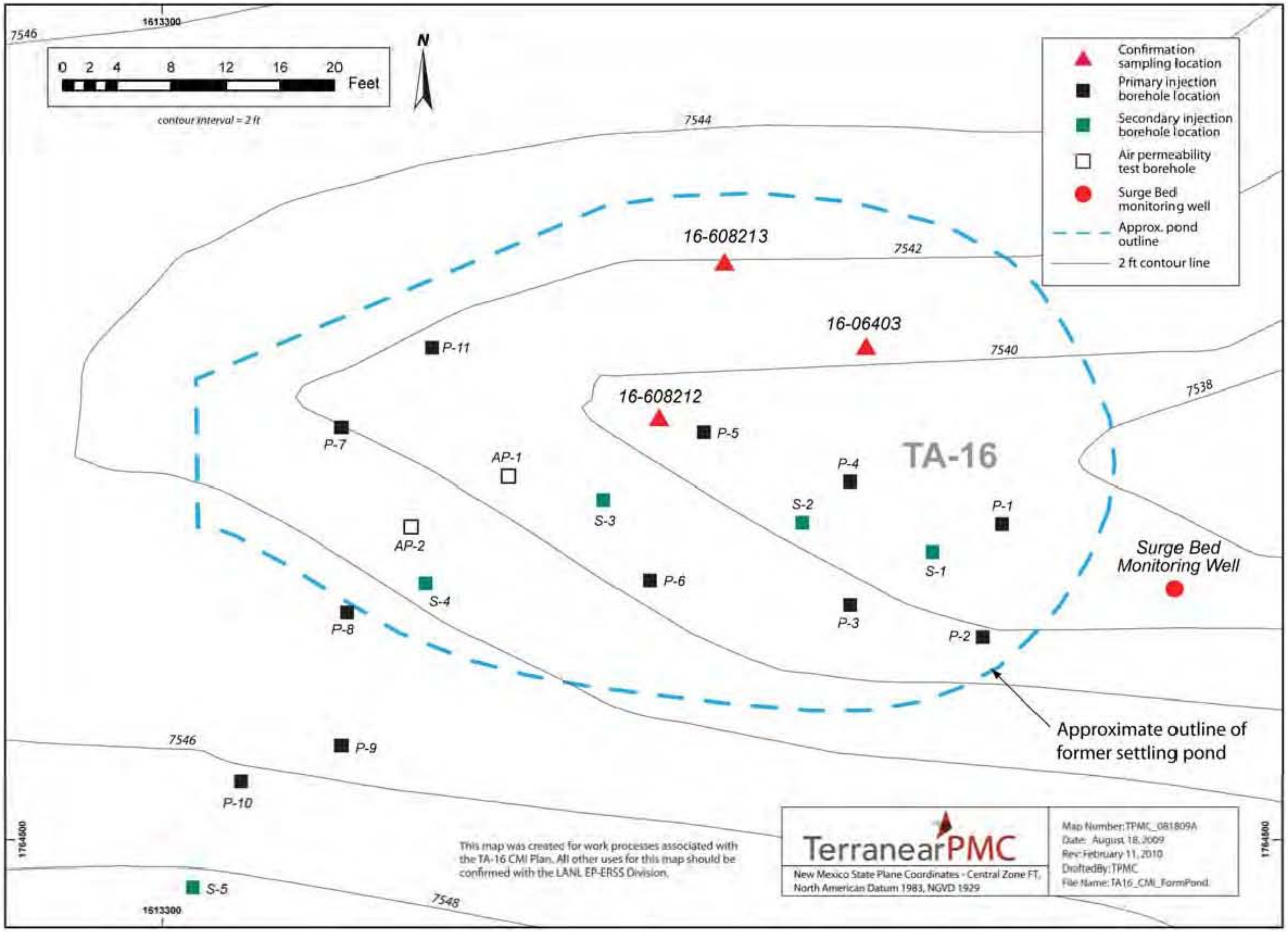


Figure 4.3-1 Former settling pond surge bed with injection well locations, monitoring well, and air-permeability test boreholes

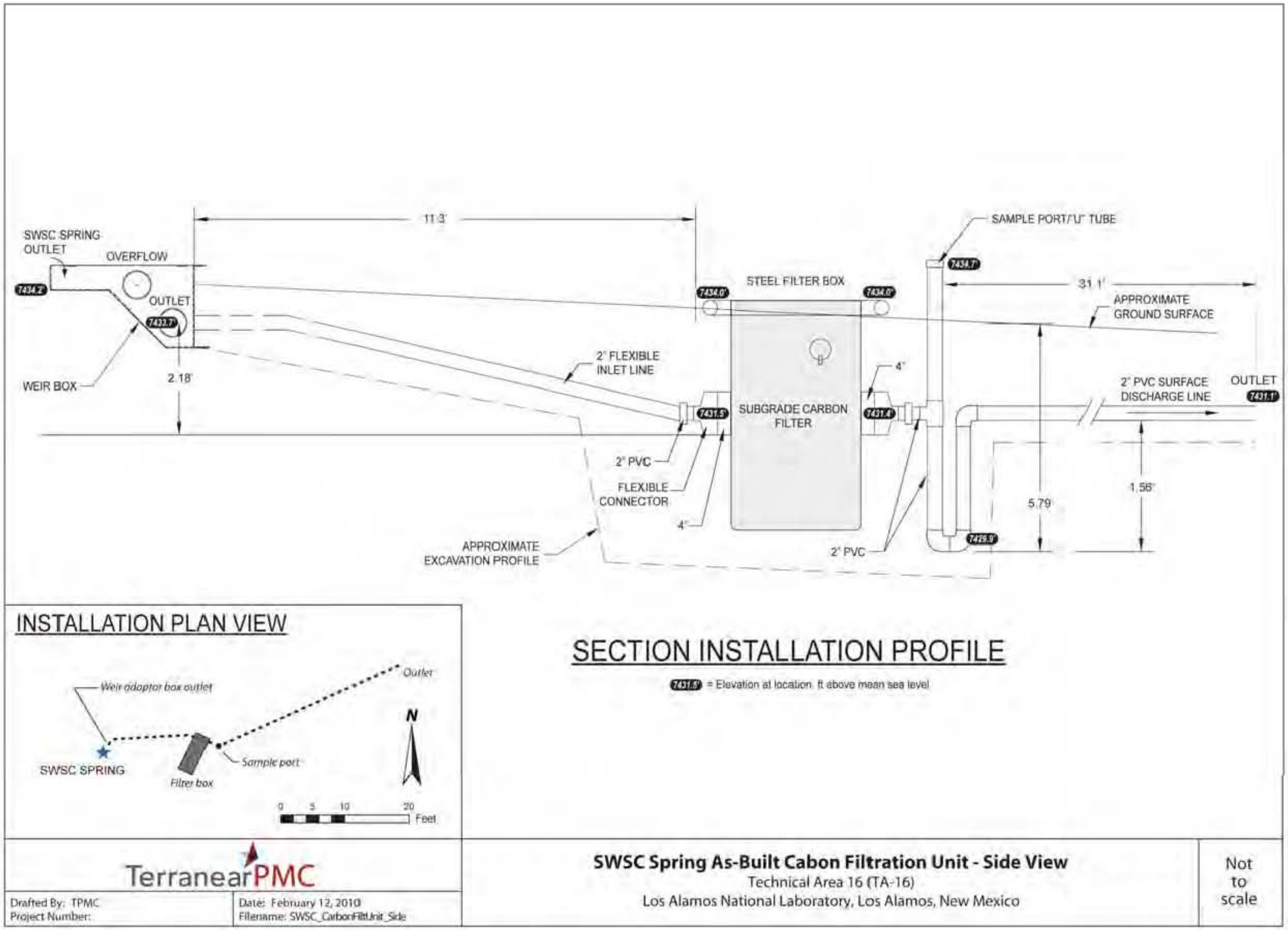


Figure 4.4-1 As-built diagram of SWSC Spring carbon-filter system

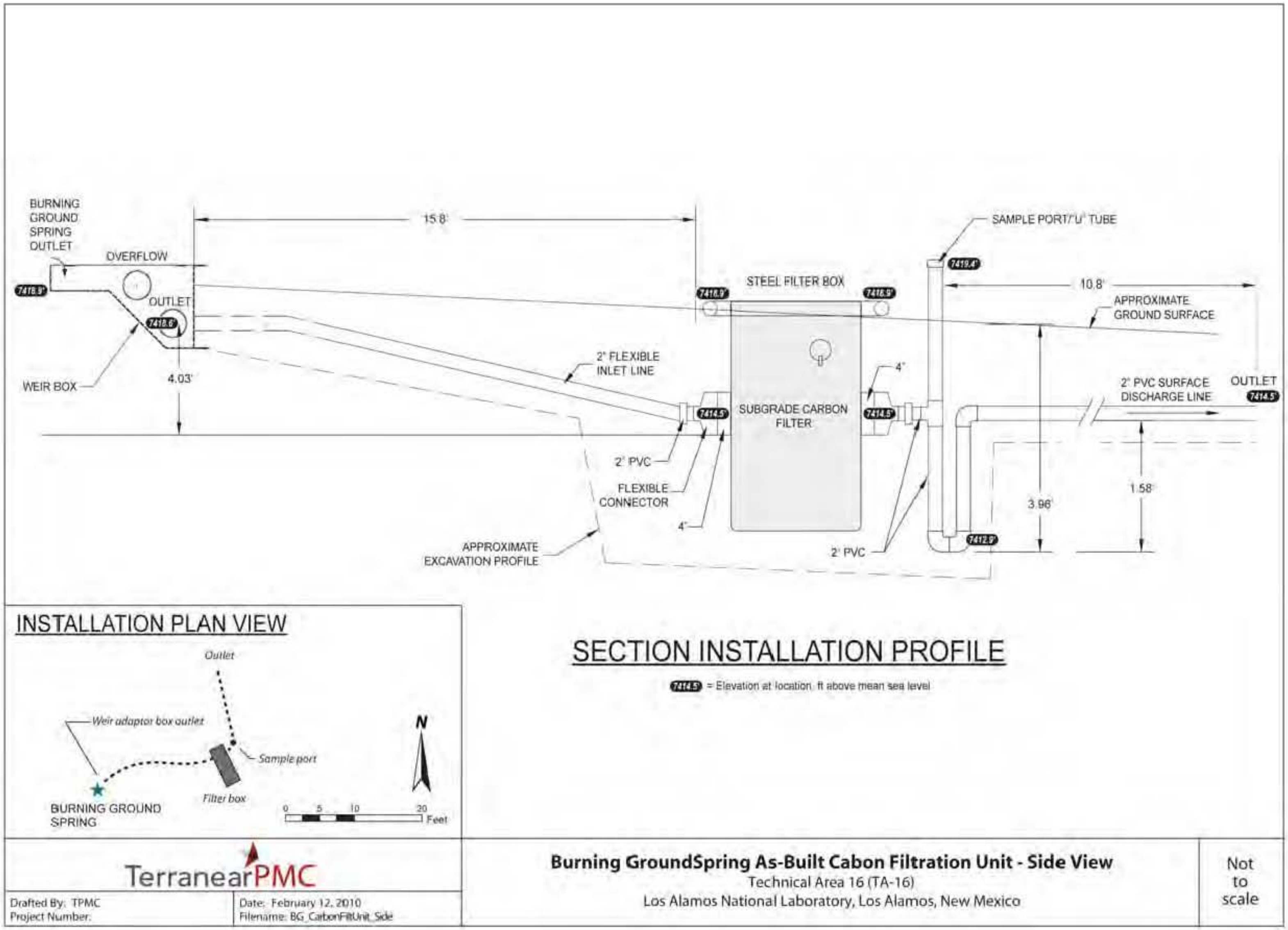


Figure 4.4-2 As-built diagram of Burning Ground Spring carbon-filter system

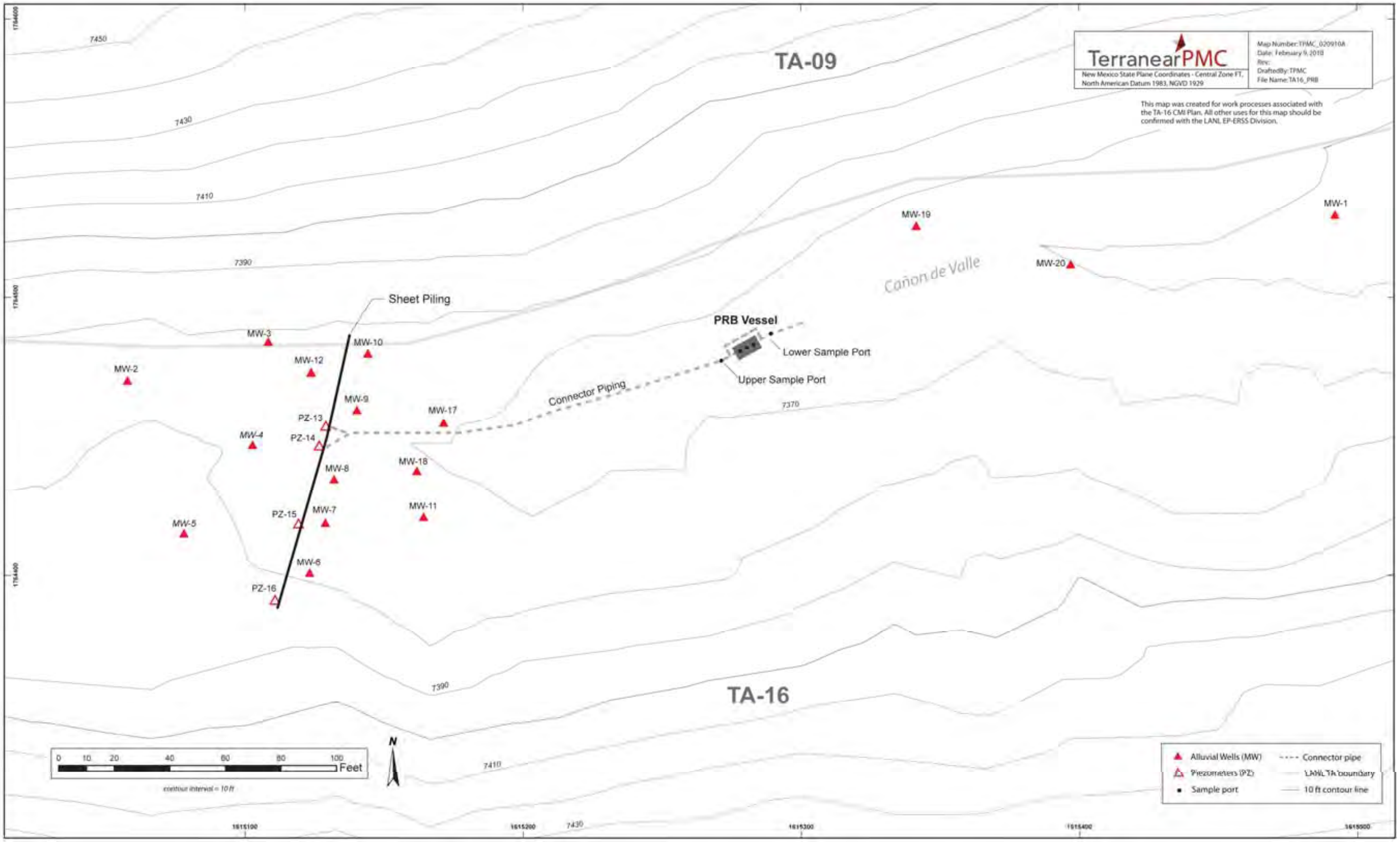


Figure 4.5-1 Location of the PRB and monitoring wells in Cañon de Valle

Table 4.1-1
Field-Screening Results for 260 Outfall Concrete Trough

Distance from Outfall Terminus (ft)	Depth (ft bgs)	Collection Date	HE Spot Test	RDX (mg/kg)	TNT (mg/kg)	Barium (mg/kg)
0	**0–0.5**	**10/30/2009**	**Negative**	**66.9**	**0.5**	**3590**
0	**0–0.5**	**10/30/2009**	**Negative**	**2.9**	**0.0**	**1411**
6	0–0.5	10/30/2009	Negative	0	1.0	363
12	**0–0.5**	**10/30/2009**	**Negative**	**12.5**	**138**	**1034**
12	**0–0.5**	**10/30/2009**	**Negative**	**1.7**	**0.0**	**826**
18	0–0.5	10/30/2009	Negative	0.7	0.0	419
24	0–0.5	10/30/2009	Negative	0.4	0.0	387
30	0–0.5	10/30/2009	Negative	0.4	1.0	273
36	0–0.5	10/30/2009	Negative	0.8	0.0	339
42	0–0.5	10/30/2009	Negative	2.3	0.0	444
48	0–0.5	10/30/2009	Negative	1.8	0.0	584
54	0–0.5	10/30/2009	Negative	1.3	0.0	323
60	0–0.5	10/30/2009	Negative	0.4	0.0	361
66	0–0.5	10/30/2009	Negative	2.0	0.0	478
72	0–0.5	10/30/2009	Negative	0.4	0.0	427
78	0–0.5	10/30/2009	Negative	0.0	0.0	769
84	0–0.5	10/30/2009	Negative	0.1	0.0	320
90	0–0.5	10/30/2009	Negative	2.2	0.0	296
96	0–0.5	10/30/2009	Negative	0.8	0.0	532
102	0–0.5	10/30/2009	Negative	0.4	0.0	398
108	0–0.5	10/30/2009	Negative	0.6	0.0	850
114	0–0.5	10/30/2009	Negative	0.6	0.0	679
120	0–0.5	10/30/2009	Negative	0.5	0.0	291
126	0–0.5	10/30/2009	Negative	0.7	0.0	379
132	**0–0.5**	**10/30/2009**	**Negative**	**49.5**	**0.0**	**411**
132	**0–0.5**	**10/30/2009**	**Negative**	**19.6**	**0.0**	**595**
138	0–0.5	10/30/2009	Negative	6.9	0.0	373
144	0–0.5	10/30/2009	Negative	0.3	0.0	376
150	0–0.5	10/30/2009	Negative	2.4	0.0	430

Note: Bold values indicate contamination was removed and the areas were rescreened.

Table 4.1-2
Summary of Samples Collected and Analyses Requested at the 260 Outfall Concrete Trough, Former Settling Pond, and Drainage Channel

Sample ID	Collection Date	Location ID	Depth (ft)	Media	HEXP	TAL Metals (SW 846 6010B)	VOC (SW 846 8260B)	SVOC (SW-846 8270C)
260 Outfall Concrete Trough								
RE16-09-13515	11/06/2009	16-611358	8.0–8.5	SOIL	10-409	10-409	10-409	10-409
RE16-09-13516	11/06/2009	16-611357	6.0–6.5	SOIL	10-409	10-409	10-409	10-409
RE16-09-13517	11/06/2009	16-611207	6.0–6.5	SOIL	10-409	10-409	10-409	10-409
RE16-09-13525	11/06/2009	16-611207	6.0–6.5	SOIL*	10-409	10-409	10-409	10-409
RE16-09-13526	11/06/2009	16-611207	6.0–6.5	SOIL*	10-409	10-409	10-409	10-409
260 Outfall Former Settling Pond								
RE16-09-13533	10/11/2009	16-608212	2.5–3.0	QBT4	10-274	10-274	10-274	10-274
RE16-09-13534	10/11/2009	16-608213	2.0–2.5	Fill	10-274	10-274	10-274	10-274
RE16-09-13541	10/17/2009	16-608403	2.0–2.5	ALLH	10-274	10-274	10-274	10-274
RE16-09-13542	10/17/2009	16-608403	2.0–2.5	ALLH*	10-274	10-274	10-274	10-274
RE16-09-13536	10/17/2009	16-608403	2.0–2.5	ALLH*	10-274	10-274	10-274	10-274
260 Outfall Drainage Channel								
RE16-09-13529	10/17/2009	16-608208	2.0–2.5	QBT4	10-274	10-274	10-274	10-274
RE16-09-13530	10/17/2009	16-608209	1.5–2.0	QBT4	10-274	10-274	10-274	10-274
RE16-09-13531	10/17/2009	16-608210	2.0–2.5	QBT4	10-274	10-274	10-274	10-274
RE16-09-13532	10/26/2009	16-608211	3.0–3.5	SED	10-274	10-274	10-274	10-274

Note: Numbers in analyte columns are request numbers.
* Field duplicates.

Table 4.1-3
Summary of Inorganic Chemicals above BVs in 260 Outfall Concrete Trough Samples

Sample ID	Location ID	Depth (ft)	Media	Antimony	Barium	Cadmium	Cobalt	Lead	Manganese
Soil BV[a]				**0.83**	**295**	**0.4**	**8.64**	**22.3**	**671**
Industrial SSL[b]				**454**	**224000**	**1120**	**300**[c]	**800**	**145000**
Residential SSL[b]				**31.3**	**15600**	**77.9**	**230**[c]	**400**	**10700**
RE16-09-13517	16-608207	6.0–6.5	SOIL	—[d]	561	—	—	—	—
RE16-09-13516	16-611357	6.0–6.5	SOIL	1.1 (U)	—	0.552 (U)	10.3	27.5	883
RE16-09-13515	16-611358	8.0–8.5	SOIL	1.25 (U)	571	0.627 (U)	—	—	—

Notes: Units are in mg/kg. U = The analyte was analyzed for but not detected.

[a] BVs from LANL (1998, 059730).

[b] SSLs from NMED (2009, 108070).

[c] SSLs from EPA regional screening table (http://www.epa.gov/region06/6pd/rcra_c/pd-n/screen.htm).

[d] — = Not detected or not detected above BV.

Table 4.1-4
Summary of Organic Chemicals Detected in Samples from 260 Outfall Concrete Trough

Sample ID	Location ID	Depth (ft)	Media	Acetone	Amino-2,6-dinitrotoluene[4-]	Amino-4,6-dinitrotoluene[2-]	HMX	RDX	TATB	Trinitrobenzene[1,3,5-]	Trinitrotoluene[2,4,6-]
Industrial SSL[a]				**851000**[b]	**1900**[b]	**2000**[b]	**34200**	**174**	**na**[c]	**27000**[b]	**469**
Residential SSL[a]				**67500**[b]	**150**[b]	**150**[b]	**3060**	**44.2**	**na**	**2200**[b]	**35.9**
RE16-09-13517	16-608207	6.0–6.5	SOIL	0.0462 (J)	0.374 (J)	0.23 (J)	2.63	8.09 (J+)	—[d]	0.648	2.77
RE16-09-13516	16-611357	6.0–6.5	SOIL	—	—	—	4.46	3.55 (J+)	—	—	—
RE16-09-13515	16-611358	8.0–8.5	SOIL	—	—	—	84.4	34.5 (J+)	3.2 (J)	0.18 (J)	—

Notes: Units are in mg/kg. J = The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis. J+ = The analyte was positively identified, and the result is likely to be biased high.

[a] SSLs from NMED (2009, 108070).

[b] SSLs from EPA regional screening table (http://www.epa.gov/region06/6pd/rcra_c/pd-n/screen.htm).

[c] na = Not available.

[d] — = Not detected.

Table 4.1-5
Summary of Field-Screening Results for the 260 Outfall Former Settling Pond

Location ID	Location Description	Depth (ft bgs)	Collection Date	HE Spot Test	RDX (mg/kg)	TNT (mg/kg)
16-608212	Middle	2.0–2.5	10/11/2009	Negative	2.7	0.402
16-608212	Southwest	2.0–2.5	10/11/2009	Negative	2.6	3.077
16-608212	North	2.0–2.5	10/11/2009	Negative	1.6	3.077
16-608213	Middle	4.0–4.4	10/11/2009	Negative	2.7	0.526
16-608213	North	4.0–4.4	10/11/2009	Negative	5.8	0.341
16-608213	South	4.0–4.4	10/11/2009	Negative	2.6	0.433
16-06403	Center original	0.5–1.0	10/17/2009	Negative	43.3	0.77
16-06403	Center	2.0–2.5	10/17/2009	Negative	10.9	NA*
16-06403	North	2.0–2.5	10/17/2009	Negative	13.6	NA
16-06403	Southeast	2.0–2.5	10/17/2009	Negative	15.7	NA

*NA = Not analyzed.

Table 4.1-6
Summary of Inorganic Chemicals above BVs in Samples from the Former Settling Pond

Sample ID	Location ID	Depth (ft)	Media	Antimony	Barium	Cadmium	Selenium
Soil BV[a]				**0.83**	**295**	**0.4**	**1.52**
Qbt 2, 3, 4 BV[a]				**0.5**	**46**	**1.63**	**0.3**
Industrial SSL[b]				**454**	**224000**	**1120**	**5680**
Residential SSL[b]				**31.3**	**15600**	**77.9**	**391**
RE16-09-13541	16-06403	2.0–2.5	SOIL	1.2 (U)	1320	0.602 (U)	—[c]
RE16-09-13542	16-06403	2.0–2.5	SOIL	1.31 (U)	1300	0.653 (U)	—
RE16-09-13533	16-608212	0.0–3.0	QBT4	1.16 (U)	—	—	1.13 (U)
RE16-09-13534	16-608213	0.0–2.5	FILL	1.25 (U)	—	0.627 (U)	—

Notes: Units are in mg/kg. U = The analyte was analyzed for but not detected.

[a] BVs from LANL (1998, 059730).

[b] SSLs from NMED (2009, 108070).

[c] — = Not detected or not detected above BV.

Table 4.1-7
Summary of Organic Chemicals Detected in Samples from the Former Settling Pond

Sample ID	Location ID	Depth (ft)	Media	Amino-2,6-dinitrotoluene[4-]	Amino-4,6-dinitrotoluene[2-]	HMX	RDX	TATB	Trinitrobenzene[1,3,5-]	Trinitrotoluene[2,4,6-]
Industrial SSL[a]				**1900**[b]	**2000**[b]	**34200**	**174**	**na**[c]	**27000**[b]	**469**
Residential SSL[a]				**150**[b]	**150**[b]	**3060**	**44.2**	**na**	**2200**[b]	**35.9**
RE16-09-13541	16-06403	2.0–2.5	SOIL	0.552	0.972	95.9 (J)	24.3	12.1	—[d]	0.467 (J)
RE16-09-13542	16-06403	2.0–2.5	SOIL	0.565	0.93	119 (J)	29.8	13.2	—	0.416 (J)
RE16-09-13533	16-608212	0.0–3.0	QBT4	2.56	0.645	6.9 (J)	34.7 (J)	—	0.761 (J+)	24.3 (J)
RE16-09-13534	16-608213	0.0–2.5	FILL	1.89	2.17	17.6 (J+)	44.1 (J)	0.303 (J)	1.01 (J+)	9.91 (J)

Notes: Units are in mg/kg. J = The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis. J+ = The analyte was positively identified, and the result is likely to be biased high.

[a] SSLs from NMED (2009, 108070).

[b] SSLs from EPA regional screening table (http://www.epa.gov/region06/6pd/rcra_c/pd-n/screen.htm).

[c] na = Not available.

[d] — = Not detected.

Table 4.1-8
Field-Screening Results for 260 Outfall Drainage Channel

Location ID	Location Description	Depth (ft bgs)	Collection Date	HE Spot Test	RDX (mg/kg)	TNT (mg/kg)
16-608208	Center	2.0–2.5	10/17/2009	Negative	3.3	0.43
16-608208	West	2.0–2.5	10/17/2009	Negative	2.5	0.06
16-608208	Southeast	2.0–2.5	10/17/2009	Negative	2.2	0.03
16-608209	Center	1.0–1.5	10/17/2009	Possible detect	4.4	0
16-608209	West	1.0–1.5	10/17/2009	Negative	16.8	0
16-608209	Southeast	1.0–1.5	10/17/2009	Negative	1.8	0
16-608210	Center	1.5–2.0	10/17/2009	Negative	0.133	0.50
16-608210	Northwest	1.5–2.0	10/17/2009	Positive	0.62	0.43
16-608210	South	1.5–2.0	10/17/2009	Negative	0.80	0.37
16-06404	South	2.5–3.0	10/23/2009	Negative	7.2	1.2
16-06404	Middle	2.5–3.0	10/23/2009	Negative	16.5	0.4
16-06404	South	2.5–3.0	10/23/2009	Negative	0.9	0.6
16-608211	**Center**	**1.5–2.0**	**10/28/2009**	**NA***	**67**	**0**
16-608211	Center	2.5–3.0	11/3/2009	NA	2.9	10

Table 4.1-8 (continued)

Location ID	Location Description	Depth (ft bgs)	Collection Date	HE Spot Test	RDX (mg/kg)	TNT (mg/kg)
16-06405	**Center**	**0–0.5**	**11/3/2009**	**NA**	**127**	**NA**
16-06405	West	1.0–1.2	11/22/2009	NA	63	NA
16-06405	East	1.0–1.2	11/22/2009	NA	164	NA
16-06405	Center	3.0–3.6	12/05/2009	NA	0.036	0.005

Note: Bold values indicate contamination was removed and the areas were rescreened.

* NA = Not analyzed.

Table 4.1-9
Summary of Inorganic Chemicals above BVs in Samples from the 260 Outfall Channel

Sample ID	Location ID	Depth (ft)	Media	Antimony	Barium	Beryllium	Cadmium	Iron	Selenium
Sediment BV[a]				**0.83**	**127**	**1.31**	**0.4**	**13800**	**0.3**
Qbt 2, 3, 4 BV[a]				**0.5**	**46**	**1.21**	**1.63**	**11.2**	**0.3**
Industrial SSL[b]				**454**	**224000**	**2260**	**1120**	**795000**	**5680**
Residential SSL[b]				**31.3**	**15600**	**156**	**77.9**	**54800**	**391**
RE16-09-13529	16-608208	2.0–2.5	QBT4	1.17 (U)	114	—[c]	—	—	1.16 (U)
RE16-09-13530	16-608209	1.5–2.0	QBT4	1.14 (U)	378	—	—	—	1.1 (U)
RE16-09-13531	16-608210	2.–2.5	QBT4	1.07 (U)	644	—	—	—	1.12 (U)
RE16-09-13532	16-608211	3.0–3.5	SED	1.24 (U)	2230	1.32	0.618(U)	13900	1.26(U)

Notes: Units are in mg/kg. U = The analyte was analyzed for but not detected.

[a] BVs from LANL (1998, 059730).

[b] SSLs from NMED (2009, 108070).

[c] — = Not detected or not detected above BV.

Table 4.1-10
Summary of Organic Chemicals Detected in Samples from the 260 Outfall Drainage

Sample ID	Location ID	Depth (ft)	Media	Acetone	Amino-2,6-dinitrotoluene[4-]	Amino-4,6-dinitrotoluene[2-]	HMX	RDX	TATB	Trinitrobenzene[1,3,5-]	Trinitrotoluene[2,4,6-]
Industrial SSL[a]				**851000**	**1900**[b]	**2000**[b]	**34200**	**174**	**na**[c]	**27000**[b]	**469**
Residential SSL[a]				**67500**	**150**[b]	**150**[b]	**3060**	**44.2**	**na**	**2200**[b]	**35.9**
RE16-09-13529	16-608208	2.0–2.5	QBT4	0.00867 (J)	—	—	8.19 (J)	0.665	0.461 (J)	—[d]	—
RE16-09-13530	16-608209	1.5–2.0	QBT4	—	—	—	43.6 (J)	0.576	1.97	—	—
RE16-09-13531	16-608210	2.0–2.5	QBT4	0.022 (J)	—	—	14 (J)	0.279 (J)	0.412 (J)	—	—
RE16-09-13532	16-608211	3.0–3.5	SED	—	0.891	0.535	—	16.8 (J)	16.6 (J+)	—	4.59 (J+)

Notes: Units are in mg/kg. J = The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis. J+ = The analyte was positively identified, and the result is likely to be biased high.

[a] SSLs from NMED (2009, 108070).

[b] SSLs from EPA regional screening table (http://www.epa.gov/region06/6pd/rcra_c/pd-n/screen.htm).

[c] na = Not available.

[d] — = Not detected.

Table 4.2-1
Summary of Samples Collected and Analyses Requested at the SWSC Cut

Sample ID	Collection Date	Location ID	Depth (ft)	Media	TAL Metals (SW 846 6010B)
RE16-09-13499	12/05/2009	16-608203	0.0–0.3	SED	10-837
RE16-09-13498	2/05/2009	16-608202	0.0–0.3	SED	10-837
RE16-09-13514	2/05/2009	16-608201	0.0–0.3	SED	10-837
RE16-09-13509	2/05/2009	16-608205	0.0–0.3	SED	10-837
RE16-09-13489	2/05/2009	16-608201	0.0–0.3	SED*	10-837
RE16-09-13504	2/05/2009	16-608204	0.0–0.3	SED	10-837

Note: Numbers in analyte columns are request numbers.

*Field duplicate.

Table 4.2-2
Summary of Inorganic Chemicals above BVs in Confirmation Samples at SWSC Cut

Sample ID	Location ID	Depth (ft)	Media	Antimony	Barium	Cadmium	Copper	Manganese	Nickel	Selenium	Silver	Thallium
Sediment BV[a]				**0.83**	**127**	**0.4**	**11.2**	**543**	**9.38**	**0.3**	**1**	**0.73**
Industrial SSL[b]				**454**	**224000**	**1120**	**45400**	**145000**	**22700**	**5680**	**5680**	**74.9**
Residential SSL[b]				**31.3**	**15600**	**77.9**	**3130**	**10700**	**1560**	**391**	**391**	**5.16**
RE16-09-13514	16-608201	0.0–0.3	SED	2.20 (U)	1120	1.1 (U)	—[c]	—	10.1	2.2 (U)	31.7	—
RE16-09-13498	16-608202	0.0–0.3	SED	2.43 (U)	329	1.21 (U)	—	—	—	2.42 (U)	18.9	—
RE16-09-13499	16-608203	0.0–0.3	SED	1.80 (U)	226	0.9 (U)	—	—	—	1.73(U)	11.9	—
RE16-09-13504	16-608204	0.0–0.3	SED	1.99 (U)	1730	—	11.8	—	12.4	2.0(U)	38.5	—
RE16-09-13509	16-608205	0.0–0.3	SED	4.56 (U)	1400	2.28 (U)	—	678(J+)	—	4.6(U)	24.1	0.92 (U)

Notes: Units are in mg/kg. U = The analyte was analyzed for but not detected.

[a] BVs from LANL (1998, 059730).

[b] SSLs from NMED (2009, 108070).

[c] — = Not detected or not detected above BV.

