Draft
For Public Review

Former ASARCO East Helena Facility Interim Measures Work Plan—2015 and 2016

Prepared for

The Montana Environmental Trust Group, LLC
Trustee of the Montana Environmental Custodial Trust

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CH2MHILL®
7 West 6th Avenue Suite 519
Helena, Montana 59601

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Acronyms and Abbreviations

AOC	Area of Contamination
APP	Avian Protection Plan
ARM	Administrative Rules of Montana
CAMP	Corrective Action Monitoring Plan
CAMU	Corrective Action Management Unit
CLOMR	Conditional Letter of Map Revision
CMS	Corrective Measures Study
COEH	City of East Helena
COPC	constituent of potential concern
CSM	conceptual site model
Custodial Trust	Montana Environmental Custodial Trust
EHECTIC	East Helena Entire Cleanup Team in Coordination
ERM	Environmentally Regulated Material
ESA	Endangered Species Act
ET	evapotranspiration
F&T	fate and transport
FEMA	Federal Emergency Management Agency
HDS	high-density sludge
HEC-RAS	Hydrologic Engineering Centers River Analysis System
ICS	Interim Cover System
ICS 1	Interim Cover System 1 completed in November 2014
ICS 2	Interim Cover System 2 proposed for completion in 2015
IM	interim measure
IM Work Plan 2012	Interim Measures Work Plan 2012
IM Work Plan 2013	Interim Measures Work Plan 2013
IM Work Plan 2014	Interim Measures Work Plan 2014
IM Work Plan 2015/2016	Interim Measures Work Plan 2015 and 2016
Joint Application	Joint Application for Proposed Work in Montana’s Streams, Wetlands, Floodplains, and Other Waterbodies
LCCD	Lewis and Clark Conservation District
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MDEQ	Montana Department of Environmental Quality

MDT	Montana Department of Transportation
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MPDES	Montana Pollutant Discharge Elimination System
NOI	Notice of Intent
NWE	NorthWestern Energy
OU	Operable Unit
PCB	polychlorinated biphenyl
PPC	Prickly Pear Creek
QA/QC	quality assurance and quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
ROD	Record of Decision
SPHC	South Plant Hydraulic Control
SWPPP	Stormwater Pollution Prevention Plan
TPA	Tito Park Area
TSCA	Toxic Substances Control Act
ULM	Upper Lake Marsh
UOSA	Upper Ore Storage Area
U.S.	United States
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WTP	water treatment plant
yd^3	cubic yard(s)

SECTION 1

Introduction

The purpose of this Interim Measures Work Plan 2015 and 2016 (IM Work Plan 2015/2016) is to provide information to support U.S. Environmental Protection Agency (USEPA) approval of the remaining interim measures (IMs) phases proposed for implementation in 2015 and 2016 at the East Helena Facility (Facility). This IM Work Plan 2015/2016 focuses on work proposed and as appropriate, updates information presented in the preceding IM Work Plans submitted from 2012 through 2014 (IM Work Plan 2012, CH2M HILL, 2012a; IM Work Plan 2013, CH2M HILL, 2013; and IM Work Plan 2014, CH2M HILL, 2014a).

1.1 Summary of Interim Measures

The three interrelated, interdependent IMs were proposed at the Facility in concept in the IM Work Plan 2012 and subsequently approved by USEPA on August 28, 2012. Components of these IMs have been completed as further described in the IM Work Plan 2013 and IM Work Plan 2014 approved by USEPA on January 21, 2013, and April 28, 2014, respectively. The primary purpose of the IMs is to reduce the migration of contaminants in groundwater from the operating area of the former ASARCO Smelter (former Smelter site) in order to protect public health and the environment. The three IMs are summarized as follows:

- The South Plant Hydraulic Control IM (SPHC IM) is proposed to reduce the migration of inorganic contaminants in groundwater by changing the hydrogeologic conditions at the southern end of the former Smelter site.
- The Source Removal IM is proposed to reduce the mass loading of contaminants to groundwater by reducing the volume of soil with high concentrations of inorganic contaminants that are subject to infiltration or flow-through and subsequent leaching to groundwater.
- The Evapotranspiration Cover System IM (ET Cover System IM) is proposed to further reduce the potential for inorganic soil contaminants to leach to groundwater by eliminating or substantially reducing the amount of infiltration through contaminated materials and providing a clean surface for runoff. The ET Cover System IM will also eliminate human and ecological receptor exposure to inorganic-contaminated soil.

1.2 Work Completed to Date

Implementation of the three IMs is occurring in phases over a number of years. The following phases have been implemented since 2012:

- **SPHC IM**: Relocation of utilities and subsequent construction of the Temporary Bypass for Prickly Pear Creek (PPC) (PPC Temporary Bypass) was completed to route PPC flow around Smelter Dam. The groundwater levels in the South Plant area was lowered substantially, enabling removal of the Tito Park Area (TPA) (see discussion under Source Removal IM below), and potentially enabling construction of the new PPC channel (also referred to as PPC Realignment) in mostly dry conditions. Construction of the PPC Temporary Bypass began in July 2013 and was completed in October 2013.
- **Source Removal IM—Tito Park Area Removal**: Removal of contaminated soil from the TPA, which consists of Tito Park, Upper Ore Storage Area (UOSA), Acid Plant Sediment Drying Area (APSD Area), and Lower Lake. The soil was removed to eliminate the potential for inundation and erosion from potential PPC flooding, meet the functional needs of the PPC Realignment, support the development of wetland habitat in the PPC floodplain, and reduce the overall footprint of the ET Cover System. The final design of the TPA removal provides flexibility in the construction and ultimate performance of the PPC Realignment, which is critical to the implementation of the SPHC IM. Removal of contaminated soil from the TPA was completed in October 2014.

- **ET Cover System IM**: Phase 1 and Phase 2 demolition of the buildings and infrastructure on the former Smelter site and subsequent construction of the first phase of the ET Cover System (Interim Cover System 1 [ICS 1]) to serve as the foundation layer of the western portion of the ET Cover (referred to as ET Cover West). Phase 1 demolition was completed in July 2013 and Phase 2 demolition was completed in October 2013. The ICS 1 was completed in November 2014.

1.3 Interim Measures Coordination

Although three IMs are proposed, the IMs are designed to work in conjunction with one another to reduce contaminant loading to groundwater and subsequent migration of groundwater contamination.

1.3.1 Implementation Schedule and Work Planning

The IM phases described in this work plan are proposed for concurrent implementation in 2015 and 2016 to increase the protectiveness, efficiency, and cost-effectiveness of construction activities. The overall schedule for completion is driven by the size and complexity of the PPC Realignment, with consideration to the large volume of material that will be excavated during construction of the new channel. The PPC Realignment work is being done concurrently with the ICS 2 and ET Cover so that materials managed from excavation activities as part of the PPC Realignment may be consolidated within the USEPA-approved AOC as fill to construct the ET Cover System. The following additional benefits will result:

- Protection of human health and the environment during construction by decreasing the potential for contact with contaminated media by human and ecological receptors, and stormwater
- Reduction in overall construction cost by minimizing the need to double-handle soil (i.e., eliminating the need to temporarily stockpile soil before placing it in the final location)
- Reduction in the cost of constructing the ET Cover System by using materials excavated from the PPC realignment as fill

1.3.2 Performance Evaluation to Date

Because the IMs are intended to be part of the final remedy for the Facility, groundwater monitoring is underway to evaluate their performance. To date, monitoring results show that the completed phases of the SPHC IM have lowered groundwater levels in the southern portion of the former Smelter site and reduced mass loading of inorganic contamination to groundwater. Wells located in the South Plant area report an average 7-foot drop in groundwater levels; wells located in the former Acid Plant area near the southern portion of the former Smelter site report an average 5-foot or greater drop in groundwater levels. A sustained drop in groundwater elevations has been noted since inflow to Upper Lake was cut off in 2011 (more detail is provided in Section 3.2). Decreases in arsenic and selenium concentrations are also noted in the former Acid Plant area (a summary is provided in Section 3.2.1). Continued performance of the IMs will be evaluated as part of the Corrective Measures Study (CMS), and long-term monitoring plans will be designed to evaluate IM performance over time.

Additional benefits shown in groundwater evaluations include a reduction in the potential for mass loading to groundwater and a decrease in volumes of contact- stormwater (stormwater that contacts the existing site area and becomes contaminated). The removal of contaminated soil from the TPA has eliminated the potential for future flooding to inundate the contaminated soil and subsequently mobilize the inorganic contaminants to groundwater. Speiss material, which is a high arsenic process waste generated from smelter operations, in the South Plant area was removed and disposed of in the existing Corrective Action Management Unit (CAMU) 2 landfill, eliminating contact and subsequent leaching of contaminants to groundwater. Completion of the ICS 1 has reduced the amount of contaminated stormwater collected and treated at the former Smelter site in the range of 500,000 gallons.

1.4 Proposed Activities

Figures 1-1 and 1-2 show the phases to be completed in 2015 and 2016, respectively, with the exception of the Phase 3 demolition activities; those are presented in **Figure 1-3**. The activities presented herein are submitted for USEPA review and approval as well as public review and comment:

- **PPC Realignment and Wetlands Establishment**: In 2015 and 2016, the PPC channel will be realigned to lower the groundwater table, and wetlands along the southern portion of PPC will be established. Materials excavated during construction of the PPC Realignment will be used to construct the ET Cover System. The PPC Temporary Bypass will remain in place until 2023 to aid in controlling stream flow and reducing the risk for flooding. After 2023, the wetlands will be sufficiently established to provide flooding protection and maintain stream flow.
- **ICS 2 and ET Cover System IM:** In 2015, the ET Cover System will be completed over the ICS 1 (ET Cover West), and the second phase of the ICS (referred to as ICS 2) will be constructed over the eastern portion of the former Smelter site. An open corridor (the central corridor) will be maintained for additional investigative work in support of the on-going Tier II source control measure/groundwater remedy evaluation (**Figure 1-1**). If any Tier II source control measures/groundwater remedies are determined to be necessary to augment the overall remedy, they could be integrated into the overall remedy either in conjunction with the three planned IMs, or as a supplement to the IMs based on IM performance. The ICS 2 will protectively manage soil and sediment removed during construction of the PPC Realignment and at the same time establish the subgrade for the eastern portion of the ET Cover System (referred to as ET Cover East). In 2016, the ET Cover East will be completed over the remaining areas to include the ICS 2 and central corridor (**Figure 1-2**). The ET Cover System IM will be designed to manage the excess borrow soil generated by the PPC Realignment activities.
- **Phase 3 Demolition**: The primary purpose of Phase 3 demolition activities is to provide a clear footprint in which to construct the ICS 2 and ET Cover East. In 2015, infrastructure within the ICS 2 footprint will be demolished to provide sufficient time to complete ICS 2 construction. In 2016, infrastructure within the central corridor will be demolished to accommodate the ET Cover East (**Figure 1-3**). Demolition activities associated with components of the high-density sludge (HDS) water treatment plant (WTP) will be sequenced to maintain functionality of the HDS WTP through 2016 or longer, if necessary to accommodate the overall site needs and project schedule. The building, structures, and utilities will be removed by a qualified demolition subcontractor, except for the overhead 69-kilovolt (kV) power line, associated poles, and substation, which NorthWestern Energy (NWE) will remove as part of relocating this utility to a new alignment along the perimeter access road of the ET Cover East.

1.5 Work Plan Summary

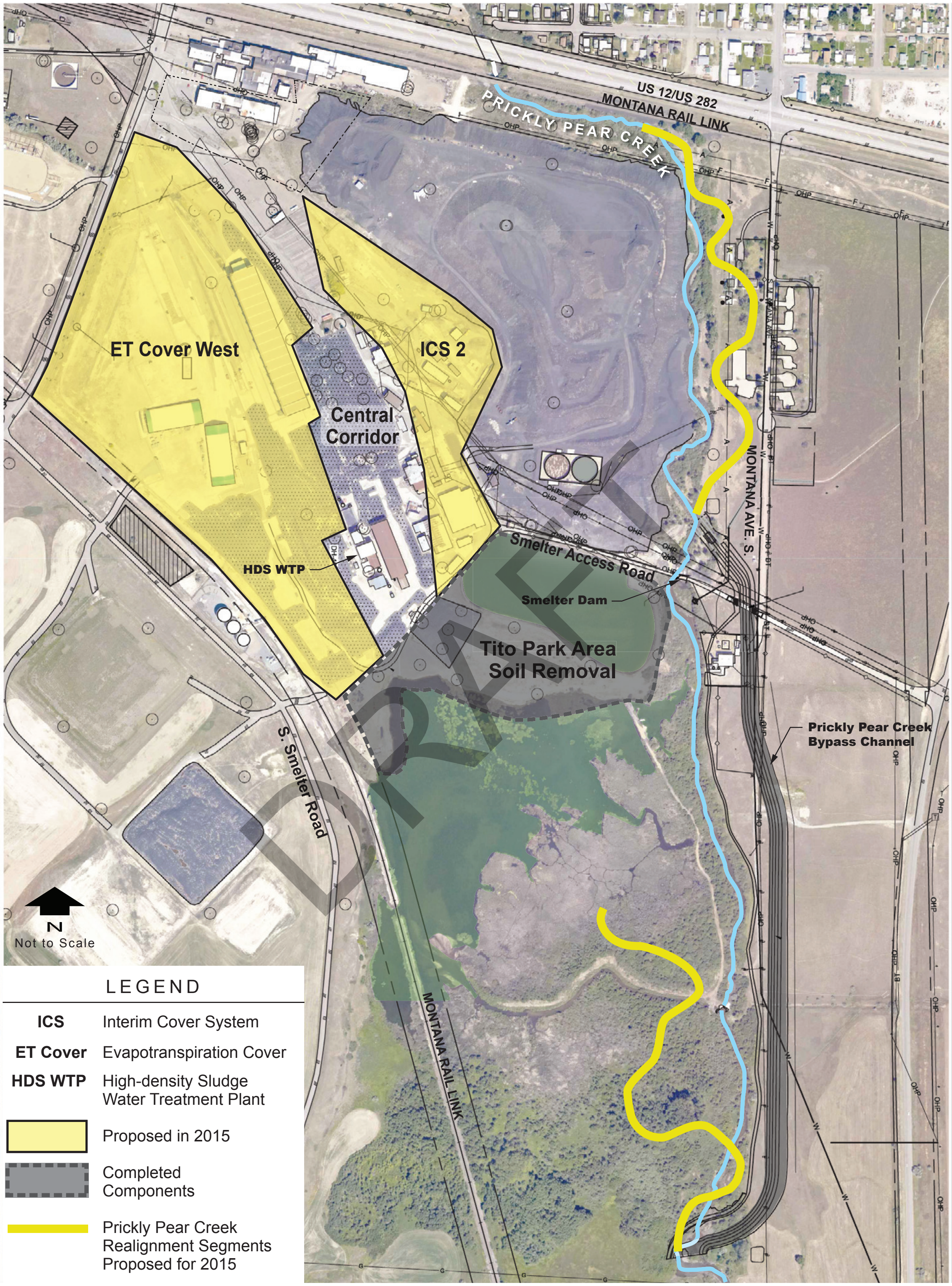
The Montana Environmental Trust Group, LLC, Trustee of the Montana Environmental Custodial Trust (Custodial Trust), is submitting this IM Work Plan 2015/2016 in compliance with Paragraph 14 of the First Modification to the 1998 Resource Conservation and Recovery Act (RCRA) Consent Decree (First Modification; Dreher et al., 2012).

This IM Work Plan 2015/2016 builds on information presented in the previous IM Work Plans, and additional reports and technical memorandums prepared by the Custodial Trust. General background information on site history and conditions is presented in the *Phase II RCRA Facility Investigation—East Helena Facility* (Phase II RFI; GSI Water Solutions, Inc., 2014). An updated understanding of groundwater flow and water quality, integrating data collected and evaluations performed since the Phase II RFI, is summarized in Section 3 and will be presented by Hydrometrics in the 2014 Groundwater Conditions Status Report. A complete list of references is provided in Section 9 of this IM Work Plan 2015/2016.

The IM Work Plan 2015/2016 is organized into the following sections:

- **Section 1: Introduction**.
- **Section 2: Overview of Proposed 2015 and 2016 Interim Measures Implementation** provides a summary-level description of the IMs proposed for implementation in 2015 and 2016 and how they fit into the overall IM concept for the Facility.
- **Section 3: Updated Conceptual Site Model** presents data and results of evaluations conducted that augment the existing conceptual site model (CSM) and may impact the proposed work.
- **Section 4: Data Sufficiency** summarizes the existing data used in the development of the work proposed for 2015 and 2016.
- **Section 5: Engineering Design and Construction Information for Proposed 2015 and 2016 Projects** provides conceptual design information and outlines construction and implementation requirements to complete the IMs and associated demolition activities proposed for 2015 and 2016. Additional design details are provided in Appendix A.
- **Section 6: Remediation Waste Management** describes how hazardous and nonhazardous remediation waste will be managed during implementation of the IMs and demolition activities described herein.
- **Section 7: Status of Permitting Activities and Approvals** provides an update on relevant activities associated with permitting and licensing requirements necessary to complete the 2015 and 2016 activities.
- **Section 8: Project Management and Schedule** provides an overview of project management activities and the proposed schedule for IM implementation. Updates to the organizational structure, lines of communication, public participation, documentation and reporting, and the schedule are described in this section.
- **Section 9: References** contains a bibliography of documents cited in text.

Supporting information is provided in three appendixes. **Appendix A** contains design details and supporting documentation. **Appendix B** contains a technical memorandum describing the results of the ET Cover System design evaluation. **Appendix C** contains public comments received on the IM Work Plan 2015/2016, with USEPA responses and a conditional letter of approval.



Note: Phase 3 Demolition activities proposed in 2015 are shown in Figure 1-3.

FIGURE 1-1
Interim Measures Components Proposed for Implementation in 2015
Interim Measures Work Plan–2015/2016
East Helena, Montana

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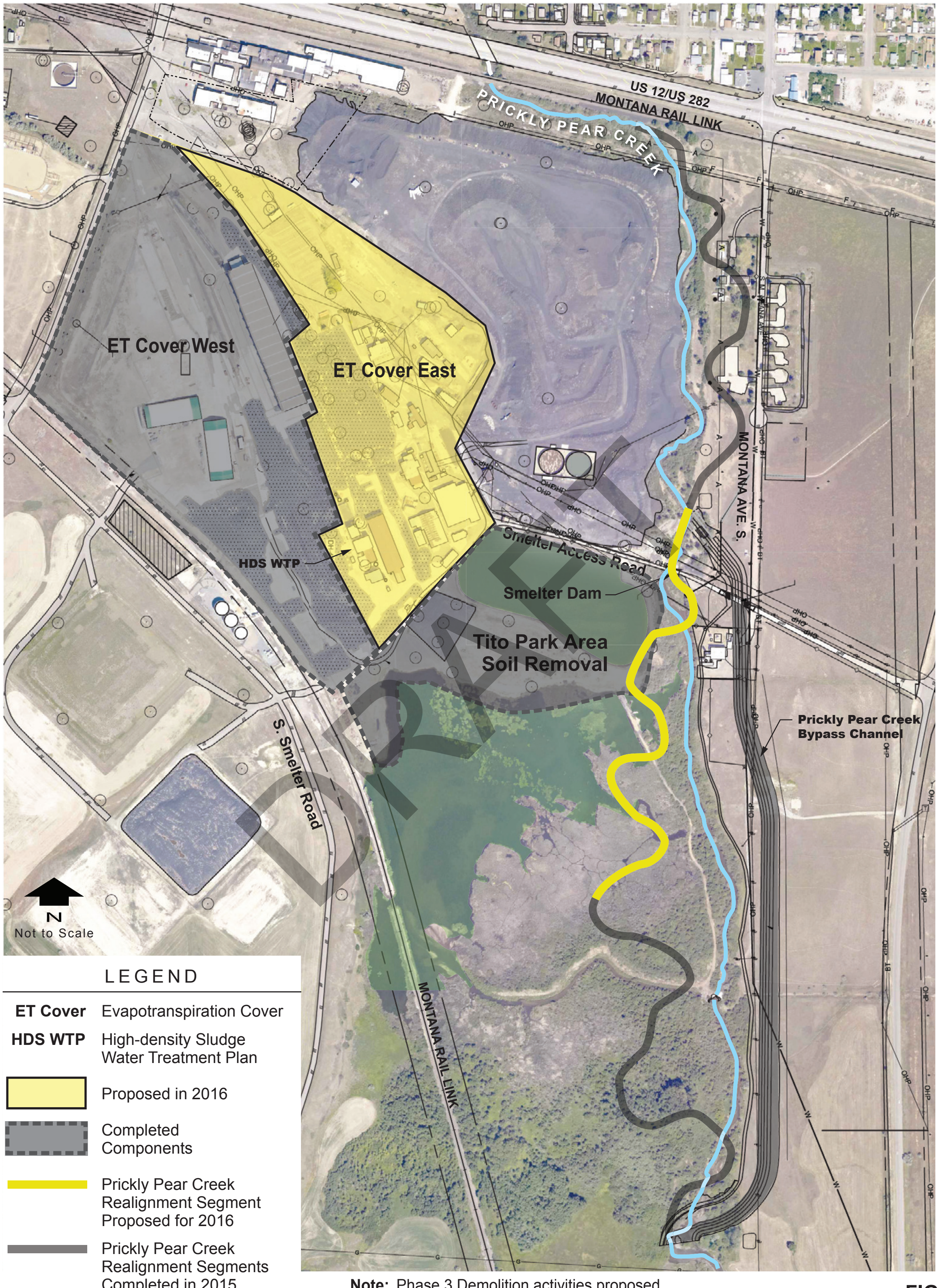

Note: Phase 3 Demolition activities proposed in 2016 are shown in Figure 1-3

FIGURE 1-2
Interim Measures Components Proposed for Implementation in 2016
Interim Measures Work Plan–2015/2016
East Helena, Montana

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LEGEND

ICS	Interim Cover System
ET Cover	Evapotranspiration Cover
HDS WTP	High-density Sludge Water Treatment Plant
	Interim Measure
	Demolished Structure
	Building Proposed for Demolition in 2015
	Building Proposed for Demolition in 2016
	Prickly Pear Creek Realignment Proposed for 2015/2016

2015 DEMOLITION

No.	General Description
9	LMPT Building
10	Dispensary/First Aid Building
11	Change House
12	Thornock Tank & Collection Piping
13	Pump House & Diesel Fuel Tank
35	MPC Transformers/ NWE Substation

2016 DEMOLITION

No.	General Description
4	Warehouse Annex
39	Powerhouse Transformer Room
40	Electric Shop
42	Pump House
49	Sampling & Monitoring Building
53	Meter House
54	Acid Plant Drain Water Sump Pump
65	Water Vault & Sump
73	Neutralization Building
74	MCC Building
75	HDS Water Treatment Building
76	Sludge Recovery Building
77	Lime Silo
78	HERO Building & Associated Tank
79	Equipment Washing Building
80	Soda Ash Silo
83	HDS Storage Tanks
75	ACM & LBP
81	Rodeo Tank (near METG Office)

FIGURE 1-3
Phase 3 Demolition Activities
Interim Measures Work Plan–2015/2016
East Helena, Montana

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SECTION 2

Overview of Proposed 2015 and 2016 Interim Measures Implementation

This section provides an overview of the next phases of IM activities proposed for implementation in 2015 and 2016. Engineering details for the work summarized in this section are provided in Section 5.

2.1 South Plant Hydraulic Control Interim Measure: Prickly Pear Creek Realignment

The next phase of the SPHC IM proposed for construction in 2015 and 2016 is the PPC Realignment. The PPC Temporary Bypass will remain in service to allow for concurrent operation and protection of the completed PPC Realignment. This section describes proposed activities.

Activities proposed in 2015 and 2016 are the excavation and construction of portions of the PPC Realignment as shown in **Figure 1-1**, completion of the PPC Realignment as shown in **Figure 1-2**, and establishment of wetlands, including vegetation of the PPC Realignment channel bank and floodplain, to replace those affected by IM activities.

2.1.1 PPC Realignment

Objectives. The objectives of the PPC Realignment are as follows:

- Further reduce groundwater levels beneath the southern portion of the former Smelter site by 1 to 2 feet in the South Plant area and an additional foot beneath the former Acid Plant area.
- Eliminate further undercutting of the eastern edge of the slag pile by moving the PPC channel 100 to 300 feet to the east of the toe of the slag pile.

Description. Activities proposed in 2015 as part of the PPC Realignment include excavation and backfill in the southern segment of the project area, west of the present stream channel (**Figure 2-1**). Material excavated from the southern segment of the project area will be placed on the main plant site as a portion of the ICS 2. Material will also be excavated from the East Bench east of the slag pile in the northern segment, below Smelter Dam **(Figure 2-1**). This excavated material will be used as streambed and floodplain substrate to replace the sandy material accumulated in the southern segment through the former Upper Lake Complex. Channel and floodplain features will be excavated and constructed generally as shown on the drawings provided in Appendix A. The stream will remain in the PPC Temporary Bypass channel around the southern segment and in the existing channel through the northern segment for the duration of the 2015 construction season. A berm will be constructed in the northern segment to isolate the existing channel from excavation activities.

In 2016, excavation and channel and floodplain construction will be completed in both the northern and southern segments, including regrading of the former TPA and Lower Lake area **(Figure 2-2**). When ready, the stream north of Smelter Dam will be rerouted into the new PPC channel, allowing for excavation and backfilling adjacent to the slag pile **(Figure 2-2**). The temporary bridge previously installed across Smelter Dam will be reset to allow for transport of excavated materials across the new PPC channel to be used in construction of the ET Cover System. An inlet structure to regulate flows into the southern end of the new PPC channel will be constructed near the present PPC Temporary Bypass channel inlet. Once all segments of the PPC channel are ready to receive water, flows will be diverted into the new channel through the southern segment and the remaining edges of the floodplain will be completed.

2.1.2 Wetlands Establishment

Objectives. The wetlands proposed as part of the PPC Realignment are designed to provide habitat restoration or replacement to at least a 1:1 ratio (impacted to mitigated) to comply with natural resource protection permitting requirements for remediation work. The wetlands are designed to provide mitigation for wetlands disturbed by the IMs being implemented. Under the monitoring and maintenance plan included in the Joint Application No. 2 (see Section 7.2.1), routine inspections will occur for at least 10 years to ensure compliance with the 1:1 ratio requirement.

Description. More than 42 acres of jurisdictional wetlands impacted by the PPC Realignment will be replaced with approximately 48 acres of similar habitat (constructed wetlands). Approximately 18 of the constructed acres will be classified as submergent/emergent habitat type and approximately 24 acres will be classified as scrub-shrub (sapling/shrub stratum). **Figure 2-3** shows the designed replacement wetlands.

Technical Evaluation. The PPC Realignment design basis documents provide a comprehensive summary of the calculations, memorandums, and reports used to develop the design and specifications of the PPC Realignment and wetlands establishment (Pioneer Technical Services, 2014). Evaluations have included stream assessments, design criteria calculations, analyses of sediment transport, construction sequencing, bypass usage, slag pile options, wetland delineations, wildlife documentation, sediment transport analyses, and plant salvage options. A list of the available documents used in the design basis is provided in Appendix A; electronic copies of the documents are available on request.

2.2 ET Cover System Interim Measure: Interim Cover System 2 and ET Cover East and West Construction

The next phase of the ET Cover System IM proposed for construction in 2015 and 2016 includes demolition of remaining structures and construction of the remaining components of the ET Cover System. Modification of the monitoring well network is proposed to decommission or protect existing wells located within the ET Cover System footprint.

2.2.1 Proposed Activities

Activities proposed in 2015 and 2016 are Phase 3 demolition, construction of the ICS 2, and construction of the ET Cover West and East over the foundation layers provided by the ICSs 1 and 2.

2.2.1.1 Phase 3 Demolition

The buildings, structures, utilities, and other features proposed for demolition are shown in **Figure 1-3** and summarized in Section 5.2.2. Activities for 2015 are proposed to remove remaining infrastructure (building, structures, debris, and utilities) within the ICS 2 while providing continuous functionality and vehicle access to the onsite HDS WTP (through 2016, or longer if needed), groundwater monitoring, and asset recovery operations at the slag pile. The building, structures, and utilities in the footprint will be removed by a qualified demolition subcontractor except for the overhead 69-kV power line, associated poles, and substation, which NWE will remove and relocate to a new alignment in coordination with ICS 2. In 2016, all remaining infrastructure within the ET Cover East footprint will be demolished. As proposed in 2015, functionality and vehicle access for groundwater monitoring and asset recovery operations at the slag pile will be maintained during construction and after 2016 construction is complete.

Objectives. The objective of this work is to remove utilities and infrastructure that interfere with the location of the ICS 2 and ET Cover East on the former Smelter site. The work will be sequenced and controlled to remove the features in support of the ICS 2 and ET Cover East construction activities and allow continued operation of the HDS WTP through 2016, or longer if needed, while preventing stormwater and associated sediment from running offsite.

Description. Demolition of currently remaining facilities, buildings, structures, and utilities located within the ET Cover East footprint will be performed in phases to support construction of the ICS 2 and ET Cover East. Under the current schedule, the HDS WTP will remain operational until mid-2016, when its removal will be necessary to complete the ET Cover East. Demolition debris such as broken concrete, pavements, and brick, will be placed in the ICS 2. Suitable materials will be sent to recycling facilities. Remaining demolition debris will be disposed of offsite at appropriate facilities, depending on the nature of the waste.

Technical Evaluations. Technical requirements for demolition include sequencing activities, categorizing waste as recycled (requiring offsite disposal) or appropriate for disposal under the ET Cover System IM, establishing management, transportation, and disposal protocols for each waste type, managing stormwater, and establishing abandonment guidelines for underground utilities.

NWE is coordinating with the Custodial Trust to decommission and demolish the substation and to relocate the 69-kV transmission line. These engineering evaluations for substation demolition and 69-kV transmission line relocation will address removal, cleanup, and line relocation. The relocated 69-kV line will follow the permanent perimeter road, which runs along the eastern border of ICS 2/ET Cover East. Construction of the ICS 2 will be coordinated with this relocation construction process.

2.2.1.2 ICS 2 Construction

The ICS 2 will consolidate and protectively manage materials excavated in 2015 from the PPC Realignment. These excavated materials will function as engineered fill within the ET Cover East footprint, and will be protected by a cap consisting of a temporary low-permeability soil cover and the biobarrier layer of the ET Cover East. **Figure 2-4** provides a cross-sectional view of the ICS 2. To allow continued access for construction personnel and ongoing activities, design of the ICS 2 includes an access road around the proposed footprint of the ET Cover East.

Objectives. The primary purpose of the ICS 2 is to protectively manage materials excavated during the PPC Realignment until the ET Cover East can be constructed. Objectives of the ICS 2 design are as follows:

- Allow the materials excavated by the PPC Realignment construction to be excavated and immediately consolidated within the Area of Contamination (AOC), minimizing the environmental considerations and costs of stockpiling and “double handling.”
- Establish grades to drain noncontact stormwater runoff to a new temporary infiltration basin on the former TPA.
- Provide a native soil cap on the fill to prevent stormwater from contacting contaminated soil. This action will eliminate the need to collect and treat stormwater from this portion of the site.
- Sequence access road construction to allow continued asset recovery from the slag pile and construction by NWE of a new, overhead, 69-kV transmission line along the road.
- Sequence construction to leave open the central corridor between the ICS 1 and the ICS 2, for potential use in implementing future Tier II source control measure/groundwater remedy actions, if any.
- Limit the extent of the ICS 2 to allow continued operation of the HDS WTP through 2016, or longer if needed.
- Accept the excess volume of soil that is expected to be generated by the PPC Realignment in 2015.

Description. As with the ICS 1, the ICS 2 will form the foundation layer, or subgrade, of the ET Cover East. The ICS 2 will cover the soil and sediment removed during the PPC Realignment and consolidated within the AOC, protectively managing them during the interim period between excavation and construction of the final layers of the ET Cover East. ICS 2 will allow “noncontact” stormwater runoff to be shed to offsite drainage structures. The proposed areal extent of ICS 2 is shown in **Figure 1-1**.

Technical Evaluations. Technical evaluations have been completed for the ET Cover System IM to evaluate whether the cover system meets remedy performance standards, and to provide background information needed in the ICS 2 design. In addition, information obtained from the following activities performed during the ICS 1 construction will be incorporated into the ICS 2 design:

- Developed the required volumetric fill capacity for the ICS 2 and the ET Cover System by analyzing the cut and fill balance. This included performing laboratory tests to assess the shrink and swell characteristics of borrow soil.
- Performed three-dimensional topographic modeling to develop the ICS 2 grading plans that provide the required volumetric fill capacity and slopes that meet requirements for stormwater management, slope stability, and erosion control.
- Performed slope stability analyses of the ICS 2 slopes to verify that finish grades have acceptable factors of safety against slope instability.
- Performed hydraulic analyses to size stormwater management structures for the ICS 2. Also performed erosion analyses to develop maximum and minimum slopes and armoring requirements.
- Evaluated existing infrastructure to select sequencing and extent of the ICS 2, as well as the need for temporary infrastructure to support Facility operations during construction.
- Evaluated implementation of quality control requirements from the ICS 1 construction to refine the ICS 2 quality control requirements.
- Conducted the ICS cover soil borrow source evaluations to define the physical and chemical properties of the soil sources.
- Completed drainage option analyses to identify the design elements needed for runoff management; the objective was to accommodate design flows from the ET Cover System while minimizing runoff contribution from the former Smelter site to adjacent Custodial Trust properties.
- Evaluated the moisture balance effects and potential impacts to groundwater of the ICS 2 during its interim functional time period.

2.2.1.3 ET Cover East and West Construction

In 2015, the ET Cover West will be placed over the foundation provided by the ICS 1. In 2016, the ET Cover East will be placed over the ICS 2 and central corridor. **Figure 2-4** provides a cross-sectional view of the ET Cover System, with details of the ICSs and the final ET Cover layers.

Objectives. Both the ET Cover East and West will be constructed to meet the same major objectives. In addition, the ET Cover East will include grading within the central corridor to accept the excess volume of soil that is expected to be generated by the PPC Realignment in 2016. The major objectives of the ET Cover East and West are as follows:

- Reduce the infiltration of precipitation and associated leaching of inorganic contaminants in surface soil to groundwater, which will further reduce the volume of contaminant mass being mobilized to groundwater and transported offsite.
- Replace the existing interim cover system.
- Reduce the volume of contaminated stormwater that is being collected and treated by the HDS WTP.
- Eliminate the potential for people and wildlife to have direct contact with contaminated surface soil.

Description. The ET Cover West will be placed over the existing biobarrier (the existing surface layer of the ICS 1), and consists of an amended storage/topsoil layer, storage layer, and capillary break layer. The ET Cover East will be completed over the ICS 2 and the central corridor by incorporating an amended storage layer/topsoil, storage layer, capillary break layer, and biobarrier layer over the central corridor fill and final layer planned over the ICS 2.

Technical Evaluations. Technical evaluations completed to design the ET Cover East and West are summarized as follows:

- Water balance modeling was conducted in 2012 and 2013 to establish the feasibility of the ET Cover System.
- Evaluated different cover options to conclude that the ET Cover System was the most cost-effective option for meeting performance objectives.
- Conducted a borrow-material investigation to locate and assess the physical and hydraulic properties of potential borrow soil. A second and more extensive borrow investigation was conducted in 2014 as part of the ET Cover System design.
- Evaluated borrow soil gradations, local animals, and similar ET cover systems to develop requirements for a biobarrier layer to inhibit bioturbation of burrowing animals.
- Performed hydraulic modeling in 2013 and 2014 to establish soil types and layer thicknesses used for design. In addition, used modeling to develop a conceptual plant community and alternative ET Cover cross-sections and layering systems.
- Conducted both water balance and hydraulic modeling to finalize the ET Cover section (soil types, soil characteristics, and layer thicknesses).
- Conducted Upper Lake Marsh (ULM) top soil sampling to assess the chemical characteristics of soil that would be used for the surface layer of the ET Cover System. This included performing laboratory and bench-scale tests to develop agronomic properties of surface soil layer required to establish a plant community.
- Calculated the volumetric fill capacity for the ET Cover System by analyzing the cut and fill balance. This included performing laboratory tests to assess the shrink and swell characteristics of borrow soil.
- Performed three-dimensional topographic modeling to develop ET Cover System grading plans that provide the required volumetric fill capacity and assure that slopes meet requirements for stormwater management, slope stability, and erosion control.
- Performed slope stability analyses of the ET Cover System slopes to verify that finish grades have acceptable factors of safety against slope instability.
- Performed hydraulic analyses to size stormwater management structures for the ET Cover System. Also performed erosion analyses to develop maximum and minimum slopes and armoring requirements.
- Evaluated similar ET cover system projects and USEPA guidance documents to develop detailed criteria for the design, construction, and operations and maintenance of the ET Cover System in 2014. In addition, the ET Cover East will incorporate technical specifications developed during the ET Cover West construction.

2.2.2 Monitoring Network Modification

Similar to work completed in 2014 for the ICS 1, the objective of this monitoring network modification is to decommission or protect existing wells that are located within the ET Cover East footprint. Wells that are necessary for future monitoring will be extended to be functional; wells that are not needed for future monitoring will be decommissioned. Experience gained from more than 30 years of monitoring and evaluation at the former Smelter site indicates that a number of wells have not been sampled in years or are no longer needed to provide an effective monitoring network. To evaluate wells for decommissioning or protection, historical and current groundwater monitoring data were reviewed with a focus on remedy performance standards (presented in the draft *Former ASARCO East Helena Facility Corrective Measures Study Work Plan 2013* (CH2M HILL, 2014b). The overall plan and strategy for monitoring the performance of the IMs and their effect on groundwater quality contamination will be developed as part of the final remedy selection.

One well located within the footprint of the Change House (Building 11) has been identified for abandonment. The well will be abandoned in accordance with Administrative Rule of Montana (ARM) 36.21.810.

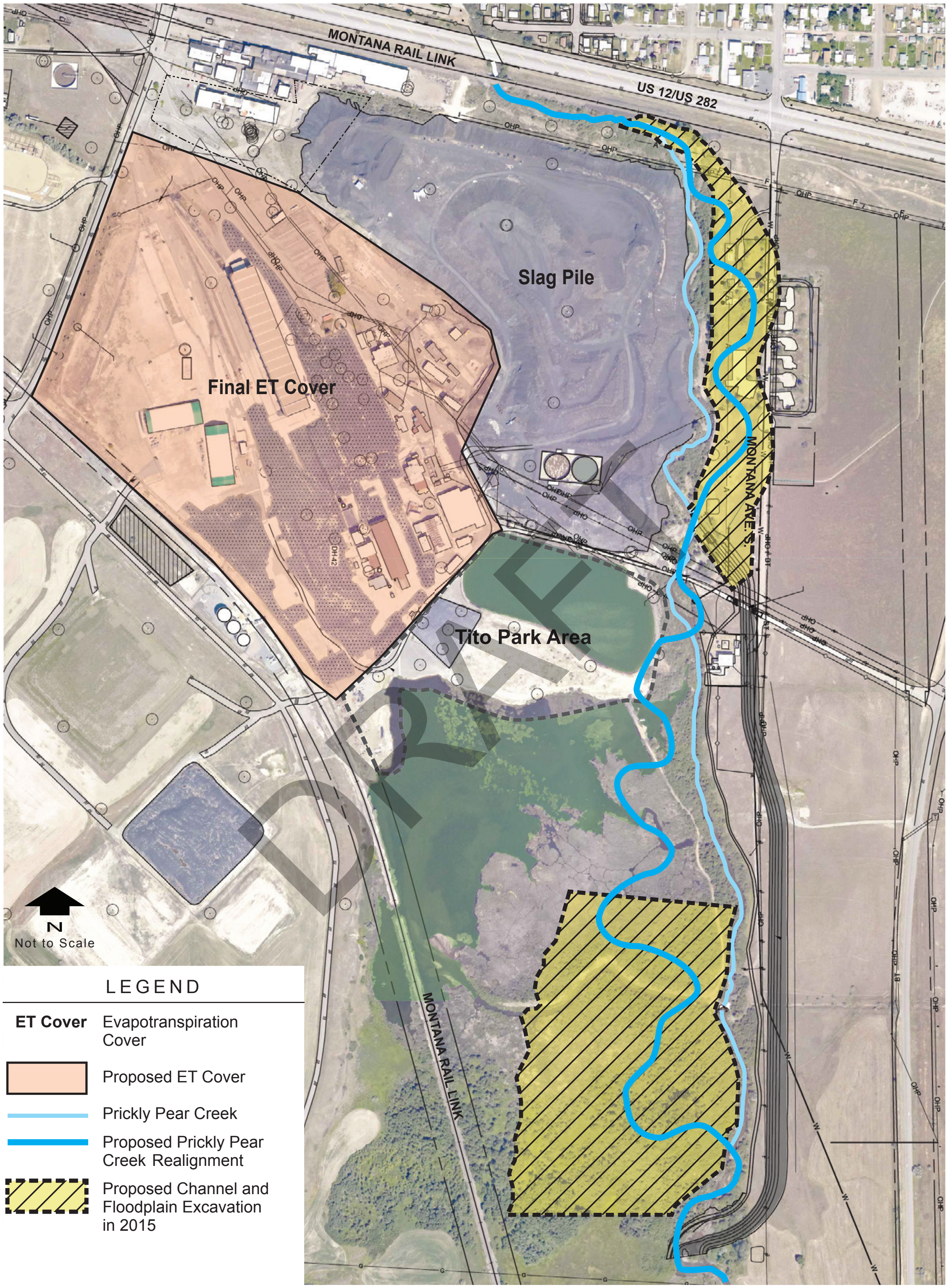


FIGURE 2-1
Channel and Floodplain Areas of Excavation Proposed in 2015
Interim Measures Work Plan–2015/2016
East Helena, Montana

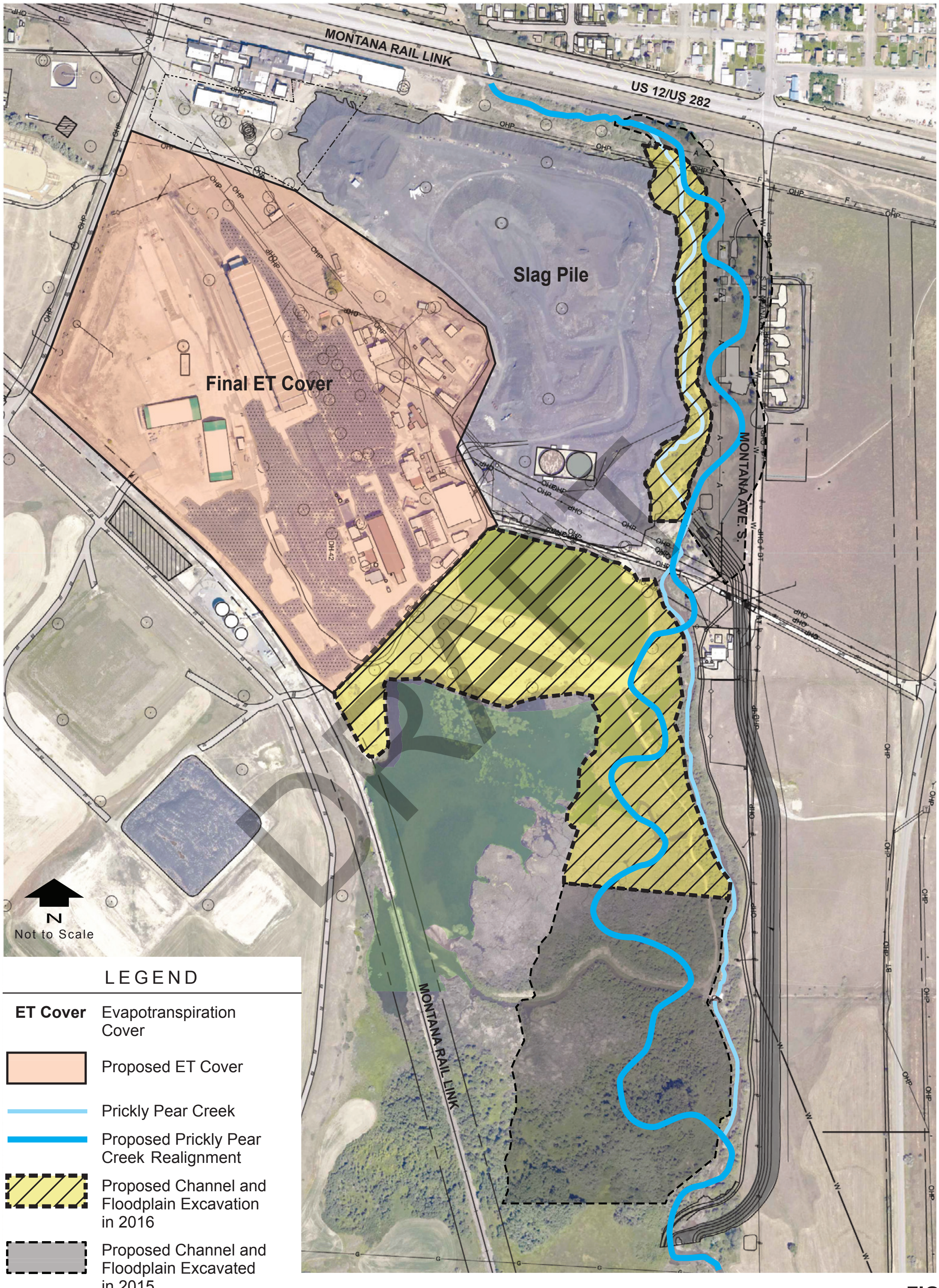
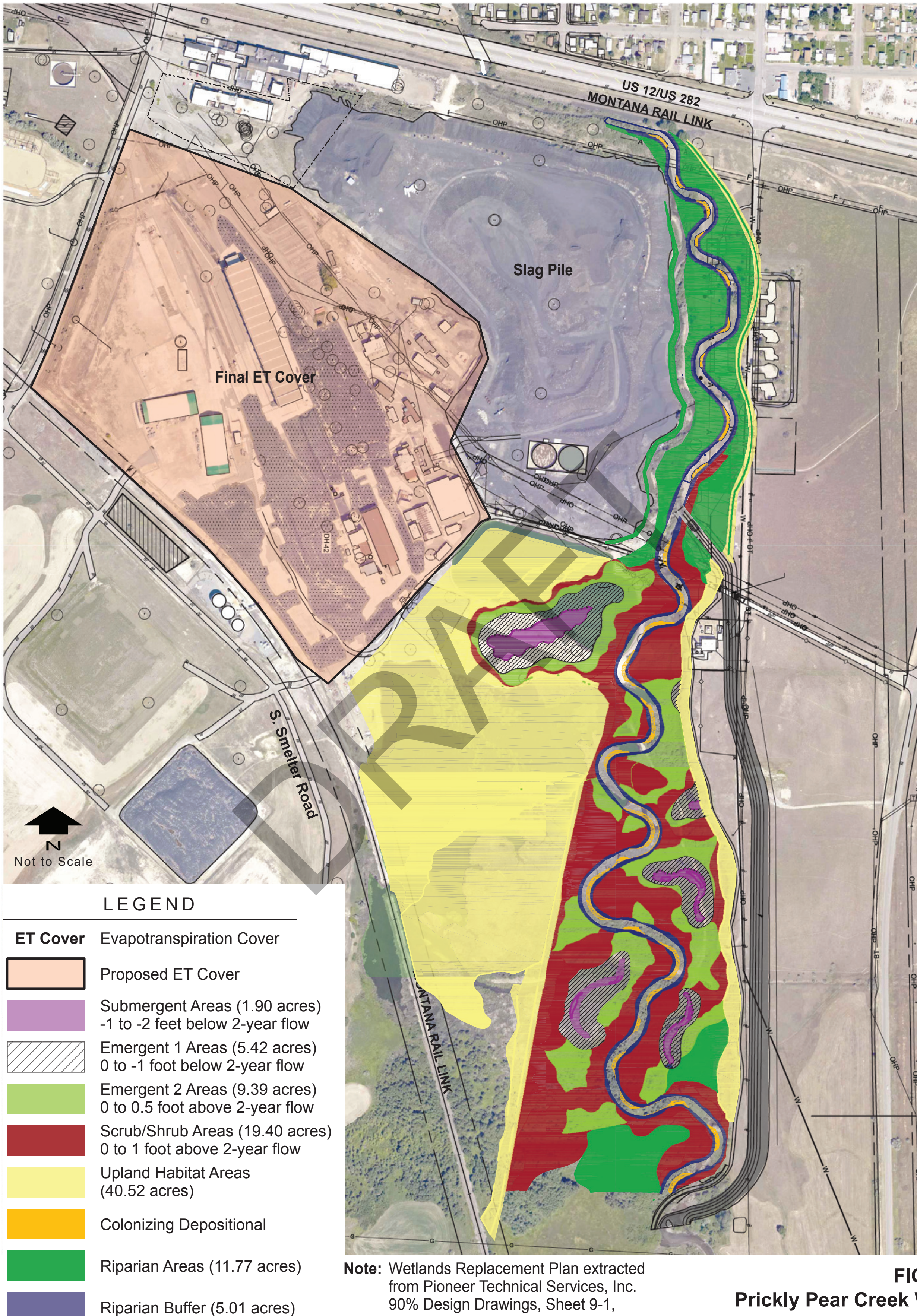
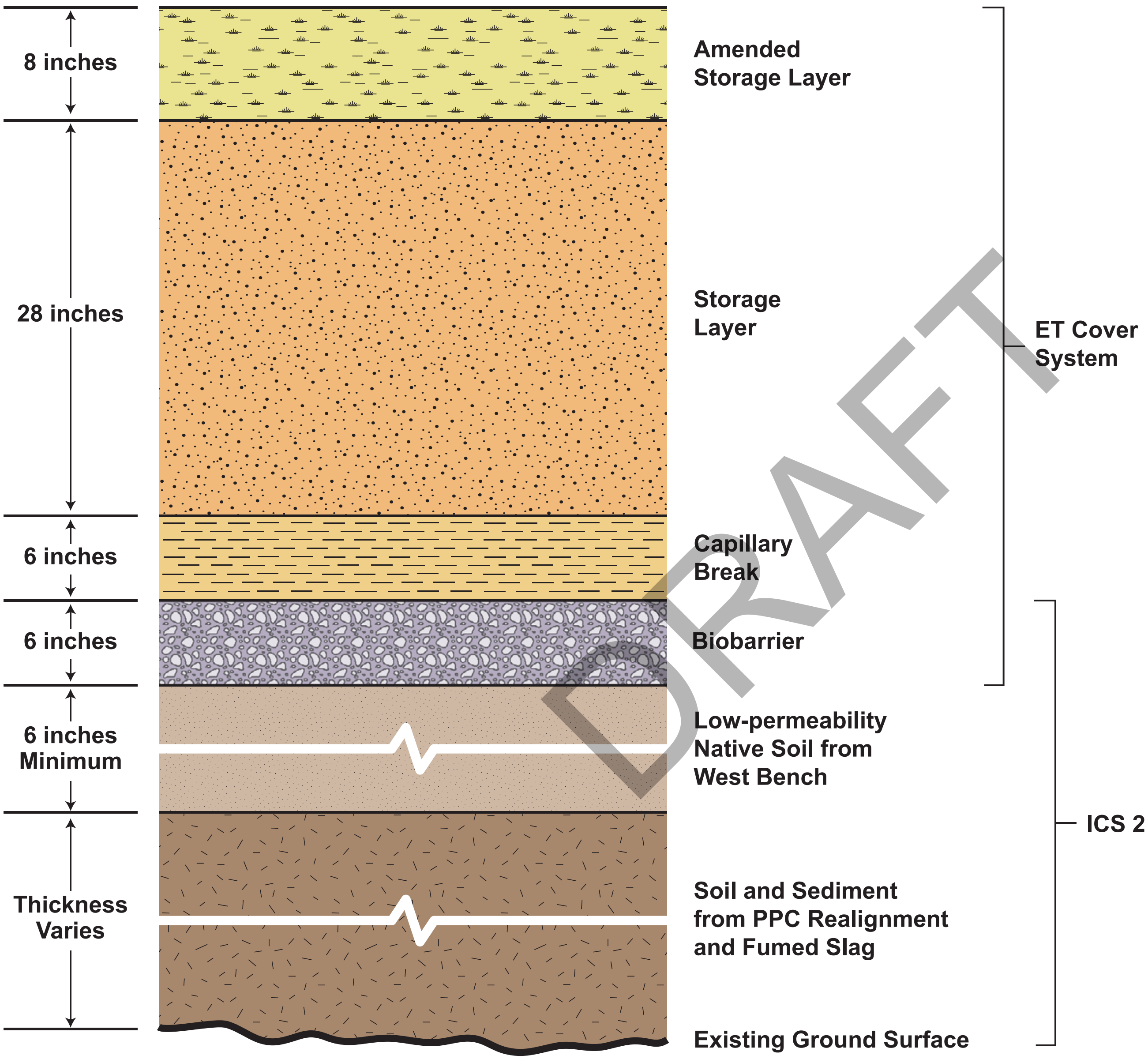


FIGURE 2-2
Channel and Floodplain Areas of Excavation Proposed in 2016
Interim Measures Work Plan–2015/2016
East Helena, Montana



Note: Wetlands Replacement Plan extracted from Pioneer Technical Services, Inc. 90% Design Drawings, Sheet 9-1, dated 10/1/14.

FIGURE 2-3
Prickly Pear Creek Wetlands Replacement Plan
Interim Measures Work Plan–2015/2016
East Helena, Montana



Notes:

1. The biobarrier is part of the ET Cover and will be installed during ICS 2 construction.
2. All the layer thicknesses for the ET Cover are estimated based on preliminary engineering and may change during final design.
3. An interim cover will not be underlain within the central corridor; therefore, the biobarrier will be installed with the ET Cover.

ET = Evapotranspiration
ICS = Interim Cover System
PPC = Prickly Pear Creek

FIGURE 2-4
ET Cover and Interim Cover System 2 Cross-Section
Interim Measures Work Plan–2015/2016
East Helena, Montana

SECTION 3

Updated Conceptual Site Model

This section provides updates to those portions of former Smelter site CSMs presented in earlier documents (e.g., the IM Work Plan 2012, IM Work Plan 2013, IM Work Plan 2014, and Phase II RFI) that are relevant to the work proposed in 2015 and 2016. This section is not intended to repeat earlier published materials but draws on those materials to provide the reader the appropriate context.

3.1 Groundwater Levels

Groundwater levels are an important component of the IM implementation at the former Smelter site for two reasons. First, groundwater elevations are a key consideration in planning and design of the PPC Realignment. Vertical alignment of the new PPC channel with the local groundwater table is critical for construction and proper long-term functioning of the realigned creek. Second, groundwater levels at the former Smelter site determine, in part, the interaction of groundwater with contaminated soil, and subsequent contaminant leaching to groundwater. The following three IM phases implemented to date have lowered groundwater elevations:

- Initiation of Upper Lake dewatering and elimination of Wilson Ditch flow as of November 1, 2011
- Diversion of the PPC through the PPC Temporary Bypass channel on October 29, 2013, effectively lowering the creek stage by up to 12 feet
- Active dewatering of Lower Lake beginning in May 2014 as part of the TPA removal action

Following is a discussion of current groundwater conditions in the ULM and main plant site areas where 2015 and 2016 IM phases are proposed.

3.1.1 Upper Lake Marsh Area Groundwater Levels

Before fall 2011, the ULM area was largely flooded year-round because of the diversion of PPC to Upper Lake. In November 2011, the Custodial Trust commenced the initial phase of the SPHC IM by dewatering Upper Lake and the associated marsh, eliminating the diversion of PPC to Upper Lake, and initiating active pumping (Hydrometrics, 2012). Surface water level monitoring in the ULM area conducted in advance of Upper Lake dewatering consisted of monitoring the lake level itself. Once Upper Lake was sufficiently drained, a number of piezometers were installed to allow for monitoring of groundwater levels as well. **Figure 3-1** shows the ULM area groundwater-level monitoring network.

Figure 3-2 shows groundwater and surface water level trends in the ULM area since August 2011, about 3 months before the start of Upper Lake dewatering. As shown in the figure, the surface water level in Upper Lake fell about 2.5 feet immediately after Upper Lake dewatering was initiated (November 1, 2011), causing groundwater levels to subsequently decline across the main plant site (Section 3.1.2). The lake level declined a total of 4.1 feet between October 2011 and October 2013.

On October 29, 2013, PPC was diverted through the PPC Temporary Bypass channel. As a result of this diversion, groundwater levels in the ULM area declined further. From October 22, 2013, to December 2, 2013, before seasonal effects on groundwater levels would be noted, declines in groundwater levels ranged from 0.5 to 2.5 feet and averaged 1.4 feet. As expected, declines were greatest in the northeastern portion of the ULM near PPC and least in the southwestern portion, farthest from PPC.

Although a partial rebound in groundwater levels in May 2014 because of spring runoff (**Figure 3-2**), active dewatering of Lower Lake conducted as part of the TPA removal action resulted in further groundwater-level declines. Groundwater levels in the ULM area declined from 0.7 to 2.2 feet between May 1, 2014, and October 22, 2014, with an average decline of 1.5 feet.

Overall, groundwater-level declines in the ULM area range from 0.07 foot at PPCRPZ-7 to 8.58 feet at PPCRPZ-1 (**Figure 3-1**), and average 4.0 feet between October 2011 and October 2014 (**Table 3-1**). Further declines on the order of 1 to 2 feet in the north ULM area (north of the former Upper Lake inlet channel) are anticipated following completion of the PPC Realignment. The realigned PPC is expected to have minimal effect on groundwater levels south of the inlet channel.

TABLE 3-1
Upper Lake Marsh Area Groundwater-Level Response to Completed Interim Measures
Interim Measures Work Plan 2015/2016

Site	Upper Lake Dewatering 10/31/11-10/22/13	Prickly Pear Creek Diversion 10/22/13-12/13/13	Lower Lake/TPA Dewatering 5/1/14-10/14/14	Total Water Level Decline 10/31/11 – 10/14/14
PPCRPZ-1	4.46	2.52	1.41	8.58
PPCRPZ-2	3.98	1.79	1.60	7.53
PPCRPZ-3	4.00	1.37	1.17	6.58
PPCRPZ-4	3.52	1.02	1.42	5.67
PPCRPZ-5	0.46	0.84	2.19	2.51
PPCRPZ-6	-1.40	0.64	1.97	0.49
PPCRPZ-7	-2.32	1.30	1.66	0.07
ULMPZ-1	4.14	-0.08	4.87	10.71
ULMPZ-2	1.16	-0.07	0.73	1.82

Notes:

TPA = Tito Park Area

Total water level declines based on Upper Lake stage of 3,920.46 feet on October 20, 2011.

Monitoring locations are shown in **Figure 3-1**.

Negative values indicate water level rise.

3.1.2 Main Plant Site Groundwater Levels

Similar to the ULM, groundwater levels at the main plant site have been influenced by the SPHC IM and TPA removal action. **Figure 3-3** shows groundwater-level trends for select monitoring wells across the southern and western portions of the main plant site where the PPC Realignment and ET Cover System are planned. As described above for the ULM area, water levels in these areas have been closely monitored since initiation of Upper Lake dewatering in November 2011, with monitoring continuing to date. Well locations are shown in **Figure 3-1**.

As shown in **Figure 3-3**, groundwater levels throughout most of the South Plant area responded to the November 2011 dewatering of Upper Lake. Lower Lake and well DH-20 both showed an immediate decline in water levels in response to the Upper Lake dewatering, while well APSD-8, located adjacent to and influenced more by PPC, showed a delayed response. Overall, water level declines in the South Plant area resulting from dewatering of Upper Lake and before the diversion of PPC through the PPC Bypass channel averaged about 2 feet (**Table 3-2**). Water level declines during this same period averaged about 2.6 feet in the former Acid Plant area and 5 feet further downgradient in the northwestern portion of the main plant site. The larger water level declines in the northwestern portion of the main plant site are attributable primarily to the elimination of flow in nearby Wilson Ditch.

TABLE 3-2
South and West Plant Site Groundwater-Level Response to Completed Interim Measures
Interim Measures Work Plan 2015/2016

Site	Upper Lake Dewatering 10/31/11-10/22/13	Prickly Pear Creek Diversion 10/22/13-12/13/13	Lower Lake/TPA Dewatering 5/1/14-10/14/14	Total Water Level Decline 10/31/11 – 10/14/14
South Plant Area				
Lower Lake	2.56	1.64	3.71	9.18
APSD-8	2.73	0.88	2.173	6.08
DH-20	0.52	3.55	0.53	5.74
Average	**1.94**	**2.02**	**2.14**	**7.00**
Former Acid Plant Area				
DH-19R	2.40	0.91	1.13	4.97
DH-42	2.54	0.92	0.92	5.13
DH-71	2.92	0.92	0.836	5.53
Average	**2.62**	**0.92**	**0.96**	**5.21**
Northwest Plant Site				
DH-17	4.91	1.21	-0.9	5.55
DH-66	5.36	1.24	-0.96	5.95
DH-51	4.78	1.25	-0.91	5.24
DH-49	5.32	1.28	-1.03	5.63
Average	**5.09**	**1.24**	**-0.95**	**5.59**

Notes:

TPA = Tito Park Area

Total water level declines based on Upper Lake stage of 3,920.46 feet on October 20, 2011.

Monitoring locations are shown in Figure 3-1.

In response to the October 29, 2013, diversion of PPC to the PPC Temporary Bypass channel, groundwater levels declined further throughout the southern and western portions of the main plant site. South Plant area groundwater levels declined about 2 feet on average, former Acid Plant area levels declined about 0.9 foot and levels in the northwestern portion of the main plant site declined about 1.2 feet between October 15, 2013, and December 13, 2013. Water level trends in response to the dewatering of Lower Lake for the TPA removal action include 2.1- and 1.0-foot declines in the South Plant area and former Acid Plant areas, respectively, and an approximate 1-foot rise in the northwestern portion of the main plant site. The approximate 1-foot rise noted in the northwestern portion of the main plant site suggests that water levels in that area may have reached a post-SPHC IM equilibrium. Overall average water level changes since Upper Lake dewatering began in November 2011 are 7.0 feet in the South Plant area, 5.2 feet in the former Acid Plant area, and 5.6 feet in the northwestern portion of the main plant site, the latter is attributed mainly to the lack of flow in Wilson Ditch (**Table 3-2**). Further groundwater declines of 1 to 2 feet in the South Plant area and up to 1 foot in the former Acid Plant area are anticipated to occur in response to the PPC Realignment; no additional decline is anticipated in the northwestern portion of the main plant site.

3.2 Arsenic and Selenium in Groundwater

The status of the arsenic and selenium groundwater plumes has been updated using the latest comprehensive groundwater monitoring data from June 2014. Based on numerous investigations, arsenic and selenium have been identified as the primary chemicals of concern in groundwater and their plumes extend farthest beyond the former Smelter site boundary. As such, this discussion summarizes the changes in the arsenic and selenium plumes.

The current understanding of the arsenic groundwater plume is shown in **Figure 3-4**. Although arsenic concentrations in the center of plume have shown varying trends, the overall extent of the plume, as defined by a concentration of 0.010-milligram per liter (mg/L) (corresponds to the USEPA maximum contaminant level [MCL] for arsenic in groundwater), has not changed significantly in nearly 10 years. This indicates a stable plume, with no current evidence of plume advancement. However, remedial actions on the former Smelter site, including slurry wall construction and implementation of IMs, have resulted in contraction of the higher concentration portions of the arsenic plume. In 2002, arsenic concentrations in excess of 10 mg/L were common throughout the former Smelter site, extending from the South Plant area (former Acid Plant area) northward into East Helena. Recently, the greater-than-10 mg/L arsenic plume boundary has contracted in some areas, and now consists of more isolated areas within the former Smelter site, and an area extending into East Helena. In particular, decreases in arsenic are noted at some wells in the former Acid Plant area, which is located immediately downgradient of the TPA removal area and where the SPHC IM has the greatest beneficial effect. At well DH-30, arsenic concentrations have decreased from about 15 mg/L in 2011 (pre-SPHC IM implementation) to about 6 mg/L and well DH-47 shows a slight decrease in arsenic concentration.

The current configuration of the selenium groundwater plume is shown in **Figure 3-5**. Key changes noted in selenium concentrations include reductions in some wells in the south part of the former Smelter site, including the Acid Plant area. Well DH-71 reported pre-SPHC IM concentrations of selenium ranging from about 0.1 to 0.25 mg/L that have decreased to consistent concentrations near 0.05 mg/L (corresponds to the USEPA MCL for selenium in groundwater). Selenium concentrations are also decreasing in well DH-30.

A westward shift observed in both the arsenic and selenium plumes since 2011 is attributable to the SPHC IM. The selenium plume indicates an approximate 20-degree shift to the west. Previously, this plume (and the arsenic plume located just to the east) would shift slightly to the east during the fall, presumably because of leaking of water in Wilson Ditch to groundwater, then back toward the west after flow in the ditch ceased. Groundwater-level changes driven by the SPHC IM, particularly the absence of water in Wilson Ditch and the associated lack of leakage recharging groundwater during the irrigation season, have resulted in the slight shift of the plumes to the west.

As noted above, the most evident effects of the SPHC IM have been (1) ongoing contraction of higher concentration portions of the plumes in some areas of the former Smelter site, also reflecting the continued effects of previous remedial actions, and (2) a shift in selenium and (to a lesser extent) arsenic plume migration direction to the west. Because the SPHC IM has been implemented in stages over the last several years, it is likely that the groundwater flow and geochemical systems remain in a state of change, and that additional time and monitoring will be necessary to fully evaluate the water quality responses at the former Smelter site and downgradient locations.