Table 4.3-1
Summary of Grout Ratios Used at Injection Wells for Surge Bed Remediation

Borehole ID	Grout Ratio (Water: Cement)	Type III Grout Volume (gal.)	Type II Grout Volume (gal.)	Type I Grout Volume (gal.)	Microfine Grout Volume (gal.)	Total Grout Volume (gal.)
P-1	3:1	—*	—	—	156	
	2:1	—	—	—	166	
	1:1	—	—	—	—	
Total volume of grout added to borehole P-1						**322**
P-2	3:1	26	—	—	—	
	2:1	—	30	—	—	
	1:1	—	—	—	—	
Total volume of grout added to borehole P-2						**56**
P-3	4:1	—	—	—	8	
	1:1	—	—	—	—	
Total volume of grout added to borehole P-3						**8**
P-4	4:1	—	—	—	10	
	1:1	—	—	—	—	
Total volume of grout added to borehole P-4						**10**
P-5	4:1	—	—	—	91	
	2:1	—	—	—	331	
	1:1	—	—	—	32	
Total volume of grout added to borehole P-5						**454**
P-6	4:1	—	—	—	20	
	1:1	—	—	—	—	
Total volume of grout added to borehole P-6						**20**
P-7	4:1	—	—	—	40	
	1:1	—	—	—	—	
Total volume of grout added to borehole P-7						**40**
P-8	4:1	—	—	—	20	
	1:1	—	—	—	—	
Total volume of grout added to borehole P-8						**20**
BH-9	3:1	—	51	—	—	
	1:1	—	—	—	—	
Total volume of grout added to borehole P-9						**51**
P-10	4:1	—	—	—	56	
	2:1	—	445	—	71	
	1:1	—	304	—	—	
Total volume of grout added to borehole P-10						**876**

Table 4.3-1 (continued)

Borehole ID	Grout Ratio (Water: Cement)	Type III Grout Volume (gal.)	Type II Grout Volume (gal.)	Type I Grout Volume (gal.)	Microfine Grout Volume (gal.)	Borehole ID
P-11	3:1	—	385	—	—	
	2:1	—	319	—	—	
	1:1	—	434	—	—	
Total volume of grout added to borehole P-11						**1138**
S1	3:1	—	—	—	8	
	1:1	—	—	—	—	
Total volume of grout added to borehole S-1						**8**
S2	4:1	—	418	—	—	
	3:1	—	—	—	80	
	2:1	—	186	—	—	
	1:1	769	567	—	—	
Total volume of grout added to borehole S-2						**2020**
S3	4:1	—	338	—	—	
	3:1	—	168	—	—	
	2:1	—	324	—	—	
	1:1	9	908	—	—	
Total volume of grout added to borehole S-3						**1747**
S4	2:1	—	768	—	—	
	1:1	503	912	—	—	
Total volume of grout added to borehole S-4						**2183**
S5	4:1	—	—	—	109	
	2:1	—	—	—	18	
	1:1	—	—	—	—	
Total volume of grout added to borehole S-5						**127**
Total volume of grout added to 11 primary and 5 secondary boreholes						**9080**

*****— = Grout mixture not used.

Appendix A

Consolidated Unit 16-021(c)-99
Corrective Measures Implementation Field Logbooks
(on CD included with this document)

Appendix B

Consolidated Unit 16-021(c)-99
Corrective Measures Implementation Completed Field Forms
(on CD included with this document)

Appendix C

Photographs of Corrective Measures Implementation Field Activities at Consolidated Unit 16-021(c)-99 (on CD included with this document)

Appendix D

Estimation of Intrinsic Permeability from
Air-Permeability Testing

Daniel B. Stephens & Associates, Inc.

Project Name LANL TA-16 CMI Number ES09.0185.00 Date 01/25/10
Subject Estimation of intrinsic permeability from air permeability testing
By J. Ayarbe Check by: S. Brady Calculation No. 01

Purpose:

Determine intrinsic permeability of surge bed from air permeability data obtained during air permeability testing performed in the TA-16 area on January 16, 2010. The test was performed by extracting air from borehole AP-2 and observing the vacuum response at borehole AP-1. The determined intrinsic permeability is then compared to a performance goal based on a saturated hydraulic conductivity value of $5x10^{-5}$ cm/s.

Data are analyzed using an approach presented in Domenico and Shwartz (1997) pages 412-413 and 435-436. This approach is based on Johnson et. al (1990).

Given:

$$K = \frac{2.3Q}{4 \cdot \pi\, b \cdot \Delta s}$$ Modified from Johnson et. al (1990)

K = air permeability of unit, *Q* = volumetric air flow rate, b = thickness of unit; Δs = drawdown (or change in vacuum) per log cycle

Volumetric air flow rate (Q):

$$Q := 41cfm = 1.935 \times 10^4 \cdot \frac{cm^3}{s}$$

Unit thickness (m):

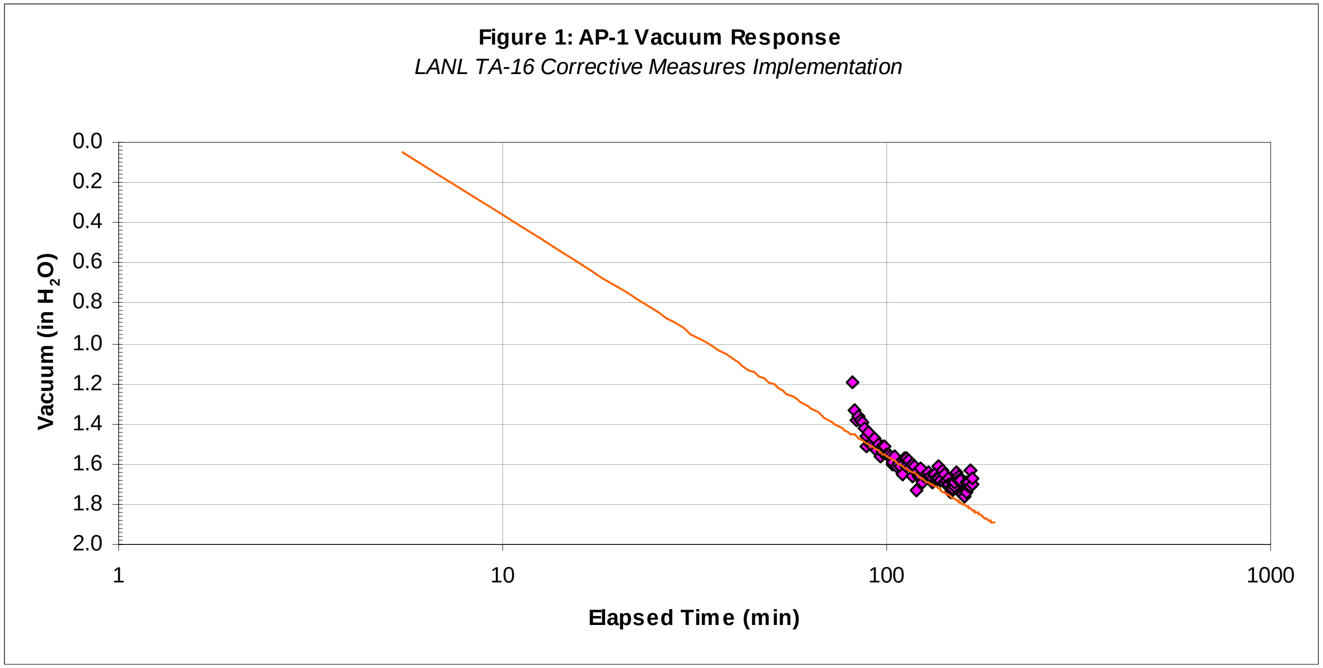
$TD := 24.05ft$ Total borehole depth below ground surface

$Packer := 12.92ft$ Packer placement below ground surface

$$b := TD - Packer = 339.242 \cdot cm$$

Drawdown per log cycle (Δs):

$$\Delta s_{H2O} := 1.56 in \cdot H2O - 0.36 in \cdot H2O = 1.2 \cdot in \cdot H2O$$



$$\rho_{air} := 0.971 \frac{kg}{m^3} \qquad \rho_{H2O} := 999 \frac{kg}{m^3}$$ densities of air and water

$$\Delta s_{air} := \frac{\Delta s_{H2O}}{in \cdot H2O} \cdot in \cdot \frac{\rho_{H2O}}{\rho_{air}} = 3136 \cdot cm$$ calculate drawdown in terms of air

Solution:

Air permeability:

$$K_{air} := \frac{2.3Q}{4 \cdot \pi \cdot b \cdot \Delta s_{air}} = 3.329 \times 10^{-3} \cdot \frac{cm}{s}$$

Intrinsic permeability:

$$\mu_{air} := 1.79 \times 10^{-4} \frac{gm}{cm \cdot s}$$

$$k := \frac{K_{air} \cdot \mu_{air}}{\rho_{air} \cdot g} = 6.3 \times 10^{-7} \cdot cm^2$$

Intrinsic permeability goal:

$$K_{H2O} := 5 \times 10^{-5} \frac{cm}{s}$$

Saturated hydraulic conductivity, grouting performance goal based on a 1-order of magnitude permeability reduction from 5×10^{-4} cm/s.

$$\mu_{H2O} := 1.12 \times 10^{-3} \frac{N \cdot s}{m^2}$$

Dynamic viscosity of water

$$\gamma_{H2O} := 9.80 \frac{kN}{m^3}$$

Specific weight of water

$$k_{goal} := \frac{K_{H2O} \cdot \mu_{H2O}}{\gamma_{H2O}} = 6 \times 10^{-10} cm^2$$

Result:

The intrinsic permeability determined from air permeability testing is 3-orders of magnitude greater than the performance goal.

$k = 6.3 \times 10^{-7}\,cm^2$ Intrinsic permeability determined from air permeability testing

$k_{goal} = 6 \times 10^{-10}\,cm^2$ Intrinsic permeability goal

References:

Domenico, Patrick A., and Franklin W. Shwartz. 1998. *Physical and chemical hydrogeology.* John Wiley & Sons, Inc. New York. Second edition.

Johnson, P.C., C.C. Stanley, M.W. Kemblowski, D.L. Byers, and J.D. Colthart. 1990. *A practical approach to the design, operation, and monitoring of in situ soil-venting systems.* GWMR. Spring 1990.

Reference:C:\Documents and Settings\362\Desktop\Calcs\MathCAD\units and constants.xmcd

Appendix E

Surge Bed Soil-Bentonite Cap Specifications and Summary Report

E-1.0 INTRODUCTION

Section 3.5 of the corrective measures implementation (CMI) plan applies to the installation of a low-permeability soil-bentonite cap at the former settling pond area behind building 260, located in Technical Area 16 (TA-16) at Los Alamos National Laboratory (LANL). More specifically, section 3.5 of the CMI plan specified a performance standard for the cap of 1×10^{-7} cm/s for saturated hydraulic conductivity (Ks), a thickness of 1 ft placed to achieve a maximum thickness of 6 in. per compacted lift and compacted to a minimum 95% of maximum density from American Society for Testing and Materials (ASTM) D-698 (standard proctor), with moisture content 0%–3% of optimum. The CMI plan also suggested determining Ks with the addition of 10% and 20% bentonite (by weight) to the soil.

E-2.0 PRODUCTS OR MATERIALS

The specification suggests using soil collected from the former cap soil stockpile for the cap (LANL 2007, 098192, Appendix D). The specification requires clean fill/soil without rocks or debris larger than ¾ in. The settling pond stockpiled soil was unacceptable for use as a cap soil/material because of the large percentage of rock over ¾ in. in diameter. An acceptable soil was located in Española, New Mexico, and supplied by Española Transit. The bentonite specification calls for a free-flowing, high-swelling, and granular sodium bentonite. The bentonite was provided by Southwestern Materials and met the specification (see Attachment D for the description of the bentonite).

E-3.0 PROJECT EXECUTION

Laboratory Testing

Moisture-density compaction and permeability testing were to be performed by an approved testing agency in accordance with the listed ASTM standards. Daniel B. Stephens & Associates, an approved laboratory, conducted all laboratory testing. Brian Dwyer, the project engineer, provided instructions on testing to the laboratory.

Approximately 75 lb of soil and 30 lb of bentonite were supplied to Daniel B. Stephens & Associates Laboratory for moisture-density compaction testing per ASTM D-698 (Standard Proctor Test) and permeability testing in accordance with ASTM D-5084. The purpose of this testing is determine if the soil-bentonite mixture meets the permeability requirement and to develop a proctor curve for field implementation and quality assurance (QA) testing.

Results and details of the laboratory testing completed per the CMI plan specification are included in the attached reports dated January 14, 2010, and January 27, 2010, provided by Daniel B. Stephens & Associates. The reports are presented in Attachments A and B, respectively.

Both soil-bentonite ratios (10% and 20% by weight) resulted in Ks values below the specified 1×10^{-7} cm/s; therefore, the 10% bentonite ratio was chosen for developing a proctor curve and for the field mixture. The lower bentonite content will result in less desiccation cracking.

Field Testing

During the soil-bentonite low-permeability cap installation, on-site field tests were conducted to verify that the materials (e.g., water) and soil-bentonite backfill mixture meet the requirements (e.g., moisture, compaction density). In-place density testing of compacted lifts was performed as identified in

Specification 31 3526.13, Soil/Bentonite Cap. The results are documented on forms in Attachment D and testing is noted on daily quality control (QC) forms. The soil-bentonite cap material was adjusted accordingly if the mixture did not meet the requirements.

The soil-bentonite (90:10 by weight) was mixed at Española Transit using a conveyor belt system. With a conveyor belt system, soil is placed in one hopper and bentonite in a second hopper. Material is dispensed onto the conveyor belt at the prescribed ratios using variable speed motors controlling the feed rates from each hopper. The conveyor belt dumps the homogeneous mixture into the bucket of a front-end loader. Brian Dwyer provided oversight of the mixing operation. Mixed material was then loaded into trucks and shipped to the LANL site.

Wooden stakes were strategically placed in the cap area to provide the backhoe and compactor operators depth guidance during soil placement and compaction. The soil-bentonite mixture was compacted in 6-in. lifts using an Ingersoll-Rand SD-70D PROPAC Vibratory Compactor sheep-foot single drum. In-place soil density and moisture content was determined in accordance with ASTM D 1556-82 (Sand Cone Method). Three representative samples from each 6-in. lift were collected. Complete results are included in Attachment C.

The basic principle for the sand-cone method is a sample of known mass of damp-to-wet soil is obtained from a small excavation of somewhat irregular shape (a hole) in the compacted soil. Sand of a known density is poured in a controlled manner into the excavation to provide an indirect means of obtaining the hole volume. Once the volume of the hole is determined, the wet density is simply computed as

$$p_{\text{WET}} = \text{ mass of soil/volume of hole.}$$

Next, the water content of the excavated soil is obtained by drying the soil and comparing the difference in weight (water lost because of evaporation), then the dry unit density of the soil is

$$p_{\text{DRY}} = p_{\text{WET}} / (1 + w).$$

where the water content *w* is in decimal not percent.

The sand used was 10 × 20 mesh Colorado silica (consolidated undrained [CU] = 1.38, 99.89% passing No. 10 sieve, and 0.11% retained on No. 25 [0.710-mm] sieve). The sand meets the ASTM requirement that the sand is free-flowing with a CU <2.0 with a maximum particle size < 2.00 mm (No. 10 sieve) and less than 3% by weight passing the No. 60 (0.25-mm) sieve.

The January 27, 2010, report (Attachment B) includes Ks testing and the standard proctor curve for the soil-bentonite mixture at 90:10 by weight ratio. This mix yielded a Ks = 6.51×10^{-8} cm/s, which is lower than 1×10^{-7} cm/s and thus meets the specification requirement. Compaction results were corrected because of the high coarse fraction in the mixture. Approximately 14% of the sample mass was from the coarse fraction. Oversize correction for the standard proctor curve is required when the coarse fraction is >5% of the composite mass. Optimum moisture content (14.4 %) and maximum dry bulk density (1.77 g/cc) values from the oversize correction curve were used for field guidance and field sample QA. Tables E-3.0-1 and E-3.0-2 below summarize in-place soil density results. Table E-3.0-1 shows field-measured moisture content (%). All samples were within the acceptable moisture range (14.4%–17.4%) developed in the laboratory proctor testing.

Table E-3.0-1
Moisture Content

Test Location	Std. Proctor Water Content *	Measured Water Content (%)	Acceptable Water Content Range (%)	Pass/Fail
1A	14.4	15.5	14.4–17.4	Pass
2A	14.4	15.1	14.4–17.4	Pass
3A	14.4	16.1	14.4–17.4	Pass
1B	14.4	16.7	14.4–17.4	Pass
2B	14.4	16.9	14.4–17.4	Pass
3B	14.4	16.7	14.4–17.4	Pass

* Results from January 27, 2010, report, Daniel B. Stephens & Associates (Attachment B).

Table E-3.0-2 contains dry bulk density data. Relative compaction is used to compare the in situ (or field) compacted dry unit weight or bulk density to the laboratory compacted maximum dry bulk density as given by the following equation:

$$RC = (p_{df} / p_{dL}) \times 100\ (\%)$$

All samples exceeded the minimum 95% of laboratory dry bulk density from the standard proctor test.

Table E-3.0-2
Dry Bulk Density

Test Location	Std. Proctor Dry Bulk Density (g/cc)*	Field Measured Dry Bulk Density (g/cc)	Required Relative Compaction (%)	Measured Relative Compaction	Pass/Fail
1A	1.77	1.76	95	99.4	Pass
2A	1.77	1.78	95	100.5	Pass
3A	1.77	1.74	95	98.3	Pass
1B	1.77	1.73	95	97.7	Pass
2B	1.77	1.76	95	99	Pass
3B	1.77	1.72	95	97	Pass

* Results from January 27, 2010, report, Daniel B. Stephens & Associates (Attachment B).

E-4.0 REFERENCE

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

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

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)

ATTACHMENT A

INITIAL STANDARD PROCTOR TEST
AND PERMEABILITY TEST REPORT

Laboratory Report for
Daniel B. Stephens & Associates
ES09.0185.00 Phase 81002 Task 32 LANL TA-16 CMI

January 14, 2010

Daniel B. Stephens & Associates, Inc.

6020 Academy NE, Suite 100 • Albuquerque, New Mexico 87109

January 14, 2010

Mr. John Ayarbe
Daniel B. Stephens & Associates
6040 Academy Rd. NE Suite 100
Albuquerque, NM 87109
(505) 822-9400

Re: DBS&A Laboratory Report for Daniel B. Stephens & Associates ES09.0185.00 Phase 81002 Task 32 LANL TA-16 CMI

Dear Mr. Ayarbe:

Enclosed is the final report for the Daniel B. Stephens & Associates ES09.0185.00 Phase 81002 Task 32 LANL TA-16 CMI samples. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed final report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the final report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to Daniel B. Stephens & Associates and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines
Laboratory Supervising Manager
Enclosure

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
5840 Osuna Rd. NE 505-889-7752
Albuquerque, NM 87109 FAX 505-889-0258

Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	Atterberg Limits	Proctor Compaction
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
PRB Soil	X																					X
PRB Soil @ 10%		X				X																
PRB Soil @ 20%		X				X																

[1] G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method

[2] CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall

[3] HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box, EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity

[4] DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer

[5] F = Fine (<4.75mm), C = Coarse (>4.75mm)

Summary of Sample Preparation/Conditions

	Proctor Data		Target Remold Parameters[1]			Actual Remold Data		
Sample Number	Optimum Moisture Content (%, g/g)	Maximum Dry Density (g/cm^3)	Moisture Content (%, g/g)	Dry Bulk Density (g/cm^3)	% of Maximum Density (%)	Moisture Content (%, g/g)	Dry Bulk Density (g/cm^3)	% of Maximum Density (%)
PRB Soil @ 10%	17.2	1.75	17.0	1.66	95%	18.3	1.64	94.0%
PRB Soil @ 20%	17.2	1.75	17.0	1.66	95%	20.1	1.62	92.5%

[1]Target Remold Parameters: Provided by the client: 95% of maximum dry density at 0-3 % of optimum moisture content.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm³/cm³)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm³/cm³)	Dry Bulk Density (g/cm³)	Wet Bulk Density (g/cm³)	Calculated Porosity (%)
PRB Soil	10.3	NA	---	—	NA	NA	NA
PRB Soil @ 10%	NA	NA	18.3	30.1	1.64	1.94	38.1
PRB Soil @ 20%	NA	NA	20.1	32.4	1.62	1.94	39.0

NA = Not analyzed

--- = This sample was not remolded

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis: Constant Head Flexible Wall	Method of Analysis: Falling Head Flexible Wall
PRB Soil @ 10%	6.51E-08	5.59E-08		X
PRB Soil @ 20%	2.23E-08	1.91E-08		X

Summary of Proctor Compaction Tests

Sample Number	Measured: Optimum Moisture Content (% g/g)	Measured: Maximum Dry Bulk Density (g/cm^3)	Oversize Corrected: Optimum Moisture Content (% g/g)	Oversize Corrected: Maximum Dry Bulk Density (g/cm^3)
PRB Soil	17.2	1.75	14.8	1.83

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not analyzed

Laboratory Data and Graphical Plots

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
PRB Soil	10.3	NA	---	---	NA	NA	NA
PRB Soil @ 10%	NA	NA	18.3	30.1	1.64	1.94	38.1
PRB Soil @ 20%	NA	NA	20.1	32.4	1.62	1.94	39.0

NA = Not analyzed

--- = This sample was not remolded

Daniel B. Stephens & Associates, Inc.

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: LANL TA-16 CMI
Job Number: ES09.0185.00
Sample Number: PRB Soil
Phase Number: 81002
Task Number: 32

Espanola Transit Soil Mix

	As Received	Remolded
Test Date:	23-Dec-09	---
Field weight of sample* (g):	2038.85	
Tare weight, ring (g):	0.00	
Tare weight, pan/plate (g):	409.89	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	1476.71	
Sample volume (cm^3):	NA	
Assumed particle density (g/cm^3):	2.65	
Gravimetric Moisture Content (% g/g):	10.3	
Volumetric Moisture Content (% vol):	NA	
Dry bulk density (g/cm^3):	NA	
Wet bulk density (g/cm^3):	NA	
Calculated Porosity (% vol):	NA	
Percent Saturation:	NA	

2038.85
− 409.89
1628.96
− 1476.71
152.25 / 1476.71
= 10.3%

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Daniel B. Stephens & Associates, Inc.

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: LANL TA-16 CMI
Job Number: ES09.0185.00
Sample Number: PRB Soil @ 10%
Phase Number: 81002
Task Number: 32

	As Received	Remolded
Test Date:	NA	4-Jan-10
Field weight of sample (g):*		614.65
Tare weight, ring (g):		0.00
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		519.48
Sample volume (cm^3):		316.56
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		18.3
Volumetric Moisture Content (% vol):		30.1
Dry bulk density (g/cm^3):		1.64
Wet bulk density (g/cm^3):		1.94
Calculated Porosity (% vol):		38.1
Percent Saturation:		79.0

614.65
− 519.48
95.17 / 519.48
= 18.3%

75.17 / 316.56 = 30.1 g/cc

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
— = This sample was not remolded

Daniel B. Stephens & Associates, Inc.

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	LANL TA-16 CMI
Job Number:	ES09.0185.00
Sample Number:	PRB Soil @ 20%
Phase Number:	81002
Task Number:	32

	As Received	Remolded
Test Date:	NA	4-Jan-10
Field weight of sample* (g):		613.95
Tare weight, ring (g):		0.00
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		511.35
Sample volume (cm^3):		316.56
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		20.1
Volumetric Moisture Content (% vol):		32.4
Dry bulk density (g/cm^3):		1.62
Wet bulk density (g/cm^3):		1.94
Calculated Porosity (% vol):		39.0
Percent Saturation:		83.0

Laboratory analysis by:	D. O'Dowd
Data entered by:	D. O'Dowd
Checked by:	J. Hines

Comments:

* Weight including tares

NA = Not analyzed

--- = This sample was not remolded

Saturated Hydraulic Conductivity

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis: Constant Head Flexible Wall	Method of Analysis: Falling Head Flexible Wall
PRB Soil @ 10%	6.51E-08	5.59E-08		X
PRB Soil @ 20%	2.23E-08	1.91E-08		X

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name LANL TA-16 CMI
Job Number ES09.0185.00
Sample Number PRB Soil @ 10%
Phase Number 81002
Task Number 32

Remolded or Initial Sample Properties

Initial Mass (g):	614.65
Diameter (cm):	7.308
Length (cm):	7.547
Area (cm^2):	41.95
Volume (cm^3):	316.56
Dry Density (g/cm^3):	1.64
Dry Density (pcf):	102.44
Water Content (%, g/g):	18.3
Water Content (%, vol):	30.1
Void Ratio (e):	0.61
Porosity (%, vol):	38.1
Saturation (%):	79.0

Post Permeation Sample Properties

Saturated Mass (g):	653.28
Dry Mass (g):	519.48
Diameter (cm):	7.392
Length (cm):	7.582
*Deformation (%)**:*	0.46
Area (cm^2):	42.92
Volume (cm^3):	325.39
Dry Density (g/cm^3):	1.60
Dry Density (pcf):	99.67
Water Content (%, g/g):	25.8
Water Content (%, vol):	41.1
Void Ratio(e):	0.66
Porosity (%, vol):	39.8
Saturation (%):*	103.4

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded ☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	14.1
Particle Density(g/cm^3):	2.65 ☑ Assumed ☐ Measured
Cell pressure (PSI):	80.0
Influent pressure (PSI):	79.0
Effluent pressure (PSI):	77.0
Panel Used:	☑ A ☐ B ☐ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.98	1/6/10 1015
B-Value (% saturation) post to test:	1.00	1/11/10 955

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.
**Percent Deformation: based on initial sample length and post permeation sample length.

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

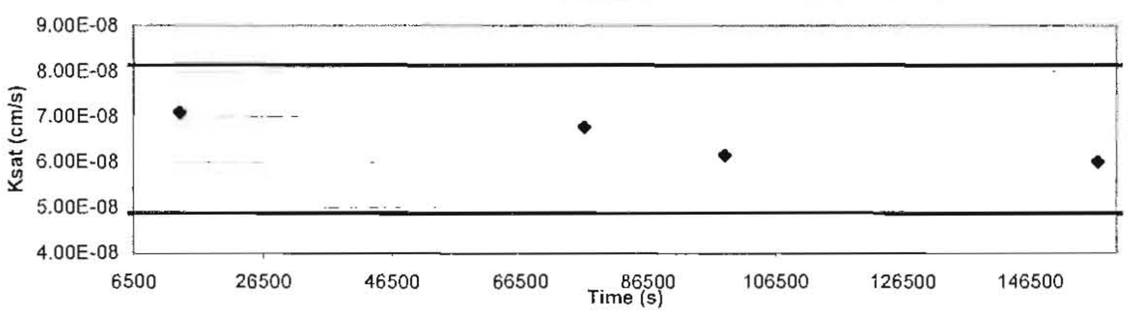
Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name LANL TA-16 CMI
Job Number ES09.0185.00
Sample Number PRB Soil @ 10%
Phase Number 81002
Task Number 32

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient (ΔH/ΔL)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
06-Jan-10	12:18:00	19.3	5.10	21.90	21.11	0.74	13690	0.89	1%	7.02E-08	7.08E-08
06-Jan-10	16:06:10	20.0	6.00	21.10	20.85						
Test # 2:											
06-Jan-10	16:06:10	20.0	6.00	21.10	20.85	3.12	62917	0.89	5%	6.69E-08	6.77E-08
07-Jan-10	09:34:47	19.0	9.80	17.70	19.76						
Test # 3:											
07-Jan-10	09:34:47	19.0	9.80	17.70	19.76	0.95	22053	0.91	2%	6.04E-08	6.16E-08
07-Jan-10	15:42:20	19.5	10.95	16.65	19.42						
Test # 4:											
07-Jan-10	15:42:20	19.5	10.95	16.65	19.42	2.38	58482	0.93	4%	5.87E-08	6.01E-08
08-Jan-10	07:57:02	18.6	13.80	14.00	18.58						

***Average Ksat* (cm/sec): 6.51E-08**

Calculated Gravel Corrected Average Ksat (cm/sec): 5.59E-08



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 4.88E-08

Ksat (+25%) (cm/s): 8.13E-08

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name	LANL TA-16 CMI
Job Number	ES09.0185.00
Sample Number	PRB Soil @ 10%
Phase Number	81002
Depth	32
Test Date:	6-Jan-10
Split (3/4", 3/8", #4):	3/8"
Calculated Porosity Fines (% vol):	39.8

	Coarse Fraction	Fines Fraction	Composite
Subsample Mass (g):	2257.50	13738.50	15996.00
Bulk Density (g/cm^3):	2.65	1.60	1.69
Volume of Solids (cm^3):	851.89	5169.11	6021.00
Volume of Voids (cm^3):	0.00	3417.45	3417.45
Total Volume (cm^3):	851.89	8586.56	9438.45
Volumetric Fraction of Subsample (%):	9.03	90.97	100.00
Ksat (cm/sec):	---	6.51E-08	5.59E-08

Comments:

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name LANL TA-16 CMI
Job Number ES09.0185.00
Sample Number PRB Soil @ 20%
Phase Number 81002
Task Number 32

Remolded or Initial Sample Properties

Initial Mass (g):	613.95
Diameter (cm):	7.308
Length (cm):	7.547
Area (cm^2):	41.95
Volume (cm^3):	316.56
Dry Density (g/cm^3):	1.62
Dry Density (pcf):	100.84
Water Content (%, g/g):	20.1
Water Content (%, vol):	32.4
Void Ratio (e):	0.64
Porosity (%, vol):	39.0
Saturation (%):	83.0

Post Permeation Sample Properties

Saturated Mass (g):	651.2
Dry Mass (g):	511.35
Diameter (cm):	7.366
Length (cm):	7.563
*Deformation (%)**:*	0.21
Area (cm^2):	42.61
Volume (cm^3):	322.29
Dry Density (g/cm^3):	1.59
Dry Density (pcf):	99.05
Water Content (%, g/g):	27.3
Water Content (%, vol):	43.4
Void Ratio(e):	0.67
Porosity (%, vol):	40.1
Saturation (%):*	108.1

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded
	☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	14.1
Particle Density(g/cm^3):	2.65 ☑ Assumed ☐ Measured
Cell pressure (PSI):	80.0
Influent pressure (PSI):	79.0
Effluent pressure (PSI):	76.0
Panel Used:	☐ A ☑ B ☐ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.98	1/6/10 1025
B-Value (% saturation) post to test:	1.00	1/11/10 1000

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.
**Percent Deformation: based on initial sample length and post permeation sample length.

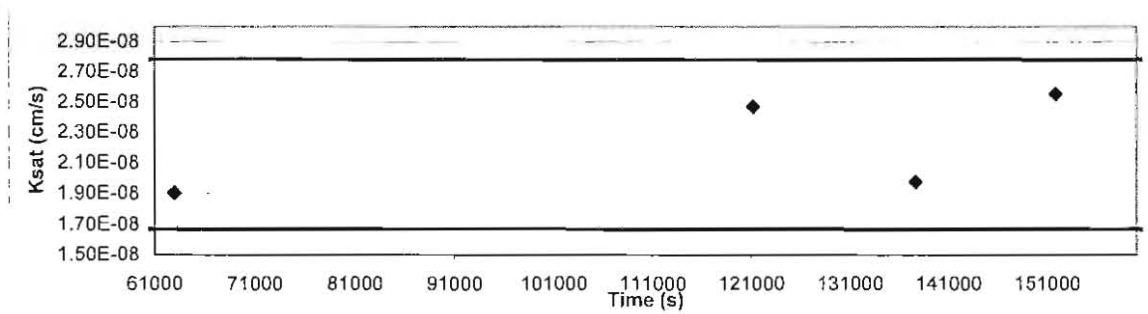
Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name LANL TA-16 CMI
Job Number ES09.0185.00
Sample Number PRB Soil @ 20%
Phase Number 81002
Task Number 32

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient (ΔH/ΔL)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
06-Jan-10	16:05:20	20.0	4.27	22.45	30.68	1.31	62980	0.75	2%	1.88E-08	1.90E-08
07-Jan-10	09:35:00	19.0	6.00	21.15	30.21						
Test # 2:											
07-Jan-10	15:43:00	19.5	7.10	20.20	29.90	1.52	58220	0.84	2%	2.41E-08	2.47E-08
08-Jan-10	07:53:20	18.6	9.00	18.60	29.37						
Test # 3:											
08-Jan-10	07:53:20	18.6	9.00	18.60	29.37	0.34	16495	0.95	0%	1.92E-08	1.98E-08
08-Jan-10	12:28:15	18.9	9.40	18.22	29.25						
Test # 4:											
08-Jan-10	12:28:15	18.9	9.40	18.22	29.25	0.38	14175	0.93	0%	2.50E-08	2.56E-08
08-Jan-10	16:24:30	19.4	9.85	17.80	29.12						

Average Ksat **(cm/sec):** **2.23E-08**
Calculated Gravel Corrected Average Ksat (cm/sec): 1.91E-08



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 1.67E-08

Ksat (+25%) (cm/s): 2.78E-08

Oversize Correction Data Sheet

Job Name	LANL TA-16 CMI
Job Number	ES09.0185.00
Sample Number	PRB Soil @ 20%
Phase Number	81002
Depth	32
Test Date:	6-Jan-10
Split (3/4", 3/8", #4):	3/8"
Calculated Porosity Fines (% vol):	40.1

	Coarse Fraction	Fines Fraction	Composite
Subsample Mass (g):	2257.50	13738.50	15996.00
Bulk Density (g/cm^3):	2.65	1.59	1.69
Volume of Solids (cm^3):	851.89	5175.70	6027.59
Volume of Voids (cm^3):	0.00	3464.87	3464.87
Total Volume (cm^3):	851.89	8640.57	9492.45
Volumetric Fraction of Subsample (%):	8.97	91.03	100.00
Ksat (cm/sec):	---	2.23E-08	1.91E-08

Comments:

Laboratory analysis by:	D. O'Dowd
Data entered by:	D. O'Dowd
Checked by:	J. Hines

Proctor Compaction

Summary of Proctor Compaction Tests

Sample Number	Measured: Optimum Moisture Content (% g/g)	Measured: Maximum Dry Bulk Density (g/cm^3)	Oversize Corrected: Optimum Moisture Content (% g/g)	Oversize Corrected: Maximum Dry Bulk Density (g/cm^3)
PRB Soil	17.2	1.75	14.8	1.83

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not analyzed

Proctor Compaction Data

Job Name: LANL TA-16 CMI
Job Number: ES09.0185.00
Sample Number: PRB Soil
Phase Number: 81002
Task Number: 32

Test Date: 30-Dec-09

As Received Moisture Content (% g/g): 10.31

Split (3/4", 3/8", #4): 3/8
Mass of coarse material (g): 2257.5
Mass of fines material (g): 13738.5
Mold weight (g): 4235
Mold volume (cm^3): 939.32

Compaction Method: Standard B
Preparation Method: Dry
Type of Rammer: Mechanical

Trial	Weight of Mold and Compacted Soil (g)	Weight of Container and Wet Soil (g)	Weight of Container and Dry Soil (g)	Weight of Container (g)	Dry Bulk Density (g/cm^3)	Moisture Content (% g/g)
1	5917	995.80	920.10	268.67	1.60	11.62
2	5999	936.30	857.70	284.66	1.65	13.72
3	6103	1064.80	960.60	289.79	1.72	15.53
4	6162	1078.90	959.60	289.22	1.74	17.80
5	6114	1070.10	939.10	282.88	1.67	19.96
6	6104	936.25	808.00	209.64	1.64	21.43

Soil Fractions

Coarse Fraction (% g/g): 14.1
Fines Fraction (% g/g): 85.9

Properties of Coarse Material

Assumed particle density (g/cm^3): 2.65
Assumed Initial Moisture Content (% g/g): 0.0

Oversize Corrected Values for Dry Bulk Density and Moisture Content

Trial	Dry Bulk Density of Composite (g/cm^3)	Moisture Content of Composite (% g/g)
1	1.70	9.98
2	1.74	11.78
3	1.81	13.34
4	1.83	15.28
5	1.76	17.15
6	1.73	18.41

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NA = Not analyzed

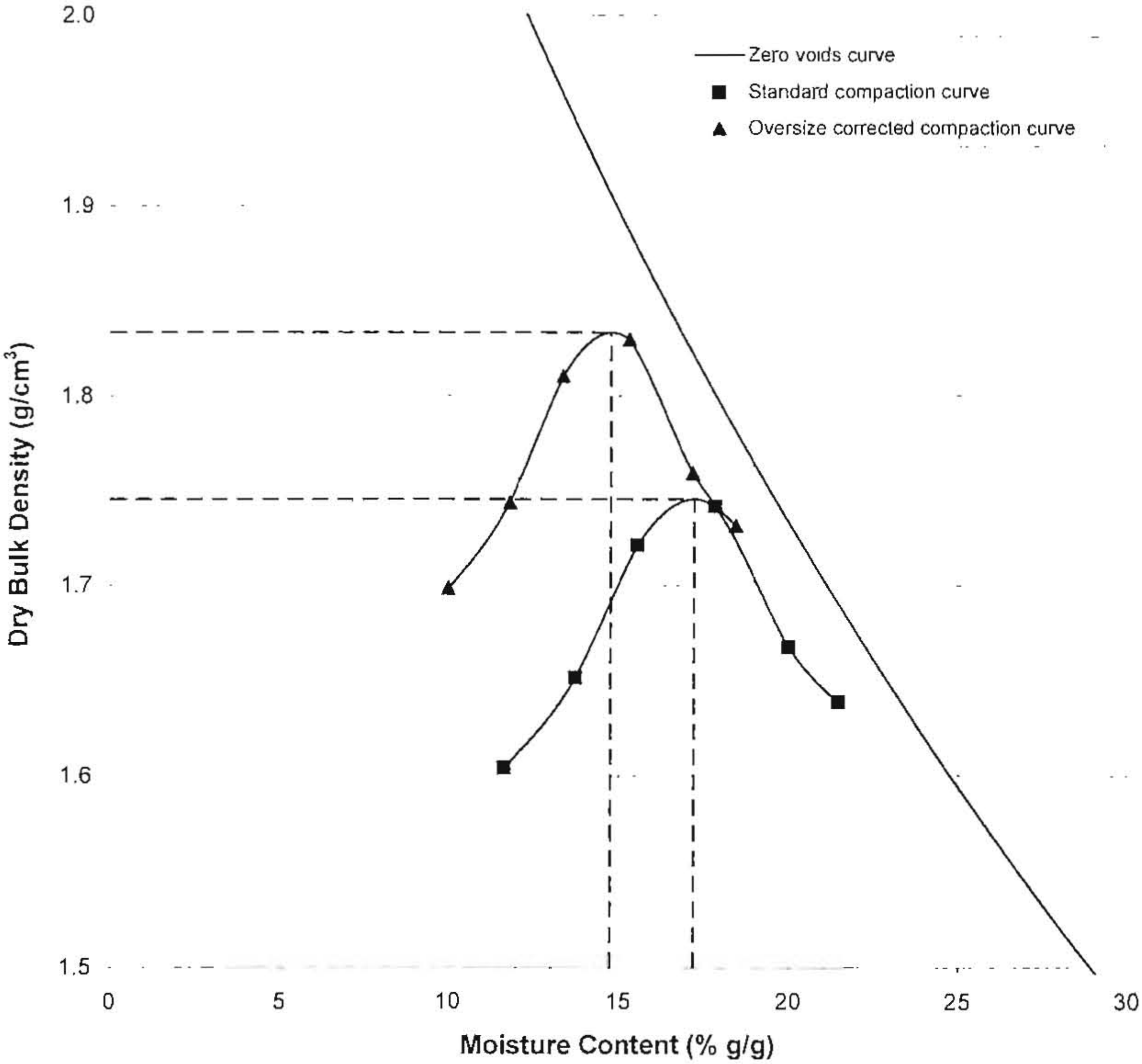
Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: PRB Soil

	Measured	Corrected
Optimum Moisture Content (% g/g):	17.2	14.8
Maximum Dry Bulk Density (g/cm³):	1.75	1.83

Test Date: 30-Dec-09



--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not analyzed

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D6836
Moisture Content:	ASTM D2216; ASTM D6836
Calculated Porosity:	ASTM D6836
Saturated Hydraulic Conductivity:	
Falling Head Rising Tail: (Flexible Wall)	ASTM D5084
Standard Proctor Compaction:	ASTM D698
Coarse Fraction (Gravel) Correction (calc):	ASTM D4718; Bouwer, H. and Rice, R.C. 1984. Hydraulic Properties of Stony Vadose Zones. Groundwater Vol. 22, No. 6

ATTACHMENT B

FINAL STANDARD PROCTOR TEST AND PERMEABILITYTEST REPORT

Laboratory Report for
Daniel B. Stephens & Associates

ES09.0185.00 Phase 81002 Task 32 LANL TA-16 CMI

January 27, 2010

Daniel B. Stephens & Associates, Inc.

6020 Academy NE, Suite 100 • Albuquerque, New Mexico 87109

January 27, 2010

Mr. John Ayarbe
Daniel B. Stephens & Associates
6040 Academy Rd. NE Suite 100
Albuquerque, NM 87109
(505) 822-9400

Re: DBS&A Laboratory Report for Daniel B. Stephens & Associates ES09.0185.00 Phase 81002 Task 32 LANL TA-16 CMI

Dear Mr. Ayarbe:

Enclosed is the final report for the Daniel B. Stephens & Associates ES09.0185.00 Phase 81002 Task 32 LANL TA-16 CMI samples. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed final report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the final report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to Daniel B. Stephens & Associates and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines
Laboratory Supervising Manager
Enclosure

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
5840 Osuna Rd. NE 505-889-7752
Albuquerque, NM 87109 FAX 505 889-0258

Summaries

Summary of Tests Performed

Laboratory	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-	Atterberg	Proctor
Sample Number	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C	eability	Limits	Compaction
PRB Soil @ 10%		X				X																X

[1] G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method

[2] CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall

[3] HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box, EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity

[4] DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer

[5] F = Fine (<4.75mm), C = Coarse (>4.75mm)

Summary of Sample Preparation/Conditions

Sample Number	Proctor Data: Optimum Moisture Content (%, g/g)	Proctor Data: Maximum Dry Density (g/cm^3)	Target Remold Parameters[1]: Moisture Content (%, g/g)	Target Remold Parameters[1]: Dry Bulk Density (g/cm^3)	Target Remold Parameters[1]: % of Maximum Density (%)	Actual Remold Data: Moisture Content (%, g/g)	Actual Remold Data: Dry Bulk Density (g/cm^3)	Actual Remold Data: % of Maximum Density (%)
PRB Soil @ 10%	16.8	1.68	17.0	1.59	95%	18.3	1.64	98%

PRB Soil @ 10% = PRB Soil with 10% bentonite added by weight.

[1]Target Remold Parameters: Provided by the client: 95% of maximum dry density at 0-3% of optimum moisture content.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

	Moisture Content						
	As Received		Remolded				
Sample Number	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
PRB Soil @ 10%	NA	NA	18.3	30.1	1.64	1.94	38.1

NA = Not analyzed
--- = This sample was not remolded

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis: Constant Head Flexible Wall	Method of Analysis: Falling Head Flexible Wall
PRB Soil @ 10%	6.51E-08	5.59E-08		X

Summary of Proctor Compaction Tests

	Measured		Oversize Corrected	
Sample Number	Optimum Moisture Content (% g/g)	Maximum Dry Bulk Density (g/cm^3)	Optimum Moisture Content (% g/g)	Maximum Dry Bulk Density (g/cm^3)
PRB Soil @ 10%	16.8	1.68	14.4	1.77

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not analyzed

Laboratory Data and Graphical Plots

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
PRB Soil @ 10%	NA	NA	18.3	30.1	1.64	1.94	38.1

NA = Not analyzed

--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name: LANL TA-16 CMI
Job Number: ES09.0185.00
Sample Number: PRB Soil @ 10%
Phase Number: 81002
Task Number: 32

	As Received	Remolded
Test Date:	NA	4-Jan-10
Field weight of sample* (g):		614.65
Tare weight, ring (g):		0.00
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		519.48
Sample volume (cm^3):		316.56
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		18.3
Volumetric Moisture Content (% vol):		30.1
Dry bulk density (g/cm^3):		1.64
Wet bulk density (g/cm^3):		1.94
Calculated Porosity (% vol):		38.1
Percent Saturation:		79.0

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Saturated Hydraulic Conductivity

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis: Constant Head Flexible Wall	Method of Analysis: Falling Head Flexible Wall
PRB Soil @ 10%	6.51E-08	5.59E-08		X

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name LANL TA-16 CMI
Job Number ES09.0185.00
Sample Number PRB Soil @ 10%
Phase Number 81002
Task Number 32

Remolded or Initial Sample Properties

Initial Mass (g):	614.65
Diameter (cm):	7.308
Length (cm):	7.547
Area (cm^2):	41.95
Volume (cm^3):	316.56
Dry Density (g/cm^3):	1.64
Dry Density (pcf):	102.44
Water Content (%, g/g):	18.3
Water Content (%, vol):	30.1
Void Ratio (e):	0.61
Porosity (%, vol):	38.1
Saturation (%):	79.0

Post Permeation Sample Properties

Saturated Mass (g):	653.28
Dry Mass (g):	519.48
Diameter (cm):	7.392
Length (cm):	7.582
*Deformation (%)**:*	0.46
Area (cm^2):	42.92
Volume (cm^3):	325.39
Dry Density (g/cm^3):	1.60
Dry Density (pcf):	99.67
Water Content (%, g/g):	25.8
Water Content (%, vol):	41.1
Void Ratio(e):	0.66
Porosity (%, vol):	39.8
Saturation (%):*	103.4

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded ☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	14.1
Particle Density(g/cm^3):	2.65 ☑ Assumed ☐ Measured
Cell pressure (PSI):	80.0
Influent pressure (PSI):	79.0
Effluent pressure (PSI):	77.0
Panel Used:	☑ A ☐ B ☐ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.98	1/6/10 1015
B-Value (% saturation) post to test:	1.00	1/11/10 955

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.
**Percent Deformation: based on initial sample length and post permeation sample length.

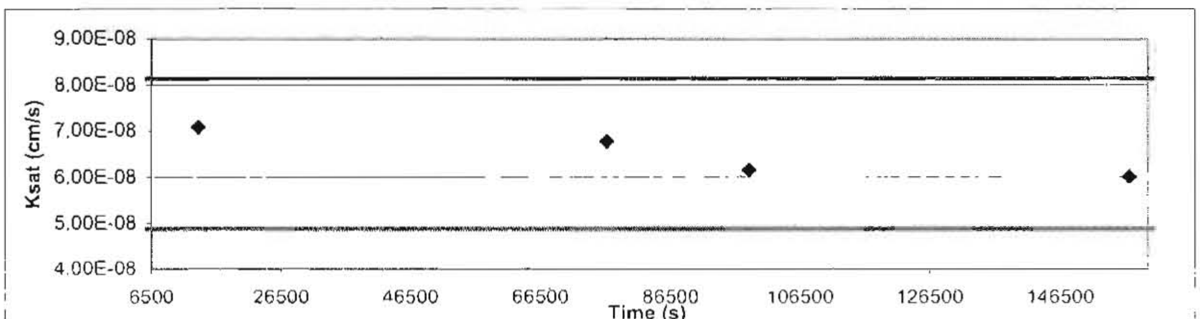
Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name LANL TA-16 CMI
Job Number ES09.0185.00
Sample Number PRB Soil @ 10%
Phase Number 81002
Task Number 32

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient (ΔH/ΔL)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
06-Jan-10	12:18:00	19.3	5.10	21.90	21.11	0.74	13690	0.89	1%	7.02E-08	7.08E-08
06-Jan-10	16:06:10	20.0	6.00	21.10	20.85						
Test # 2:											
06-Jan-10	16:06:10	20.0	6.00	21.10	20.85	3.12	62917	0.89	5%	6.69E-08	6.77E-08
07-Jan-10	09:34:47	19.0	9.80	17.70	19.76						
Test # 3:											
07-Jan-10	09:34:47	19.0	9.80	17.70	19.76	0.95	22053	0.91	2%	6.04E-08	6.16E-08
07-Jan-10	15:42:20	19.5	10.95	16.65	19.42						
Test # 4:											
07-Jan-10	15:42:20	19.5	10.95	16.65	19.42	2.38	58482	0.93	4%	5.87E-08	6.01E-08
08-Jan-10	07:57:02	18.6	13.80	14.00	18.58						

***Average Ksat* (cm/sec): 6.51E-08**
Calculated Gravel Corrected Average Ksat (cm/sec): 5.59E-08



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 4.88E-08

Ksat (+25%) (cm/s): 8.13E-08

Oversize Correction Data Sheet

Job Name	LANL TA-16 CMI
Job Number	ES09.0185.00
Sample Number	PRB Soil @ 10%
Phase Number	81002
Depth	32
Test Date:	6-Jan-10
Split (3/4", 3/8", #4):	3/8"
Calculated Porosity Fines (% vol):	39.8

	Coarse Fraction	Fines Fraction	Composite
Subsample Mass (g):	2257.50	13738.50	15996.00
Bulk Density (g/cm^3):	2.65	1.60	1.69
Volume of Solids (cm^3):	851.89	5169.11	6021.00
Volume of Voids (cm^3):	0.00	3417.45	3417.45
Total Volume (cm^3):	851.89	8586.56	9438.45
Volumetric Fraction of Subsample (%):	9.03	90.97	100.00
Ksat (cm/sec):	---	6.51E-08	5.59E-08

Comments:

Laboratory analysis by:	D. O'Dowd
Data entered by:	D. O'Dowd
Checked by:	J. Hines

Proctor Compaction

Summary of Proctor Compaction Tests

Sample Number	Measured: Optimum Moisture Content (% g/g)	Measured: Maximum Dry Bulk Density (g/cm^3)	Oversize Corrected: Optimum Moisture Content (% g/g)	Oversize Corrected: Maximum Dry Bulk Density (g/cm^3)
PRB Soil @ 10%	16.8	1.68	14.4	1.77

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not analyzed

Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data

Job Name: LANL TA-16 CMI
Job Number: ES09.0185.00
Sample Number: PRB Soil @ 10%
Phase Number: 81002
Task Number: 32

Test Date: 25-Jan-10

As Received Moisture Content (% g/g): 10.31

Split (3/4", 3/8", #4): 3/8
Mass of coarse material (g): 2257.5
Mass of fines material (g): 13738.5
Mold weight (g): 4235
Mold volume (cm^3): 939.32

Compaction Method: Standard B
Preparation Method: Dry
Type of Rammer: Mechanical

Trial	Weight of Mold and Compacted Soil (g)	Weight of Container and Wet Soil (g)	Weight of Container and Dry Soil (g)	Weight of Container (g)	Dry Bulk Density (g/cm^3)	Moisture Content (% g/g)
1	5922	1231.66	1130.02	297.78	1.60	12.21
2	6004	1197.94	1086.72	284.77	1.65	13.87
3	6087	1225.07	1086.80	296.52	1.68	17.50
4	6101	1117.55	974.22	269.94	1.65	20.35
5	6080	1124.96	963.89	270.35	1.59	23.22

Soil Fractions

Coarse Fraction (% g/g): 14.1
Fines Fraction (% g/g): 85.9

Properties of Coarse Material

Assumed particle density (g/cm^3): 2.65
Assumed Initial Moisture Content (% g/g): 0.0

Oversize Corrected Values for Dry Bulk Density and Moisture Content

Trial	Dry Bulk Density of Composite (g/cm^3)	Moisture Content of Composite (% g/g)
1	1.69	10.49
2	1.75	11.91
3	1.77	15.03
4	1.74	17.48
5	1.69	19.95

-- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NA = Not analyzed

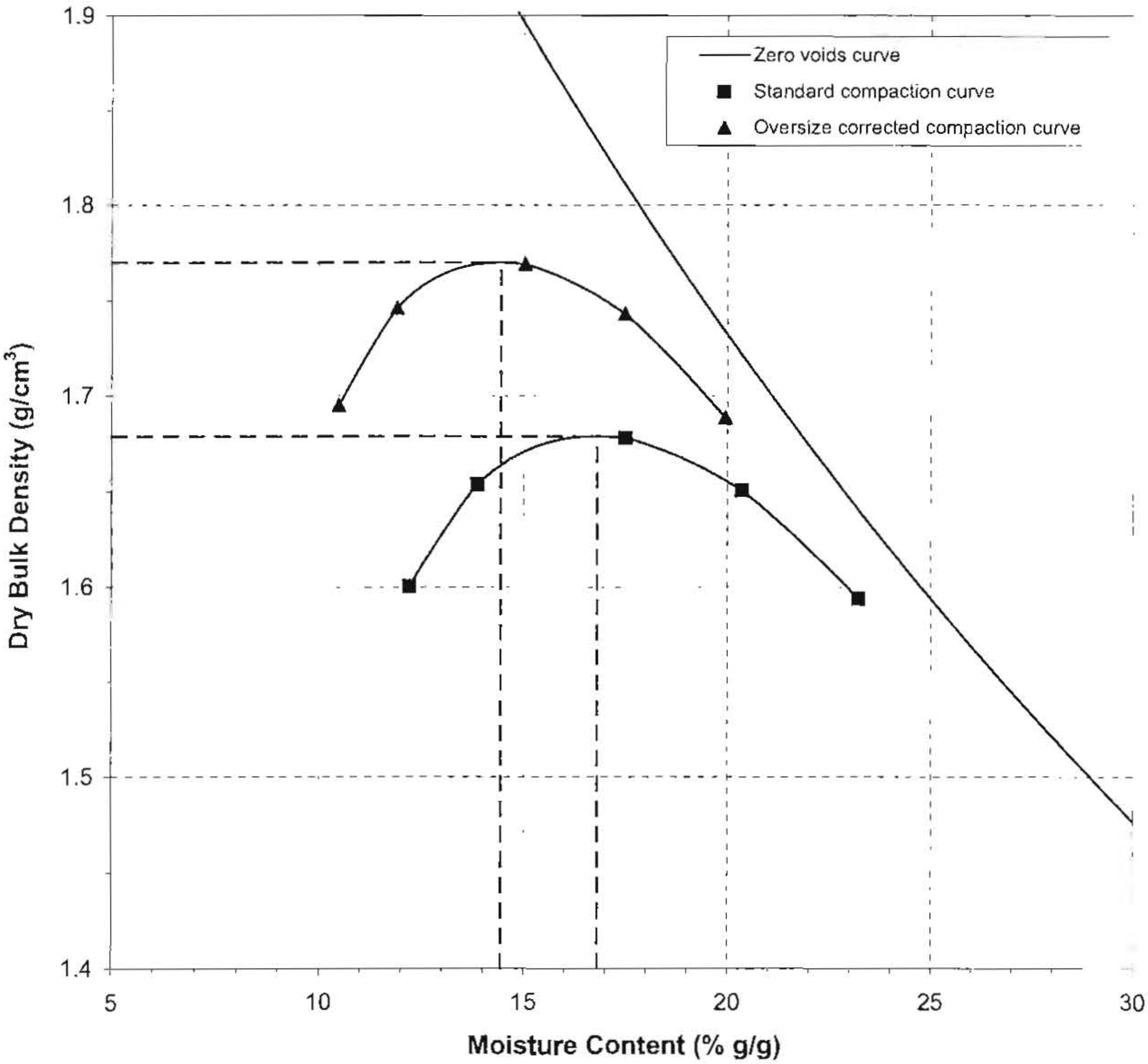
Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: PRB Soil @ 10%

	Measured	Corrected
Optimum Moisture Content (% g/g):	16.8	14.4
Maximum Dry Bulk Density (g/cm^3):	1.68	1.77

Test Date: 25-Jan-10



--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not analyzed

Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D6836
Moisture Content:	ASTM D2216; ASTM D6836
Calculated Porosity:	ASTM D6836
Saturated Hydraulic Conductivity:	
Falling Head Rising Tail: (Flexible Wall)	ASTM D5084
Standard Proctor Compaction:	ASTM D698
Coarse Fraction (Gravel) Correction (calc):	ASTM D4718; Bouwer, H. and Rice, R.C. 1984. Hydraulic Properties of Stony Vadose Zones. Groundwater Vol. 22, No. 6

ATTACHMENT C

IN-PLACE FIELD DENSITY DATA SHEETS
ASTM D 1556-82 (Sand Cone Method)

FIELD DENSITY TEST (Sand-cone, Balloon) Data Sheet 10a

Project: Surge Bed Cap TA-16, Bldg. 260 Job No. CMI Plan, Consolidated Unit 16-021(c)-99, Rev.1

Location of Project: LANL, TA-16 (Test Sample 1A)

Description of Soil: 90% SOIL, 10% BENTONITE (by weight)

Test Performed By: Brian Dwyer Date of Test: 1-30-2010

Laboratory Data from Field Test

Sand-cone method

Mass of wet soil + ~~can~~ bags: 3326.7

Mass of ~~can~~ bags: 39.6

Mass of wet soil, M': 3287.1

Mass of wet soil + pan: 4691.3

Mass of dry soil + pan: 4249.1

Mass of water: 442.2

Mass of pan: 1404.2

Mass of dry soil: 2844.9

Water content, w%: $\frac{442.2}{2844.9} = 15.5\%$

Balloon method

Mass of wet soil + can ____

Mass of can ____

Mass of wet soil, M' ____

Mass of wet soil + pan ____

Mass of dry soil + pan ____

Mass of pan ____

Mass of dry soil ____

Water content, w% ____

Field Data

Sand-cone method

Type of sand used: Colorado Silica Sand 10x20 MESH

Density of sand, ρ_{sand} = 1.56 g/cm³

Mass of jug + sand + cone before use: 7294 g

Mass of jug + cone after use: 3062.5 g

Mass of sand used (hole + cone): 4231.5 g

Mass of sand in cone (from calib.): 1705.5 g

Mass of sand in hole, M: 2526.0 g

Vol. of hole, $V_h = M/\rho_{sand}$ = $\frac{2526.0}{1.56} = 1619.3$ cm³

Balloon method

Correction factor CF = ____

Final scale reading ____ cm³

Initial scale reading ____ cm³

Vol. of hole, V'_h ____ cm³

Vol. of hole = V'_h (CF) ____ cm³

$\rho_{wet} = M'/V_h$ = $\frac{3287.1}{1619.3} = 2.03$ g/cm³

Unit Weight of Soil: Wet $\gamma_{wet} = \rho_{wet} \times 9.807$ = ____ kN/m³

Dry $\gamma_{dry} = \gamma_{wet}/(1+w)$ = ____ kN/m³

$\rho_{dry} = \frac{2.03}{(1+w)} = \frac{2.03}{(1.155)} = 1.76$

$RC = \frac{\rho_{df}}{\rho_{dL}} \times 100\ (\%)$

$RC = \frac{1.76}{1.77} \times 100 = 99.4\%$

FIELD DENSITY TEST (cont'd) Data Sheet 10*b*

Name Brian Dwyer Date of Testing 1-30-2010

Calibration Data

I. *Sand-cone method*

A. Sand density determination

Sand used Colorado Silica Sand 10x20 MESH

Type of vol. measure Graduated cylinder Vol., V_m 1000 cm^3

Mass of sand to fill vol. measure: Trial no. 1 1978 - 413.4 = 1564.6

Trial no. 2 1977 - 413.4 = 1563.6

Trial no. 3 1980 - 413.4 = 1566.6

Mass of Graduated Cylinder 413.4

Average mass M_a = 1564.9

Density of sand, $\rho_{sand} = M_a/V_m$ = 1564.9g / 1000 = 1.56 g/cm^3

B. Mass of sand to fill cone

Mass of filled jug + cone = 7296 g

Mass after trial No. 1 = 5592 Mass used = 1704

Mass after trial No. 2 = 3885 Mass used = 1707

Mass after trial No. 3 = 2179 Mass used = 1706

Average mass to fill cone = 1706. g

II. *Volumeasure (balloon apparatus) calibration*

Type of container used ________

Vol. of container, V_c = ________ cm^3

Initial reading ________

Reading after trial No. 1 ________ ; Change in vol. ________ cm^3

Reading after trial No. 2 ________ ; Change in vol. ________ cm^3

Reading after trial No. 3 ________ ; Change in vol. ________ cm^3

Average ΔV ________ cm^3

Correction factor $CF = V_c/\Delta V$ = ________

[Note, if correction factor is less than ± 0.002, neglect it.]

FIELD DENSITY TEST (Sand-cone, Balloon) Data Sheet 10*a*

Project: Surge Bed Cap — Job No. CMI Plan, 16-021(c)-99

Location of Project: LANL, TA-16, Bldg. 260 (Test Sample 1B)

Description of Soil: 90% soil, 10% bentonite (by weight)

Test Performed By: Brian Dwyer — Date of Test: 1-30-2010

Laboratory Data from Field Test

Sand-cone method

- Mass of wet soil + can: 3529.9 g
- Mass of ~~can~~ bags: 40.8 g
- Mass of wet soil, M': 3489.1 g
- Mass of wet soil + pan: 4879.3 g
- Mass of water: 458 g
- Mass of dry soil + pan: 4421.2 g
- Mass of pan: 1390.2 g
- Mass of dry soil: 3031 g
- Water content, w%: $\frac{458}{3031} = 15.1\%$

Balloon method

- Mass of wet soil + can: ______
- Mass of can: ______
- Mass of wet soil, M': ______
- Mass of wet soil + pan: ______
- Mass of dry soil + pan: ______
- Mass of pan: ______
- Mass of dry soil: ______
- Water content, w%: ______

x = 3031

Field Data

Sand-cone method

- Type of sand used: Colorado Silica Sand 10×20 mesh
- Density of sand, ρ_{sand} = 1.56 g/cm³
- Mass of jug + cone before use: 7319 g
- Mass of jug + cone after use: 2958 g
- Mass of sand used (hole + cone): 4361 g
- Mass of sand in cone (from calib.): 1706 g
- Mass of sand in hole, M: 2655 g
- Vol. of hole, $V_h = M/\rho_{sand} = \frac{2655}{1.56} = 1702$ cm³

Balloon method

- Correction factor CF = ______
- Final scale reading ______ cm³
- Initial scale reading ______ cm³
- Vol. of hole, V'_h ______ cm³
- Vol. of hole = V'_h (CF) ______ cm³

$\rho_{wet} = M'/V_h = \frac{3489.1}{1702} = 2.05$ g/cm³

Unit Weight of Soil: Wet $\gamma_{wet} = \rho_{wet} \times 9.807$ = ______ kN/m³

Dry $\gamma_{dry} = \gamma_{wet}/(1 + w)$ = ______ kN/m³

$\rho_{dry} = \frac{2.05}{(1+w)} = \frac{2.05}{1.151} = 1.78$

$RC = \frac{1.78}{1.77} \times 100 = 100.6\%$

FIELD DENSITY TEST (cont'd)

Data Sheet 10*b*

Name Brian Dwyer Date of Testing 1-30-2010

Calibration Data

I. *Sand-cone method*

A. Sand density determination

Sand used Colorado Silica Sand (10x20 mesh)

Type of vol. measure Graduated Cylinder Vol., V_m 1000 cm^3

Mass of sand to fill vol. measure: Trial no. 1 1978 − 413.4 = 1564.6

Trial no. 2 1977 − 413.4 = 1563.6

Trial no. 3 1980 − 413.4 = 1566.6

Mass of 1000 ml Graduated Cylinder = 413.4 g

Average mass M_a = 1564.9

Density of sand, $\rho_{sand} = M_a/V_m$ = $\frac{1564.9}{1000}$ = 1.56 g/cm^3

B. Mass of sand to fill cone

Mass of filled jug + cone = 7296 g

Mass after trial No. 1 = 5592 g Mass used = 1704 g

Mass after trial No. 2 = 3885 g Mass used = 1707 g

Mass after trial No. 3 = 2179 g Mass used = 1706 g

Average mass to fill cone = 1706 g

II. *Volumeasure (balloon apparatus) calibration*

Type of container used ______

Vol. of container, V_c = ______ cm^3

Initial reading ______

Reading after trial No. 1 ______ ; Change in vol. ______ cm^3

Reading after trial No. 2 ______ ; Change in vol. ______ cm^3

Reading after trial No. 3 ______ ; Change in vol. ______ cm^3

Average ΔV ______ cm^3

Correction factor CF = $V_c/\Delta V$ = ______

[Note, if correction factor is less than ± 0.002, neglect it.]

1C

FIELD DENSITY TEST (Sand-cone, Balloon) Data Sheet 10*a*

Project: Surge Bed Cap   Job No.: CMI Plan, 16-021(c)-99

Location of Project: LANL, TA-16, Bldg 260 (Test Sample 1C)

Description of Soil: 90% soil, 10% bentonite (by weight)

Test Performed By: Brian Dwyer   Date of Test: 1-30-2010

Laboratory Data from Field Test

Sand-cone method		Balloon method	
Mass of wet soil + ~~can~~ bags	3294.1 g	Mass of wet soil + can	
Mass of ~~can~~ bags	42.1 g	Mass of can	
Mass of wet soil, M'	3252 g	Mass of wet soil, M'	
Mass of wet soil + pan	4634 g	Mass of wet soil + pan	
Mass of water	451 g		
Mass of dry soil + pan	4183 g	Mass of dry soil + pan	
Mass of pan	1382 g	Mass of pan	
Mass of dry soil	2801 g	Mass of dry soil	
Water content, w%	$\frac{451}{2801} = 16.1\%$	Water content, w%	

Field Data

Sand-cone method		Balloon method	
Type of sand used	Colorado Silica 10x20 Mesh	Correction factor CF =	
Density of sand, ρ_{sand} =	1.56 g/cm³	Final scale reading	cm³
Mass of jug + cone before use	7281 g	Initial scale reading	cm³
Mass of jug + cone after use	3063 g	Vol. of hole, V'_h	cm³
Mass of sand used (hole + cone)	4218 g	Vol. of hole = V'_h (CF)	cm³
Mass of sand in cone (from calib.)	1706 g		
Mass of sand in hole, M	2512 g		
Vol. of hole, $V_h = M/\rho_{sand}$ =	$\frac{2512}{1.56} = 1610$ cm³	$\rho_{wet} = M'/V_h$ =	$\frac{3252}{1610} = 2.02$ g/cm³

Unit Weight of Soil: Wet $\gamma_{wet} = \rho_{wet} \times 9.807$ = ______ kN/m³

Dry $\gamma_{dry} = \gamma_{wet}/(1 + w)$ = ______ kN/m³

$$\frac{2.02}{1.161} = 1.74$$

$$RC = \frac{\rho_{df}}{\rho_{dL}} \times 100 \ (\%)$$

$$RC = \frac{1.74}{1.77} \times 100 = 98.3\%$$

Name Brian Dwyer Date of Testing 1-30-2010

Calibration Data

I. *Sand-cone method*

A. Sand density determination

Sand used Colorado Silica Sand (10x20 mesh)

Type of vol. measure graduated cylinder Vol., V_m 1000 cm^3

Mass of sand to fill vol. measure: Trial no. 1 1978 - 413.4 = 1564.6

Trial no. 2 1977 - 413.4 = 1563.6

Trial no. 3 1980 - 413.4 = 1566.6

Mass of 1000ml graduated cylinder = 413.4g

Average mass M_a = 1564.9

Density of sand, $\rho_{sand} = M_a/V_m$ = $\frac{1564.9}{1000}$ = 1.56 g/cm^3

B. Mass of sand to fill cone

Mass of filled jug + cone = 7296g

Mass after trial No. 1 = 5592g Mass used = 1704g

Mass after trial No. 2 = 3885 Mass used = 1707g

Mass after trial No. 3 = 2179 Mass used = 1706g

Average mass to fill cone = 1706 g

II. *Volumeasure (balloon apparatus) calibration*

Type of container used ______

Vol. of container, V_c = ______ cm^3

Initial reading ______

Reading after trial No. 1 ______ ; Change in vol. ______ cm^3

Reading after trial No. 2 ______ ; Change in vol. ______ cm^3

Reading after trial No. 3 ______ ; Change in vol. ______ cm^3

Average ΔV ______ cm^3

Correction factor CF = $V_c/\Delta V$ = ______

[Note, if correction factor is less than ± 0.002, neglect it.]

FIELD DENSITY TEST (Sand-cone, Balloon) Data Sheet 10a

Project: Surge Bed Cap — Job No. CMI Plan, 16-021 (c)-99

Location of Project: LANL, TA-16, Bldg 260 (Test Sample 2A)

Description of Soil: 90% soil, 10% bentonite (by weight)

Test Performed By: Brian Dwyer — Date of Test: 1-31-2010

Laboratory Data from Field Test

Sand-cone method

Mass of wet soil + ~~can~~ bags: 3128.9 g

Mass of ~~can~~ bags: 39.9 g

Mass of wet soil, M': 3089 g

Mass of wet soil + pan: 4493.2 g

MASS OF WATER: 442 g

Mass of dry soil + pan: 4051.2 g

Mass of pan: 1404.2

Mass of dry soil: 2647

Water content, $w\%$: $\frac{442}{2647} = 16.7\%$

Balloon method (crossed out)

Mass of wet soil + can ______

Mass of can ______

Mass of wet soil, M' ______

Mass of wet soil + pan ______

Mass of dry soil + pan ______

Mass of pan ______

Mass of dry soil ______

Water content, $w\%$ ______

Field Data

Sand-cone method

Type of sand used: Colorado Silica 10 X 20 MESH.