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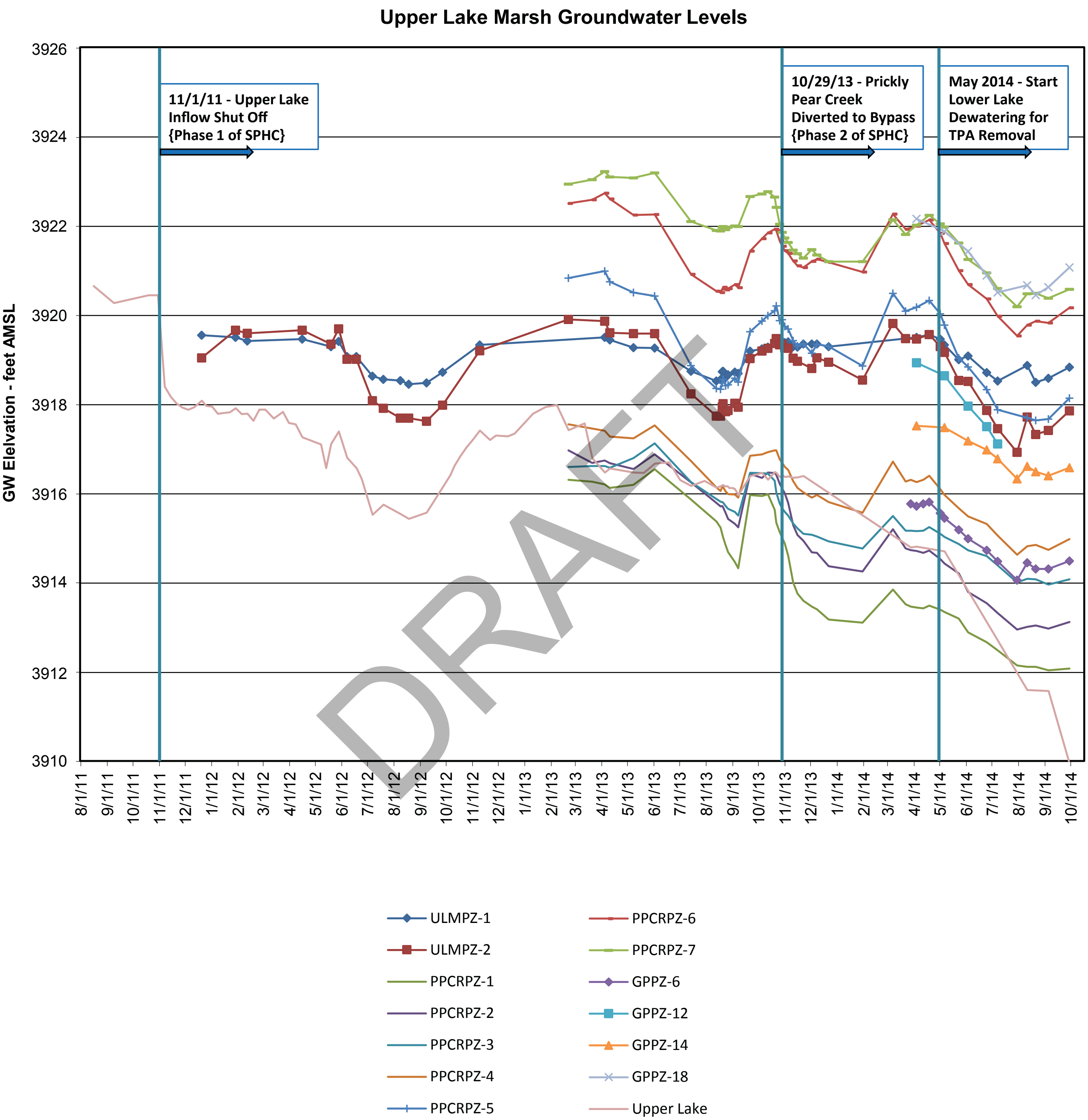
Hydrometrics, Inc.
Consulting Scientists and Engineers

LEGEND

- Groundwater Level Monitoring Well
- Existing Site Well

Note: This figure was prepared by Hydrometrics, Inc., 2014.

Figure 3-1
Plant Site Area Monitoring Wells/Piezometers
Interim Measures Work Plan–2015/2016
East Helena, Montana



Hydrometrics, Inc.
Consulting Scientists and Engineers

Note:
This figure was prepared by
Hydrometrics, Inc., 2014.

FIGURE 3-2
Groundwater Elevation Trends in Upper Lake Marsh
Interim Measures Work Plan–2015/2016
East Helena, Montana

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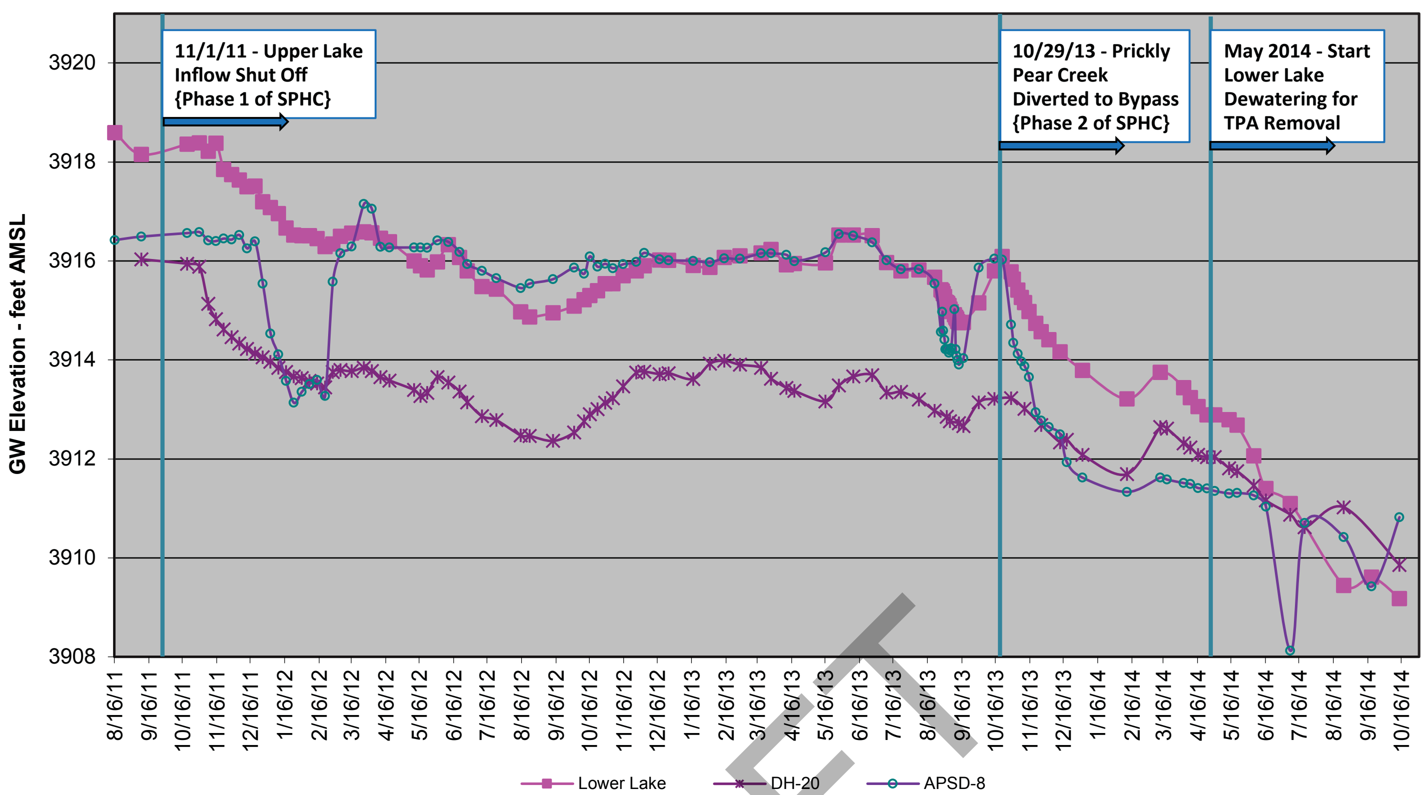
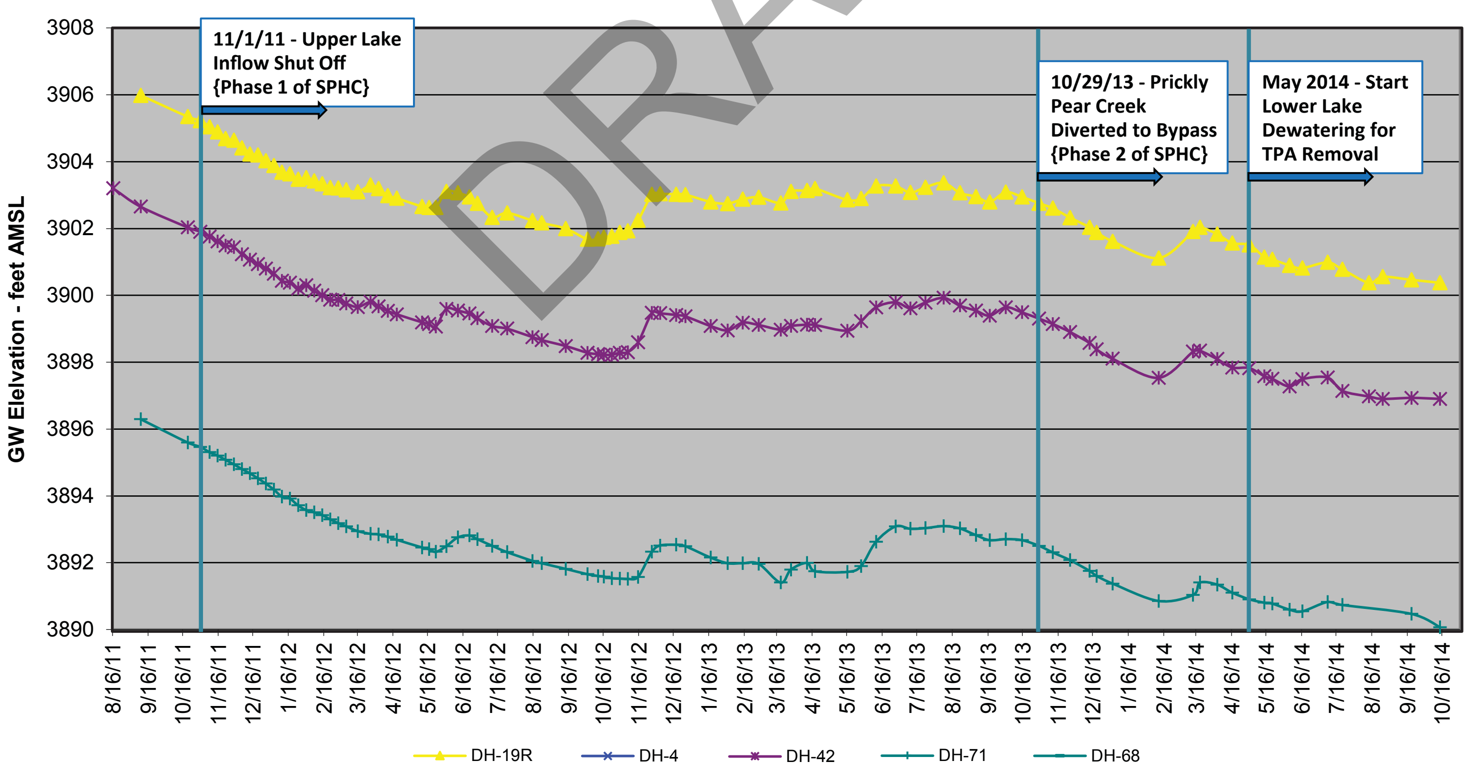
South Zone Groundwater Levels



Acid Plant Area Groundwater Levels



Hydrometrics, Inc.
Consulting Scientists and Engineers

Note:
This figure was prepared by Hydrometrics, Inc., 2014.

FIGURE 3-3
Groundwater Elevation Trends in Plant Site Wells
Interim Measures Work Plan–2015/2016
East Helena, Montana

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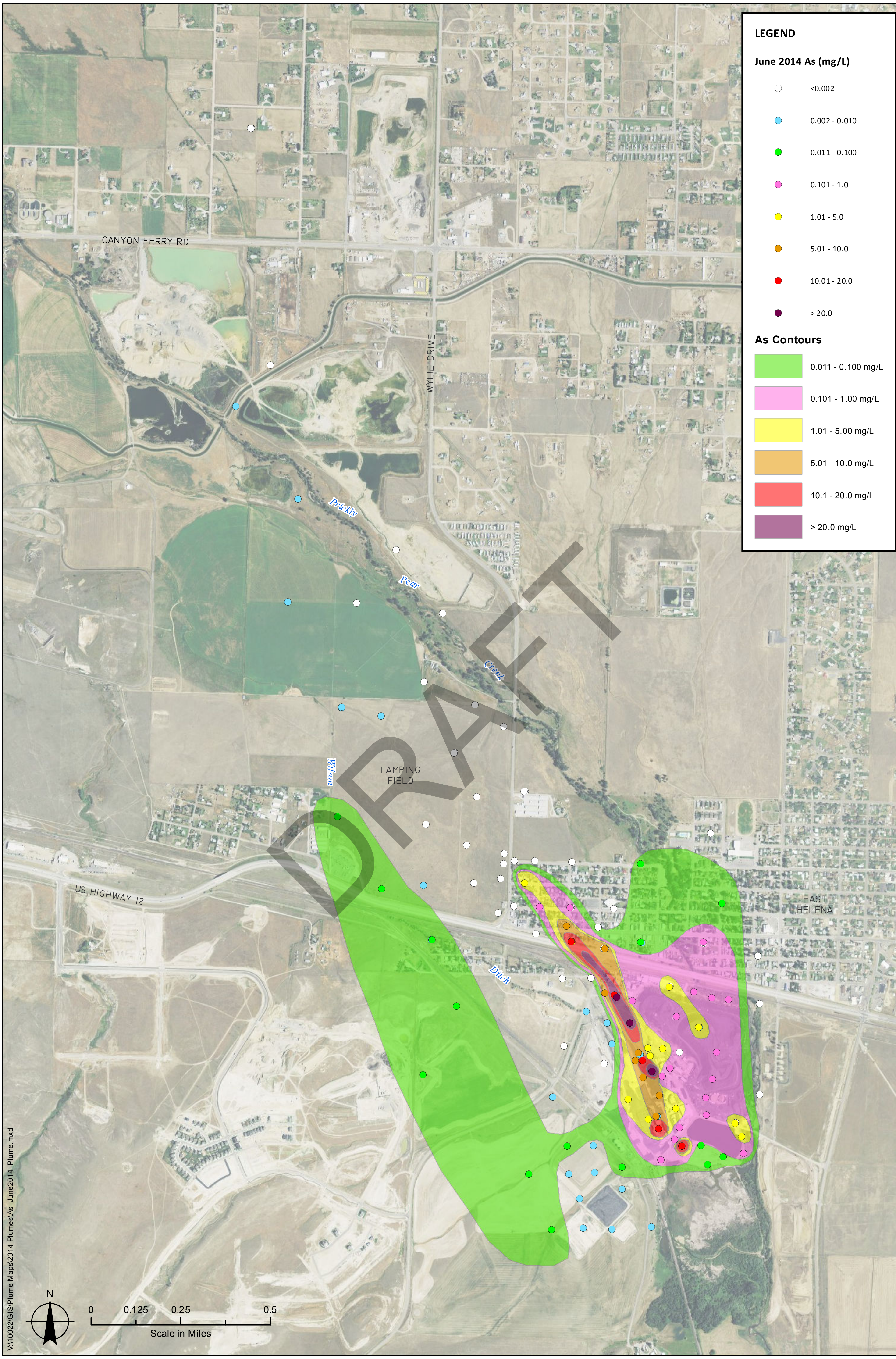

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Note:
This figure was prepared by Hydrometrics, Inc. as part of the "Former East Helena Smelter Groundwater Status Report" (December, 2014).

FIGURE 3-4
June 2014 Dissolved Arsenic Plume
Interim Measures Work Plan–2015/2016
East Helena, Montana

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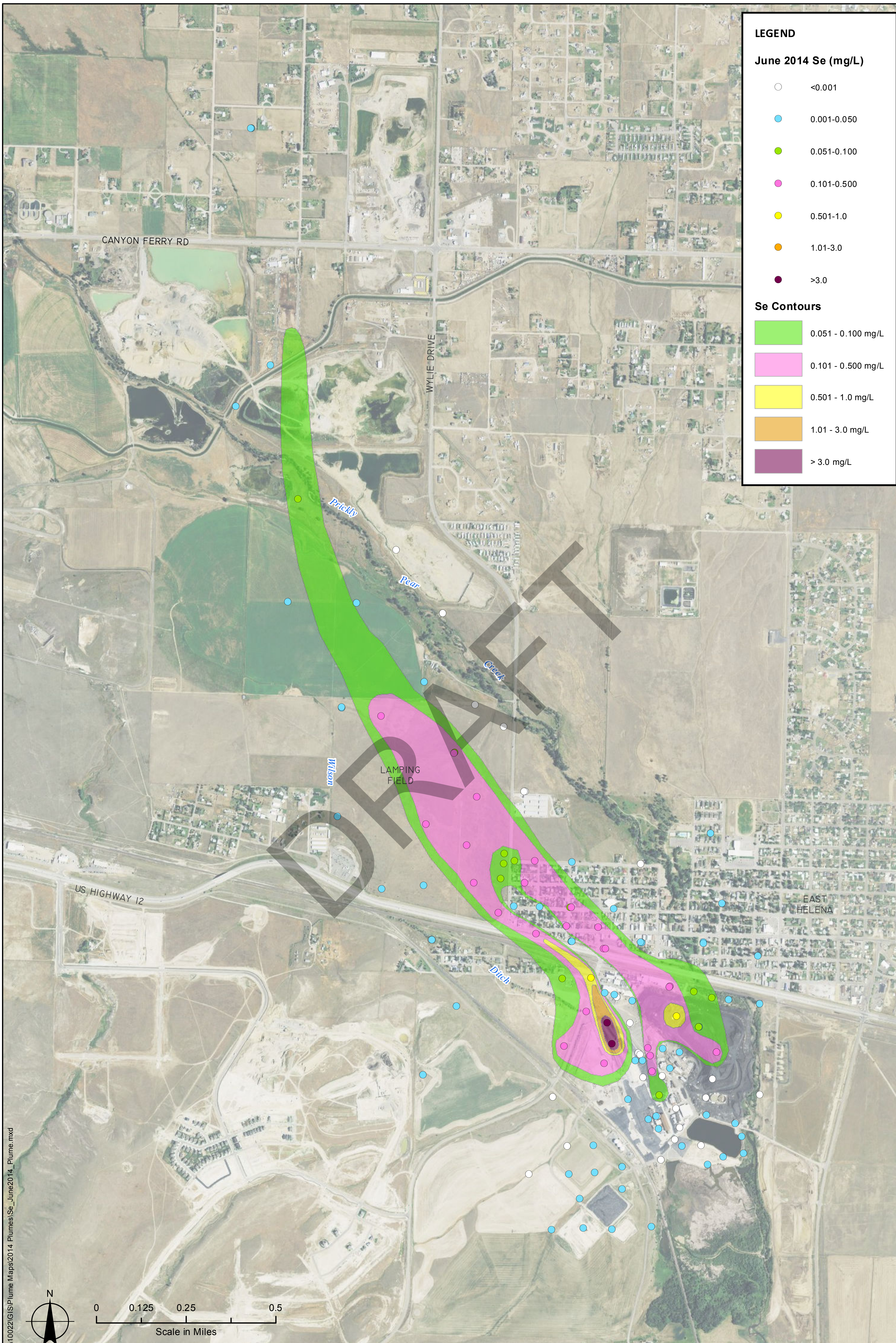

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Consulting Scientists and Engineers

Note:
This figure was prepared by Hydrometrics, Inc. as part of the "Former East Helena Smelter Groundwater Status Report" (December, 2014).

FIGURE 3-5
June 2014 Dissolved Selenium Plume
Interim Measures Work Plan–2015/2016
East Helena, Montana

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SECTION 4

Data Sufficiency

Data developed to date are sufficient to support the conceptual development of the IMs and design of the projects proposed for implementation in 2015 and 2016. Included in this section are a summary of existing data and potential data needs for the proposed work.

4.1 Summary of Existing Data

A variety of data have been used to evaluate, design, and construct the work described in this IM Work Plan 2015/2016. The summary data collected and incorporated into one or more IMs were originally presented in the IM Work Plan 2012 and updated in the subsequent IM Work Plans. Updates relevant to the proposed 2015 and 2016 work incorporate information collected and completed through November 2014. Updates are summarized as follows:

- Hydrogeology—Ongoing. Significant investigations over the last 20 years have contributed to a thorough understanding of groundwater conditions at the former Smelter site and offsite areas. This understanding will continue to be refined based on the results of routine (generally quarterly and semiannual) monitoring by the Custodial Trust, as summarized in the Corrective Action Monitoring Plan (CAMP; Hydrometrics, 2014). Available data collected during 2014 have been incorporated as appropriate into the IM designs, as will results of ongoing groundwater monitoring. Actual field results were used to continue calibrating the coupled groundwater flow and fate and transport (F&T) model. Groundwater sampling will continue on a routine basis pursuant to the CAMP.
- Groundwater Flow Model—Ongoing. The groundwater flow model initially was used to predict the performance of the SPHC IM (NewFields, 2013). The flow model simulates changes in hydrologic conditions over time to predict the efficacy of the SPHC IM at different operational stages: when the PPC Temporary Bypass was completed, when the northern segment of the PPC Realignment is completed, and when the PPC Realignment is completed in its entirety. Actual groundwater elevation data collected after the PPC Temporary Bypass was completed were used to update the predicted performance of the SPHC IM (NewFields, 2014). To further refine the flow model, additional groundwater elevation data will be collected when the northern segment of the PPC Realignment is completed and the PPC Realignment is completed in its entirety.
- Groundwater F&T Model—Ongoing. The groundwater F&T model will be used to predict the performance of the IMs in terms of their effects on the arsenic and selenium plumes. The F&T model will simulate the current extent of the arsenic and selenium plumes. To support project planning, design, and management, the calibrated model will evaluate predicted effects of planned IMs on groundwater chemistry.
- Stream flow—Completed. Flow calculations were summarized in the *PPC Realignment Design Basis Documentation* and in the Conditional Letter of Map Revision (CLOMR) permit applications submitted to the Federal Emergency Management Agency (FEMA) for the PPC Temporary Bypass and PPC Realignment floodplain permits. The data are published in the *PPC Realignment Channel Stability Analysis and Engineering Design Report* (Pioneer Technical Services, 2013).
- Soil chemistry—Ongoing. Data are summarized in the Phase II RFI.
  - Additional test pits were excavated in the former Lower Ore Storage Area in the fall of 2012. Soil chemistry data from the test pits were compiled and input into the project environmental database.
  - Soil chemistry data available as of April 2014 were compiled into a soil contaminant distribution model constructed using Mining Visualization System software.

- Shallow soil samples from ULM were collected in July 2014. Additional soil samples from the ULM were collected in November 2014 and will be integrated into the designs of the PPC Realignment, the ICS 2, and the ET Cover East and West.
- Soil borings were advanced in September 2014 as part of source area investigations to augment the understanding of subsurface conditions, mostly beneath process areas and suspected source areas of the former Smelter site.
- Soil samples of the TPA removal area (includes Tito Park, UOSA, and Lower Lake) surfaces were collected between September and October 2014. The soil chemistry will be integrated into the designs of the PPC Realignment.

- Groundwater chemistry—Ongoing. The Phase II RFI summarizes work conducted through 2010. Groundwater monitoring pursuant to the annual Field Sampling and Analysis Plan (Hydrometrics, 2013b) provided updated information.
- Stormwater flows, chemistry, and discharge data—Ongoing. Data are available from former Smelter site personnel operating the HDS WTP, data collected as required under the Montana Pollutant Discharge Elimination System (MPDES) permit, and stormwater permits.
- Utility types and locations—Completed. Existing utility drawings and underground utility information obtained by the Custodial Trust have been used to identify and locate as many underground utilities as possible.
- Structures—Completed. ASARCO engineering drawings available onsite have been compiled and reviewed as needed for demolition.
- Borrow sources and geotechnical data—Ongoing. Existing data are summarized in the Phase II RFI. Additional test pits were excavated along the East Bench in January 2012 to establish soil types and aggregate sizes to estimate quantities of construction materials. Test pits were also excavated in the Valley View Landfill stockpiles in January 2013 to define soil characteristics for ET Cover System modeling using HYDRUS-1D software (see Appendix B). ULM soil was sampled in July 2014 to assess the appropriate mixing ratio of borrow soil and ULM soil for use as the final cover soil on the ET Cover System, and more specifically, to meet the agronomic properties necessary to establish a plant community on the ET Cover System. Additional ULM samples were collected in November 2014 to further evaluate these criteria and to assess the potential for elevated metals concentrations in PPC Realignment construction dewatering water.
- Environmentally Regulated Material (ERM) Survey—Completed. An ERM Survey was performed during the summer of 2012. All remaining facilities were surveyed. Data from the ERM survey are summarized in the contract documents.

4.2 Additional Data Requirements for 2015 and 2016 Work

Additional data requirements for engineering and construction of the work identified in this IM Work Plan 2015 and 2016 are limited. The following data are being developed and factored in to the final design and implementation of the activities described herein:

- Substation Soil Chemistry Data Collection—Soil samples collected in 2013 by Hydrometrics along the perimeter of the substation indicate presence of low-level polychlorinated biphenyl (PCB) aroclors in the ground surface (Hydrometrics, 2013a). Additional surface and subsurface soil samples will be collected by NWE during the planning and engineering design phase for substation decommissioning. Collection of these soil samples will be timed to coincide with deenergizing the facility. The results will be used to establish the extent of required soil excavation to be completed during substation demolition and the requirements for disposal of this soil. NWE will be responsible for the testing and final disposition of the soil.

SECTION 5

Engineering Design and Construction Information for Proposed 2015 and 2016 Projects

This section summarizes engineering design and construction activities planned for 2015 and 2016 associated with the PPC Realignment, Phase 3 demolition activities (including the NWE substation removal and 69-kV transmission line relocation), ICS 2 construction, ET Cover System construction (includes both the ET Cover East and ET Cover West), and cleanup standards for surface soil that will be incorporated into the final designs. A schedule for task implementation is provided in Section 8.

5.1 Prickly Pear Creek Realignment

The PPC Realignment will construct a new PPC channel and floodplain to a more natural elevation in order to lower the groundwater elevations at the former Smelter site. Approximately 800,000 cubic yards (yd^3) of contaminated material in and adjacent to PPC and proximal waterbodies will be removed. In addition, the 12-foot-high Smelter Dam will be removed. The significant components of the SPHC IM proposed in 2015 and 2016 to complete the PPC Realignment are as follows:

- Removal of the Upper Lake Diversion (2015)
- Permanent realignment of PPC (2015 and 2016)
- Floodplain and wetland reconstruction (2016)

5.1.1 Key Design Objectives

The key design objective of the PPC Realignment is to lower groundwater elevations in the southern part of the former Smelter site as part of the SPHC IM. Major objectives associated with the PPC Realignment and wetlands construction and restoration are as follows:

- Support implementation of the cleanup management strategy for the site.
- Facilitate stabilization of the slag pile.
- Provide wetland habitat restoration or replacement to comply with natural resource permitting requirements.
- Provide materials for other IM construction actions.
- Facilitate elimination of the HDS WTP discharge to PPC.
- Reconstruct PPC to a more natural functioning waterbody.
- Mitigate wetlands at an impacted to mitigated ratio of 1 to 1.
- Develop stream and wetland functions and values equal to or better than those affected.
- Provide upstream passage for adult native fish species and downstream passage for all salmonid age classes.
- In consultation with the U.S. Fish and Wildlife Service (USFWS), avoid to the extent possible the taking, killing, possession, and transportation (among other actions) of migratory birds, their eggs, parts, and nests, in adherence with the Migratory Bird Treaty Act (MBTA).

5.1.2 Design and Construction Features

The design and construction features documented in Appendix A meet the following design criteria and objectives for the PPC Realignment:

- Modify hydraulic regime to reduce mass and rate of contaminant transport away from the site.

- Realign the PPC to support modification of groundwater flow paths.
- Realign the PPC to prevent entrainment of slag materials into the creek.
- Provide a bankfull hydraulic capacity for a 2-year runoff event, slightly larger than the bankfull discharge.
- Design the channel to transport the estimated incoming sediment load without reach-scale aggradation, degradation, or large-scale instability.
- Create the channel with meandering planform and deformable banks, where geomorphically appropriate, and incorporate pool, riffle, and run sequences.
- Incorporate wetlands into the floodplain where hydrologically feasible and geomorphically stable.
- Incorporate grade controls or nondeformable bank treatments where vertical or horizontal stability is required to protect infrastructure or previously remediated areas.
- Construct deformable banks to be stable with woody vegetation allowing for some undercutting and habitat formation over time.
- Provide upstream fish passage for adult species and downstream passage for all age classes.
- Establish a total canopy that covers 80 percent within streambanks and riparian habitats; 95 percent within submergent and emergent habitat; and 60 percent in upland areas.
- Provide riparian vegetation that consists of native species of different growth forms suitable for hydrologic and climatic regimes at the project area.
- Incorporate multiple habitat types including open water, submergent, two emergent types, riparian, scrub-shrub, and upland habitats.

Construction of the PPC Realignment includes a temporary flow control structure expected to remain in place for 5 to 7 years after floodplain, wetland, and realignment construction is completed. The structure will divert only high flows through the PPC Temporary Bypass channel to maintain less than bankfull flow in the realigned PPC until vegetation along the banks has become sufficiently established to withstand unregulated flows.

5.1.3 Construction and Quality Management

Standard construction quality control and quality assurance (QA/QC) practices will be employed throughout the project to facilitate completion in accordance with the design and project objectives. Typical construction testing, surveying, and inspection and documentation measures will be employed to ensure that the materials and workmanship meet necessary project objectives. The *90% Design Basis Documentation for Stakeholder Review* (Pioneer Technical Services, 2014) provides the specific alignment, grade, and construction tolerances applicable to the PPC Realignment, as well as requirements pertaining to QA/QC activities for the entire project.

Key construction and quality management activities and issues associated with the PPC Realignment are as follows:

- Sequence operations to coordinate with the ICS 2, corridor subgrade, and ET Cover construction and availability of East Bench materials, and allow use of soil from areas north of Smelter Dam as substrate for channel/floodplain construction in the area south of the dam.
- Time seeding and plantings based on groundwater levels and season.
- Manage surface and groundwater to optimize surface water groundwater interaction, develop wetland areas, and enhance planting survival.

- Manage stormwater runoff to meet Stormwater Pollution Prevention Plan (SWPPP) criteria.
- Manage groundwater during construction to meet construction dewatering permit requirements.
- Handle materials for both the PPC Realignment and the ICS 2 to protect human health and the environment.
- Place materials (soil and riprap) to meet design objectives.
- Collect and store plant materials (cuttings and salvaged plants) to facilitate cutting and plant survival, and overall vigor.

5.1.4 Preliminary List of Drawings and Specifications

The complete list of drawings from the 90 percent design of the PPC Realignment and wetlands restoration are provided in Appendix A. Appendix A also includes the list of the technical specifications for the PPC Realignment and wetlands restoration activities.

5.2 Phase 3 Demolition

Phase 3 demolition activities include the demolition of buildings and infrastructure located within the footprint of the ET Cover East, removal of the NWE substation and transmission line relocation, and abandonment of monitoring wells.

5.2.1 Key Design Objectives

The primary purpose of the Phase 3 demolition activities is to provide a clear footprint in which to construct the ICS 2 and ET Cover East. Major objectives of the demolition design include the following:

- Demolish infrastructure in the ICS 2 footprint in early 2015 to provide sufficient time to complete the ICS 2 construction in 2015.
- Protect and preserve infrastructure associated with the HDS WTP to allow continued operation as necessary to treat storm water and other remediation waters, currently planned through early 2016.
- Demolish early in 2016 the remaining buildings, structures, utilities, and other features to support construction of the ET Cover East.
- Phase the demolition of stormwater management structures to prevent stormwater and associated sediment from running offsite.
- Perform all work in a manner that is protective of human health and the environment, efficient, and cost-effective.
- Salvage or recycle materials from the demolition activities to the extent possible, and dispose of or recycle debris appropriately.
- Manage stormwater runoff through collection, treatment, and discharge.
- Consider the impacts of weather on the project when scheduling the work and plan to mitigate impacts.
- Provide protection from groundwater infiltration during the demolition activities by limiting the amount of time bare soil is exposed at the ground surface.
- In consultation with USFWS, avoid to the extent possible the taking, killing, possession, and transportation (among other actions) of migratory birds, their eggs, parts, and nests, in adherence with the MBTA.

The demolition sequencing plan has been designed to maximize the safety, efficiency, and cost-effective management of the project. The sequencing has been established to fulfill the following objectives:

- Allow for the effective use of the existing facilities to support the demolition activities.

- Protect the existing stormwater system until construction of the ET Cover East.
- Provide emergency storage capacity for stormwater.
- Consider the other IM activities that will be conducted and coordinate the demolition packages accordingly.

In addition to building demolition, removal of the NWE substation and relocation of the 69-kV transmission line will be conducted by NWE. Major objectives of the substation removal and line relocation include:

- Perform all work in a manner that is protective of human health and the environment, efficient, cost-effective, and in compliance with applicable regulations.
- In consultation with USFWS, avoid to the extent possible and technically feasible the disturbance of migratory bird nest areas during nesting season.
- Manage stormwater runoff during construction in accordance with applicable regulations.
- Remove electrical utilities from the former Smelter site that would prevent or interfere with construction of the ET Cover East.
- Provide NWE adequate means of accessing the relocated transmission line to complete all needed long-term maintenance activities.
- If present, remove contaminated soil from the substation as required for compliance with applicable state and federal regulations (NWE will be responsible for all activities related to removal and proper disposal of all materials and soils within the substation).
- Provide for temporary power supply to HDS WTP and other onsite buildings until they are demolished.

5.2.2 Design and Construction Features

Phase 3 demolition activities will remove all remaining buildings, structures, debris, utilities, and other features from the footprint of the ET Cover East. Demolition work will be sequenced with the ICS 2 and ET Cover East to provide stormwater management. As such, the work will be sequenced to maintain functionality of the HDS WTP through 2016, or longer if needed, and associated portions of the stormwater collection and storage system.

The structures that will be demolished in 2015 and 2016 are shown in **Figure 1-3**.

Technical requirements for demolition include the following:

- Recycling and salvage will be required to maximize use of sustainable remediation approaches.
- Solid, nonorganic debris that is not suitable for recycling or salvage will be placed onsite in the fill areas under the ET Cover East.
- Aboveground structures, to include walls and associated foundations, will be removed to the top of the adjacent grade. Concrete reinforcing steel and other metal protruding from concrete will be cut so that it does not extend above grade.
- Demolition excavations or below-grade areas in the Phase 3 demolition area will be backfilled and compacted in a manner that provides an incompressible, void-free fill to prevent detrimental settlement to the overlying ET Cover East.
- Concrete and concrete masonry unit debris will be reduced in size as part of the process to remove the reinforcing steel for recycling. The particles will be small enough to allow placement and compaction in an incompressible, void-free fill to prevent detrimental settlement to the ET Cover East.

- Pavements, concrete slabs, and reinforced polyethylene membrane covers will be broken or perforated so that water will not perch on the layers under the ET Cover East.
- Underground utilities will be abandoned and the ends will be cut and capped. Larger-diameter pipes and conduits will be filled to eliminate voids under the fill.
- Diesel fuel from the Pump House will be properly disposed of in advance of demolition.
- The former X-ray room in Building 10 contains lead lining that will be removed in advance of demolition.
- Iron filings associated with Warehouse Annex 4 are USEPA property and will be removed in advance of demolition.
- Decommissioning the HDS WTP will include collection and transport of residual water and water used for decommissioning, proper disposal of all remaining reagents, and removal of all sludge collected from tanks, sumps, and piping in buildings 73, 74, 75, 76, 77, 78, 79, and 83. Water collected from the decommissioning process will be collected in the Tank Farm (two 1-million-gallon tanks). Depending on water quality and volumes, the collected water will be either treated for discharge, evaporated within the tanks, or shipped offsite to an appropriate disposal facility.
- Demolition of the Rodeo Tank will include protecting the existing stormwater piping entering the tank to allow future use.

The above-grade concrete walls, slabs, foundations, and footings will be demolished using a track-mounted excavator equipped with hydraulic breakers and pulverizers. Horizontal surfaces will be fractured to reduce subsurface disturbance. Footings and foundations will be exposed by an excavator that will excavate around each below-grade structure to gain access.

Specific design and construction features associated with substation demolition and transmission line relocation are not currently available. Design criteria and construction features will be provided by NWE by early 2015.

5.2.3 Construction and Quality Management

Key construction and quality management activities and issues associated with Phase 3 demolition are as follows:

- Sequencing mechanical demolition techniques should help ensure safe working conditions during the building demolition.
- Various excavators equipped with special attachments will be used to demolish the building in a controlled manner with minimal dusting.
- The approach used to conduct the Phase 3 demolition will be employed to reduce the work force, minimize dust and waste, and prevent potential exposure to workers and the community. Materials will be segregated and staged into universal waste and recyclable waste piles for disposal. Throughout construction, site personnel and equipment will salvage all potential ferrous and nonferrous metals to maximize recycling value.
- Buried utilities will be removed concurrent with foundation demolition; smaller utilities will be cut and capped, larger utilities will be plugged. Exposed utilities will be removed.
- Trash, carpet, insulation, glass, wall partitions, and other materials will be removed from the interior and exterior of the structures after abatement. These “soft” demolition activities will be carried out by skid steers and small tracked vehicles.
- The structures will generally be demolished using a “top-down” approach. The structures generally consist of steel and concrete framing on concrete and concrete at-grade foundations. Steps will be taken to reduce the amount of below-grade demolition and soil disturbance. Mechanical demolition

equipment such as hydraulic excavators equipped with special attachments (e.g., breakers and shears) will be used to improve worker safety, facilitate sorting and recycling, and reduce the release of dust.

- Where the building structures are removed, remaining foundations and intact, below-grade slab foundations will be broken up to prevent potential subsurface ponding areas. Any pavement left intact will then be fractured (but not removed) as part of subsequent interim or remedial measure construction.
- Construction and quality management requirements associated with substation demolition and transmission line relocation will be performed by NWE in accordance with their policy and procedures.
- Monitoring wells designated for removal or abandonment will be removed or abandoned in accordance with the *Borehole Abandonment Plan for the Former Asarco East Helena Facility* (Hydrometrics, 2010). Wells will be abandoned in a manner that effectively and permanently prohibits the movement of water (vertically and horizontally) within the abandoned borehole. A borehole abandonment documentation form will be completed for each monitoring well that is decommissioned.

5.2.3.1 Materials Management

ERM abatement will be conducted before demolition begins and will include the removal, management, and disposal of existing nonhazardous, hazardous, and regulated building materials. ERM identified through building surveys includes mercury in switches and gauges, lead-based paint, light bulbs (fluorescent, mercury vapor, and sodium), and asbestos-containing material. These materials will be handled, transported, and disposed in accordance with regulatory requirements.

Properly dewatered sludge and other select nonliquid demolition debris such as broken concrete, pavements, and brick, will be placed in the ICS 2. Suitable materials will be sent to recycling facilities. Remaining demolition debris will be disposed of offsite at appropriate facilities, depending on the nature of the waste. Additional information regarding management of waste is provided in Section 6.

5.2.3.2 Protective Measures during Implementation

Demolition activities will follow all applicable federal, state, and local laws and regulations as well as any specific site or permit requirements. Contractors working on the site will comply with the site-specific health and safety plan, and will be required to develop and follow plans related to asbestos-containing material (ACM) regulations, Universal Waste Management, recycling, dust control, stormwater pollution prevention, site security, and decontamination. Protection of migratory birds will be performed in accordance with an Avian Protection Plan (APP) prepared to support construction activities. The APP covers the advanced review of construction/demolition areas, bird nesting deterrents (such as closing up or netting off potential nesting locations), and establishment of buffers for active nests.

5.2.4 Preliminary List of Drawings and Specifications

Design drawings and technical specifications of the Phase 3 demolition activities, the ICS 2, and both the ET Cover East and West are included in Appendix A.

5.3 Interim Cover System 2

5.3.1 Key Design Objectives

Key design objectives for the ICS 2 construction are summarized as follows:

- Construct an interim cover that will protect consolidated soil and sediment until the ET Cover East is constructed.
- Design the ICS surface and finished grades to enable noncontact runoff to be shed to perimeter drainages.
- Manage stormwater runoff during construction in accordance with applicable regulations.

- Perform all work in a manner that is protective of human health and the environment, efficient, cost-effective, and in compliance with applicable regulations.
- In consultation with USFWS, avoid to the extent possible and technically feasible the disturbance of migratory bird nest areas during nesting season.
- Provide adequate engineered fill capacity to consolidate all of the excavated soil removed from the PPC Realignment.
- Incorporate soil consolidated from the PPC Realignment into a prepared subgrade on which to build the ET Cover East.
- Provide a native cover soil layer that prevents direct contact with the consolidated soil, protects the soil from erosion, reduces infiltration in advance of ET Cover construction, and minimizes ET Cover System construction costs.
- In consultation with USFWS, avoid to the extent possible the taking, killing, possession, and transportation (among other actions) of migratory birds, their eggs, parts, and nests, in adherence with the MBTA.

5.3.2 Design and Construction Features

The ICS 2 will be constructed over the eastern portion of the former Smelter site. The area was selected to preserve and protect infrastructure scheduled for demolition in 2016 and to leave open a corridor in the center of the site to provide access for potential future source removal or Tier II remedial actions (see **Figure 1-1**). The ICS 2 will be constructed in three layers. The lowest layer in the ICS 2, the engineered fill layer, will be consolidated material from the PPC Realignment. This layer will be capped with a low-permeability native soil layer, and a biobarrier/erosion protection cover layer.

The engineered fill layer of the ICS 2 will be designed and constructed to accept the excess soil generated by the PPC Realignment, meet grading requirements to manage and control runoff, and provide a subgrade capable of supporting the ET Cover East. The engineered fill layer is expected to consist solely of material excavated from the PPC Realignment.

The ICS 2 will be capped with 12 inches of native soil. This cap will include a 6-inch-thick layer of compacted sandy clay, covered by a 6-inch-thick layer of 6-inch-minus gravel, acting as the bio-barrier/subgrade for the ET Cover East. The gravel layer of the cap will also provide erosion protection for the sandy clay layer.

5.3.3 Construction and Quality Management

Implementation considerations associated with constructing the ICS 2 include coordination of the PPC Realignment and haul operations, placement, compaction, and grading of the subgrade materials; management of stormwater runoff collection and treatment during construction; and erosion control during and following construction.

5.3.3.1 Materials Management

Construction of the ICS 2 will involve the dewatering, excavation, transport, and placement of approximately 207,000 yd^3 of soil from the PPC Realignment. For cost effectiveness and construction efficiency, as noted in Section 5.1.3.1, PPC Realignment activities will be sequenced concurrently with the ICS 2 construction. Soil excavated from the PPC Realignment will be loaded into haul trucks and transported directly to the ICS 2 consolidation location within the AOC where it will be moisture-conditioned (if required) and compacted into place. Dewatering of the materials will occur before excavation to the maximum extent possible. Sequencing construction in this manner will facilitate protective and efficient implementation by minimizing handling and processing activities and stockpiling requirements.

5.3.3.2 Protective Measures during Implementation

Construction of the ICS 2 will fulfill specific requirements to ensure that work is conducted in a manner that is safe, protective of the environment, and in accordance with applicable permits, laws, and regulations. The design and contract specifications will require measures to safely handle and control erosion of material from the PPC Realignment during consolidation of this material within the ICS 2. Measures will be taken to prevent spillage during transport. Traffic routes, laydown and parking areas, and other temporary facilities and controls will be specified to reduce effects on nearby residences and the environment. In addition, temporary erosion and sedimentation control plans (including the SWPPP, as discussed in Section 7) will be implemented for work and material processing areas.

Construction of the cap and erosion protection layers of the ICS 2 will take place after the engineered fill has been brought to grade. Infiltration of contact runoff will be for the shortest possible timeframe needed to allow for safe and cost-efficient construction. As early in the construction sequence as possible, the top layers of the ICS 2 will be placed and noncontact runoff directed to perimeter drainages.

5.4 ET Cover System (East and West)

5.4.1 Key Design Objectives

Key design objectives associated with the ET Cover System (including ET Covers East and West) are as follows:

- Provide sufficient capacity to store infiltration, thereby reducing percolation through contaminated media and subsequent leaching to groundwater.
- Provide physical separation between consolidated material and the ground surface.
- Inhibit bioturbation and animals from contacting consolidated material.
- Resist wind and water erosion.
- Prevent inundation from flooding events.
- Meet media cleanup objectives for soil, as described in Section 5.5, and surface water, i.e., DEQ-7 standards (MDEQ, 2012), by designing a cover surface and stormwater conveyance structures that manage and control stormwater.
- Protect human health and the environment by designing a cover system footprint that incorporates existing site access controls including fencing, signs, and gates.
- In consultation with USFWS, avoid to the extent possible and technically feasible the disturbance of migratory bird nest areas during nesting season.

5.4.2 Design and Construction Features

The ET Cover System will be constructed in stages. The ET Cover West will be completed over the existing ICS 1 in 2015. In 2016, the remaining half of the cover will be constructed over the ICS 2 and central corridor. Because the ET Cover System will be completed in stages, the fill will be placed in four primary locations: the perimeter access road, the ICS 1, the ICS 2, and the central corridor. The footprint of the perimeter access road was selected to provide long-term access to the ET Cover System and long-term slag pile operations, maintenance, and recycling.

The ET Cover West will be placed directly over the existing ground surface, which is the armored biobarrier layer (i.e., the top layer of the ICS 1). The ET Cover East will be placed on the biobarrier surface of ICS 2 and in the central corridor over engineered fill consisting of excess soil from the PPC Realignment. In the central corridor, the entire ET Cover System (biobarrier, capillary break, storage layer, and topsoil layer) will be placed above the engineered fill and no interim cover layer will be necessary.

The thickness of the ET Cover storage and amended storage layers were designed using two hydraulic models: HYDRUS-1D and the Desert Research Institute (DRI) analytical method. Both methods used site-specific climate data and laboratory test results for soil moisture retention and gradation for soil from two potential borrow areas. Percolation rates were predicted using the HYDRUS-1D model to design appropriate cover thickness and select appropriate soil properties (Appendix B). The capillary break layer increases the water-holding capacity of the overlying storage layer by providing a gradation and permeability contrast between the two layers. The biobarrier layer inhibits animals from burrowing into contaminated soil by providing enough rock-to-rock contact to make digging difficult. In addition to providing water-holding capacity, the amended storage layer is designed to support a plant community that will remove moisture from the cover by evapotranspiration.

The finish grade surface of the ET Cover System will be steep enough to avoid ponding water on the ground surface and flat enough to avoid promoting erosion.

5.4.3 Construction and Quality Management

Construction of the ET Cover System will involve the excavation, transport, and placement of approximately 600,000 yd^3 of soil from the PPC Realignment and borrow areas. For cost effectiveness and construction efficiency, PPC Realignment activities will be sequenced concurrently with construction of both portions of the ET Cover System (East and West). Soil excavated from the PPC Realignment and borrow areas will be loaded into haul trucks and transported directly to the ET Cover East and West locations within the AOC, where it will be moisture-conditioned (if required) and compacted into place. Sequencing construction in this manner will facilitate protective and efficient implementation by minimizing handling activities, and stockpiling requirements.

Testing of ET cover materials will be performed using an independent testing laboratory. The sampling and testing proposed to meet QA/QC requirements will be included within the ET Cover implementation plan and submitted to MDEQ prior to construction for review.

5.5 Cleanup Standards for Surface Soil

One of the design criteria for the final exposure surfaces of the PPC Realignment and ET Cover System are the cleanup standards for arsenic and lead in surface soil. The draft CMS Work Plan proposed potential cleanup standards and their basis as presented in Table 2-2 of the CMS Work Plan. Additional evaluation of the cleanup standards has been completed based on anticipated future use. The reasonably anticipated future use for the portion of the former Smelter site covered by the ET Cover System, and the PPC Realignment and its floodplain, is currently considered to be recreational. An arsenic cleanup standard of 794 milligrams per kilogram (mg/kg) was selected to meet the recreational land use criterion defined in the East Helena Superfund Site Operable Unit 2 (OU-2) Record of Decision (ROD), and a lead cleanup standard of 650 mg/kg was selected to be protective of ecological receptors (Gradient, 2010 and USEPA, 2005), as summarized in **Table 5-1**.

In order to evaluate whether these criteria would also be protective of other constituents of potential concern (COPCs) identified in the Phase II RFI, a tiered evaluation approach was used in which soil data were compared against conservative USEPA Regional Screening Levels and state of Montana background soil concentrations (Hydrometrics, 2013c). Of the 16 COPC metals, arsenic and lead were identified as presenting the highest percentage of exceedances against the screening criteria. As described in the OU-2 ROD, "… once areas are cleaned up to address lead and arsenic, low-level risks of exposure to the other, coexisting contaminants are further minimized" (USEPA, 2009).

TABLE 5-1
Cleanup Standards for Arsenic and Lead in Surface Soil
Interim Measures Work Plan 2015/2016

Constituent	Cleanup Standard (mg/kg)	Rationale
Arsenic	794	Consistent with the East Helena OU-2 ROD
Lead	650	Criterion for the Protection of Ecological Receptors

Notes:

mg/kg = milligrams per kilogram

OU = Operable Unit

ROD = Record of Decision

SECTION 6

Remediation Waste Management

This section describes the proposed approach for managing remediation waste associated with implementation of the proposed 2015 and 2016 IM components.

6.1 Use of the Area of Contamination

A RCRA AOC has been designated as part of the implementation of the Facility remediation activities. The description and rationale for the AOC was approved by USEPA in their conditional approval of the IM Work Plan 2012, dated August 28, 2012. As shown in **Figure 6-1**, the AOC covers Parcels 16 and 19 (the former Smelter site operating area); the area of Parcel 15 containing CAMUs 1 and 2, portions of Tito Park, Lower Lake, and Upper Lake; the portion of Parcel 8 west of State Highway 18; and Parcels 10, 11, 12, 17, 18, and 23. The ability to consolidate hazardous remediation waste within the designated AOC allows interim and final remedial measures to be conducted in a protective, efficient, sustainable, and cost-effective manner, and also reserved CAMU capacity for the management and treatment of other hazardous remediation waste that clearly should be segregated from site soil.

Two onsite CAMUs have been approved, constructed, and filled, and final closure was completed in November 2014. The onsite CAMUs were constructed to manage remediation waste generated during the site cleanup. CAMUs 1 and 2 were constructed by ASARCO on Parcel 15 and the southwestern corner of Parcel 19. CAMU 1 was constructed in 2001 with a final cover placed in 2008. CAMU 2 was constructed in 2008 and used to manage remediation waste and debris from cleanup operations. CAMU 2 was closed in November 2014 with a final cover.

6.2 Remediation Waste Management in 2015 and 2016

The remediation waste expected to be associated with implementation of the 2015 and 2016 IM components is summarized in **Table 6-1** and described briefly in the following paragraphs. Detailed work plans, as appropriate, for each of the components described will be prepared during final design, or will be required submittals as part of the construction contract(s).

6.2.1 Prickly Pear Creek Realignment

PPC Realignment is estimated to require the excavation of more than 800,000 yd^3 of soil. Although the majority of soil to be excavated is not contaminated and would not be considered a remediation waste, investigation work to date has indicated that a portion of the surface soil has high concentrations of COPC metals. All excavated material that will not be reused in the PPC channel or floodplain reconstruction is considered remediation waste and may be consolidated within the ET Cover System boundary. Appropriately detailed soil and remediation waste management plans will be prepared as part of final design for the IMs. The plans may include testing if necessary to develop the appropriate management of excavated material. Protocols for stockpiling, transportation, and dust suppression to minimize potential contaminant migration during construction will be specified during detailed design.

6.2.2 Phase 3 Demolition

Remediation waste management associated with the Phase 3 demolition activities is summarized as follows:

- Consistent with previous demolition work conducted, demolition will encourage the appropriate beneficial reuse of debris, and incorporate a recyclable material plan for proper handling of materials believed to have salvage or recycle value.
- Given that the majority of the demolition work will be performed within the footprint of the ET Cover System, concrete rubble and debris can be stockpiled, consolidated, and used as appropriate for fill.

TABLE 6-1
Interim Measures Remediation Waste Management
Interim Measures Work Plan 2015/2016

IM Component	Remediation Waste	Disposition
2015		
Interim Cover System 2 Construction	PPE and decontamination waste	Transport heavily soiled PPE and solid decontamination waste to appropriately permitted offsite disposal facility.
Removal of Substation and Relocation of 69-kilovolt Line	TSCA and non-TSCA PCB waste	If encountered, NWE will transport PCB materials to an appropriately permitted offsite disposal facility.
2015 through 2016		
Prickly Pear Creek Realignment	Soil	Soil with metals concentrations meeting cleanup standards will be used for reconstruction; soil exceeding applicable criteria will be consolidated within the ET Cover System footprint.
	Decontamination Water	Implement best management practices according to the approved SWPPP and comply with the MPDES General Permit for Stormwater Discharges Associated with Construction Activities.
	Stormwater and Construction Dewatering	Manage water from construction dewatering activities within the work areas, treat (if required), and discharge in accordance with MPDES General Permit for Construction Dewatering Activities.
	Debris	Evaluated for consolidation within the ET Cover System footprint
ET Cover System (East and West)	PPE and decontamination waste	Transport heavily soiled PPE and solid decontamination waste to appropriately permitted offsite disposal facility.
Phase 3 Demolition	Debris	Building debris that is not suitable for salvage or recycling will be evaluated for consolidation within the ET Cover System footprint
	Lead-based paint materials	Transport to appropriately permitted offsite disposal facility.
	Miscellaneous nonliquid and solidified chemicals	Transport to appropriately permitted offsite disposal facility.
	Asbestos from building structures	Transport to appropriately permitted offsite disposal facility
	Flushing water or stormwater	Collect and treat in the onsite HDS WTP. Discharge treated water per MPDES permit (MT0030147).
	ACM, TSCA, liquid waste not specified above, and universal waste (for example: batteries and mercury-containing equipment)	Transport to appropriately permitted offsite disposal facility.
	Process residual sludge	Transport to appropriately permitted offsite disposal facility.
Monitoring Well Decommissioning	Debris	Evaluated for consolidation as fill within the ET Cover System footprint

Note:

Abbreviations:

AOC	=	Area of Contamination
ACM	=	asbestos-containing material
HDS WTP	=	high-density sludge water treatment plant
MPDES	=	Montana Pollutant Discharge Elimination System
PPE	=	personal protective equipment
TSCA	=	Toxic Substances Control Act
PCB	=	polychlorinated biphenyl
NWE	=	NorthWestern Energy

Excavation of soil may be necessary as part of the underground utility/infrastructure work. Because all of the utility relocation work is being done within the footprint of the AOC, soil that is excavated will be temporarily stockpiled adjacent to the work area and then placed back in the excavation as fill.

Control of stormwater runoff will be a priority throughout the demolition activities. To direct and control runoff as areas are demolished, fumed slag or other fill will be placed at predetermined interim grades in the demolition areas. The grading plan will be designed to coordinate with the ET Cover System, and channel clean runoff in a controlled manner to proposed drainage discharge areas. During demolition, stormwater will be collected and managed as currently permitted under the HDS WTP MPDES permit.

6.2.2.1 Substation Removal and Transmission Line Relocation

NWE will be conducting the work associated with removing the substation and relocating the 69-kV transmission line. Any remediation waste management associated with this work will be handled by NWE.

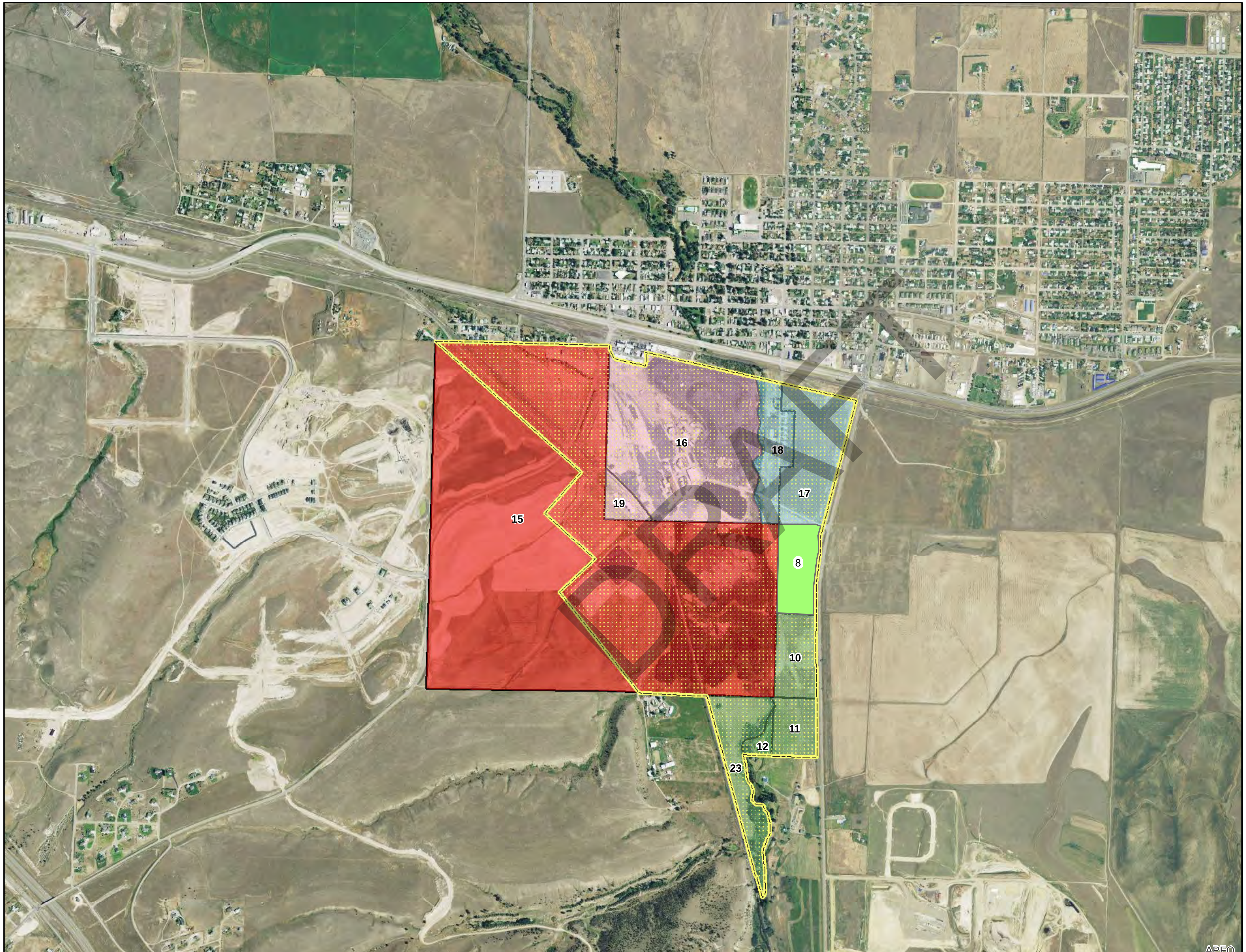
6.2.2.2 Monitoring Well Decommissioning

For monitoring wells less than 20 feet deep, well casing and screens will be pulled in accordance with ARM 36.21.810. Any decommissioning debris will be evaluated for placement as fill within the ICS 2 or subgrade for the ET Cover East.

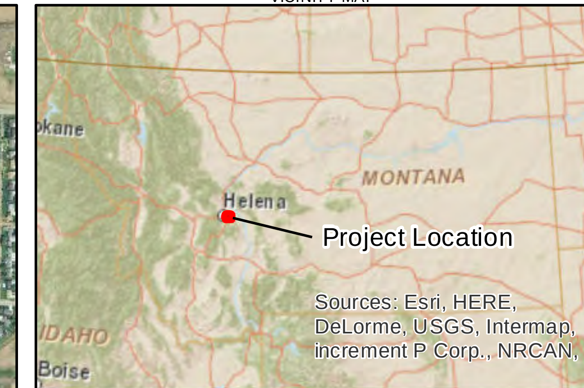
6.2.3 Interim Cover System and ET Cover System Construction

No remediation waste is expected to be generated during construction of the ICS 2 and the ET Cover System, with the exception of personal protective equipment and decontamination waste, which will be transported to a permitted offsite disposal facility.

At the completion of ICS 2 and the ET Cover System construction, the stormwater runoff will no longer be in contact with soil affected by former Smelter site operations. Stormwater runoff from the ET Cover System will report to three locations; one on the north end of the former Smelter site and two on the south end, as shown on the design drawings. Stormwater runoff from ICS 2 and the ET Cover System will be managed in accordance with the SWPPP developed in accordance with the Montana Multi-Sector Permit for Stormwater Discharges Associated with Industrial Activity.



VICINITY MAP



LEGEND

- Portion of Parcel 8 West of State Highway 518
- Parcel 15
- Parcels 16 and 19
- Parcels 17 and 18
- Parcels 10, 11, 12, and 23
- Area of Contamination Boundary

N

0 750 1,500
Feet

Figure 6-1
Area of Contamination Boundary
Interim Measures Work Plan–2015/2016
East Helena, Montana

DEN \\COBRA\PROJ\MONTANA_ENVIRONMENTAL_TRUST_PROJECT\GIS\MAPFILES\FIGURE6_1.MXD ZANDERSO 12/18/2014 12:23:23 PM

CH2MHILL.

SECTION 7

Status of Permitting Activities and Approvals

This section provides an update to the federal, state, and local permit and licensing measures outlined in the IM Work Plans 2012, 2013, and 2014, and discusses the permits under evaluation for 2015 and 2016.

7.1 Past Permitting and Authorization Activities

7.1.1 Joint Application and Conditional Letter of Map Revision

The Joint Application for Proposed Work in Montana's Streams, Wetlands, Floodplains, and Other Waterbodies (Joint Application) is used to simultaneously apply for several different water resource permits from multiple permitting agencies. In September 2012, Joint Application No. 1 for the PPC Temporary Bypass project was submitted to the City of Helena, the U.S. Army Corps of Engineers (USACE), MDEQ, and the Lewis and Clark Conservation District (LCCD). This work was conducted concurrently with the submittal of the CLOMR No. 1 for the PPC Temporary Bypass.

The CLOMR No. 1 approval was received in December 2012, and all other agency approvals under Joint Application No. 1 (including the 404, 318, 310, and City of East Helena Floodplain Permit) were received by February 2013.

Joint Application No. 1 was submitted to USACE to address work necessary to install the PPC Temporary Bypass and did not include the proposed soil removal actions for the TPA. However, the proposed TPA actions did not disturb additional wetlands beyond those identified in Joint Application No. 1. Therefore, a request was made to USACE, MDEQ, and LCCD to provide an administrative authorization of the actions as an amendment to Joint Application No. 1. A technical memorandum summarizing the proposed activities, with figures illustrating the work, was submitted to these agencies as part of the authorization process.

7.1.2 Floodplain Development Permit

Because the excavation in Tito Park altered the location and elevation of the regulatory floodplain to a greater degree than was shown in CLOMR No. 1, an updated Floodplain Development Permit was obtained from the City of East Helena. Additional Hydrologic Engineering Centers River Analysis System (HEC-RAS) modeling, reflecting the removal of Tito Park, was performed and submitted to FEMA for their PPC project file. A request was made to FEMA for a written letter of concurrence that the TPA source removal project is consistent with the CLOMR issued for the PPC Temporary Bypass (Case No. 12-08-0919R, December 4, 2012), and that it meets the minimum requirements of the National Flood Insurance Program. The concurrence letter from FEMA was the basis for subsequent TPA source removal authorization amendments to the existing PPC Temporary Bypass 404, 318, and 310 permits (by USACE, MDEQ, and LCCD) and an updated Floodplain Development Permit from the City of East Helena. As part of the permit process, and before issuing the updated permit, the City of East Helena solicited public comments on the application for a 15-day period. The Floodplain Development Permit from the City is anticipated to be issued in January 2015.

7.1.3 Montana Dam Safety Act

In May 2013, the Dam Safety Office of the Montana Department of Natural Resources and Conservation issued a determination that Smelter Dam does not impound at least 50 acre-feet of water. Therefore, a downstream hazard evaluation will not need to be performed, an operating permit will not be required, and a demolition permit will not need to be obtained for removal of the dam.

7.1.4 National Emissions Standards for Hazardous Air Pollutants (NESHAP) Compliance

In compliance with ARM Title 17, Chapter 74, Subchapters 3 and 4, NESHAP notifications were submitted for Demolition Phase 1 and 2 activities in 2013. Acknowledgements were received from MDEQ for Demolition

Phase 1 originally on April 8, 2013, and subsequently (as related to project revisions) on June 12 and July 11, 2013. Acknowledgements were received from MDEQ for Demolition Phase 2 on June 25, 2013 (with no follow-on revisions).

7.1.5 Montana Pollutant Discharge Elimination System Permits

The Custodial Trust holds the following two MPDES permits for ongoing site remedial operations: (1) an individual permit (MT0030147) that provides authorization to discharge treated effluent from the HDS WTP to an outfall in Lower Lake, and (2) authorization under the General Permit for Stormwater Discharges Associated with Industrial Activity (MTR000072). In addition, the Custodial Trust holds two additional MPDES permits for the remedial construction activity: (1) construction dewatering permit, and (2) construction stormwater permit.

7.1.5.1 HDS Plant Discharge

The Custodial Trust holds an MPDES Minor Industrial Individual Permit Number MT0030147 for authorization to discharge under the MPDES program. This permit allows for the discharge of treated effluent from the HDS WTP to an outfall located on Lower Lake. The HDS Plant will need to remain operational as long as necessary to treat contact stormwater collected from the former Smelter site, as well as other remediation waters.

7.1.5.2 Industrial Stormwater Discharges

The former Smelter site is permitted to discharge stormwater associated with industrial activities to waters of the United States pursuant to the MPDES General Permit for Stormwater Discharges (MTR000072). In accordance with permit requirements, stormwater management at the site is accomplished in accordance with an approved SWPPP. However, there have been no smelting operations at the plant site since April 2001. An updated SWPPP, representing current site conditions, was prepared for the Custodial Trust by Hydrometrics and submitted to MDEQ on November 10, 2014.