Density of sand, ρ_{sand} = 1.56 g/cm³

Mass of jug + cone before use: 7107.2 g

Mass of jug + cone after use: 2991 g

Mass of sand used (hole + cone): 4116.2 g

Mass of sand in cone (from calib.): 1706 g

Mass of sand in hole, M: 2410 g

Vol. of hole, $V_h = M/\rho_{sand} = \frac{2410}{1.56} = 1545$ cm³

Balloon method (crossed out)

Correction factor CF = ______

Final scale reading ______ cm³

Initial scale reading ______ cm³

Vol. of hole, V'_h ______ cm³

Vol. of hole = V'_h (CF) ______ cm³

$\rho_{wet} = M'/V_h = \frac{3089}{1545} = 2.00$ g/cm³

Unit Weight of Soil: Wet $\gamma_{wet} = \rho_{wet} \times 9.807$ = ______ kN/m³

Dry $\gamma_{dry} = \gamma_{wet}/(1 + w)$ = ______ kN/m³

$\rho_{dry} = \frac{\rho_{wet}}{1+w} = \frac{2.00}{(1+.158)} = 1.73$

$RC = \frac{\rho_{dF}}{\rho_{dL}} \times 100\ (\%)$

$RC = \frac{1.73}{1.77} \times 100 = 97.7\%$

FIELD DENSITY TEST (cont'd) Data Sheet 10*b*

Name Brian Dwyer Date of Testing 1-31-2010

Calibration Data

I. *Sand-cone method*

A. Sand density determination

Sand used Colorado Silica Sand 10x20 Mesh

Type of vol. measure Graduated Cylinder Vol., V_m 1000 cm^3

Mass of sand to fill vol. measure: Trial no. 1 1978 - 413.4 = 1564.6

Trial no. 2 1977 - 413.4 = 1563.6

Trial no. 3 1980 - 413.4 = 1566.6

Mass of Graduated Cylinder = 413.4

Average mass M_a = 1564.9

Density of sand, $\rho_{sand} = M_a/V_m$ = $\frac{1564.9}{1000}$ = 1.56 g/cm^3

B. Mass of sand to fill cone

Mass of filled jug + cone = 7296 g

Mass after trial No. 1 = 5592 Mass used = 1704

Mass after trial No. 2 = 3885 Mass used = 1707

Mass after trial No. 3 = 2179 Mass used = 1706

Average mass to fill cone = 1706 g

II. *Volumeasure (balloon apparatus) calibration*

Type of container used ______

Vol. of container, V_c = ______ cm^3

Initial reading ______

Reading after trial No. 1 ______ ; Change in vol. ______ cm^3

Reading after trial No. 2 ______ ; Change in vol. ______ cm^3

Reading after trial No. 3 ______ ; Change in vol. ______ cm^3

Average ΔV ______ cm^3

Correction factor CF = $V_c/\Delta V$ = ______

[Note, if correction factor is less than ± 0.002, neglect it.]

FIELD DENSITY TEST (Sand-cone, Balloon)

Data Sheet 10a

Project: Surge Bed Cap

Job No.: CMI Plan, 16-021(c)-99

Location of Project: LANL, TA-16, Bldg. 260 (Test Sample 2B)

Description of Soil: 90% soil, 10% bentonite (by weight)

Test Performed By: Brian Dwyer

Date of Test: 1-31-2010

Laboratory Data from Field Test

Sand-cone method

Mass of wet soil + ~~can~~ bags: 3037 g

Mass of ~~can~~ bags: 41.2 g

Mass of wet soil, M': 2996 g

Mass of wet soil + pan: 4386.2 g

MASS OF WATER = 433 g

Mass of dry soil + pan: 3953.2 g

Mass of pan: 1390.2 g

Mass of dry soil: 2563

Water content, w%: $\frac{433}{2563}$ = 16.9%

Balloon method

Mass of wet soil + can: ______

Mass of can: ______

Mass of wet soil, M': ______

Mass of wet soil + pan: ______

Mass of dry soil + pan: ______

Mass of pan: ______

Mass of dry soil: ______

Water content, w%: ______

Field Data

Sand-cone method

Type of sand used: Colorado Silica 10 X 20 Mesh

Density of sand, ρ_{sand} = 1.56 g/cm³

Mass of jug + cone before use: 7162 g

Mass of jug + cone after use: 3187 g

Mass of sand used (hole + cone): 3975 g

Mass of sand in cone (from calib.): 1706 g

Mass of sand in hole, M: 2269 g

Vol. of hole, $V_h = M/\rho_{sand}$ = $\frac{2269}{1.56}$ = 1454 cm³

Balloon method

Correction factor CF = ______

Final scale reading ______ cm³

Initial scale reading ______ cm³

Vol. of hole, V'_h ______ cm³

Vol. of hole = V'_h (CF) ______ cm³

$\rho_{wet} = M'/V_h$ = $\frac{2996\text{ g}}{1454\text{ cc}}$ = 2.06 g/cm³

Unit Weight of Soil: Wet $\gamma_{wet} = \rho_{wet} \times 9.807$ = ______ kN/m³

Dry $\gamma_{dry} = \gamma_{wet}/(1+w)$ = ______ kN/m³

$\rho_{dry} = \frac{\rho_{wet}}{1+w} = \frac{2.06}{(1+.169)} = 1.76$

$RC = \frac{1.76}{1.77} \times 100 = 99\ \%$

FIELD DENSITY TEST (cont'd) Data Sheet 10*b*

Name Brian Dwyer Date of Testing 1-31-2010

Calibration Data

I. *Sand-cone method*

A. Sand density determination

Sand used Colorado Silica Sand 10x20 mesh

Type of vol. measure Graduated Cylinder Vol., V_m 1000 cm^3

Mass of sand to fill vol. measure: Trial no. 1 1978 - 413.4 = 1564.6

Trial no. 2 1977 - 413.4 = 1563.6

Trial no. 3 1980 - 413.4 = 1566.6

Mass of Graduated Cylinder = 413.4

Average mass M_a = 1564.9

Density of sand, $\rho_{sand} = M_a/V_m$ = $\frac{1564.9}{1000}$ = 1.56 g/cm^3

B. Mass of sand to fill cone

Mass of filled jug + cone = 7296 g

Mass after trial No. 1 = 5592 Mass used = 1704

Mass after trial No. 2 = 3885 Mass used = 1707

Mass after trial No. 3 = 2179 Mass used = 1706

Average mass to fill cone = 1706 g

II. *Volumeasure (balloon apparatus) calibration*

Type of container used ______

Vol. of container, V_c = ______ cm^3

Initial reading ______

Reading after trial No. 1 ______ ; Change in vol. ______ cm^3

Reading after trial No. 2 ______ ; Change in vol. ______ cm^3

Reading after trial No. 3 ______ ; Change in vol. ______ cm^3

Average ΔV ______ cm^3

Correction factor CF = $V_c/\Delta V$ = ______

[Note, if correction factor is less than ± 0.002, neglect it.]

2C

FIELD DENSITY TEST (Sand-cone, Balloon) Data Sheet 10*a*

Project: Surge Bed Cap, TA-16 Job No.: CMI Plan, 16-021(c)-99

Location of Project: LANL, TA-16, Bldg. 260 Outfall

Description of Soil: 90% soil, 10% bentonite (by weight)

Test Performed By: Brian Dwyer Date of Test: 1-31-2010

Laboratory Data from Field Test

Sand-cone method		**Balloon method**	
Mass of wet soil + can	3156.9 g	Mass of wet soil + can	
Mass of can	39.9 g	Mass of can	
Mass of wet soil, M'	3117 g	Mass of wet soil, M'	
Mass of wet soil + pan	4499 g	Mass of wet soil + pan	
Mass of Water	446 g		
Mass of dry soil + pan	4053 g	Mass of dry soil + pan	
Mass of pan	1382 g	Mass of pan	
Mass of dry soil	2671 g	Mass of dry soil	
Water content, w%	$\frac{446}{2671}$ = 16.7%	Water content, w%	

Field Data

Sand-cone method		**Balloon method**	
Type of sand used	Colorado Silica 10x20 mesh	Correction factor CF =	
Density of sand, ρ_{sand} =	1.56 g/cm³	Final scale reading	cm³
Mass of jug + cone before use	7096 g	Initial scale reading	cm³
Mass of jug + cone after use	2971 g	Vol. of hole, V'_h	cm³
Mass of sand used (hole + cone)	4125 g	Vol. of hole = V'_h (CF)	cm³
Mass of sand in cone (from calib.)	1706 g		
Mass of sand in hole, M	2419 g		
Vol. of hole, $V_h = M/\rho_{sand}$ =	$\frac{2419 \text{ g}}{1.56 \text{ g/cc}}$ = 1551 cm³	$\rho_{wet} = M'/V_h$ =	$\frac{3117 \text{ g}}{1551 \text{ cc}}$ = 2.01 g/cm³

Unit Weight of Soil: Wet $\gamma_{wet} = \rho_{wet} \times 9.807$ = ______ kN/m³

Dry $\gamma_{dry} = \gamma_{wet}/(1 + w)$ = ______ kN/m³

$$\rho_{dry_F} = \frac{\rho_{wet_F}}{1+w} = \frac{2.01}{(1+.167)} = 1.72$$

$$R.C. = \frac{1.72}{1.77} \times 100 = 97\%$$

FIELD DENSITY TEST (cont'd) Data Sheet 10*b*

Name Brian Duyar Date of Testing 1-31-2010

Calibration Data

I. *Sand-cone method*

A. Sand density determination

Sand used Colorado Silica Sand 10×20 mesh

Type of vol. measure Graduated Cylinder Vol., V_m 1000 cm^3

Mass of sand to fill vol. measure: Trial no. 1 1978 − 413.4 = 1564.6

Trial no. 2 1977 − 413.4 = 1563.6

Trial no. 3 1980 − 413.4 = 1566.6

Mass of Graduated Cylinder = 413.4

Average mass M_a = 1564.9

Density of sand, $\rho_{sand} = M_a/V_m$ = $\frac{1564.9}{1000}$ = 1.56 g/cm^3

B. Mass of sand to fill cone

Mass of filled jug + cone = 7296 g

Mass after trial No. 1 = 5592 Mass used = 1704

Mass after trial No. 2 = 3885 Mass used = 1707

Mass after trial No. 3 = 2179 Mass used = 1706

Average mass to fill cone = 1706 g

II. *Volumeasure (balloon apparatus) calibration*

Type of container used ____

Vol. of container, V_c = ____ cm^3

Initial reading ____

Reading after trial No. 1 ____ ; Change in vol. ____ cm^3

Reading after trial No. 2 ____ ; Change in vol. ____ cm^3

Reading after trial No. 3 ____ ; Change in vol. ____ cm^3

Average ΔV ____ cm^3

Correction factor CF = $V_c/\Delta V$ = ____

[Note, if correction factor is less than ± 0.002, neglect it.]

ATTACHMENT D

BENTONITE DATA SHEETS

TECHNICAL DATA SHEET

Environmental Grout & Sealant

Pond Sealer

SODIUM BENTONITE POND SEALANT

DESCRIPTION

Pond Sealer is a high swelling chemically unaltered sodium bentonite that contains no additives. It is an economical and environmentally safe way to accomplish pond and lake sealing to reduce seepage losses. Sodium bentonite is a natural clay which has the characteristic of swelling many times its dry size when it becomes wet. When bentonite is applied in a layer over porous soil or mixed with a porous soil, and then, moistened with water, it forms an impermeable layer. Bentonite does not affect the water or the wildlife

APPLICATION

Pond Sealer can be applied directly to the soil in the bottom of the lake or pond. If conditions necessitate sprinkling the bentonite through water, to the bottom, we recommend using Granular Seal, which contains no powder. Treatment is usually more effective if the bentonite is applied directly to the soil. The sprinkle method is recommended only when it is impractical to drain the water from the area to be treated For more information on application methods, please see our website. **www.pondsealer.net**

APPLICATION RATE

Soil type and pond size are key factors in determining the amount of bentonite required for sealing. The chart to the right provides an estimate based on various soil conditions. It is always recommended to perform a soil test yourself or contact your local soil conservation service which usually provides free soil testing.

Soil Type	lbs per ft^2
Clay	1.0 – 1.5
Sandy Silt	2.0 - 2.5
Silty Sand	2.5 – 3.0
Clean Sand	3.5 – 4.0
Rock or Gravel	4.0 – 5.0

PACKAGING

Available in 50 lb polyethylene bags, 3,000 lbs bulk bags and bulk loads

PERMEABILITY 1.9×10^{-9} cm/sec

CHEMICAL ANALYSIS

SiO_2	66.60	%
Al_2O_3	17.60	%
Fe_2O_3	3.87	%
CaO	0.57	%
MgO	1.80	%
Na_2O	2.50	%
K_2O	0.31	%
Bound Water	6.51	%
Moisture at 20^0F	0.14	%

X-RAY ANALYSIS

Montmorillonite	85	%
Quartz	5	%
Feldspars	5	%
Cristobalite	2	%
Illite	2	%
Calcium & Gypsum	1	%

Southwestern Materials
P.O. Box 1270
Manchaca, TX 78652

phone: 512-280-7801
fax: 512-280-7842

MATERIAL SAFETY DATA SHEET

OSHA Hazard Communication Standard
29 CFR 1910.12000

U. S. Department of Labor
Occupational Safety and Health Adm.
OMB 1218-0072

Identity (used on label): PDSCo Granular Seal

SECTION I

Manufacturer

SouthWestern Materials
P.O. Box 1270
Manchaca, Texas 78652

Emergency Phone : 888-600-6077
Information Phone : 512-280-7801

SECTION II HAZARDOUS INGREDIENTS

Hazardous Components	OSHA PEL	TLV	Other Limits	%
Crystalline Quartz CAS# 14808-60-7 (naturally occurring contaminant)	-	-	*	2-6%
Respirable Crystalline Quartz			NIOSH	
present (TWA)	0.1 mg/m^3	0.1 mg/m^3	50ug/m^3	<2%
proposed (TWA)	-	50ug/m^3	-	-
Nuisance Dust:				
Respirable	5 mg/ m^3	5 mg/ m^3	-	-
Total Dust	15 mg/ m^3	10 mg/ m^3	-	-

* Warning: This product contains a small amount of crystalline silica which may cause delayed respiratory disease if inhaled over a prolonged period of time. Avoid breathing dust. Use NIOSH/MSHA approved respirator when TLV for crystalline silica may be exceeded. IARC Monographs on the evaluation of the Carcinogenic Risk of Chemicals to Humans (volume 42, 1987) concluded that there is "limited evidence" of the carcinogenicity of crystalline silica to humans. IARC classification 2A.

SECTION III PHYSICAL CHEMICAL CHARACTERISTICS

Boiling Point : N/A
Vapor Pressure (mm Hg at 20^{0}C) N/A
Vapor Density (Air = 1) N/A
Solubility in Water : Negligible
Appearance & Odor : Pale grey to buff powder or granules, odorless
Specific Gravity 2.5
Melting Point N/A
Evaporation Rate N/A

SECTION IV FIRE AND EXPLOSION HAZARD DATA

Flash Point N/A
Flammable Limit : N/A
LEL : N/A
UEL : N/A
Extinguishing Media : Not Applicable
Special Fire Fighting Procedure : Inorganic mineral/non-flammable.
Unusual Fire and Explosion Hazards : N/A

SECTION V REACTIVITY DATA

Stability	:	Unstable		Stable	X
Conditions to Avoid	:	None Known			
Materials to Avoid	:	None Known			
Hazardous Decomposition	:	None Known			
Hazardous Polymerization	:	May Occur		Will Not Occur	X

SECTION VI HEALTH HAZARD DATA

Routes of Entry : Inhalation: Yes Skin: No Ingestion: No

Health Hazards (Acute-Chronic) : May cause delayed respiratory disease if dust inhaled over a prolonged period of time.

Carcinogenicity N/A NTP: No IARC: Yes OSHA Req: No

IARC Monographs on the evaluation of the Carcinogenic Risk of Chemicals to Humans (volume 42, 1987) concludes that there is "limited evidence" of the carcinogenicity of crystalline silica to humans. IARC classification 2A.

Sighs and Symptoms of Exposure : Excessive inhalation of dust may result in shortness of breath and reduced pulmonary function.

Conditions Aggravated by Exposure : Individuals with pulmonary and/or respiratory disease including but not limited to asthma and bronchitis be precluded from exposure to dust.

Emergency First Aid : Eyes. Flush with water.

Gross inhalation of dust: Remove to fresh air. Give oxygen or artificial respiration if necessary. Get medical attention immediately.

SECTION VII PRECAUTIONS FOR SALE HANDLING AND USE

In Case Released or Spilled : Vacuum if possible to avoid generating airborne dust. Avoid breathing duct. Wear an approved respirator. Avoid adding water, the product will become slippery when wet.

Waste Disposal Consult appropriate Federal, State, and Local regulatory agencies to ascertain proper disposal procedures.

Caution In Handling and Storing Avoid breathing dust, use NOISH/MSHA approved respirator when TLV limits for Crystalline Silica may be exceeded.

Other Precautions Slippery when wet.

SECTION VIII CONTROL MEASURES

Respiratory Protection	:	OSHA standard 1910.134 or ANSI Z88.2-1980 specification.
Ventilation	:	Local and mechanical exhaust as appropriate.
Protective Gloves	:	Not Required.
Eye Protection	:	Recommended.
Other Protection Equipment	:	Not required for normal use.
Work/Hygienic Practices	:	Normal personal hygiene required.

Appendix F

As-Build Diagrams for Permeable Reactive Barrier

VICINITY MAP NORTH
NTS

DBS&A engineering hydrology geoscience

TerranearPMC

SITE MAP NORTH
NTS

CORRECTIVE MEASURES IMPLEMENTATION
CONSOLIDATED UNIT 16-021(c)-99
CAÑON DE VALLE/MARTIN SPRING CANYON
PILOT PERMEABLE REACTIVE BARRIER
LOS ALAMOS, NEW MEXICO

PREPARED FOR LOS ALAMOS NATIONAL LABORATORIES

LANL DRAWING NUMBER CONTROL LIST

DRAWING NO.	TITLE	REVISION 0	1	2	3	REMARKS
81002-PRB-001, SHEET 1	TITLE SHEET					
81002-PRB-001, SHEET 2	GENERAL NOTES AND LEGEND					
81002-PRB-001, SHEET 3	OVERALL EXISTING SITE PLAN AND SURVEY CONTROL					
81002-PRB-001, SHEET 4	SITE PLAN					
81002-PRB-001, SHEET 5	MONITORING WELL LOCATION PLAN					
81002-PRB-001, SHEET 6	CUT-OFF WALL PLAN AND PROFILE					
81002-PRB-001, SHEET 7	GROUNDWATER TRANSFER LINE PLAN AND PROFILE					
81002-PRB-001, SHEET 8	PERMEABLE REACTIVE BARRIER TREATMENT VESSEL LOCATION PLAN					
81002-PRB-001, SHEET 9	PERMEABLE REACTIVE BARRIER TREATMENT VESSEL DETAILS					
81002-PRB-001, SHEET 10	UPGRADIENT COLLECTION GALLERY AND STREAM CROSSING DETAILS					
81002-PRB-001, SHEET 11	PERMEABLE REACTIVE BARRIER MONITORING DETAILS					

No	Revision	Date	Drawn By	Design By	Chkd Eng	Apprvd PM
1	AS-BUILT	2/18/2010	KDB	BPD	KR	PG
0	ISSUED FOR CONSTRUCTION	12/04/2009	KDB	BPD	KR	PG

Daniel B. Stephens & Associates, Inc.
ENVIRONMENTAL SCIENTISTS & ENGINEERS
6020 ACADEMY NE, SUITE 100
ALBUQUERQUE, NM 87109
(505) 822-9400

CORRECTIVE MEASURES IMPLEMENTATION
CONSOLIDATED UNIT 16-021(c)-99
CAÑON DE VALLE/MARTIN SPRING CANYON PPRB
TITLE SHEET

DRAWING NO.
81002-PRB-001
Sheet 1 of 11

CONSTRUCTION NOTES

GENERAL

ALL WORK ON THIS PROJECT SHALL BE PERFORMED IN ACCORDANCE WITH APPLICABLE FEDERAL, STATE AND LDCAL LAWS, RULES AND REGULATIDNS CONCERNING CONSTRUCTION SAFETY AND HEALTH.

EXISTING FENCING THAT IS NOT DESIGNATED FOR REMOVAL SHALL NOT BE DISTURBED. ANY SUCH FENCING THAT IS DISTURBED OR ALTERED BY THE CONTRACTOR SHALL BE RESTORED TO ITS ORIGINAL CONDITION AT THE CONTRACTOR'S EXPENSE. IF THE CONTRACTOR DETERMINES THERE IS A NEED TO REMOVE FENCING TO FACILITATE CONSTRUCTION OPERATIONS, THIS MAY BE DONE WITH THE OWNER'S PERMISSION, AND THE CONTRACTOR SHALL RESTORE THE FENCE TO ITS ORIGINAL CONDITION PRIOR TO THE CLOSE OF THE PROJECT. CONTRACTOR IS RESPONSIBLE FOR SECURITY OF THE SITE UNTIL THE FENCE IS REPLACED. REPLACEMENT FENCE MATERIAL AND FENCE CONSTRUCTION DETAILS SHALL BE APPROVED BY THE OWNER.

AT THE END OF EACH WORK DAY, THE CONTRACTOR SHALL CLEAN AND PICK UP THE WORK AREA. AT NO TIME SHALL THE WORK BE LEFT IN A MANNER THAT COULD ENDANGER WORKERS OR THE PUBLIC.

ALL MATERIALS AND WORKMANSHIP SHALL CONFORM TO PROJECT SPECIFICATIONS AND PLANS, AS AMENDED AND REVISED BY THE ENGINEER. ALL INSTALLATION DETAILS ARE TYPICAL AND MAY BE CHANGED TO BETTER FIT EXISTING LOCAL CONDITIONS IF APPRDVED BY THE ENGINEER.

THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL ASPECTS OF JOB SITE SAFETY ON THIS PROJECT. ALL WORK, INCLUDING WORK WITHIN TRENCHES, SHALL BE IN COMPLIANCE WITH THE OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA).

ESTIMATED QUANTITIES SHOWN HEREIN ARE FOR INFORMATION ONLY; FINAL QUANTITIES WILL BE DETERMINED BASED ON ACTUAL WORK ACCOMPLISHED, UPON COMPLETION OF PROJECT AND ON FINAL MEASUREMENTS.

DRAINAGE STRUCTURE LOCATIONS SHOWN HEREIN MAY REQUIRE FIELD ADJUSTMENT TO MATCH EXISTING DRAINAGE PATTERNS AND FLOW LINES. THE ENGINEER SHALL APPROVE ANY ADJUSTMENTS.

EROSION CONTROL, ENVIRONMENTAL PROTECTION, AND STORM WATER POLLUTION PREVENTION PLAN

THE CONTRACTOR SHALL CONFORM TO ALL CITY, COUNTY, STATE, AND FEDERAL DUST AND EROSION CONTROL REGULATIONS. THE CONTRACTOR SHALL PREPARE, OBTAIN AND PAY FOR ANY NECESSARY DUST OR EROSION CONTROL PERMITS FROM REGULATORY AGENCIES.

THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONSTRUCTION ACTIVITY EROSION AND SEDIMENT CONTROL MEASURES IN ACCORDANCE WITH THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES).

THE CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE REGULATIONS CONCERNING SURFACE AND UNDERGROUND WATER. CONTACT WITH SURFACE WATER BY CONSTRUCTION EQUIPMENT AND PERSONNEL SHALL BE MINIMIZED. EQUIPMENT MAINTENANCE AND REFUELING OPERATIONS SHALL BE PERFORMED IN AN ENVIRONMENTALLY SAFE MANNER IN COMPLIANCE WITH GOVERNMENT REGULATIONS.

THE CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE REGULATIONS CONCERNING CONSTRUCTION NOISE.

ADDITIONAL SPECIFICATIONS

1. SHEET PILING SHALL BE RIGID PVC IN 24" WIDE SECTIONS HAVING A SECTIONAL MODULUS (Z) OF 11.1 IN^3/FT, A MOMENT OF INERTIA (I) OF 39 IN^4/FT, A THICKNESS OF 0.25D IN. SHEET PILING SHALL HAVE A BOX PROFILE WITH I-BEAM LOCKING. ALL I-BEAM LOCK JOINTS SHALL BE SEALED WITH A HYDROPHILIC WATER SEAL. INSTALL SHEET PILING PER MANUFACTURERS SPECIFICATIONS.
2. ALL SHEET PILING JOINTS SHALL BE SEALED FOR THE ENTIRE VERTICAL LENGTH WITH JOINT SEALANT. APPLY JOINT SEALANT PER MANUFACTURERS SPECIFICATIONS.
3. BENTONITE FOR THE SHEET PILING BOTTOM SEAL SHALL BE A FREE FLOWING HIGH SWELLING SODIUM BENTONITE. THE BENTONITE SHALL BE A GRANULAR 8x40 MESH WITH NO ADDITIVES.
4. GEOTEXTILE SHALL BE A POLYPROPYLENE, STAPLE FIBER, NEEDLE PUNCHED NONWOVEN GEOTEXTILE. TENSILE STRENGTH SHALL BE 180 LBS., PUNCTURE SHALL BE 85 LBS., APPARENT OPENING SIZE (AOS) SHALL BE 70 US STD. SIEVE, WATER FLOW RATE SHALL BE 11D GPM/FT^2.
5. ALL PVC PIPING SHALL COMPLY WITH ASTM D1785-06 STANDARD SPECIFICATION FOR POLY (VINYL CHLORIDE) (PVC) PLASTIC PIPE, SCHEDULES 40, 80, AND 12D.
6. ALL PVC PIPING SHALL BE PRIMED PRIOR TO GLUING. PRIMERS SHALL COMPLY WITH ASTM F656-08 STANDARD FOR PRIMERS FOR USE IN SOLVENT CEMENT JOINTS OF POLY (VINYL CHLORIDE) (PVC) PLASTIC PIPE AND FITTINGS. ALL GLUE SHALL MEET ASTM D-2564 STANDARDS.

ABBREVIATIONS

AOS	=	APPARENT OPENING SIZE
APPROX	=	APPROXIMATELY
CO	=	CLEANOUT
CMP	=	CORRUGATED METAL PIPE
DIA	=	DIAMETER
ELEV	=	ELEVATION
EXIST	=	EXISTING
EG	=	EXISTING GRADE
FMSL	=	FEET ABOVE MEAN SEA LEVEL
FG	=	FINAL GRADE
FH	=	FIRE HYDRANT
FL	=	FLOW LINE
HDPE	=	HIGH DENSITY POLYETHYLENE
HOR	=	HORIZONTAL
INV	=	INVERT ELEVATION
LBS	=	POUNDS
LF	=	LINEAR FEET
MAX.	=	MAXIMUM
MIN.	=	MINIMUM
NTS	=	NOT TO SCALE
OC	=	ON CENTER
PP	=	POLYPROPYLENE
PRB	=	PERMEABLE REACTIVE BARRIER
PPRB	=	PILOT PERMEABLE REACTIVE BARRIER
PLS	=	PURE LIVE SEED
SIM	=	SIMILAR
STD	=	STANDARD
TYP	=	TYPICAL
VERT	=	VERTICAL

LEGEND

EXISTING TOPOGRAPHY INDEX CONTOUR AND ELEVATION 5' INTERVAL(FMSL)	7395
EXISTING TOPOGRAPHY CONTOUR 1' INTERVAL(FMSL)	
EXISTING SITE ACCESS ROAD	
EXISTING FLOW LINE OF STREAM	
BRASS CAP	
WELL HEAD CASING	
PIEZOMETER PIPE	
1/2" REBAR OR "MAG" NAIL	
GROUND MONITORING WELL	MW-##

COORDINATE CALLOUTS

18094.41 = NORTHING
40396.27 = EASTING
3680.62 = ELEVATION (FMSL)

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ENVIRONMENTAL SCIENTISTS & ENGINEERS
6020 ACADEMY NE, SUITE 100
ALBUQUERQUE, NM 87109
(505) 822-9400

CORRECTIVE MEASURES IMPLEMENTATION
CONSOLIDATED UNIT 16-021(c)-99
CAÑON DE VALLE/MARTIN SPRING CANYON PPRB

GENERAL NOTES AND LEGEND

TerranearPMC

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81002-PRB-001

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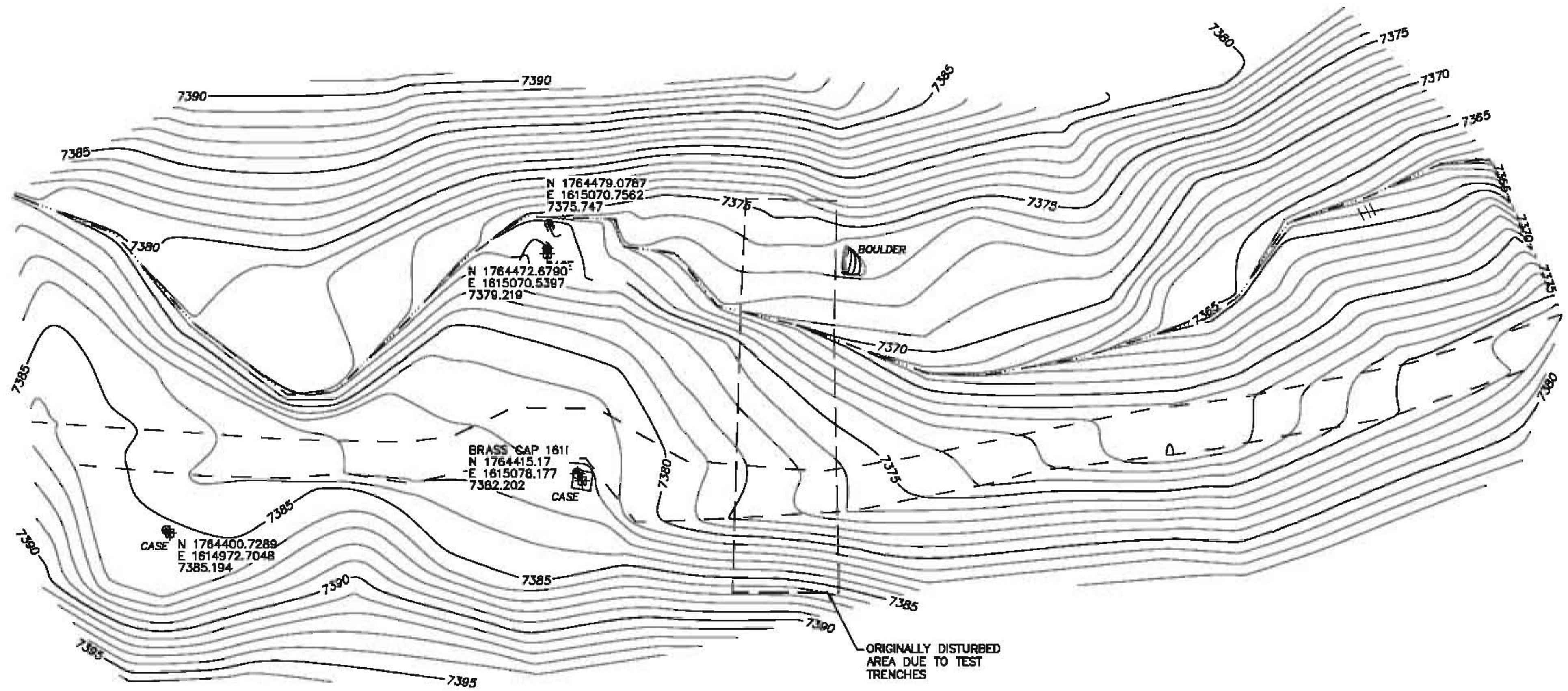

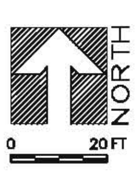

FLOW LINE
DIRT ROAD
WELL HEAD CASING
BRASS CAP
1/2" REBAR OR "MAG" NAIL
PIEZOMETER PIPE

TerranearPMC

XREF: none

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ALBUQUERQUE, NM 87109
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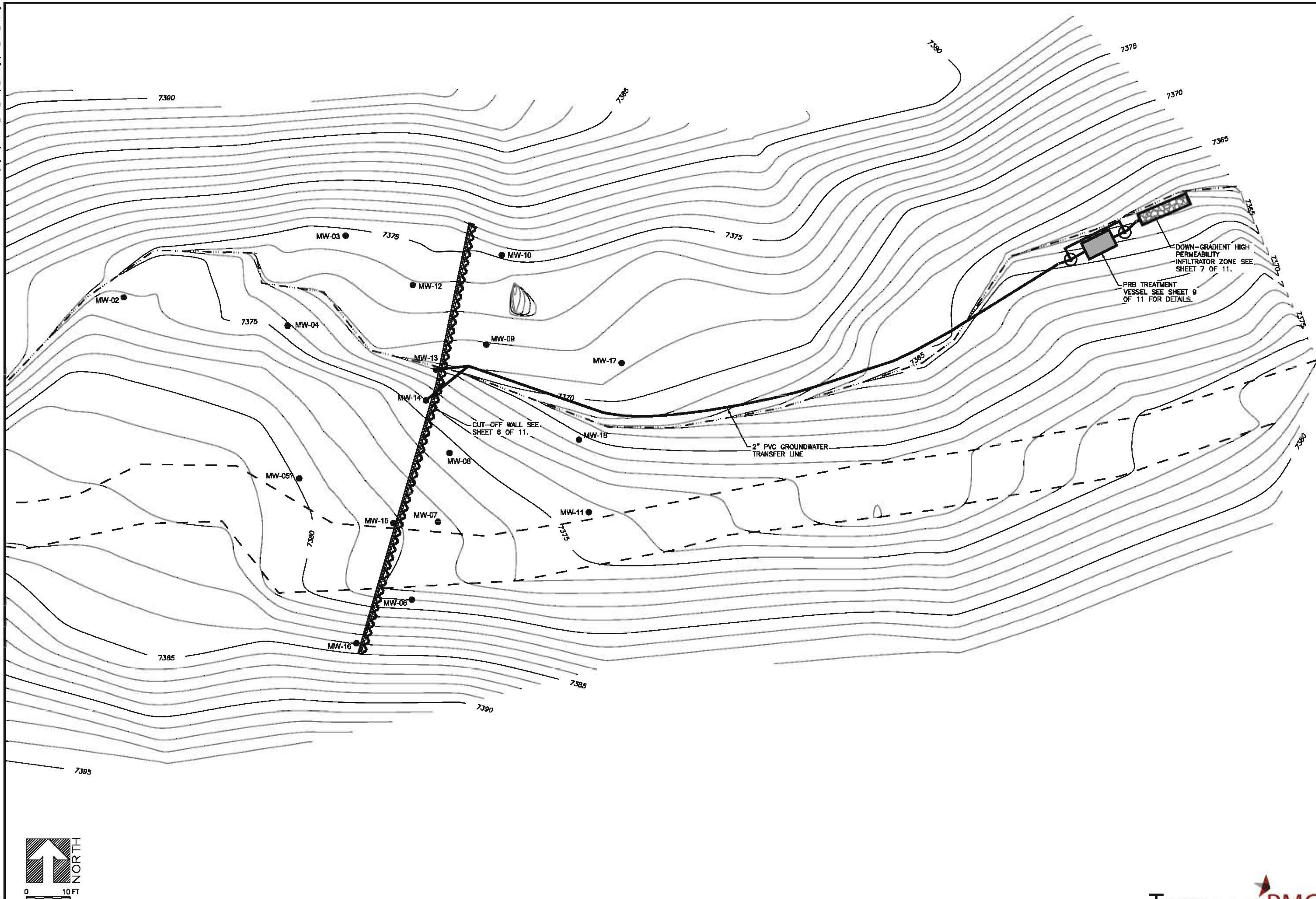
CORRECTIVE MEASURES IMPLEMENTATION
CONSOLIDATED UNIT 16-021(c)-99
CAÑON DE VALLE/MARTIN SPRING CANYON PPRB

OVERALL EXISTING SITE PLAN AND SURVEY CONTROL

DRAWING NO.
81002-PRB-001
Sheet 3 of 11

FILE NAME: S:\Projects\E509.0185_TMPC_PRB\VR_Drawings\E509_0185_D38.dwg



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CORRECTIVE MEASURES IMPLEMENTATION
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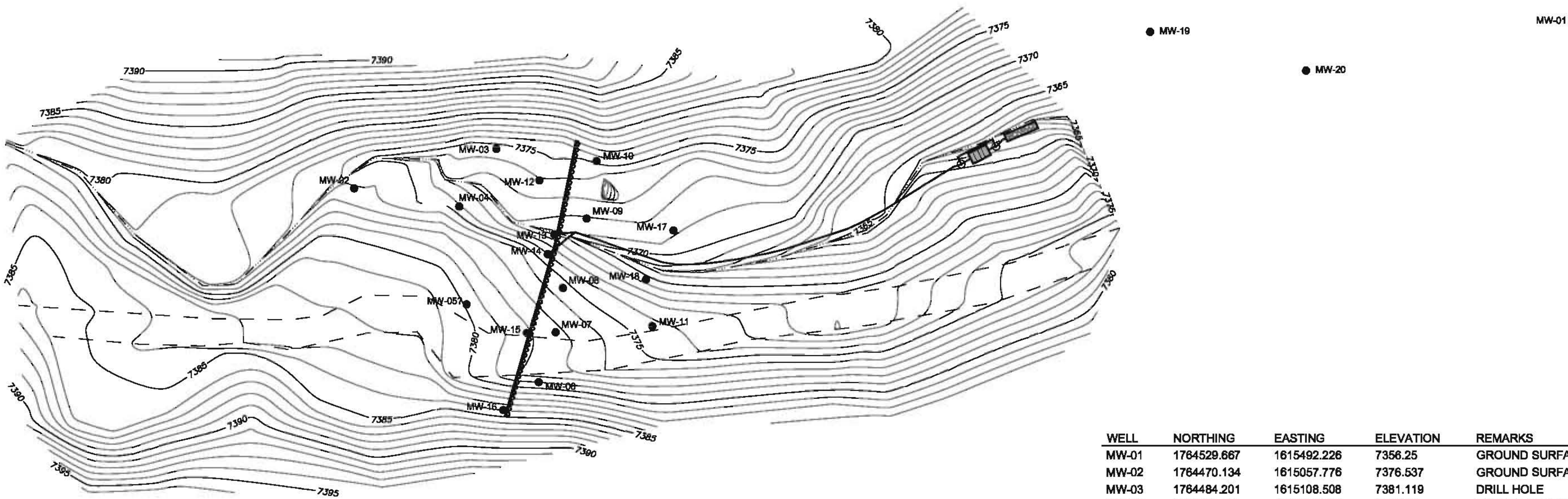
CAÑON DE VALLE/MARTIN SPRING CANYON PPRB

SITE PLAN

DRAWING NO.
81002-PRB-001
Sheet 4 of 11

FILE NAME: S:\Projects\ES09.0185_TMPC_PRB\VR_Drawings\ES09_0185_D38.dwg



WELL	NORTHING	EASTING	ELEVATION	REMARKS
MW-01	1764529.667	1615492.226	7356.25	GROUND SURFACE
MW-02	1764470.134	1615057.776	7376.537	GROUND SURFACE
MW-03	1764484.201	1615108.508	7381.119	DRILL HOLE
MW-04	1764463.669	1615095.232	7374.22	SIDE OF CHANNEL
MW-05?	1764428.83	1615097.887	7380.016	PRV(?)
MW-06	1764401.129	1615123.817	7382.163	TOP CASING
MW-07	1764418.932	1615129.6	7381.025	TOP CASING
MW-08	1764434.631	1615132.233	7379.886	TOP CASING
MW-09	1764459.407	1615140.674	7376.611	TOP CASING
MW-10	1764479.789	1615144.227	7378.343	TOP CASING
MW-11	1764421.035	1615164.148	7377.549	TOP CASING
MW-12	1764472.96	1615123.647	7376.428	TOP CASING
MW-13	1764453.7	1615129.134	7376.018	TOP CASING
MW-14	1764446.673	1615126.863	7377.182	TOP CASING
MW-15	1764418.613	1615119.418	7381.083	TOP CASING
MW-16	1764391.195	1615110.975	7386.908	TOP CASING
MW-17	1764455.147	1615171.653	7374.105	TOP CASING
MW-18	1764437.667	1615161.86	7373.512	TOP CASING
MW-19	1764525.586	1615341.624	7360.129	GROUND SURFACE
MW-20	1764511.882	1615397.198	7359.565	GROUND SURFACE

XREF: none

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CORRECTIVE MEASURES IMPLEMENTATION
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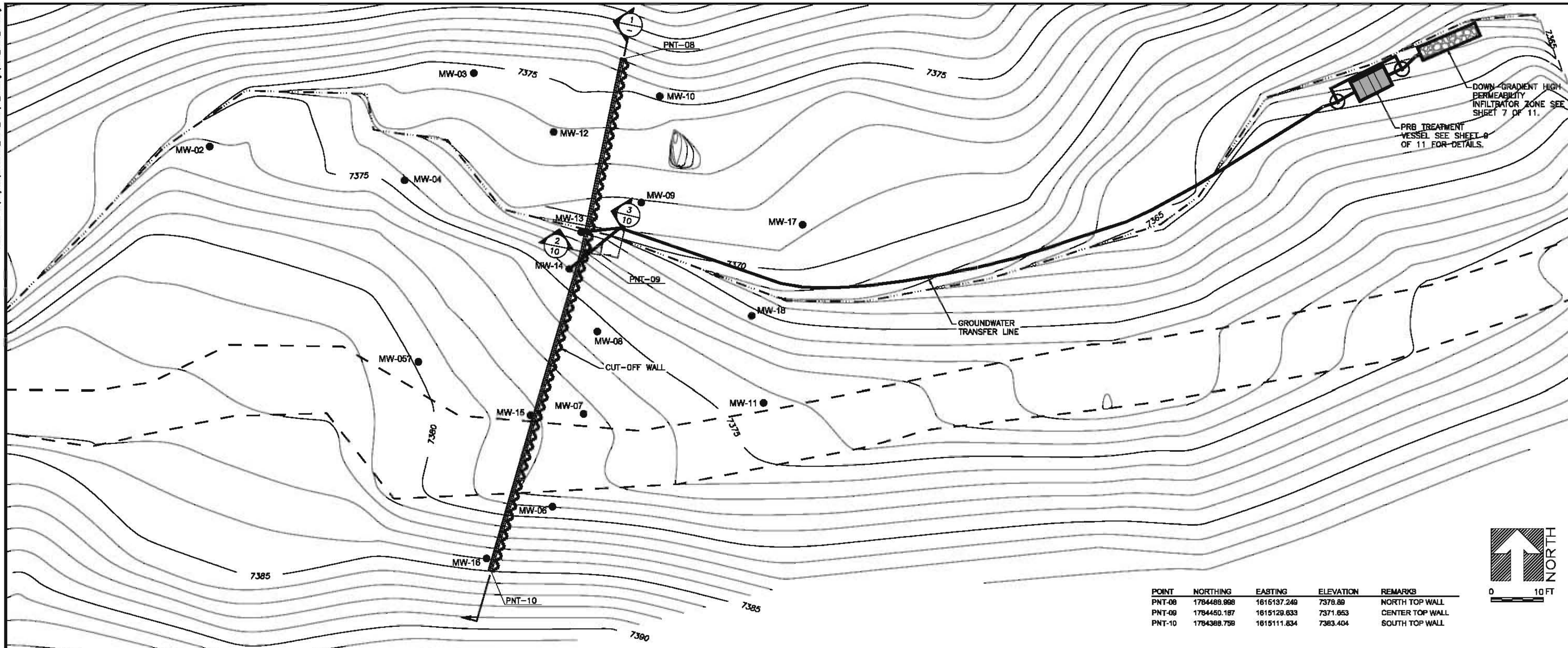
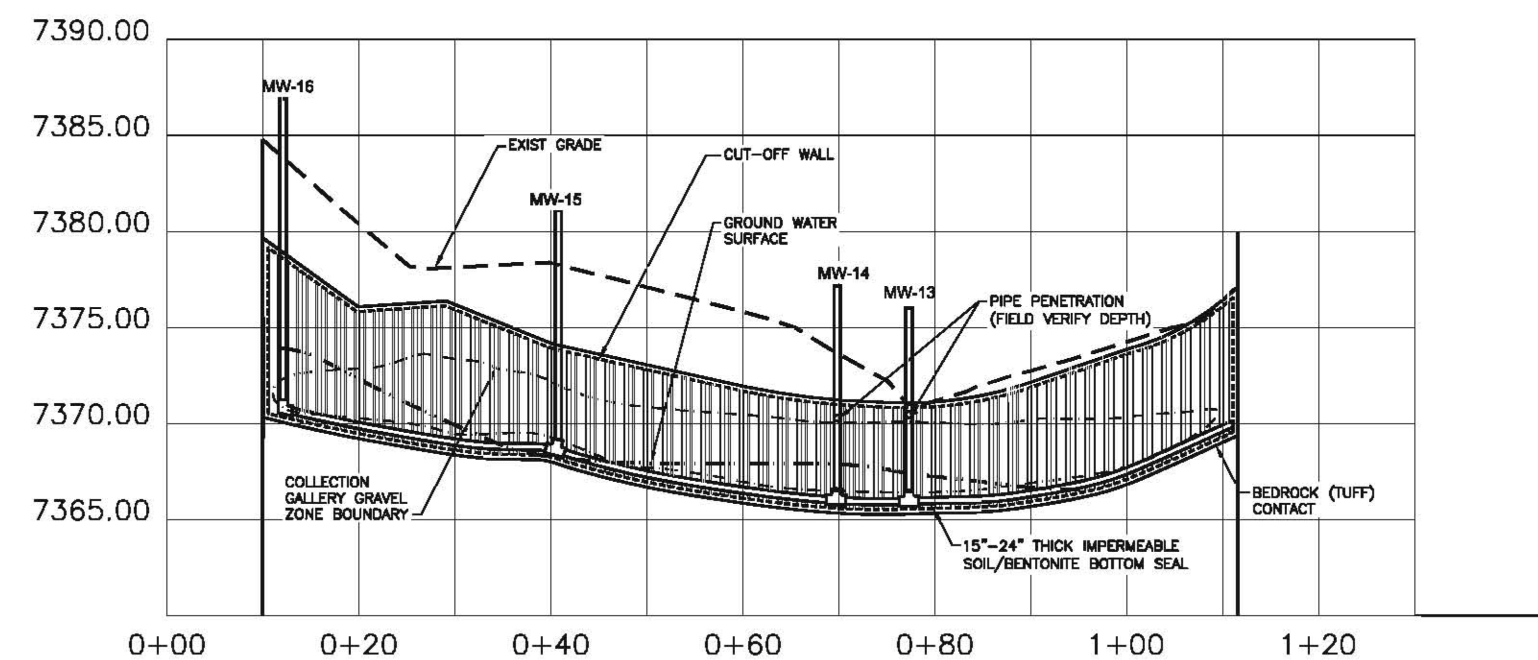
CAÑON DE VALLE/MARTIN SPRING CANYON PPRB

MONITORING WELL LOCATION PLAN

DRAWING NO.
81002-PRB-001
Sheet 5 of 11



POINT	NORTHING	EASTING	ELEVATION	REMARKS
PNT-08	1784486.998	1615137.249	7376.89	NORTH TOP WALL
PNT-09	1784450.187	1615129.633	7371.653	CENTER TOP WALL
PNT-10	1784388.759	1615111.834	7383.404	SOUTH TOP WALL



CUT-OFF WALL PROFILE (1 / -)

HORIZONTAL SCALE: 1"=10'
VERTICAL SCALE: 1"=5'

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CUT-OFF WALL PLAN AND PROFILE

DRAWING NO.
81002-PRB-001
Sheet 6 of 11

FILE NAME: S:\Projects\E509.0185_TMPC_PRB\VR_Drawings\E509_0185_D38.dwg
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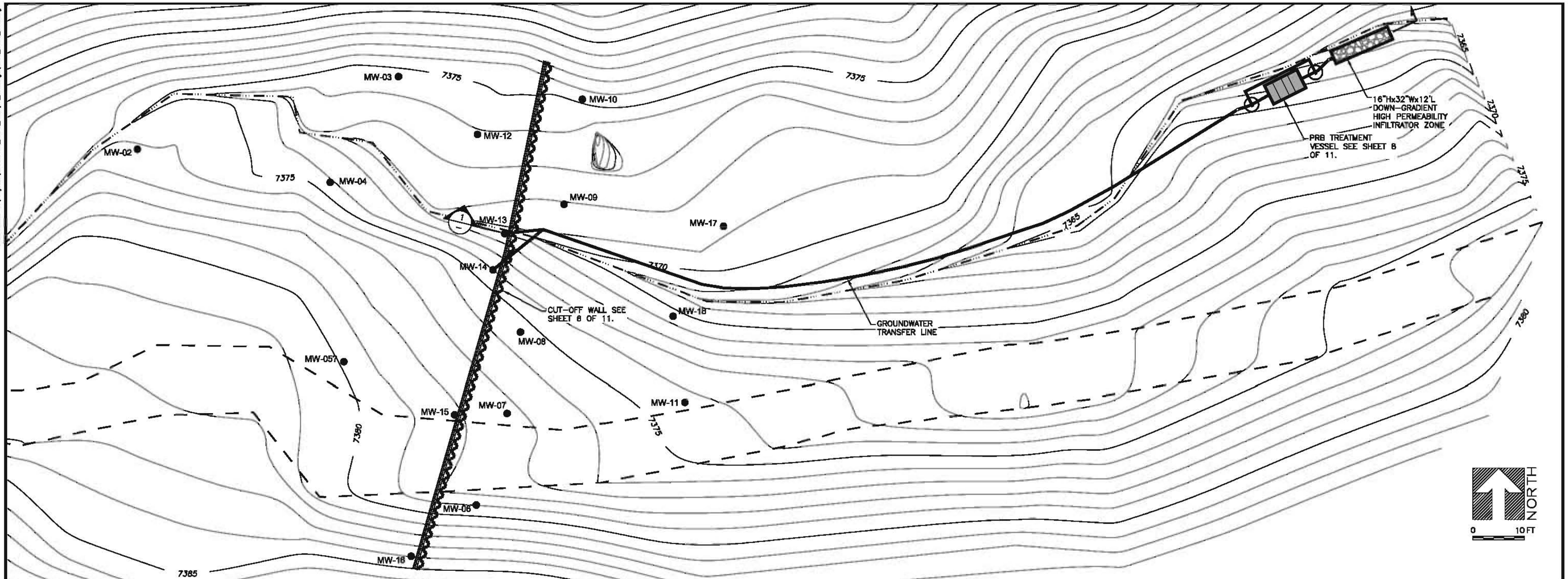

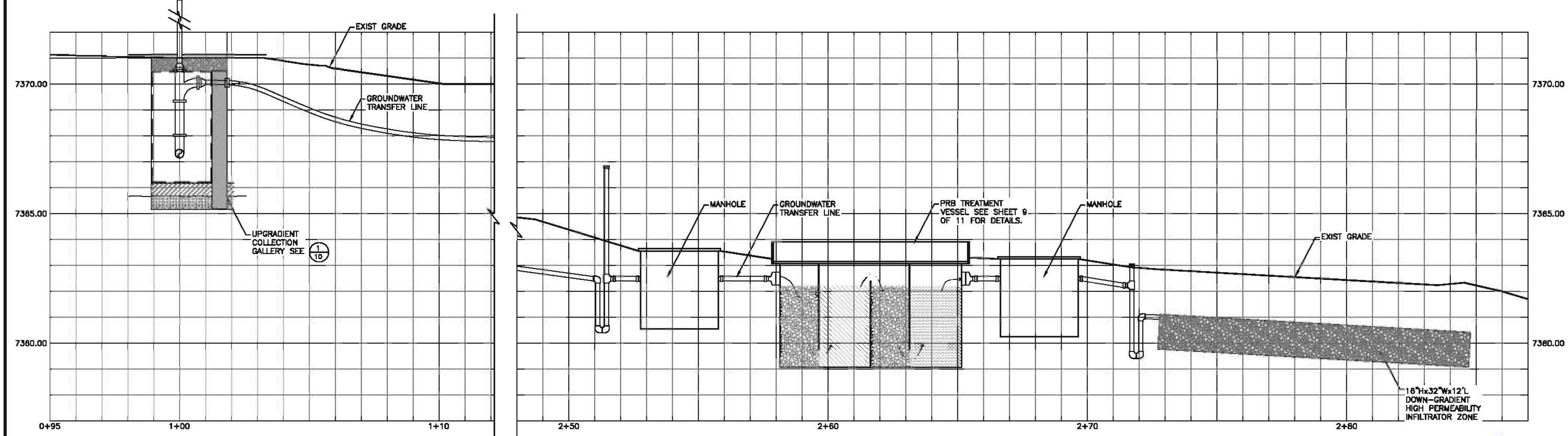

GROUNDWATER TRANSFER LINE PROFILE (1)

HORIZONTAL SCALE: 1"=2'
VERTICAL SCALE: 1"=2'

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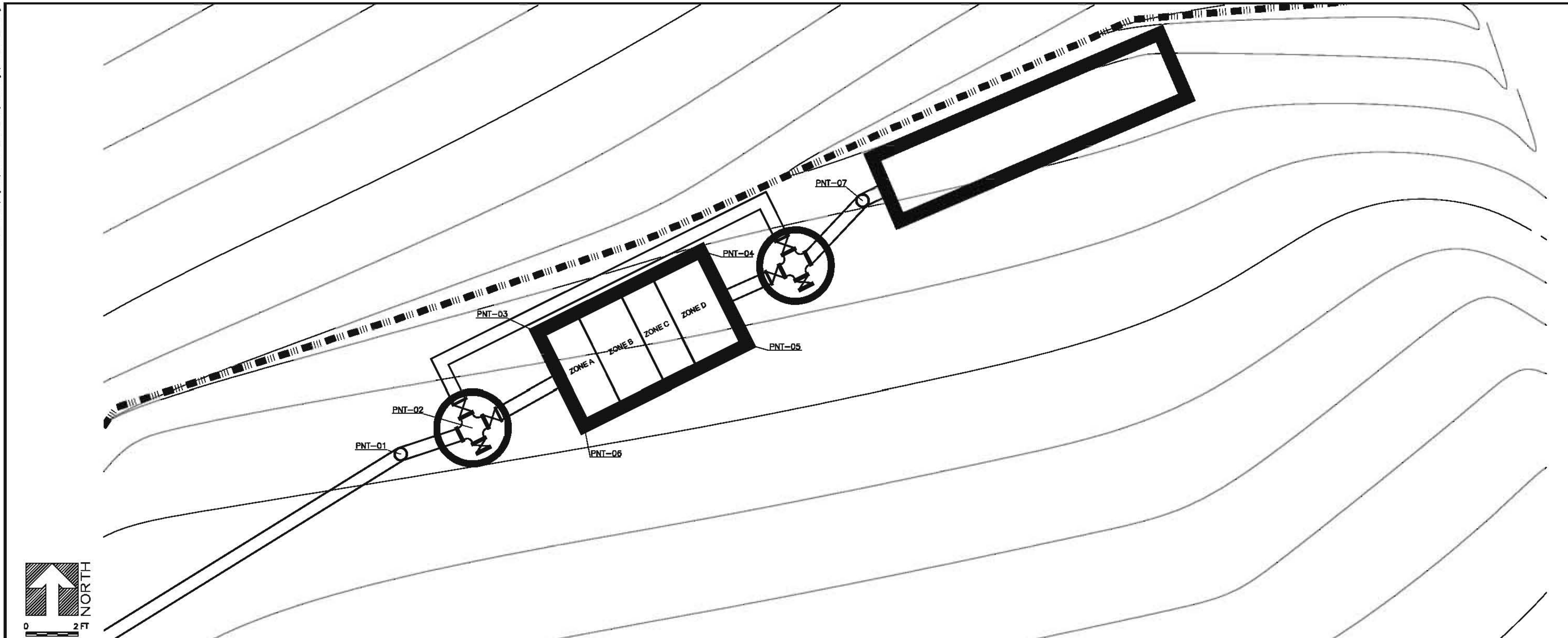
GROUNDWATER TRANSFER LINE PLAN AND PROFILE

DRAWING NO. 81002-PRB-001
Sheet 7 of 11



Pipe Diameter, Velocity, Flowrate Calculations

Q = flowrate (gpm)
v = velocity (ft/sec)
A = cross sectional area (ft^2)
D = pipe diameter (ft)
P = pressure (atmospheres)
H = elevation head (ft)
g = gravitational constant = 32.2 ft/sec^2

Groundwater Transfer Line

Assumptions: (1) Fluid is water (incompressible)
(2) Fluid is inviscid (because travel distance is short, viscosity effect is negligible)
(3) Flow is steady state
(4) Flow is along stream line
(5) P_2 and P_1 are atmospheric pressure
(6) $V_1=0$, due to $A_1 >> A_2$

A_1 = diversion wall capture area
A_2 = 2" I.D. pipe

Bernoulli Equation: $$\frac{V_1^2}{2g} + \frac{P_1}{\gamma} + Z_1 = \frac{V_2^2}{2g} + \frac{P_2}{\gamma} + Z_2$$

since $P_1 = P_2 = 0$, and $V_1^2 = 0$

$$\frac{V_2^2}{2g} = Z_1 - Z_2 = H = 4 \text{ ft}$$

$$V_2 = \sqrt{2gH} = \sqrt{2\,(32.2\ ft/sec^2)\,(4\ ft)}$$

V_2 = 16 ft/sec

Check Pipe Diameter

Given: Q = 0.1 gpm
Q = vA

Find minimum cross sectional pipe area A

$$A = \frac{Q}{v} = \frac{0.1\ gpm}{16\ ft/sec}\left(\frac{ft^3}{7.48\ gal}\right)\left(\frac{1\ min}{60\ sec}\right)$$

$A = 1.4 \times 10^{-5}$ ft << 2 inch
Therefore 2" I.D. pipe is ok

Pipe Diameter, Velocity, Flowrate Calculations

Zone	Media	Volume (ft^3)	Ks (ft/day)	High Flowrate - Q (gpm)	Actual Residence Time Tr (hrs)	Minimum Design Residence Time Tr (hrs)
A	3/ 8" pea gravel	18	250	0.1	22.4	N/A
B	ZV1/sand	25	200	0.1	29.9	8.7
C	3/ 8" pea gravel	18	250	0.1	22.4	N/A
D	Zeolite	25	150	0.1	29.9	6.0

Contaminant Removal Residence Time

Contaminant	Maximum Expected Concentration (ug/L)	NMED Treatment Goal (ug/L)	Half Life (hrs)		Number of Half Lifes to Reach NMED Goal	Minimum Residence Time, Tr_{min} (hrs)	Minimum Design Residence Time Tr (hrs)	Factor of Safety (F.S.)	Design Residence Time Tr (hrs)
			RDX	Barium					
RDX	27	6.1	1	-	4.43	22.4	4.43	2	8.7
Barium	18,000	1,000	-	0.17	16	29.8	3.0	2	6.0

POINT	NORTHING	EASTING	ELEVATION	REMARKS
PNT-01	1764477.779	1615271.512	7366.829	TOP CASING
PNT-02	1764478.777	1615274.268	7363.558	MANHOLE
PNT-03	1764482.553	1615276.49	7363.967	NW CORNER VESSEL
PNT-04	1764485.843	1615283.123	7363.984	NE CORNER VESSEL
PNT-05	1764481.891	1615285.075	7363.873	SE CORNER VESSEL
PNT-06	1764478.551	1615278.46	7363.814	SW CORNER VESSEL
PNT-07	1764487.487	1615289.238	7363.049	TOP CASING

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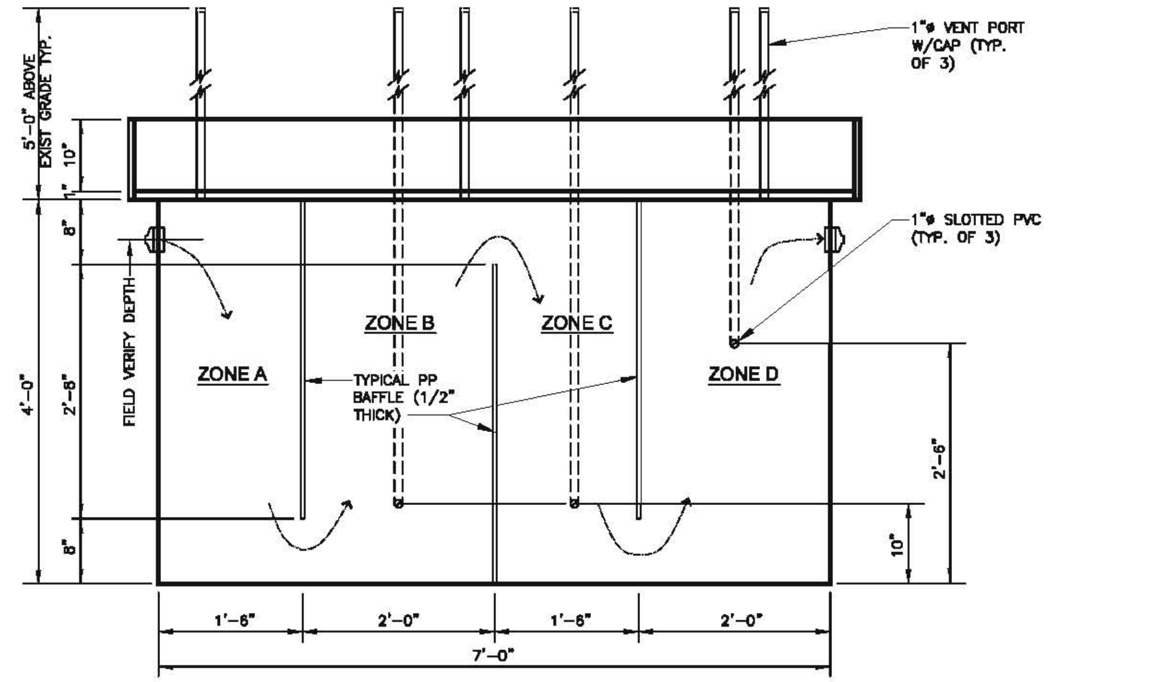
CORRECTIVE MEASURES IMPLEMENTATION
CONSOLIDATED UNIT 16-021(c)-99
CAÑON DE VALLE/MARTIN SPRING CANYON PPRB

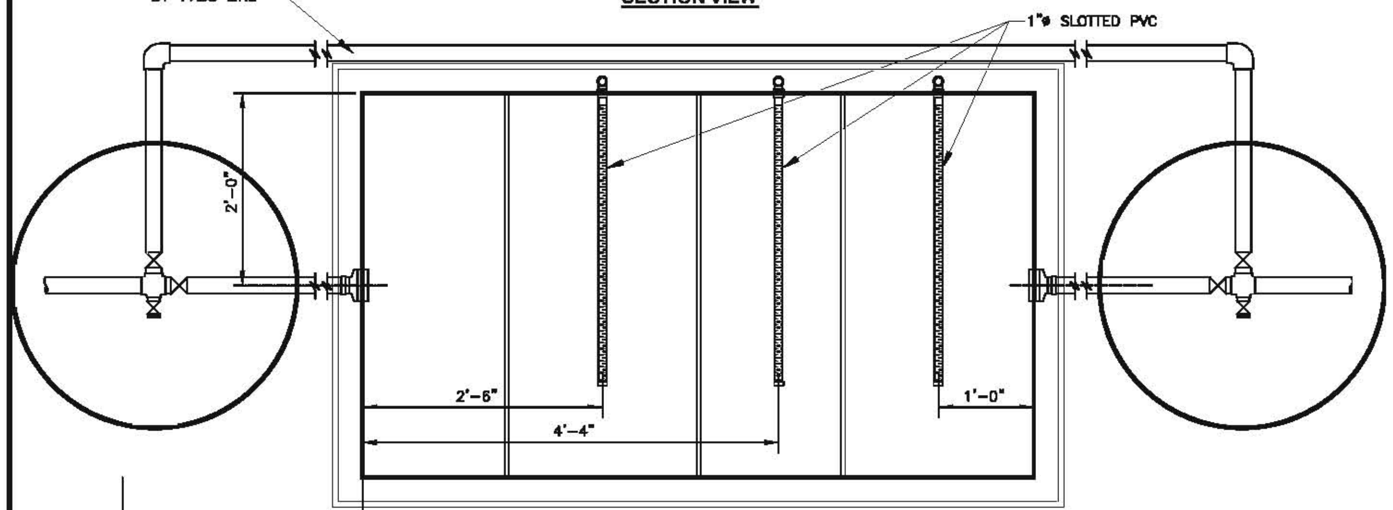
PRB VESSEL LOCATION PLAN

DRAWING NO.
81002-PRB-001
Sheet 8 of 11

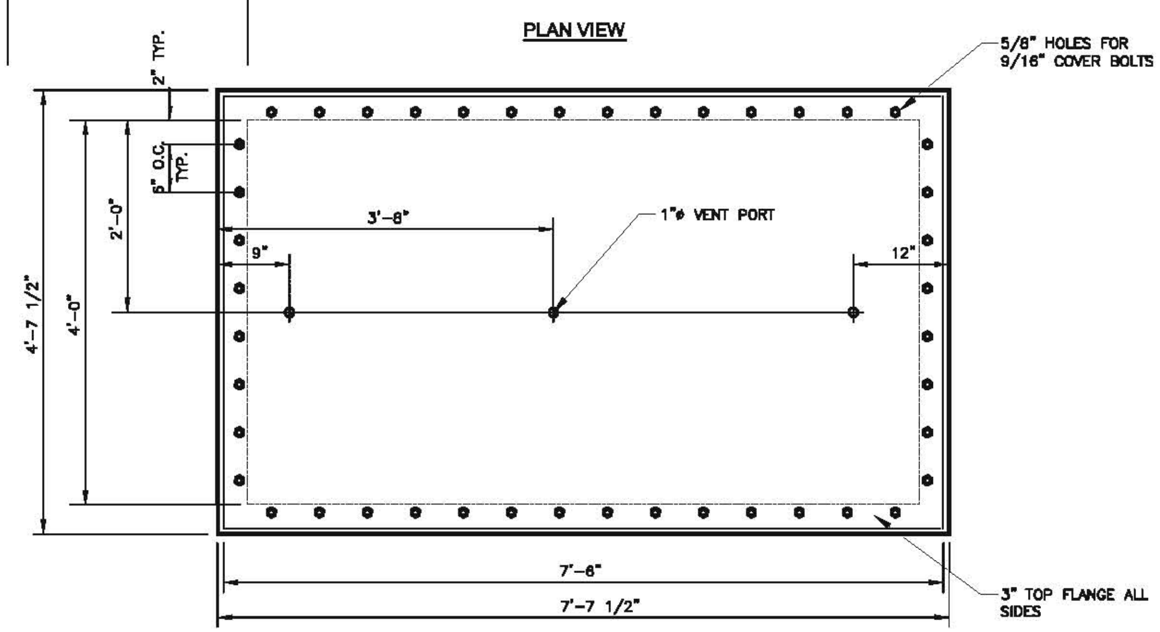
FILE NAME: S:\Projects\ES09.0185_TMPC_PRB\VR_Drawings\ES09_0185_D28.dwg