7.1.5.3 Construction Dewatering Discharges

Construction of the PPC Temporary Bypass channel required construction dewatering. Water was pumped from the work area into sediment ponds, from which the water either percolated into the ground or flowed over a weir and into PPC. Authorization to discharge under the Construction Dewatering General Permit was applied for and approved by MDEQ in August 2013. This work was completed in October 2013 and the permit was closed out with MDEQ.

7.1.5.4 Construction Stormwater Discharges

Stormwater discharge associated with construction activity, as defined in ARM 17.30.1102 (28), was addressed through the applicable requirements of the MPDES Construction Activity General Discharge Permit obtained for the former Smelter site. The IM designs include all necessary sediment controls needed to meet applicable requirements of the General Discharge Permit. A Notice of Intent (NOI) and SWPPP were submitted before construction after other permits, approvals, and authorizations were obtained. The current permit will remain in effect until a notice of termination is submitted to MDEQ either due to completion of activities covered by the existing permit or due to transfer of responsibilities.

7.1.5.5 Endangered Species Act Compliance

Endangered Species Act (ESA) compliance must be demonstrated for any federal permit approval that may be necessary during the course of IM implementation. A technical memorandum entitled *Montana Environmental Trust Group Endangered Species Act Compliance* (CH2M HILL, 2012b) was issued to USFWS on September 5, 2012. USFWS concurrence that the project complies with the ESA was received by CH2M HILL for the Custodial Trust on September 19, 2012.

7.2 Anticipated 2015 and 2016 Permitting and Authorization Activities

The following permits and authorizations are necessary for execution of the proposed 2015 and 2016 IM activities, including construction of the PPC Realignment, implementing Phase 3 demolition, removal of the NWE substation and relocation of the 69-kV line, and the placement of the ICS 2 and both ET Cover East and West.

7.2.1 Joint Application No. 2 and CLOMR No. 2

The USACE must issue a 404 Permit to any party proposing project work that will place fill material into "waters of the U.S." The purpose of the permit is to provide regulatory review of the activity and restore or maintain chemical, physical, and biological integrity of the nation's waters. A Joint Application No. 2 was submitted to USACE in October 2014 to address work necessary to install the PPC Realignment. This application was prepared concurrently with the CLOMR No. 2 for the PPC Realignment. The Joint Application No. 2 provides detailed information on the wetlands affected by all IMs and provides the mitigation plan for those impacted wetlands and subsequent monitoring.

The CLOMR No. 2 application was submitted in May 2014 and approved on November 6, 2014. The 404 Permit was approved on December 5, 2014. FEMA has completed the technical review process and the Custodial Trust has notified adjacent landowners of the proposed changes. Changes to water surface elevations resulting from the PPC Realignment are below acceptable change criteria. All other agency approvals under Joint Application No. 2 (including the 318 and City of East Helena Floodplain Permit) are expected by February 2015.

7.2.2 310 Permit

The Montana Natural Streambed and Land Preservation Act requires any nongovernmental entity proposing work that physically alters or modifies the bed or banks of a perennially flowing stream to obtain a 310 Permit from the County Conservation District. The purpose of the permit is to minimize sedimentation and protect streams from adverse development. The Custodial Trust submitted Joint Application No. 2 to the LCCD in October 2014. The LCCD consults with Montana Fish, Wildlife and Parks in approving the permit with recommendations and requirements. Additionally, the LCCD makes a recommendation to MDEQ on the 318 Authorization for short-term water quality standard for turbidity. The agency approved the 310 permit under Joint Application No. 2 on December 12, 2014.

7.2.3 318 Authorization

MDEQ provides 318 Authorization for short-term water quality standards for turbidity based on recommendation from the FWP during the 310 Permit review process. The 318 Authorization provides a measure of protection to water quality while allowing for construction activities in or proximal to state surface waters. MDEQ received a copy of Joint Application No. 2 and is participating in the agency review process. Agency approvals for the 318 Authorization under Joint Application No. 2 are expected by February 2015.

7.2.4 Floodplain Development Permit

The Montana Floodplain and Floodway Management Act requires a Floodplain Development Permit be obtained by any entity planning construction within a designated 100-year floodplain. The purpose of the permit is to restrict development and uses that present hazards, thereby limiting the expenditure of public revenues for emergency operations. The Custodial Trust submitted Joint Application No. 2 to the administering body, the City of East Helena, in October 2014. A CLOMR is required as well for the review process and is under review by FEMA with approval expected in November 2014. Approval of the floodplain development permit by the City of East Helena is expected in January 2015.

7.2.5 MPDES Permits

For the proposed 2015 and 2016 IM activities, the associated MPDES permitting incorporates HDS WTP discharges, industrial stormwater discharges, construction dewatering discharges, and construction stormwater discharges as described in the following subsections.

7.2.5.1 HDS WTP Discharges

As previously noted in Section 7.1.5.1, the Custodial Trust holds an MPDES Minor Industrial Individual Permit Number MT0030147 for authorization to discharge under the MPDES program. This permit allows for the discharge of treated effluent from the HDS WTP to an outfall located on Lower Lake. The MPDES permit is valid until July 31, 2015, and the current IM schedule indicates that the HDS Plant will continue to operate into at least 2016 and possibly longer in the event that the IM schedule needs to be modified. Therefore, the Custodial Trust is submitting a permit renewal application to MDEQ in early 2015 for the MPDES program, as stated in 40 C*ode of Federal Regulations* 122 and adopted by reference in ARM Title 17, Chapter 30 – Water Quality.

The Custodial Trust has also requested (in a letter dated April 21, 2014) that MDEQ issue an administrative order on consent to extend the interim numerical effluent discharge limits for 4 of the 12 constituents currently regulated by the MPDES permit. This is necessary to obviate the need for expensive mechanical system upgrades to the HDS Plant, which are not cost-effective given the relatively short operational life that is currently anticipated.

7.2.5.2 Industrial Stormwater Discharges

The Custodial Trust holds an MPDES General Permit for Stormwater Discharges from Industrial Activity. The current SWPPP (submitted to MDEQ in November 2014) is kept up-to-date to reflect current conditions on the site. A SWPPP update is expected to be prepared and submitted to MDEQ in the summer of 2015 to incorporate the addition of a stormwater discharge outfall to Lower Lake (Outfall 3B).

7.2.5.3 Construction Dewatering Discharges

The PPC Realignment may require a construction dewatering permit. The IM designs will include all necessary controls needed to meet applicable requirements of the MPDES Authorization to discharge under the Construction Dewatering General Permit. An application package for the General Permit will be submitted before construction after other permits, approvals, and authorizations have been obtained.

7.2.5.4 Construction Stormwater Discharges

The permit for stormwater discharge associated with construction activity will be required for ongoing IM activities such as the ICS 2 and both ET Cover East and West. The IM designs include all necessary sediment controls needed to meet applicable requirements of the MPDES Construction Activity General Discharge Permit. The NOI and SWPPP will be submitted to MDEQ before construction after other permits, approvals, and authorizations have been obtained.

7.2.6 Montana Department of Transportation Permits

Any work done within the Montana Department of Transportation (MDT) right-of-way will require the appropriate permit. MDT will be contacted to secure all required permits in advance of starting construction activities. It is not anticipated at this time that work will be completed in any MDT right-of-ways, except delivery of materials to the site by on-highway vehicles in road-legal loads.

7.2.7 Montana Water Use Act (Water Right Permit and Change Authorization)

As noted in the IM Work Plan 2013, the PPC Realignment will require two changes to the Point of Diversion. One change will be required to support the PPC Temporary Bypass, and another will be required to cover the change associated with the PPC Realignment. Existing water rights for the owners legally tied to the Wilson Ditch headgate will be affected. Work continues to appropriately address those effects.

7.2.8 City of East Helena — Partial Abandonment of South Montana Avenue

As part of the PPC Realignment, the Custodial Trust will work with the City of East Helena (COEH) in preparing a petition for road abandonment for COEH review and comment that seeks approval to abandon (vacate) a portion of the roads within the area of South Montana Avenue. Communications to date with the COEH indicate the City would like to preserve the existing railroad crossing and the northernmost section of the South Montana Avenue.

The Custodial Trust will work with the COEH to evaluate the additional property needs for providing a new connection to the remaining portion of South Montana Avenue, and new right-of-way for access from Highway 518.

7.2.9 Migratory Bird Treaty Act

The Custodial Trust will continue to coordinate and consult with USFWS and USEPA regarding deterrence activities aimed at minimizing noncompliance with the MBTA associated with all IMs. The MBTA was enacted to protect migratory birds in the U.S. All but a few of the bird species naturally occurring in the U.S. are protected from take under the MBTA, and, therefore warrant consideration to avoid and minimize potential impacts.

In coordination with USFWS, an approach was developed to provide migratory bird protection within the primary nesting areas involved in upcoming construction within the PPC Realignment construction areas. Early clearing outside of the nesting season (before April 15) will be performed as part of a plant salvage and clearing plan, to be implemented in March 2015. In addition, an APP will be prepared which will provide a framework for avoiding impacts to nesting birds and outline response actions in the event that an active nest is found within the project impact area or buffer, either before construction starts or during the course of the PPC Realignment. This APP will satisfy the requirements of the MBTA and identify the types of birds that may nest in the project area and the proposed buffers, monitoring requirements, and reporting standards that will be implemented to demonstrate compliance with MBTA.

SECTION 8

Project Management and Schedule

This section provides an overview of project management activities and the proposed schedule for 2015 and 2016 IM implementation. Organization and lines of communication, public participation, documentation and reporting, and the preliminary schedule are described.

The Custodial Trust will manage all IM activities as part of the responsibilities and obligations set forth in the Settlement Agreement and First Modification to the 1998 Consent Decree. The Custodial Trust will communicate relevant information about the IM task plans, results, and progress to USEPA, as Lead Agency, as well as to the federal and state beneficiaries of the Custodial Trust. Communication will occur on a frequent and timely basis, to review progress on the IMs, to solicit input from the beneficiaries, and to ensure that the beneficiaries are kept well informed of activities onsite.

8.1 Organization and Lines of Communication

The Custodial Trust will procure the services of consultants and contractors to implement the IMs as efficiently and cost-effectively as possible. **Figure 8-1** shows the current overall Project Organization Chart and the lines of communication. **Table 8-1** identifies the anticipated consultant leads for IM design and construction.

TABLE 8-1
Interim Measure Consultant Leads
Interim Measures Work Plan 2015/2016

Name	Lead Contact	Description of Role
CH2M HILL	Jay Dehner: 509-979-5733	Project management and overall engineering design and construction lead for former Smelter site IMs
Pioneer Technical Services	Joel Gerhart: 406-490-2530	Overall lead for PPC Realignment design, permitting, and construction
Hydrometrics	Bob Anderson: 406-443-4150	Hydrogeology and engineering design
NewFields	Cam Stringer: 406-549-8270	Groundwater flow and F&T modeling
Morrison Maierle Inc.	Mark Brooke: 406-495-3469	Engineering design support and floodplain modeling
Applied Geomorphology	Karin Boyd: 406-587-6352	Stream geomorphology
Confluence	Jim Lovell: 406-585-9500	Stream geomorphology

8.2 Public Participation

Public involvement is a critical part of the overall cleanup process for the former Smelter site. General communication with the public will continue to follow the *Draft Community Relations Plan, Former ASARCO Smelter Facility, East Helena, Montana* prepared by the Custodial Trust (2010), as well as the requirements of the First Modification to the 1998 Consent Decree. In 2014, the Custodial Trust held the following meetings and workshops:

- A series of meetings were held to discuss the Controlled Groundwater Area, including a public/stakeholder meeting held in August 2014.
- A meeting of the East Helena Entire Cleanup Team in Coordination (EHECTIC) was held in March 2014 to provide project stakeholders and the community information on the PPC Realignment design.

- Two Town Hall meetings were held in 2014. In March 2014, a meeting was held to update the community on the PPC Realignment design. An additional Town Hall meeting was held on December 17, 2014, to provide the community another update on the PPC Realignment design. In August 2014, a public/stakeholder meeting was held to update the community on the impacts observed in groundwater as a result of the implementation of several components of the SPHC IM, and the progress of 2014 IM construction activities.

An informational meeting will be held in February 2015 to provide the community with an overview of the 2015 and 2016 IM work described herein.

In addition, the Custodial Trust holds meetings with the EHECTIC group to provide information to key local stakeholders and attends the East Helena City Council meetings. The Custodial Trust's website: http://www.mtenvironmentaltrust.org/east-helena contains links to news on cleanup progress, design documents, meeting materials, and future meeting dates. As described in the IM Work Plan 2014, a video of the PPC Realignment project is available for viewing.

8.3 Documentation and Reporting

The following IM documentation is under development:

- Contract scopes of work and schedules
- Engineering technical reports and memorandums
- Modeling results
- Permit application packages
- Detailed engineering designs (plans and specifications)
- Construction contract packages (drawings and specifications)
- Operation and maintenance plans
- Record drawings and contract close-out documents

Core plans that have been developed for the Facility will be incorporated by reference, or amended as appropriate, to ensure that IM activities follow relevant protocols and methods. Core plans include the following:

- Health and Safety Plan for the East Helena former Smelter site
- QA/QC Plan
- Sampling and Analyses Plans

IM progress will be summarized in the monthly progress reports.

8.4 Preliminary Interim Measure Implementation Schedule

Table 8-2 summarizes key dates for the proposed 2015 and 2016 IM implementation and provides schedule updates for the work proposed and approved in the IM Work Plans 2012, 2013, and 2014. The schedule is considered a living document and will be revised on a regular basis as needed to reflect planned implementation requirements for each IM. The preliminary schedule was developed in coordination with other ongoing work being conducted by the Custodial Trust pursuant to the First Modification. The schedule for these activities is subject to refinement as input is received from the Custodial Trust, beneficiaries, and other stakeholders.

TABLE 8-2
Summary of Proposed 2015 and 2016 Implementation Schedule
Interim Measures Work Plan 2015/2016

East Helena Facility Planning and Construction Activities	Start	End
2015/2016 Interim Measures Work Plan		
Public Comment Period	February 2015	March 2015
U.S. Environmental Protection Agency Approval		April 2015
2015—PPC Realignment		
Bidding and Award	March 2015	May 2015
Construction	May 2015	November 2015
2015—ET Cover West/ICS 2/Phase 3 Demolition Construction		
Bidding and Award	February 2015	May 2015
Construction	May 2015	November 2015
2016—PPC Realignment (including Smelter Dam Demolition)		
Bidding and Award	March 2015	May 2015
Construction	April 2016	October 2016
2016—ET Cover East/Phase 3 Demolition Construction		
Bidding and Award	February 2015	May 2015
Construction	May 2016	October 2016

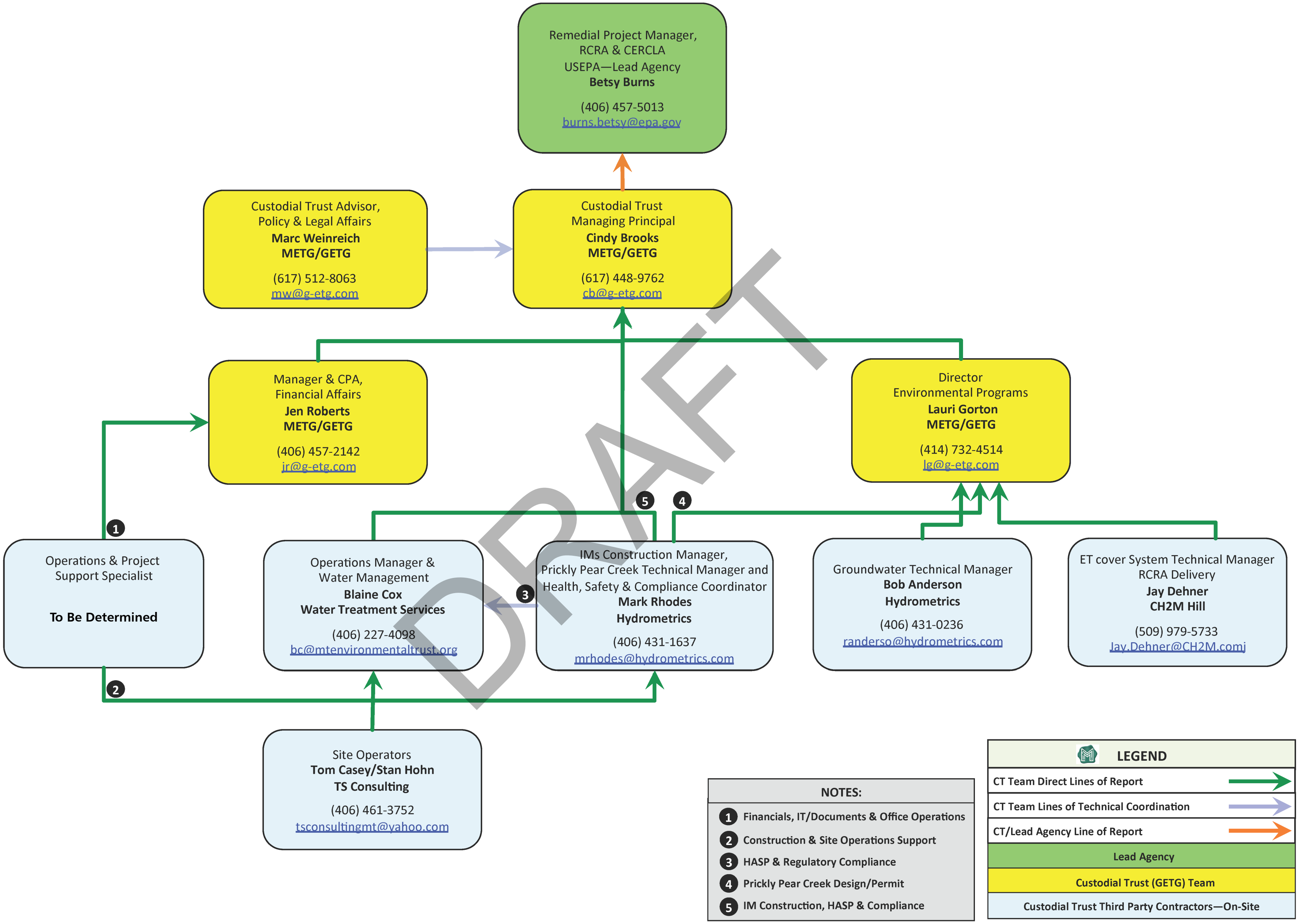


FIGURE 8-1
Project Organization and Lines of Communication
Interim Measures Work Plan–2015/2016
East Helena, Montana

CH2MHILL.

SECTION 9

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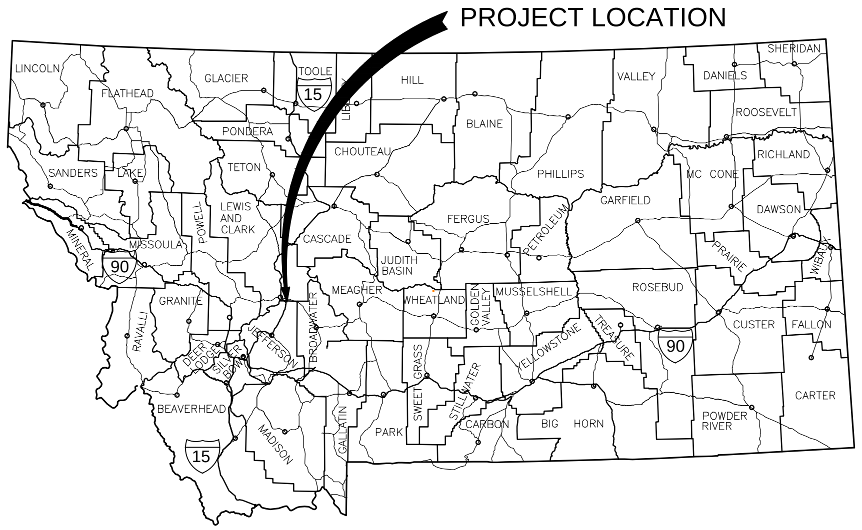
Appendix A
Design Details and Supporting Documentation

Select Prickly Pear Creek Realignment Design Drawings

Note: The index of drawings summarized below lists the design drawings that will be included in the final design and bid package; however, only a portion of those are included in this appendix for review. The attached drawings are highlighted in yellow.



LOCATION MAP

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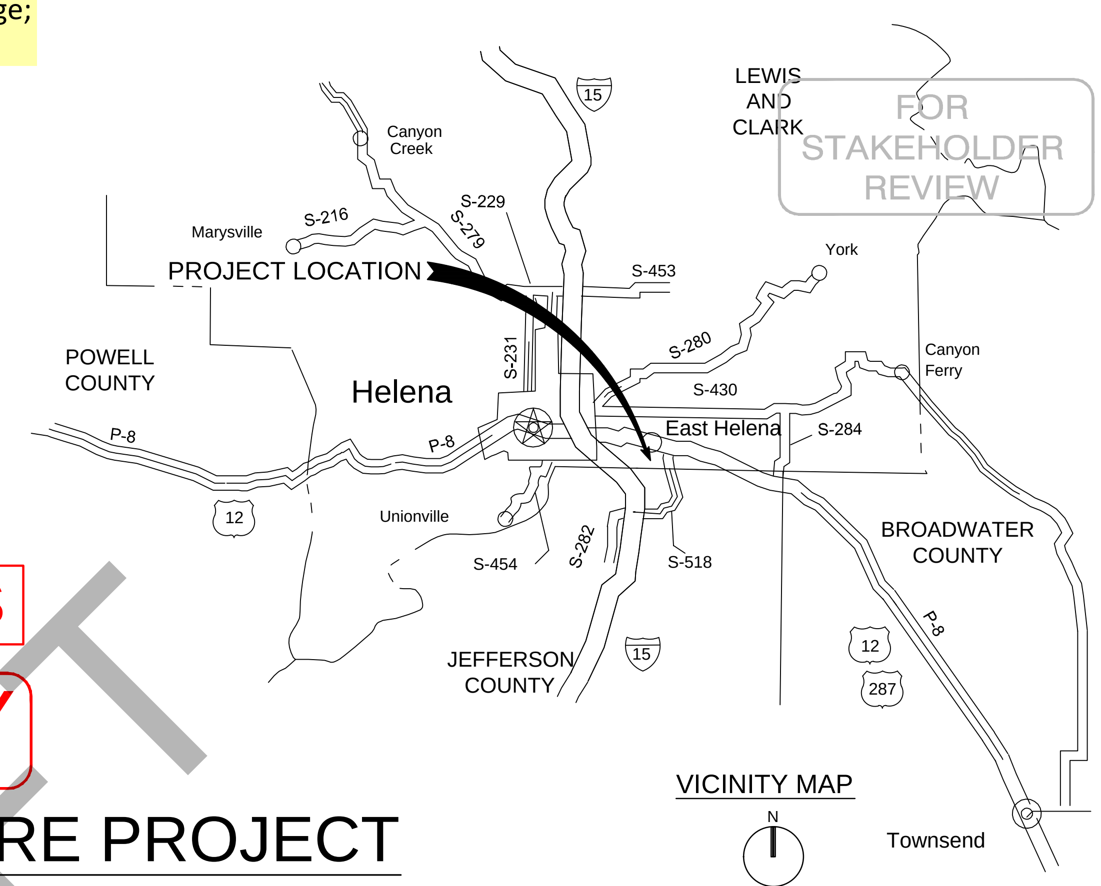

VICINITY MAP

N

90% DOCUMENTS

PRELIMINARY

NOT FOR CONSTRUCTION

DRAFT

EAST HELENA SMELTER CLOSURE PROJECT

PRICKLY PEAR CREEK REALIGNMENT

GENERAL

SHEET NO.	DRAWING NO.	DRAWING TITLE
1	1-1	TITLE, LOCATION AND VICINITY MAP, INDEX TO DRAWINGS
2	1-2	CIVIL LEGENDS, ABBREVIATIONS AND GENERAL NOTES (1 OF 2)
3	1-3	CIVIL LEGENDS, ABBREVIATIONS AND GENERAL NOTES (2 OF 2)
4	1-4	CIVIL SITE LAYOUT/EXISTING CONDITIONS
5	1-5	EXISTING WELL PROTECTION/ABANDONMENT PLAN

CONSTRUCTION STAGING

SHEET NO.	DRAWING NO.	DRAWING TITLE
6	2-1	CONSTRUCTION STAGING STAGE 1 PLAN
7	2-2	CONSTRUCTION STAGING STAGE 2 PLAN
8	2-3	CONSTRUCTION STAGING STAGE 3 PLAN
9	2-4	CONSTRUCTION STAGING STAGE 4 PLAN
10	2-5	CONSTRUCTION STAGING STAGE 5 PLAN
11	2-6	CONSTRUCTION STAGING STAGE 6 PLAN

GROUNDWATER DEWATERING

SHEET NO.	DRAWING NO.	DRAWING TITLE
*12	3-1	SOUTH FLOODPLAIN DEWATERING PLAN
*13	3-2	NORTH FLOODPLAIN DEWATERING PLAN
*14	3-3	SEDIMENT POND PLAN AND DETAILS
*15	3-4	DEWATERING DETAILS

EROSION CONTROL PLAN

SHEET NO.	DRAWING NO.	DRAWING TITLE
16	4-1	STAGE 1B EXCAVATION STORMWATER BMP'S PLAN
17	4-2	STAGE 4 EXCAVATION STORMWATER BMP'S PLAN
18	4-3	STORMWATER BMP DETAILS

EXCAVATION

SHEET NO.	DRAWING NO.	DRAWING TITLE
19	5-1	FLOODPLAIN EXCAVATION PLAN AND PROFILE
20	5-2	STAGE 1A/3 FLOODPLAIN EXCAVATION PLAN AND PROFILE
21	5-3	STAGE 1B FLOODPLAIN EXCAVATION PLAN AND PROFILE (1 OF 2)
22	5-4	STAGE 1B FLOODPLAIN EXCAVATION PLAN AND PROFILE (2 OF 2)
23	5-5	TITO PARK FLOODPLAIN EXCAVATION PLAN AND PROFILE
24	5-6	STAGE 4 FLOODPLAIN EXCAVATION PLAN AND PROFILE (1 OF 2)

EXCAVATION(CONT.)

SHEET NO.	DRAWING NO.	DRAWING TITLE
25	5-7	STAGE 4 FLOODPLAIN EXCAVATION PLAN AND PROFILE (2 OF 2)
26	5-8	SLAG PILE GRADING
27	5-9	STAGE 5 FLOODPLAIN EXCAVATION PLAN AND PROFILE
28	5-10	STAGE 5 FLOODPLAIN EXCAVATION PLAN AND PROFILE
29	5-11	FLOODPLAIN EXCAVATION DETAILS
30	5-12	FLOODPLAIN EXCAVATION DETAILS

FLOODPLAIN

SHEET NO.	DRAWING NO.	DRAWING TITLE
31	6-1	FLOODPLAIN CONSTRUCTION PLAN AND PROFILE
32	6-2	STAGE 1A/3 FLOODPLAIN CONSTRUCTION PLAN AND PROFILE
33	6-3	STAGE 1B FLOODPLAIN CONSTRUCTION PLAN AND PROFILE (1 OF 2)
34	6-4	STAGE 1B FLOODPLAIN CONSTRUCTION PLAN AND PROFILE (1 OF 2)
35	6-5	TITO PARK FLOODPLAIN CONSTRUCTION PLAN AND PROFILE
36	6-6	STAGE 4 FLOODPLAIN CONSTRUCTION PLAN AND PROFILE (1 OF 2)
37	6-7	STAGE 4 FLOODPLAIN CONSTRUCTION PLAN AND PROFILE (2 OF 2)
38	6-8	BUTTRESS AND VEGETATED RIPRAP DETAIL
39	6-9	FLOODPLAIN CONSTRUCTION DETAILS
40	6-10	BURIED SILL DETAIL
41	6-11	SLAG PILE EMBANKMENT PLAN AND PROFILE (1 OF2)
42	6-12	SLAG PILE EMBANKMENT PLAN AND PROFILE (2 OF 2)

CHANNEL RECONSTRUCTION

SHEET NO.	DRAWING NO.	DRAWING TITLE
43	7-1	CHANNEL RECONSTRUCTION PLAN AND PROFILE
44	7-2	STAGE 2A CHANNEL RECONSTRUCTION PLAN AND PROFILE
45	7-3	STAGE 2B CHANNEL RECONSTRUCTION PLAN AND PROFILE (1 OF 2)
46	7-4	STAGE 2B CHANNEL RECONSTRUCTION PLAN AND PROFILE (2 OF 2)
47	7-5	STAGE 4 CHANNEL RECONSTRUCTION PLAN AND PROFILE
48	7-6	STAGE 5 CHANNEL RECONSTRUCTION PLAN AND PROFILE
49	7-7	STAGE 6 CHANNEL RECONSTRUCTION PLAN AND PROFILE
50	7-8	DEFORMABLE RUN, RIFFLE AND POOL SECTIONS
51	7-9	RUN-RIFFLE, RIFFLE-POOL TRANSITION TYPICAL SECTIONS
52	7-10	CHANNEL SECTION TABLES
53	7-11	NON-DEFORMABLE CHANNEL AND STREAM BANK DETAILS
54	7-12	CHANNEL RECONSTRUCTION ROCK RAMP DETAILS
55	7-13	PPC INLET STAGE 1 PLAN AND PROFILE
56	7-14	PPC INLET STAGE 2 PLAN AND PROFILE AND DETAILS
57	7-15	FABRIC ENCAPSULATED SOIL LIFT INSTALLATION DETAILS
58	7-16	TBC OUTLET TIE IN
59	7-17	SMELTER DAM BRIDGE PLACEMENT
60	7-18	STREAMBANK CONSTRUCTION FORM DETAILS
61	7-19	FABRIC ENCAPSULATED SOIL LIFT CONSTRUCTION SEQUENCING

FINAL GRADING

SHEET NO.	DRAWING NO.	DRAWING TITLE
62	8-1	FINAL GRADING OVERALL PLAN VIEW
63	8-2	FINAL PLAN VIEW(1 OF 6)
64	8-3	FINAL PLAN VIEW(2 OF 6)
65	8-4	FINAL PLAN VIEW(3 OF 6)
66	8-5	FINAL PLAN VIEW(4 OF 6)
67	8-6	FINAL PLAN VIEW(5 OF 6)
68	8-7	FINAL PLAN VIEW(6 OF 6)

VEGETATION

SHEET NO.	DRAWING NO.	DRAWING TITLE
69	9-1	VEGETATION OVERALL PLAN
70	9-2	VEGETATION PLAN(1 OF 6)
71	9-3	VEGETATION PLAN (2 OF 6)
72	9-4	VEGETATION PLAN (3 OF 6)
73	9-5	VEGETATION PLAN (4 OF 6)
74	9-6	VEGETATION PLAN (5 OF 6)
75	9-7	VEGETATION PLAN (6 OF 6)
76	9-8	MEANDER BEND PLANTING DETAILS
77	9-9	RUN-RIFFLE PLANTING DETAILS
78	9-10	HARVESTING AND PLANTING DETAILS
79	9-11	EROSION CONTROL BLANKET SLOPE PROTECTION DETAIL
80	9-12	EROSION CONTROL BLANKET SWALE PROTECTION DETAIL

PROJECT SECTIONS

SHEET NO.	DRAWING NO.	DRAWING TITLE
81	10-1	PPC REALIGNMENT CROSS-SECTIONS OVERVIEW
82	10-2	PPC REALIGNMENT CROSS-SECTIONS STA 1+00 TO 8+00
83	10-3	PPC REALIGNMENT CROSS-SECTIONS STA 9+00 TO 16+00
84	10-4	PPC REALIGNMENT CROSS-SECTIONS STA 17+00 TO 29+00
85	10-5	PPC REALIGNMENT CROSS-SECTIONS STA 30+00 TO 47+00
86	10-6	PPC REALIGNMENT CROSS-SECTIONS STA 48+00 TO 53+00

PROJECT COMPLETION GRADING

SHEET NO.	DRAWING NO.	DRAWING TITLE
87	11-1	PROJECT COMPLETION GRADING OVERVIEW PLAN AND PROFILE
88	11-2	PROJECT COMPLETION GRADING NORTH PLAN AND PROFILE
89	11-3	PROJECT COMPLETION GRADING SOUTH PLAN AND PROFILE
90	11-4	PROJECT COMPLETION GRADING CROSS SECTIONS STA 1+06 TO 34+54
91	11-5	PROJECT COMPLETION GRADING CROSS SECTIONS STA 37+33 TO 52+38

REVISION: DATE: BY: DESC:

DRAWN BY: JJJ
DESIGNED BY: GEA
CHECKED BY: CEB
APPROVED BY: JG
PROJECT NO:
DATE: 10/1/14

DISPLAYED AS:
COORD SYS/ZONE: NA
DATUM: NA
UNITS: NA
SOURCE: PIONEER

SCALE IN FEET
0
NTS

MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
TITLE, LOCATION AND VICINITY MAP INDEX OF DRAWINGS

PIONEER TECHNICAL SERVICES, INC.
201 E. BROADWAY, STE. C
HELENA, MONTANA 59601
(406) 457-8252

SHEET
1-1

ABBREVIATIONS

AB	ANCHOR BOLT, ABOVE
ABDN	ABANDON
AC	ASPHALTIC CONCRETE
AD	AREA DRAIN
ADDL	ADDITIONAL
ADJ	ADJACENT
AGGR	AGGREGATE
AHR	ANCHOR
AJ	ADJUSTABLE
APPROX	APPROXIMATE
APVD	APPROVED
AUTO	AUTOMATIC
AUX	AUXILIARY
AVG	AVERAGE
@	AT
BETW	BETWEEN
BF	BLIND FLANGE, BOTTOM FACE
BG	BELOW GRADE
BLDG	BUILDING
BLK	BLOCK
BM	BEAM, BENCHMARK
BOT	BOTTOM
BRG	BEARING
BRKR	BREAKER
BVC	BEGINNING OF VERTICAL CURVE
C	CONDUIT, CASEMENT
C TO C	CENTER TO CENTER
CAB	CABINET
CB	CATCH BASIN, CIRCUIT BREAKER
CC	CONTROL CABLE
CCL	COMPACTED CLAY LAYER
CCP	CENTRAL CONTROL PANEL
CCS	CENTRAL CONTROL SYSTEM
CDN	COMPOSITE DRAINAGE NET
CIP	CAST IN PLACE
CIP	CULVERT INLET PROTECTION
CJ	CONSTRUCTION JOINT
CL	CENTERLINE
CLSF	CONTROLLED LOW STRENGTH FILL
CLR	CLEAR, CLEARANCE
CMP	CORRUGATED METAL PIPE
CO	CLEANOUT, CARBON MONOXIDE
CONC	CONCRETE
CONN	CONNECTION
CONSTR	CONSTRUCTION
CONT	CONTINUED, CONTINUATION
COORD	COORDINATE
CRS	COLD ROLLED STEEL
CRS	CONSTRUCTION ROAD STABILIZATION
CTR	CENTER
CTRD	CENTERED
CU	CUBIC
CU FT	CUBIC FOOT
CU IN	CUBIC INCH
CY, CU YD	CUBIC YARD
DET	DETAIL
DIA	DIAMETER
DIAG	DIAGONAL
DIR	DIRECTION
DISCH	DISCHARGE
DWG	DRAWING
△	DELTA
E	EAST, EMPTY
EA	EACH
EF	EACH FACE
EL	ELEVATION
ELB	ELBOW
ELC	ELECTRICAL LOAD CENTER
ELEC	ELECTRIC, ELECTRICAL
ENGR	ENGINEER
EQL SP	EQUALLY SPACED
EQPT	EQUIPMENT
ESC	EROSION AND SEDIMENT CONTROL
EVC	END OF VERTICAL CURVE
EW	EACH WAY
EXP	EXPANSION, EXPOSED
EXP AB	EXPANSION ANCHOR BOLT
EXP JT	EXPANSION JOINT
EXST, EXIST	EXISTING
EXT	EXTERIOR
FC	FLEXIBLE CONDUIT/ CONNECTOR
FCA	FLANGED COUPLING ADAPTER
FDN	FOUNDATION
FG	FINISH GRADE
FHY	FIRE HYDRANT
FIG	FIGURE
FL	FLOW LINE
FLG	FLANGE
FL	FLOOR
FLEX	FLEXIBLE
FNSH	FINISH
FOB	FLAT ON BOTTOM
FP	FIELD PANEL
FPL	FROST PROTECTION LAYER
FPM	FEET PER MINUTE
FT	FOOT OR FEET
FWD	FORWARD
G, GND	GROUND
GA	GAUGE
GAL	GALLON
GALV	GALVANIZED
GC	GROOVED COUPLING
GCL	GEOSYNTHETIC CLAY LINER
GVL	GRAVEL
HDPE	HIGH DENSITY POLYETHYLENE
HH	HANDHOLE
HORIZ	HORIZONTAL
HP	HORSEPOWER
HPT	HIGH POINT
HWL	HIGH WATER LEVEL
IE	INVERT ELEVATION
I.F.	INSIDE FACE
IN	INCH(ES)
INVT	INVERT
IP	INLET PROTECTION
IRRIG	IRRIGATION
JB	JUNCTION BOX
JCT	JUNCTION
JT	JOINT
L	ANGLE, LENGTH
LB(S)	POUND(S)
LCRS	LEACHATE COLLECTION AND RECOVERY SYSTEM
LDS	LEAK DETECTION SYSTEM
LF	LINEAR FEET
LG	LONG
LONG	LONGITUDINAL
LP	LIGHT POLE
LPT	LOW POINT
LR	LONG RADIUS
LT	LEFT
LTG, LTS	LIGHTS OR LIGHTING
MATL	MATERIAL
MAX	MAXIMUM
MECH	MECHANICAL
MFD	MANUFACTURED
MFR	MANUFACTURER
MH	MANHOLE, MOUNTING HEIGHT
MIN	MINIMUM
MISC	MISCELLANEOUS
MS	MANUFACTURER'S STANDARD
MT	MOUNT
MTD	MOUNTED
MTG	MOUNTING
MU	MULCHING
MWS	MAXIMUM WATER SURFACE
N	NORTH
NA	NOT APPLICABLE
NEUT	NEUTRAL
NG	NATURAL GAS
NGVD	NATIONAL GEODETIC VERTICAL DATUM
NIC	NOT IN CONTRACT
N.O.	NORMALLY OPEN
NO., #	NUMBER
NOM	NOMINAL
N-S	NORTH - SOUTH
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
OF	OVERFLOW
O.F.	OUTSIDE FACE
OPNG	OPENING
OPP	OPPOSITE
OZ	OUNCE
PC	POINT OF CURVE
PCF	POUNDS PER CUBIC FOOT
PI	POINT OF INTERSECTION
PJF	PREMOULDED JOINT FILLER
PL	PROPERTY LINE
PLYWD	PLYWOOD
PMP	PUMP
PNL	PANEL
POE	POINT OF ENDING
PP	POWER POLE
PPC	PRICKLY PEAR CREEK
PR	PAIR
PRC	POINT OF REVERSE CURVE
PRCST	PRECAST
PRES	PRESSURE
PRI	PRIMARY
PROP	PROPERTY
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
PSIG	POUNDS PER SQUARE INCH, GAUGE
PT	POINT OF TANGENCY
PT	PRESSURE TREATED
PVI	POINT OF VERTICAL INTERSECTION
PVMT	PAVEMENT
PVT	POINT OF VERTICAL TANGENCY
R OR RAD	RADIUS
RC	REINFORCED CONCRETE
RDCR	REDUCER
REF	REFER OR REFERENCE
REINF	REINFORCED, REINFORCING, REINFORCE
REQD	REQUIRED
RH	RIGHT HAND
RHR	RIGHT HAND REVERSE
RPE	REINFORCED POLYETHYLENE
RST	REINFORCING STEEL
RT	RIGHT
RTN	RETURN
R/W	RIGHT OF WAY
S	SWITCH
SB	SEDIMENT BASIN
SCHED	SCHEDULE
SEC	SECONDARY
SED	SEDIMENTATION
SH	SHEET
SIM	SIMILAR
SPEC, SPECS	SPECIFICATIONS
SQ	SQUARE
SQ FT	SQUARE FOOT, FEET
SQ IN	SQUARE INCH
ST	STRAIGHT
STA	STATION
STD	STANDARD
STL	STEEL
STRUCT	STRUCTURE
T&B	TOP AND BOTTOM
TAN	TANGENT
TBC	TEMPORARY BYPASS CHANNEL
TECH	TECHNICAL
TEL	TELEPHONE
TEMP	TEMPORARY, TEMPERATURE
THK	THICKNESS
THRU	THROUGH
TOC	TOP OF CONCRETE
TOS	TOP OF SLAB
TP	TURNING POINT
TRANSV	TRANSVERSE
TX	TRANSFORMER
TYP	TYPICAL
UON	UNLESS OTHERWISE NOTED
VC	VERTICAL CURVE
VERT	VERTICAL
VPC	POINT OF VERTICAL CURVATURE
VPI	POINT OF VERTICAL INTERSECTION
VPT	POINT OF VERTICAL TANGENT
W	WEST
W/	WITH

NOTES:

1. CONTACT ENGINEER FOR ABBREVIATIONS USED BUT NOT SHOWN ON THIS DRAWING.

DRAFT

GENERAL SITE

1. SOURCE OF TOPOGRAPHY SHOWN ON THE CIVIL PLANS ARE BASE MAPS PROVIDED BY DJ&A, P.C. EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN ON THESE PLANS. THE CONTRACTOR SHALL VERIFY EXISTING CONDITIONS AND ADJUST WORK PLAN ACCORDINGLY PRIOR TO BEGINNING CONSTRUCTION.
2. EXISTING TOPOGRAPHY, STRUCTURES, AND SITE FEATURES ARE SHOWN SCREENED AND/OR LIGHT-LINED. NEW FINISH GRADE, STRUCTURES, AND SITE FEATURES ARE SHOWN HEAVY-LINED.
3. HORIZONTAL DATUM: NAD 83, MONTANA STATE PLANE COORDINATE SYSTEM, INTERNATIONAL FEET.
4. VERTICAL DATUM: N.A.V.D. 88, U.S. SURVEY FEET.
5. MAINTAIN, RELOCATE, OR REPLACE EXISTING SURVEY MONUMENTS, CONTROL POINTS, AND STAKES WHICH ARE DISTURBED OR DESTROYED. PERFORM THE WORK TO PRODUCE THE SAME LEVEL OF ACCURACY AS THE ORIGINAL MONUMENT(S) IN A TIMELY MANNER, AND AT THE CONTRACTOR'S EXPENSE.
6. STAGING AREA SHALL BE FOR CONTRACTOR'S EMPLOYEE PARKING, CONTRACTOR'S TRAILERS AND ON-SITE STORAGE OF MATERIALS.
7. PROVIDE TEMPORARY FENCING AS NECESSARY TO MAINTAIN SECURITY AT ALL TIMES.
8. ELEVATIONS GIVEN ARE TO FINISH GRADE UNLESS OTHERWISE NOTED.
9. SLOPE UNIFORMLY BETWEEN CONTOURS AND SPOT ELEVATIONS SHOWN.
10. EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE MAINTAINED AND INSPECTED AS STATED IN THE APPROVED EROSION AND SEDIMENTATION PLAN APPROVED IN THE STORMWATER DISCHARGE PERMIT.
11. ALL CONTRACTORS AND SUBCONTRACTORS SHALL COMPLY WITH THE FIELD SAFETY INSTRUCTIONS APPROVED (FSI)FOR THIS SITE AT ALL TIMES.
12. EXISTING SITE DRAINAGE FLOW PATTERNS/DIRECTIONS SHALL BE MAINTAINED UNLESS OTHERWISE INDICATED ON THE PLANS.
13. CONSTRUCTION ACTIVITY BY OTHERS MAY IMPACT THE WORK CONTEMPLATED WITHIN THIS PACKAGE. THE CONTRACTOR SHALL NOTIFY THE ENGINEER IMMEDIATELY IF A CONFLICT ARISES RELATING TO THE PROGRESS OF THE WORK. FINAL COORDINATION/RESOLUTION OF SUCH CONFLICTS SHALL BE THE RESPONSIBILITY OF THE CONTRACTORS INVOLVED.
14. EXISTING FEATURES AND UTILITIES ARE SHOWN ON THE PLANS BASED UPON INFORMATION AVAILABLE AT THE TIME THE PLANS WERE PREPARED. SHOULD UNIDENTIFIED UTILITY OR SERVICE ELEMENTS BE ENCOUNTERED, NOTIFY THE ENGINEER AND THE APPROPRIATE UTILITY OWNER IMMEDIATELY.
15. ACCESS TO THE GENERAL SITE, AND TO SPECIFIC WORK AREAS SHALL BE LIMITED TO THE LOCATIONS SHOWN ON THE PLANS.
16. WATER FOR CONSTRUCTION ACTIVITIES SHALL BE OBTAINED BY THE CONTRACTOR AT THEIR SOLE EXPENSE. ANY AND ALL PERMITS REQUIRED SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR.

STAMP HOLDER

90% DOCUMENTS

PRELIMINARY
NOT FOR CONSTRUCTION

GENERAL NOTE:

1. THIS IS A STANDARD LEGEND SHEET. THEREFORE, NOT ALL OF THE INFORMATION SHOWN MAY BE USED ON THIS PROJECT.

REVISION: DATE:	BY:	DESC:

DRAWN BY: JJJ
DESIGNED BY: GEA
CHECKED BY: CEB
APPROVED BY: JG
PROJECT NO:
DATE: 10/1/14

DISPLAYED AS:
COORD SYS/ZONE: NA
DATUM: NA
UNITS: NA
SOURCE: PIONEER

SCALE IN FEET
0 NTS

MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
CIVIL LEGENDS ABBREVIATIONS AND GENERAL NOTES (1 OF 2)

PIONEER TECHNICAL SERVICES, INC.
201 E. BROADWAY, STE. C
HELENA, MONTANA 59601
(406) 457-8252

SHEET
1-2

CIVIL LEGEND

EXISTING	THIS CONTRACT	
× 157.7	⊗ 158.5	SPOT ELEVATION
155	155	CONTOUR LINE
	3:1	EMBANKMENT AND SLOPE
		DRAINAGEWAY OR DITCH
		COMPLETED CONSTRUCTION
		CURRENT FLOW AREA
	Ⓓ OR Ⓟ	MANHOLE D = STORM DRAIN P = PROCESS
E	E	ELECTRICAL MANHOLE
H	H	ELECTRIC HANDHOLE
		POST OR GUARD POST
		GUY ANCHOR
		FIRE HYDRANT
		UTILITY POLE
		LIGHT POLE
	BM	BENCH MARK
		SURVEY CONTROL POINT OR POINT OF INTERSECTION
		BRUSH/TREE LINE
		TREE
		PROPERTY LINE
		CENTER LINE, BUILDING, ROAD, ETC.
		STAGING OR WORK AREA LIMITS
	N 1000.00 E 1000.00	STRUCTURE, BUILDING OR FACILITY LOCATION POINT - COORDINATES
	B-1	BORING LOCATION AND NUMBER
OR	OR	STRUCTURE, BUILDING OR FACILITY
		SINGLE SWING GATE
		DOUBLE SWING GATE
		SLIDING GATE
		GUARD RAIL
		CHAIN LINK FENCE
		WIRE FENCE
		CULVERT
		TEMPORARY CONSTRUCTION FENCE
W	W	WATER LINE
A	A	AIR LIQUID LINE
FO	FO	FIBER OPTIC BURIED
OHP	OHP	POWER OVERHEAD
G	G	NATURAL GAS
BT	BT	TELEPHONE LINE BURIED
OIL	OIL	HIGH PRESSURE OIL LINE
PW	PW	PRESSURIZED WATER LINE
		TRACK LINE
	Ⓦ	GROUND MONITORING WELL

SECTION OR DETAIL DESIGNATION

DRAWING NUMBER (REPLACED WITH A LINE IF TAKEN AND SHOWN ON SAME SHEET)

A / - 3 / 5-9

ON DRAWING WHERE SECTION OR DETAIL IS TAKEN:

SHEET/DRAWING NUMBER WHERE SHOWN

B / C7-2 SECTION SCALE

ON DRAWING WHERE SECTION IS SHOWN:

DRAWING NUMBER(S) WHERE TAKEN ADDITIONAL SHEETS SHOWN BY SCALE

2 / C7-2 DETAIL SCALE

ON DRAWING WHERE DETAIL IS SHOWN:

DRAWING NUMBER(S) WHERE TAKEN ADDITIONAL SHEETS SHOWN BY SCALE

DRAWING TITLE
SCALE

ON DRAWING WHERE ONLY A TITLE IS REQUIRED WITH NO REFERENCE (eg: ELEVATIONS)

A / -

SECTION CALLOUT WHERE SECTION IS ON THE SAME SHEET AND CUT EXTENDS TO A FIXED LIMIT

A / 4-7 A / 4-7

SECTION CALLOUT WHERE SECTION IS ON ANOTHER SHEET AND CUT EXTENDS THROUGHOUT ENTIRE SHEET

1 KEYED NOTES

1 REVISION NUMBER

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FOR STAKEHOLDER REVIEW

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PROJECT NO:
DATE: 10/1/14

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COORD SYS/ZONE: NA
DATUM: NA
UNITS: NA
SOURCE: PIONEER

SCALE IN FEET
0 NTS

MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
CIVIL LEGENDS ABBREVIATIONS AND GENERAL NOTES (2 OF 2)

PIONEER TECHNICAL SERVICES, INC.
201 E. BROADWAY, STE. C
HELENA, MONTANA 59601
(406) 457-8252

SHEET 1-3

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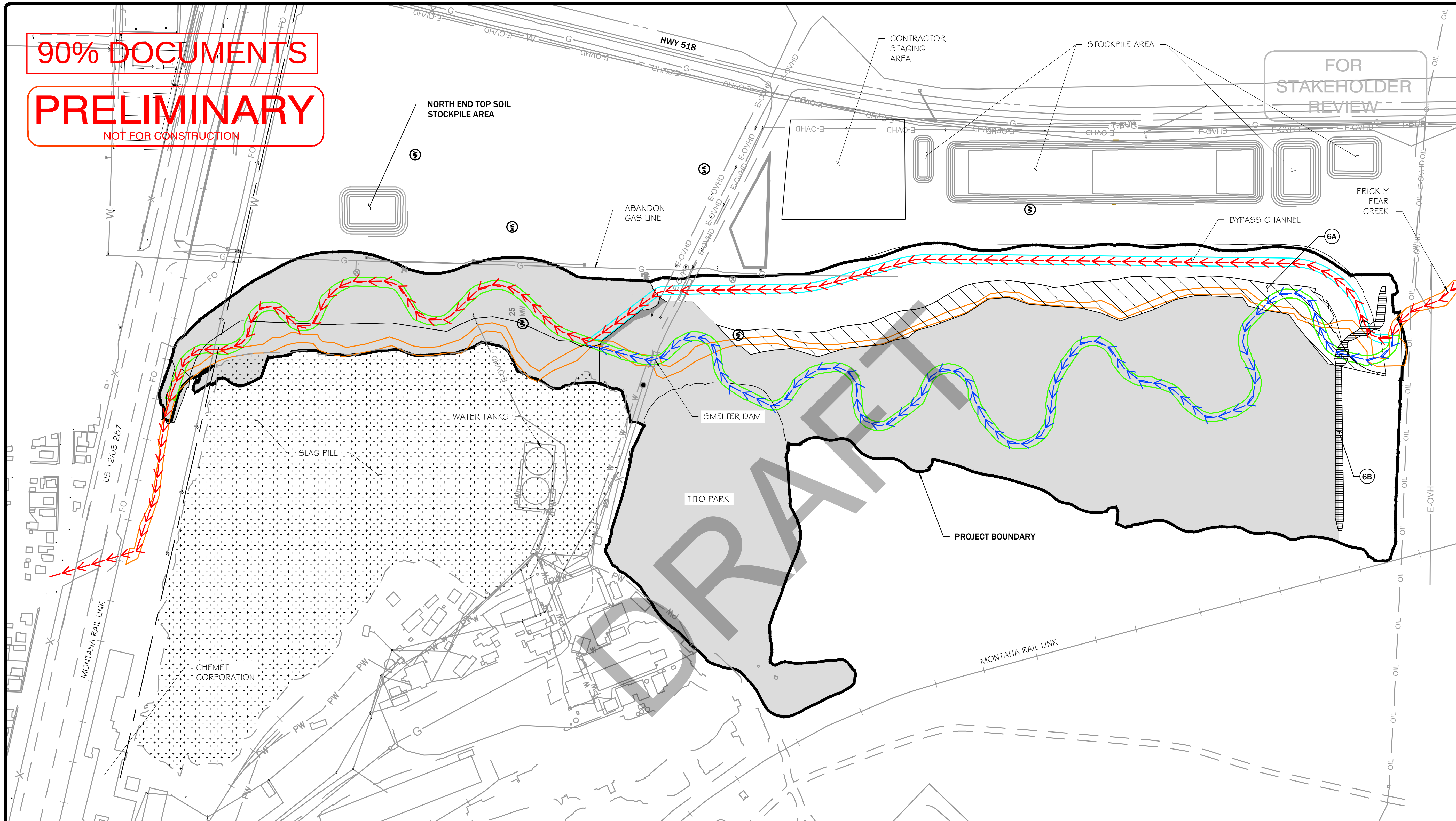

CONSTRUCTION SEQUENCE:

STAGE 6A: EXCAVATE AND BACKFILL CHANNEL AND FLOODPLAIN FEATURES IN DESIGNATED AREA PER EXCAVATION PLANS, FLOODPLAIN PLANS, CHANNEL RECONSTRUCTION, FINAL GRADING PLANS AND TECHNICAL SPECIFICATIONS. INSTALL VEGETATION PER VEGETATION PLANS AND SPECIFICATIONS.

STAGE 6B: CONSTRUCT SHEETPILE AND PPC INLET STRUCTURE. DIVERT FLOW INTO RE-CONSTRUCTED PPC, BUILD TBC INLET SILL AND ONCE TBC MODIFICATIONS ARE COMPLETE RETURN FLOW TO TBC AS DIRECTED BY ENGINEER.

LEGEND:

- (1A) CONSTRUCTION SEQUENCE
- TEMPORARY PPC FLOW DIVERSION 6A
- TEMPORARY PPC FLOW DIVERSION 6B
- ACTIVE EXCAVATION AREA
- ACTIVE EXCAVATION AREA (6B)
- COMPLETED EXCAVATION AND BACKFILL AREA

REVISION: DATE:	BY: DESC:
DRAWN BY:	JJJ
DESIGNED BY:	GEA
CHECKED BY:	CEB
APPROVED BY:	JG
PROJECT NO:	
DATE:	10/1/14

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COORD SYS/ZONE:	MSP
DATUM:	NAD83
UNITS:	INT. FEET
SOURCE:	PIONEER

MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
CONSTRUCTION SEQUENCING STAGE 6 PLAN

PIONEER TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

SHEET 2-6

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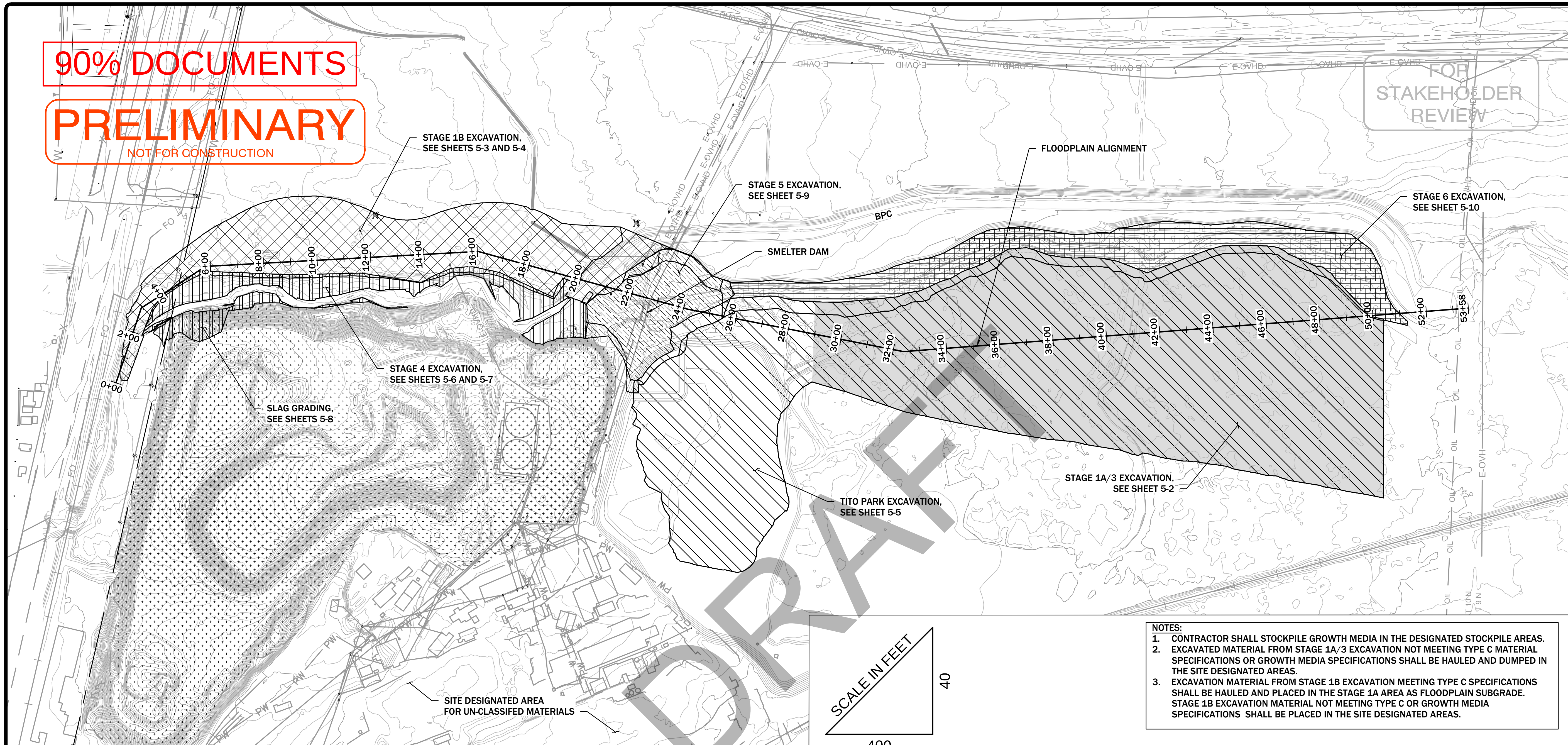
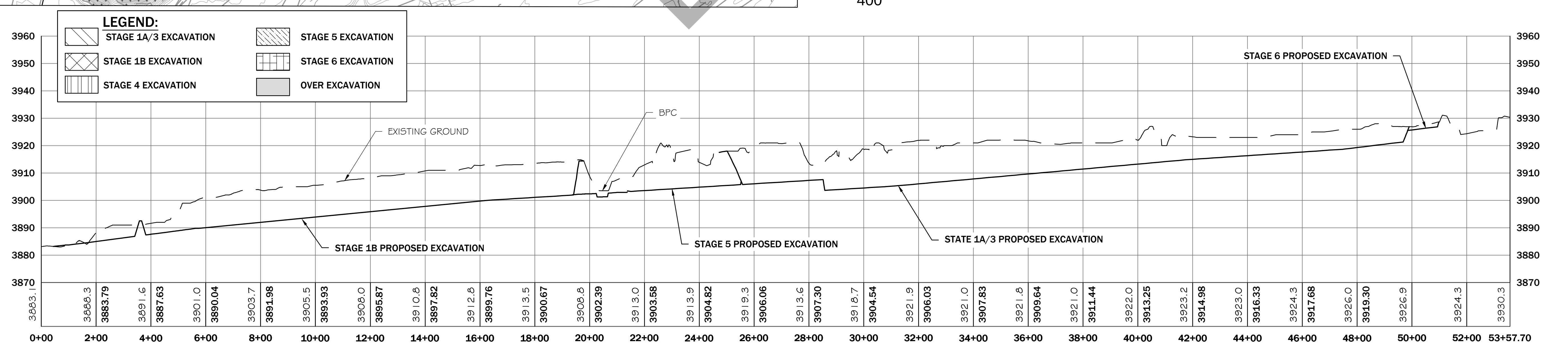
FOR STAKEHOLDER REVIEW



NOTES:
1. CONTRACTOR SHALL STOCKPILE GROWTH MEDIA IN THE DESIGNATED STOCKPILE AREAS.
2. EXCAVATED MATERIAL FROM STAGE 1A/3 EXCAVATION NOT MEETING TYPE C MATERIAL SPECIFICATIONS OR GROWTH MEDIA SPECIFICATIONS SHALL BE HAULED AND DUMPED IN THE SITE DESIGNATED AREAS.
3. EXCAVATION MATERIAL FROM STAGE 1B EXCAVATION MEETING TYPE C SPECIFICATIONS SHALL BE HAULED AND PLACED IN THE STAGE 1A AREA AS FLOODPLAIN SUBGRADE. STAGE 1B EXCAVATION MATERIAL NOT MEETING TYPE C OR GROWTH MEDIA SPECIFICATIONS SHALL BE PLACED IN THE SITE DESIGNATED AREAS.

LEGEND:
- STAGE 1A/3 EXCAVATION
- STAGE 1B EXCAVATION
- STAGE 4 EXCAVATION
- STAGE 5 EXCAVATION
- STAGE 6 EXCAVATION
- OVER EXCAVATION



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REVISION:
DATE: BY: DESC:

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DATUM: NAD83
UNITS: INT. FEET
SOURCE: PIONEER

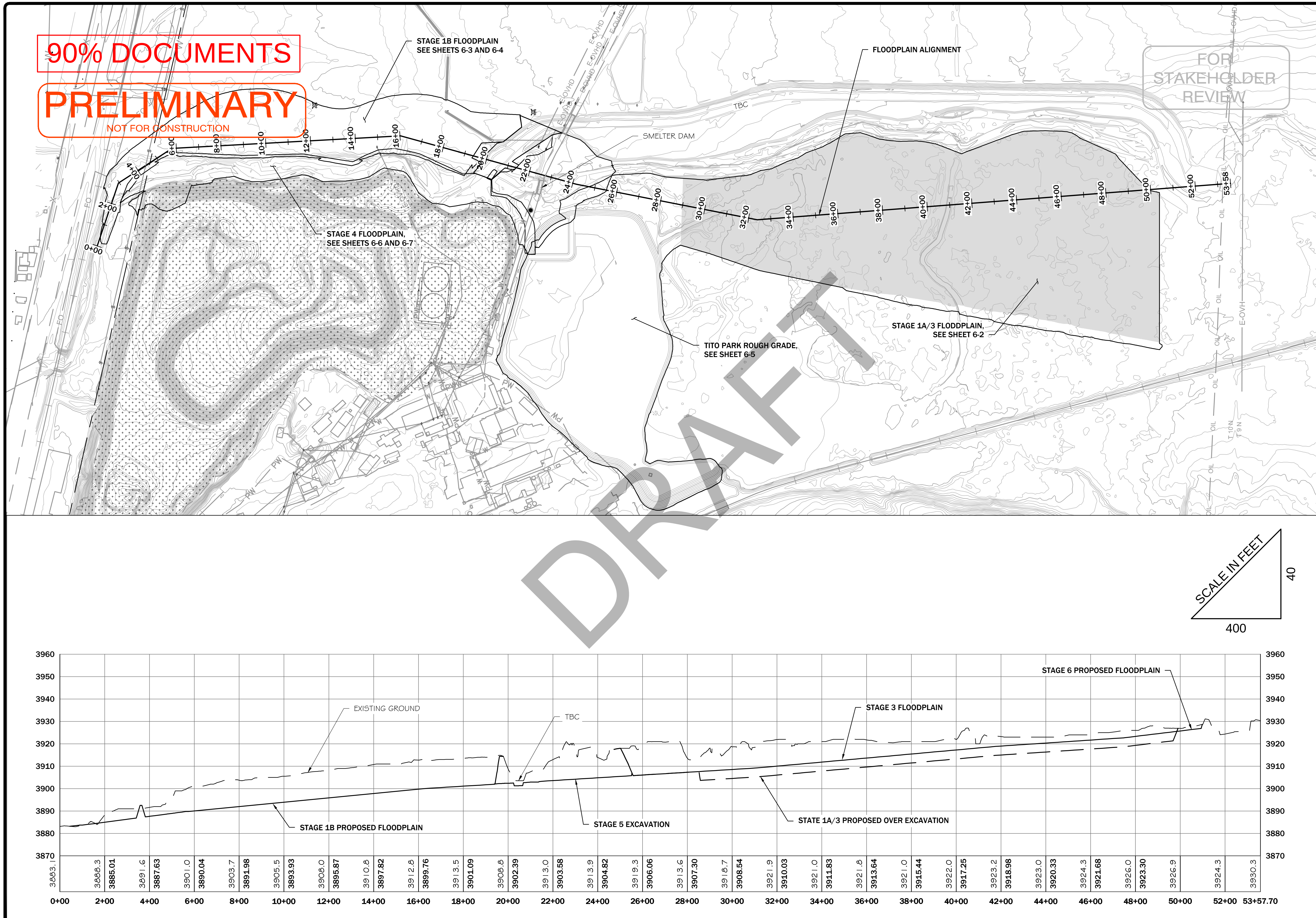
SCALE IN FEET
0 200 400

MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
FLOODPLAIN EXCAVATION PLAN AND PROFILE

PIONEER TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

SHEET
5-1



REVISION:
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DRAWN BY: JJJ
DESIGNED BY: GEA
CHECKED BY: CEB
APPROVED BY: JG
PROJECT NO:
DATE: 10/1/14

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COORD SYS/ZONE: MSP
DATUM: NAD83
UNITS: INT. FEET
SOURCE: PIONEER

SCALE IN FEET
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MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
FLOODPLAIN CONSTRUCTION PLAN AND PROFILE

PIONEER TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

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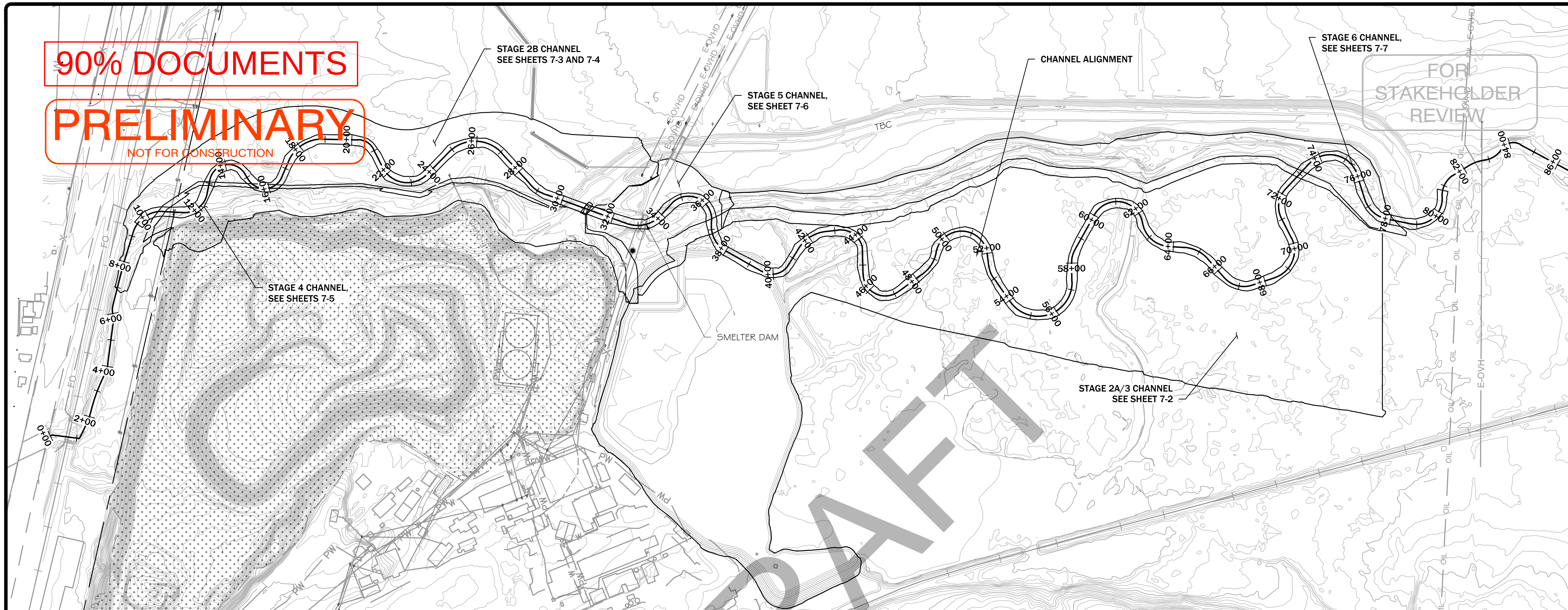

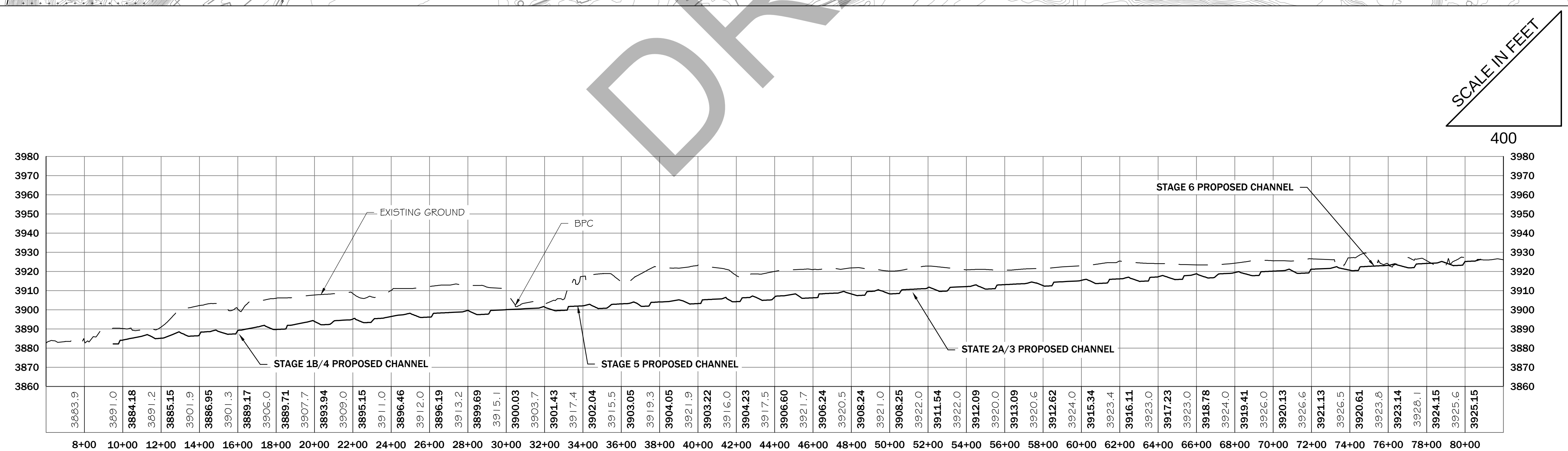

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MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
CHANNEL RECONSTRUCTION PLAN AND PROFILE

PIONEER
TECHNICAL SERVICES, INC.
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(406) 457-8252

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7-1

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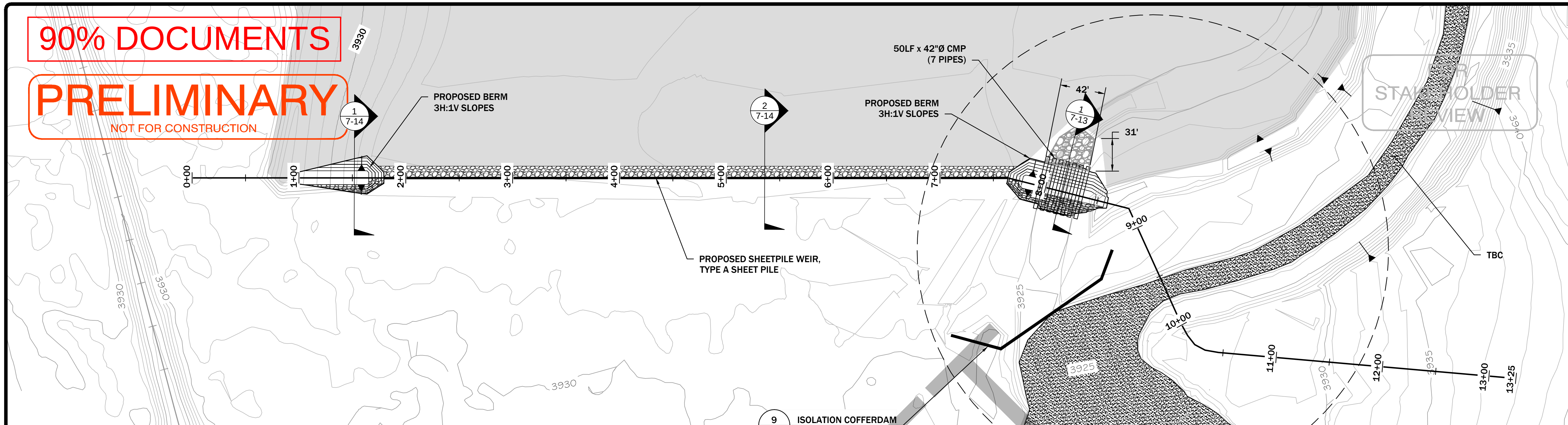
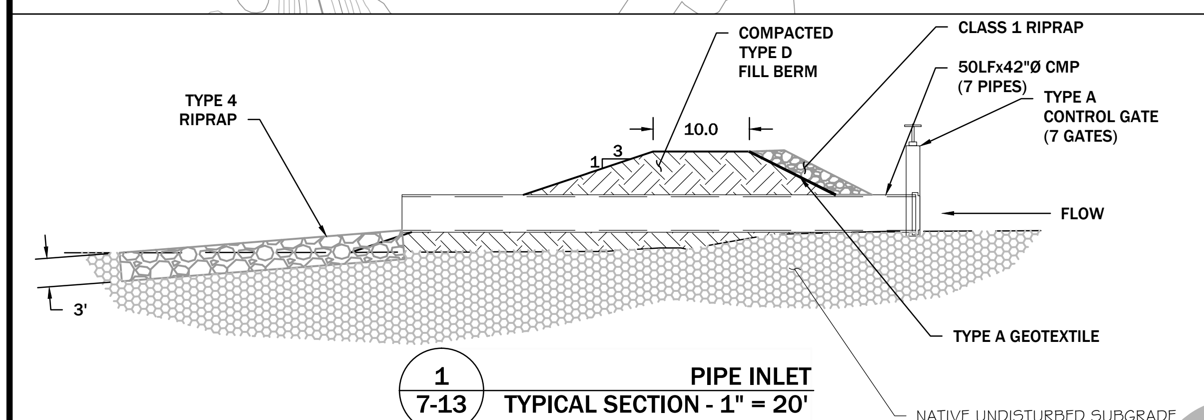
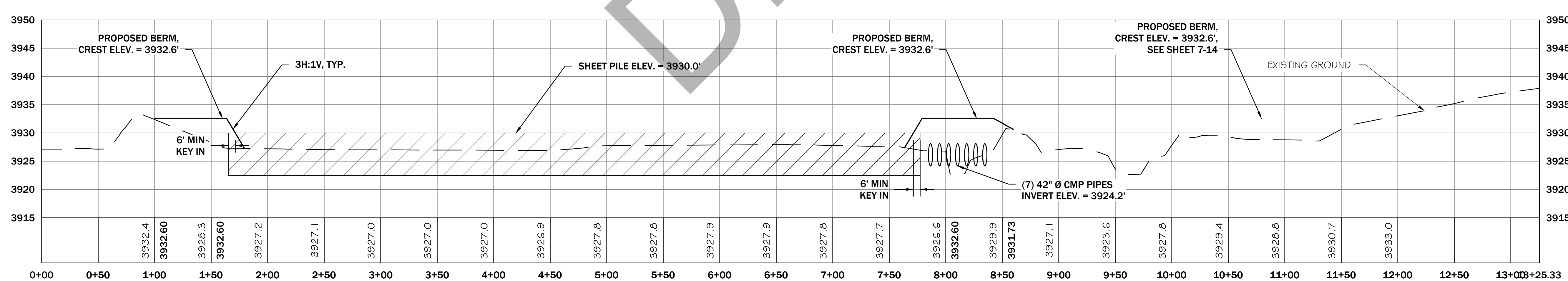




1 / 7-13 PIPE INLET
TYPICAL SECTION - 1" = 20'

NOTES:

1. CONSTRUCT SHEETPILE WEIR, PROPOSED BERM ON WEST SIDE OF FLOODPLAIN.
2. CONSTRUCT TEMPORARY COFFERDAM TO DIRECT ALL FLOW INTO TBC AWAY FROM ACTIVE WORK AREA DURING LOW FLOW CONDITIONS.
3. INSTALL BASEFLOW PIPES AND COMPACTED FILL BERM WITH GATES CLOSED.
4. REMOVE TEMPORARY COFFERDAM



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SOURCE:	PIONEER

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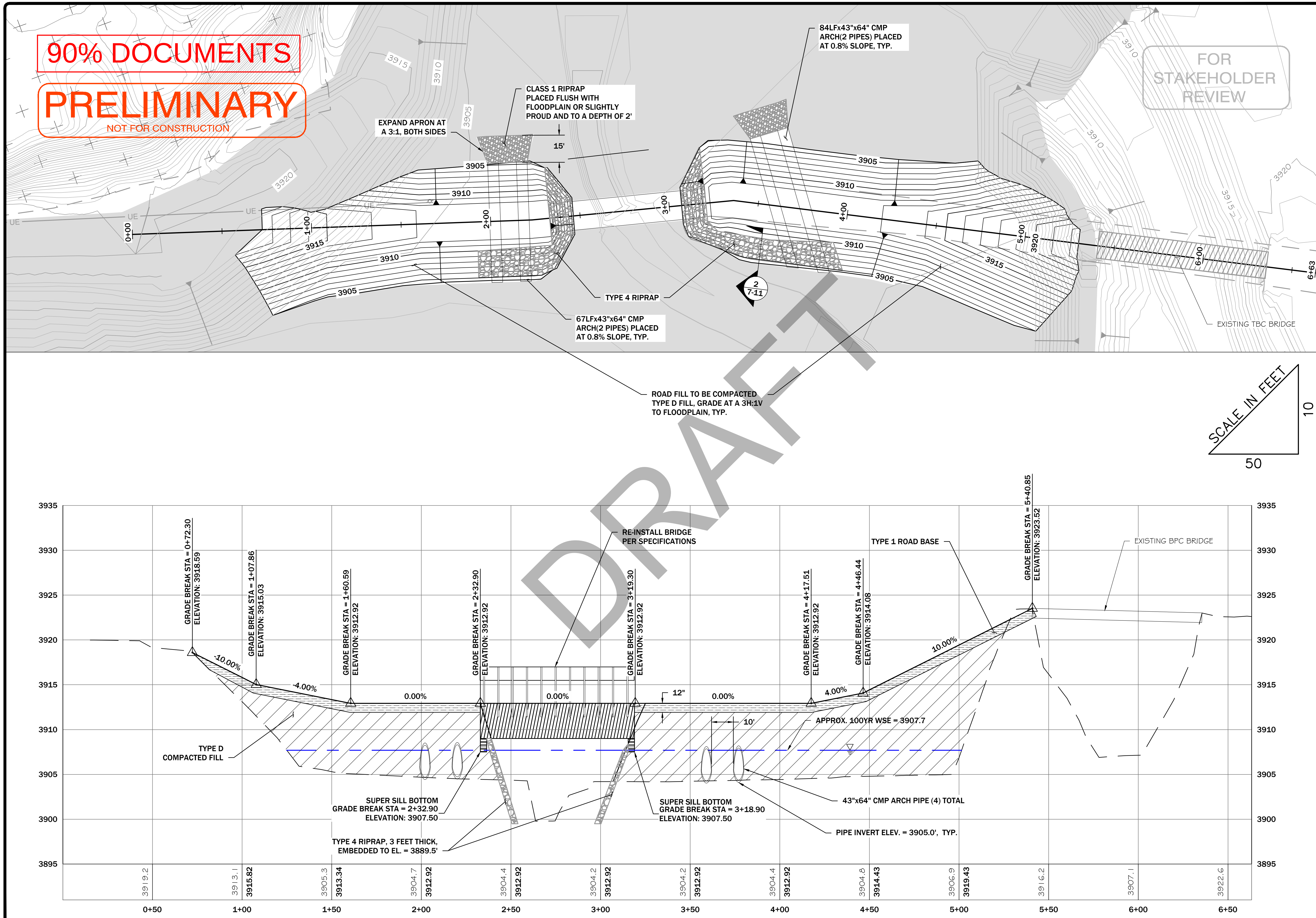
MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT

PPC INLET STAGE 1 PLAN AND PROFILE

PIONEER TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

SHEET 7-13



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APPROVED BY: JG
PROJECT NO:
DATE: 10/1/14

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MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
SMELTER DAM BRIDGE PLACEMENT

PIONEER TECHNICAL SERVICES, INC.
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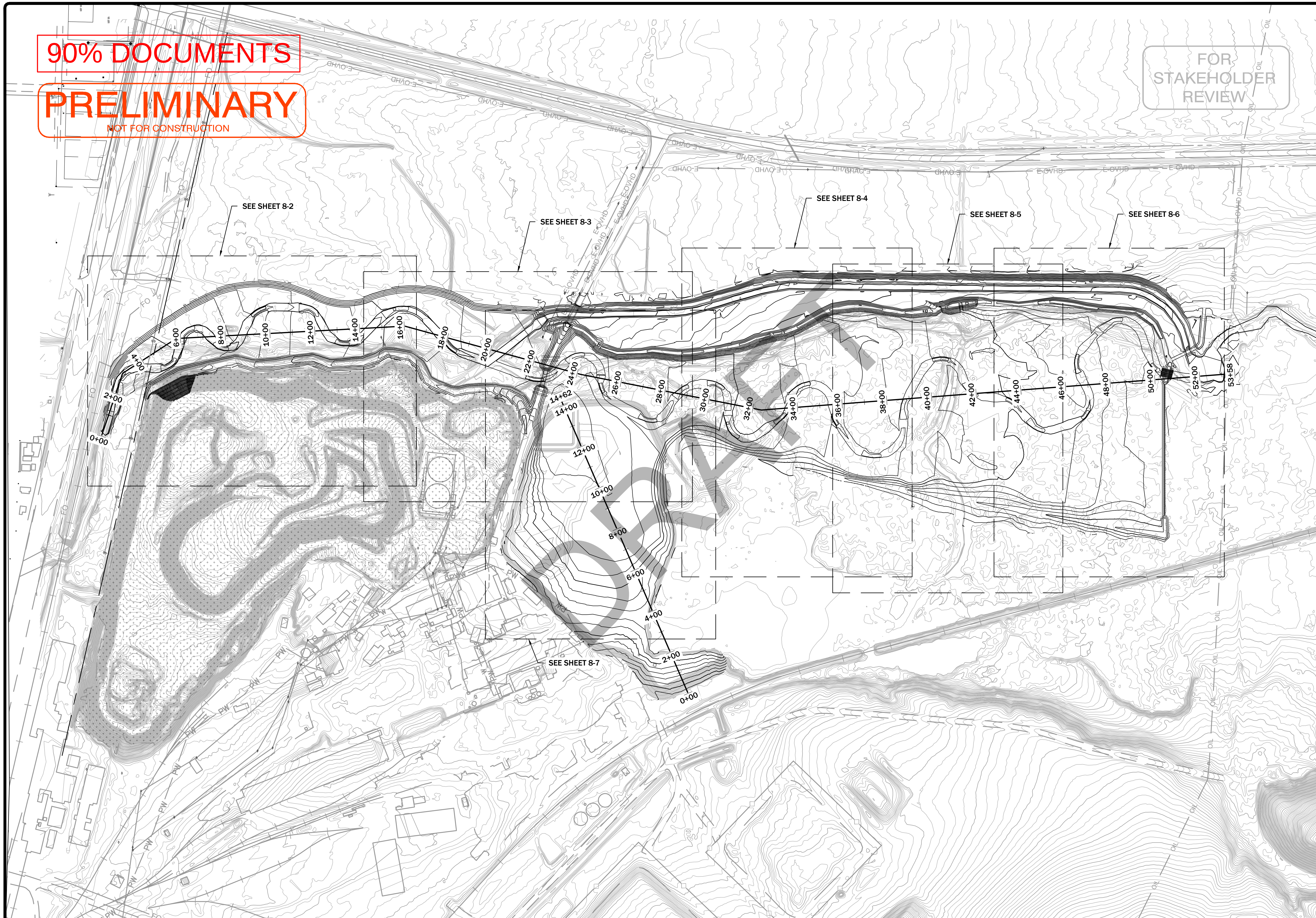
(406) 457-8252

SHEET
7-17



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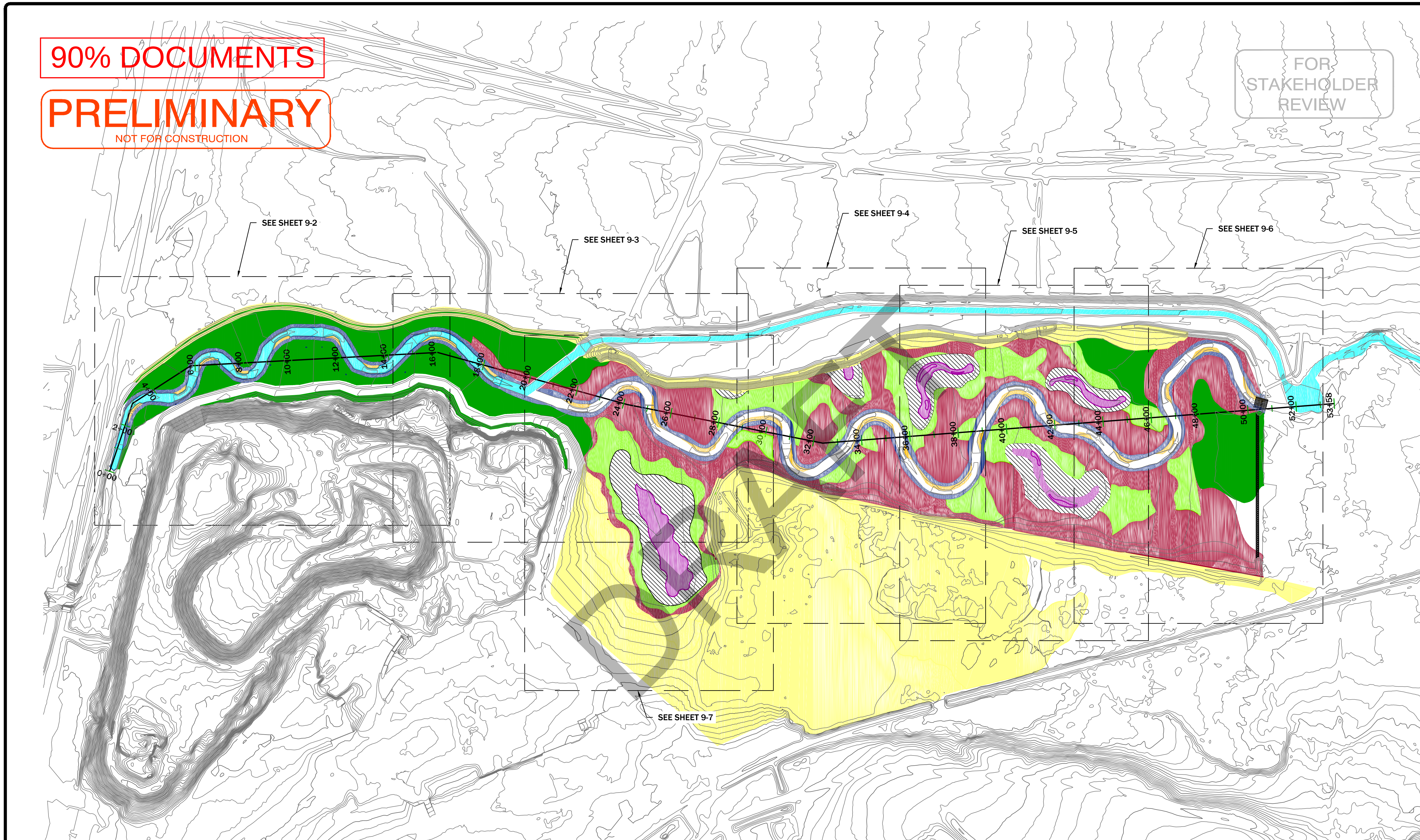
MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT

FINAL GRADING OVERALL PLAN VIEW

PIONEER TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

SHEET
8-1



Legend

SUBMERGENT AREAS -1' TO -2' BELOW 2YR FLOW (1.90 ACRES)	SCRUB/SHRUB AREAS 0' TO 1' ABOVE 2YR FLOW (19.40 ACRES)
EMERGENT 1 AREAS 0' TO -1' BELOW 2YR FLOW (5.42 ACRES)	UPLAND HABITAT AREAS (40.52 ACRES)
EMERGENT 2 AREAS 0' TO 0.5' ABOVE 2YR FLOW (9.39 ACRES)	COLONIZING DEPOSITIONAL
RIPARIAN AREAS (11.77 ACRES)	RIPARIAN BUFFER (5.01 ACRES)

NOTE:
1. GROUNDWATER ELEVATION BASED ON 2-28-13 POST SPHC ESTIMATE EQUAL TO APPROXIMATELY 2' BELOW Q2.
2. PROPOSED RE-ALIGNED PPC SHOWN AT A FLOW OF 50 CFS.

NOTES:
1. SEED AND PLANT INDIVIDUAL HABITATS ACCORDING TO SPECIAL PROVISIONS AND TECHNICAL SPECIFICATIONS.
2. ALL FLOODPLAIN HABITAT AREAS SHALL BE BOTH DRILL SEEDED AND BROADCAST SEEDED.
3. STAGING AREA AND ALL ANCILLARY DISTURBANCE AREAS SHALL BE SEEDED WITH UPLAND SEED MIXTURE UNLESS OTHERWISE DIRECTED BY ENGINEER.
4. SLOPES STEEPER THAN 3:1 SHALL BE HYDRAULIC SEEDED ACCORDING TO SPECIAL PROVISIONS AND TECHNICAL SPECIFICATIONS.
5. WOODY DEBRIS SHALL BE PLACED UNIFORMLY ACROSS THE FLOODPLAIN FOLLOWING SEEDING AND ACCORDING TO SPECIAL PROVISIONS.

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SOURCE: PIONEER

SCALE IN FEET
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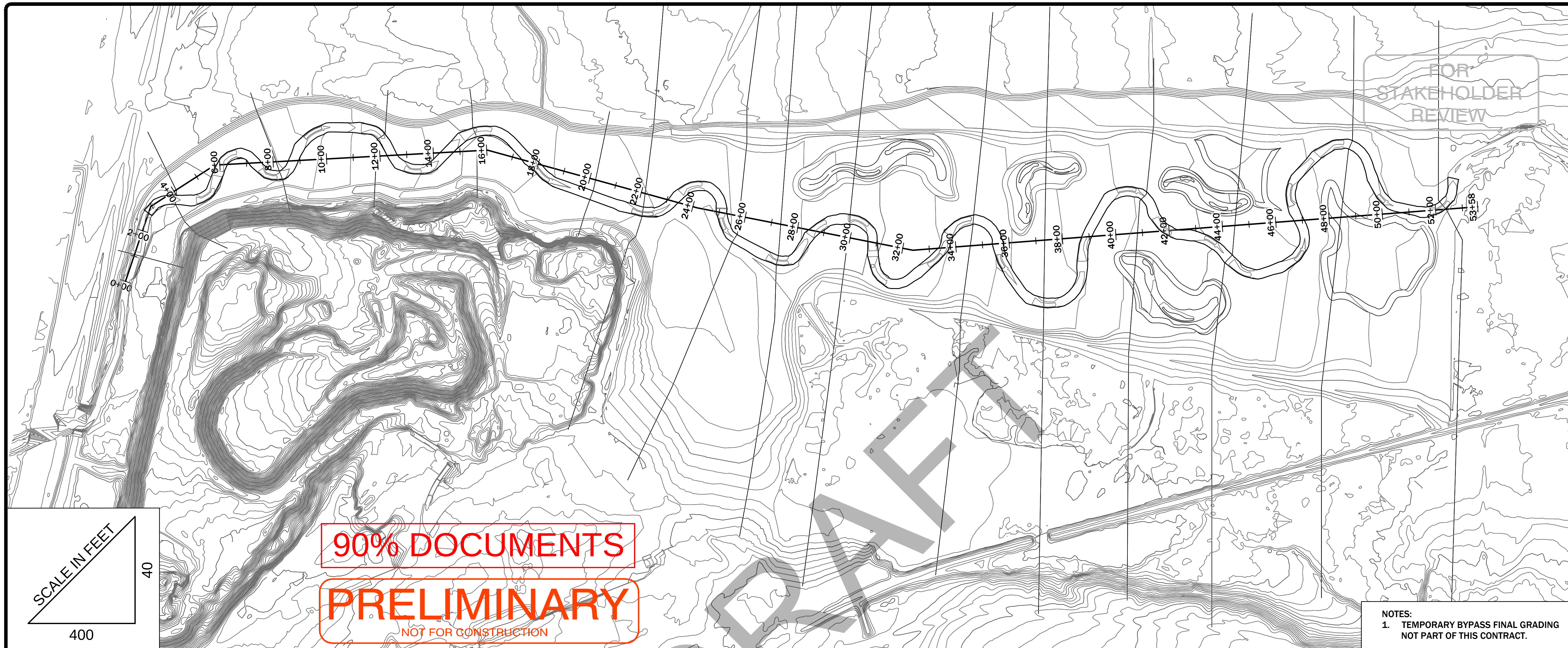
MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

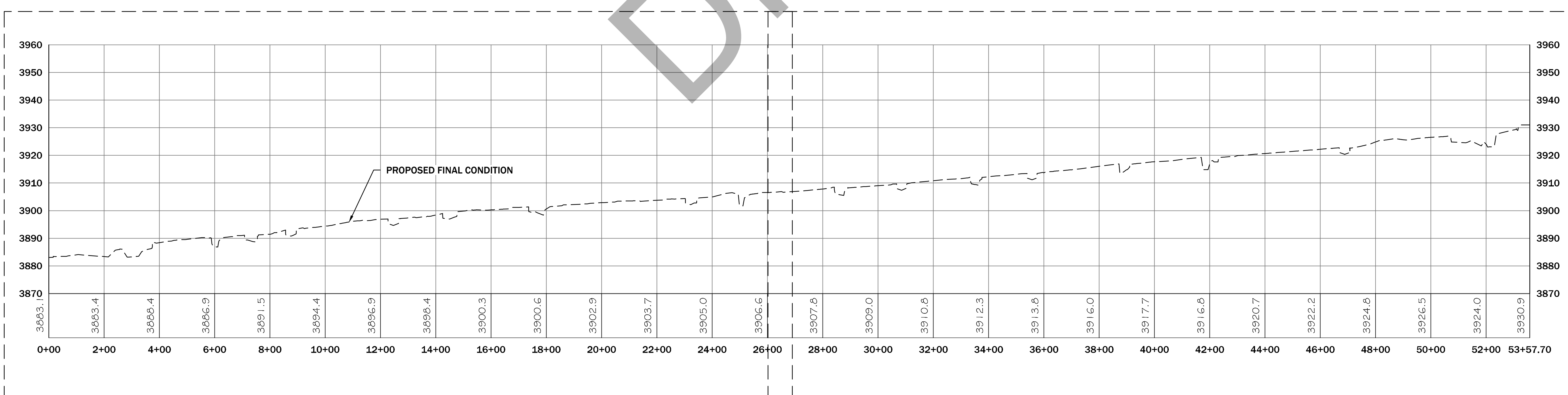
PRICKLY PEAR CREEK REALIGNMENT
VEGETATION OVERALL PLAN VIEW

PIONEER TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

SHEET 9-1



NOTES:
1. TEMPORARY BYPASS FINAL GRADING NOT PART OF THIS CONTRACT.



NORTH PLAN AND PROFILE, SEE SHEET 11-2

SOUTH PLAN AND PROFILE, SEE SHEET 11-3

REVISION:

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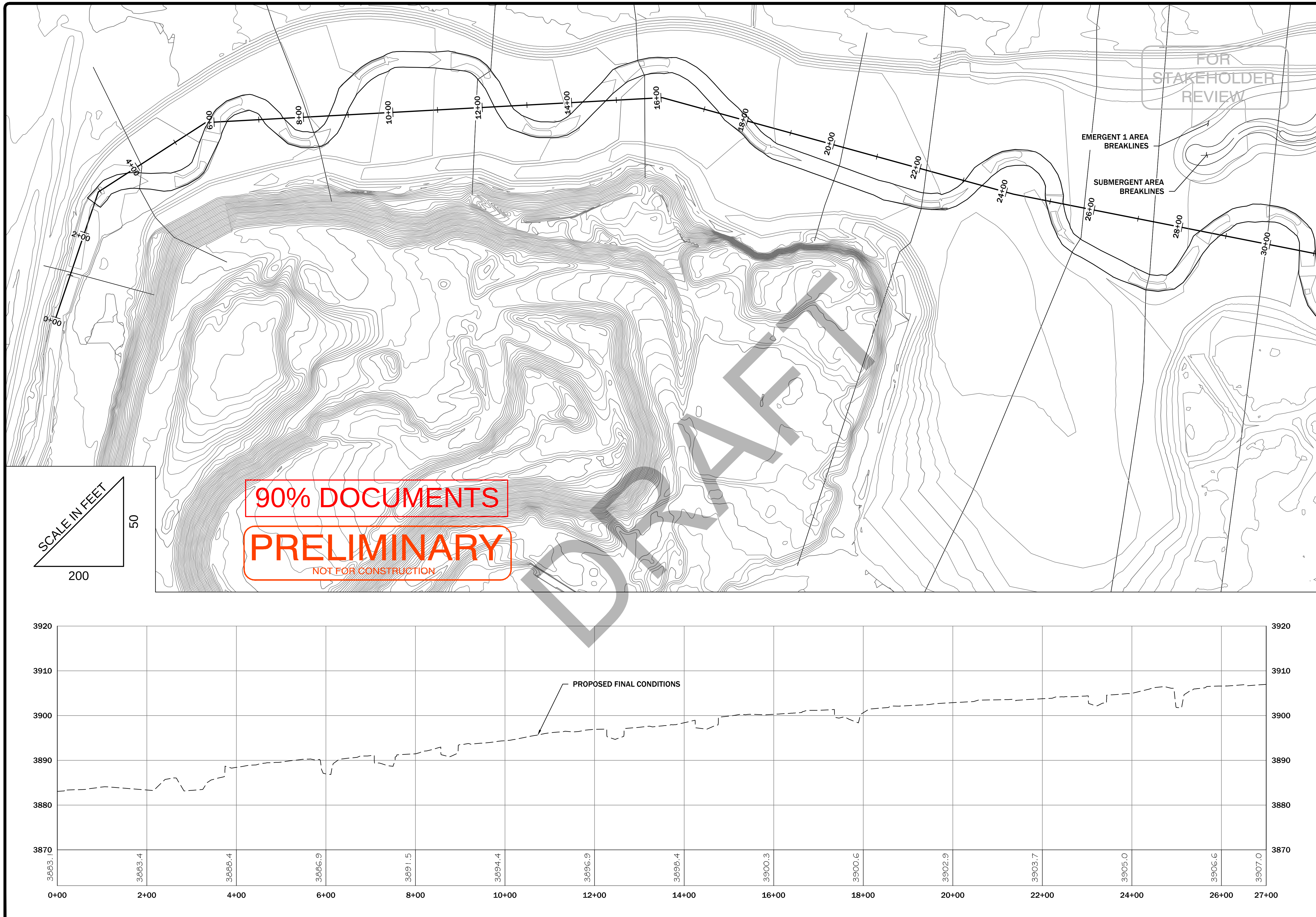
MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
PROJECT COMPLETION GRADING OVERVIEW PLAN & PROFILE

PIONEER TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

SHEET
11-1



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UNITS: INT. FEET
SOURCE: PIONEER

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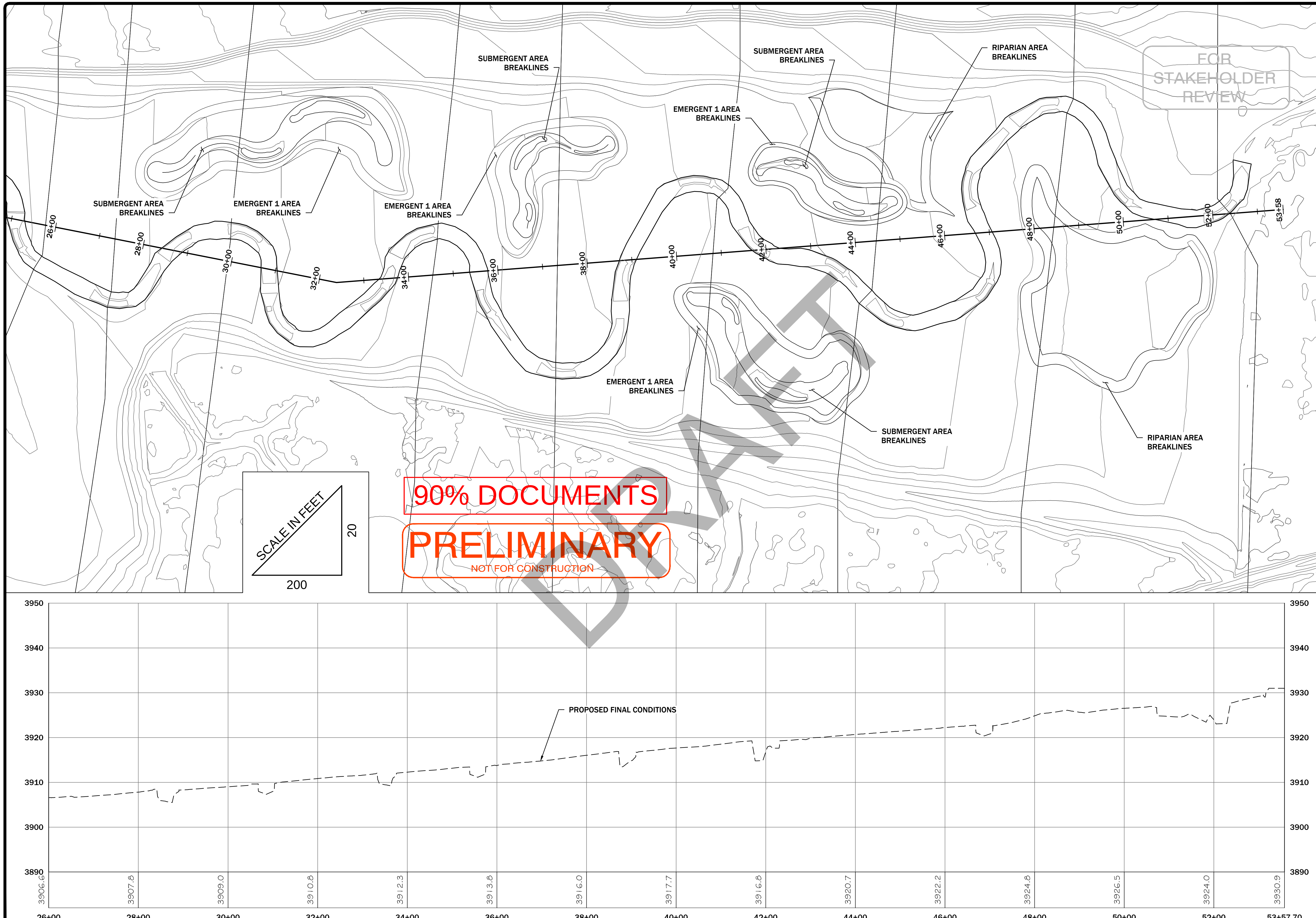
MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
PROJECT COMPLETION GRADING
NORTH
PLAN & PROFILE

PIONEER TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

SHEET
11-2



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DESIGNED BY: CEB
CHECKED BY: GEA
APPROVED BY: JL
PROJECT NO:
DATE: 10/1/14

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COORD SYS/ZONE: MSP
DATUM: NAD83
UNITS: INT. FEET
SOURCE: PIONEER

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MONTANA ENVIRONMENTAL TRUST GROUP
FORMER ASARCO SMELTER SITE
EAST HELENA, MONTANA

PRICKLY PEAR CREEK REALIGNMENT
PROJECT COMPLETION
GRADING
SOUTH
PLAN & PROFILE

PIONEER
TECHNICAL SERVICES, INC.
201 E BROADWAY
HELENA, MONTANA 59601
(406) 457-8252

SHEET
11-3

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Prickly Pear Creek Technical Specifications List

STANDARD TECHNICAL SPECIFICATIONS FOR PRICKLY PEAR CREEK REALIGNMENT

DIVISION 1 – GENERAL REQUIREMENTS

SECTION 01010 GENERAL REQUIREMENTS
SECTION 01041 PROJECT COORDINATION
SECTION 01050 FUEL PRICE ADJUSTMENT
SECTION 01090 SOURCES FOR REFERENCE PUBLICATIONS
SECTION 01300 SUBMITTAL PROCEDURES
SECTION 01310 ENVIRONMENTAL PROTECTION
SECTION 01320 SAFETY, HEALTH, AND EMERGENCY RESPONSE
SECTION 01330 WINTERIZATION
SECTION 01400 CONTRACTOR QUALITY CONTROL
SECTION 01500 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS
SECTION 01570 TEMPORARY TRAFFIC CONTROL
SECTION 01580 TEMPORARY WATER SUPPLY*
SECTION 01600 FIELD SURVEYING
SECTION 01700 CONTRACT CLOSEOUT

DIVISION 2 – SITE WORK

SECTIONS 02100 – SITE PREPARATION

SECTION 02110 MOBILIZATION AND DEMOBILIZATION
SECTION 02120 CLEARING AND GRUBBING
SECTION 02130 ROAD MAINTENANCE AND DUST CONTROL
SECTION 02140 PROVIDE WATER
SECTION 02150 EROSION AND SEDIMENT CONTROL

SECTIONS 02200 – EARTHWORK

SECTION 02210 EARTHWORK
SECTION 02212 HAULING
SECTION 02213 DEBRIS AND STRUCTURE DISPOSAL
SECTION 02214 DIVERSION AND DEWATERING
SECTION 02221 TRENCH EXCAVATION AND BACKFILL FOR PIPELINES AND APPURTENANT STRUCTURES*
SECTION 02236 STOCKPILING OF MATERIALS

SECTIONS 02300 – RIPRAP AND GABIONS

SECTION 02300 RIPRAP

SECTIONS 02400 – CONSTRUCTION FABRICS

SECTION 02410 GEOTEXTILE

SECTIONS 02800 – FENCING AND GATING

SECTION 02810 ACCESS CONTROLS
SECTION 02820 WIRE FENCES AND GATES
SECTION 02822 CHAIN LINK FENCES AND GATES
SECTION 02824 REMOVE AND REPLACE FENCE

SECTIONS 02900 – LANDSCAPING

SECTION 02900 GROWTH MEDIA (COVER SOIL)
SECTION 02901 ORGANIC AMENDMENT (COMPOST)
SECTION 02910 FERTILIZING AND SEEDING
SECTION 02911 MISCELLANEOUS PLANTING
SECTION 02912 WOODY MATERIAL MANAGEMENT
SECTION 02930 NEW STREAM CHANNEL CONSTRUCTION
SECTION 02940 LIME PRODUCTS

DIVISION 3 – CONCRETE

SECTIONS 03200 – CONCRETE REINFORCEMENT

SECTION 03210 REINFORCING STEEL*
SECTION 03310 STRUCTURAL CONCRETE*

Notes:
*Refer to the Montana Public Works Standard Specification, most recent edition.

Prickly Pear Creek List of Available Documents

List of Available Documents used in Prickly Pear Creek Realignment and Wetland Design

- Joint Application No. 2 Binder
  - Application Form
  - Compensatory Mitigation Report
  - Design Documents (see List Below)
  - Design Basis Documents on CD (see List Below)
- Design Documents (Included in Joint Application No. 2, Provided in Hard Copy to Stakeholders)
  - Special Provisions
  - Technical Specifications
  - Drawings
- Design Basis Documents (Provided on CD with Joint Application No. 2 and to all Stakeholders with Design Documents)
  - Baseline Reports
    - Initial Wetlands Delineation Report
    - Baseline Stream Assessment Report
    - Photos, Forms, and Assessments
    - Wildlife Species/T&E Documentation
  - Conceptual Design Report
    - Goals and Objectives
    - Basic Design Criteria
    - Sediment Continuity Analysis
    - Baseline Calculation Summaries (hydrology, hydraulics, sediment transport, etc.)
  - Additional Technical Memos
    - East Helena Geomorphic Assessment and Sediment Transport Analysis
    - Construction Sequencing Options
    - Temporary Bypass Use
    - Slag Pile Regrading Options
    - Plant Salvage
    - Materials Balance
    - Geotechnical/Soils Investigations
  - Even More Calculation Summaries
    - Basic Design Calculations – Scour, Riprap Sizing, Filter, Fish Passage, etc.
    - Temporary Bypass Inlet Design Calculations
    - Updated Sediment Continuity Analysis
    - Conditional Letter of Map Revision No. 2 Floodplain Modeling Technical Memorandum
  - Comments and Responses to Comments on 60 percent Design

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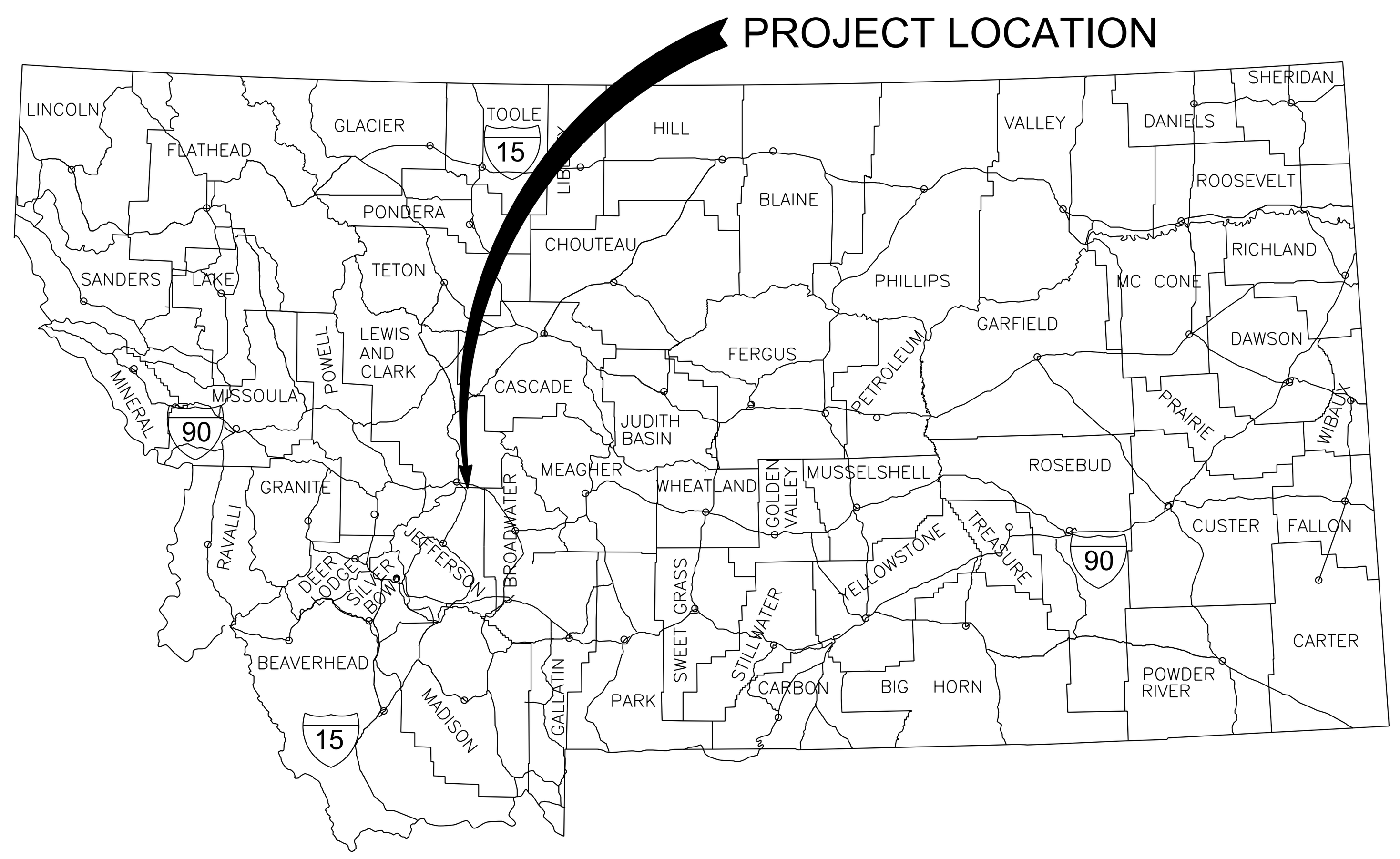
Select Evapotranspiration Cover System, Interim Cover System 2, and Demolition Phase 3 Design Drawings



LOCATION MAP

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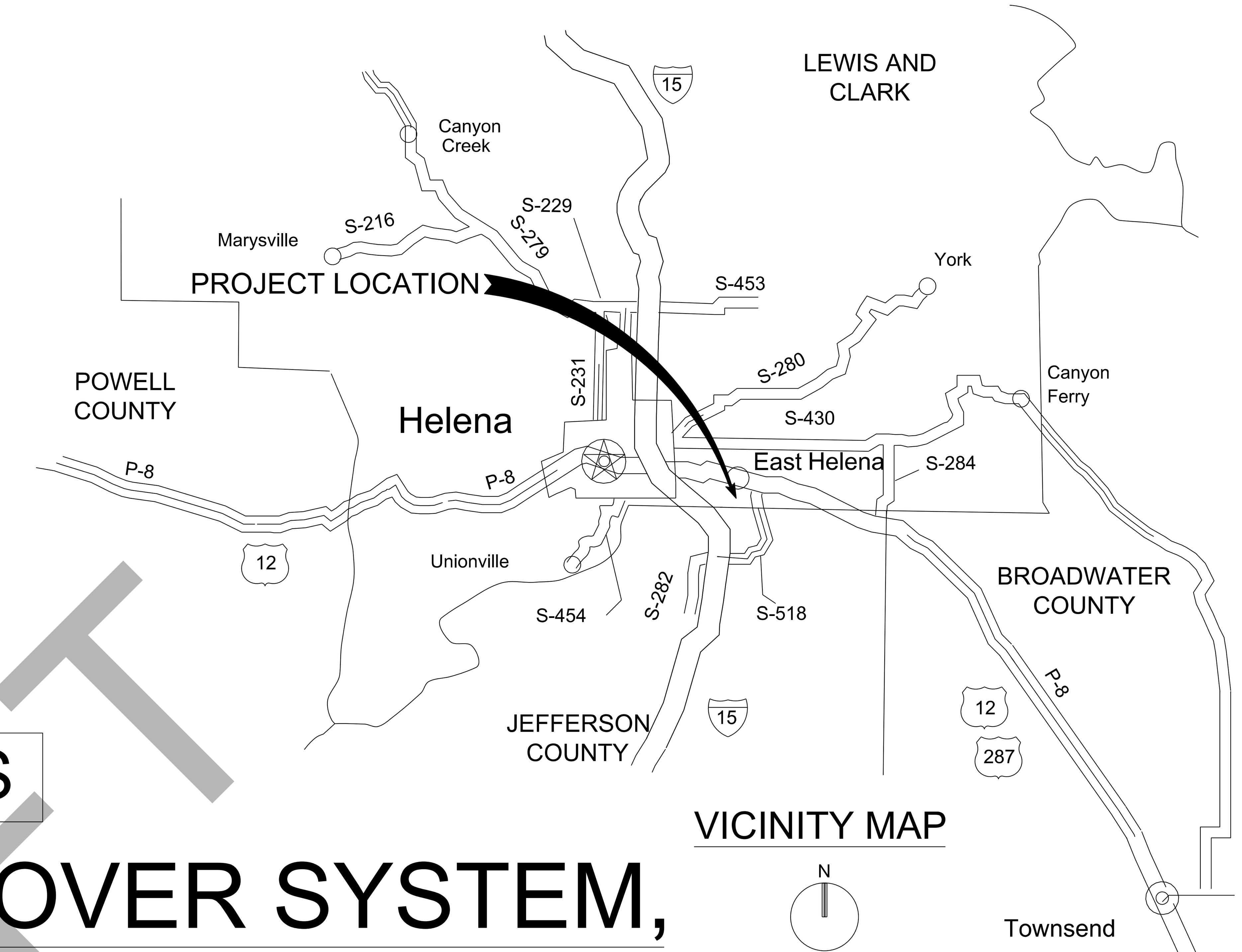

VICINITY MAP

N

60% DRAWINGS

EVAPOTRANSPIRATION (ET) COVER SYSTEM, INTERIM COVER SYSTEM 2 (ICS 2) AND DEMOLITION PHASE 3 FORMER ASARCO EAST HELENA FACILITY

DRAFT

INDEX OF DRAWINGS

GENERAL

SHEET NO.	DRAWING NO.	DRAWING TITLE
1	G-1	TITLE, LOCATION AND VICINITY MAP, INDEX OF DRAWINGS
2	G-2	LEGENDS, ABBREVIATIONS, SYMBOLS AND GENERAL NOTES
3	G-3	OVERALL SITE PLAN

CIVIL AND DEMOLITION

SHEET NO.	DRAWING NO.	DRAWING TITLE
4	C-1	OVERALL INTERIM COVER GRADING AND SEQUENCING PLAN 2015
5	C-2	OVERALL ET COVER GRADING AND SEQUENCING PLAN PHASE 2015
6	C-3	OVERALL INTERIM COVER GRADING AND SEQUENCING PLAN 2016
7	C-4	OVERALL ET COVER GRADING AND SEQUENCING PLAN PHASE 2016
8	C-5	PERIMETER ROAD PLAN AND PROFILE 1
9	C-6	PERIMETER ROAD PLAN AND PROFILE 2
10	C-7	PERIMETER ROAD PLAN AND PROFILE 3
11	C8	GRADING PLAN 1 OF 4
12	C-9	GRADING PLAN 2 OF 4
13	C-10	GRADING PLAN 3 OF 4
14	C-11	GRADING PLAN 4 OF 4
15	C-12	SECTIONS
16	C-13	CIVIL DETAILS 1 OF 2
17	C-14	CIVIL DETAILS 2 OF 2
18	C-15	TRANSPORTATION AND STOCKPILE PLAN
19	C-16	BORROW AREA, MATERIAL PROCESSING, AND STOCKPILE SITE PLAN
20	C-17	DRAINAGE PLAN - ICS 2
21	C-18	DRAINAGE PLAN - FINAL ET COVER
22	C-19	PIPING PLAN
23	C-20	INFILTRATION POND

SHEET NO.	DRAWING NO.	DRAWING TITLE
24	C-21	DRAINAGE DETAILS
25	EC-1	TEMPORARY EROSION AND STORMWATER PLAN
26	EC-2	SOIL STABILIZATION - ET COVER
27	EC-3	SOIL STABILIZATION - BORROW, PROCESSING, AND STOCKPILES AREAS
28	EC-4	EROSION, STORMWATER, AND STABILIZATION DETAILS
29	D-1	EXISTING CONDITIONS
30	D-2	SEQUENCING PLAN 1 2015 DEMOLITION
31	D-3	SEQUENCING PLAN 2 2016 DEMOLITION
32	D-4	DEMOLITION DETAILS (NOT INCLUDED)
33	D-5	2015 DEMOLITION DETAILS
34	D-6	2016 DEMOLITION DETAILS
35	D-7	2016 DEMOLITION DETAILS
36	D-8	WET UTILITY PLANS
37	D-9	DRY UTILITY PLANS
38	D-10	MONITORING WELL LOCATIONS

Note: The index of drawings summarized below lists the design drawings that will be included in the final design and bid package; however, only a portion of those are included in this appendix for review. The attached drawings are highlighted in yellow.

PRELIMINARY NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD
B	11/07/14	60 PERCENT DESIGN	NB	JD
A	09/30/14	30 PERCENT DESIGN	NB	JD

DSGN N. BETTS | DR R. VILORIA | CHK J. SMESRUD | APVD J. DEHNER

METG Montana Environmental Trust Group

Former ASARCO Smelter Site
East Helena, Montana
Montana Environmental Trust Group
East Helena, Montana

CH2MHILL

POWER BLOCK BUILDING
7 WEST 6TH AVE, # 519
HELENA, MT 59601-5036
PHONE: (406) 457-5494

ET COVER SYSTEM, ICS 2, AND DEMOLITION PHASE 3
FORMER ASARCO EAST HELENA FACILITY

TITLE, LOCATION AND VICINITY MAP, INDEX OF DRAWINGS

NTS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
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DATE	SEPTEMBER 2014
PROJ	467300
DWG	G-1
SHEET	1 OF 38

PRELIMINARY - NOT FOR CONSTRUCTION

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ABBREVIATIONS

ADDL	ADDITIONAL
ADJ	ADJACENT
APPROX	APPROXIMATE
APSD	ACID PLANT SEDIMENT DRYING
AS	ACTION SUBMITTAL
BG	BELOW GRADE
BM	BEAM, BENCHMARK
BOT	BOTTOM
BRG	BEARING
CAMU	CORRECTIVE ACTION MANAGEMENT UNIT
CDN	COMPOSITE DRAINAGE NET
CIP	CAST IN PLACE
CL	CENTERLINE
CLSM	CONTROLLED LOW STRENGTH MATERIAL
CONC	CONCRETE
CONT	CONTINUED, CONTINUATION
COORD	COORDINATE
CTR	CENTER
CTRD	CENTERED
CU	CUBIC
CY, CU YD	CUBIC YARD
DET	DETAIL
DIA	DIAMETER
DWG	DRAWING
E	EAST
EA	EACH
EL	ELEVATION
ELC	ELECTRICAL LOAD CENTER
ESC	EROSION AND SEDIMENT CONTROL
EW	EACH WAY
EXC	EXCAVATION
EXST, EXIST	EXISTING
EXT	EXTERIOR
FG	FINISH GRADE
FL	FLOW LINE
FLEX	FLEXIBLE
FT	FOOT OR FEET
FWD	FORWARD
G, GND	GROUND
GALV	GALVANIZED
GM	GEOMEMBRANE
GPM	GALLONS PER MINUTE
GVL	GRAVEL
HDS	HIGH DENSITY SLUDGE
HORIZ	HORIZONTAL
IAW	IN ACCORDANCE WITH
ICS	INTERIM COVER SYSTEM
IE	INVERT ELEVATION
IN	INCH(ES)
INVT	INVERT
IS	INFORMATION SUBMITTAL
L	ANGLE, LENGTH
LF	LINEAR FEET
LG	LONG
LGP	LOW GROUND PRESSURE
LL	LOWER LAKE
LOC	LOCATION
LONG	LONGITUDINAL
LPT	LOW POINT
MATL	MATERIAL
MAX	MAXIMUM
MDT	MONTANA DEPARTMENT OF TRANSPORTATION
MFR	MANUFACTURER
MIL	$^1/_{1000}$ OF 1 INCH
MIN	MINIMUM
MISC	MISCELLANEOUS
N	NORTH
NA	NOT APPLICABLE
NEUT	NEUTRAL
NO.,#	NUMBER
NOM	NOMINAL
N-S	NORTH - SOUTH
NTS	NOT TO SCALE
OD	OUTSIDE DIAMETER
OZ	OUNCE
PCF	POUNDS PER CUBIC FOOT
PI	POINT OF INTERSECTION
PL	PROPERTY LINE
PLS	PROFESSIONAL LAND SURVEYOR
PNL	PANEL
POC	POINT OF CONTACT
PPC	PRICKLY PEAR CREEK
PRI	PRIMARY
PROP	PROPERTY
RDCR	REDUCER
REF	REFER OR REFERENCE
PSI	POUNDS PER SQUARE INCH
PT	POINT
PVC	POLYVINYL CHLORIDE
REQD	REQUIRED
RPE	REINFORCED POLYETHYLENE
R/W	RIGHT OF WAY
SCHED	SCHEDULE
SEC	SECONDARY
SF	SQUARE FEET
SH	SHEET
SIM	SIMILAR
SPEC, SPECS	SPECIFICATIONS
SQ	SQUARE
STD	STANDARD
SY	SQUARE YARDS
TECH	TECHNICAL
TEMP	TEMPORARY, TEMPERATURE
THK	THICKNESS
THRU	THROUGH
TPA	TITO PARK AREA
TYP	TYPICAL
UL	UPPER LAKE
UON	UNLESS OTHERWISE NOTED
UOSA	UPPER ORE STORAGE AREA
UV	ULTRAVIOLET
VERT	VERTICAL
VVL	VALLEY VIEW LANDFILL
W	WEST
WTP	WATER TREATMENT PLANT
W/	WITH

NOTES:

1. CONTACT CONTRACTOR FOR ABBREVIATIONS USED BUT NOT SHOWN ON THIS DRAWING

REFERENCE SYMBOLS

SECTION (LETTER) OR DETAIL (NUMERAL) DESIGNATION

DRAWING NUMBER (REPLACED WITH A LINE IF TAKEN AND SHOWN ON SAME SHEET)

A

3 C-9 — ON DRAWING WHERE SECTION OR DETAIL IS TAKEN: SHEET/DRAWING NUMBER WHERE SHOWN

B C-1 SECTION SCALE — ON DRAWING WHERE SECTION IS SHOWN: DRAWING NUMBER(S) WHERE TAKEN

2 C-3 DETAIL SCALE — ON DRAWING WHERE DETAIL IS SHOWN: DRAWING NUMBER(S) WHERE TAKEN

DRAWING TITLE SCALE — ON DRAWING WHERE ONLY A TITLE IS REQUIRED WITH NO REFERENCE (eg: ELEVATIONS)

A — SECTION CALLOUT WHERE SECTION IS ON THE SAME SHEET AND CUT EXTENDS TO A FIXED LIMIT

A C-7 — SECTION CALLOUT WHERE SECTION IS ON ANOTHER SHEET AND CUT EXTENDS THROUGHOUT ENTIRE SHEET

1 — KEYED NOTES

A1 — ALIGNMENT CURVE NUMBER

1 — REVISION NUMBER

N — NORTH ARROW

CIVIL LEGEND

EXISTING	THIS CONTRACT	
157.7	⊗ 158.5	SPOT ELEVATION
155	155	CONTOUR LINE
	3:1	EMBANKMENT AND SLOPE
		DRAINAGEWAY OR DITCH
	CB OR CB	CATCH BASIN OR INLET
		TRENCH DRAIN
	OR	SIGN
	D OR P	MANHOLE D = STORM DRAIN P = PLANT
	BM	BENCH MARK
		SURVEY CONTROL POINT OR POINT OF INTERSECTION
		BRUSH/TREE LINE
		TREE
		PROPERTY LINE
		CENTER LINE, BUILDING, ROAD, ETC.
		STAGING OR WORK AREA LIMITS
	N 1000.00 E 1000.00	STRUCTURE, BUILDING OR FACILITY LOCATION POINT - COORDINATES
OR	OR	STRUCTURE, BUILDING OR FACILITY
		DOUBLE SWING GATE
		CHAIN LINK FENCE
		SILT FENCE
W	W	WATER LINE
PW	PW	PLANT WATER (DRAINAGE)
	CU	BURIED INSTRUMENT CABLE
		TRACK LINE
		JERSEY BARRIER
W	W	GROUNDWATER MONITORING WELL
G	G	STAFF GAUGE
	⊗	SPOT ELEVATION
		DEMOLISHED STRUCTURES

GENERAL NOTE:

1. THIS IS A STANDARD LEGEND SHEET. THEREFORE, NOT ALL OF THE INFORMATION SHOWN MAY BE USED ON THIS PROJECT.

GENERAL NOTES:

1. SOURCE OF TOPOGRAPHY FOR EXISTING GROUND IN ICS 1, THE FORMER TITO PARK AREA, THE FORMER LOWER LAKE AREA, AND THE WEST FIELDS BORROW AREA ARE BASED ON A GROUND SURVEY CONDUCTED BY HELENA SAND AND GRAVEL DATED NOVEMBER XX, 2014. SOURCE OF TOPOGRAPHY FOR OTHER AREAS, IS AN AERIAL SURVEY CONDUCTED DJ&A, P.C. BETWEEN AUGUST AND OCTOBER 2011. EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN ON THESE PLANS. VERIFY EXISTING CONDITIONS AND ADJUST WORK PLAN ACCORDINGLY PRIOR TO BEGINNING CONSTRUCTION.
2. EXISTING TOPOGRAPHY, STRUCTURES, AND SITE FEATURES ARE SHOWN SCREENED AND/OR LIGHT-LINED. NEW FINISH GRADE, STRUCTURES, AND SITE FEATURES ARE SHOWN HEAVY-LINED.
3. HORIZONTAL DATUM: NAD 83, MONTANA STATE PLANE COORDINATE SYSTEM, INTERNATIONAL FEET.
4. VERTICAL DATUM: N.A.V.D. 88, U.S. SURVEY FEET.
5. MAINTAIN, RELOCATE, OR REPLACE EXISTING SURVEY MONUMENTS, CONTROL POINTS, AND STAKES WHICH ARE DISTURBED OR DESTROYED. PERFORM THE WORK TO PRODUCE THE SAME LEVEL OF ACCURACY AS THE ORIGINAL MONUMENT(S) IN A TIMELY MANNER, AND AT THE SUBCONTRACTOR'S EXPENSE.
6. PROVIDE TEMPORARY FENCING AS NECESSARY TO MAINTAIN SECURITY AT ALL TIMES.
7. ELEVATIONS GIVEN ARE TO FINISH GRADE UNLESS OTHERWISE NOTED.
8. SLOPE UNIFORMLY BETWEEN CONTOURS AND SPOT ELEVATIONS SHOWN.
9. EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE MAINTAINED AND INSPECTED AS STATED IN THE APPROVED EROSION AND SEDIMENTATION PLAN APPROVED IN THE STORMWATER DISCHARGE PERMIT.
10. COMPLY WITH THE FIELD SAFETY INSTRUCTIONS (FSI) APPROVED FOR THIS SITE AT ALL TIMES.
11. EXISTING SITE DRAINAGE FLOW PATTERNS/DIRECTIONS SHALL BE MAINTAINED UNLESS OTHERWISE INDICATED ON THE PLANS.
12. CONSTRUCTION ACTIVITY BY OTHERS MAY IMPACT THE WORK IN THIS PACKAGE. COORDINATE WITH OTHERS AS SPECIFIED. NOTIFY THE CONTRACTOR IMMEDIATELY IF A CONFLICT ARISES RELATING TO THE PROGRESS OF THE WORK. FINAL COORDINATION/RESOLUTION OF SUCH CONFLICTS SHALL BE THE RESPONSIBILITY OF THE SUBCONTRACTOR.
13. EXISTING FEATURES AND UTILITIES ARE SHOWN ON THE PLANS BASED UPON INFORMATION AVAILABLE AT THE TIME THE PLANS WERE PREPARED. SHOULD UNIDENTIFIED UTILITY OR SERVICE ELEMENTS BE ENCOUNTERED, NOTIFY THE CONTRACTOR AND THE APPROPRIATE UTILITY OWNER IMMEDIATELY.
14. ACCESS TO THE GENERAL SITE, AND TO SPECIFIC WORK AREAS SHALL BE LIMITED TO THE LOCATIONS SHOWN ON THE PLANS.
15. WATER FOR CONSTRUCTION ACTIVITIES SHALL BE OBTAINED BY THE SUBCONTRACTOR AT THEIR SOLE EXPENSE. ANY AND ALL PERMITS REQUIRED SHALL BE THE RESPONSIBILITY OF THE SUBCONTRACTOR.