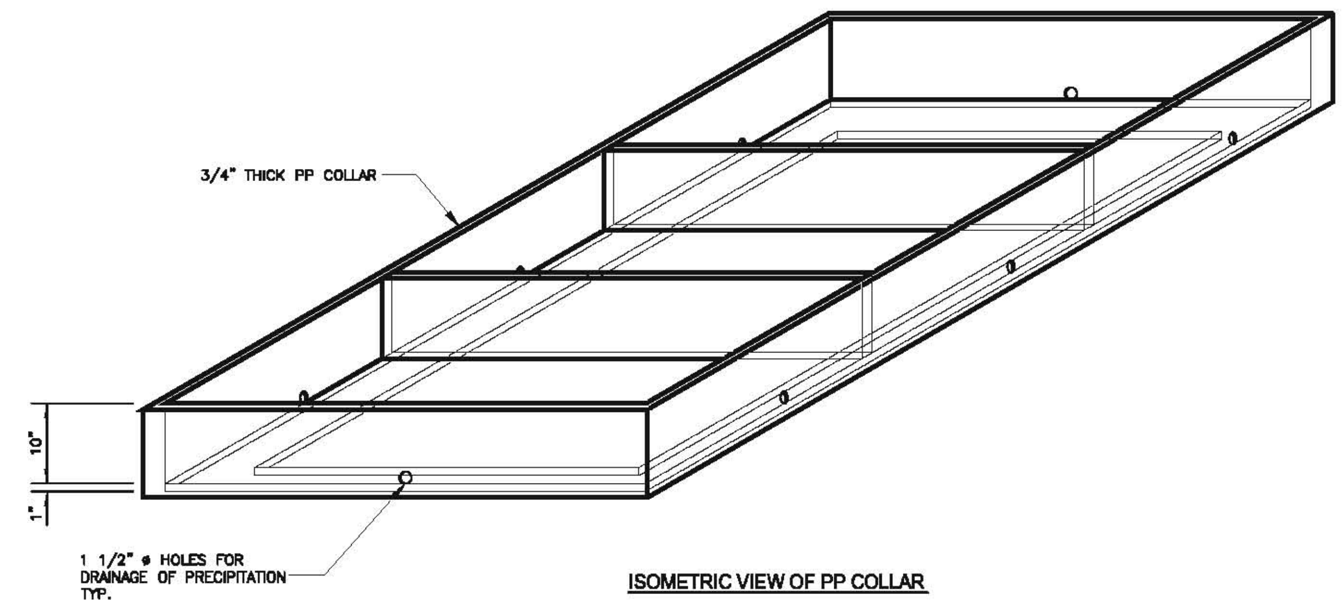
SECTION VIEW



PLAN VIEW



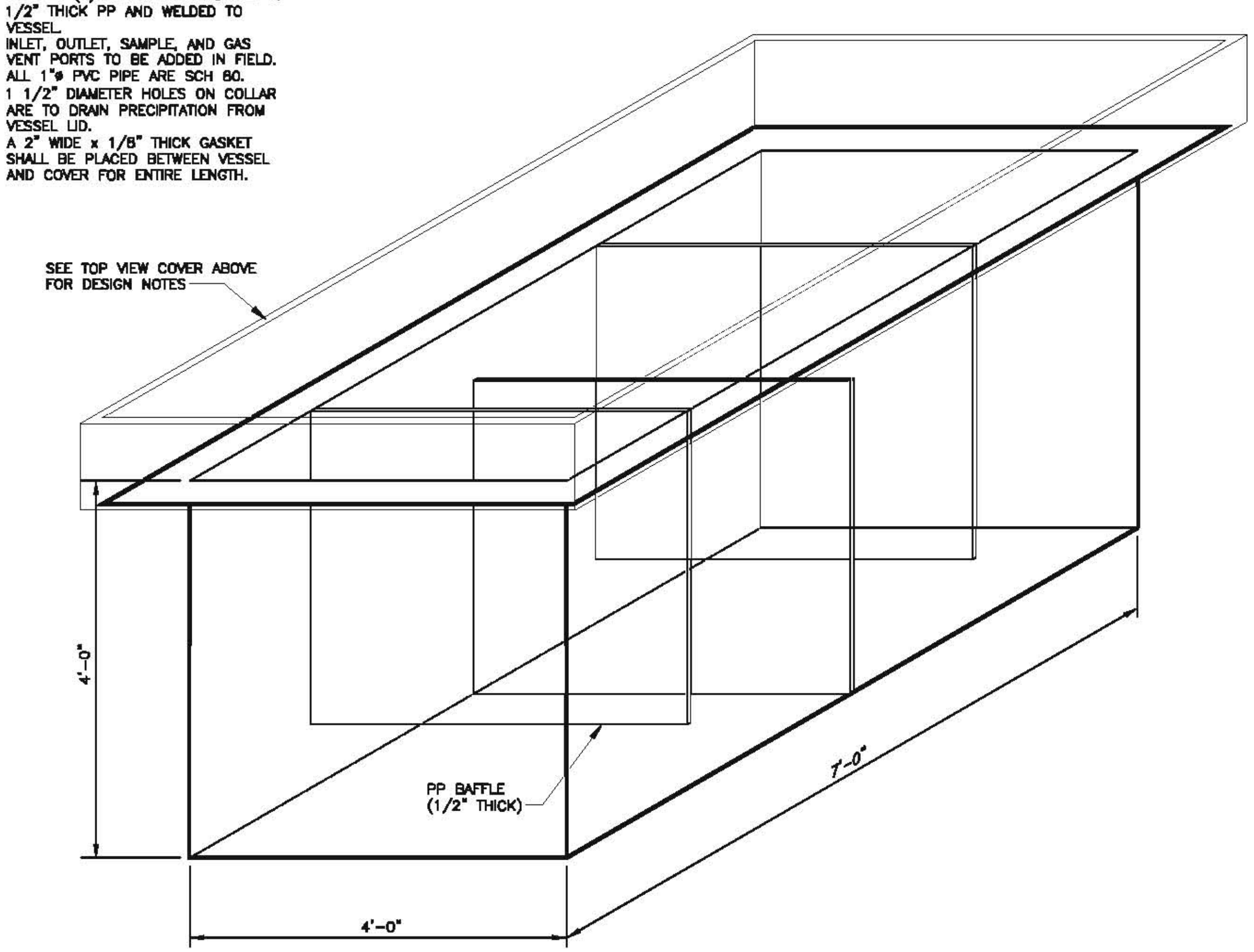
TOP VIEW COVER



ISOMETRIC VIEW OF PP COLLAR

GENERAL NOTES:

1. REACTION CELL CONSTRUCTED OF 1" THICK POLYPROPYLENE.
2. WALL THICKNESS SHALL NOT BE LESS THAN 7/8" THICK.
3. BAFFLES (3) TO BE CONSTRUCTED OF 1/2" THICK PP AND WELDED TO VESSEL.
4. INLET, OUTLET, SAMPLE, AND GAS VENT PORTS TO BE ADDED IN FIELD.
5. ALL 1"ø PVC PIPE ARE SCH 80.
6. 1 1/2" DIAMETER HOLES ON COLLAR ARE TO DRAIN PRECIPITATION FROM VESSEL LID.
7. A 2" WIDE x 1/8" THICK GASKET SHALL BE PLACED BETWEEN VESSEL AND COVER FOR ENTIRE LENGTH.



ISOMETRIC VIEW

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6020 ACADEMY NE, SUITE 100
ALBUQUERQUE, NM 87109
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CORRECTIVE MEASURES IMPLEMENTATION
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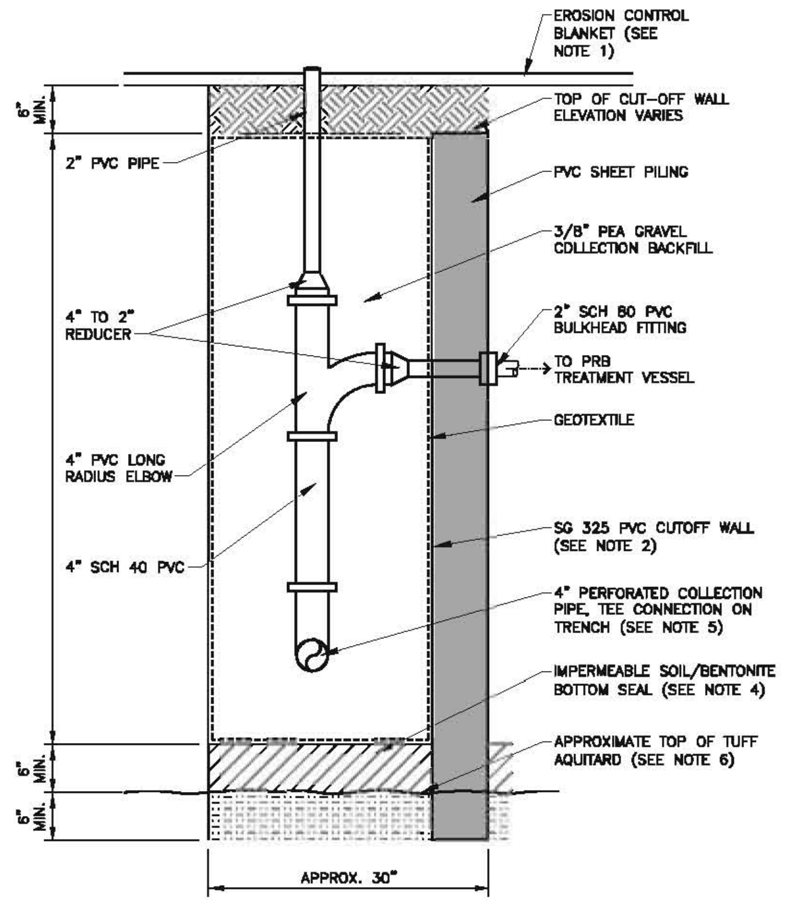
CAÑON DE VALLE/MARTIN SPRING CANYON PPRB

PERMEABLE REACTIVE BARRIER TREATMENT VESSEL DETAILS

DRAWING NO.
81002-PRB-001
Sheet 9 of 11

TerranearPMC

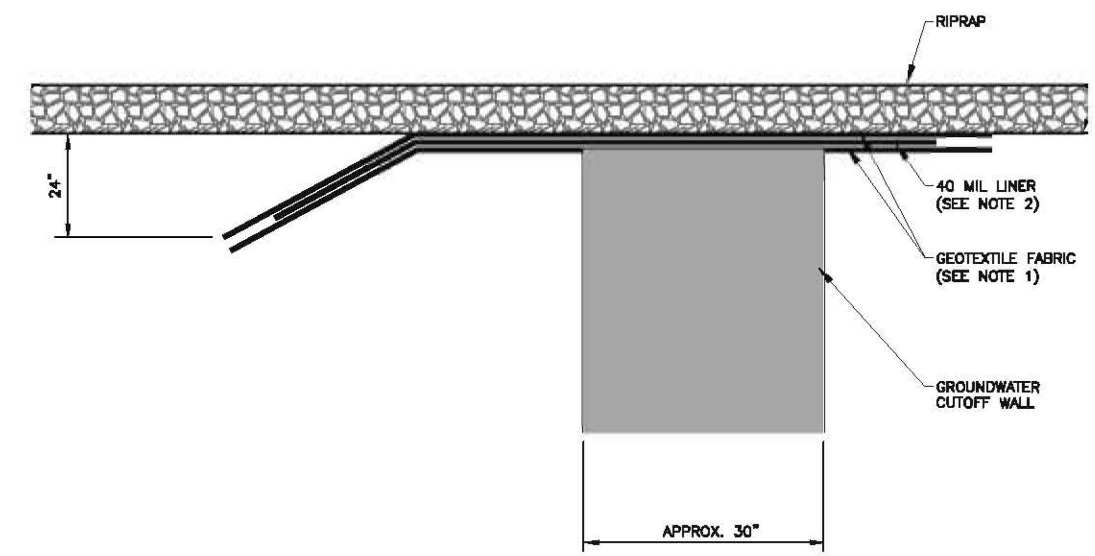
XREF: none



CONSTRUCTION NOTES:

1. INSTALL EROSION CONTROL BLANKET (SEE SPECIFICATION 32-7200) ON GROUND SURFACE OF CUTOFF WALL, EXCEPT AT STREAM CROSSING.
2. INTERLOCKING PVC SHEET PILES (SEE SPECIFICATION NOTE 1 ON SHEET 2 OF 11).
3. SEPARATION GEOTEXTILE (SEE SPECIFICATION NOTE 3 ON SHEET 2 OF 11).
4. SOIL-BENTONITE BOTTOM SEAL COMPOSED OF A MINIMUM OF 20% (BY VOLUME) BENTONITE, 80% SOIL (SEE SPECIFICATION NOTE 2 ON SHEET 2 OF 11). SEAL WILL BE 12" TO 18" INCLUDING 6" MINIMAL KEY INTO TUFF.
5. 4" SCH. 40 PVC PERFORATED UNDER-DRAIN PIPE OR EQUIVALENT. PIPE TO BE FULLY WRAPPED WITH 4" GEOTEXTILE SOCK.
6. TRENCH WILL BE KEYED INTO TUFF MINIMUM 6".
7. ALL ELEVATIONS TO BE FIELD VERIFIED.

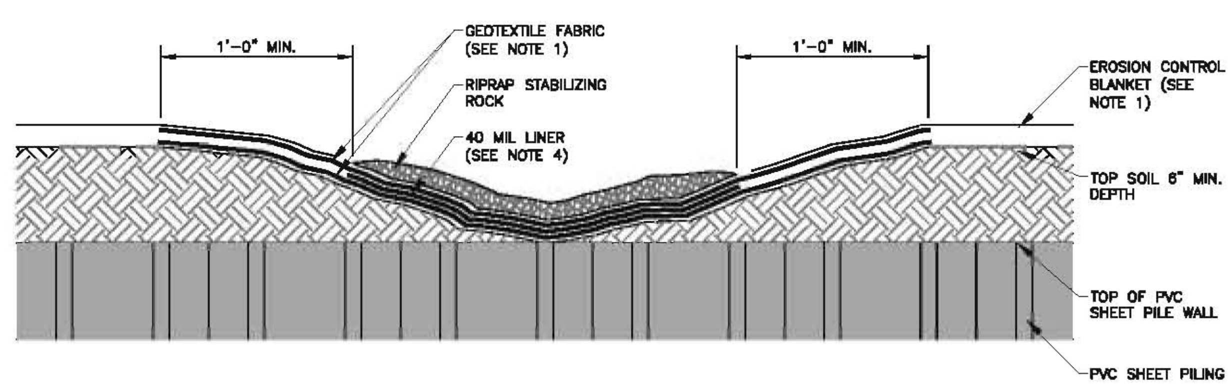
UPGRADIENT COLLECTION GALLERY DETAIL 1/7
NTS



CONSTRUCTION NOTES:

1. SEPARATION GEOTEXTILE (SEE SPECIFICATION NOTE 3 ON SHEET 2 OF 11).
2. 40 MIL THICK HIGH DENSITY POLYETHYLENE (HDPE) IMPERMEABLE LINER.

SECTION AT STREAM CROSSING ABOVE CUT-OFF WALL 2/6
NTS



GENERAL NOTES:

1. GEOTEXTILE FABRIC SHALL BE NON-WOVEN, MINIMUM 6OZ., 100 GAL/FT² MINIMUM WATER FLOW RATE, AOS = 70 US STD. SIEVE.
2. EROSION CONTROL BLANKET OVERLAPPING GEOTEXTILE BY 12" (MIN.).
3. REINFORCED BRAIDED TUBING CONNECTED BOTH ENDS WITH 2" BARB x 2" MALE THREAD SCH 80 PVC FITTINGS. SECURED WITH SS MARINE GRADE 2" HOSE CLAMPS.
4. 40 MIL THICK HIGH DENSITY POLYETHYLENE (HDPE) IMPERMEABLE LINER.

STREAM CHANNEL SECTION AT DIVERSION WALL 3/6
NTS

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CORRECTIVE MEASURES IMPLEMENTATION
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CAÑON DE VALLE/MARTIN SPRING CANYON PPRB

UPGRADIENT COLLECTION GALLERY AND STREAM CROSSING DETAILS

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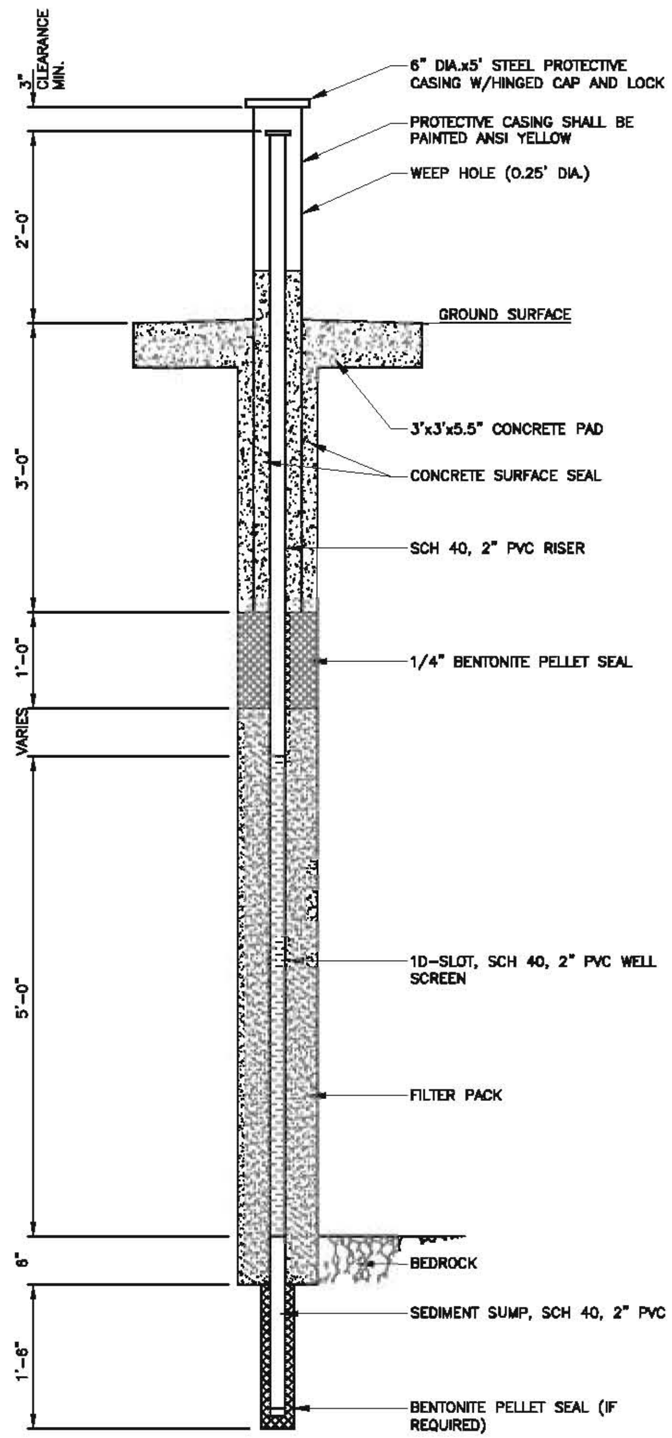
81002-PRB-001
Sheet 10 of 11



MONITORING PIEZOMETER DETAIL (1/–)
NTS

FILE NAME: S:\Projects\ES09.0185_TMPC_PRB\VR_Drawings\ES09_0185_D28.dwg
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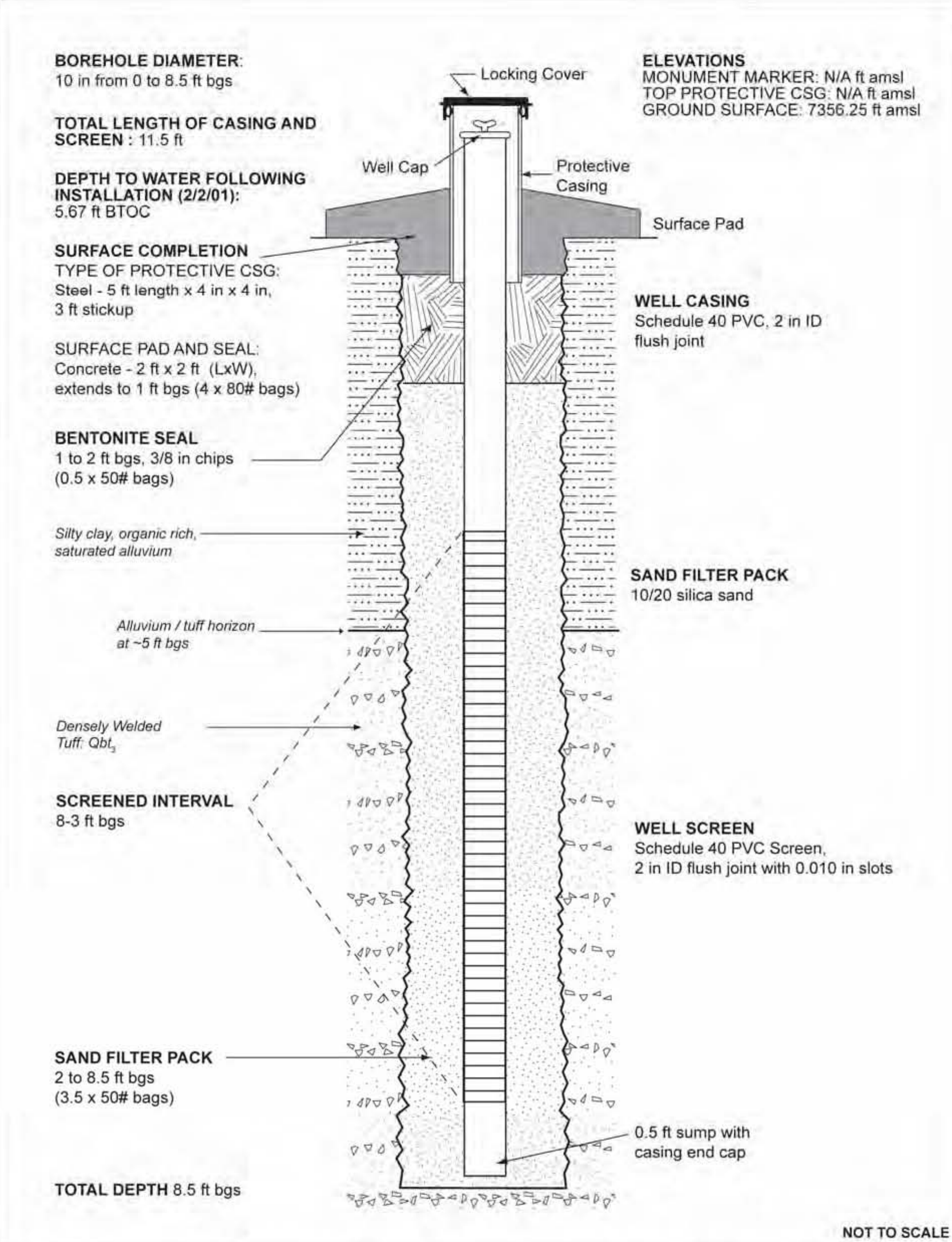
PERMEABLE REACTIVE BARRIER MONITORING DETAILS

TerranearPMC

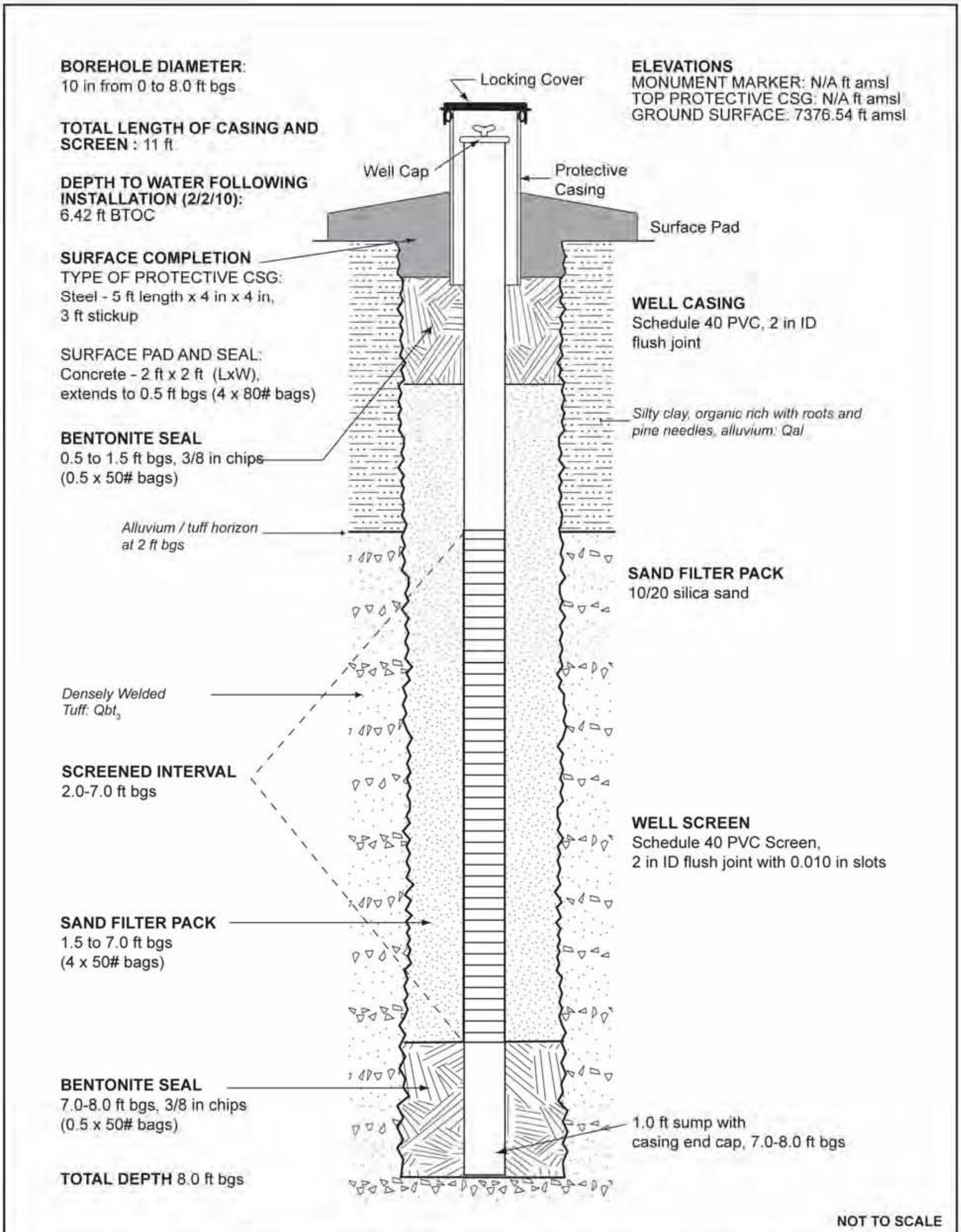
DRAWING NO.
81002-PRB-001
Sheet 11 of 11

Appendix G

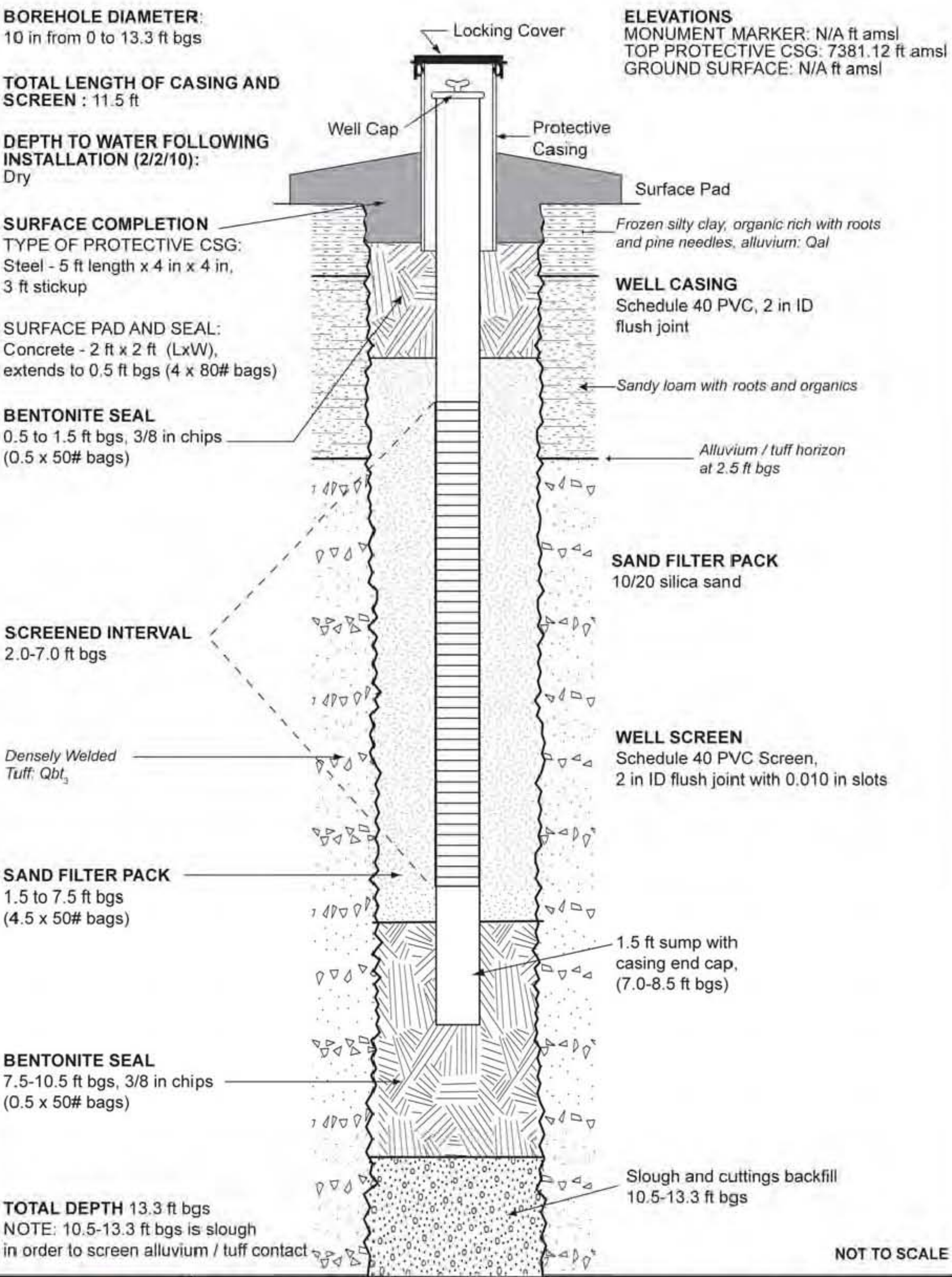
Alluvial Monitoring Well Construction Diagrams and Lithologic Logs



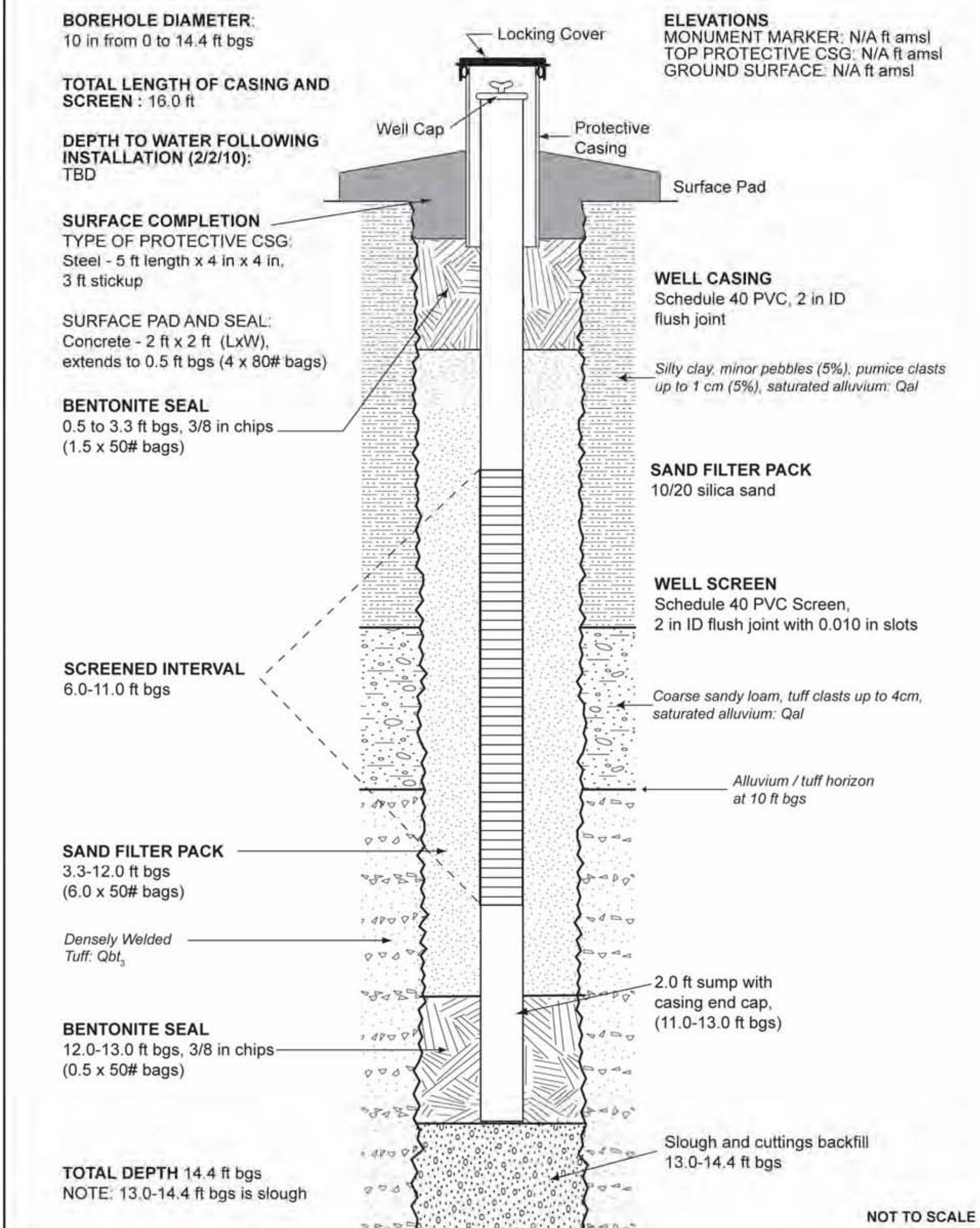
TerranearPMC	Drafted By: A. Stocker	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-1
	Date: February 8, 2010	Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



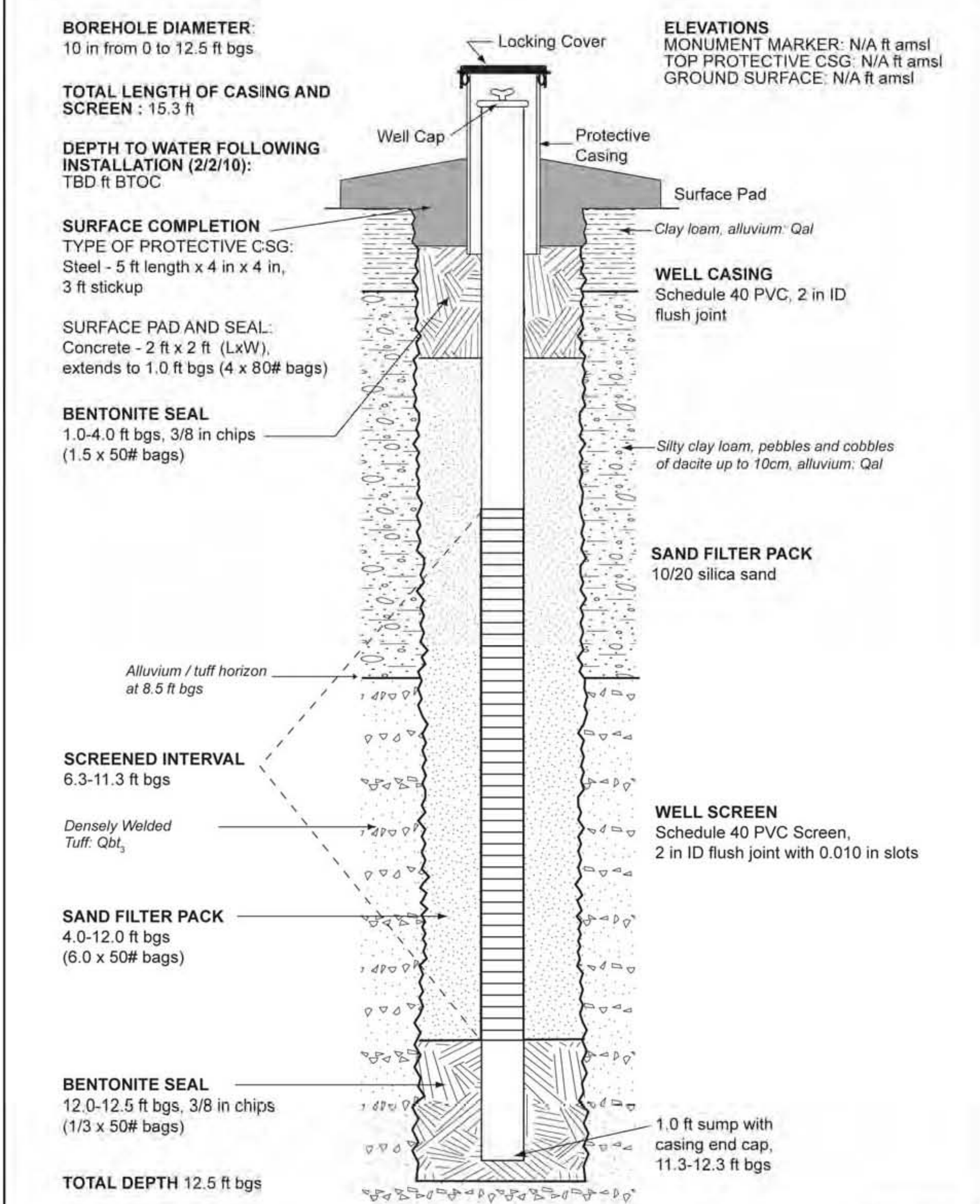
TerranearPMC	Drafted By: A. Stocker Date: February 8, 2010	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-2 Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