SURVEY CONTROL POINTS

POINT #	NORTHING, IN FEET	EASTING, IN FEET	ELEVATION, IN FEET	MONUMENT DESCRIPTION
2	859807.77	1358978.72	3931.69	SET - AC
101	858847.195	1359848.197	3935.396	ASARCO - BM1
103	859423.257	1361402.417	3919.772	BRIDGE - STAFFNUT
106	861564.695	1359088.903	3899.418	E-459 USGS
125	859721.970	1360039.615	3913.60	FND - MAGNAIL
250	861078.79	1359099.59	3911.8	SET - REBAR CAP
251	861179.74	1359415.57	3907.15	SET - MAGNAIL
354	858981.56	1362515.45	3923.47	FND 3/4 REBAR

DRAFT

PRELIMINARY NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD
B	11/07/14	60 PERCENT DESIGN	NB	JD

DSGN N. BETTS; DR R. VILORIA; CHK J. SMESRUD; APVD J. DEHNER

METG Montana Environmental Trust Group

Former ASARCO Smelter Site, East Helena, Montana

Montana Environmental Trust Group, East Helena, Montana

CH2MHILL
POWER BLOCK BUILDING
7 WEST 6TH AVE, # 519
HELENA, MT 59601-5036
PHONE: (406) 457-5494

ET COVER SYSTEM, ICS 2 AND, DEMOLITION PHASE 3
FORMER ASARCO EAST HELENA FACILITY

LEGENDS, ABBREVIATIONS, SYMBOLS AND GENERAL NOTES

NTS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2014
PROJ	467300
DWG	G-2
SHEET	2 OF 38

1 2 3 4 5 6

A B C D

N

0 200 400 600
SCALE IN FEET

NOTES:

1. THE PPC REALIGNMENT (RA) PROJECT IS NOT INCLUDED IN THIS CONTRACT. COORDINATE WORK WITH THE PPC RA CONTRACTOR AS SPECIFIED.
2. LOWER LAKE, TITO PARK, AND UPPER LAKE WERE REMOVED IN 2014.
3. REFER TO BORROW DRAWINGS FOR MORE DETAIL.

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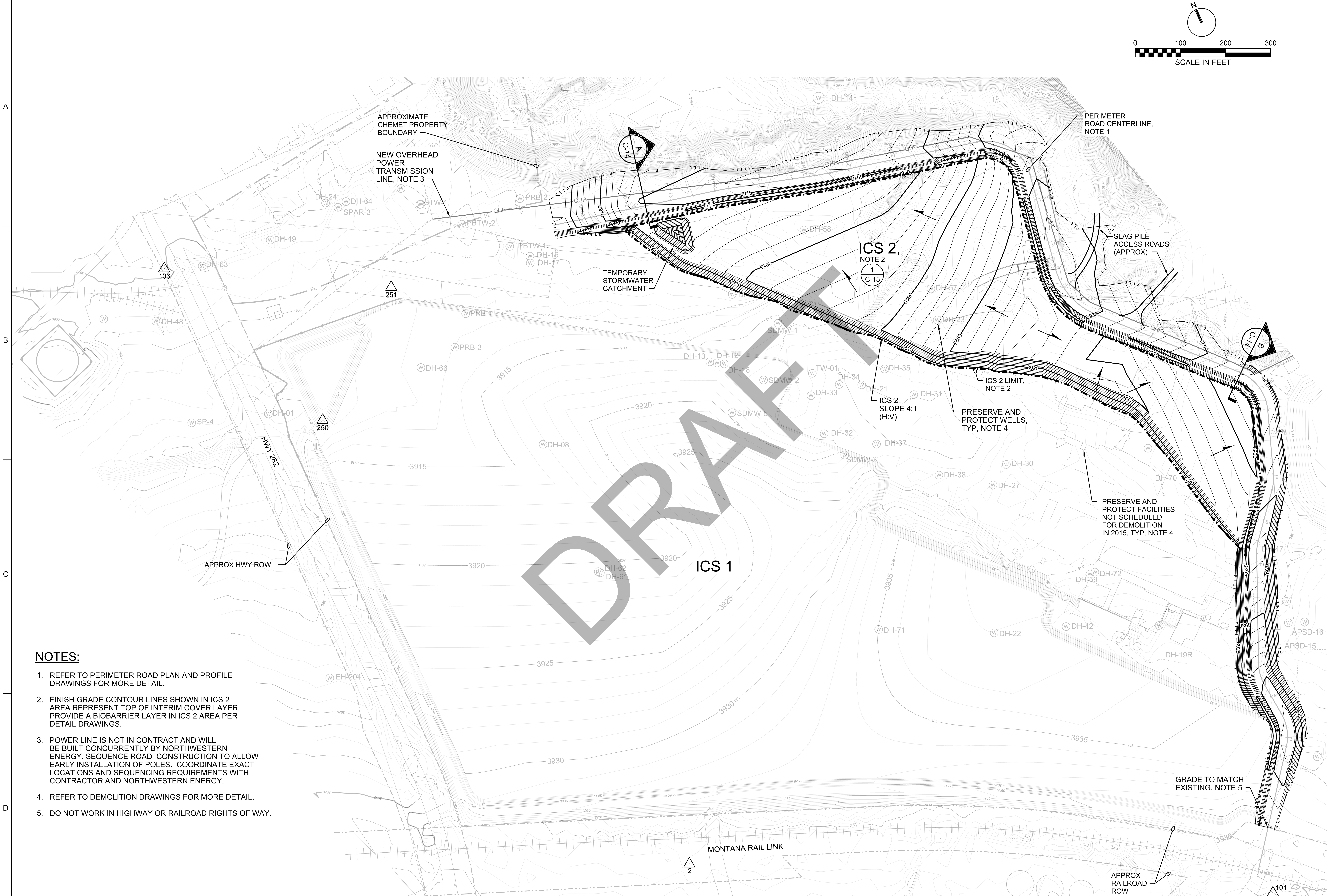
ET COVER SYSTEM, ICS2 AND, DEMOLITION PHASE 3
FORMER ASARCO EAST HELENA FACILITY

OVERALL SITE PLAN

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2014
PROJ	467300
DWG	G-3
SHEET	3 OF 38



NOTES:

1. REFER TO PERIMETER ROAD PLAN AND PROFILE DRAWINGS FOR MORE DETAIL.
2. FINISH GRADE CONTOUR LINES SHOWN IN ICS 2 AREA REPRESENT TOP OF INTERIM COVER LAYER. PROVIDE A BIOBARRIER LAYER IN ICS 2 AREA PER DETAIL DRAWINGS.
3. POWER LINE IS NOT IN CONTRACT AND WILL BE BUILT CONCURRENTLY BY NORTHWESTERN ENERGY. SEQUENCE ROAD CONSTRUCTION TO ALLOW EARLY INSTALLATION OF POLES. COORDINATE EXACT LOCATIONS AND SEQUENCING REQUIREMENTS WITH CONTRACTOR AND NORTHWESTERN ENERGY.
4. REFER TO DEMOLITION DRAWINGS FOR MORE DETAIL.
5. DO NOT WORK IN HIGHWAY OR RAILROAD RIGHTS OF WAY.

PRELIMINARY NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD
B	11/07/14	60 PERCENT DESIGN	NB	JD
A	09/30/14	30 PERCENT DESIGN	NB	JD

DSGN	DR	CHK	APVD
N. BETTS	R. VILORIA	J. SMESRUD	J. DEHNER

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East Helena, Montana
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PHONE: (406) 457-5494

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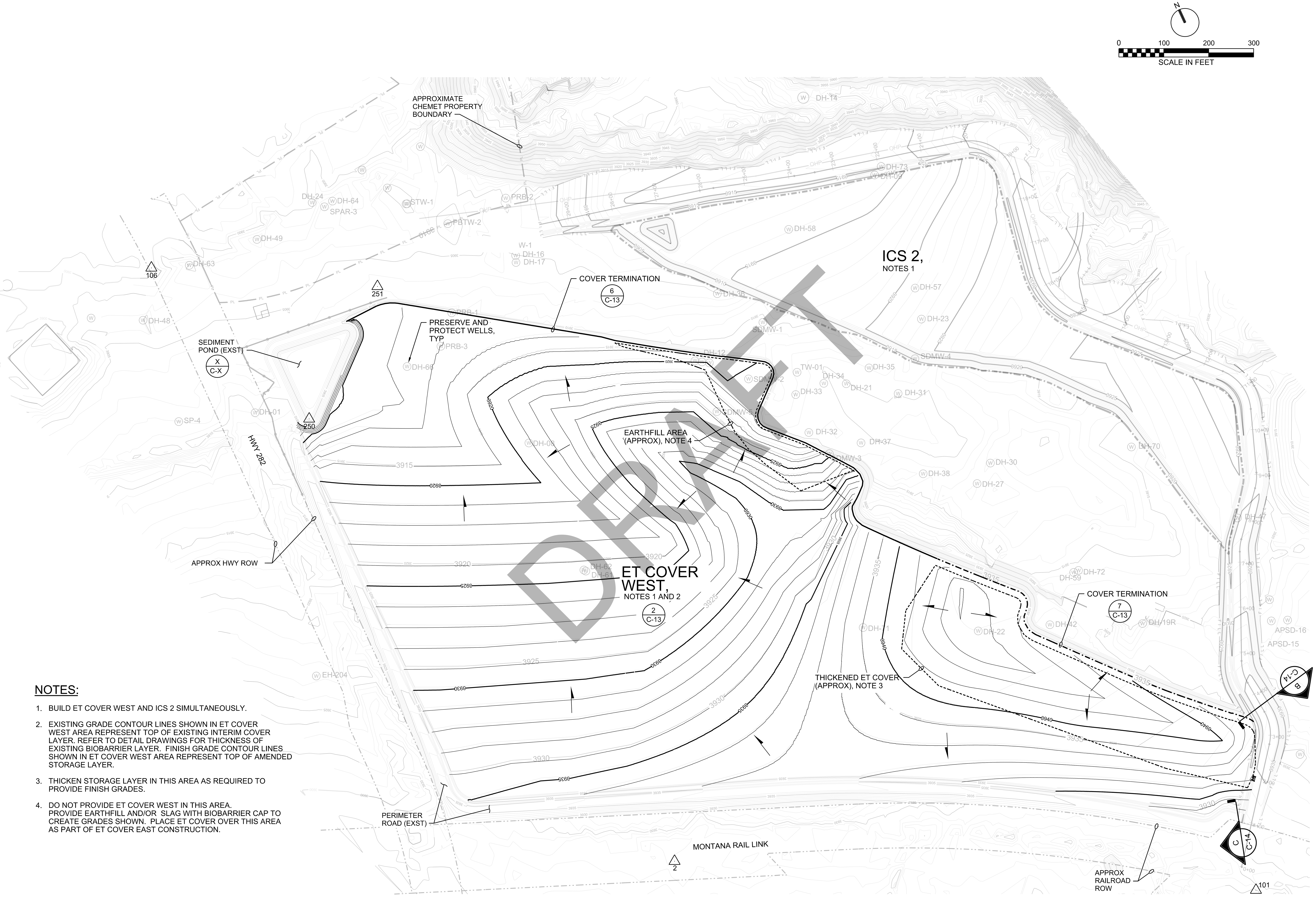
ET COVER SYSTEM, ICS 2 AND, DEMOLITION PHASE 3
FORMER ASARCO EAST HELENA FACILITY

OVERALL INTERIM COVER GRADING AND SEQUENCING PLAN 2015

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2014
PROJ	467300
DWG	C-1
SHEET	4 OF 38

PRELIMINARY - NOT FOR CONSTRUCTION



NOTES:

1. BUILD ET COVER WEST AND ICS 2 SIMULTANEOUSLY.
2. EXISTING GRADE CONTOUR LINES SHOWN IN ET COVER WEST AREA REPRESENT TOP OF EXISTING INTERIM COVER LAYER. REFER TO DETAIL DRAWINGS FOR THICKNESS OF EXISTING BIOBARRIER LAYER. FINISH GRADE CONTOUR LINES SHOWN IN ET COVER WEST AREA REPRESENT TOP OF AMENDED STORAGE LAYER.
3. THICKEN STORAGE LAYER IN THIS AREA AS REQUIRED TO PROVIDE FINISH GRADES.
4. DO NOT PROVIDE ET COVER WEST IN THIS AREA. PROVIDE EARTHFILL AND/OR SLAG WITH BIOBARRIER CAP TO CREATE GRADES SHOWN. PLACE ET COVER OVER THIS AREA AS PART OF ET COVER EAST CONSTRUCTION.

PRELIMINARY NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD
B	11/07/14	60 PERCENT DESIGN	NB	JD
A	09/30/14	30 PERCENT DESIGN	NB	JD

DSGN	DR	CHK	APVD
P. KRYCH	R. VILORIA	J. SMESRUD	J. DEHNER

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East Helena, Montana
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East Helena, Montana

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POWER BLOCK BUILDING
7 WEST 6TH AVE. # 519
HELENA, MT 59601-5036
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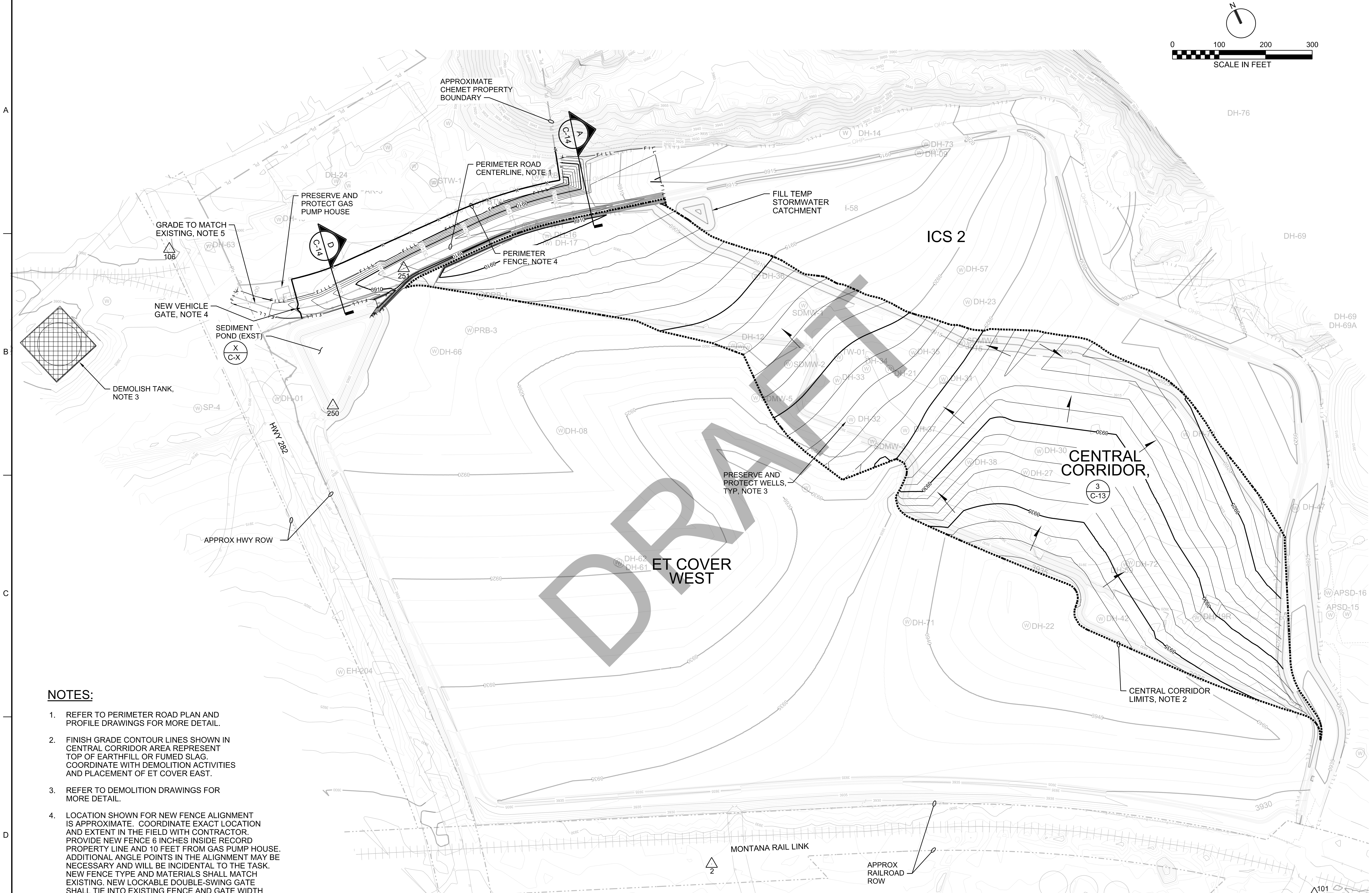
ET COVER SYSTEM, ICS 2, AND DEMOLITION PHASE 3
FORMER ASARCO EAST HELENA FACILITY

OVERALL ET COVER GRADING AND SEQUENCING PLAN 2015

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2014
PROJ	467300
DWG	C-2
SHEET	5 OF 38

PRELIMINARY - NOT FOR CONSTRUCTION



NOTES:

1. REFER TO PERIMETER ROAD PLAN AND PROFILE DRAWINGS FOR MORE DETAIL.
2. FINISH GRADE CONTOUR LINES SHOWN IN CENTRAL CORRIDOR AREA REPRESENT TOP OF EARTHFILL OR FUMED SLAG. COORDINATE WITH DEMOLITION ACTIVITIES AND PLACEMENT OF ET COVER EAST.
3. REFER TO DEMOLITION DRAWINGS FOR MORE DETAIL.
4. LOCATION SHOWN FOR NEW FENCE ALIGNMENT IS APPROXIMATE. COORDINATE EXACT LOCATION AND EXTENT IN THE FIELD WITH CONTRACTOR. PROVIDE NEW FENCE 6 INCHES INSIDE RECORD PROPERTY LINE AND 10 FEET FROM GAS PUMP HOUSE. ADDITIONAL ANGLE POINTS IN THE ALIGNMENT MAY BE NECESSARY AND WILL BE INCIDENTAL TO THE TASK. NEW FENCE TYPE AND MATERIALS SHALL MATCH EXISTING. NEW LOCKABLE DOUBLE-SWING GATE SHALL TIE INTO EXISTING FENCE AND GATE WIDTH SHALL MATCH ROAD WIDTH.
5. DO NOT WORK IN HIGHWAY OR RAILROAD RIGHTS OF WAY.

PRELIMINARY NOT FOR CONSTRUCTION

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P. KRYCH	R. VILORIA	J. SMESRUD	J. DEHNER

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Former ASARCO Smelter Site
East Helena, Montana
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East Helena, Montana

CH2MHILL
POWER BLOCK BUILDING
7 WEST 6TH AVE, # 519
HELENA, MT 59601-5036
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ET COVER SYSTEM, ICS2, AND DEMOLITION PHASE 3
FORMER ASARCO EAST HELENA FACILITY

OVERALL INTERIM COVER GRADING AND SEQUENCING PLAN 2016

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2014
PROJ	467300
DWG	C-3
SHEET	6 OF 38

PRELIMINARY - NOT FOR CONSTRUCTION

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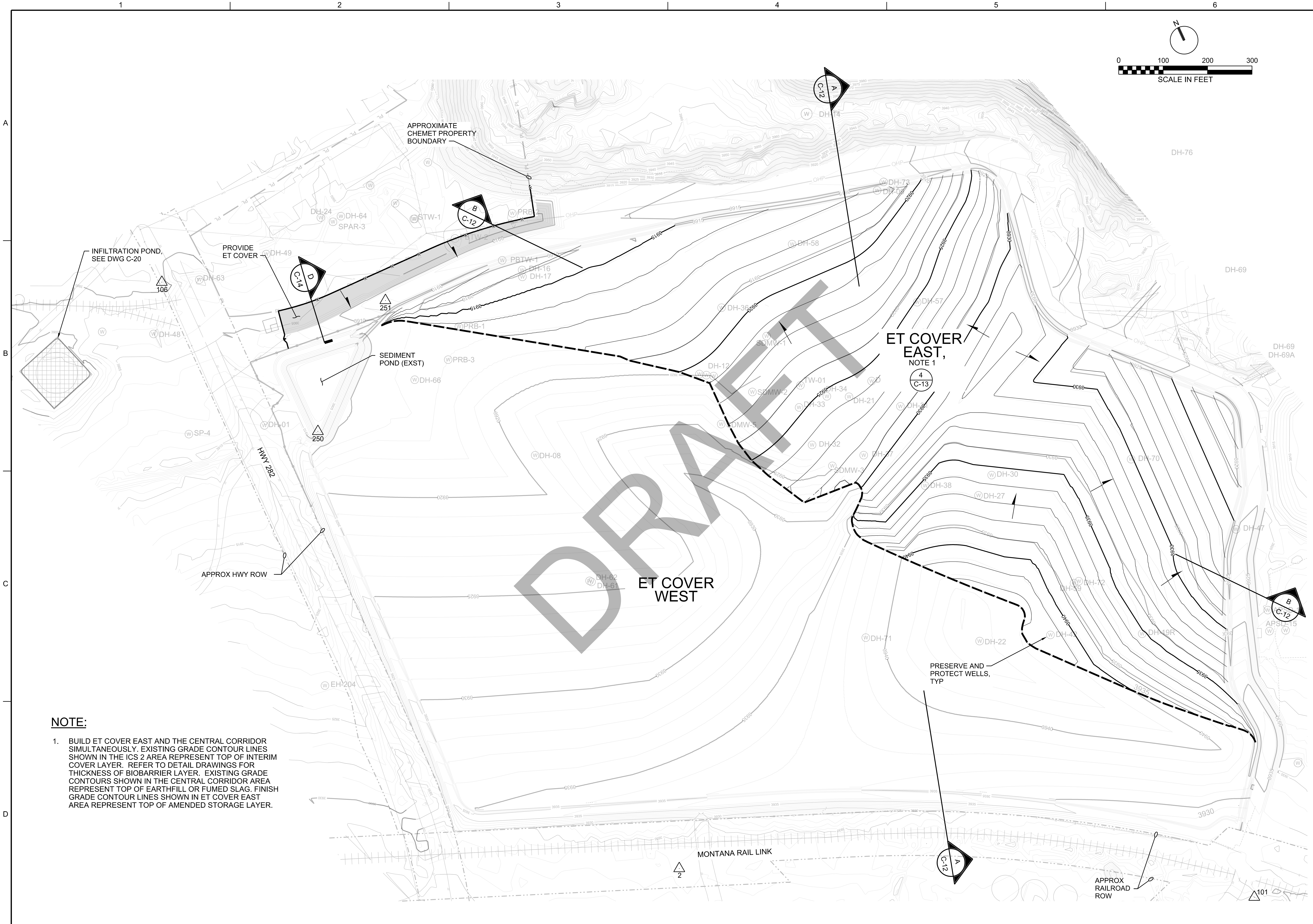

NOTE:

1. BUILD ET COVER EAST AND THE CENTRAL CORRIDOR SIMULTANEOUSLY. EXISTING GRADE CONTOUR LINES SHOWN IN THE ICS 2 AREA REPRESENT TOP OF INTERIM COVER LAYER. REFER TO DETAIL DRAWINGS FOR THICKNESS OF BIOBARRIER LAYER. EXISTING GRADE CONTOURS SHOWN IN THE CENTRAL CORRIDOR AREA REPRESENT TOP OF EARTHFILL OR FUMED SLAG. FINISH GRADE CONTOUR LINES SHOWN IN ET COVER EAST AREA REPRESENT TOP OF AMENDED STORAGE LAYER.

PRELIMINARY NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD
B	11/07/14	60 PERCENT DESIGN	NB	JD
A	09/30/14	30 PERCENT DESIGN	NB	JD

DSGN	DR	CHK	APVD
P. KRYCH	R. VILORIA	J. SMESRUD	J. DEHNER

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Former ASARCO Smelter Site
East Helena, Montana
Montana Environmental Trust Group
East Helena, Montana

CH2MHILL
POWER BLOCK BUILDING
7 WEST 6TH AVE. # 519
HELENA, MT 59601-5036
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ET COVER SYSTEM, ICS 2, AND DEMOLITION PHASE 33
FORMER ASARCO EAST HELENA FACILITY

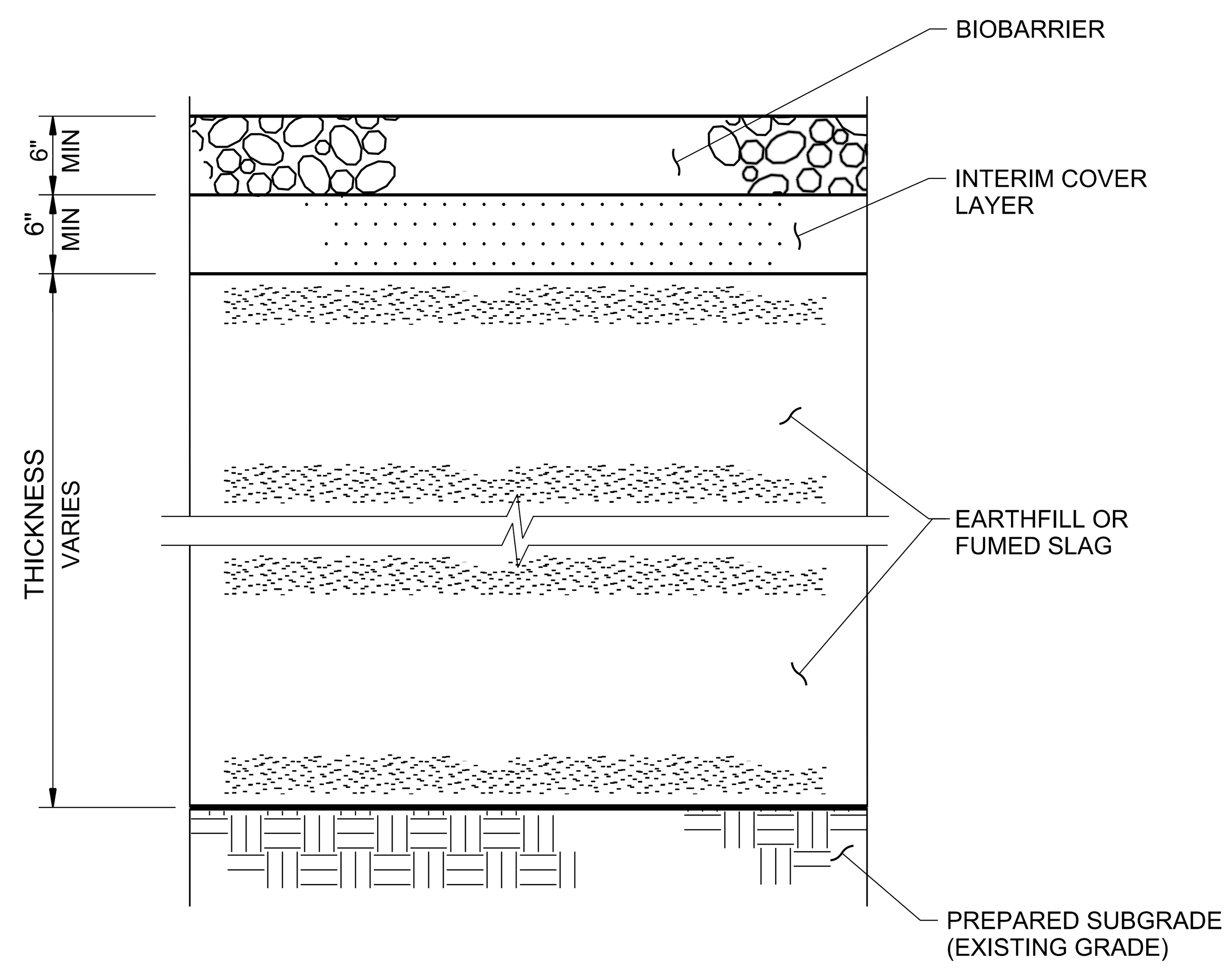
OVERALL ET COVER GRADING AND SEQUENCING PLAN 2016

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

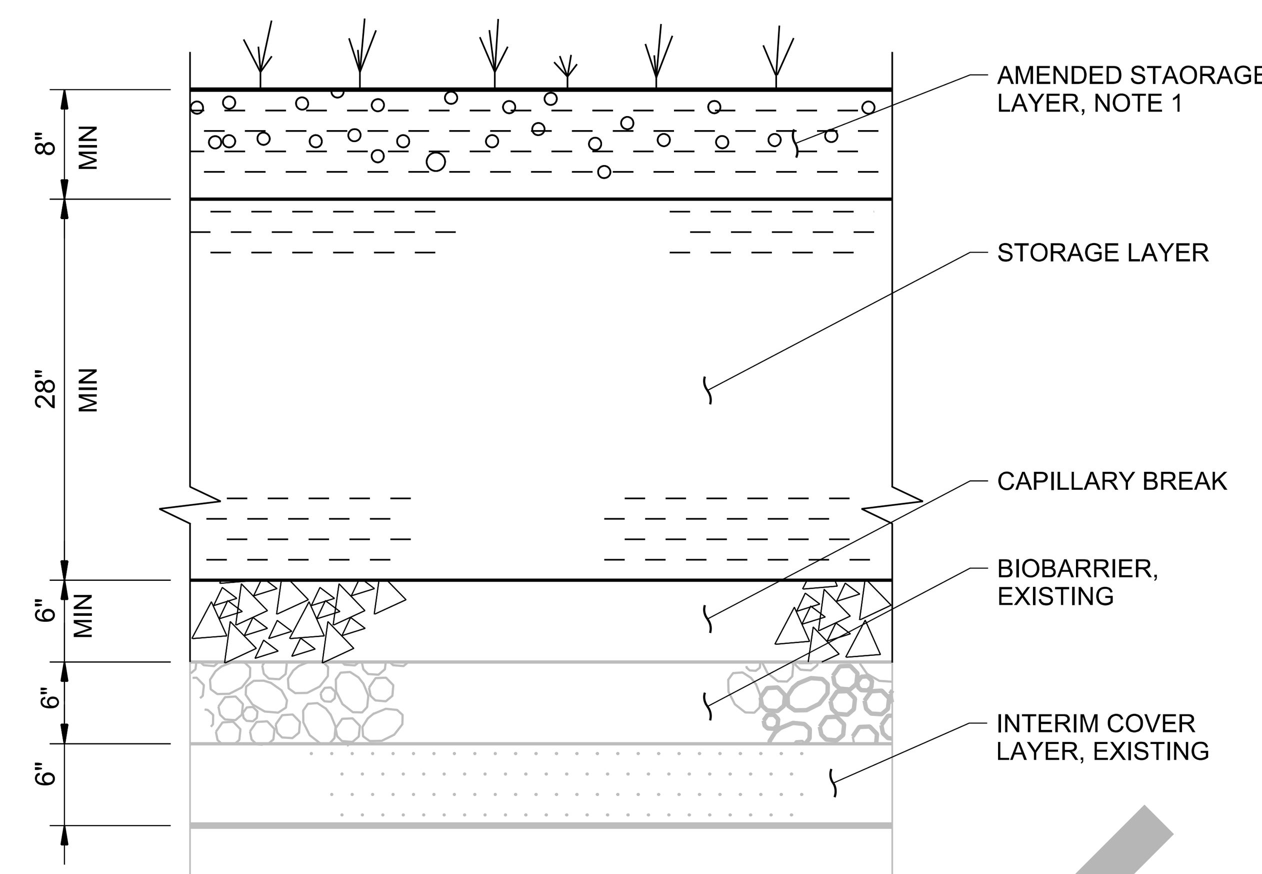
DATE	SEPTEMBER 2014
PROJ	467300
DWG	C-4
SHEET	7 OF 36

FILENAME: P043C004D_467300.dgn PLOT DATE: 2014\11\07 PLOT TIME: 3:42:12 PM

1 TYPICAL ICS 2 SECTION
NTS
C-1

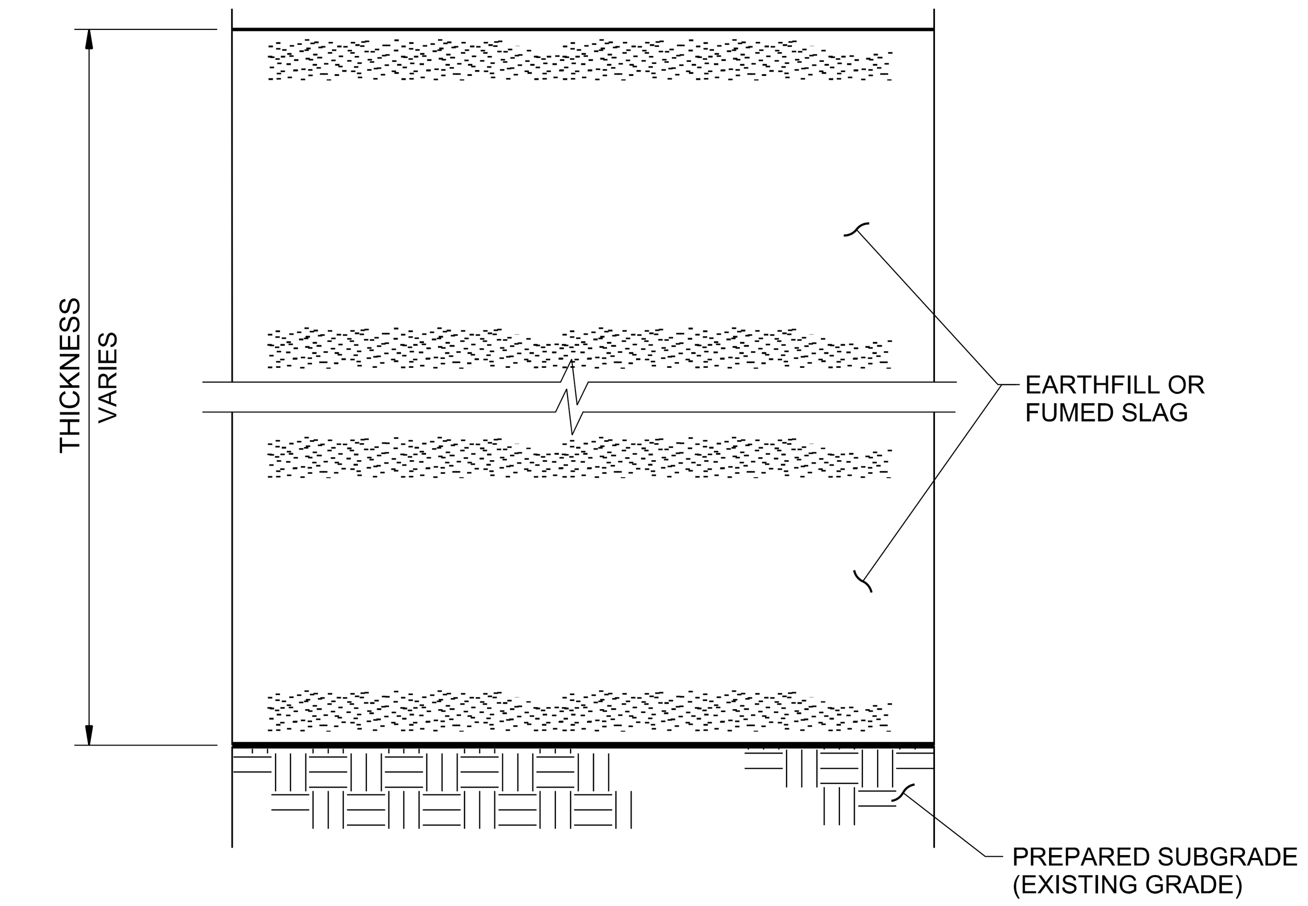


2 TYPICAL ET COVER WEST SECTION
NTS
C-1
C-2

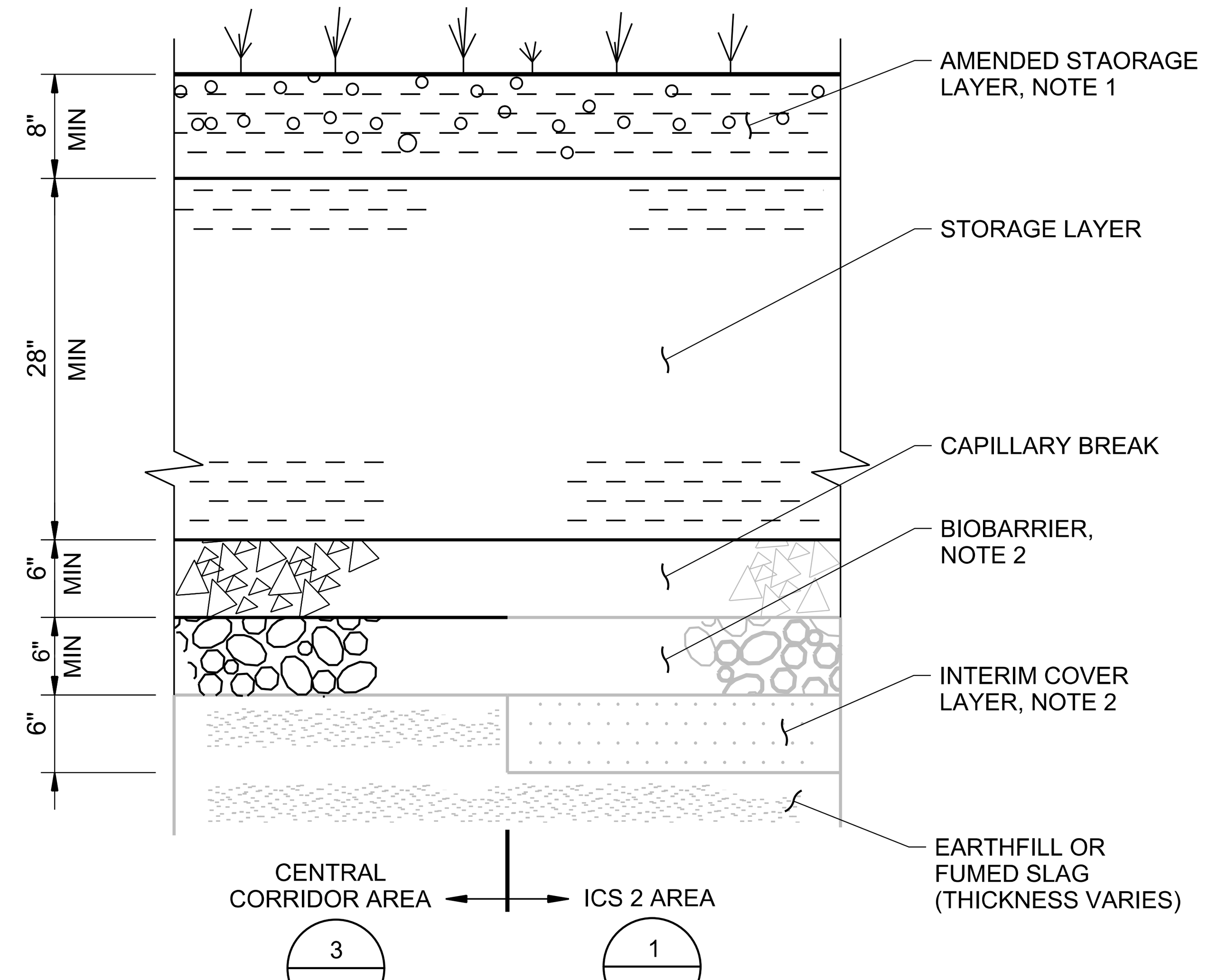


NOTE:
1. PREPARE, SEED, AND MAINTAIN LAYER AS SPECIFIED.

3 TYPICAL CENTRAL CORRIDOR SECTION
NTS
C-3

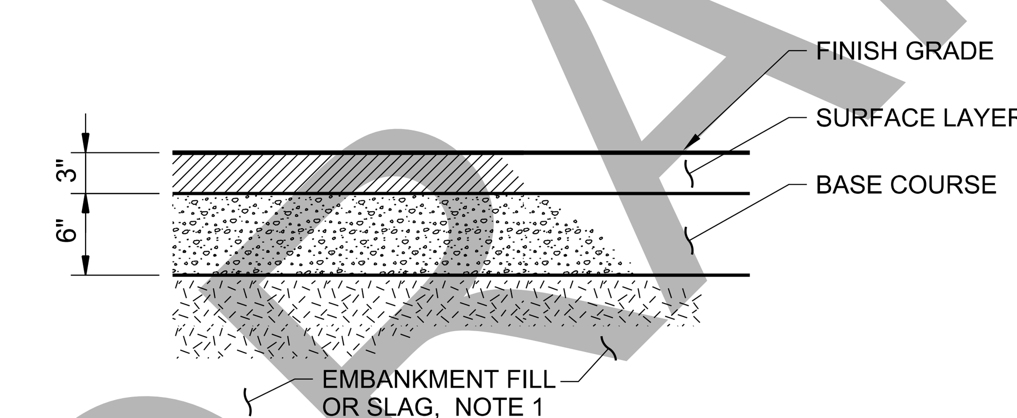


4 TYPICAL ET COVER EAST SECTION
NTS
C-4



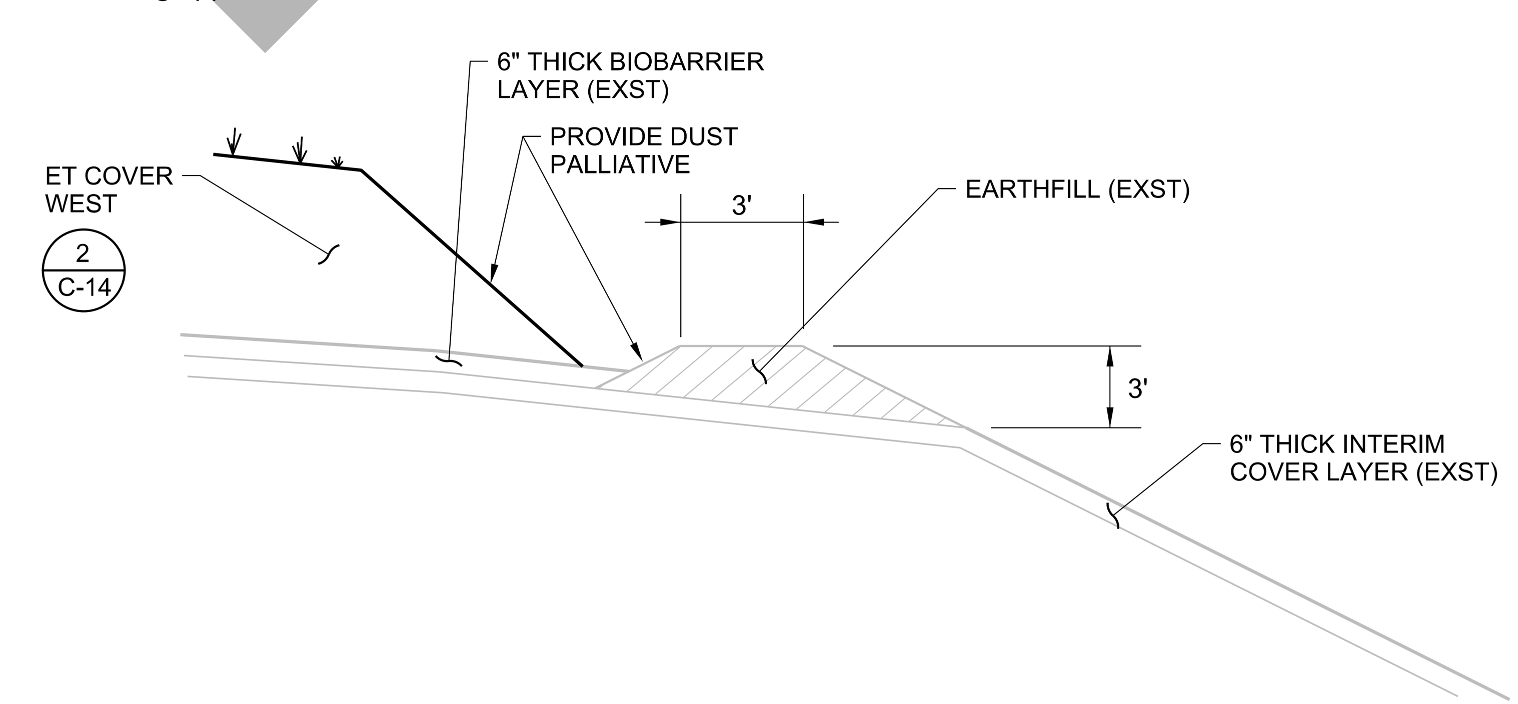
NOTES:
1. PREPARE, SEED, AND MAINTAIN LAYER AS SPECIFIED.
2. PROVIDE BIOBARRIER AND INTERIM COVER LAYER IN ICS 2 AREA IN 2015. PRESERVE AND PROTECT EXISTING LAYERS. PROVIDE BIOBARRIER IN CENTRAL CORRIDOR AREA IN 2016. DO NOT PROVIDE INTERIM COVER LAYER IN CENTRAL CORRIDOR AREA.

5 GRAVEL SURFACING
NTS
C -14

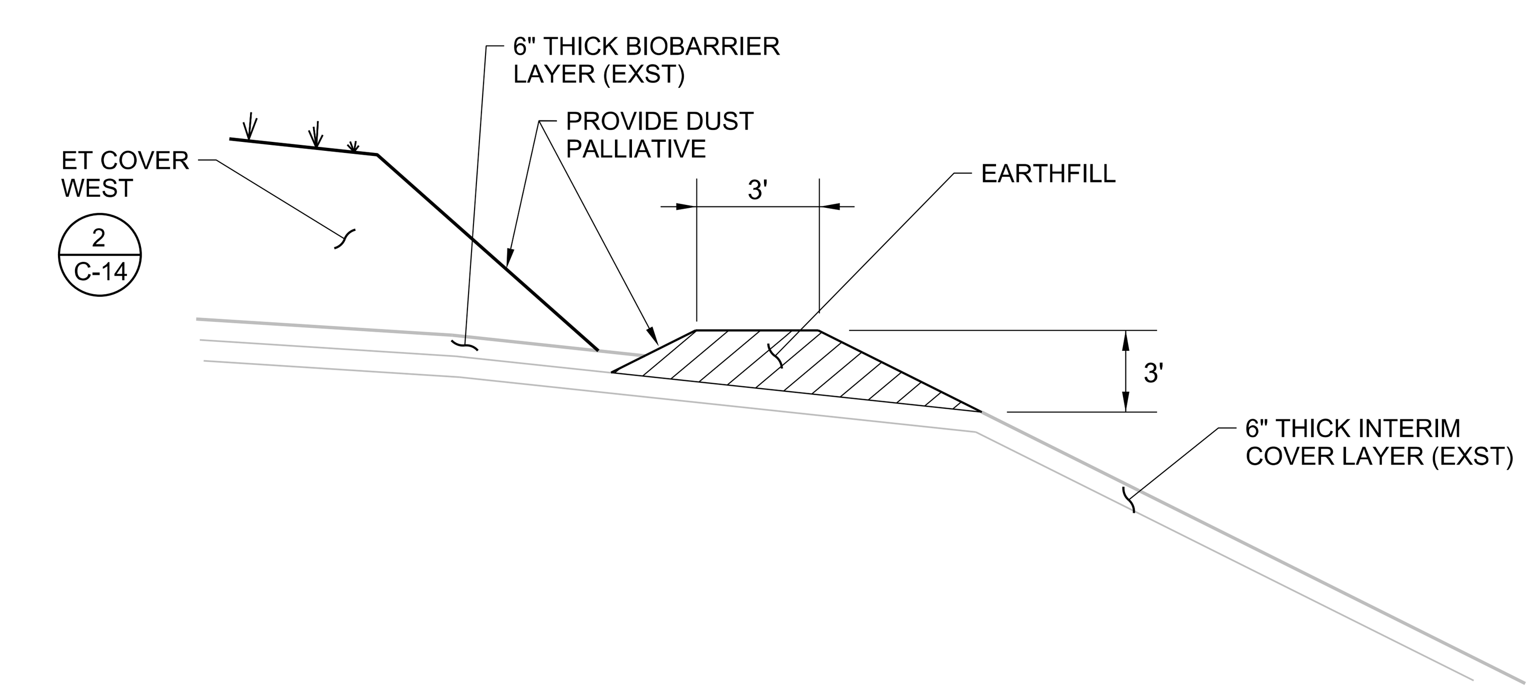


NOTE:
1. REFER TO SPECIFICATIONS FOR SPECIAL PLACEMENT AND COMPACTION UNDER ROADS

6 ET COVER TERMINATION - EXST BERM
NTS
C-2



7 ET COVER TERMINATION - NEW BERM
NTS
C-2



8 ET COVER TERMINATION - PERMANENT
TBD @ 90% DESIGN

DRAFT

PRELIMINARY NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD
B	11/07/14	60 PERCENT DESIGN	NB	JD
A	09/30/14	30 PERCENT DESIGN	NB	JD

DSGN N. BETTS | DR R. VILORIA | CHK J. SMESRUD | APVD J. DEHNER

METG Montana Environmental Trust Group

Former ASARCO Smelter Site
East Helena, Montana
Montana Environmental Trust Group
East Helena, Montana

CH2MHILL
POWER BLOCK BUILDING
7 WEST 6TH AVE. # 519
HELENA, MT 59601-5036
PHONE: (406) 457-5494

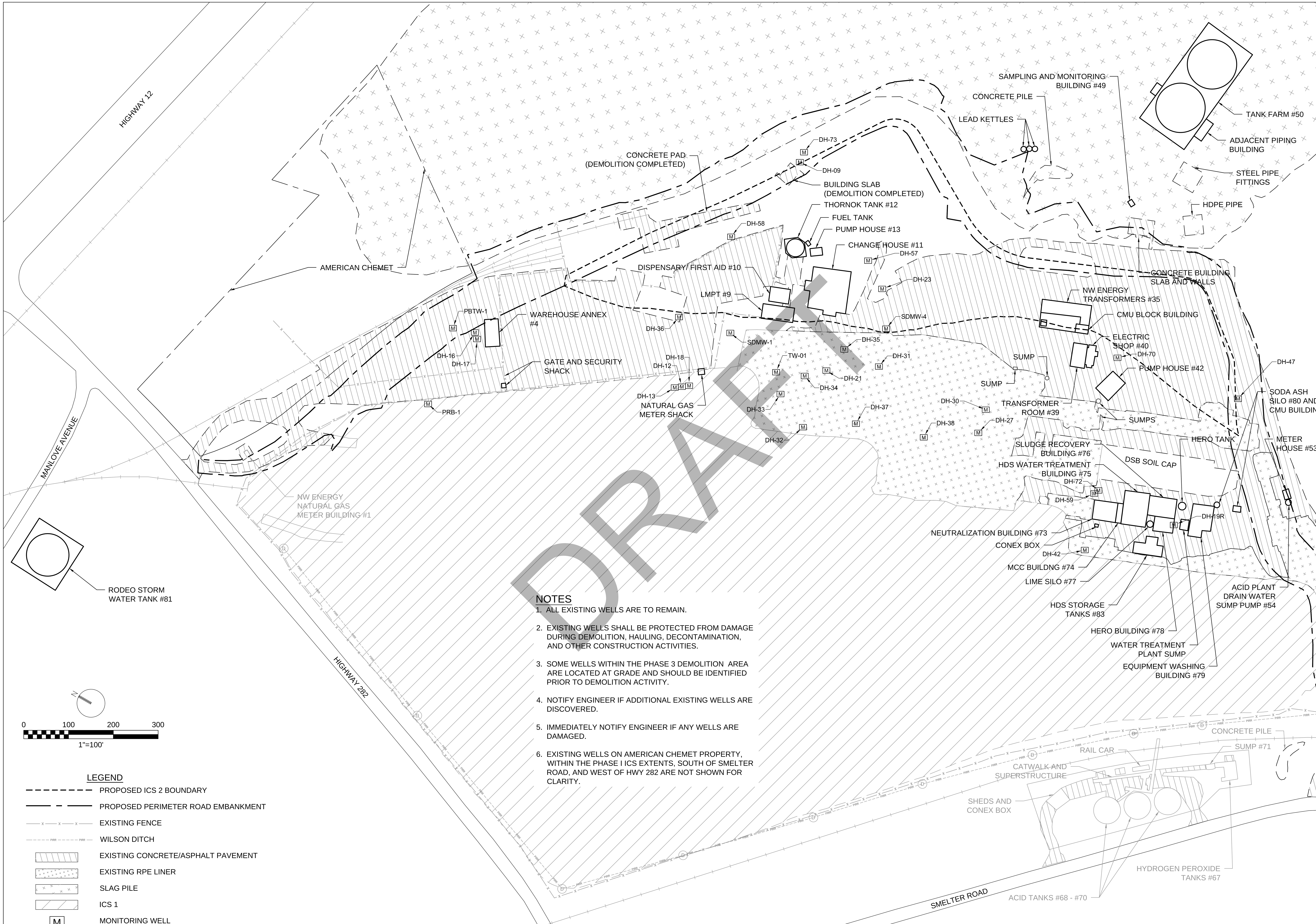
ET COVER SYSTEM, ICS 2, AND DEMOLITION PHASE 3
FORMER ASARCO EAST HELENA FACILITY

CIVIL DETAILS
1 OF 2

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2014
PROJ	467300
DWG	C-13
SHEET	16 OF 38

PRELIMINARY - NOT FOR CONSTRUCTION



NOTES

1. ALL EXISTING WELLS ARE TO REMAIN.
2. EXISTING WELLS SHALL BE PROTECTED FROM DAMAGE DURING DEMOLITION, HAULING, DECONTAMINATION, AND OTHER CONSTRUCTION ACTIVITIES.
3. SOME WELLS WITHIN THE PHASE 3 DEMOLITION AREA ARE LOCATED AT GRADE AND SHOULD BE IDENTIFIED PRIOR TO DEMOLITION ACTIVITY.
4. NOTIFY ENGINEER IF ADDITIONAL EXISTING WELLS ARE DISCOVERED.
5. IMMEDIATELY NOTIFY ENGINEER IF ANY WELLS ARE DAMAGED.
6. EXISTING WELLS ON AMERICAN CHEMET PROPERTY, WITHIN THE PHASE I ICS EXTENTS, SOUTH OF SMELTER ROAD, AND WEST OF HWY 282 ARE NOT SHOWN FOR CLARITY.

LEGEND

- PROPOSED ICS 2 BOUNDARY
- PROPOSED PERIMETER ROAD EMBANKMENT
- EXISTING FENCE
- WILSON DITCH
- EXISTING CONCRETE/ASPHALT PAVEMENT
- EXISTING RPE LINER
- SLAG PILE
- ICS 1
- M MONITORING WELL

NO.	DATE	REVISION	BY	APVD
B	11/07/14	60 PERCENT DESIGN	GL	JD
A	09/30/14	30 PERCENT DESIGN	GL	JD

DSGN C.LORENSON | DR A.JOURDONNAIS | CHK M.RHODES | APVD J.DEHNER

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Former ASARCO Smelter Site
East Helena, Montana
Montana Environmental Trust Group
East Helena, Montana

CH2MHILL Hydrometrics, Inc. Consulting Scientists and Engineers

ET COVER SYSTEM, ICS 2, AND DEMOLITION 3
FORMER ASARCO EAST HELENA FACILITY

MONITORING WELL LOCATIONS

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	SEPTEMBER 2014
PROJ	467300
DWG	D-10
SHEET	38 of 38

FILENAME: 1201503H019.dwg PLOT DATE: 4-Nov-14 PLOT TIME: 6:19 PM

Evapotranspiration Cover System, Interim Cover System 2, and Demolition Phase 3 Technical Specifications List

MONTANA ENVIRONMENTAL TRUST GROUP (METG)

FORMER ASARCO EAST HELENA FACILITY

EAST HELENA, MONTANA

SPECIFICATIONS

for construction of

EVAPOTRANSPIRATION (ET) COVER SYSTEM,

INTERIM COVER SYSTEM 2 (ICS 2),

AND

DEMOLITION PHASE 3

****

60 Percent

****

CH2M HILL

Helena, MT

November 7, 2014

Project No. 467300 Copy No.____________________

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END OF SECTION

Technical Memorandum: Evapotranspiration Cover System Design, Construction, Operation, and Maintenance Criteria

Evapotranspirative Cover System Design, Construction, Operation, and Maintenance Criteria, Former ASARCO Smelter Site, East Helena, Montana

PREPARED FOR: Lauri Gorton/Custodial Trust

PREPARED BY: Nathan Betts/CH2M HILL
Bob Martin/CH2M HILL
Jason Smesrud/CH2M HILL
Scott Dethloff/CH2M HILL

REVIEWED BY: Bill Albright/Desert Research Institute
Bob Anderson/Hydrometrics

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Introduction

This technical memorandum (TM) summarizes the criteria and approach that will be used to guide the different phases for implementing the Evapotranspirative (ET) Cover System Interim Measure (IM) planned for the former ASARCO smelter in East Helena, Montana. The ET Cover System IM is one of three inter-related, inter-dependent IMs proposed in the Interim Measures Work Plan 2012, and subsequently conceptually approved by the US Environmental Protection Agency (USEPA) on August 28, 2012. The IMs are being implemented by the Montana Environmental Trust Group, LLC, Trustee of the Montana Environmental Custodial Trust (the Custodial Trust) as part of the Custodial Trust's Resource Conservation and Recovery Act (RCRA) obligations pursuant to the First Modification to the 1998 Consent Decree (Dreher et al., 2012) for the East Helena Facility (Facility).

The primary purpose of the IMs is to reduce the migration of contaminants in groundwater from the former Smelter Site in order to protect public health and the environment. The ET Cover System is proposed to further reduce the potential for site-related soil contaminants leaching to groundwater by eliminating or substantially reducing the amount of precipitation that infiltrates through contaminated materials. The ET Cover System will also lessen human and ecological receptor exposure to inorganic-contaminated soil.

The ET Cover System design has been developed to an approximately 15 percent level of completion to outline the preliminary grading, material balances, and orientation of the site-wide layout. The design will be developed to a 30 percent level of completion to further define the grading and site drainage necessary to interface efficiently and effectively with the Interim Cover System Phase 1 design. However, prior to moving further forward in the design phase for the ET cover layering system (material types and thicknesses for the cover itself), it is necessary to establish the criteria that can be used to direct the completion of the design, construction, and long-term monitoring. The following sections discuss the proposed criteria for each phase of ET cover implementation. Those phases are engineering design, construction, and monitoring and maintenance.

Remedy Performance Criteria

In accordance with USEPA's RCRA regulations and guidance, the Custodial Trust is proposing the following remedy performance criteria in the draft Corrective Measures Study (CMS) Work Plan, currently being updated for re-submittal in first quarter 2014. These performance standards will be considered the primary criteria for use in remedy evaluation, and are defined for the purposes of the East Helena Facility as follows:

1. Protection of human health and the environment
    a. Human and ecological receptors—No direct contact (dermal, inhalation or ingestion) with environmental media having concentrations of COPCs exceeding relevant risk-based standards (see Media Cleanup Objectives below).
    b. Protection of the environment will appropriately consider the surrounding ecological setting during remedy alternative evaluation.
    c. Surface water—Prevent groundwater from discharging to surface water at concentrations that would cause the surface water to exceed Montana State Surface Water Standards and/or at concentrations that would degrade surface water quality beyond existing upstream water quality.
2. Source Control
    a. Soils
        i. Prevent migration of contaminated surface soils via wind-blown deposition or surface water runoff.
        ii. Reduce—to the extent practicable—the potential for groundwater to contact soils with COPC concentrations exceeding relevant protection to groundwater standards through the following activities
            1) Reducing and/or eliminating to the extent practicable infiltration of stormwater into and though areas of contaminated soils and sediments
            2) Reducing to the extent practicable the amount of contaminated soil in contact with groundwater
            3) Reducing to the extent practicable COPC concentrations or mass where such removal will yield immediate reductions in contaminant loading to groundwater.
    b. Slag
        i. Reduce—to the extent practicable—the potential for groundwater to contact slag through removal and recovery of recyclable slag.
            1) Reducing infiltration of stormwater
            2) Reducing contact with groundwater
3. Media Cleanup Objectives
    a. Soil
        i. Surface (0 to 2 feet below the ground surface [bgs])
            1) Soil cleanup levels based on protection of human health and the environment for current and/or future new land uses (as shown in Table 2-2). Note that if numeric standards cannot be achieved, engineering and or institutional controls will be implemented to interrupt pathways for exposure and to maintain protective conditions.
        ii. At depth (>2 feet bgs)
            1) Numeric standards based on protection of groundwater (as shown in Table 2-2, established regional background levels, <u>or</u>
            2) Non-numeric/concentration objective(s) based on impracticability associated with addressing large source mass (i.e., reduce toxicity, mobility, or ability of groundwater to come into contact with, leachable contaminant mass).
    b. Groundwater

i. Return usable groundwater to maximum beneficial uses wherever practicable, within a time that is reasonable considering all property-specific conditions.

ii. Reduce COPC concentrations in groundwater within the operating facility boundary such that the Montana Numeric Water Quality Standards (as defined in Circular DEQ-7, and hereafter referred to as DEQ-7) are met at the points of compliance established by USEPA.

iii. To the extent practicable maintain stability and continue attenuation of offsite (i.e., beyond the operating facility boundary) plumes such that COPC concentrations can be expected to meet DEQ-7 standards within a reasonable time.

iv. During the timeframe when attainment of the DEQ-7 standards has not been achieved, minimize further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction approaches. To the extent practical, control or eliminate other surface water and subsurface sources of contamination to groundwater within control of the Custodial Trust.

c. Surface Water—Meet DEQ-7 and other applicable surface water quality standards for surface water bodies contaminated by ASARCO's historical activities, including present migration of existing contamination.

d. Sediment—USEPA Region III's Biological Technical Assistance Group (BTAG) has developed values to be used for the evaluation of sampling data at Superfund sites. Referred to as the Region III BTAG Screening Benchmarks, they represent an appropriate set of screening criteria to evaluate ecological risk in freshwater sediment for the CMS properties (http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm).

The ET Cover System is a source control measure and is being implemented as an IM, with the intention that it will become a part of the final remedy for the Facility. The remedy performance standards form the primary objectives shown below, from which the design criteria have been derived.

Engineering Design Phase

The overarching goal of the engineering design phase is to design a cover system that supports the overall site-wide remedy. The objectives, criteria, and demonstrations that will be used to design the ET cover are shown below in Table 1. The design objectives listed in the first column correspond directly to the remedy performance criteria to provide assurance that the design will support the overall site-wide final remedy. The design criteria listed in the second column are the standards to which the cover will be designed. The criteria are divided into groups to show which design objectives they support. The demonstrations listed in the third column will be used to show that the completed design meets the design criteria. The design deliverables will include engineered drawings and specifications.

The ET cover system will be designed in accordance with methods that have been successfully used to design ET cover systems under similar site conditions, including those in Helena, Montana. The thickness, gradation, and other characteristics of the ET cover soil layers will be selected to optimally and efficiently reduce the predicted volume of percolation. This selection will be based upon a water balance analysis, site-specific hydraulic modeling, a borrow source investigation, the expected vegetation community, and data gathered from nearby ET covers, test plots, and lysimeters. Developing an optimized storage layer thickness will be based on conservative soil characteristics and predicted percolation ranges from modeling, and not a predetermined percolation value. The performance will be based on the level of conservancy and extra storage capacity provided by the design, quality assurance and quality control conducted and documented during construction, and operational observations on cover maintenance. The effect of the predicted percolation volume on site-wide groundwater contamination is not part of the cover system evaluation, but will be addressed as part of a separate analysis performed under the groundwater component of the Corrective Measures Study.

TABLE 1
Engineering Design Criteria
ET Cover System, East Helena Facility

Design Objective	Design Criteria	Demonstration
1. Protect human health and the environment.	1a. The cover system will provide a physical separation between the contaminated soil and ground surface.	1a. The cover system will have a specified minimum thickness that will encompass the former smelter site with sufficient slope and drainage to provide for surface water runoff.
	1b. The cover system will inhibit bioturbation and contact with animals.	1b. The cover system design will have a burrowing animal barrier layer with a specified amount of cobble-sized rocks and a minimum thickness.
	1c. The cover system footprint will accommodate existing site access controls including fencing, signs, and gates.	1c. The cover system design will utilize existing site-security features and modify them as necessary to encircle the cover footprint.
2. Control potential sources of contamination migration.	2a. The cover system will resist wind erosion.	2a. The combination of soil and vegetation will resist wind erosion. The design will include vegetation specifications based on similar ET covers used in Montana and other similar climates. Temporary erosion control measures will be provided during the establishment of permanent cover vegetation.
	2b. The cover system will resist water erosion.	2b. The combination of soil, vegetation, slopes, and drainage features will resist water erosion. The design will include vegetation specifications based on similar ET covers used in Montana and other similar climates. Drainage features will be armored as necessary along flow concentration areas (e.g., ditches and channels). Temporary erosion control measures will be provided during the establishment of permanent cover vegetation.
	2c. The cover will not be subject to inundation from flooding.	2c. The cover will be outside the 100-year floodplain of Prickly Pear Creek.
	2d. The cover system thickness, soil gradation, soil-moisture holding characteristics, and vegetation community will store infiltrating precipitation, reduce percolation through contaminated soil, and reduce contact with groundwater.	2d. Hydrologic modeling will be performed with site-specific climate data, soil characteristics, and design vegetation conditions to estimate anticipated percolation rates for the cover system. The design will also be compared to other ET cover systems in Montana and in similar climates in the western USA.
3. Meet media cleanup objectives for soil.	3a. The cover system will be comprised of soils with contaminant levels that are below cleanup levels for shallow surface soil (<2 feet bgs).	3a. The design will specify frequencies for field sampling and laboratory testing and minimum standards for compliance.
	3b. The cover system will be constructed with a slope, thickness, gradation, and moisture holding capacity that provides for infiltration storage and percolation reduction; reducing the contribution of COPC to groundwater and attenuation of groundwater plumes.	3b. The design will specify frequencies for field and laboratory testing, construction observation, inspection, and minimum standards for compliance; including cover layer thickness, gradation, placement, density, and surface grades.
4. Meet media cleanup objectives for surface	4a. The cover system surface will be designed to manage and control stormwater runoff.	4a. The cover surface will be sloped to provide positive drainage and reduce surface water collection that could drive infiltration. Surface

TABLE 1
Engineering Design Criteria
ET Cover System, East Helena Facility

Design Objective	Design Criteria	Demonstration
water (i.e. DEQ-7 standards).		water runoff will be discharged to the perimeter drainage system without coming into contact with sources of contamination. Cover grading will divert stormwater run-on around the cover.
	4b. Ditches, swales, and other drainage features will be designed to accommodate stormwater runoff and limit erosion.	4b. Features will be sloped to provide positive drainage and convey the flow from a specified design storm (e.g., 100-year 24-hour precipitation event). Ditches and other stormwater management structures may be lined to further reduce potential contact with contaminated soil.

Construction Phase

The overarching goal of the construction phase is to provide an ET cover system that meets the design requirements listed previously in Table 1. The objectives, criteria, and demonstrations that will be used to construct the cover system are shown below in Table 2. The construction objectives listed in the first column correspond directly to important design elements to provide assurance that construction activities are aligned with the cover design. The construction criteria listed in the second column are the procedures that will be used to construct the cover. The criteria are divided into groups to show which construction objectives they support. The quantifiable standards for each construction criterion will be determined during the engineering design phase and the ET cover system will be constructed and quality controlled in accordance with methods that have been successfully used to construct similar ET covers. The demonstrations listed in the third column will be used to show that the construction meets the construction criteria. The frequency and procedures for each demonstration will be developed during engineering design.

TABLE 2
Construction Criteria
ET Cover System, East Helena Facility

Construction Objective	Construction Criteria	Demonstration
1. Implement construction quality management system.	1a. Construction subcontractor will develop and implement a contractor quality control plan.	1a. Plan will be reviewed and approved by the construction manager.
	1b. Construction subcontractor will provide the services of an independent material testing firm to conduct field and laboratory testing.	1b. The firm will be certified to conduct testing by nationally recognized associations.
	1c. Construction subcontractor will provide services of a land surveyor to conduct ground surveys.	1c. The surveyor will be licensed to conduct surveys in the State of Montana.
2. Provide soil layers and grades that meet design requirements.	2a. Construction subcontractor will test/measure the properties and thicknesses of the soil layers. Properties may include gradation, moisture content, relative compaction, agronomic properties (for vegetation layer), and chemical properties.	2a. The testing firm will certify test results and the surveyor will stamp survey deliverables.

TABLE 2
Construction Criteria
ET Cover System, East Helena Facility

Construction Objective	Construction Criteria	Demonstration
	2b. Owner will provide independent verification of construction quality control.	2b. Independent testing results and reporting conducted by Owner.
3. Provide a stand of vegetation that meets design requirements.	3. Construction subcontractor will maintain or enhance the vegetation until a satisfactory stand is established.	3. Construction subcontractor warranty or guarantee the vegetation.
4. Temporarily stabilize the cover surface to manage stormwater and limit erosion before vegetation has been established.	4. Construction subcontractor will provide temporary stormwater, erosion, and sediment controls during and at completion of construction.	4. Cover surfaces will be visually inspected for signs of erosion or ponding. Control measures will be visually inspected for proper installation and adequate coverage.

Monitoring and Maintenance Phase

The ET cover system will provide long-term performance if constructed to meet design requirements. As with any system, however, periodic monitoring and maintenance will be required to allow the cover system to perform as intended over time. The ET cover system will be monitored and maintained in accordance with methods that have been successfully used on similar ET cover projects as well as conventional geosynthetic cover systems. Monitoring and maintenance will be based on visual observations of the cover condition. If monitoring observations identify conditions that could potentially result in a lower performance (e.g., vegetation failure or overly-flat slopes due to settlement), then the condition would be addressed as part of ongoing maintenance. The criteria listed below in Table 3 will be used to monitor and maintain the ET cover system. The objectives and criteria correspond to key design elements.

The monitoring program focuses on visual observations because that is the best way to verify that the design requirements are being maintained over the long term. For example, checking that the system's storage capacity is being maintained is best done by looking for changes in the cover thickness due to erosion, settlement, and other actions. Similarly, checking that the system's ET capacity is being maintained is best done by observing the vegetation community.

TABLE 3
Monitoring and Maintenance Criteria
ET Cover System, Former ASARCO Smelter Site

Monitoring and Maintenance Objective	Monitoring and Maintenance Criteria	Demonstration
1. Conduct regular monitoring to identify required maintenance.	1. Develop and follow a monitoring and maintenance plan.	1. Plan will contain the elements outlined in this table.
2. Monitor the vegetation stand.	2. Maintain a stand of vegetation that meets requirements.	2. Visual inspection to check for signs of failing vegetation.
3. Monitor the cover soil surface and drainage systems.	3. Maintain a soil surface the resists erosion and promotes stormwater runoff.	3. Visual inspection for signs or erosion, settlement, changes in surface water flow, or ponding water.

Summary

The ET cover will be designed to meet the remedy performance criteria established in the draft CMS Work Plan and will consider existing performance information from existing ET Cover systems in the region to establish section properties. Technical evaluations to be conducted during final design will focus on identification of materials with the necessary physical properties. Construction documents will specify the materials and methods necessary to implement the design. Performance monitoring of the ET Cover system will be integrated into the overall groundwater monitoring plan for the East Helena Facility, to demonstrate that the cover is meeting the performance criteria and to assess the short- and long-term benefits to groundwater.

Appendix B
Technical Memorandum: Evapotranspiration Cover System Design for the East Helena Former ASARCO Smelter Site

Evapotranspiration Cover System Design for the East Helena Former ASARCO Smelter Site

PREPARED FOR: Jay Dehner/CH2M HILL
Nathan Betts/CH2M HILL

PREPARED BY: Robert Martin/CH2M HILL
Bill Albright/DRI
Craig Sauer/CH2M HILL

REVIEWED BY: Jason Smesrud/CH2M HILL
Dan Dolmar/CH2M HILL
Bob Anderson/Hydrometrics, Inc.

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1.0 Introduction

An evaluation was conducted to support the design of a sitewide evapotranspiration (ET) cover system proposed for use at the former ASARCO smelter site (former Smelter site) in East Helena, Montana. This technical memorandum (TM) summarizes the evaluation results. The ET Cover System interim measure (IM) is designed in accordance with the *Former ASARCO East Helena Facility Interim Measures Work Plan–Conceptual Overview of Proposed Interim Measures and Details of 2012 Activities* (CH2M HILL, 2012).

A review of case studies was conducted to consider the applicability of the site for an ET cover system. The case studies included existing ET cover systems implemented in Montana under similar climatologic conditions, conclusions from the Alternative Cover Assessment Project (ACAP) Phase I report by the Desert Research Institute (Albright et al., 2002), and *USEPA Fact Sheet on ET Cover Systems for Waste Containment* (U.S. Environmental Protection Agency [USEPA], 2011). Case studies were reviewed for applicability and compared to the proposed ET Cover System. The ACAP consisted of two sites in Montana: the Polson Municipal Landfill (Lake County) and the Helena Valley Municipal Landfill (Clark County). Additionally, the Valley View Landfill (VVL) is located approximately 1 mile from the former Smelter site and was completed with an ET cover system using similar soil types and borrow materials. The existing ET cover recommendations and designs were reviewed and incorporated into this evaluation.

Two different methods were used to evaluate site-specific climate conditions and soil, a water balance method and unsaturated hydrologic numerical modeling. The water balance method used was based on results from the ACAP funded by the USEPA and described in *Water Balance Covers for Waste Containment: Principles and Practice* (Albright et al., 2010). The hydrologic modeling was performed using the HYDRUS-1D model (PC-Progress, 2014) which requires a large amount of site-specific input parameters encompassing daily meteorological data, vegetation properties, and borrow source soil hydraulic properties. The development of the HYDRUS model was guided by hydraulic modeling previously conducted for conceptual design (CH2M HILL, 2013) and also by the results of the water balance analysis conducted by Hydrometrics (Hydrometrics and CH2M HILL, 2012).

Hydrometrics conducted a borrow source field investigation on July 2, 3, and 25 of 2014, to provide borrow-specific soil sample analytical results (Attachment 1) for use in the evaluation. The borrow sources included area from the adjacent VVL (described in more detail in Section 3.0) and borrows located adjacent to the former Smelter site.

The results of the evaluation were used to define an ET cover storage layer thickness based on borrow soil samples and define engineering parameters for use in the design and construction of the ET Cover System section.

2.0 Purpose and Objectives

The primary purpose of the ET Cover System IM is summarized as follows:

- Further reduce the potential for inorganic soil contaminants to leach to groundwater by eliminating or substantially reducing the amount of infiltration through contaminated materials.
- Provide a clean surface for runoff.
- Eliminate human and ecological receptor exposure to inorganic-contaminated soil.

The specific objectives of the ET Cover System IM are as follows:

- Reduce the percolation of precipitation and associated leaching of inorganic contaminants in vadose zone soil to groundwater.
- Replace the existing temporary cover system, which is deteriorating.
- Eliminate the potential for people and wildlife to have direct contact with contaminated surface soil and from windblown sediment.
- Reduce the volume and improve the quality of contaminated stormwater that is being collected and treated by the onsite high-density sludge water treatment system.

The uppermost vegetated soil layer of the ET Cover System will be designed to store and release infiltration through evaporation and transpiration processes, and provide for shedding of clean stormwater in the event of runoff. The cover system uses the water storage capacity of the soil layer to minimize percolation, as an alternative to lower-permeability barriers using traditional cover materials (for example, clays, asphalt, and geotextiles), where performance primarily is based on increased runoff as a trade-off to decreased infiltration. Under appropriate, site-specific conditions, the ET Cover System can be a more cost-effective and sustainable (long-term) alternative for minimizing infiltration than traditional engineered cover designs.

3.0 Case Study Evaluations

This section summarizes the case study evaluations conducted by Hydrometrics as part of the *ET Cover System Hydrologic Evaluation and Interim Measures Engineer Plan* (Hydrometrics and CH2M HILL, 2012). The ACAP was a 6-year, multistate, multitechnology research collaboration intended to answer questions regarding the adequacy of alternative cover designs to be protective as landfill applications. The field study data report (Albright and Benson, 2005) provides a field dataset and summarizes the data and supporting analysis. The ACAP included two sites in Montana that have conditions similar to those found in the East Helena site: one located in Polson and the other located in the Helena Valley. Both were constructed with an ET cover that included a capillary break layer. Additionally, the ET cover system installed at the VVL, located approximately 1 mile from the former Smelter site, was evaluated as it was completed using similar soil types and borrow materials proposed for the ET Cover System. Finally, studies of ET covers for mine waste were incorporated into the evaluation.

3.1 Alternative Cover Assessment Project Case Study

The test section at the Polson Municipal Landfill in Lake County was constructed with a 115-centimeter (cm) (45-inch) storage layer comprising sandy gravel, silty sand, silt, and topsoil. The sandy gravel, silty sand, and topsoil were obtained onsite. The silty sand was obtained from a local borrow source approximately 3 miles from the site. Numerical modeling was performed for the alternative cover using HYDRUS for a ten year period, using the highest precipitation year on record (1998) for all ten years. The results predicted approximately 0.6 millimeter (mm) of percolation in the first year, and 0.1 mm per year for the remaining years in the 10-year simulation (Albright and Benson, 2005). Field data collected from November 1999 to October 2004 measured a total percolation through the ET cover of 0.8 mm (0.2 mm per year average). The Polson site receives approximately 25 percent more precipitation annually than the former Smelter site.

The test section at the Helena Valley Municipal Landfill in Lewis and Clark County was constructed with a 135-cm (53-inch) storage layer consisting of gravel, sandy clay, and topsoil. The gravel was used to simulate an interim cover and was obtained from a local gravel pit. The sandy clay for the ET cover was obtained onsite and is currently being used for daily cover at the landfill. Numerical modeling was performed with HYDRUS for a 10-year period, using the highest precipitation year on record (1975) for all 10 years. The results predicted a percolation rate of less than 1 mm per year average over the 10-year period simulated. Field data collected from October 1999 to October 2004 measured a total percolation of 0.1 mm at the site.

As part of the ACAP, performance data were developed for ET covers, including threshold values. The threshold values are based on conditions under which a percolation rate of less than 3 mm per year can be readily met. Threshold values are intended for use in establishing general guidelines to help evaluate a site for potential applicability of a successful ET cover. The exceedance of threshold value indicates that it might be more difficult to design and meet the target percolation rate with an ET cover. However, detailed site-specific hydrologic evaluations are necessary to address all factors influencing cover performance. Table 1 shows the ACAP threshold values (USEPA, 2006) and precipitation values for the Helena area.

The Helena area precipitation values are from the National Weather Service meteorological station at the Helena Regional Airport. The precipitation and potential evapotranspiration (PET) values are from the Helena Valley Agrimet Station (Bureau of Reclamation, 2012). Table 1 shows the ACAP threshold values (USEPA, 2006) and that the Helena area conditions are within the threshold values for ET cover performance with the exception of the ratio of precipitation to potential evapotranspiration (precipitation/PET), which is slightly higher. The exceedance of the precipitation to PET ratio indicates that additional detailed evaluation and design are required for application of an ET cover in the Helena area. Additional evaluations were conducted as summarized in this TM.

TABLE 1
Alternative Cover Assessment Project Evapotranspiration Performance Data*

Factor	Threshold	Helena Area
Annual precipitation	<325 mm	270 mm
Spring/summer precipitation	<380 mm	206 mm
Fall/winter precipitation	<190 mm	64 mm
Snow and spring precipitation	<250 mm	184 mm
Precipitation/PET	<0.20	0.24

*Modified from November 2006 U.S. Environmental Protection Agency *Proceedings from Alternative Covers for Landfills, Waste Repositories and Mine Wastes Workshop, Denver, CO.*

3.2 Valley View Landfill Case Study

In addition to the ACAP study and performance data, the VVL has an ET cover and is located approximately 1 mile southeast of the East Helena site. The VVL design was based on the use of onsite source materials and was evaluated by numerical modeling using HYDRUS (Albright, 2003).

The ET cover at the VVL was monolithic, meaning it did not include a capillary break layer that would help increase storage within the storage layer. However, on the basis of soil testing for onsite materials and HYDRUS modeling evaluating different soil types and ET cover thickness, a 60-cm (24-inch) storage layer was determined to be adequate for reducing the average annual percolation rate to less than 3 mm per year over the 10-year model simulation period (Albright, 2003). Soil conditions are similar between the two locations, suggesting that onsite materials may be similar to those found at the VVL and may be adequate for use in the ET cover.

ACAP study results and more site-specific data available from the VVL strongly suggest that the use of an ET cover at the site could provide adequate performance. These results were used to further refine a conceptual ET cover design for the site, and evaluate that conceptual design through analytical and numerical methods described in the following sections.

3.3 Mine Waste Studies

In addition to municipal waste type landfills, soil-based covers that employ water storage and evapotranspiration for reducing percolation have been used in Montana for mine waste, including Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Superfund sites related to historical mine activities. Table 2 provides a summary of ET covers, including comments regarding their use. Several of the covers contain soil amendments such as lime. The use of these amendments appears to reduce infiltration rather than increase ET performance. In particular, South Emma Dump was designed with a 6-inch amended vegetated layer and a 39-inch storage and release layer. The South Emma Dump cover is similar to the cover considered for the former Smelter site; however, it did not include a performance-enhancing capillary break layer.

TABLE 2
ET Covers for Mine Waste Approved in Montana

Project/Location	Program	Cover Design	Annual Precip. (Inch)	Waste Type and Amount	Comments
Mineral Hill Mine[a] Park County, Montana 2000-2001	Montana Mine Reclamation Act Operating Permit	Topsoil (12-inch). Subsoil (36-inch). No capillary break.	10	1 Mt mine tailings. Repository area = 13 acres	Includes synthetic underliner and drainage collection system. Placed synthetic liner over portion of cap in 2005; reduced toe seepage from 2.5 to 1.5 gallons per minute. Seepage believed attributable in part to lateral groundwater inflow.
Subarea 1 Streamside Tailings Operable Unit[b] Silver Bow County, Montana Ongoing	CERCLA	Amended soil. No capillary break (22-inch).	13	Fluvial tailings. 197,750 CY	Lime added to uppermost 3 feet of tailings. Design plan requirements include depth to groundwater < 10 to 20 feet. Percolation through repository cannot cause exceedances of groundwater quality standards.
Corbin Flats[c] Jefferson County, Montana 2009	CERCLA Voluntary Cleanup Program	Topsoil (12-inch). Capillary break (6-inch).	12	Tailings 307,600 CY	Geotextile filter fabric above capillary break. Fertilizer and mulch applied. Cap includes only soil, not specifically designed as ET cap.
Anaconda-Deer Lodge Old Works/East Anaconda Operable Unit[d] Silver Bow County, Montana	CERCLA	Topsoil (18-inch). No capillary break.	13	Mine waste	Original temporary 6-inch soil cover increased to 18 inches in 2010.
Milltown Sediments and Opportunity Ponds Remedial Design Unit[e] Silver Bow County, Montana	CERCLA	Amended topsoil (12-inch). No capillary break.	13	Mine waste/ sediments 600 acres	Amended upper 6 inches of tailings with Lime Kiln Dust. Amended upper 4 inches of cover with 1.5 percent OM to enhance water-holding capacity. Cover failure resulting from phytotoxic soil cover conditions and failure of vegetation growth.
Emma Dump; Silver Bow Creek/Butte NPL Site; Butte Priority Soils Operable Unit[f]	CERCLA	Soil North Emma Dump (12-inch). Soil South Emma	12	Tailings 130,828 CY	Upper 6 inches of soil amended with OM (manure) plus fertilizer, straw mulch crimped on top.

TABLE 2
ET Covers for Mine Waste Approved in Montana

Project/Location	Program	Cover Design	Annual Precip. (Inch)	Waste Type and Amount	Comments
Silver Bow County, Montana		Dump (39-inch). No capillary break.			Only South Emma Dump designed as true ET cover.

Notes:

[a] *Mineral Hill Mine: As-Built Report TSF and OTS Reclamation, Mineral Hill Mine Site, Jardine, MT*. Bronson Engineering, Inc. and Shepherd Miller. February 2002. Three volumes.

[b] *Final Design Report – Reach A of Subarea 1 – Streamside Tailings Operable Unit*. Maxim Technologies, Inter-Fluve, Reclamation Research Unit, and Bighorn Environmental. June 1999.

[c] *Corbin Flats Tailings Site Voluntary Cleanup Plan*. Olympus Technical Services, Inc. July 1997.

[d] *Request for Change to Final Vegetative Cover, July 2010. Old Works/East Anaconda Development Area Operable Unit. Remedial Action Work Plan/Final Design Report*. Volume III Addenda. August 1996.

[e] Letter from S. Dunlap ARCO to C. Coleman, USEPA Region 8, dated December 21, 2011. Re: Final Cover Plan for Milltown Sediments at the Opportunity Ponds RDU 8.

[f] *Silver Bow Creek/Butte Area NPL Site Butte Priority Soils OU Final Construction Completion Report*. Emma Dump. October 1999.

Abbreviations:

CY = cubic yards

Mt = million tons

OM = organic matter amendment

4.0 Water Balance Analysis

A water balance analysis was conducted to calculate an estimate of the required thickness of the ET Cover using site-specific climatologic data and borrow source soil types. The results of the water balance analysis were used as the starting point for the final design and refined with hydrologic modeling using HYDRUS for the cover design. An initial water balance analysis was conducted by Hydrometrics to evaluate site conditions, applicability of the site, and potential borrow sources for an ET cover (Hydrometrics and CH2M HILL, 2012). The following water balance analysis builds on the Hydrometrics evaluation using additional borrow source locations and sampling data.

The method employed in this water balance analysis is described in Albright et al. (2010). This method uses the precipitation and PET values, and empirical factors developed through the ACAP program to estimate the monthly change in soil water storage. The monthly changes in soil water storage are then summed to required water storage capacity to prevent deep percolation through the cover, for a particular year. The required cover thickness is than calculated from the required storage capacity, using the soil water storage capacity (field capacity - wilting point) obtained from laboratory analysis of the soil water characteristic curves.

The application of the method for the site was conducted by Dr. William Albright of the Desert Research Institute and is described in Attachment 2. A summary of the analytical method, input values used, and results of the analytical evaluation follows.

The analytical method uses a monthly calculated water balance with the following formulas. The precipitation and PET values were for the Helena area from years 1979 to 2011. The maximum annual required storage calculated over this period was 49 mm (1985 – 1986). The soil thickness required to store 49 mm of infiltration was calculated for 18 different soil types from various borrow locations. The estimates were completed for the large range of soil types to help qualify the uncertainty of soil across the site, and from specific borrow sources.

Monthly Computation of Required Storage (S_r)

$$S_r = \sum_{m=1}^{6} \left\{ \left(P_m - \beta_{FW} PET_m \right) - \Lambda_{FW} \right\}$$

Fall-Winter Months

$$+ \sum_{m=1}^{6} \left\{ \left(P_m - \beta_{SS} PET_m \right) - \Lambda_{SS} \right\}$$

Spring-Summer Months

P_m = monthly precipitation

PET_m = monthly PET

β_{FW} = ET/PET in fall-winter

β_{SS} = ET/PET in spring-summer

Λ_{FW} = runoff & other losses in fall-winter

Λ_{SS} = runoff & other losses in spring-summer

Include only months that exceed P/PET threshold

If $\Delta S_m < 0$, set $\Delta S_m = 0$

The required soil thickness ranged from 0.24 to 1.17 meters (see Table 3). The calculations show that two of the soil types were considered less desirable for the ET Cover, samples EB-ET-1 and EB-ET-2, derived from a relatively coarse soil with low fines content from the east field excavations.

TABLE 3
Unsaturated Soil Hydraulic Parameters and Layer Thickness of Each Soil Required for Maximum Storage

			Volumetric Water Content (%)					
Soil Sample	**α (cm^{-1})**	**N**	**Residual**	**Saturated**	**Field Capacity**	**Wilting Point**	**Plant Available**	**Soil Thickness (m) Required to Store 49 mm of Water***
EB-ET-1	0.0441 (0.0573)	1.29 (1.42)	0	20.2	9.1 (5.8)	3.0 (1.2)	6.1 (4.6)	0.80 (1.07)
EB-ET-2	0.0164 (0.0213)	1.34 (1.48)	0	25.2	13.6 (9.6)	3.8 (1.6)	9.8 (8.0)	0.50 (0.61)
EB-ET-3	0.0155 (0.0202)	1.31 (1.45)	1.42	39.9	23.8 (17.4)	8.4 (4.3)	15.4 (13.1)	0.32 (0.37)
VV-ET-1	0.0090 (0.0117)	1.20 (1.33)	0	45.2	34.7 (27.8)	16.5 (8.2)	18.2 (19.6)	0.27 (0.25)
VV-ET-2	0.0095 (0.0124)	1.23 (1.36)	1.81	38.8	28.9 (23.2)	13.4 (7.4)	15.5 (15.8)	0.32 (0.31)
VV-ET-3	0.0121 (0.0157)	1.28 (1.41)	1.83	35.6	23.9 (18.5)	9.6 (5.4	14.3 (13.1)	0.34 (0.37)
VVL Comp 0-10	0.0061 (0.0079)	1.30 (1.43)	1.12	44.6	28.9 (24.1)	10.5 (5.8)	18.4 (18.3)	0.27 (0.27)
VVL Comp 11-15	0.0140 (0.0181)	1.32 (1.45)	0.27	43.0	22.7 (16.7)	7.2 (3.3)	15.5 (13.4)	0.32 (0.37)
VVL Comp 16-20	0.0094 (0.0123)	1.26 (1.39	0.00	46.9	30.3 (23.9)	11.6 (5.6)	18.7 (18.3)	0.26 (0.27)

TABLE 3
Unsaturated Soil Hydraulic Parameters and Layer Thickness of Each Soil Required for Maximum Storage

			Volumetric Water Content (%)					
Soil Sample	**α (cm^{-1})**	**N**	**Residual**	**Saturated**	**Field Capacity**	**Wilting Point**	**Plant Available**	**Soil Thickness (m) Required to Store 49 mm of Water***
VVL Comp 21-30	0.0089 (0.0116)	1.26 (1.39)	0.00	48.7	30.7 (24.4)	11.8 (5.7)	18.9 (18.7)	0.26 (0.26)
VVL Comp 31+	0.0065 (0.0837)	1.21 (1.46)	0.00	57.4	43.2 (11.7)	20.3 (2.0)	22.9 (9.7)	0.21 (0.51)
VVL Comp TP-10	0.0231 (0.0300)	1.31 (1.44)	1.43	43.9	20.4 (14.4)	7.2 (3.7)	13.2 (10.7)	0.37 (0.46)
VVL Comp TP-12	0.0059 (0.0077)	1.30 (1.43)	3.43	46.8	32.0 (26.9)	13.0 (8.0)	19.0 (18.9)	0.26 (0.26)
VVL Comp TP-13	0.0083 (0.0108)	1.25 (1.37)	0.00	49.4	34.0 (27.3)	14.0 (7.0)	20.0 (20.3)	0.25 (0.24)
WB Borrow-1	0.0179 (0.0233)	1.29 (1.42)	1.94	47.4	26.6 (19.4)	10.3 (5.4)	16.3 (14.0)	0.30 (0.35)
WB Stockpile-1	0.0118 (0.1522)	1.29 (1.54)	1.45	44.3	27.8 (6.2)	10.6 (2.0)	17.3 (4.2)	0.28 (1.17)
WB Stockpile-2	0.0153 (0.0199)	1.36 (1.50)	3.35	47.1	22.7 (17.0)	7.9 (5.0)	14.8 (12.0)	0.33 (0.41)
Topsoil-1	0.0137 (0.0177)	1.39 (1.52)	3.92	59.7	34.0 (25.6)	11.1 (7.0)	22.9 (18.6)	0.21 (0.26)

* Numbers in parentheses are corrected by the method described in the NRC report (Benson et al., 2011).

Abbreviations:

α = empirical related to inverse of the air entry suction
m = meter
mm = millimeter
N = empirical related to pore-size distribution

The effect of natural pedogenic processes including wet-dry and freeze-thaw cycles and biointrusion were included in the evaluated soil types. The laboratory soil parameters were adjusted to reflect these processes and the required soil thickness recalculated. Some soil is more susceptible to changes over time (Benson et al., 2011). Two soil types (WL Comp 31+ and WB Stockpile-1) indicated significant increases in required soil thickness. Both consisted of soil types that are considered highly plastic (unified soil classification system types CL and CH) and less desirable for the ET Cover. When adjusted for the effects of pedogenesis, cover thickness for desirable soil types ranged between 0.24 and 0.46 meter. However, this range is based solely on storage, and the required thickness to establish and maintain vegetation for adequate transpiration is greater, as discussed in Section 5.0.

A factor of safety for design of ET covers helps offset some of the uncertainties associated with in-place soil properties, and vegetation growth. A reasonable factor of safety based on field performance of ET covers to use as a guide is 1.25 times the calculated required soil thickness, or 0.9 meter, whichever is greater (USEPA, 2004). Given the results of the water balance analysis and soil types selected for use in construction, maintenance, and successful vegetation critical for an ET cover, the 0.9-meter (approximately 36-inch) soil thickness was selected for hydraulic modeling. The modeling was then used to refine and validate the design with more realistic (daily) meteorological data and soil characteristics. Results of the modeling were used for design and quality control during construction.

5.0 Evapotranspiration Cover System HYDRUS Modeling

The ET Cover System is defined by the following layers (from top to bottom): an amended storage layer (storage layer blended with Upper Lake Marsh (ULM) material), storage layer, and capillary break layer. The ET Cover is proposed to be placed over the interim cover system. The HYDRUS modeling employed the results from laboratory analysis of borrow source samples proposed for use in the ET Cover System IM. The soil sample results from previously conducted sampling and analysis (CH2M HILL, 2013) and additional samples collected from the VVL and West Fields borrow area were used as part of this evaluation. In addition, field investigation and sampling was conducted by Hydrometrics to support this evaluation and is documented in Attachment 1. A summary of the sample results is provided in Table 4. A total of 15 soil types were used in the HYDRUS evaluation, of which 14 soil types were used for the storage layers and one soil type was used as the capillary break layer.

The ET Cover System was evaluated using the HYDRUS-1D finite element numerical model designed for simulating saturated/unsaturated flow through soil. HYDRUS has been used to model ET covers for the Montana Department of Environmental Quality and others (such as USEPA and the Desert Research Institute) and was also used in the case study evaluations. This modeling evaluated an ET Cover scenario, considering conservative but reasonable site conditions. Previously conducted model scenarios with varying key design parameters were run to evaluate sensitivity of the cover performance (CH2M HILL, 2013). This modeling evaluated the variability of soil types proposed for use as potential borrow sources and guided the selection of design characteristics to be used in construction.

5.1 Model Inputs

The following sections describe the key parameters used to develop the ET Cover base case scenario. Key parameters in the HYDRUS model input are as follows:

- Top boundary condition (precipitation, potential evaporation, and potential transpiration)
- Bottom boundary condition (flow past base of capillary break layer – percolation)
- Soil properties (soil water retention hydraulic parameters, saturated hydraulic conductivity)
- ET Cover thickness (individual soil layer thickness, root depth, and relative root density)
- Initial condition (soil moisture representative of relatively steady state conditions)

A conceptual diagram of the HYDRUS model inputs is shown in Attachment 3. The modeling was conducted for a 35-year period. The highest percolation over 10 consecutive years was used to calculate an average annual percolation rate for evaluation of ET Cover performance. Specific information required for processes simulated in the HYDRUS-1D package are described in the HYDRUS user manual (Simunek et al., 2012).

5.1.1 Top Boundary Condition

The top boundary condition of the soil profile was defined by three atmosphere-land surface interaction processes: precipitation, potential evaporation (PE), and potential transpiration (PT). PT relates mainly to atmospheric conditions and leaf coverage of the surface and is therefore discussed here along with PE as part of the climatological data that define the upper boundary condition of the HYDRUS-1D model. The upper boundary is flat; however, runoff is addressed when precipitation exceeds the infiltration capacity of the soil type. The infiltration is reduced at the volume of precipitation exceeding the saturated hydraulic conductivity of the soil to account for runoff.

Precipitation data from the Helena, Montana, station (Weather Source COOP ID: 244055, managed by the Great Falls Weather Forecast Office) from 1979 through 2013 were used.

The reference evapotranspiration (ET_0) was calculated using the American Society of Civil Engineers (ASCE) Penman-Monteith Standardized Form using the Ref-ET software (Allen, 2012) for the 1997 to 2013 meteorological data from the AgriMet station located in Helena, Montana. The calculation used the daily maximum and minimum temperature, solar, humidity, and wind data. The ET_0 for the remaining precipitation period was post-processed using correlations developed between the AgriMet/REF-ET and NLDAS dataset for 1997 through 2013 and applied to the 1979 through 1997 dataset.

Total PET was calculated according to the ASCE Penman-Monteith Standardized Form ET_0 using grass as the reference crop. The leaf area index (LAI) and Ritchie-Burnett-Ankeny Function (Albright et al., 2010) [$PT=0.52xPETxLAI^{0.5}$] were then used to calculated the PT for the design ET cover vegetation community. The PE was calculated as the remainder of the PET: PE = PET - PT.

A seasonal distribution of LAI was developed to represent ranges of probable LAIs for western wheatgrass under similar climate conditions. The design LAI is based on the average monthly values reported by Frank (2002), which are considered conservative. Annual precipitation at the Frank (2002) study sites near Mandan, North Dakota, averaged 13.3 inches per year during the study period compared to the Helena site average of approximately 10.6 inches per year. The grasses at the Frank (2002) study sites were also grazed, suggesting lower LAI values than for an ungrazed site such as the design ET Cover. For the model, input for the LAI was interpolated linearly between adjacent end-of-the-month values that could be calculated directly, in order to generate the daily LAIs that were required.

TABLE 4
Soil Sample Analytical Summary

	Summary of Moisture Retention				Calculated Unsaturated Hydraulic Properties									
	Oversize Correction			Hydraulic Conductivity - Constant Head	As Tested		Oversize Corrected							
Sample ID	**1/3 Bar Point Volumetric (% cm³/cm³)**	**15 Bar Point Volumetric (% cm³/cm³)**	**Water Holding Capacity (% cm³/cm³)**	**Oversize Corrected K_{sat} (cm/sec)**	**α (cm^{-1})**	**N**	**θ_r (% vol)**	**θ_s (% vol)**	**AWHC (oversized corrected)**	**Percent Gravel (% USCS)**	**Passing #200**	**Max. Dry Bulk Density (oversized corrected g/cm³)**	**Relative Compaction of Test Samples**	**USCS**
EB-ET-1	8.2	2.4	5.8	1.10E-02	0.0441	1.2937	0.0	20.16	0.058	57.1	5.3	2.27	85	GP
EB-ET-2	13	8.2	4.8	7.70E-03	0.0164	1.3434	0.0	25.06	0.048	49.4	9.3	2.17	85	GM
EB-ET-3	25.3	8.2	17.1	6.70E-04	0.0155	1.3145	1.4	40	0.17	10	44	1.87	85	SM
VV-ET-1	35.7	16	19.8	6.00E-05	0.009	1.2048	0.0	45	0.20	36	34	1.73	85	GC
VV-ET-2	29.3	12.6	16.7	2.90E-04	0.0095	1.2335	1.8	39	0.17	40	27	1.86	85	GC
VV-ET-3	24.3	9.6	14.7	7.90E-04	0.0121	1.282	1.8	36	0.15	49	15	1.89	85	GC
VVL-Comp 0-10	29.8	10.5	19.4	2.20E-04	0.0061	1.3021	1.0	38	0.19	39	25	1.87	85	GC
VVL-Comp 11-15	24	7.1	16.9	1.20E-03	0.014	1.317	0.2	38	0.17	38	20	1.88	85	SM
VVL-Comp 16-20	31.7	11.5	20.2	4.50E-04	0.0094	1.2646	0.0	43	0.20	40	28	1.8	85	GC
VVL-Comp 21-30	31.7	11.7	20	2.60E-04	0.0089	1.2641	0.0	43	0.20	40	29	1.76	85	GC
VVL-Comp 31+	43.8	20.2	23.6	9.50E-05	0.0065	1.213	0.0	54	0.24	18	60	1.52	85	CH
VVL Comp TP-10	20.7	7.1	13.6	2.00E-03	0.0231	1.3099	1.2	38	0.14	34	22	1.9	85	SC
VVL Comp TP-12	32.4	12.9	19.6	9.60E-05	0.0059	1.3005	3.0	41	0.20	36	30	1.78	85	GC
VVL Comp TP-13	35.4	14	21.4	2.30E-04	0.0083	1.245	0.0	46	0.21	29	33	1.69	85	SC
WB Borrow-1	24.5	10.3	14.3	4.40E-04	0.0179	1.2868	1.8	44	0.14	12	47	1.75	85	SC
WB Stockpile-1	26.7	10.5	16.2	3.80E-04	0.0118	1.2869	1.4	42	0.16	9	62	1.84	85	CL
WB Stockpile-2	21.8	7.9	13.9	3.70E-04	0.0153	1.3648	2.8	40	0.14	24	48	1.89	85	SC
Topsoil-1	32.9	11	21.9	4.40E-04	0.0137	1.3859	3.9	60	0.22	0	62	1.3	85	ML

Abbreviations:
AWHC = available water holding capacity
cm³ = cubic centimeter
cm/sec = centimeter per second
USCS = United Soil Classification System

Table 5 shows the average LAI values reported for the end-of-month value. The average LAI was used to calculate the PE and PT for the base case simulation and is considered representative. The average value was used based on the sensitivity analysis conducted as part of the previously conducted HYDRUS modeling, and was used as the recommended values (CH2M HILL, 2013). LAI values of zero were used for the months of October through March of each year.

TABLE 5
Leaf Area Index End-of-Month Values for Potential Transpiration Calculation

Month	Average (Design Values)
Apr	0.11
May	0.36
Jun	0.45
Jul	0.43
Aug	0.35
Sep	0.22

5.1.2 Bottom Boundary Condition

A free draining boundary condition was placed at the base of the capillary break layer. Flow through this bottom boundary was counted as percolation that escaped evapotranspiration and migrated below the cover system.

5.1.3 Soil Properties

Table 3 summarizes the laboratory soil water retention hydraulic properties (laboratory results found in Attachment 1). The soil hydraulic parameters for the capillary break layer were from the EB-ET-2 material. The corrected values represent the parameters for the soil including the 3-inch to ¾-inch fraction. A simulation was run for each of the VVL and West Fields (WB) borrow soil types. The simulation was used to evaluate the percolation rates across a broad range of potential borrow sources and soil types.

The laboratory testing was conducted at 85 percent of maximum soil compaction density to mimic naturally occurring in-situ borrow soil density. This lower compaction at construction provides a less restrictive structure to establish plant rooting in the cover material and vegetation. Therefore, the modeling used the soil properties from the laboratory results based on a target soil density of 85 percent.

5.1.4 Evapotranspiration Storage Layer Thickness

The results of water balance analysis were used to determine a design storage layer thickness of 36 inches. The storage layer consists of a combined amended storage and storage layer of 36 inches overlying a capillary break layer of 6 inches. Previously conducted HYDRUS modeling (Hydrometrics and CH2M HILL, 2012, and CH2M HILL, 2013) indicated relatively low percolation rates with thinner storage sections. However, the minimum design thickness of 36 inches was used as the basis of this evaluation to allow for vegetation growth, uncertainties in precipitation, modeling, material properties, and long-term potential for erosion as recommended by USEPA guidance (USEPA, 2004). This guidance is considered appropriate for the former Smelter site.

The amended portion of the storage layer (upper 8 inches) includes addition of a to-be-determined volume of ULM material to help establish vegetation growth on the cover. The HYDRUS model simulation used the same properties of the storage layer for the amended layer. This is considered a conservative assumption given that the addition of the ULM material silt would increase the water-holding capacity of the amended layer.

The cover is assumed to be planted with mixed perennial bunchgrasses dominated by wheatgrass species. The rooting depth was assumed to be 36 inches, which meant that the combined vegetated and storage layer was assumed to have roots present throughout. Root density distributions for similar grassland plant communities were measured as part of the ACAP on a test site near Helena. The measured root density with depth was reported in Albright (2003) and is used in this modeling effort for the ET cover (see Table 6). Table 7 shows the plant stress parameters, which are representative of wheatgrass-dominated vegetation, used in the model. The depth of the root distribution was limited to the first 32 inches of the storage layer and was not extended into the capillary break or deeper layers.

TABLE 6
Rooting Depth Relative Distribution

Depth (cm)	Relative Root Density (cm^{-1})
0-10	0.284
10-20	0.213
20-30	0.159
30-40	0.119
40-50	0.089
50-60	0.067
60-70	0.050
70-80	0.037
80-90	0.028

Abbreviation: cm = centimeter

TABLE 7
Plant Water Stress Parameters for the Wheatgrass-Dominated Vegetation Community

Parameter	Description	Units	Values for Model
P0	Upper water content limit for root uptake to occur	cm	-10
Popt	Upper limit of optimum uptake range	cm	-25
P2H	Lower limit of optimum range (for pt of r2H)	cm	-5099
P2L	Lower limit of optimum range (for pt of r2L)	cm	-5099
P3	Lower water content limit for root uptake to occur-wilting point	cm	-30591
r2H	Potential transpiration rate at P2H	cm/day	0.5
r2L	Potential transpiration rate at P2L	cm/day	0.1

Sources: Trlica and Biondini, 1990; Frank and Ries, 1990

Abbreviations: cm = centimeters, cm/day = centimeters per day

5.2 Initial Condition

The initial soil water pressure potential was set to an arbitrary -8 cm. The simulation was conducted for a 35-year time period (1979 to 2013), with model runs including an additional 10 years, repeating the first 10 years of climatic data (1979 to 1988), to provide for calibration of initial soil moisture profile conditions in the model. This procedure allows a length of time for initial soil water volumes and profile distribution in the soil column to approach representative equilibrium conditions prior to evaluation of the percolation over the 35-year period of evaluation. Check runs were conducted looking at soil profile moisture conditions at the end of this “stabilization” period and at the end of 10 years in the evaluation period. The check runs confirm that initial soil conditions had stabilized and the results were not influenced artificially by transitory initial soil conditions. For evaluation of percolation rates, the 35-year period after the initial 10 years of stabilization was used.

5.3 HYDRUS Model Results

The model results for all soil types were reviewed over the entire period of simulation from 1979 to 2013 to determine the consecutive 10 years with the highest cumulative percolation for calculating an average annual percolation rate based on the highest percolation decade. The 10-year "highest" percolation was the simulation period from 1981 to 1990. The percolation rates calculated in the model were used because the highest precipitation events do not necessarily result in the highest percolation under ET cover conditions. Using a 10-year average annual percolation rate provides a representative but conservative estimate of cover performance for consistent comparison over a range of soil types.

Table 8 summarizes the HYDRUS modeling results for each soil type and average annual percolation rates. A more detailed summary is provided in Attachment 4. As shown in Table 8, the percolation rates ranged from 0.001 to 0.68 mm per year. The percolations rates are all relatively low for a 36-inch-thick ET storage layer, which is consistent with the water balance analysis.

TABLE 8
Summary of HYDRUS Modeling Results

Soil Type	Average Annual Bottom Percolation Rate (mm/year)
VV-ET-1	0.002
VV-ET-2	0.075
VV-ET-3	0.490
VVL-Comp 0-10	0.090
VVL-Comp 11-15	0.360
VVL-Comp 16-20	0.034
VVL-Comp 21-30	0.011
VVL-Comp 31+	0.001
VVL-Comp TP-10	0.680
VVL-Comp TP-12	0.017
VVL-Comp TP-13	0.006
WB-Borrow-1	0.003
WB Stockpile-1	0.023
WB Stockpile-2	0.006

Abbreviation:
mm/year = millimeter per year

The next step was to consider the water balance analysis, HYDRUS model results, and individual soil type properties to establish design criteria that would result in the predicted ET storage layer performance from a selected borrow source.

6.0 Design Criteria

The water balance analysis and the HYDRUS model results show that various borrow sources and soil types are acceptable for use as an ET cover. The results also show that some soil types are less desirable for the storage layer owing to potential pedogenic effects on the soil properties. Table 9 summarizes the soil types, soil characteristics, percolation rates, and evaluation of design criteria on selected borrow soil types.

In the evaluation, the two soil types VVL-Comp 31+ and WB Stockpile-1 initially were eliminated because of a potential pedogenic process that could influence ET storage performance. Both soil types as tested resulted in relatively low percolation rates, yet are greater than 50 percent fines (passing sieve size 200) and have higher plasticity (classified as a CH and CL soil). Based on the evaluation, soil types that are greater than 50 percent fines would only be desirable if they classify with low plasticity, as a ML or CL-ML soil. The soil types used in the evaluation that meet this criteria are highlighted dark green.

Gravel content influences the performance of the storage layer given a specified thickness. The greater the gravel content, the decreased storage available with the 36-inch storage layer. However, a certain volume of gravel is allowable and considered as part of this evaluation. Based on the borrow sample results and the HYDRUS model for storage layer, 40 percent gravel or lower is reasonable (equal to or greater than 60 percent passing ¾ inches). Only one soil type, VV-ET-E, did not meet this criterion. All other soil types were considered acceptable based on this criterion and are shaded a lighter green.

The fines content is a critical component to the ET storage layer performance. Given the soil types characterized, a reasonable fines percentage of 25 percent to 50 percent was selected as a design criterion based on the percolation rates. While soil types with less fines can result in acceptable percolation rates, the design criterion of 25 percent to 50 percent is reasonable from selected borrow sources, provides a conservative design criterion during construction, and allows for variability in source materials and placement in the ET cover. Fines greater than 50 percent would be allowable if the soil classifies as a ML or CL-ML as discussed previously.

Application of these design criteria results in five general soil types and gradations that would provide percolation rates in the range of 0.002 to 0.060 mm per year, which are extremely low rates through the ET Cover. The following design criteria are proposed based on this evaluation and to provide for an as-constructed cap that meets the design performance:

- 100 percent passing 3 inch
- Greater than 60 percent passing ¾ inch
- Greater than 25 percent passing No. 200 sieve
- Less than 50 percent passing No. 200 for high plasticity soil

Figure 1 shows the application of these design criteria for the different borrow sources and soil type gradations. This figure provides another method of review and analysis of the selected design criteria to the potential borrow soil types, similar to Table 9. Figure 1 shows that the soil types should be readily available from selected borrow sources, though some selection and processing during placement might be necessary to ensure the cover meets the criteria as constructed.

TABLE 9
Evaluation of Soil Types, Percolation Rates, and Pedogenic Influences on Design Criteria

	Summary of Moisture Retention				Calculated Unsaturated Hydraulic Properties										
	Oversize Correction			Hydraulic Conductivity - Constant Head	As Tested		Oversize Corrected								
Sample ID	1/3 Bar Point Volumetric (% cm^3/cm^3)	15 Bar Point Volumetric (% cm^3/cm^3)	Water Holding Capacity (% cm^3/cm^3)	Oversize Corrected K_{sat} (cm/sec)	α (cm-1)	N	θ_r (% vol)	θ_s (% vol)	AWHC (oversized corrected)	Percent Gravel (% USCS)	Passing #200	Percolation (mm/yr)	Max. Dry Bulk Density (oversized corrected g/cm^3)	Relative Compaction of Test Samples	USCS
VV-ET-1	35.7	16	19.8	6.00E-05	0.0090	1.2048	0	45.21	0.20	35.6	33.87	0.002	1.73	85	GC
VV-ET-2	29.3	12.6	16.7	2.90E-04	0.0095	1.2335	1.8	39	0.17	40	27	0.075	1.86	85	GC
VV-ET-3	24.3	9.6	14.7	7.90E-04	0.0121	1.282	1.8	36	0.15	49	15	0.494	1.89	85	GC
VVL-Comp 0-10	29.8	10.5	19.4	2.20E-04	0.0061	1.3021	1.0	38	0.19	39	25	0.090	1.87	85	GC
VVL-Comp 11-15	24	7.1	16.9	1.20E-03	0.014	1.317	0.2	38	0.17	38	20	0.360	1.88	85	SM
VVL-Comp 16-20	31.7	11.5	20.2	4.50E-04	0.0094	1.2646	0.0	43	0.20	40	28	0.034	1.8	85	GC
VVL-Comp 21-30	31.7	11.7	20	2.60E-04	0.0089	1.2641	0.0	43	0.20	40	29	0.011	1.76	85	GC
VVL-Comp 31+	43.8	20.2	23.6	9.50E-05	0.0065	1.213	0.0	54	0.24	18	60	0.001	1.52	85	CH
VVL Comp TP-10	20.7	7.1	13.6	2.00E-03	0.0231	1.3099	1.2	38	0.14	34	22	0.676	1.9	85	SC
VVL Comp TP-12	32.4	12.9	19.6	9.60E-05	0.0059	1.3005	3.0	41	0.20	36	30	0.017	1.78	85	GC
VVL Comp TP-13	35.4	14	21.4	2.30E-04	0.0083	1.245	0.0	46	0.21	29	33	0.006	1.69	85	SC
WB Borrow-1	24.5	10.3	14.3	4.40E-04	0.0179	1.2868	1.8	44	0.14	12	47	0.003	1.75	85	SC
WB Stockpile-1	26.7	10.5	16.2	3.80E-04	0.0118	1.2869	1.4	42	0.16	9	62	0.023	1.84	85	CL
WB Stockpile-2	21.8	7.9	13.9	3.70E-04	0.0153	1.3648	2.8	40	0.14	24	48	0.060	1.89	85	SC

Notes:

Darker green highlight = soil types that are greater than 50 percent fines and are classified with low plasticity, as a ML or CL-ML soil.

Lighter green highlight = soil types less than 40 percent gravel.

Bold text = desirable soil types.

Abbreviations:

AWHC = available water holding capacity

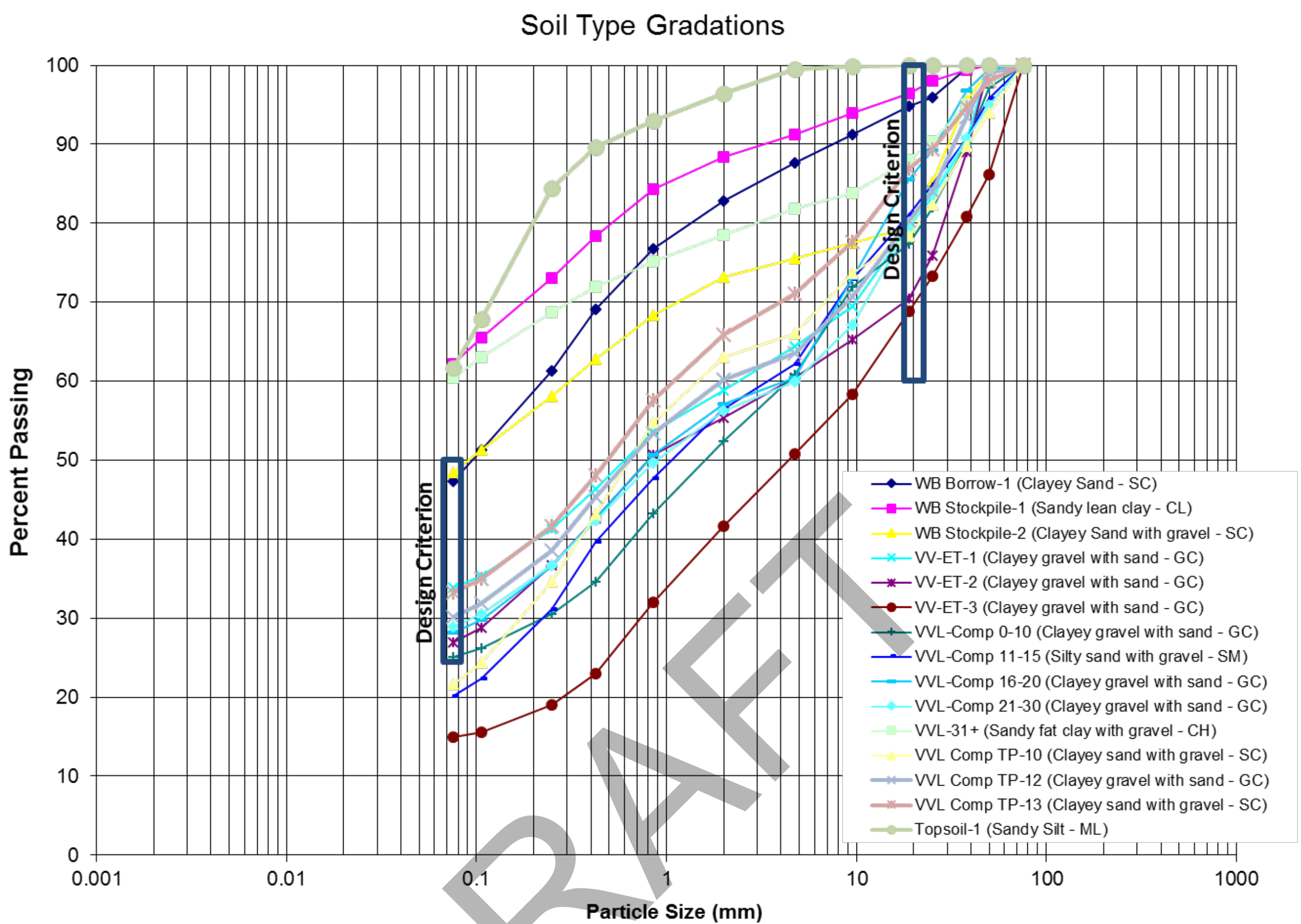
cm^3 = cubic centimeters

cm/sec = centimeters per second

g/cm^3 = grams per cubic centimeter

USCS = United Soil Classification System

FIGURE 1
Soil Type Gradation and Design Criteria



7.0 Conclusions

The water balance evaluation and hydraulic modeling support the use of an ET cover and predict that it would be effective under site conditions and available borrow source soil types. The evaluation determined soil types that are less desirable because of potential site pedogenic effects after construction. The evaluation also determined that required storage layers thicknesses are well within the recommended thickness for other cover considerations such as viable vegetation and variability in as-constructed conditions. The HYDRUS model results evaluated the performance of a 36-inch combined vegetated/storage layer with a 6-inch-thick capillary break layer for the remaining, desirable soil types. These results were used to refine the cover design and define the borrow soil design criteria.

8.0 Recommendations

Based on the results of the water balance evaluation and HYDRUS modeling, the following recommendations are provided:

- Both borrow sources could provide desirable ET cover soil types for a recommended 36-inch storage layer.
- The ULM material can be used as an amendment as long as the final, as-placed material meets the defined storage layer design criteria.

- Storage layer design criteria for either borrow source should include the following:
  - 100 percent passing 3 inch
  - Greater than 60 percent passing ¾ inch
  - Greater than 25 percent passing No. 200 sieve
  - Less than 50 percent passing No. 200 sieve unless classified as low plasticity (ML, CL-ML)
  - Placement density of 85 percent

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Attachment 1
Field Sampling and Analytical Testing Results for Potential Borrow Material

ET Cover System: Valley View Landfill and West Bench Soil Sampling and Analysis

PREPARED FOR: Nathan Betts, P.E., CH2M Hill

PREPARED BY: Mark Rhodes, P.E., Hydrometrics

DATE: November 7, 2014

Summary

Soil samples were collected for analysis as part of the ET Cover System Final Design for the East Helena Facility. Collected samples were then analyzed for suitability as borrow soil for the ET cover. Field sampling at Valley View Landfill (VVL) took place on July 2 and 3, 2014, and sampling of the West Bench area soils was conducted on July 25, 2014. This memorandum discusses the sampling procedure, preparation for laboratory analysis, and laboratory results.

Field Sampling

A Field Sampling and Analysis Plan (FSAP) was prepared prior to field sampling to provide guidance on sample collection and analysis. The FSAP anticipated sampling from 15 test pit locations spaced approximately 100 feet apart in the VVL future Cell 4 expansion area.

An excavator operated by VVL was used to construct test pits at locations specified by Hydrometrics. Actual test pit locations were based on the FSAP and observations made in the field. A survey grade GPS was used to record test pit location and ground surface elevation, as shown in Attachment A. Test pits were excavated to the maximum depth possible with the excavator, which ranged from 23 to 26 feet below ground surface (BGS).

Soils were documented on field logs and photographed during excavation. Lithological information recorded on field logs included soil color, texture, moisture, and estimated percentage of 3-inch-plus material. Information was recorded for each visually distinct layer within the test pit. Field data were used to generate test pit logs, which are included in Attachment B.

Soil samples were also collected from each visually distinct layer. Material was collected with a shovel from the test pit spoils as it was excavated. Material greater than three inches, as verified with a tape measure, was removed from the sample. Soil was collected throughout the sample depth interval and placed in a five-gallon bucket. Each bucket was sealed with a lid immediately after sample collection. Sample number, date, time, and depth were recorded on each bucket and field log. A total of 53 samples were collected.

Based on initial visual estimates of oversized material in the VVL samples, the design team determined sampling of additional soils from an alternate borrow area was necessary. Previous geotechnical investigations of soils located on the west bench indicated suitable ET

Cover materials may be available in the area. Two soil samples were collected from the CAMU 2 excavation soil stockpile, and one sample was collected from the former CAMU 2 clay liner borrow area. Soil samples were collected from several locations within the soil stockpile and borrow area using a shovel and placed in five-gallon buckets. Each bucket was sealed with a lid immediately after sample collection and the sample number, date, time, and location were recorded on the bucket. Approximate sample locations are shown in Attachment A.

Sample Analysis

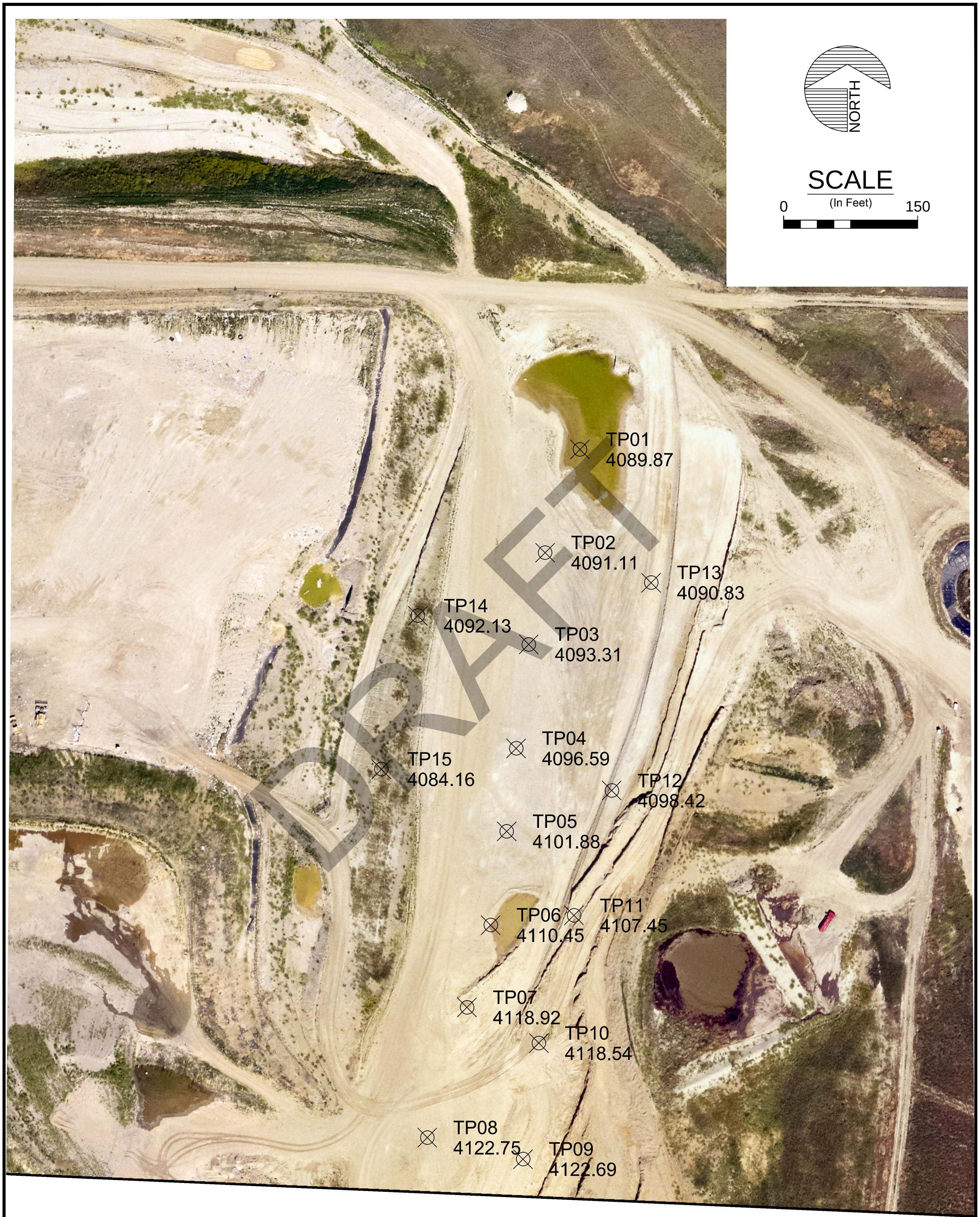
VVL soil samples were taken to the Hydrometrics lab for analysis of the fraction finer than the #200 sieve as well as preparation for additional laboratory analysis. Thirty of the 53 samples were selected for fine fraction analysis. The thirty samples represented the visually distinct layers of material spatially distributed throughout the sampling area. Five-gallon samples were reduced to approximately 500 grams for sieve analysis. Samples were spread on a clean tarp, mixed to homogenize, and reduced by quartering until an appropriate sample size was obtained. Leftover material was returned to sealed five-gallon buckets. The reduced samples were dried in an oven and weighed. Wet sieve analysis was completed with the #200 sieve. The remaining material was again dried and weighed, and the percentage passing the #200 sieve was calculated.

Extensive gradation testing of the west bench soils had been conducted during previous geotechnical investigations and no additional gradation testing was conducted on these soils.

Field data and percentage of fines results were circulated to the design team to determine which samples to composite and ship to the Daniel B Stephens and Associates (DBSA) laboratory in Albuquerque, New Mexico. The design team determined eight composite samples were to be produced from the VVL samples, each composed of two to three individual samples. Individual samples were reduced by quartering to generate five-gallon composite samples. Initial gradation results and the individual samples included in each composite sample are shown in Attachment C.

The VVL composite samples and three west bench samples were shipped with a chain-of-custody form and cover letter to DBSA for lab analysis on August 5, 2014. Due to the coarse nature of the VVL soil samples, DBSA requested additional material for analysis. An additional five-gallon bucket was prepared for each composite sample and shipped to DBSA with a chain-of-custody form and cover letter on August 14, 2014. Laboratory analysis at DBSA consisted of particle size analysis with hydrometer, soil water characteristic curves, rigid wall saturated hydraulic conductivity, calculated unsaturated K, van Genuchten modeling parameters, field capacity, wilting point, moisture content, bulk density, total porosity, and standard proctor tests. The DBSA lab report is included as Attachment D.

Attachment A
Sample Locations



ET COVER SYSTEM TECHNICAL MEMORANDUM	**VVL TEST PIT LOCATIONS**	FIGURE **A-1**

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ET COVER SYSTEM TECHNICAL MEMORANDUM	**WEST BENCH SOIL SAMPLE APPROXIMATE LOCATIONS**	FIGURE **A-2**

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Attachment B
VVL Test Pit Logs

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP01

Date Hole Started: 7/2/2014 Date Hole Finished: 7/2/2014

Client: CH2M Hill
Project:
County: Lewis and Clark State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

COORDINATES
Northing: 853299.32
Easting: 1365764.62
Ground Elevation: 4089.87

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 24
Water Table Depth (ft):

Remarks: Sample 001 is a 5-gallon bucket from 0.0 to 4.0 feet, Sample 002 is a 5-gallon bucket from 4.0 to 7.5 feet, Sample 003 is a 5-gallon bucket from 7.5 to 14.0 feet, Sample 004 is a 5-gallon bucket from 14.0 to 22.5 feet with material greater than 3 inch diameter excluded. Water observed in test pit at depth of 21.5 feet on July 3, 2014.

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DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0.0 - 4.0	001											0.0 - 4.0' **Gravelly Sand** Some reddish mottles, cobbles to 8 inches, little clay, slightly moist, loose.	
4.0 - 7.5 (5)	002											4.0 - 7.5' **Sandy Loam** Consolidated clay, slightly moist, stiff.	
7.5 - 14.0 (10)	003											7.5 - 14.0' **Sandy Loam with Gravels** Loose, slightly moist, more gravel at 12 feet, few red and black lenses, subrounded fractured gravels.	
14.0 - 22.5 (15, 20)	004											14.0 - 24.0' **Gravelly Sand** Moist, cobbles to 10 inches, increased fine sand/fines, loose.	
25													

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Helena, Montana

Test Pit Log

Hole Name: TP02

Date Hole Started: 7/2/2014   Date Hole Finished: 7/2/2014

Client: CH2M Hill
Project:
COORDINATES
Northing: 853183.79
Easting: 1365725.61
Ground Elevation: 4091.11

County: Lewis and Clark   State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 23
Water Table Depth (ft):

Remarks: Sample 005 is a 5-gallon bucket from 0.0 to 2.5 feet, Sample 006 is a 5-gallon bucket from 2.5 to 8.5 feet, Sample 007 is a 5-gallon bucket from 8.5 to 19.0 feet with material greater than 3 inch diameter excluded. Water observed in test pit at depth of 22.0 feet on July 3, 2014.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0.0 - 2.5	005											0.0 - 2.5' **Sand** Reddish mottles to 18 inch depth, loose, transition to sandy clay, slightly moist.	
2.5 - 8.5 (5)	006											2.5 - 8.5' **Sandy Loam** Consolidated, slightly moist, few white mottles, sand lenses, red mottles past 6 feet.	
8.5 - 12.5 (10)	007											8.5 - 12.5' **Gravelly Sand** Slightly moist, loose, few red, black, greenish mottles.	
12.5 - 23.0 (15, 20)												12.5 - 23.0' **Gravelly Sand** Same as above with slightly more gravel, moist.	

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Helena, Montana

Test Pit Log

Hole Name: TP03

Date Hole Started: 7/2/2014 Date Hole Finished: 7/2/2014

Client: CH2M Hill
Project:
COORDINATES
Northing: 583081.18
Easting: 1365707.32
Ground Elevation: 4093.31

County: Lewis and Clark State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 26
Water Table Depth (ft):

Remarks: Sample 008 is a 5-gallon bucket from 0.0 to 5.5 feet, Sample 009 is a 5-gallon bucket from 5.5 to 10.0 feet, Sample 010 is a 5-gallon bucket from 10.0 to 14.0 feet, Sample 011 is a 5-gallon bucket from 14.0 to 19.0 feet, Sample 012 is a 5-gallon bucket from 19.0 to 23.5 feet with material greater than 3 inch diameter excluded. Water observed in test pit at depth of 23.5 feet on July 3, 2014.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0 – 5.5	008											0.0 - 5.5' **Sand** Slightly moist, loose, red mottles.	
5.5 – 10.0	009											5.5 - 10.0' **Cobbles and Sand** Partially consolidated, more fines.	
10.0 – 14.0	010											10.0 - 14.0' **Sandy Loam** Consolidated, slightly moist, stiff.	
14.0 – 19.0	011											14.0 - 19.0' **Sand** Slightly moist, loose.	
19.0 – 23.5	012											19.0 - 26.0' **Sand** Some gray, slightly more moist, loose.	
23.5 – 26.0													

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Helena, Montana

Test Pit Log

Hole Name: TP04

Date Hole Started: 7/2/2014 Date Hole Finished: 7/2/2014

Client: CH2M Hill
County: Lewis and Clark
State: Montana
Project:
Property Owner: MT Environmental Trust Group
COORDINATES
Legal Description: T9N R2W S6
Northing: 852964.77
Location Description: Valley View Landfill Cell 4
Easting: 1365693.23
Ground Elevation: 4096.59

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 25.5
Water Table Depth (ft):

Remarks: Sample 013 is a 5-gallon bucket from 0.0 to 5.5 feet, Sample 014 is a 5-gallon bucket from 5.5 to 14.5 feet, Sample 015 is a 5-gallon bucket from 17.5 to 24.5 feet with material greater than 3 inch diameter excluded. Water observed in test pit at depth of 25.0 feet on July 3, 2014.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)		GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0–5.5	013												**0.0 - 5.5' Sand** Red mottles, slightly moist, loose.	
5.5–14.5	014												**5.5 - 17.5' Sandy Loam** Consolidated, slightly moist, stiff.	
14.5–17.5														
17.5–24.5	015												**17.5 - 25.5' Sand** Gray lenses, slightly moist, loose.	
24.5–25.5														

Depth scale (ft): 5, 10, 15, 20, 25

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Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP05

Date Hole Started: 7/2/2014 Date Hole Finished: 7/2/2014

Client: CH2M Hill
Project:
COORDINATES
Northing: 852964.77
Easting: 1365693.23
Ground Elevation: 4101.88

County: Lewis and Clark
State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 25
Water Table Depth (ft):

Remarks: Sample 016 is a 5-gallon bucket from 0.0 to 13.0 feet, Sample 017 is a 5-gallon bucket from 13.0 to 21.0 feet, Sample 018 is a 5-gallon bucket from 21.0 to 25.0 feet with material greater than 3 inch diameter excluded.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	DEPTH	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0.0–13.0	016												**0.0 - 13.0' Sand** Some gray in top 2 feet, thin partially consolidated layer at 2 feet, slightly moist, loose, some red mottles.	
13.0–21.0	017												**13.0 - 21.0' Sandy Loam** Consolidated, slightly moist, stiff.	
21.0–25.0	018												**21.0 - 25.0' Sand** Slightly moist, loose.	