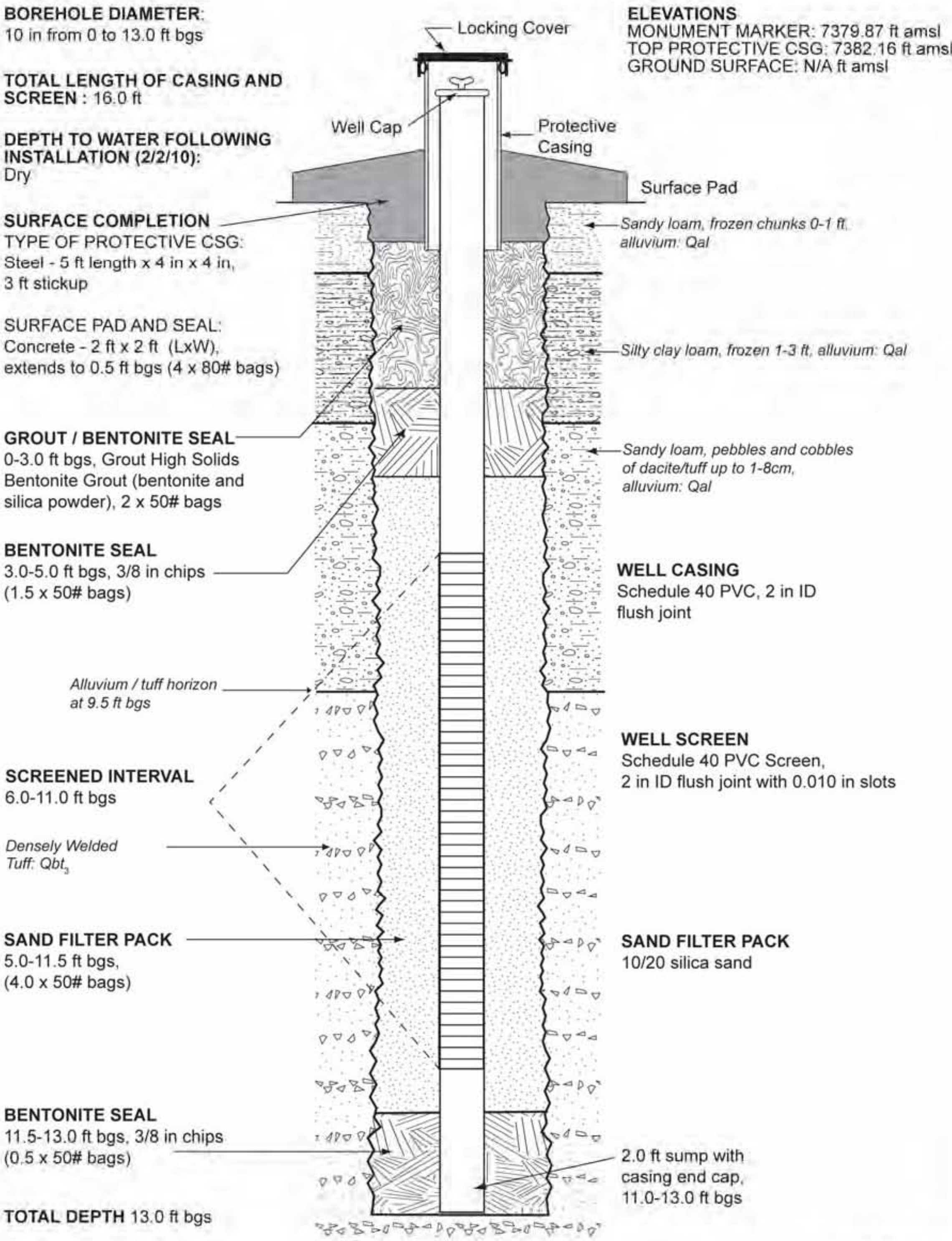
TerranearPMC	Drafted By: A. Stocker	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-3
	Date: February 9, 2010	Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



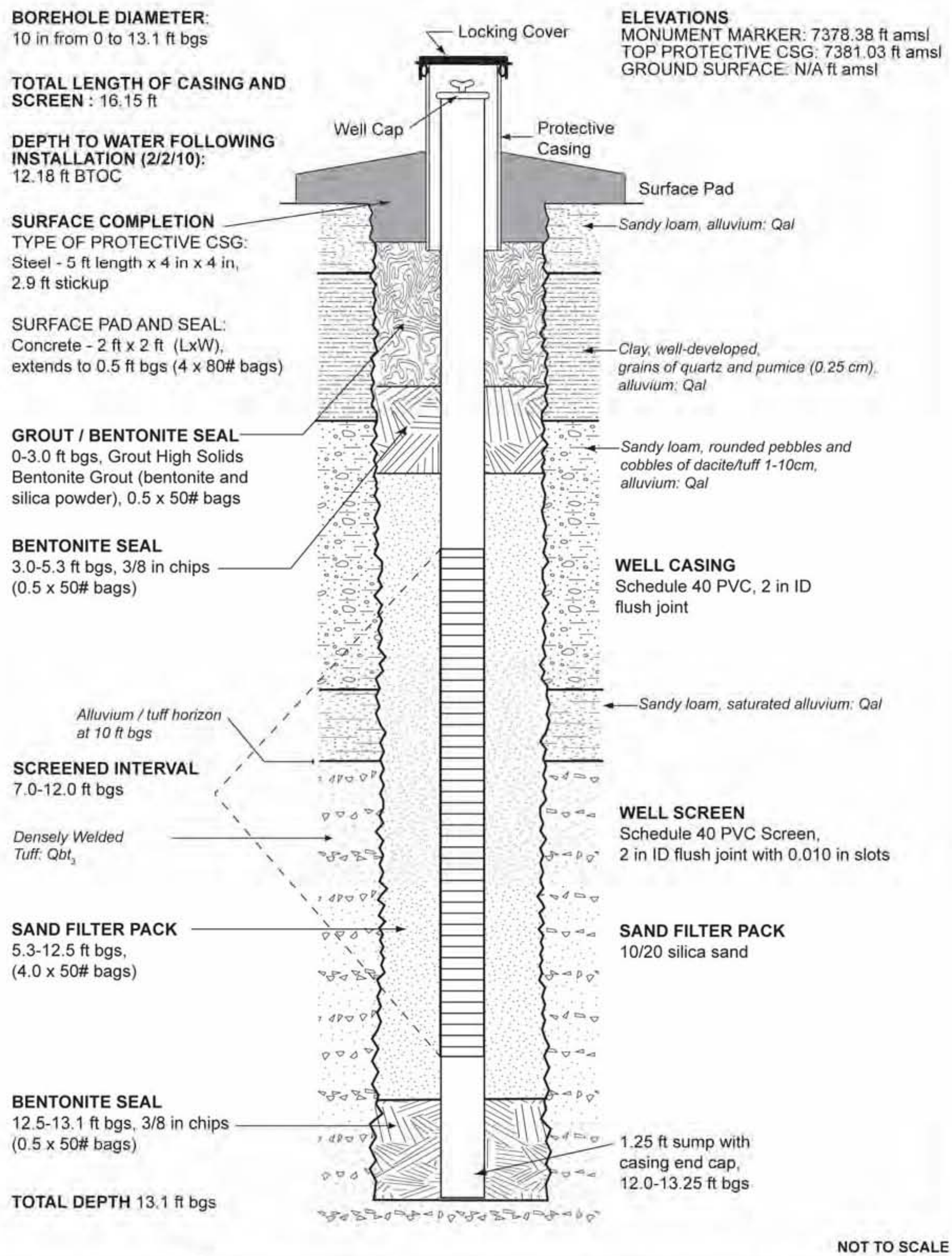
TerranearPMC	Drafted By: A. Stocker	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-4
	Date: February 9, 2010	Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



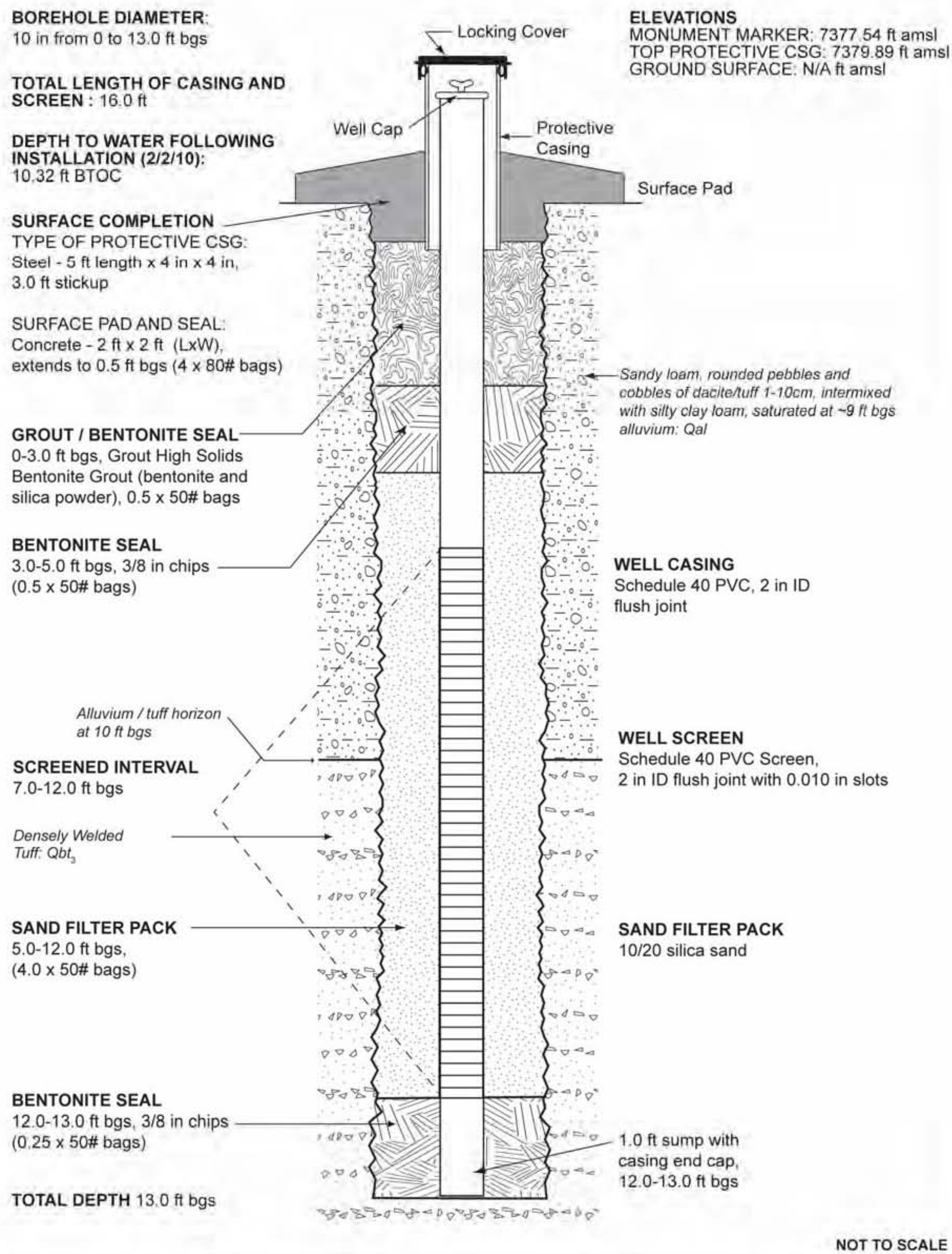
TerranearPMC	Drafted By: A. Stocker	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-5
	Date: February 8, 2010	Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



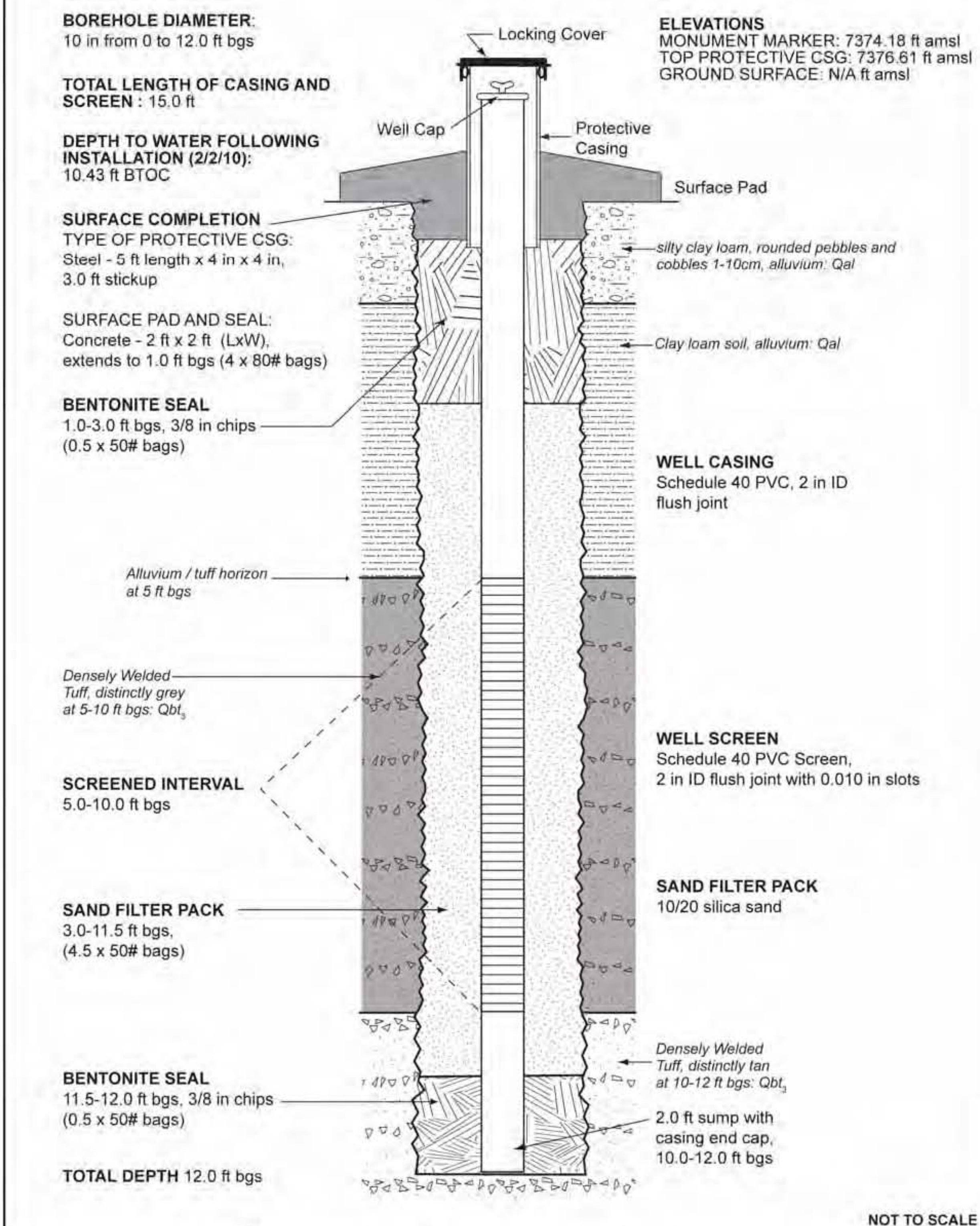
TerranearPMC	Drafted By: A. Stocker Date: February 8, 2010	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-6 Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



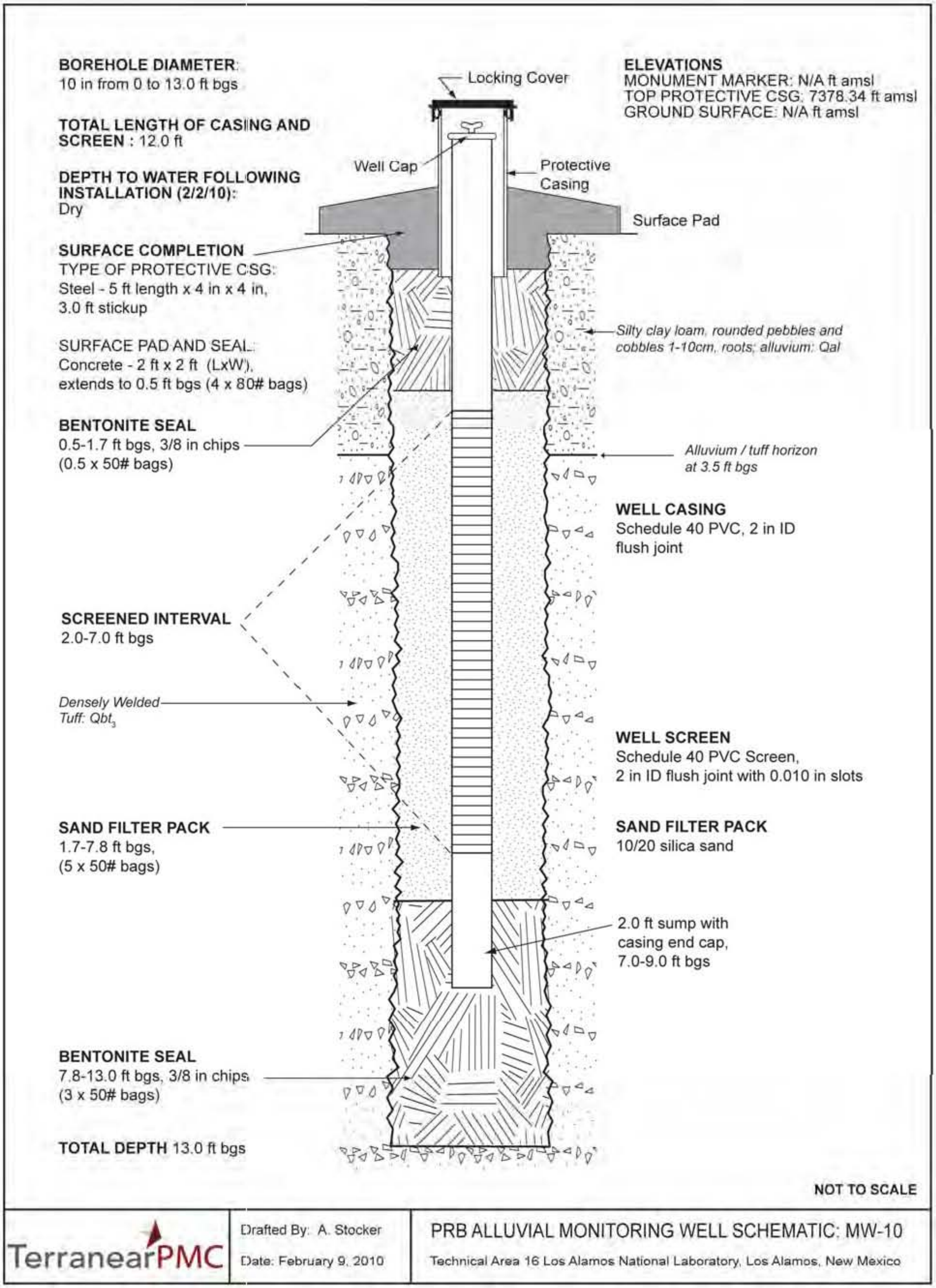
TerranearPMC	Drafted By: A. Stocker	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-7
	Date: February 9, 2010	Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico

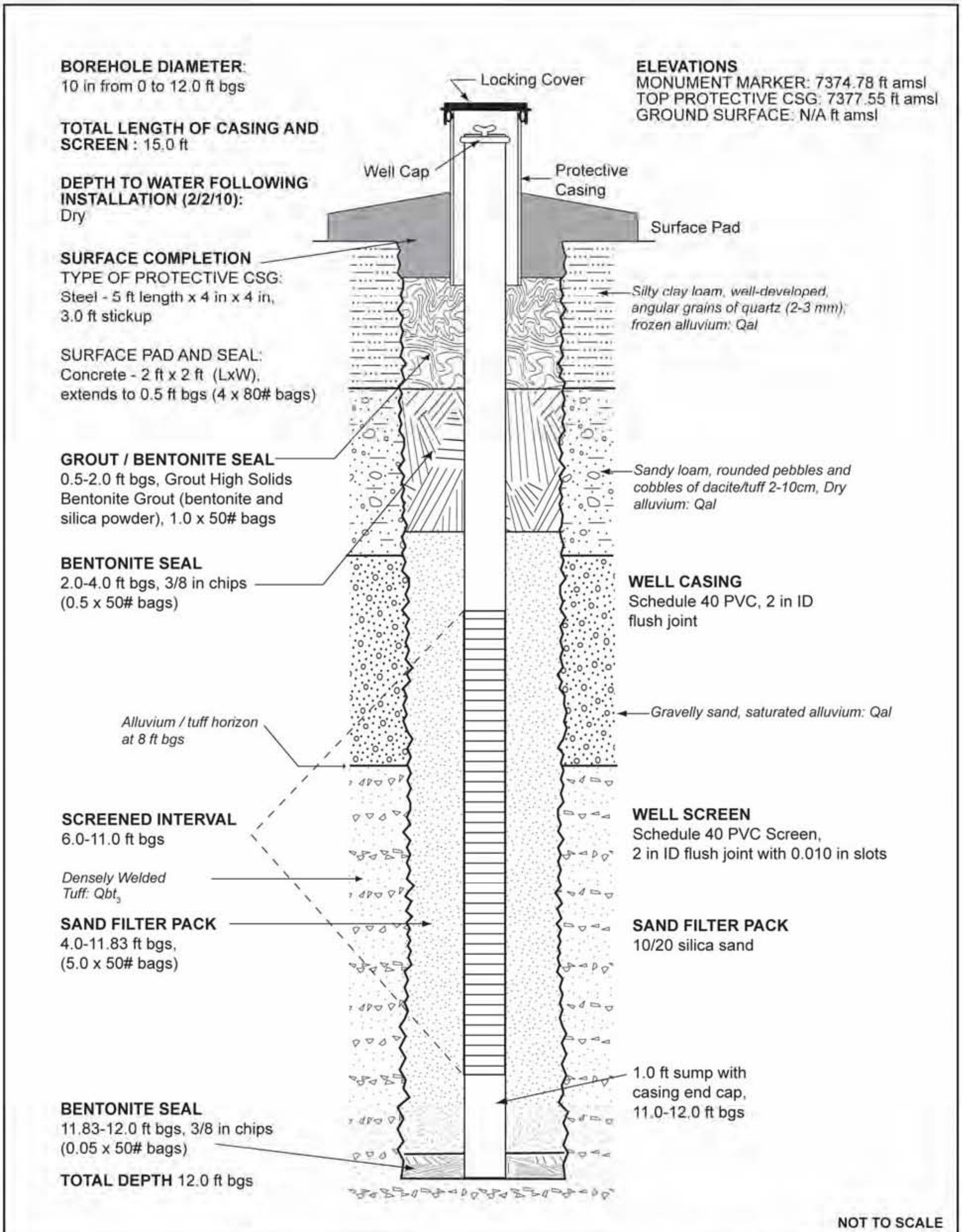


TerranearPMC	Drafted By: A. Stocker	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-8
	Date: February 9, 2010	Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



TerranearPMC	Drafted By: A. Stocker Date: February 9, 2010	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-9 Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico


BOREHOLE DIAMETER:
10 in from 0 to 13.0 ft bgs
TOTAL LENGTH OF CASING AND SCREEN : 12.0 ft
DEPTH TO WATER FOLLOWING INSTALLATION (2/2/10):
Dry
SURFACE COMPLETION
TYPE OF PROTECTIVE CSG:
Steel - 5 ft length x 4 in x 4 in,
3.0 ft stickup
SURFACE PAD AND SEAL:
Concrete - 2 ft x 2 ft (LxW),
extends to 0.5 ft bgs (4 x 80# bags)
BENTONITE SEAL
0.5-1.7 ft bgs, 3/8 in chips
(0.5 x 50# bags)
SCREENED INTERVAL
2.0-7.0 ft bgs
Densely Welded Tuff: Qbt3
SAND FILTER PACK
1.7-7.8 ft bgs,
(5 x 50# bags)
BENTONITE SEAL
7.8-13.0 ft bgs, 3/8 in chips
(3 x 50# bags)
TOTAL DEPTH 13.0 ft bgs
Locking Cover
Well Cap
Protective Casing
Surface Pad
ELEVATIONS
MONUMENT MARKER: N/A ft amsl
TOP PROTECTIVE CSG: 7378.34 ft amsl
GROUND SURFACE: N/A ft amsl
Silty clay loam, rounded pebbles and cobbles 1-10cm, roots; alluvium: Qal
Alluvium / tuff horizon at 3.5 ft bgs
WELL CASING
Schedule 40 PVC, 2 in ID
flush joint
WELL SCREEN
Schedule 40 PVC Screen,
2 in ID flush joint with 0.010 in slots
SAND FILTER PACK
10/20 silica sand
2.0 ft sump with
casing end cap,
7.0-9.0 ft bgs
NOT TO SCALE
TerranearPMC
Drafted By: A. Stocker
Date: February 9, 2010
PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-10
Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



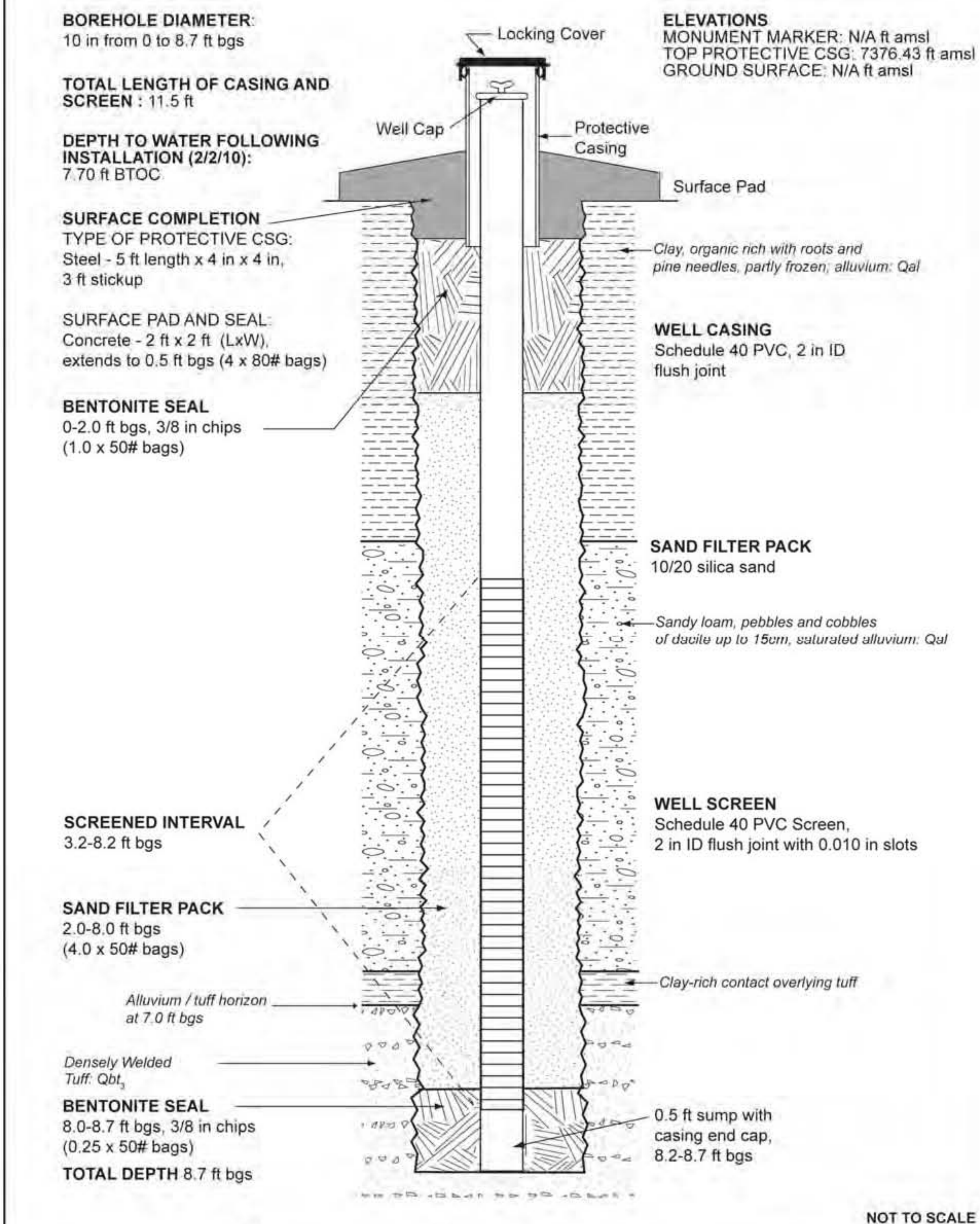
TerranearPMC

Drafted By: A. Stocker

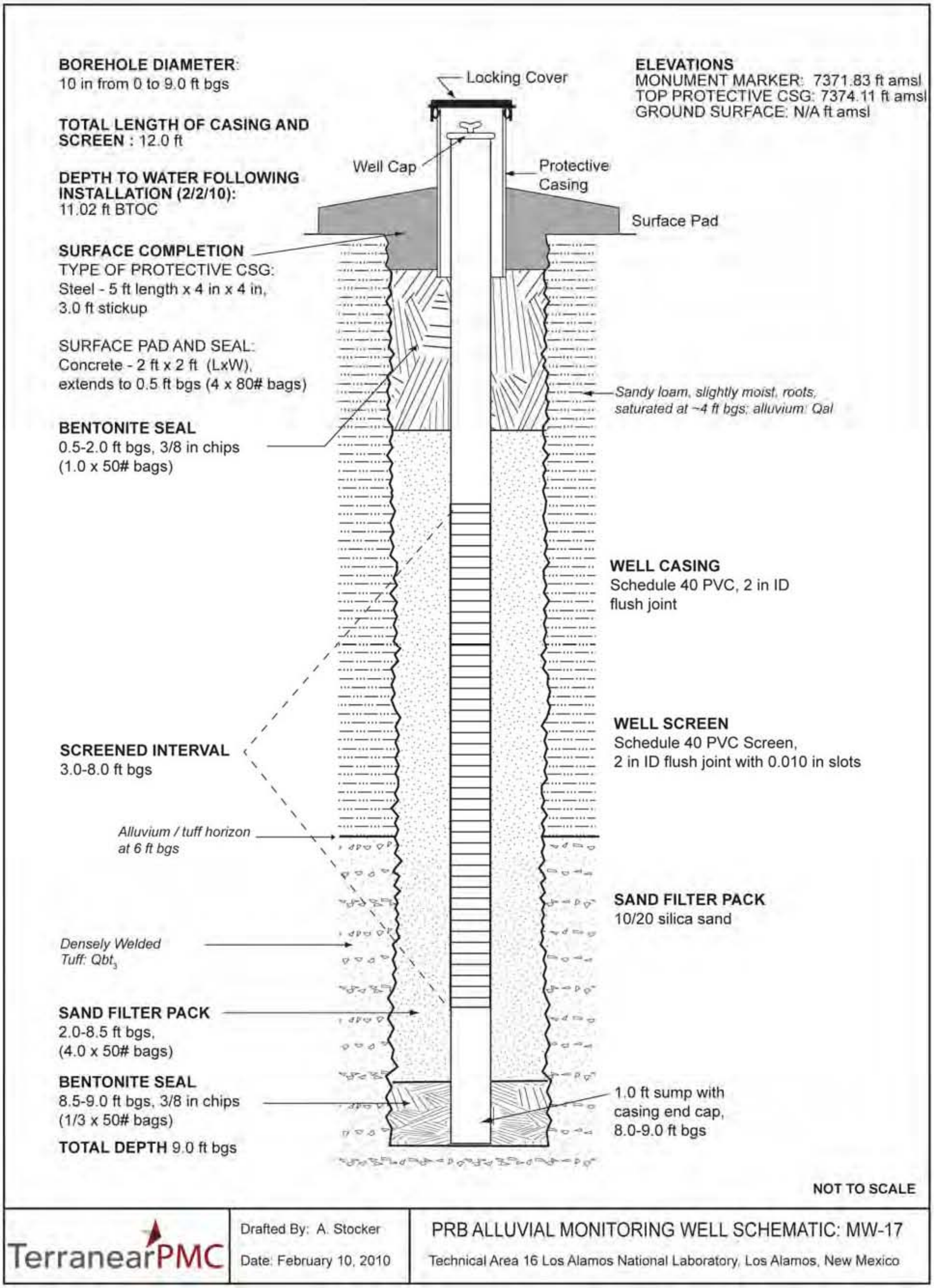
Date: February 9, 2010

PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-11

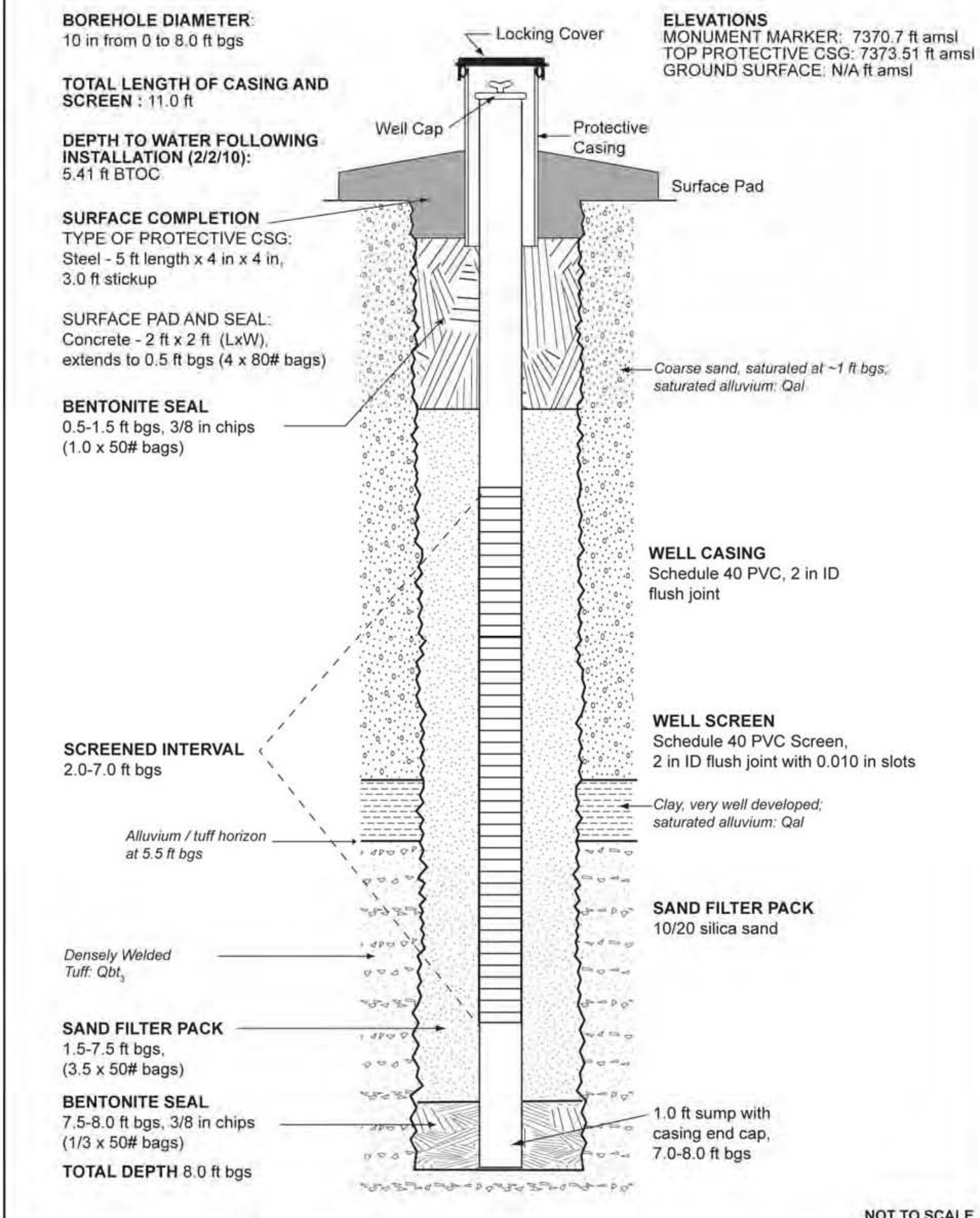
Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