Depth scale: 5, 10, 15, 20, 25

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Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP06

Date Hole Started: 7/2/2014 Date Hole Finished: 7/2/2014

Client: CH2M Hill
Project:
COORDINATES
Northing: 852767.02
Easting: 1365664.71
Ground Elevation: 4110.45

County: Lewis and Clark State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 26
Water Table Depth (ft):

Remarks: Sample 019 is a 5-gallon bucket from 0.0 to 5.0 feet, Sample 020 is a 5-gallon bucket from 5.0 to 16.0 feet, Sample 021 is a 5-gallon bucket from 17.0 to 23.0 feet with material greater than 3 inch diameter excluded.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)		GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0–5	019												0.0 - 5.0' **Sandy Loam** Slightly moist, loose, some clay lenses.	
5–16	020												5.0 - 17.0' **Sand** Rust color prevalent, slightly moist, loose.	
17–23	021												17.0 - 26.0' **Gravelly Sand** Moist, loose.	

Depth scale: 5, 10, 15, 20, 25

Hydrometrics, Inc.
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Helena, Montana

Test Pit Log

Hole Name: TP07

Date Hole Started: 7/2/2014 Date Hole Finished: 7/2/2014

Client: CH2M Hill
County: Lewis and Clark
State: Montana
Project:
Property Owner: MT Environmental Trust Group
COORDINATES
Legal Description: T9N R2W S6
Northing: 852674.93
Location Description: Valley View Landfill Cell 4
Easting: 1365638.29
Ground Elevation: 4118.92

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:
Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 26
Water Table Depth (ft):

Remarks: Sample 022 is a 5-gallon bucket from 0.0 to 3.5 feet, Sample 023 is a 5-gallon bucket from 3.5 to 12.0 feet, Sample 024 is a 5-gallon bucket from 12.0 to 21.0 feet, Sample 025 is a 5-gallon bucket from 21.0 to 26.0 feet with material greater than 3 inch diameter excluded.

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DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)		GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
	022												0.0 - 3.5' **Fine Sandy Loam** Slightly moist, loose.	
5											5			
	023												3.5 - 12.0' **Sand** Slightly moist, loose.	
10											10			
15											15		12.0 - 21.0' **Gray/Brown Sand** Slightly moist, loose.	
	024													
20											20			
	025												21.0 - 26.0' **Sand** Slightly moist, loose.	
25											25			

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Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP08

Date Hole Started: 7/2/2014 Date Hole Finished: 7/2/2014

Client: CH2M Hill
County: Lewis and Clark
State: Montana
Project:
Property Owner: MT Environmental Trust Group
COORDINATES
Legal Description: T9N R2W S6
Northing: 852529.23
Location Description: Valley View Landfill Cell 4
Easting: 13365593.84
Ground Elevation: 4122.75

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:
Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 24
Water Table Depth (ft):

Remarks: Sample 026 is a 5-gallon bucket from 0.0 to 10.0 feet, Sample 027 is a 5-gallon bucket from 13.0 to 24.0 feet with material greater than 3 inch diameter excluded.

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DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0–10	026											0.0 - 13.0' **Fine Sand** Slightly moist, loose.	
13–24	027											13.0 - 24.0' **Sand** Green mottles past 18 feet, slightly moist, loose, plastic.	

Hydrometrics, Inc.
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Helena, Montana

Test Pit Log

Hole Name: TP09

Date Hole Started: 7/2/2014 Date Hole Finished: 7/2/2014

Client: CH2M Hill
Project:
COORDINATES
Northing: 852505.15
Easting: 1365700.96
Ground Elevation: 4122.69

County: Lewis and Clark
State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 25
Water Table Depth (ft):

Remarks: Sample 028 is a 5-gallon bucket from 0.0 to 10.0 feet, Sample 029 is a 5-gallon bucket from 10.0 to 19.0 feet, Sample 030 is a 5-gallon bucket from 19.0 to 23.0 feet with material greater than 3 inch diameter excluded.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0–10	028											0.0 - 10.0' **Fine Sand** Slightly moist, loose.	
10–19	029											10.0 - 19.0' **Sand** Slightly more moist, loose.	
19–22	030											19.0 - 22.0' **Sand** Slightly moist, loose, green mottles.	
22–25												22.0 - 25.0' **Sand** Same as above with slightly less oversize material.	

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP10

Date Hole Started: 7/2/2014   Date Hole Finished: 7/2/2014

Client: CH2M Hill
Project:
COORDINATES
Northing: 852634.99
Easting: 1365718.59
Ground Elevation: 4118.54

County: Lewis and Clark   State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 25
Water Table Depth (ft):

Remarks: Sample 031 is a 5-gallon bucket from 0.0 to 7.5 feet, Sample 032 is a 5-gallon bucket from 7.5 to 15.0 feet, Sample 033 is a 5-gallon bucket from 16.0 to 17.0 feet, Sample 034 is a 5-gallon bucket from 17.0 to 25.0 feet with material greater than 3 inch diameter excluded. Water observed in test pit at depth of 24.0 feet on July 3, 2014.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0.0 - 7.5	031											0.0 - 7.5' **Sand** Slightly moist, loose, red and gray lenses.	
7.5 - 15.0	032											7.5 - 12.5' **Sand** Some gray, slightly plastic, slightly moist, loose, approximately 5%, 10 inches plus.	
												12.5 - 16.0' **Sand** Same with little more gray and 12 inches plus material.	
16.0 - 17.0	033											16.0 - 17.0' **Sand** Gray lenses, wet, loose, water at 16 feet, perched this layer seeped for 5 minutes and stopped.	
17.0 - 25.0	034											17.0 - 25.0' **Sandy Loam** Moist, loose, more plastic, green mottles, few red at bottom of pit.	

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GEOTECH_COMPLETE K:\GINT\PROJECTS\12015.GPJ HYDHLN2.GDT 7/17/14

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP11

Date Hole Started: 7/2/2014   Date Hole Finished: 7/2/2014

Client: CH2M Hill
Project:
COORDINATES
Northing: 852777.95
Easting: 1365758.02
Ground Elevation: 4107.45

County: Lewis and Clark   State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 25
Water Table Depth (ft):

Remarks: Sample 035 is a 5-gallon bucket from 0.0 to 4.0 feet, Sample 036 is a 5-gallon bucket from 4.0 to 9.0 feet, Sample 037 is a 5-gallon bucket from 9.0 to 13.0 feet, Sample 038 is a 5-gallon bucket from 13.0 to 23.0 feet, Sample 039 is a 5-gallon bucket from 23.0 to 25.0 feet with material greater than 3 inch diameter excluded.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0.0 - 4.0	035											0.0 - 4.0' **Fine Sandy Loam** Slightly moist, loose, plastic.	
4.0 - 9.0	036											4.0 - 9.0' **Sand** Slightly moist, loose, red mottles.	
9.0 - 13.0	037											9.0 - 13.0' **Sand** Discontinuous consolidated layers, loose, slightly moist.	
13.0 - 19.0	038											13.0 - 19.0' **Sand** Slightly more moist, loose, plastic, few green mottles.	
19.0 - 23.0	038											19.0 - 23.0' **Sand** Same as above, 15% oversize.	
23.0 - 25.0	039											23.0 - 25.0' **Sandy Loam** Consolidated, moist, loose.	

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP12

Date Hole Started: 7/3/2014 Date Hole Finished: 7/3/2014

Client: CH2M Hill
County: Lewis and Clark
State: Montana
Project:
Property Owner: MT Environmental Trust Group
COORDINATES
Legal Description: T9N R2W S6
Northing: 852917.64
Location Description: Valley View Landfill Cell 4
Easting: 1365800.2
Ground Elevation: 4098.42

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 25.5
Water Table Depth (ft):

Remarks: Sample 040 is a 5-gallon bucket from 0.0 to 4.0 feet, Sample 041 is a 5-gallon bucket from 4.0 to 14.5 feet, Sample 042 is a 5-gallon bucket from 14.5 to 21.5 feet, Sample 043 is a 5-gallon bucket from 21.5 to 25.5 feet with material greater than 3 inch diameter excluded.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0–4.0	040											0.0 - 4.0' **Sand** Slightly moist, loose.	
4.0–14.5 (5, 10)	041											4.0 - 14.5' **Sandy Loam** Slightly moist, loose, plastic, red mottles.	
14.5–21.5 (15, 20)	042											14.5 - 21.5' **Sandy Loam** Consolidated, slightly moist.	
21.5–25.5 (25)	043											21.5 - 25.5' **Sand with Gravel** Moist, loose.	

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP13

Date Hole Started: 7/3/2014 Date Hole Finished: 7/3/2014

Client: CH2M Hill
County: Lewis and Clark
State: Montana
Project:
Property Owner: MT Environmental Trust Group
COORDINATES
Legal Description: T9N R2W S6
Northing: 853150.26
Location Description: Valley View Landfill Cell 4
Easting: 1365844.2
Ground Elevation: 4090.83

Recorded By: George Metzger
Sample Hammer Drop System:
Drilling Company:
Inner Rod Size (ID/OD, in):
Driller:
Hole Diameter (in):
Drilling Method:
Total Depth Drilled (ft): 24
Drilling Machine:
Water Table Depth (ft):
Drilling Fluid:

Remarks: Sample 044 is a 5-gallon bucket from 0.0 to 3.0 feet, Sample 045 is a 5-gallon bucket from 3.0 to 9.0 feet, Sample 046 is a 5-gallon bucket from 9.0 to 24.0 feet with material greater than 3 inch diameter excluded.

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DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)	GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0.0 - 3.0	044											0.0 - 3.0' **Sandy Loam** Loose, slightly moist.	
3.0 - 9.0	045											3.0 - 9.0' **Sandy Loam** Consolidated, slightly moist, green mottles, small seep developed at 5 feet after 10 minutes.	
9.0 - 24.0	046											9.0 - 13.0' **Sand** Moist, loose, plastic, few red and green mottles, few black striations. 13.0 - 24.0' **Sand** Same with little more gray, slightly more consolidated material.	

Depth scale: 5, 10, 15, 20, 25

Hydrometrics, Inc.

Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP14

Date Hole Started: 7/3/2014 Date Hole Finished: 7/3/2014

Client: CH2M Hill
Project:
COORDINATES
Northing: 853113.27
Easting: 1365583.14
Ground Elevation: 4092.13

County: Lewis and Clark State: Montana
Property Owner: MT Environmental Trust Group
Legal Description: T9N R2W S6
Location Description: Valley View Landfill Cell 4

Recorded By: George Metzger
Drilling Company:
Driller:
Drilling Method:
Drilling Machine:
Drilling Fluid:

Sample Hammer Drop System:
Inner Rod Size (ID/OD, in):
Hole Diameter (in):
Total Depth Drilled (ft): 24
Water Table Depth (ft):

Remarks: Sample 047 is a 5-gallon bucket from 0.0 to 4.5 feet, Sample 048 is a 5-gallon bucket from 4.5 to 10.0 feet, Sample 049 is a 5-gallon bucket from 10.0 to 14.0 feet, Sample 050 is a 5-gallon bucket from 14.0 to 24.0 feet with material greater than 3 inch diameter excluded.

DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)		GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0–4.5	047												0.0 - 4.5' **Silty Sand** Slightly moist, loose.	
5	048										5		4.5 - 10.0' **Sandy Loam** Partially consolidated, slightly moist to moist.	
10	049										10		10.0 - 14.0' **Sand** Slightly moist, loose.	
15	050										15		14.0 - 24.0' **Sand** Moist, loose, red mottles.	
20											20			
25											25			

Hydrometrics, Inc.
Consulting Scientists and Engineers
Helena, Montana

Test Pit Log

Hole Name: TP15

Date Hole Started: 7/3/2014 Date Hole Finished: 7/3/2014

Client: CH2M Hill
County: Lewis and Clark
State: Montana
Project:
Property Owner: MT Environmental Trust Group
COORDINATES
Legal Description: T9N R2W S6
Northing: 852941.53
Location Description: Valley View Landfill Cell 4
Easting: 1365542.42
Ground Elevation: 4084.16

Recorded By: George Metzger
Sample Hammer Drop System:
Drilling Company:
Inner Rod Size (ID/OD, in):
Driller:
Hole Diameter (in):
Drilling Method:
Total Depth Drilled (ft): 26
Drilling Machine:
Water Table Depth (ft):
Drilling Fluid:

Remarks: Sample 051 is a 5-gallon bucket from 0.0 to 4.5 feet, Sample 052 is a 5-gallon bucket from 4.5 to 21.0 feet, Sample 053 is a 5-gallon bucket from 21.0 to 26.0 feet with material greater than 3 inch diameter excluded.

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DEPTH	SAMPLE NUMBER	SPT(N) BPF	(N1)60 BPF	RECOVERY (feet)	Qu (tsf) PENETROMETER	Cu (tsf) SHEAR VANE	USCS	DRY DENSITY (pcf)	PI (%)	MOISTURE CONTENT (%)		GRAPHICS	GEOLOGICAL DESCRIPTION	PIEZOMETER COMPLETION
0.0–4.5	051												0.0 - 4.5' **Silty Sand** Slightly moist, partially consolidated.	
4.5–21.0	052												4.5 - 21.0' **Sand** Green mottles, moist, loose, slightly more 12 inches plus as depth increases.	
21.0–26.0	053												21.0 - 26.0' **Sandy Silt** Consolidated, moist, sand and gravel pockets, very stiff.	

Depth scale (ft): 5, 10, 15, 20, 25

Attachment C
VVL Sample Summary Table

VVL SAMPLE SUMMARY TABLE

Sample	Test Pit	Depth	Estimated % >3"	% of 3" Minus Passing #200 Sieve	DBSA Composite Sample
VV-TP-13-001	TP01	0-4	15%	26%	
VV-TP-13-002	TP01	4-7.5	<5%	25%	
VV-TP-13-003	TP01	7.5-14	10%	8%	
VV-TP-13-004	TP01	14-22.5	15%	11%	
VV-TP-13-005	TP02	0-2.5	5%	19%	
VV-TP-13-006	TP02	2.5-8.5	<5%		
VV-TP-13-007	TP02	8.5-19	10%		
VV-TP-13-008	TP03	0-5.5	10%		
VV-TP-13-009	TP03	5.5-10	15%	23%	VVL_Composite_21-30
VV-TP-13-010	TP03	10-14	<5%		
VV-TP-13-011	TP03	14-19	5%	9%	VVL_Composite_0-10
VV-TP-13-012	TP03	19-23.5	5%		
VV-TP-13-013	TP04	0-5.5	10%	9%	VVL_Composite_0-10
VV-TP-13-014	TP04	5.5-17.5	<2%	42%	
VV-TP-13-015	TP04	17.5-24.5	15%		
VV-TP-13-016	TP05	0-13	10%		
VV-TP-13-017	TP05	13-21	<2%		
VV-TP-13-018	TP05	21-25	10%		
VV-TP-13-019	TP06	0-5	5%	36%	VVL_Composite_31+
VV-TP-13-020	TP06	5-17	10%	7%	VVL_Composite_0-10
VV-TP-13-021	TP06	17-23	10%	16%	VVL_Composite_16-20
VV-TP-13-022	TP07	0-3.5	0%		
VV-TP-13-023	TP07	3.5-12	10%		
VV-TP-13-024	TP07	12-21	10%	21%	VVL_Composite_21-30
VV-TP-13-025	TP07	21-26	10%		
VV-TP-13-026	TP08	0-10	<2%	30%	
VV-TP-13-027	TP08	13-24	5%	19%	VVL_Composite_16-20
VV-TP-13-028	TP09	0-10	<2%	15%	VVL_Composite_11-15
VV-TP-13-029	TP09	10-19	5%		
VV-TP-13-030	TP09	19-23	5%	20%	
VV-TP-13-031	TP10	0-7.5	10%		VVL_CompositeTP-10
VV-TP-13-032	TP10	7.5-15	15%		VVL_CompositeTP-10
VV-TP-13-033	TP10	16-17	5%		
VV-TP-13-034	TP10	17-25	5%	14%	VVL_CompositeTP-10
VV-TP-13-035	TP11	0-4	<2%		
VV-TP-13-036	TP11	4-9	10%	25%	
VV-TP-13-037	TP11	9-13	5%	28%	VVL_Composite_21-30
VV-TP-13-038	TP11	13-23	10%		
VV-TP-13-039	TP11	23-25	<5%	56%	VVL_Composite_31+
VV-TP-13-040	TP12	0-4	10%		
VV-TP-13-041	TP12	4-14.5	15%		VVL_CompositeTP-12
VV-TP-13-042	TP12	14.5-21.5	<2%		VVL_CompositeTP-12
VV-TP-13-043	TP12	21.5-25.5	10%	13%	VVL_CompositeTP-12
VV-TP-13-044	TP13	0-3	5%	46%	
VV-TP-13-045	TP13	3-9	<2%	47%	VVL_CompositeTP-13
VV-TP-13-046	TP13	9-24	15%		VVL_CompositeTP-13
VV-TP-13-047	TP14	0-4.5	5%	17%	VVL_Composite_16-20
VV-TP-13-048	TP14	4.5-10	<2%	58%	
VV-TP-13-049	TP14	10-14	5%	9%	
VV-TP-13-050	TP14	14-24	10%	14%	VVL_Composite_11-15
VV-TP-13-051	TP15	0-4.5	<2%		
VV-TP-13-052	TP15	4.5-21	15%	11%	VVL_Composite_11-15
VV-TP-13-053	TP15	21-26	5%	43%	VVL_Composite_31+

Attachment D
Daniel B Stephens & Associates Lab Report

Laboratory Report for Hydrometrics, Inc.

VVL Composite Samples #12015

October 16, 2014

Daniel B. Stephens & Associates, Inc.

4400 Alameda Blvd. NE, Suite C • Albuquerque, New Mexico 87113

October 16, 2014

Mark Rhodes
Hydrometrics, Inc.
3020 Bozeman Ave.
Helena, MT 59601
(406) 443-4150

Re: DBS&A Laboratory Report for the Hydrometrics, Inc. Project: VVL Composite Samples PO#12015

Dear Mr. Rhodes:

Enclosed is the report for the Hydrometrics, Inc. Project: VVL Composite Samples PO#12015 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 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 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 Hydrometrics, Inc. 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

DRAFT

Daniel B. Stephens & Associates, Inc.
Soil Testing & Research Laboratory
4400 Alameda Blvd. NE, Suite C
Albuquerque, NM 87113
505-889-7752
FAX 505-889-0258

Summaries

Daniel B. Stephens & Associates, Inc.

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			
VVL Composite 0-10																X	X				X	X
VVL Composite 0-10 (85%, 1.46)	X	X		X			X	X		X	X		X	X								
VVL Composite 11-15																X	X				X	X
VVL Composite 11-15 (85%, 1.50)	X	X		X			X	X		X	X		X	X								
VVL Composite 16-20																X	X				X	X
VVL Composite 16-20 (85%, 1.45)	X	X		X			X	X		X	X		X	X								
VVL Composite 21-30																X	X				X	X
VVL Composite 21-30 (85%, 1.38)	X	X		X			X	X		X	X		X	X								
VVL Composite 31+																X	X				X	X
VVL Composite 31+ (85%, 1.22)	X	X		X			X	X		X	X		X	X								
VVL Composite TP-10																X	X				X	X
VVL Composite TP-10 (85%, 1.51)	X	X		X			X	X		X	X		X	X								
VVL Composite TP-12																X	X				X	X
VVL Composite TP-12 (85%, 1.40)	X	X		X			X	X		X	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 Tests Performed (Continued)

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			
VVL Composite TP-13																X	X				X	X
VVL Composite TP-13 (85%, 1.37)	X	X		X			X	X		X	X		X	X								
WB Borrow-1																X	X				X	X
WB Borrow-1 (85%, 1.42)	X	X		X			X	X		X	X		X	X								
WB Stockpile-1																X	X				X	X
WB Stockpile-1 (85%, 1.52)	X	X		X			X	X		X	X		X	X								
WB Stockpile-2																X	X				X	X
WB Stockpile-2 (85%, 1.48)	X	X		X			X	X		X	X		X	X								
Topsoil-1																X	X				X	X
Topsoil-1 (85%, 1.10)	X	X		X			X	X		X	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)

Notes

Sample Receipt:
Twelve samples arrived, each in a full 5-gallon bucket sealed with a lid and tape, on August 7, 2014. Eight buckets of additional sample material arrived, each in a full 5-gallon bucket sealed with a lid and tape, on August 19, 2014.

Preparation and Testing Notes:
Each of the twelve samples were subjected to standard proctor compaction testing. Based on the proctor compaction test results, a sub-sample was prepared for each sample by remolding each material into a testing ring to target 85% of the respective maximum dry bulk density at 1% below the respective optimum moisture content. The actual percent of maximum density reached and dry bulk density achieved were added to each sub-sample ID. The remolded sub-samples were subjected to initial properties testing, saturated hydraulic conductivity testing, and the hanging column and pressure chamber portions of the moisture retention testing. Based on the standard proctor compaction method, material larger than 3/4" (19.0mm) or #4 (4.75mm), as appropriate, was removed from the sample material prior to compacting or remolding. Oversize correction calculations are presented if the fraction removed was greater than 5% of the bulk sample mass.

Remaining sample material was used for the particle size analysis, Atterberg limits testing, and the dewpoint potentiometer and relative humidity chamber portions of the moisture retention testing.

The reported volumetric moisture contents are adjusted for volume changes, when applicable. Due to the irregularities formed on the sample surfaces, volume measurements obtained after the initial reading should be considered estimates.

Porosity calculations, and the particle diameter calculations in the hydrometer portion of the particle size analysis testing, are based on the use of an assumed specific gravity value of 2.65.

Summary of Sample Preparation/Volume Changes

	Proctor Data		Target Remold Parameters[1]			Actual Remold Data			Volume Change Post Saturation[2]			Volume Change Post Drying Curve[3]		
Sample Number	Opt. Moist. Cont. (%, g/g)	Max. Dry Density (g/cm^3)	Moist. Cont. (%, g/g)	Dry Bulk Density (g/cm^3)	% of Max. Density (%)	Moist. Cont. (%, g/g)	Dry Bulk Density (g/cm^3)	% of Max. Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Max. Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Max. Density (%)
VVL Composite 0-10 (85%, 1.46)	17.6	1.72	16.6	1.46	85%	16.5	1.46	85.0%	1.46	---	85.0%	1.46	---	85.0%
VVL Composite 11-15 (85%, 1.50)	15.0	1.76	14.0	1.50	85%	13.9	1.50	85.1%	1.50	---	85.1%	1.52	-1.2%	86.1%
VVL Composite 16-20 (85%, 1.45)	17.9	1.71	16.9	1.45	85%	17.1	1.45	85.1%	1.45	---	85.1%	1.45	---	85.1%
VVL Composite 21-30 (85%, 1.38)	19.5	1.62	18.5	1.38	85%	18.1	1.38	85.3%	1.38	---	85.3%	1.38	---	85.3%
VVL Composite 31+ (85%, 1.22)	27.5	1.44	26.5	1.22	85%	27.1	1.22	84.6%	1.22	---	84.6%	1.22	---	84.6%
VVL Composite TP-10 (85%, 1.51)	16.7	1.77	15.7	1.50	85%	15.7	1.51	85.1%	1.51	---	85.1%	1.59	-5.6%	90.1%
VVL Composite TP-12 (85%, 1.40)	19.5	1.65	18.5	1.40	85%	18.6	1.40	85.1%	1.40	---	85.1%	1.49	-5.6%	90.1%
VVL Composite TP-13 (85%, 1.37)	22.2	1.61	21.2	1.37	85%	21.1	1.37	85.4%	1.37	---	85.4%	1.35	1.8%	83.9%
WB Borrow-1 (85%, 1.42)	18.9	1.67	17.9	1.42	85%	18.3	1.42	84.8%	1.42	---	84.8%	1.42	---	84.8%
WB Stockpile-1 (85%, 1.52)	15.8	1.79	14.8	1.52	85%	14.8	1.52	84.7%	1.52	---	84.7%	1.52	---	84.7%
WB Stockpile-2 (85%, 1.48)	17.3	1.74	16.3	1.47	85%	16.6	1.48	85.3%	1.48	---	85.3%	1.48	---	85.3%
Topsoil-1 (85%, 1.10)	29.2	1.30	28.2	1.11	85%	28.7	1.10	84.7%	1.10	---	84.7%	1.10	---	84.7%

[1]Target Remold Parameters: Provided by the client: 85% of maximum dry density at 1% below optimum moisture content.

[2]Volume Change Post Saturation: Volume change measurements were obtained after saturated hydraulic conductivity testing.

[3]Volume Change Post Drying Curve: Volume change measurements were obtained throughout hanging column and pressure plate testing. The 'Volume Change Post Drying Curve' values represent the final sample dimensions after the last pressure plate point.

Notes:

"+" indicates sample swelling, "-" indicates sample settling, and "---" indicates no volume change occurred.

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 (%)
VVL Composite 0-10 (85%, 1.46)	NA	NA	16.5	24.1	1.46	1.70	44.8
VVL Composite 11-15 (85%, 1.50)	NA	NA	13.9	20.9	1.50	1.71	43.4
VVL Composite 16-20 (85%, 1.45)	NA	NA	17.1	24.8	1.45	1.70	45.2
VVL Composite 21-30 (85%, 1.38)	NA	NA	18.1	25.1	1.38	1.64	47.7
VVL Composite 31+ (85%, 1.22)	NA	NA	27.1	33.0	1.22	1.55	54.0
VVL Composite TP-10 (85%, 1.51)	NA	NA	15.7	23.7	1.51	1.74	43.2
VVL Composite TP-12 (85%, 1.40)	NA	NA	18.6	26.1	1.40	1.66	47.1
VVL Composite TP-13 (85%, 1.37)	NA	NA	21.1	28.9	1.37	1.66	48.2
WB Borrow-1 (85%, 1.42)	NA	NA	18.3	26.0	1.42	1.68	46.4
WB Stockpile-1 (85%, 1.52)	NA	NA	14.8	22.4	1.52	1.74	42.8
WB Stockpile-2 (85%, 1.48)	NA	NA	16.6	24.5	1.48	1.72	44.2
Topsoil-1 (85%, 1.10)	NA	NA	28.7	31.7	1.10	1.42	58.4

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	Falling Head
VVL Composite 0-10 (85%, 1.46)	2.9E-04	2.2E-04	X	
VVL Composite 11-15 (85%, 1.50)	1.5E-03	1.2E-03	X	
VVL Composite 16-20 (85%, 1.45)	5.3E-04	4.5E-04	X	
VVL Composite 21-30 (85%, 1.38)	3.3E-04	2.6E-04	X	
VVL Composite 31+ (85%, 1.22)	1.1E-04	9.5E-05	X	
VVL Composite TP-10 (85%, 1.51)	2.5E-03	2.0E-03	X	
VVL Composite TP-12 (85%, 1.40)	1.2E-04	9.6E-05	X	
VVL Composite TP-13 (85%, 1.37)	2.6E-04	2.3E-04	X	
WB Borrow-1 (85%, 1.42)	5.0E-04	4.4E-04	X	
WB Stockpile-1 (85%, 1.52)	4.1E-04	3.8E-04	X	
WB Stockpile-2 (85%, 1.48)	4.9E-04	3.7E-04	X	
Topsoil-1 (85%, 1.10)	4.4E-04	---	X	

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

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VVL Composite 0-10 (85%, 1.46)	0	44.8
	13	44.7
	35	43.5
	105	38.7
	337	34.7
	17235	11.3
	70060	8.0
	215994	6.3
	851293	4.6
VVL Composite 11-15 (85%, 1.50)	0	42.7
	8	42.7
	24	41.7
	77	34.1
	337	27.2 ‡‡
	15093	7.0 ‡‡
	52010	5.4 ‡‡
	460950	3.1 ‡‡
	851293	3.0 ‡‡
VVL Composite 16-20 (85%, 1.45)	0	47.2
	13	47.0
	35	44.1
	108	38.9
	337	34.7
	18968	11.1
	60066	8.8
	285136	6.1
	851293	4.3

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VVL Composite 21-30 (85%, 1.38)	0	48.7
	12	48.7
	31	46.9
	104	41.3
	337	36.0
	9076	14.5
	41506	10.3
	164596	7.3
	851293	4.7
VVL Composite 31+ (85%, 1.22)	0	57.2
	12	57.2
	32	56.6
	93	51.8
	337	46.6
	19070	20.3
	52112	16.8
	449630	10.7
	851293	8.8
VVL Composite TP-10 (85%, 1.51)	0	43.3
	8	43.0
	21	41.7
	73	33.2 ‡‡
	337	24.1 ‡‡
	13971	8.4 ‡‡
	54559	5.9 ‡‡
	146545	4.8 ‡‡
	851293	3.6 ‡‡

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VVL Composite TP-12 (85%, 1.40)	0	46.7
	12	46.6
	32	46.2
	105	41.6
	337	36.9 ‡‡
	5303	17.7 ‡‡
	22742	14.1 ‡‡
	185502	9.4 ‡‡
	851293	6.2 ‡‡
VVL Composite TP-13 (85%, 1.37)	0	49.8
	13	49.3 ‡‡
	34	47.3 ‡‡
	103	42.1 ‡‡
	337	38.1 ‡‡
	20090	13.5 ‡‡
	82196	10.1 ‡‡
	148381	8.7 ‡‡
	851293	5.7 ‡‡
WB Borrow-1 (85%, 1.42)	0	46.7
	7	46.2
	29	45.8
	102	37.7
	337	26.4
	23251	11.8
	67307	8.8
	220379	5.7
	851293	3.5

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
WB Stockpile-1 (85%, 1.52)	0	43.6
	8	43.6
	27	43.2
	91	38.5
	337	28.2
	32430	10.2
	164494	6.5
	510308	4.8
	851293	3.9
WB Stockpile-2 (85%, 1.48)	0	46.2
	8	46.1
	29	45.6
	91	37.2
	337	25.7
	24883	9.5
	64961	7.8
	285646	5.1
	851293	3.5
Topsoil-1 (85%, 1.10)	0	58.8
	9	58.2
	30	58.0
	103	46.4
	337	32.9
	12646	12.6
	78729	8.5
	412101	5.6
	851293	4.3

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Retention (-1/3 Bar, -15 Bar, and Water Holding Capacity*)

Sample Number	-1/3 Bar Point Volumetric (%, cm^3/cm^3)	-15 Bar Point Volumetric (%, cm^3/cm^3)	Water Holding Capacity (%, cm^3/cm^3)	Oversize Corrected -1/3 Bar Point Volumetric (%, cm^3/cm^3)	Oversize Corrected -15 Bar Point Volumetric (%, cm^3/cm^3)	Oversize Corrected Water Holding Capacity (%, cm^3/cm^3)
VVL Composite 0-10 (85%, 1.46)	34.7	12.2	22.5	29.8	10.5	19.4
VVL Composite 11-15 (85%, 1.50)	27.2	8.1	19.2	24.0	7.1	16.9
VVL Composite 16-20 (85%, 1.45)	34.7	12.6	22.1	31.7	11.5	20.2
VVL Composite 21-30 (85%, 1.38)	36.0	13.3	22.7	31.7	11.7	20.0
VVL Composite 31+ (85%, 1.22)	46.6	21.5	25.0	43.8	20.2	23.6
VVL Composite TP-10 (85%, 1.51)	24.1	8.3	15.8	20.7	7.1	13.6
VVL Composite TP-12 (85%, 1.40)	36.9	14.6	22.2	32.4	12.9	19.6
VVL Composite TP-13 (85%, 1.37)	38.1	15.1	23.0	35.4	14.0	21.4
WB Borrow-1 (85%, 1.42)	26.4	11.0	15.4	24.5	10.3	14.3
WB Stockpile-1 (85%, 1.52)	28.2	11.1	17.1	26.7	10.5	16.2
WB Stockpile-2 (85%, 1.48)	25.7	9.3	16.4	21.8	7.9	13.9
Topsoil-1 (85%, 1.10)	32.9	11.0	21.9	---	---	---

*Water Holding Capacity (WHC) is defined here as the difference in the moisture content of the sample at -1/3 bar of water potential (commonly referred to as 'Field Capacity') and the moisture content of the sample at -15 bars of water potential (commonly referred to as 'Wilting Point').

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

Summary of Particle Size Characteristics

Sample Number	d_{10} (mm)	d_{50} (mm)	d_{60} (mm)	C_u	C_c	Method	ASTM Classification	USDA Classification
VVL Composite 0-10	0.00024	1.6	4.4	1.8E+04	50	WS/H	Clayey gravel with sand (GC)s	Sandy Clay Loam † (Est)
VVL Composite 11-15	0.0069	1.1	3.4	493	2.1	WS/H	Silty sand with gravel (SM)g	Sandy Loam †
VVL Composite 16-20	2.8E-05	0.81	4.2	1.5E+05	103	WS/H	Clayey gravel with sand (GC)s	Sandy Clay Loam † (Est)
VVL Composite 21-30	0.00020	0.89	4.8	2.4E+04	9.2	WS/H	Clayey gravel with sand (GC)s	Sandy Clay Loam † (Est)
VVL Composite 31+	2.3E-10	0.021	0.058	2.5E+08	5877	WS/H	Sandy fat clay with gravel s(CH)g	Clay † (Est)
VVL Composite TP-10	0.0082	0.64	1.5	183	2.3	WS/H	Clayey sand with gravel (SC)g	Sandy Loam †
VVL Composite TP-12	1.2E-06	0.63	1.9	1.6E+06	2274	WS/H	Clayey gravel with sand (GC)s	Sandy Clay Loam † (Est)
VVL Composite TP-13	0.00038	0.49	1.1	2895	4.4	WS/H	Clayey sand with gravel (SC)g	Sandy Clay Loam † (Est)
WB Borrow-1	0.0013	0.095	0.22	169	3.1	WS/H	Clayey sand (SC)	Sandy Loam † (Est)
WB Stockpile-1	0.00028	0.035	0.063	225	9.6	WS/H	Sandy lean clay s(CL)	Loam † (Est)
WB Stockpile-2	0.0011	0.091	0.31	282	2.0	WS/H	Clayey sand with gravel (SC)g	Loam † (Est)
Topsoil-1	0.0036	0.047	0.070	19	1.3	WS/H	Sandy silt s(ML)	Loam

d_{50} = Median particle diameter

Est = Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

$$C_u = \frac{d_{60}}{d_{10}}$$

$$C_c = \frac{(d_{30})^2}{(d_{10})(d_{60})}$$

DS = Dry sieve

H = Hydrometer

WS = Wet sieve

† Greater than 10% of sample is coarse material

DRAFT

Percent Gravel, Sand, Silt and Clay*

Sample Number	% Gravel (>4.75mm)	% Sand (<4.75mm, >0.075mm)	% Silt (<0.075mm, >0.002mm)	% Clay (<0.002mm)
VVL Composite 0-10	39.3	35.6	11.4	13.7
VVL Composite 11-15	37.8	42.0	12.7	7.5
VVL Composite 16-20	39.6	32.3	14.7	13.4
VVL Composite 21-30	40.1	31.0	13.4	15.5
VVL Composite 31+	18.2	21.4	27.6	32.8
VVL Composite TP-10	34.1	44.3	15.1	6.5
VVL Composite TP-12	36.4	33.5	13.8	16.3
VVL Composite TP-13	28.9	37.8	15.6	17.6
WB Borrow-1	12.4	40.3	35.7	11.6
WB Stockpile-1	8.7	29.1	46.9	15.3
WB Stockpile-2	24.4	27.1	35.3	13.1
Topsoil-1	0.4	37.9	53.6	8.0

*USCS classification does not classify clay fraction based on particle size. USDA definition of clay (<0.002mm) used in this table.

Summary of Atterberg Tests

Sample Number	Liquid Limit	Plastic Limit	Plasticity Index	Classification
VVL Composite 0-10	75	25	50	CH
VVL Composite 11-15	33	27	6	ML
VVL Composite 16-20	54	24	30	CH
VVL Composite 21-30	68	25	43	CH
VVL Composite 31+	65	30	35	CH
VVL Composite TP-10	38	24	14	CL
VVL Composite TP-12	72	25	47	CH
VVL Composite TP-13	66	26	40	CH
WB Borrow-1	34	23	11	CL
WB Stockpile-1	31	19	12	CL
WB Stockpile-2	32	21	11	CL
Topsoil-1	---	---	---	ML

--- = Soil requires visual-manual classification due to non-plasticity

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)
VVL Composite 0-10	17.6	1.72	13.6	1.87
VVL Composite 11-15	15.0	1.76	12.2	1.88
VVL Composite 16-20	17.9	1.71	15.3	1.80
VVL Composite 21-30	19.5	1.62	15.5	1.76
VVL Composite 31+	27.5	1.44	24.2	1.52
VVL Composite TP-10	16.7	1.77	13.1	1.90
VVL Composite TP-12	19.5	1.65	15.7	1.78
VVL Composite TP-13	22.2	1.61	19.3	1.69
WB Borrow-1	18.9	1.67	16.6	1.75
WB Stockpile-1	15.8	1.79	14.4	1.84
WB Stockpile-2	17.3	1.74	13.0	1.89
Topsoil-1	29.2	1.30	---	---

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

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 (%)
VVL Composite 0-10 (85%, 1.46)	NA	NA	16.5	24.1	1.46	1.70	44.8
VVL Composite 11-15 (85%, 1.50)	NA	NA	13.9	20.9	1.50	1.71	43.4
VVL Composite 16-20 (85%, 1.45)	NA	NA	17.1	24.8	1.45	1.70	45.2
VVL Composite 21-30 (85%, 1.38)	NA	NA	18.1	25.1	1.38	1.64	47.7
VVL Composite 31+ (85%, 1.22)	NA	NA	27.1	33.0	1.22	1.55	54.0
VVL Composite TP-10 (85%, 1.51)	NA	NA	15.7	23.7	1.51	1.74	43.2
VVL Composite TP-12 (85%, 1.40)	NA	NA	18.6	26.1	1.40	1.66	47.1
VVL Composite TP-13 (85%, 1.37)	NA	NA	21.1	28.9	1.37	1.66	48.2
WB Borrow-1 (85%, 1.42)	NA	NA	18.3	26.0	1.42	1.68	46.4
WB Stockpile-1 (85%, 1.52)	NA	NA	14.8	22.4	1.52	1.74	42.8
WB Stockpile-2 (85%, 1.48)	NA	NA	16.6	24.5	1.48	1.72	44.2
Topsoil-1 (85%, 1.10)	NA	NA	28.7	31.7	1.10	1.42	58.4

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

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

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10 (85%, 1.46)
Project Name: VVL Composite Samples
PO Number: 12015

	As Received	Remolded
Test Date:	NA	5-Sep-14
Field weight of sample* (g):		3970.40
Tare weight, ring (g):		265.08
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		3181.06
Sample volume (cm^3):		2175.34
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		16.5
Volumetric Moisture Content (% vol):		24.1
Dry bulk density (g/cm^3):		1.46
Wet bulk density (g/cm^3):		1.70
Calculated Porosity (% vol):		44.8
Percent Saturation:		53.8

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:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite 11-15 (85%, 1.50)
Project Name:	VVL Composite Samples
PO Number:	12015

	As Received	Remolded
Test Date:	NA	5-Sep-14
Field weight of sample* (g):		4068.50
Tare weight, ring (g):		270.65
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		3332.92
Sample volume (cm^3):		2220.20
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		13.9
Volumetric Moisture Content (% vol):		20.9
Dry bulk density (g/cm^3):		1.50
Wet bulk density (g/cm^3):		1.71
Calculated Porosity (% vol):		43.4
Percent Saturation:		48.3

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

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

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite 16-20 (85%, 1.45)
Project Name:	VVL Composite Samples
PO Number:	12015

	As Received	Remolded
Test Date:	NA	5-Sep-14
Field weight of sample* (g):		3999.70
Tare weight, ring (g):		269.93
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		3186.29
Sample volume (cm^3):		2194.77
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		17.1
Volumetric Moisture Content (% vol):		24.8
Dry bulk density (g/cm^3):		1.45
Wet bulk density (g/cm^3):		1.70
Calculated Porosity (% vol):		45.2
Percent Saturation:		54.8

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

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

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 21-30 (85%, 1.38)
Project Name: VVL Composite Samples
PO Number: 12015

	As Received	Remoulded
Test Date:	NA	5-Sep-14
Field weight of sample* (g):		3872.50
Tare weight, ring (g):		271.14
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		3048.84
Sample volume (cm^3):		2201.91
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		18.1
Volumetric Moisture Content (% vol):		25.1
Dry bulk density (g/cm^3):		1.38
Wet bulk density (g/cm^3):		1.64
Calculated Porosity (% vol):		47.7
Percent Saturation:		52.6

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: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+ (85%, 1.22)
Project Name: VVL Composite Samples
PO Number: 12015

	As Received	Remolded
Test Date:	NA	28-Aug-14
Field weight of sample* (g):		3705.80
Tare weight, ring (g):		272.82
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		2700.23
Sample volume (cm^3):		2217.25
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		27.1
Volumetric Moisture Content (% vol):		33.0
Dry bulk density (g/cm^3):		1.22
Wet bulk density (g/cm^3):		1.55
Calculated Porosity (% vol):		54.0
Percent Saturation:		61.1

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

DRAFT

Daniel B. Stephens & Associates, Inc.

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

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10 (85%, 1.51)
Project Name: VVL Composite Samples
PO Number: 12015

	As Received	Remolded
Test Date:	NA	28-Aug-14
Field weight of sample* (g):		4140.03
Tare weight, ring (g):		272.60
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		3342.18
Sample volume (cm^3):		2220.60
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		15.7
Volumetric Moisture Content (% vol):		23.7
Dry bulk density (g/cm^3):		1.51
Wet bulk density (g/cm^3):		1.74
Calculated Porosity (% vol):		43.2
Percent Saturation:		54.7

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

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

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite TP-12 (85%, 1.40)
Project Name:	VVL Composite Samples
PO Number:	12015

	As Received	Remolded
Test Date:	NA	28-Aug-14
Field weight of sample* (g):		3935.70
Tare weight, ring (g):		270.01
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		3091.19
Sample volume (cm^3):		2203.81
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		18.6
Volumetric Moisture Content (% vol):		26.1
Dry bulk density (g/cm^3):		1.40
Wet bulk density (g/cm^3):		1.66
Calculated Porosity (% vol):		47.1
Percent Saturation:		55.4

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

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

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite TP-13 (85%, 1.37)
Project Name:	VVL Composite Samples
PO Number:	12015

	As Received	Remolded
Test Date:	NA	5-Sep-14
Field weight of sample* (g):		4012.10
Tare weight, ring (g):		275.53
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		3086.05
Sample volume (cm^3):		2250.16
Assumed particle density (g/cm^3):		2.65

Gravimetric Moisture Content (% g/g):		21.1
Volumetric Moisture Content (% vol):		28.9
Dry bulk density (g/cm^3):		1.37
Wet bulk density (g/cm^3):		1.66
Calculated Porosity (% vol):		48.2
Percent Saturation:		59.9

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:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	WB Borrow-1 (85%, 1.42)
Project Name:	VVL Composite Samples
PO Number:	12015

	As Received	Remolded
Test Date:	NA	28-Aug-14
Field weight of sample* (g):		247.63
Tare weight, ring (g):		53.27
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		164.29
Sample volume (cm^3):		115.77
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		18.3
Volumetric Moisture Content (% vol):		26.0
Dry bulk density (g/cm^3):		1.42
Wet bulk density (g/cm^3):		1.68
Calculated Porosity (% vol):		46.4
Percent Saturation:		55.9

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

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

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	WB Stockpile-1 (85%, 1.52)
Project Name:	VVL Composite Samples
PO Number:	12015

	As Received	Remolded
Test Date:	NA	28-Aug-14
Field weight of sample* (g):		263.07
Tare weight, ring (g):		55.22
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		181.10
Sample volume (cm^3):		119.42
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		14.8
Volumetric Moisture Content (% vol):		22.4
Dry bulk density (g/cm^3):		1.52
Wet bulk density (g/cm^3):		1.74
Calculated Porosity (% vol):		42.8
Percent Saturation:		52.4

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

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

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2 (85%, 1.48)
Project Name: VVL Composite Samples
PO Number: 12015

	As Received	Remoulded
Test Date:	NA	28-Aug-14
Field weight of sample* (g):		267.66
Tare weight, ring (g):		72.21
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		167.66
Sample volume (cm^3):		113.33
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		16.6
Volumetric Moisture Content (% vol):		24.5
Dry bulk density (g/cm^3):		1.48
Wet bulk density (g/cm^3):		1.72
Calculated Porosity (% vol):		44.2
Percent Saturation:		55.5

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

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

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: Topsoil-1 (85%, 1.10)
Project Name: VVL Composite Samples
PO Number: 12015

	As Received	Remolded
Test Date:	NA	28-Aug-14
Field weight of sample* (g):		451.75
Tare weight, ring (g):		133.75
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		247.04
Sample volume (cm^3):		224.14
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		28.7
Volumetric Moisture Content (% vol):		31.7
Dry bulk density (g/cm^3):		1.10
Wet bulk density (g/cm^3):		1.42
Calculated Porosity (% vol):		58.4
Percent Saturation:		54.2

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	Falling Head
VVL Composite 0-10 (85%, 1.46)	2.9E-04	2.2E-04	X	
VVL Composite 11-15 (85%, 1.50)	1.5E-03	1.2E-03	X	
VVL Composite 16-20 (85%, 1.45)	5.3E-04	4.5E-04	X	
VVL Composite 21-30 (85%, 1.38)	3.3E-04	2.6E-04	X	
VVL Composite 31+ (85%, 1.22)	1.1E-04	9.5E-05	X	
VVL Composite TP-10 (85%, 1.51)	2.5E-03	2.0E-03	X	
VVL Composite TP-12 (85%, 1.40)	1.2E-04	9.6E-05	X	
VVL Composite TP-13 (85%, 1.37)	2.6E-04	2.3E-04	X	
WB Borrow-1 (85%, 1.42)	5.0E-04	4.4E-04	X	
WB Stockpile-1 (85%, 1.52)	4.1E-04	3.8E-04	X	
WB Stockpile-2 (85%, 1.48)	4.9E-04	3.7E-04	X	
Topsoil-1 (85%, 1.10)	4.4E-04	---	X	

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

Saturated Hydraulic Conductivity
Constant Head Method

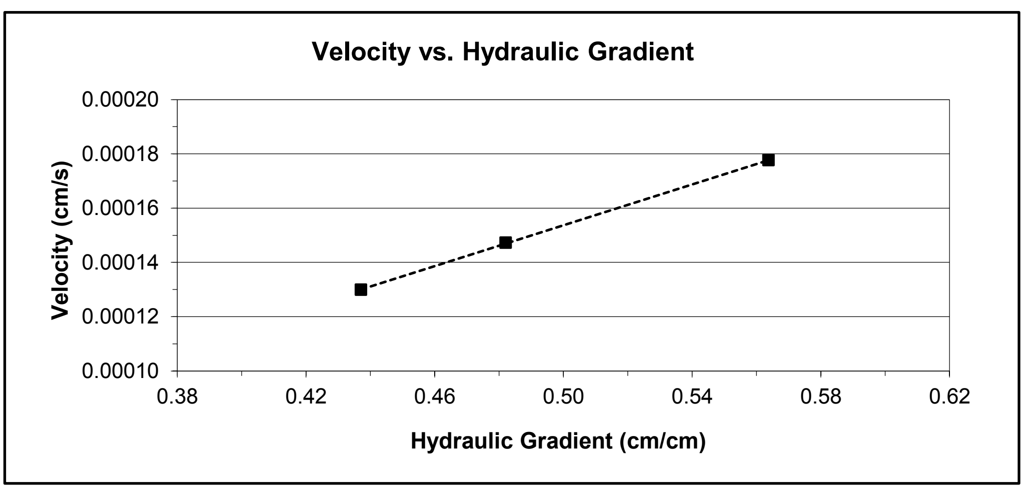
Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10 (85%, 1.46)
Project Name: VVL Composite Samples
PO Number: 12015

Type of water used: TAP
Collection vessel tare (g): 11.01
Sample length (cm): 12.24
Sample diameter (cm): 15.04
Sample x-sectional area (cm^2): 177.75

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
8-Sep-14	9:46:41	22.5	6.9	16.82	5.8	184	3.2E-04	3.0E-04
8-Sep-14	9:49:45							
Test # 2:								
8-Sep-14	10:00:36	22.5	5.9	19.80	8.8	336	3.1E-04	2.9E-04
8-Sep-14	10:06:12							
Test # 3:								
8-Sep-14	10:14:21	22.5	5.35	18.26	7.3	314	3.0E-04	2.8E-04
8-Sep-14	10:19:35							

***Average Ksat* (cm/sec):** **2.9E-04**
***Oversize Corrected Ksat* (cm/sec):** **2.2E-04**

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



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

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10 (85%, 1.46)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4
Calculated Porosity of Fines (% vol): 44.8

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	22.66	77.34	100.00
Bulk Density (g/cm^3):	2.65	1.46	1.63
Volume of Solids (cm^3):	8.55	29.19	37.74
Volume of Voids (cm^3):	0.00	23.70	23.70
Total Volume (cm^3):	8.55	52.89	61.44
Volumetric Fraction (%):	13.91	86.09	100.00
Mass Fraction (%):	22.66	77.34	100.00
Ksat (cm/sec):	NM	2.9E-04	2.2E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Saturated Hydraulic Conductivity
Constant Head Method

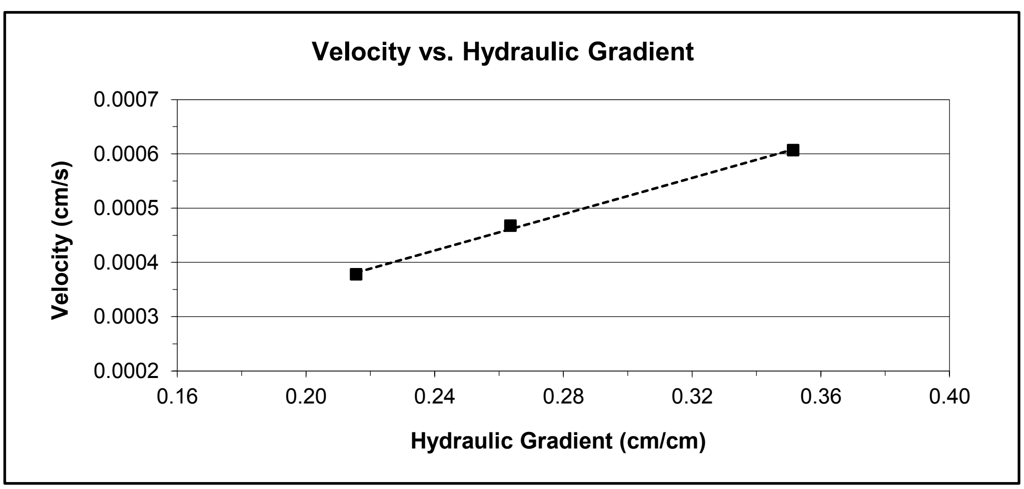
Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 11-15 (85%, 1.50)
Project Name: VVL Composite Samples
PO Number: 12015

Type of water used: TAP
Collection vessel tare (g)*:* 10.98
Sample length (cm)*:* 12.52
Sample diameter (cm)*:* 15.03
Sample x-sectional area (cm^2)*:* 177.37

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
8-Sep-14	9:45:30	22.5	4.4	29.83	18.9	191	1.6E-03	1.5E-03
8-Sep-14	9:48:41							
Test # 2:								
8-Sep-14	9:59:55	22.5	3.3	31.33	20.4	275	1.6E-03	1.5E-03
8-Sep-14	10:04:30							
Test # 3:								
8-Sep-14	10:14:00	22.5	2.7	28.07	17.1	294	1.5E-03	1.4E-03
8-Sep-14	10:18:54							

Average Ksat* (cm/sec)*: **1.5E-03**
Oversize Corrected Ksat* (cm/sec)*: **1.2E-03**

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



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

Oversize Correction Data Sheet

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite 11-15 (85%, 1.50)
Project Name:	VVL Composite Samples
PO Number:	12015
Split (3/4", 3/8", #4):	3/4
Calculated Porosity of Fines (% vol):	43.4

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	18.97	81.03	100.00
Bulk Density (g/cm^3):	2.65	1.50	1.64
Volume of Solids (cm^3):	7.16	30.58	37.74
Volume of Voids (cm^3):	0.00	23.40	23.40
Total Volume (cm^3):	7.16	53.98	61.14
Volumetric Fraction (%):	11.71	88.29	100.00
Mass Fraction (%):	18.97	81.03	100.00
Ksat (cm/sec):	NM	1.5E-03	1.2E-03

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Saturated Hydraulic Conductivity
Constant Head Method

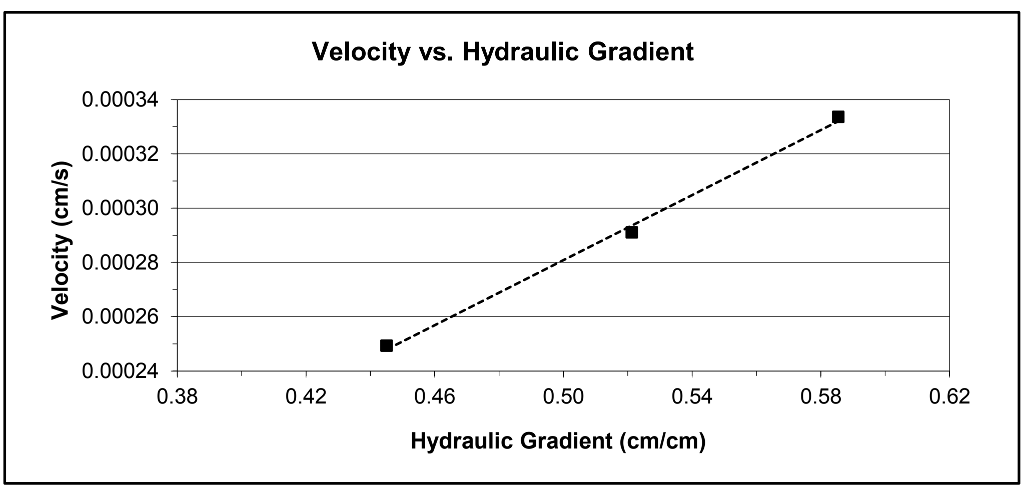
Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 16-20 (85%, 1.45)
Project Name: VVL Composite Samples
PO Number: 12015

Type of water used: TAP
Collection vessel tare (g)*:* 11.00
Sample length (cm)*:* 12.47
Sample diameter (cm)*:* 14.97
Sample x-sectional area (cm^2)*:* 176.03

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
8-Sep-14	9:46:14	22.5	7.3	20.98	10.0	170	5.7E-04	5.4E-04
8-Sep-14	9:49:04							
Test # 2:								
8-Sep-14	10:00:04	22.5	6.5	28.67	17.7	345	5.6E-04	5.3E-04
8-Sep-14	10:05:49							
Test # 3:								
8-Sep-14	10:14:12	22.5	5.55	24.29	13.3	303	5.6E-04	5.3E-04
8-Sep-14	10:19:15							

***Average Ksat* (cm/sec):** **5.3E-04**
***Oversize Corrected Ksat* (cm/sec):** **4.5E-04**

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



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

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 16-20 (85%, 1.45)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4
Calculated Porosity of Fines (% vol): 45.2

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	14.48	85.52	100.00
Bulk Density (g/cm^3):	2.65	1.45	1.55
Volume of Solids (cm^3):	5.46	32.27	37.74
Volume of Voids (cm^3):	0.00	26.64	26.64
Total Volume (cm^3):	5.46	58.91	64.37
Volumetric Fraction (%):	8.49	91.51	100.00
Mass Fraction (%):	14.48	85.52	100.00
Ksat (cm/sec):	NM	5.3E-04	4.5E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	Hydrometrics, Inc.	*Type of water used:*	TAP
Job Number:	LB14.0168.00	*Collection vessel tare* (g)*:*	11.02
Sample Number:	VVL Composite 21-30 (85%, 1.38)	*Sample length* (cm)*:*	12.44
Project Name:	VVL Composite Samples	*Sample diameter* (cm)*:*	15.01
PO Number:	12015	*Sample x-sectional area* (cm^2)*:*	176.97

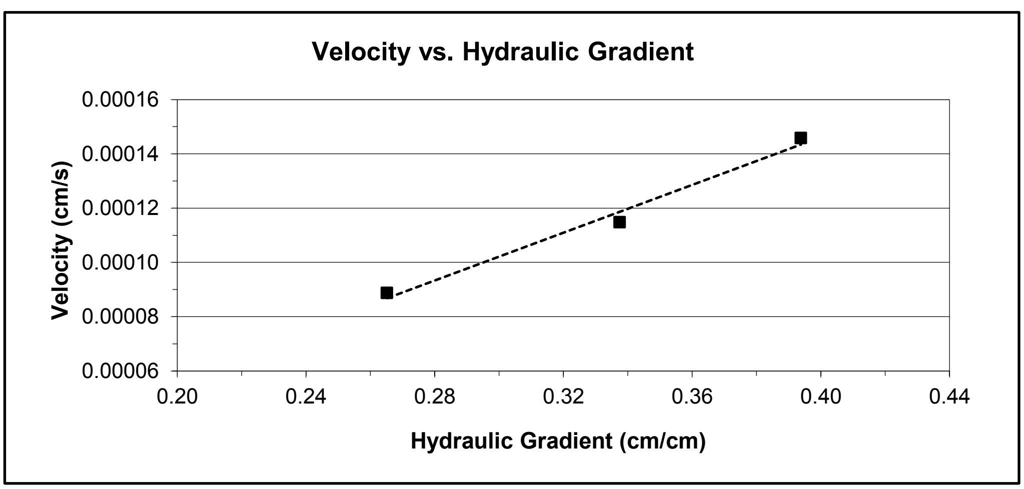
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
8-Sep-14	9:45:03	22.5	4.9	15.12	4.1	159	3.7E-04	3.5E-04
8-Sep-14	9:47:42							
Test # 2:								
8-Sep-14	9:59:33	22.5	4.2	17.60	6.6	324	3.4E-04	3.2E-04
8-Sep-14	10:04:57							
Test # 3:								
8-Sep-14	10:13:33	22.5	3.3	15.27	4.3	271	3.3E-04	3.2E-04
8-Sep-14	10:18:04							

Average Ksat* (cm/sec)*: **3.3E-04**

Oversize Corrected Ksat* (cm/sec)*: **2.6E-04**

Comments:

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



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

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite 21-30 (85%, 1.38)
Project Name:	VVL Composite Samples
PO Number:	12015
Split (3/4", 3/8", #4):	3/4
Calculated Porosity of Fines (% vol):	47.7

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	20.52	79.48	100.00
Bulk Density (g/cm^3):	2.65	1.38	1.54
Volume of Solids (cm^3):	7.74	29.99	37.74
Volume of Voids (cm^3):	0.00	27.41	27.41
Total Volume (cm^3):	7.74	57.40	65.14
Volumetric Fraction (%):	11.89	88.11	100.00
Mass Fraction (%):	20.52	79.48	100.00
Ksat (cm/sec):	NM	3.3E-04	2.6E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	Hydrometrics, Inc.	*Type of water used:*	TAP
Job Number:	LB14.0168.00	*Collection vessel tare* (g):	10.95
Sample Number:	VVL Composite 31+ (85%, 1.22)	*Sample length* (cm):	12.53
Project Name:	VVL Composite Samples	*Sample diameter* (cm):	15.01
PO Number:	12015	*Sample x-sectional area* (cm^2):	176.93

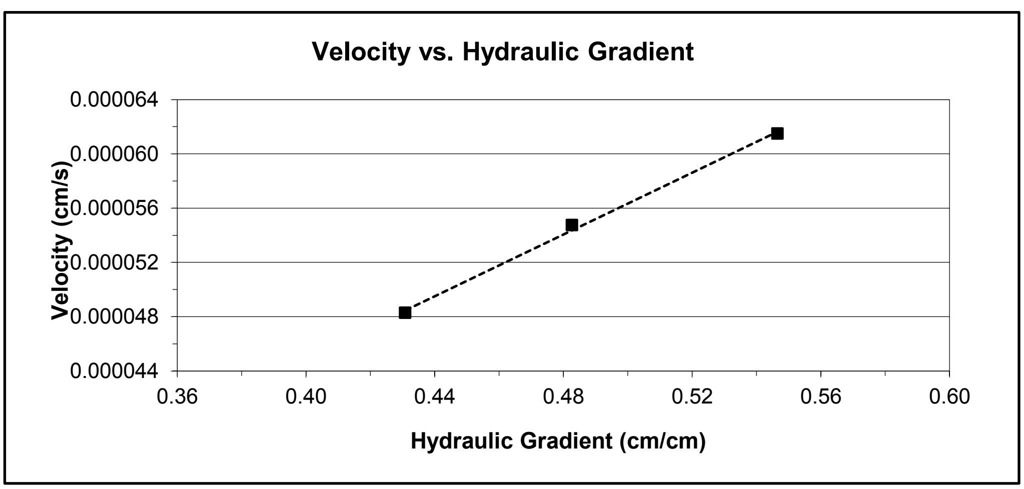
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
2-Sep-14	12:56:59	22.0	6.85	12.81	1.9	171	1.1E-04	1.1E-04
2-Sep-14	12:59:50							
Test # 2:								
2-Sep-14	13:16:30	22.0	6.05	12.80	1.9	191	1.1E-04	1.1E-04
2-Sep-14	13:19:41							
Test # 3:								
2-Sep-14	13:30:14	22.0	5.4	12.53	1.6	185	1.1E-04	1.1E-04
2-Sep-14	13:33:19							

***Average Ksat* (cm/sec): 1.1E-04**

***Oversize Corrected Ksat* (cm/sec): 9.5E-05**

Comments:

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



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Oversize Correction Data Sheet

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite 31+ (85%, 1.22)
Project Name:	VVL Composite Samples
PO Number:	12015
Split (3/4", 3/8", #4):	3/4
Calculated Porosity of Fines (% vol):	54.0

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	12.02	87.98	100.00
Bulk Density (g/cm^3):	2.65	1.22	1.30
Volume of Solids (cm^3):	4.54	33.20	37.74
Volume of Voids (cm^3):	0.00	39.04	39.04
Total Volume (cm^3):	4.54	72.24	76.78
Volumetric Fraction (%):	5.91	94.09	100.00
Mass Fraction (%):	12.02	87.98	100.00
Ksat (cm/sec):	NM	1.1E-04	9.5E-05

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	Hydrometrics, Inc.	*Type of water used:*	TAP
Job Number:	LB14.0168.00	*Collection vessel tare* (g):	10.98
Sample Number:	VVL Composite TP-10 (85%, 1.51)	*Sample length* (cm):	12.57
Project Name:	VVL Composite Samples	*Sample diameter* (cm):	15.00
PO Number:	12015	*Sample x-sectional area* (cm^2):	176.71

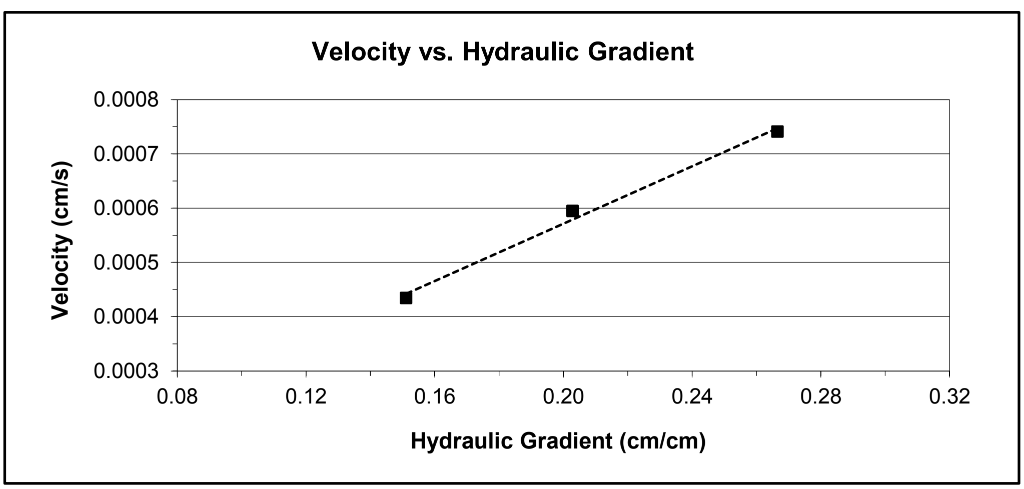
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
2-Sep-14	12:55:00	22.0	3.35	18.30	7.3	60	2.6E-03	2.5E-03
2-Sep-14	12:56:00							
Test # 2:								
2-Sep-14	13:16:00	22.0	2.55	16.75	5.8	60	2.7E-03	2.6E-03
2-Sep-14	13:17:00							
Test # 3:								
2-Sep-14	13:30:00	22.0	1.9	15.05	4.1	60	2.5E-03	2.4E-03
2-Sep-14	13:31:00							