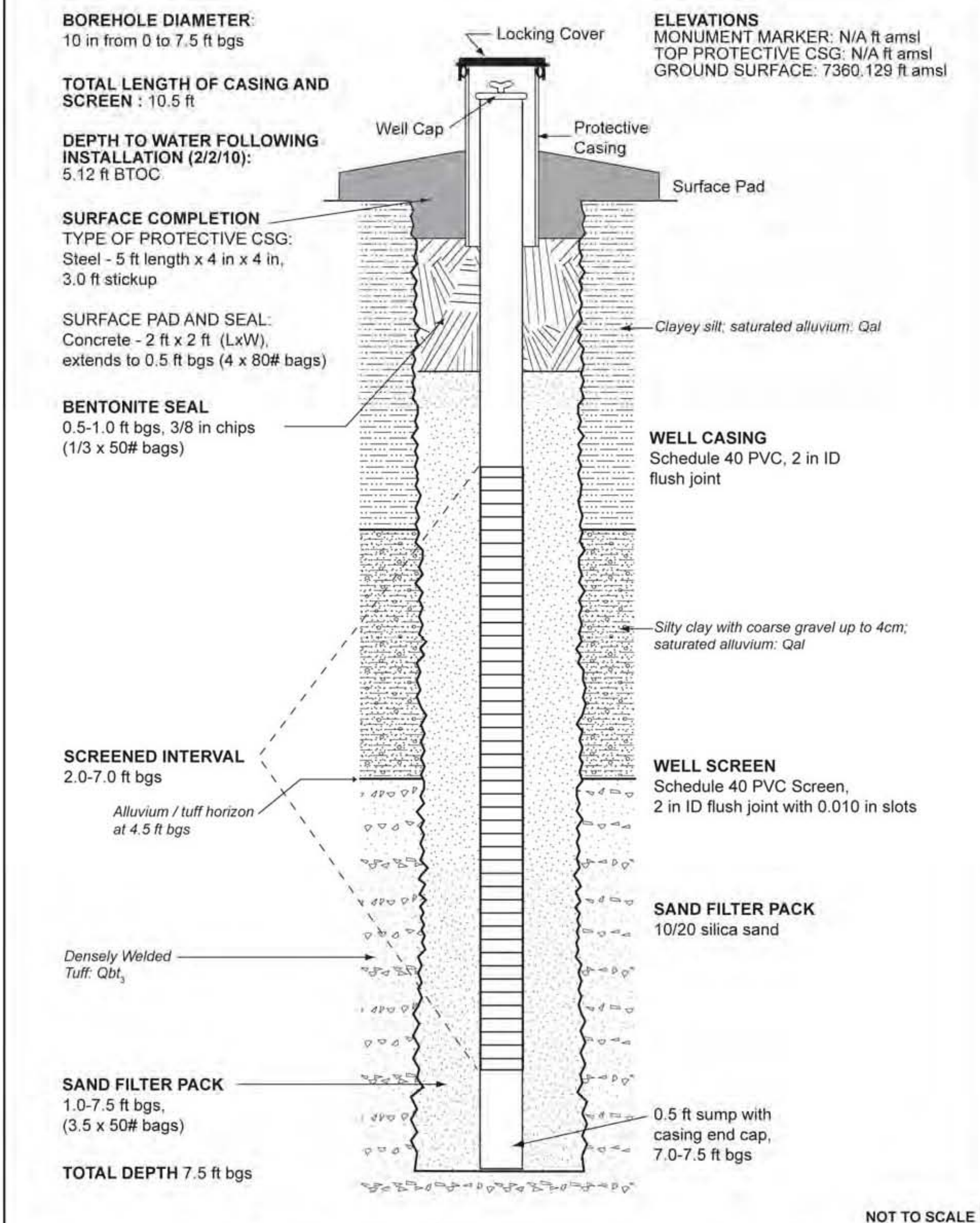
TerranearPMC	Drafted By: A. Stocker Date: February 10, 2010	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-12 Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



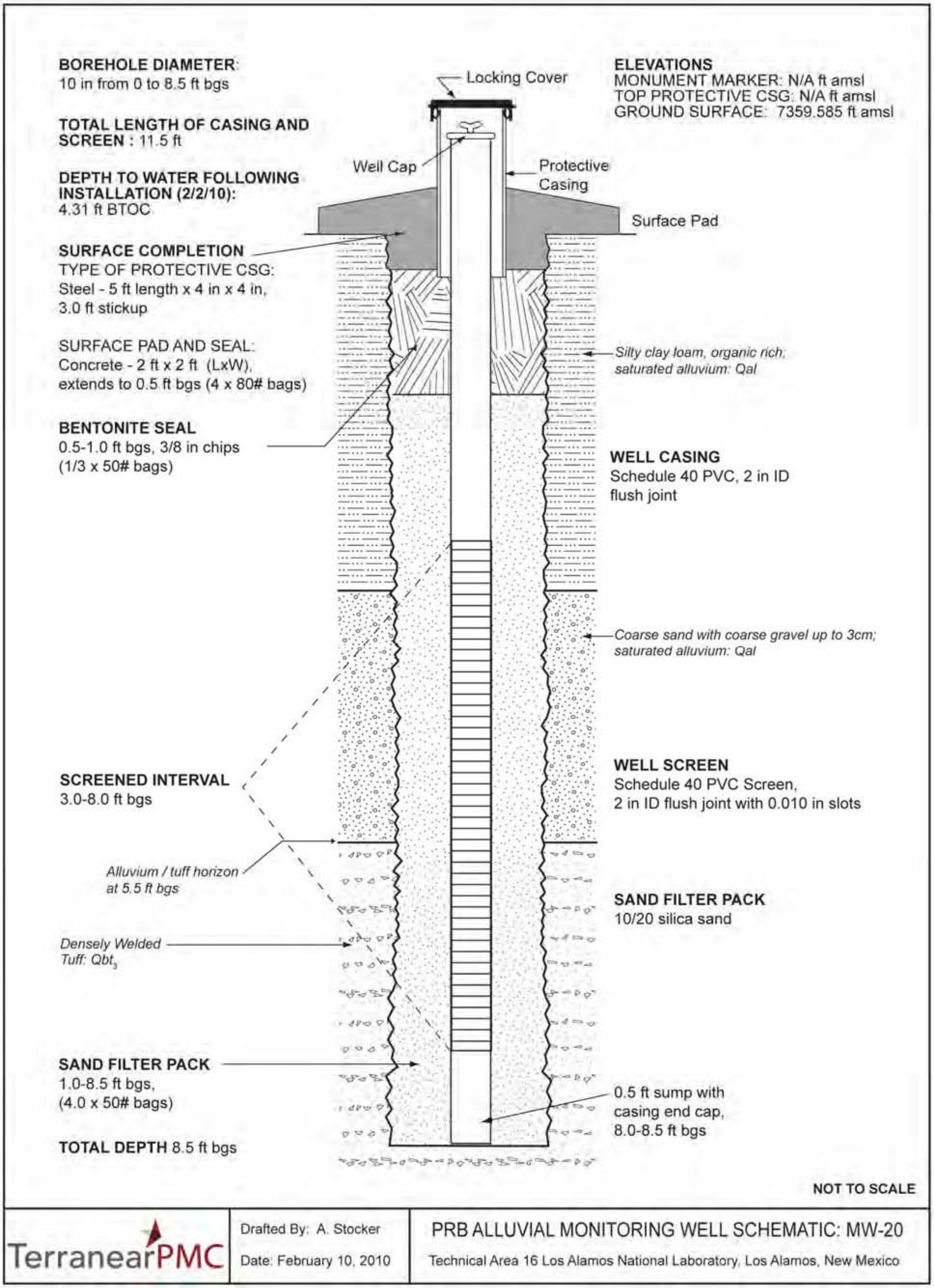
BOREHOLE DIAMETER:
10 in from 0 to 9.0 ft bgs
TOTAL LENGTH OF CASING AND SCREEN : 12.0 ft
DEPTH TO WATER FOLLOWING INSTALLATION (2/2/10):
11.02 ft BTOC
SURFACE COMPLETION
TYPE OF PROTECTIVE CSG:
Steel - 5 ft length x 4 in x 4 in,
3.0 ft stickup
SURFACE PAD AND SEAL:
Concrete - 2 ft x 2 ft (LxW),
extends to 0.5 ft bgs (4 x 80# bags)
BENTONITE SEAL
0.5-2.0 ft bgs, 3/8 in chips
(1.0 x 50# bags)
SCREENED INTERVAL
3.0-8.0 ft bgs
Alluvium / tuff horizon at 6 ft bgs
Densely Welded Tuff: Qbt3
SAND FILTER PACK
2.0-8.5 ft bgs,
(4.0 x 50# bags)
BENTONITE SEAL
8.5-9.0 ft bgs, 3/8 in chips
(1/3 x 50# bags)
TOTAL DEPTH 9.0 ft bgs
Locking Cover
Well Cap
Protective Casing
Surface Pad
ELEVATIONS
MONUMENT MARKER: 7371.83 ft amsl
TOP PROTECTIVE CSG: 7374.11 ft amsl
GROUND SURFACE: N/A ft amsl
Sandy loam, slightly moist, roots, saturated at ~4 ft bgs; alluvium: Qal
WELL CASING
Schedule 40 PVC, 2 in ID
flush joint
WELL SCREEN
Schedule 40 PVC Screen,
2 in ID flush joint with 0.010 in slots
SAND FILTER PACK
10/20 silica sand
1.0 ft sump with casing end cap, 8.0-9.0 ft bgs
NOT TO SCALE
TerranearPMC
Drafted By: A. Stocker
Date: February 10, 2010
PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-17
Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



TerranearPMC	Drafted By: A. Stocker Date: February 10, 2010	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-18 Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico



TerranearPMC	Drafted By: A. Stocker	PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-19
	Date: February 10, 2010	Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico


BOREHOLE DIAMETER:
10 in from 0 to 8.5 ft bgs
TOTAL LENGTH OF CASING AND SCREEN : 11.5 ft
DEPTH TO WATER FOLLOWING INSTALLATION (2/2/10):
4.31 ft BTOC
SURFACE COMPLETION
TYPE OF PROTECTIVE CSG:
Steel - 5 ft length x 4 in x 4 in,
3.0 ft stickup
SURFACE PAD AND SEAL:
Concrete - 2 ft x 2 ft (LxW),
extends to 0.5 ft bgs (4 x 80# bags)
BENTONITE SEAL
0.5-1.0 ft bgs, 3/8 in chips
(1/3 x 50# bags)
SCREENED INTERVAL
3.0-8.0 ft bgs
Alluvium / tuff horizon at 5.5 ft bgs
Densely Welded Tuff: Qbt3
SAND FILTER PACK
1.0-8.5 ft bgs,
(4.0 x 50# bags)
TOTAL DEPTH 8.5 ft bgs
Locking Cover
Well Cap
Protective Casing
ELEVATIONS
MONUMENT MARKER: N/A ft amsl
TOP PROTECTIVE CSG: N/A ft amsl
GROUND SURFACE: 7359.585 ft amsl
Surface Pad
Silty clay loam, organic rich; saturated alluvium: Qal
WELL CASING
Schedule 40 PVC, 2 in ID
flush joint
Coarse sand with coarse gravel up to 3cm; saturated alluvium: Qal
WELL SCREEN
Schedule 40 PVC Screen,
2 in ID flush joint with 0.010 in slots
SAND FILTER PACK
10/20 silica sand
0.5 ft sump with
casing end cap,
8.0-8.5 ft bgs
NOT TO SCALE
TerranearPMC
Drafted By: A. Stocker
Date: February 10, 2010
PRB ALLUVIAL MONITORING WELL SCHEMATIC: MW-20
Technical Area 16 Los Alamos National Laboratory, Los Alamos, New Mexico

BOREHOLE ID: MW-1 Technical Area (TA): 16, 16-021(c)-99 Page 1 of 1

DRILLING COMPANY: Precision Sampling START DATE/TIME: 1/31/2010:1040 FINISH DATE/TIME: 1/31/2010:1105

DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring

SAMPLING EQUIPMENT/METHOD: CBS

GROUND ELEVATION: 7356.25' TOTAL DEPTH: 8.5'

DRILLER: D. Toney GEOLOGIST: K. Reid

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0	1040	0.5/3.5	0–3.5 ft, Silty Clay Soil Organic-rich with some roots and pine needles, very dark grey (10YR 3/1), saturated		Qal	Borehole located in flood plane of CdV's stream
			3.5-5 ft, Silty Clay Soil Organic-rich with some roots and pine needles, very dark gray (10YR 3/1), saturated			
5.0	1050	2/5	5-8.5 ft, Densely Welded Tuff Brown (7.5 YR 5/2). Quartz and sanidine in glassy matrix		Qbt3	Alluvium/tuff contact at 5' bgs
10.0						
15.0						

BOREHOLE ID: MW-2	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/29/2010:1540	FINISH DATE/TIME: 1/29/2010:1620
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: 7376.537' amsl		TOTAL DEPTH: 8.0'
DRILLER: D. Toney		GEOLOGIST: A. Stocker

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0			**0–2 ft, Clay-rich Soil** Organic-rich with roots and pine needles, very dark grey (7.5YR 3/1), damp		Qal	
	1540	3/3	**2-3 ft, Densely Welded Tuff** Gray (7.5 YR 5/1), Quartz 25%, sanidine 8-10%, Fe-oxidized mineral 5%, in glassy matrix 60%. Fractured and altered Alluvium/tuff contact.			Alluvium/altered tuff contact at 2' bgs
			3-8 ft, Densely Welded Tuff Same as above			
5.0	1500	3/5			Qbt3	
10.0						
15.0						

BOREHOLE ID: MW-3	Technical Area (TA): 16, 16-021(c)-99		Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/29/2010:1335	FINISH DATE/TIME: 1/29/2010:1400	
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring			
SAMPLING EQUIPMENT/METHOD: CBS			
GROUND ELEVATION: 7378.1' amsl*		TOTAL DEPTH: 13.3'	
DRILLER: D. Toney		GEOLOGIST: A. Stocker	

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Lithologic Symbol	ADDITIONAL COMMENTS
0.0			**0-0.25 ft, Clay-rich Soil** Organic-rich with roots and pine needles, very dark grey (7.5YR 3/1), frozen.	Qal	Frozen soil with overlying snow
	1335	1.58 / 3	**0.25-2.5 ft, Sandy Loam** Sand-sized grains 70%, silt 15%, and clay 15%. Organic-rich with roots and pine needles. Dry.	Qal	
			2.5-3 ft, Densely Welded Tuff Gray (7.5 YR 5/1), Quartz 30%, sanidine 10%, Fe-oxidized mineral 5%, in glassy matrix 55%. Fractured and altered Alluvium/tuff contact.		Alluvium/altered tuff contact at 2.5' bgs
5.0	1340	2.25 / 5	**3-8 ft, Densely Welded Tuff** Same as above	Qbt3	
10.0	1350	2.42 / 5.3	**8-13.3 ft, Densely Welded Tuff** Same as above		
15.0					

* Measured Elevation from top of casing

BOREHOLE ID: MW-4	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/30/2010:1400	FINISH DATE/TIME: 1/30/2010:1450
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: TBD' amsl DRILLER: D. Toney		TOTAL DEPTH: 14.4' GEOLOGIST: K. Reid

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0	1400	3.5/4.4	**0-4.4 ft, Silty clay Soil** Organic-rich with roots and pine needles, very dark grayish brown (10YR 3/2), minor pebbles 5% and altered pumice clasts up to 1 cm. Soil frozen 0-1.5 ft.		Qal	Frozen soil with overlying snow
5.0	1420	1.5/5	**4.4-5 ft, Silty Clay Soil** Same as above			Saturated at ~5.5' bgs
10.0	1435	1.5/5	**9-10 ft, Coarse Sandy Loam** Coarse sand sized grains 80% (~1mm), with tuff clasts up to 4cm, clay ~10%, and silt ~10%. Brown (7.5YR 4/3) and saturated **2.5-3 ft, Densely Welded Tuff** Grayish brown (10YR 5/2), Quartz 20%, sanidine 10%, in glassy matrix 55%. Fractured and altered Alluvium/tuff contact. Dry.		Qbt3	Alluvium/altered tuff contact at 10' bgs
15.0						

BOREHOLE ID: MW-5	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/30/2010:1150	FINISH DATE/TIME: 1/30/2010:1230

DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring

SAMPLING EQUIPMENT/METHOD: CBS

GROUND ELEVATION: TBD' amsl — TOTAL DEPTH: 12.5'

DRILLER: D. Toney — GEOLOGIST: K. Reid

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0	1150	0.5/2.5	**0-2.5 ft, Clay Loam Soil** Very dark brown (10YR 2/2), clay ~40%, silt ~40%, sand ~20%.		Qal	Dry soil with overlying snow
5.0	1200	1.5/5	**2.5-7.5 ft, Silty Clay Loam** Brown (7.5YR 4/2), 40% clay, 50% silt, and 10% sand. Loam also has pebbles and cobbles up to 10cm in diameter of dacite and tuff. Dry except for bottom of shoe of auger.		Qal	
			7.5-8.5 ft, Silty Clay Loam Same as above except saturated		Qal	Saturated at 7.5-8.5' bgs
10.0	1215	3.5/5	**8.5-12.5 ft, Densely Welded Tuff** Pinkish giray (7.5YR 6/2), Quartz 20%, sanidine 10%, in glassy matrix 55%. Fractured and altered Alluvium/tuff contact. Dry.		Qbt3	Alluvium/altered tuff contact at 8.5' bgs
15.0						

BOREHOLE ID: MW-6	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/27/2010:1050	FINISH DATE/TIME: 1/27/2010:1145
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: 7379.54' amsl*		TOTAL DEPTH: 13.0'
DRILLER: D. Toney		GEOLOGIST: A. Stocker

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0			**0-1 ft, Sandy Loam** Brown, clay ~15%, silt ~35%, sand ~50%. Composed of frozen soil chunks.			Frozen soil with overlying snow
	1050	3/5	**1-5 ft, Silt Loam** Brown (7.5YR 4/2), 25% clay, 65% silt, and 10% sand. Loam also has angular pebbles and cobbles up to 10cm in diameter of dacite and tuff. Mostly frozen 1-2.5 ft and 2.5-3 ft is partialy frozen.		Qal	
5.0			**5-9.5 ft, Sandy Loam** Brown, clay ~15%, silt ~35%, sand ~50% with angular pebbles and cobbles 1-8cm of dacite and tuff. Saturated.			Saturated at 5' bgs
	1115	1.5/5			Qal	
			9.5-10 ft, Densely Welded Tuff Pinkish gray (7.5YR 6/2), Quartz 20%, sanidine 10%, in glassy matrix 55%. Fractured and altered Alluvium/tuff contact. Dry.			Alluvium/altered tuff contact at 9.5' bgs
10.0			**10-13 ft, Densely Welded Tuff** Same as above.			
	1130	2.3/3			Qbt3	
15.0						

* Measured from monument.

BOREHOLE ID: MW-7	Technical Area (TA): 16, 16-021(c)-99		Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/26/2010:1400	FINISH DATE/TIME: 1/26/2010:1450	
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring			
SAMPLING EQUIPMENT/METHOD: CBS			
GROUND ELEVATION: 7378' amsl*		TOTAL DEPTH: 13.1'	
DRILLER: D. Toney		GEOLOGIST: A. Stocker	

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0			0-1 ft, Sandy Loam Brown, clay ~15%, silt ~35%, sand ~50%. Dry.			Dry soil with overlying snow
	1400	2.5/4	1-4 ft, Clay Well developed clay, 60% clay, 20% silt, with 15% angular grains of quartz (~0.25cm) and 5% pumice clasts (~0.5cm).		Qal	
5.0	1415	2.5/5	5-9.5 ft, Loamy Sand Light brown, clay ~10%, silt ~20%, sand ~70% with rounded pebbles and cobbles 1-10cm of dacite and tuff. Dry. Dacite boulder encountered 6-6.5 ft bgs.		Qal	Saturated at 9' bgs
10.0			9.5-10 ft, Sandy Loam Brown, clay ~15%, silt ~35%, sand ~50%. Saturated.			Alluvium/altered tuff contact at 10' bgs
	1430	1/4	10-13 ft, Densely Welded Tuff Pinkish gray (7.5YR 6/2), Quartz 20%, sanidine 10%, in glassy matrix 55%. Fractured and altered Alluvium/tuff contact. Dry.		Qbt3	
15.0						

* Measured from monument.

BOREHOLE ID: MW-8	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/26/2010:1630	FINISH DATE/TIME: 1/26/2010:1700
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: 7377.16' amsl*		TOTAL DEPTH: 13'
DRILLER: D. Toney		GEOLOGIST: A. Stocker

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0		NO RECOVERY - Due to core barrel adjusting rod	0-10 ft. Alluvium Sandy clay soil intermixed with cobbles up to 10 cm. Dry. **Determined from cuttings**		Qal	Dry soil with overlying snow
5.0					Qal	
			Saturated Alluvium **Determined from cuttings**			Approximately saturated at 9' bgs
10.0			10-13 ft. Densely Welded Tuff Contact felt at 10 ft bgs. Pinkish gray (7.5YR 6/2). Quartz 20%, sanidine 10%, in glassy matrix 55%. Fractured and altered Alluvium/tuff contact. Dry. **Determined from cuttings**		Qbt3	Alluvium/altered tuff contact at 10' bgs
15.0						

* Measured from monument.

BOREHOLE ID: MW-9	Technical Area (TA): 16, 16-021(c)-99		Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/28/2010:1310	FINISH DATE/TIME: 1/28/2010:1400	
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring			
SAMPLING EQUIPMENT/METHOD: CBS			
GROUND ELEVATION: 7373.9' amsl*		TOTAL DEPTH: 12'	
DRILLER: D. Toney		GEOLOGIST: K. Reid	

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0			0-1 ft, Silty Clay Loam / Fill Gray brown, clay ~30%, silt ~60%, sand ~10% with pebbles and cobbles up to 10cm. Dry.			Dry soil with overlying snow
	1310	2.5/3	1-3 ft, Clay Loam ~40% silt, ~20% sand and ~40% clay		Qal	
			3-5 ft, Clay Loam Same as clay loam above.			
5.0	1325	3/5	5-10 ft, Densely Welded Gray Tuff Distinctly gray (7.5YR 5/1), Quartz 25%, sanidine 10%, in glassy matrix 65%. Fractured and altered Alluvium/tuff contact. Dry.		Qbt3	Alluvium/altered tuff contact at 5' bgs
10.0	1345	0/4	10-13 ft, Densely Welded Tuff Weak red (10R 4/2), Quartz 30%, sanidine 8%, in glassy matrix 62%. Fractured and altered Alluvium/tuff contact. Dry.		Qbt3	Contact between gray and weak red tuffs at 10' bgs NOTE: observed from cuttings because no recovery
15.0						

* Measured from monument.

BOREHOLE ID: MW-10	Technical Area (TA): 16, 16-021(c)-99		Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/28/2010:1450	FINISH DATE/TIME: 1/28/2010:1550	
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring			
SAMPLING EQUIPMENT/METHOD: CBS			
GROUND ELEVATION: 7375.3' amsl*		TOTAL DEPTH: 13'	
DRILLER: D. Toney		GEOLOGIST: K. Reid	

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Lithologic Symbol	ADDITIONAL COMMENTS
0.0	1450	1.5/3	**0-3 ft, Silty Clay Loam / Fill** Gray brown, clay ~30%, silt ~60%, sand ~10%. Dry.	Qal	Dry soil with overlying snow
3.0			**3-3.5 ft, Silty Clay Loam / Fill** Same as above.		Alluvium/altered tuff contact at 3.5' bgs
3.5 – 5.0	1530	3/5	**3.5-8 ft, Moderately Welded Tuff** Light tan/gray-brown (7.5YR 5/2), Quartz 15%, sanidine 10%, in glassy matrix 75%. Dry.	Qbt3	
8.0 – 10.0	1540	2/5	**8-12 ft, Moderately Welded Tuff** Same as above.		
15.0					

* Measured from top of casing.

BOREHOLE ID: MW-11	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/27/2010:1235	FINISH DATE/TIME: 1/27/2010:1320
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: 7374.4' amsl*		TOTAL DEPTH: 12'
DRILLER: D. Toney		GEOLOGIST: A. Stocker

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0			**0-2 ft, Silty Clay Loam** Frozen very dark grayish brown (10YR 3/2) loam, well developed, clay ~45%, silt ~40%, and 15% angular grains of quartz (2-4mm). Dry.			Dry soil with overlying snow
	1235	2/4	**2-4 ft, Loamy Sand** Light brown, clay ~10%, silt ~20%, sand ~70% with rounded pebbles and cobbles 5-10cm of dacite and tuff. Roots present. Dry.		Qal	Saturated at 4' bgs
5.0	1250	1.2/5	**4-8 ft, Gravelly Sand** Saturated. 5% clay, 30% silt, 40% sand, and 25% gravel.		Qal	Alluvium/altered tuff contact at 8' bgs
			8-9 ft, Densely Welded Tuff Weak red (10R 4/2), Quartz 25%, sanidine 10%, 0.5% iron oxide, 0.5% altered lithic, in glassy matrix 64%. Fractured and altered Alluvium/tuff contact. Dry.			
10.0	1310	2.8/3	**9-12 ft, Densely Welded Tuff** Same as above.		Qbt3	
15.0						

* Measured from monument.

BOREHOLE ID: MW-12	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/29/2010:1030	FINISH DATE/TIME: 1/29/2010:1130
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: 7373.4' amsl* DRILLER: D. Toney		TOTAL DEPTH: 9.5' GEOLOGIST: A. Stocker

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0						Dry soil with overlying snow
	1030	1.42/3.5	**0-3.5 ft, Clay** Clay-rich soil with roots and pine needles. ~60% clay, ~30% silt, and ~10% sand-sized angular dacite clasts.		Qal	
						Saturated at 3.5' bgs
5.0	1055	1.92/5	**3.5-6.5 ft, Sandy loam / fill** Brown, clay ~10%, silt ~20%, sand ~70% with rounded pebbles and cobbles 2-15cm of dacite and tuff. Saturated.		Qal	
			6.5-7 ft, Clay Very well developed clay overlying tuff contact.			Alluvium/altered tuff contact at 7' bgs
			7-8.5 ft, Densely Welded Tuff Weak red (10R 4/2). Quartz 30%, sanidine 10%, 0.5% iron oxide, 0.5% altered lithic, in glassy matrix 59%. Fractured and altered Alluvium/tuff contact. Dry.		Qbt3	
	1055	1/1	**8.5-9.5 ft, Densely Welded Tuff** Same as above			
10.0						
15.0						

* Measured from top of casing.

BOREHOLE ID: MW-17	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/28/2010:1100	FINISH DATE/TIME: 1/28/2010:1200
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: 7371.5' amsl*		TOTAL DEPTH: 9'
DRILLER: D. Toney		GEOLOGIST: K. Reid

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0	1100	2/3	0-2 ft, Snow Snow overlying soil.			Dry soil with overlying snow
			2-3 ft, Sandy Clay Loam Moist with minor roots. ~50% sand, ~30% clay, ~20% silt.			
5.0	1130	3/5	3-3.5 ft, Sandy Clay Loam Same as above.		Qal	Alluvium saturated at 4' bgs
			3.5-8 ft, Welded Tuff Weak red (10R 4/2), Quartz 30%, sanidine 10%, 0.5% iron oxide, 0.5% altered lithic, in glassy matrix 59%. Fractured and altered Alluvium/tuff contact. Dry		Qbt3	Alluvium/altered tuff contact at 6' bgs
	1150	2/5	8-12 ft, Welded Tuff Same as above.			
10.0						
15.0						

* Measured from monument.

BOREHOLE ID: MW-18	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/27/2010:1510	FINISH DATE/TIME: 1/27/2010:1545
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: 7370.4' amsl*		TOTAL DEPTH: 8'
DRILLER: D. Toney		GEOLOGIST: K. Reid

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0						Dry soil with overlying snow
	1510	1/3	**0-3 ft, Coarse Sand** Coarse sand that is saturated at ~1 ft bgs		Qal	Saturated at 1' bgs
			3-5 ft, Coarse Sand Same as above		Qal	
5.0			**5-5.5 ft, Clay** Very well developed clay overlying tuff contact			
	1530	4.5/5	**5.5-8 ft, Densely Welded Tuff** Weak red (10R 4/2), Quartz 30%, sanidine 10%, 0.5% iron oxide, 0.5% altered lithic, in glassy matrix 59%. Fractured and altered Alluvium/tuff contact. Dry.		Qbt3	Alluvium/altered tuff contact at 5.5' bgs
10.0						
15.0						

* Measured from monument.

BOREHOLE ID: MW-19 Technical Area (TA): 16, 16-021(c)-99 Page 1 of 1

DRILLING COMPANY: Precision Sampling START DATE/TIME: 1/31/2010:1445 FINISH DATE/TIME: 1/31/2010:1530

DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring

SAMPLING EQUIPMENT/METHOD: CBS

GROUND ELEVATION: 7360.129' amsl TOTAL DEPTH: 7.5'

DRILLER: D. Toney GEOLOGIST: K. Reid

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0						Saturated soil with overlying snow
	1445	2/2.5	**0-3.5 ft, Clay** Clay-rich soil with roots and pine needles. ~60% clay, ~30% silt, and ~10% sand-sized angular dacite clasts		Qal	All alluvium saturated
			2.5-4.5 ft, Silty Clay Loam Dark brown, clay ~30%, silt ~50%, sand ~20% with rounded pebbles and cobbles up to 4cm of dacite and tuff. Saturated.		Qal	Alluvium/altered tuff contact at 4.5' bgs
5.0	1510	2.5/5	**4.5-7.5 ft, Densely Welded Tuff** Weak red (10R 4/2), Quartz 30%, sanidine 10%, 0.5% iron oxide, 0.5% altered lithic, in glassy matrix 59%. Fractured and altered Alluvium/tuff contact. Dry		Qbt3	
10.0						
15.0						

BOREHOLE ID: MW-20	Technical Area (TA): 16, 16-021(c)-99	Page 1 of 1
DRILLING COMPANY: Precision Sampling	START DATE/TIME: 1/31/2010:1210	FINISH DATE/TIME: 1/31/2010:1240
DRILLING EQUIPMENT/METHOD: CME 55/Continous Coring		
SAMPLING EQUIPMENT/METHOD: CBS		
GROUND ELEVATION: 7359.585' amsl		TOTAL DEPTH: 8.5'
DRILLER: D. Toney		GEOLOGIST: K. Reid

Depth (ft bgs)	Time	Recovery (ft)	LITHOLOGY - DESCRIPTION	Graphic Log	Lithologic Symbol	ADDITIONAL COMMENTS
0.0–3.5	1210	0/3.5	0-3.5 ft, Silty Loam Organic-rich soil. Saturated. NOTE: logged from cuttings.		Qal	Saturated soil with overlying snow All alluvium saturated
3.5–5.5			3.5-5.5 ft, Coarse Sand Brown, coarse grained sand with rounded pebbles and cobbles up to 3cm. Saturated.		Qal	Alluvium/altered tuff contact at 5.5' bgs
5.5–8.5	1225	3/5	5.5-8.5 ft, Densely Welded Tuff Weak red (10R 4/2), Quartz 30%, sanidine 10%, 0.5% iron oxide, 0.5% altered lithic, in glassy matrix 59%. Fractured and altered Alluvium/tuff contact. Dry.		Qbt3	

Depth scale: 0.0, 5.0, 10.0, 15.0