***Average Ksat* (cm/sec): 2.5E-03**

***Oversize Corrected Ksat* (cm/sec): 2.0E-03**

Comments:

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



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10 (85%, 1.51)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4
Calculated Porosity of Fines (% vol): 43.2

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	21.58	78.42	100.00
Bulk Density (g/cm^3):	2.65	1.51	1.66
Volume of Solids (cm^3):	8.14	29.59	37.74
Volume of Voids (cm^3):	0.00	22.51	22.51
Total Volume (cm^3):	8.14	52.10	60.25
Volumetric Fraction (%):	13.52	86.48	100.00
Mass Fraction (%):	21.58	78.42	100.00
Ksat (cm/sec):	NM	2.5E-03	2.0E-03

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Saturated Hydraulic Conductivity
Constant Head Method

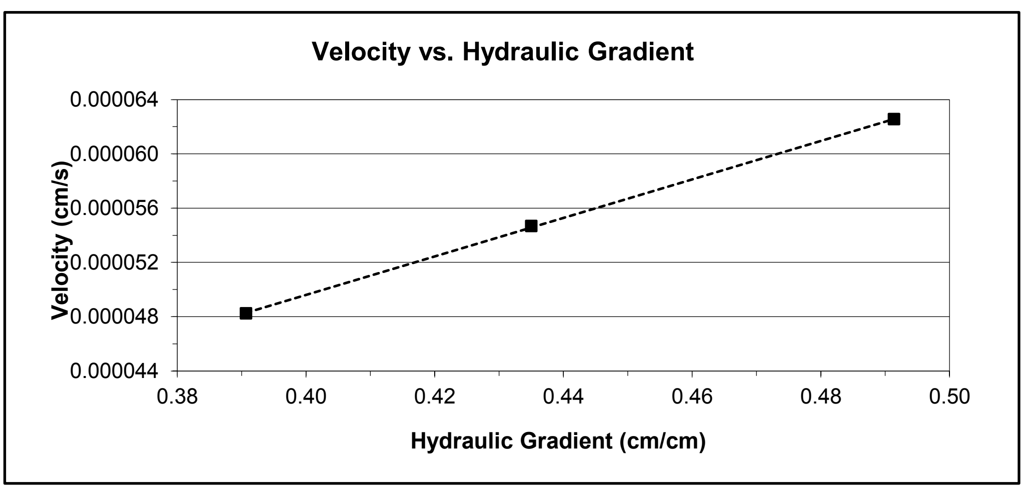
Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12 (85%, 1.40)
Project Name: VVL Composite Samples
PO Number: 12015

Type of water used: TAP
Collection vessel tare (g)*:* 10.96
Sample length (cm)*:* 12.41
Sample diameter (cm)*:* 15.04
Sample x-sectional area (cm^2)*:* 177.54

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
2-Sep-14	12:56:44	22.0	6.1	12.77	1.8	163	1.3E-04	1.2E-04
2-Sep-14	12:59:27							
Test # 2:								
2-Sep-14	13:16:18	22.0	5.4	12.61	1.7	170	1.3E-04	1.2E-04
2-Sep-14	13:19:08							
Test # 3:								
2-Sep-14	13:30:04	22.0	4.85	12.39	1.4	167	1.2E-04	1.2E-04
2-Sep-14	13:32:51							

***Average Ksat* (cm/sec):** **1.2E-04**
***Oversize Corrected Ksat* (cm/sec):** **9.6E-05**

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



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

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12 (85%, 1.40)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4
Calculated Porosity of Fines (% vol): 47.1

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	19.61	80.39	100.00
Bulk Density (g/cm^3):	2.65	1.40	1.55
Volume of Solids (cm^3):	7.40	30.33	37.74
Volume of Voids (cm^3):	0.00	26.98	26.98
Total Volume (cm^3):	7.40	57.31	64.71
Volumetric Fraction (%):	11.44	88.56	100.00
Mass Fraction (%):	19.61	80.39	100.00
Ksat (cm/sec):	NM	1.2E-04	9.6E-05

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	Hydrometrics, Inc.	*Type of water used:*	TAP
Job Number:	LB14.0168.00	*Collection vessel tare* (g)*:*	11.02
Sample Number:	VVL Composite TP-13 (85%, 1.37)	*Sample length* (cm)*:*	12.66
Project Name:	VVL Composite Samples	*Sample diameter* (cm)*:*	15.04
PO Number:	12015	*Sample x-sectional area* (cm^2)*:*	177.68

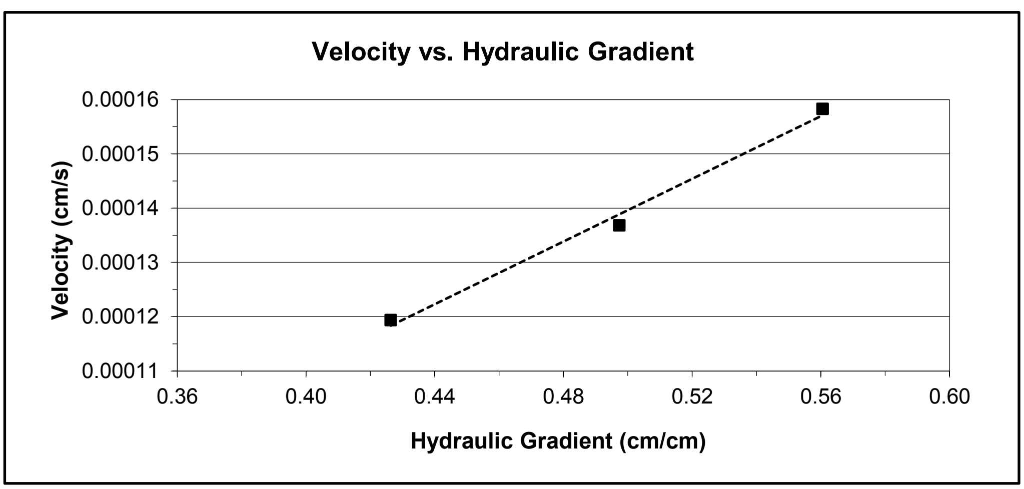
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
8-Sep-14	9:45:13	22.5	7.1	15.94	4.9	175	2.8E-04	2.7E-04
8-Sep-14	9:48:08							
Test # 2:								
8-Sep-14	9:59:43	22.5	6.3	19.26	8.2	339	2.7E-04	2.6E-04
8-Sep-14	10:05:22							
Test # 3:								
8-Sep-14	10:13:41	22.5	5.4	17.19	6.2	291	2.8E-04	2.6E-04
8-Sep-14	10:18:32							

Average Ksat* (cm/sec)*: **2.6E-04**

Oversize Corrected Ksat* (cm/sec)*: **2.3E-04**

Comments:

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



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-13 (85%, 1.37)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4
Calculated Porosity of Fines (% vol): 48.2

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	13.14	86.86	100.00
Bulk Density (g/cm^3):	2.65	1.37	1.46
Volume of Solids (cm^3):	4.96	32.78	37.74
Volume of Voids (cm^3):	0.00	30.56	30.56
Total Volume (cm^3):	4.96	63.33	68.29
Volumetric Fraction (%):	7.26	92.74	100.00
Mass Fraction (%):	13.14	86.86	100.00
Ksat (cm/sec):	NM	2.6E-04	2.3E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	Hydrometrics, Inc.	*Type of water used:*	TAP
Job Number:	LB14.0168.00	*Collection vessel tare* (g):	11.02
Sample Number:	WB Borrow-1 (85%, 1.42)	*Sample length* (cm):	3.81
Project Name:	VVL Composite Samples	*Sample diameter* (cm):	6.22
PO Number:	12015	*Sample x-sectional area* (cm^2):	30.39

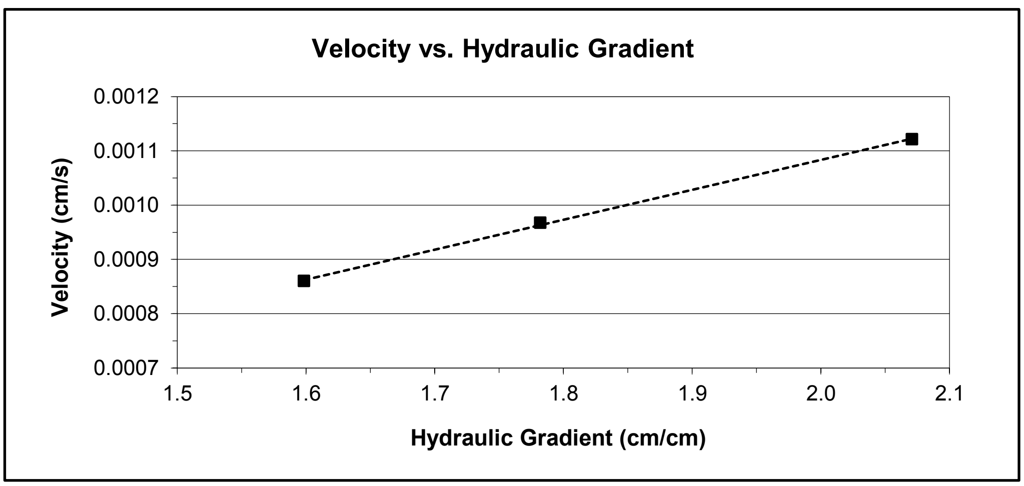
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
2-Sep-14	12:57:19	22.0	7.7	17.27	6.3	192	5.3E-04	5.1E-04
2-Sep-14	13:00:31							
Test # 2:								
2-Sep-14	13:17:25	22.0	6.6	16.37	5.4	192	5.3E-04	5.1E-04
2-Sep-14	13:20:37							
Test # 3:								
2-Sep-14	13:30:33	22.0	5.9	16.68	5.7	230	5.2E-04	5.0E-04
2-Sep-14	13:34:23							

***Average Ksat* (cm/sec): 5.0E-04**

***Oversize Corrected Ksat* (cm/sec): 4.4E-04**

Comments:

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



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Borrow-1 (85%, 1.42)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4
Calculated Porosity of Fines (% vol): 46.4

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	12.36	87.64	100.00
Bulk Density (g/cm^3):	2.65	1.42	1.51
Volume of Solids (cm^3):	4.66	33.07	37.74
Volume of Voids (cm^3):	0.00	28.68	28.68
Total Volume (cm^3):	4.66	61.76	66.42
Volumetric Fraction (%):	7.02	92.98	100.00
Mass Fraction (%):	12.36	87.64	100.00
Ksat (cm/sec):	NM	5.0E-04	4.4E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Saturated Hydraulic Conductivity
Constant Head Method

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-1 (85%, 1.52)
Project Name: VVL Composite Samples
PO Number: 12015

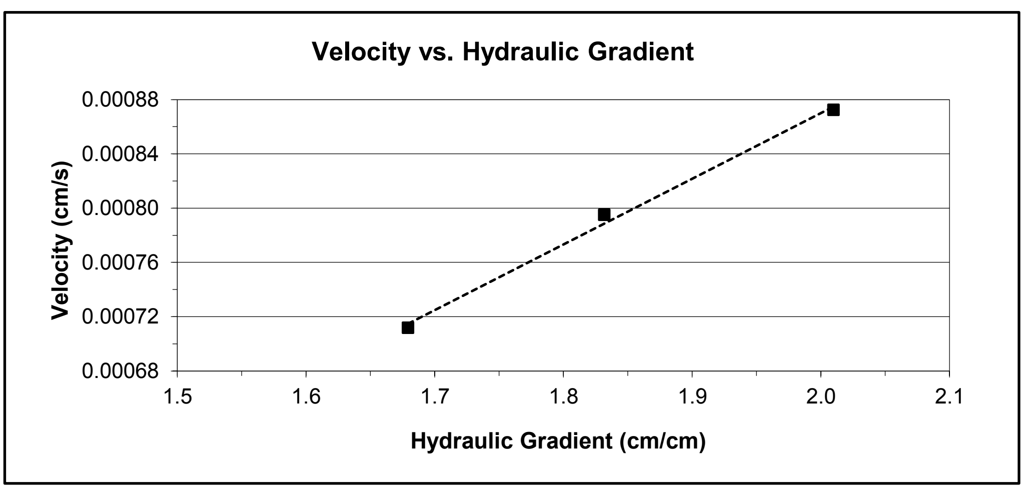
Type of water used: TAP
Collection vessel tare (g)*:* 11.02
Sample length (cm)*:* 3.93
Sample diameter (cm)*:* 6.22
Sample x-sectional area (cm^2)*:* 30.39

Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
2-Sep-14	12:57:58	22.0	7.9	16.40	5.4	203	4.3E-04	4.1E-04
2-Sep-14	13:01:21							
Test # 2:								
2-Sep-14	13:17:43	22.0	7.2	16.60	5.6	231	4.3E-04	4.1E-04
2-Sep-14	13:21:34							
Test # 3:								
2-Sep-14	13:30:54	22.0	6.6	16.62	5.6	259	4.2E-04	4.0E-04
2-Sep-14	13:35:13							

Average Ksat* (cm/sec)*: **4.1E-04**
Oversize Corrected Ksat* (cm/sec)*: **3.8E-04**

Comments:

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



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

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-1 (85%, 1.52)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4
Calculated Porosity of Fines (% vol): 42.8

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	8.73	91.27	100.00
Bulk Density (g/cm^3):	2.65	1.52	1.58
Volume of Solids (cm^3):	3.30	34.44	37.74
Volume of Voids (cm^3):	0.00	25.74	25.74
Total Volume (cm^3):	3.30	60.18	63.48
Volumetric Fraction (%):	5.19	94.81	100.00
Mass Fraction (%):	8.73	91.27	100.00
Ksat (cm/sec):	NM	4.1E-04	3.8E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	Hydrometrics, Inc.	*Type of water used:*	TAP
Job Number:	LB14.0168.00	*Collection vessel tare* (g)*:*	11.03
Sample Number:	WB Stockpile-2 (85%, 1.48)	*Sample length* (cm)*:*	3.84
Project Name:	VVL Composite Samples	*Sample diameter* (cm)*:*	6.13
PO Number:	12015	*Sample x-sectional area* (cm^2)*:*	29.51

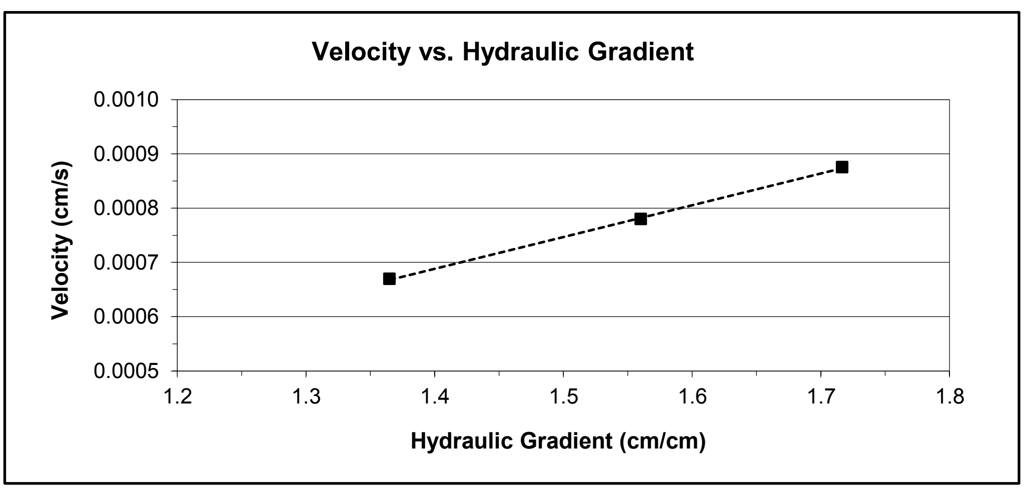
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
2-Sep-14	12:57:45	22.0	6.4	15.86	4.8	187	5.3E-04	5.0E-04
2-Sep-14	13:00:52							
Test # 2:								
2-Sep-14	13:17:36	22.0	5.8	15.77	4.7	206	5.2E-04	4.9E-04
2-Sep-14	13:21:02							
Test # 3:								
2-Sep-14	13:30:43	22.0	5.05	15.71	4.7	237	5.1E-04	4.9E-04
2-Sep-14	13:34:40							

Average Ksat* (cm/sec)*: **4.9E-04**

Oversize Corrected Ksat* (cm/sec)*: **3.7E-04**

Comments:

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



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2 (85%, 1.48)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4
Calculated Porosity of Fines (% vol): 44.2

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	24.42	75.58	100.00
Bulk Density (g/cm^3):	2.65	1.48	1.66
Volume of Solids (cm^3):	9.21	28.52	37.74
Volume of Voids (cm^3):	0.00	22.57	22.57
Total Volume (cm^3):	9.21	51.09	60.30
Volumetric Fraction (%):	15.28	84.72	100.00
Mass Fraction (%):	24.42	75.58	100.00
Ksat (cm/sec):	NM	4.9E-04	3.7E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NM = Not measured

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

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	Hydrometrics, Inc.	*Type of water used:*	TAP
Job Number:	LB14.0168.00	*Collection vessel tare* (g)*:*	10.94
Sample Number:	Topsoil-1 (85%, 1.10)	*Sample length* (cm)*:*	7.60
Project Name:	VVL Composite Samples	*Sample diameter* (cm)*:*	6.13
PO Number:	12015	*Sample x-sectional area* (cm^2)*:*	29.50

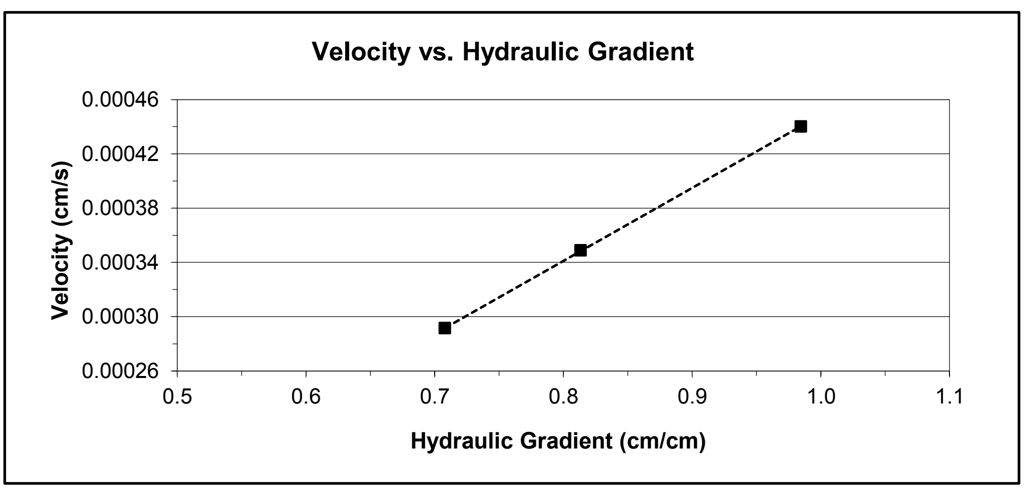
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
2-Sep-14	12:57:11	22.0	7.1	13.29	2.4	181	4.7E-04	4.5E-04
2-Sep-14	13:00:12							
Test # 2:								
2-Sep-14	13:16:44	22.0	5.8	13.08	2.1	208	4.6E-04	4.4E-04
2-Sep-14	13:20:12							
Test # 3:								
2-Sep-14	13:30:24	22.0	5	12.66	1.7	200	4.4E-04	4.2E-04
2-Sep-14	13:33:44							

Average Ksat **(cm/sec):** **4.4E-04**

Oversize Corrected Ksat **(cm/sec):** **---**

Comments:

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



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Moisture Retention Characteristics

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VVL Composite 0-10 (85%, 1.46)	0	44.8
	13	44.7
	35	43.5
	105	38.7
	337	34.7
	17235	11.3
	70060	8.0
	215994	6.3
	851293	4.6
VVL Composite 11-15 (85%, 1.50)	0	42.7
	8	42.7
	24	41.7
	77	34.1
	337	27.2 ‡‡
	15093	7.0 ‡‡
	52010	5.4 ‡‡
	460950	3.1 ‡‡
	851293	3.0 ‡‡
VVL Composite 16-20 (85%, 1.45)	0	47.2
	13	47.0
	35	44.1
	108	38.9
	337	34.7
	18968	11.1
	60066	8.8
	285136	6.1
	851293	4.3

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VVL Composite 21-30 (85%, 1.38)	0	48.7
	12	48.7
	31	46.9
	104	41.3
	337	36.0
	9076	14.5
	41506	10.3
	164596	7.3
	851293	4.7
VVL Composite 31+ (85%, 1.22)	0	57.2
	12	57.2
	32	56.6
	93	51.8
	337	46.6
	19070	20.3
	52112	16.8
	449630	10.7
	851293	8.8
VVL Composite TP-10 (85%, 1.51)	0	43.3
	8	43.0
	21	41.7
	73	33.2 ‡‡
	337	24.1 ‡‡
	13971	8.4 ‡‡
	54559	5.9 ‡‡
	146545	4.8 ‡‡
	851293	3.6 ‡‡

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
VVL Composite TP-12 (85%, 1.40)	0	46.7
	12	46.6
	32	46.2
	105	41.6
	337	36.9 ‡‡
	5303	17.7 ‡‡
	22742	14.1 ‡‡
	185502	9.4 ‡‡
	851293	6.2 ‡‡
VVL Composite TP-13 (85%, 1.37)	0	49.8
	13	49.3 ‡‡
	34	47.3 ‡‡
	103	42.1 ‡‡
	337	38.1 ‡‡
	20090	13.5 ‡‡
	82196	10.1 ‡‡
	148381	8.7 ‡‡
	851293	5.7 ‡‡
WB Borrow-1 (85%, 1.42)	0	46.7
	7	46.2
	29	45.8
	102	37.7
	337	26.4
	23251	11.8
	67307	8.8
	220379	5.7
	851293	3.5

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Moisture Characteristics of the Initial Drainage Curve (Continued)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
WB Stockpile-1 (85%, 1.52)	0	43.6
	8	43.6
	27	43.2
	91	38.5
	337	28.2
	32430	10.2
	164494	6.5
	510308	4.8
	851293	3.9
WB Stockpile-2 (85%, 1.48)	0	46.2
	8	46.1
	29	45.6
	91	37.2
	337	25.7
	24883	9.5
	64961	7.8
	285646	5.1
	851293	3.5
Topsoil-1 (85%, 1.10)	0	58.8
	9	58.2
	30	58.0
	103	46.4
	337	32.9
	12646	12.6
	78729	8.5
	412101	5.6
	851293	4.3

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1})	N (dimensionless)	θ_r (% vol)	θ_s (% vol)	Oversize Corrected θ_r (% vol)	Oversize Corrected θ_s (% vol)
VVL Composite 0-10 (85%, 1.46)	0.0061	1.3021	1.12	44.60	0.97	38.39
VVL Composite 11-15 (85%, 1.50)	0.0140	1.3170	0.27	42.99	0.23	37.96
VVL Composite 16-20 (85%, 1.45)	0.0094	1.2646	0.00	46.90	0.00	42.92
VVL Composite 21-30 (85%, 1.38)	0.0089	1.2641	0.00	48.73	0.00	42.94
VVL Composite 31+ (85%, 1.22)	0.0065	1.2130	0.00	57.37	0.00	53.98
VVL Composite TP-10 (85%, 1.51)	0.0231	1.3099	1.43	43.91	1.23	37.97
VVL Composite TP-12 (85%, 1.40)	0.0059	1.3005	3.43	46.81	3.02	41.45
VVL Composite TP-13 (85%, 1.37)	0.0083	1.2450	0.00	49.39	0.00	45.81
WB Borrow-1 (85%, 1.42)	0.0179	1.2868	1.94	47.42	1.80	44.09
WB Stockpile-1 (85%, 1.52)	0.0118	1.2869	1.45	44.26	1.38	41.97
WB Stockpile-2 (85%, 1.48)	0.0153	1.3648	3.35	47.09	2.83	39.90
Topsoil-1 (85%, 1.10)	0.0137	1.3859	3.92	59.68	---	---

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3181.06
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	265.08
Sample Number:	VVL Composite 0-10 (85%, 1.46)	*Tare wt., screen & clamp* (g):	48.27
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2175.34
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.46
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	44.82

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	8-Sep-14	14:00	4468.60	0	44.78
	15-Sep-14	10:00	4466.20	13.0	44.67
	22-Sep-14	15:33	4440.30	35.0	43.48
	29-Sep-14	16:20	4337.12	104.5	38.74
Pressure plate:	8-Oct-14	13:05	4248.60	337	34.67

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	13.0	---	---	---	---
	35.0	---	---	---	---
	104.5	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: VVL Composite 0-10 (85%, 1.46)

Initial sample bulk density (g/cm^3)*:* 1.46
Fraction of test sample used (<2.00mm fraction) (%): 52.36

Dry weight of dew point potentiometer sample* (g)*:* 164.36
Tare weight, jar (g)*:* 110.60

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	10-Sep-14	13:06	172.28	17235	11.28
	10-Sep-14	9:30	170.01	70060	8.05
	9-Sep-14	14:42	168.75	215994	6.25

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	17235	---	---	---	---
	70060	---	---	---	---
	215994	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 72.21
Tare weight (g)*:* 40.97

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	9-Sep-14	11:00	74.08	851293	4.59

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

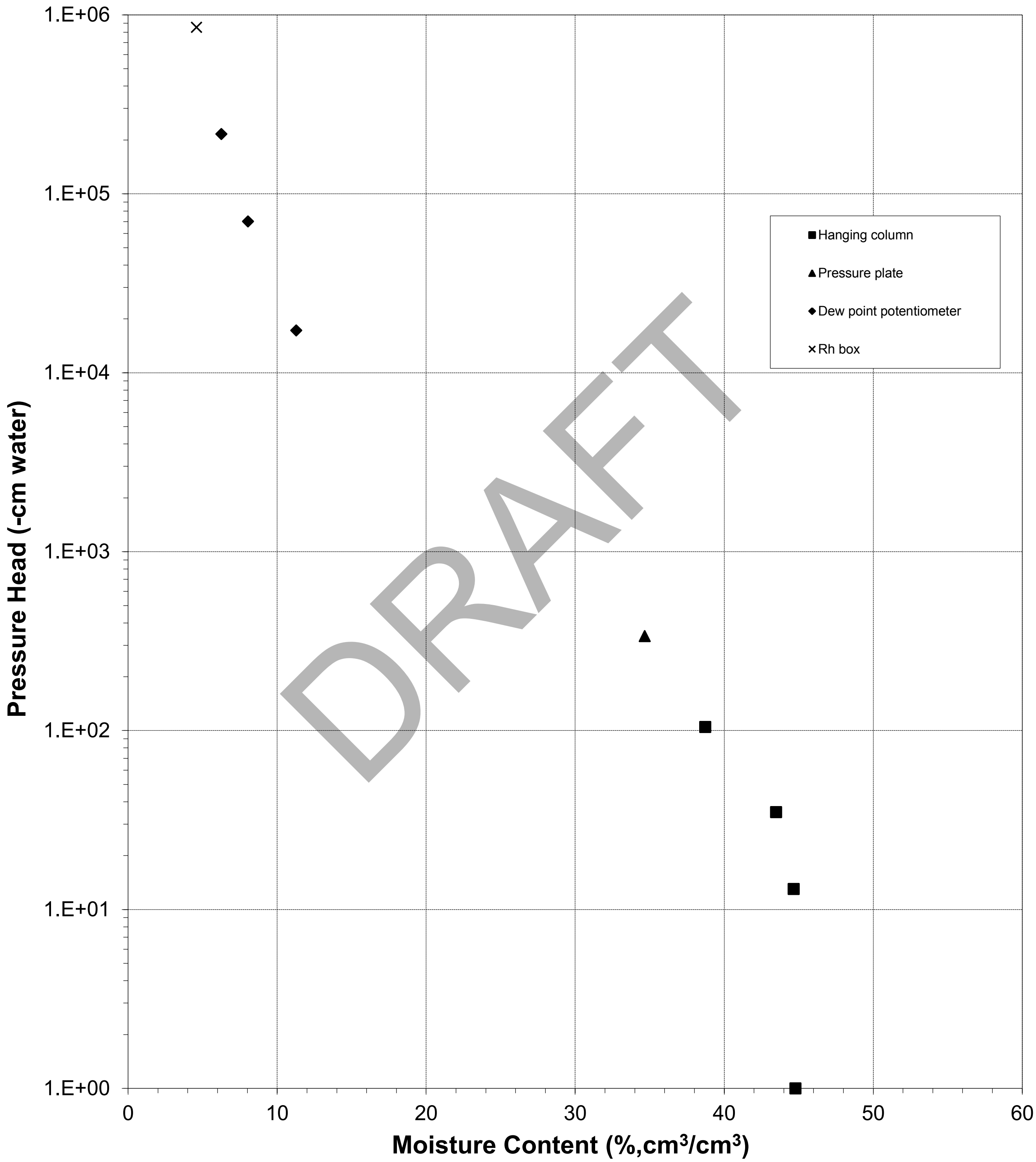
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

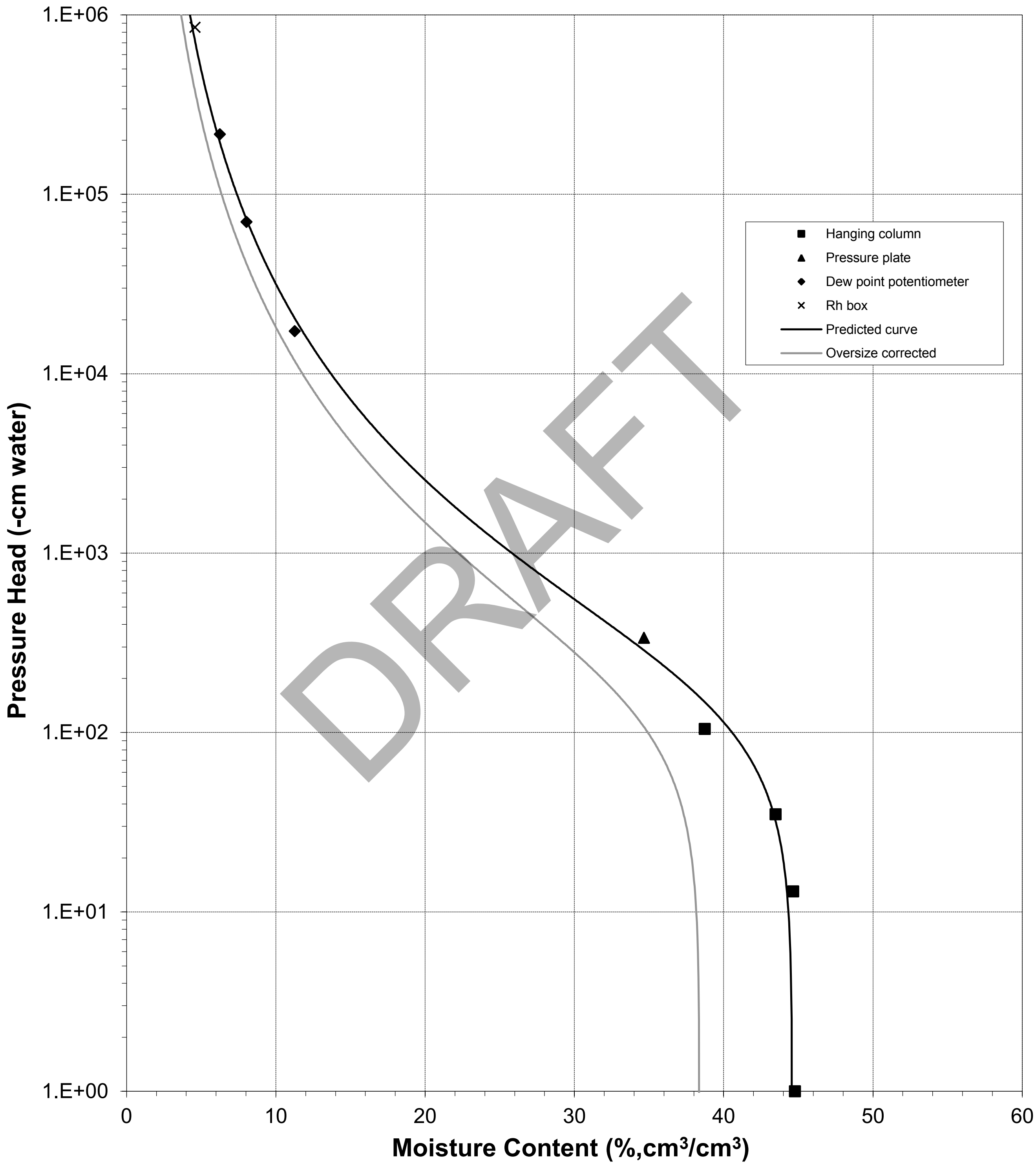
Water Retention Data Points

Sample Number: VVL Composite 0-10 (85%, 1.46)



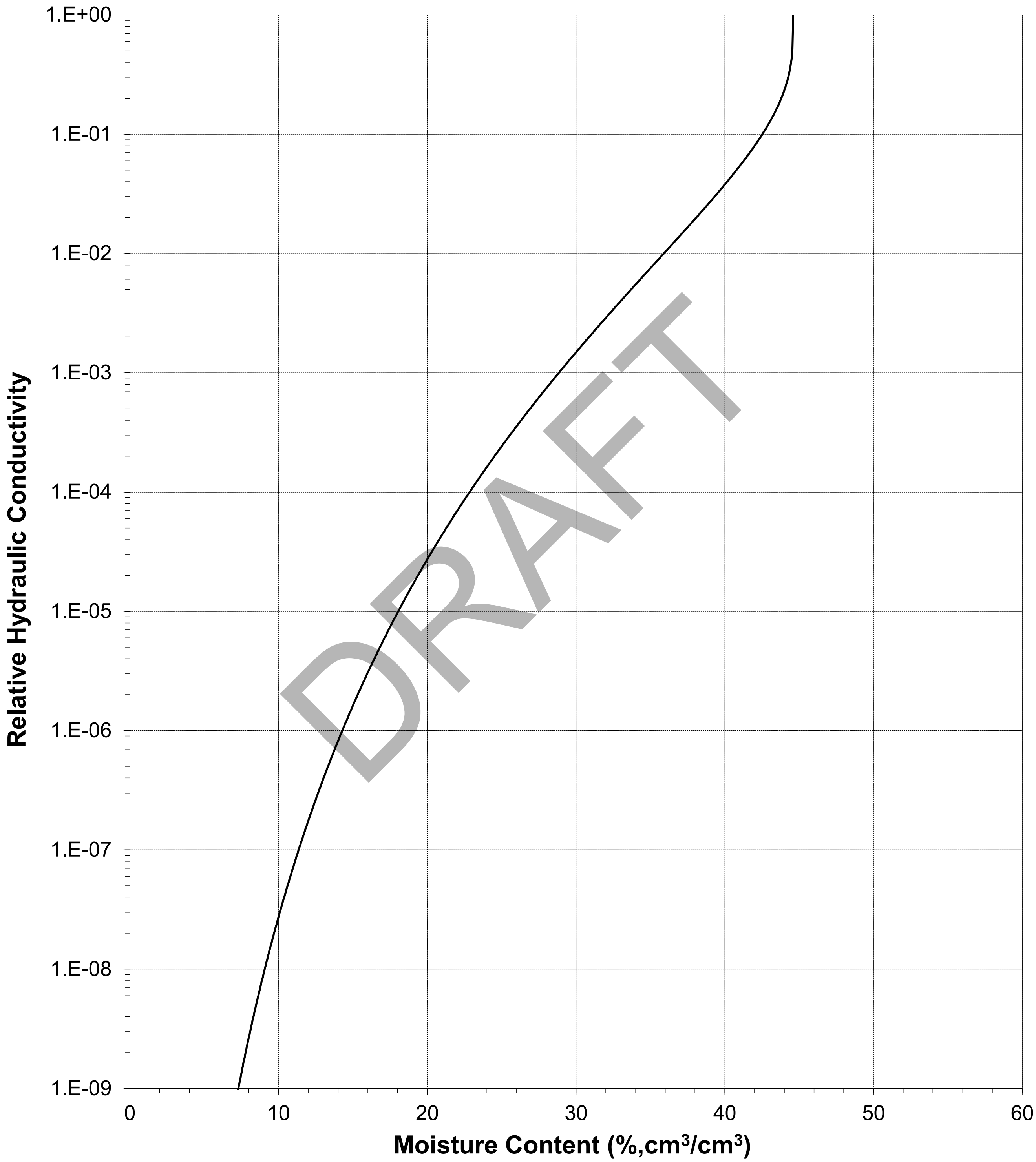
Predicted Water Retention Curve and Data Points

Sample Number: VVL Composite 0-10 (85%, 1.46)



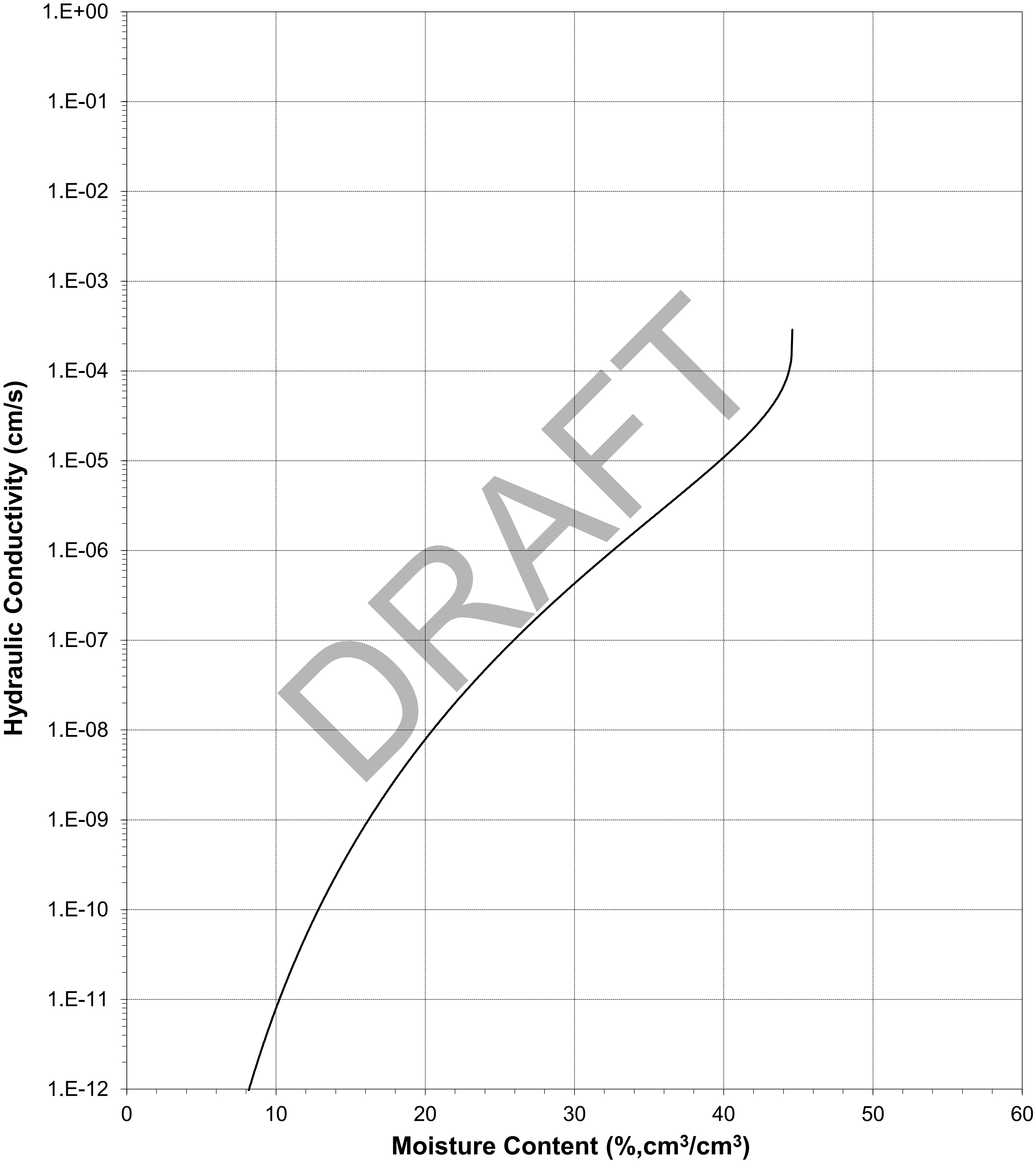
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite 0-10 (85%, 1.46)



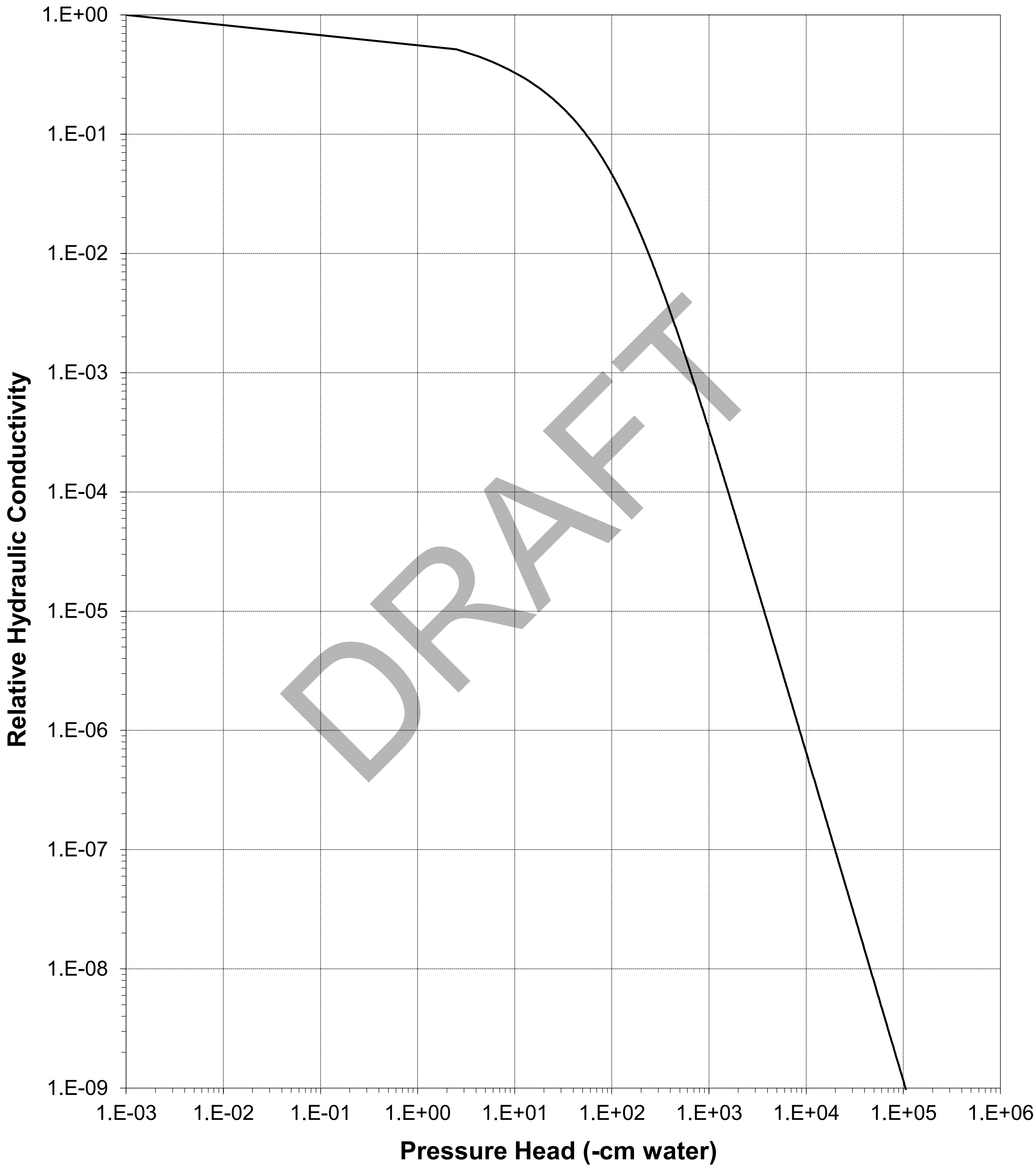
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite 0-10 (85%, 1.46)



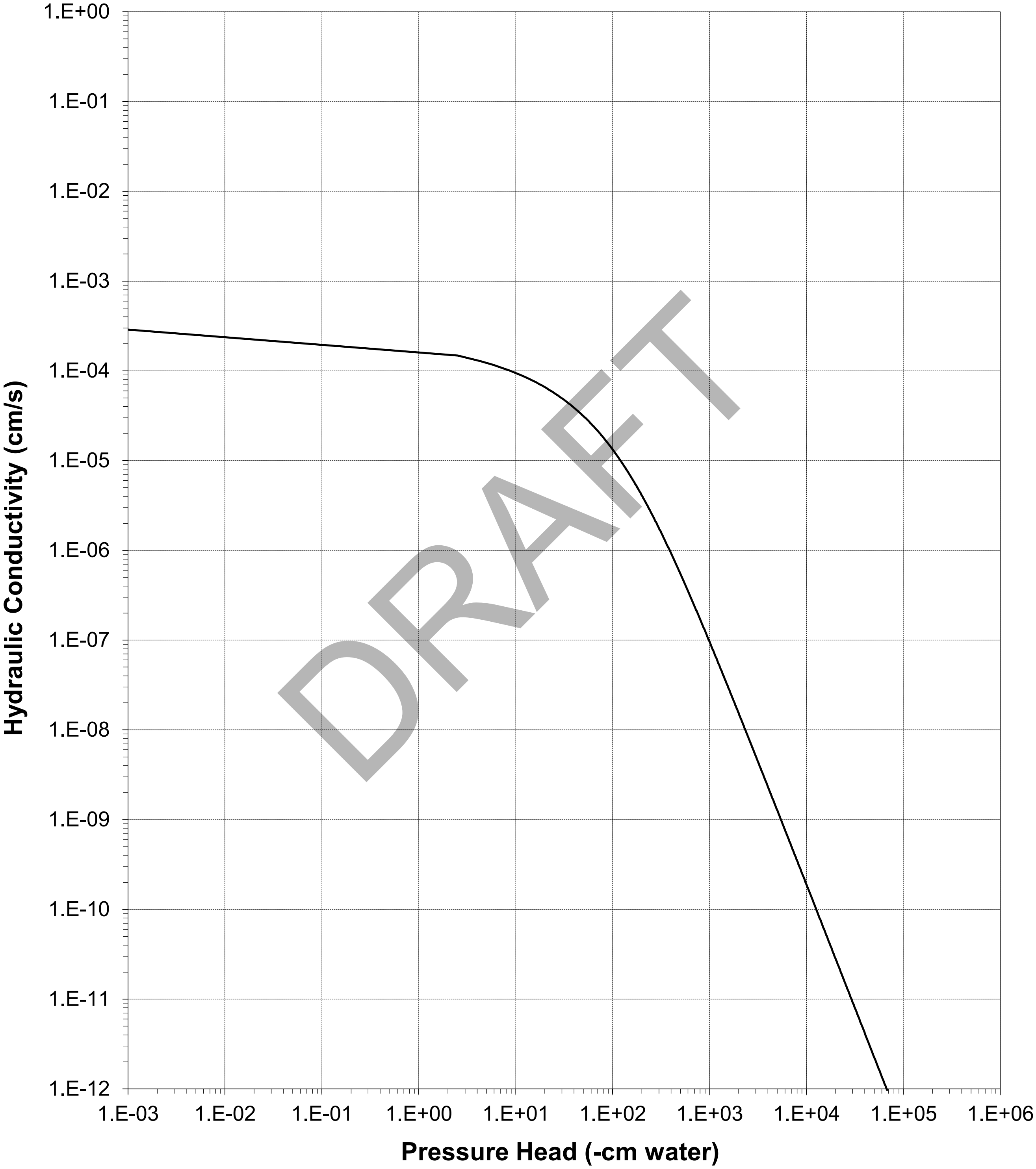
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 0-10 (85%, 1.46)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 0-10 (85%, 1.46)



Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10 (85%, 1.46)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	22.66	77.34	100.00
Mass Fraction (%):	22.66	77.34	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.46	1.63
Calculated Porosity (% vol):	0.00	44.82	38.58
Volume of Solids (cm^3):	8.55	29.19	37.74
Volume of Voids (cm^3):	0.00	23.70	23.70
Total Volume (cm^3):	8.55	52.89	61.44
Volumetric Fraction (%):	13.91	86.09	100.00
Initial Moisture Content (% vol):	0.00	24.10	20.75
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.46	1.63
Calculated Porosity (% vol):	0.00	44.82	38.58
Volume of Solids (cm^3):	8.55	29.19	37.74
Volume of Voids (cm^3):	0.00	23.70	23.70
Total Volume (cm^3):	8.55	52.89	61.44
Volumetric Fraction (%):	13.91	86.09	100.00
Saturated Moisture Content (% vol):	0.00	44.60	38.39
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.46	1.63
Calculated Porosity (% vol):	0.00	44.82	38.58
Volume of Solids (cm^3):	8.55	29.19	37.74
Volume of Voids (cm^3):	0.00	23.70	23.70
Total Volume (cm^3):	8.55	52.89	61.44
Volumetric Fraction (%):	13.91	86.09	100.00
Residual Moisture Content (% vol):	0.00	1.12	0.97
Ksat (cm/sec):	NM	2.9E-04	2.2E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Moisture Retention Data
Hanging Column / Pressure Plate
(Soil-Water Characteristic Curve)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3332.92
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	270.65
Sample Number:	VVL Composite 11-15 (85%, 1.50)	*Tare wt., screen & clamp* (g):	57.66
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2220.20
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.50
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	43.35

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	8-Sep-14	14:00	4609.50	0	42.71	
	15-Sep-14	9:30	4610.06	7.5	42.74	
	22-Sep-14	15:20	4586.50	24.0	41.68	
	29-Sep-14	16:00	4419.38	76.5	34.15	
Pressure plate:	9-Oct-14	7:40	4259.00	337	27.24	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	7.5	---	---	---	---
	24.0	---	---	---	---
	76.5	---	---	---	---
Pressure plate:	337	2194.13	-1.17%	1.52	42.68

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: VVL Composite 11-15 (85%, 1.50)

Initial sample bulk density (g/cm^3)*:* 1.50

Fraction of test sample used (<2.00mm fraction) (%): 56.44

Dry weight of dew point potentiometer sample* (g)*:* 178.32

Tare weight, jar (g)*:* 117.95

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Dew point potentiometer:	10-Sep-14	12:40	183.27	15093	7.03	‡‡
	10-Sep-14	8:41	182.10	52010	5.37	‡‡
	9-Sep-14	14:10	180.49	460950	3.08	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	15093	2194.13	-1.17%	1.52	42.68
	52010	2194.13	-1.17%	1.52	42.68
	460950	2194.13	-1.17%	1.52	42.68

Dry weight of relative humidity box sample* (g)*:* 73.44

Tare weight (g)*:* 41.63

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Relative humidity box:	9-Sep-14	11:00	74.55	851293	2.98	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	2194.13	-1.17%	1.52	42.68

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

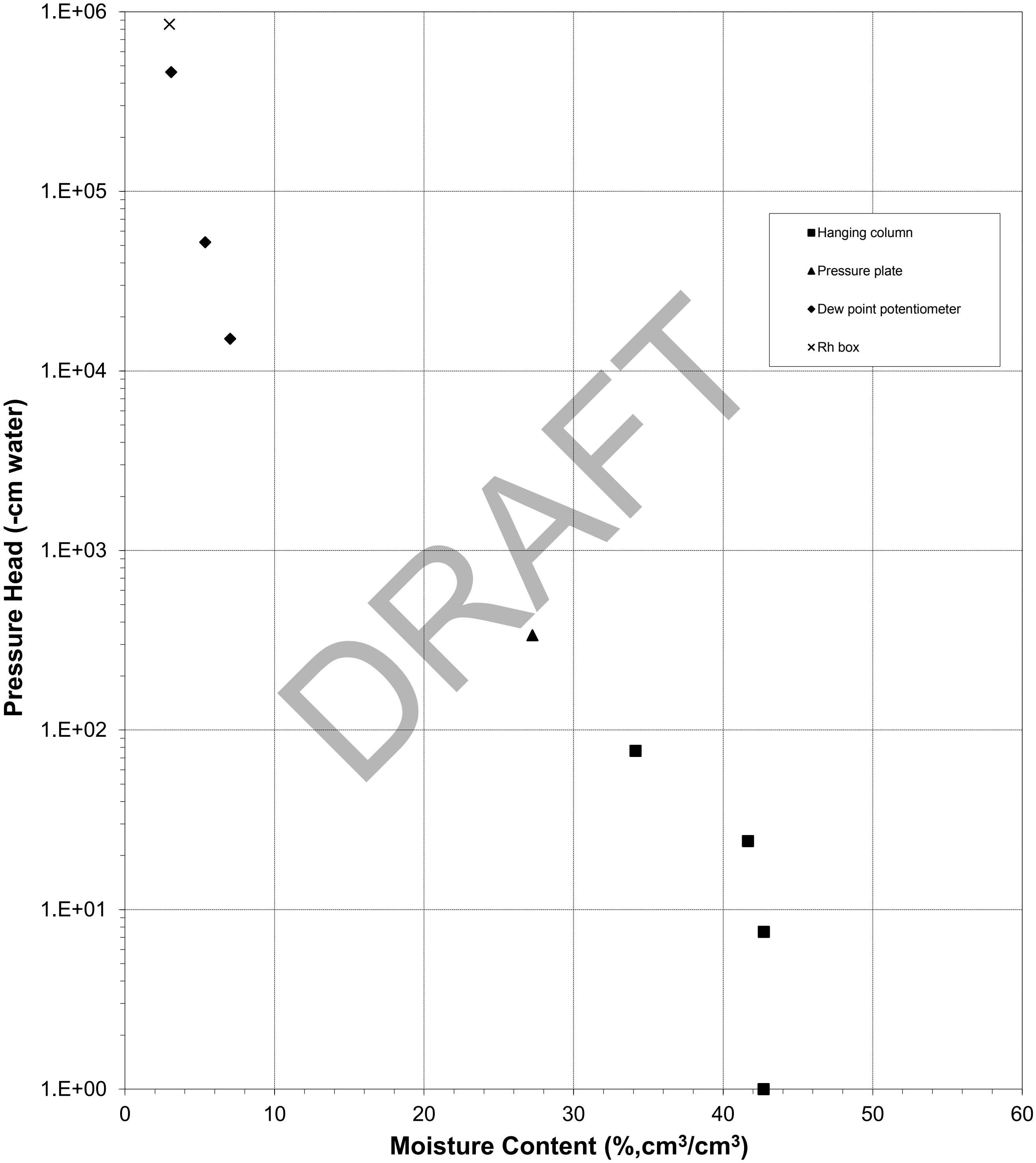
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

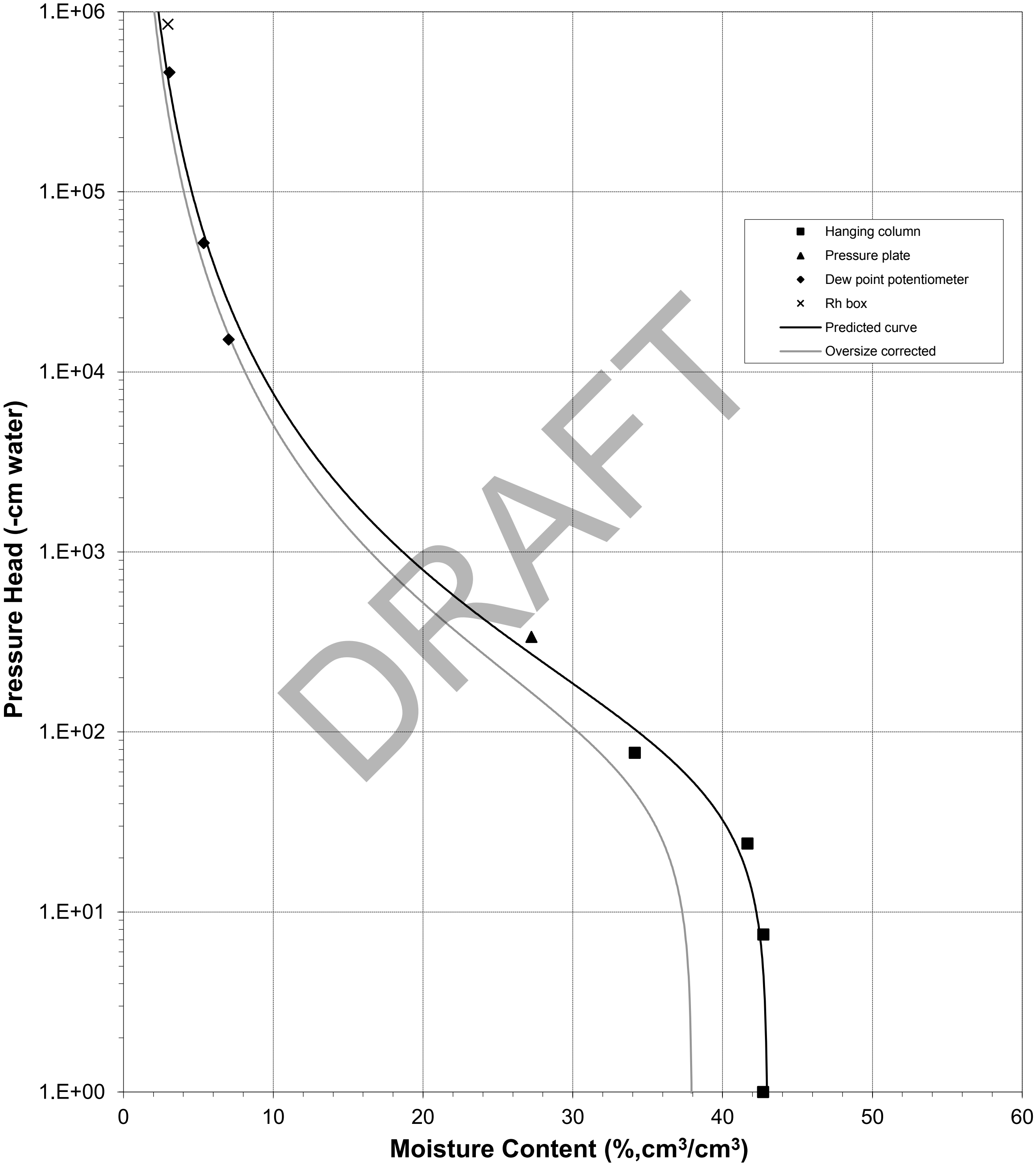
Water Retention Data Points

Sample Number: VVL Composite 11-15 (85%, 1.50)



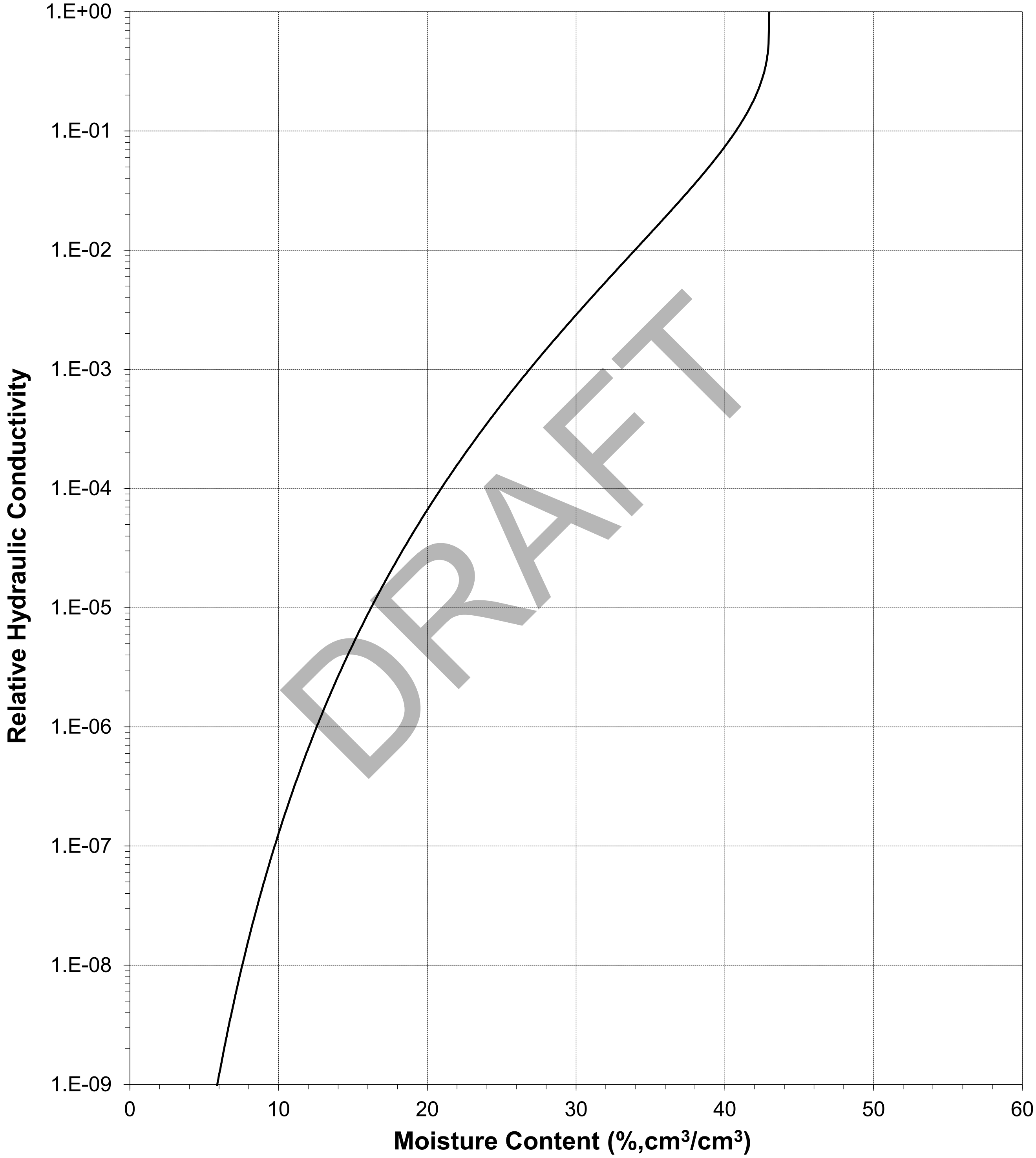
Predicted Water Retention Curve and Data Points

Sample Number: VVL Composite 11-15 (85%, 1.50)



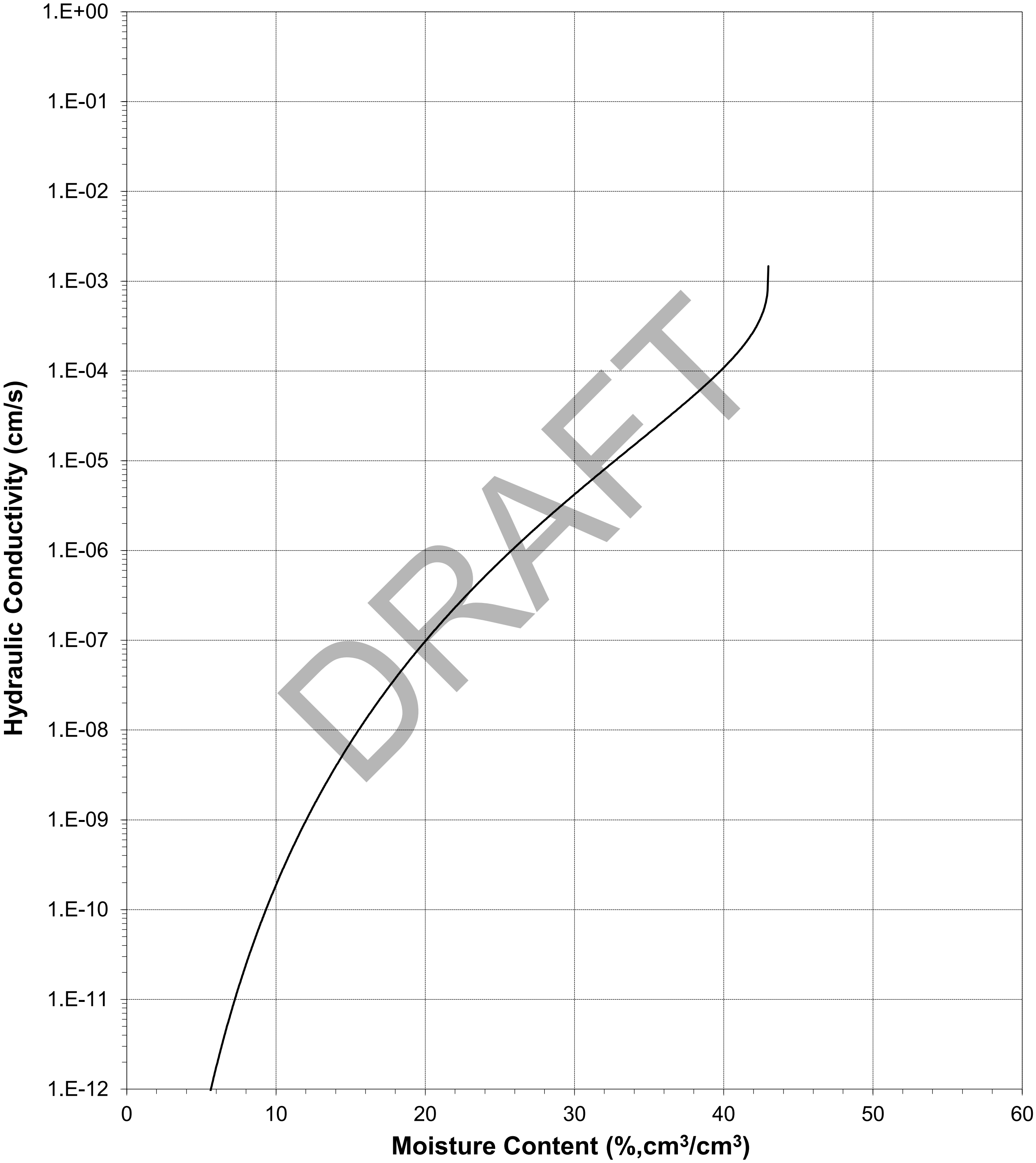
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite 11-15 (85%, 1.50)



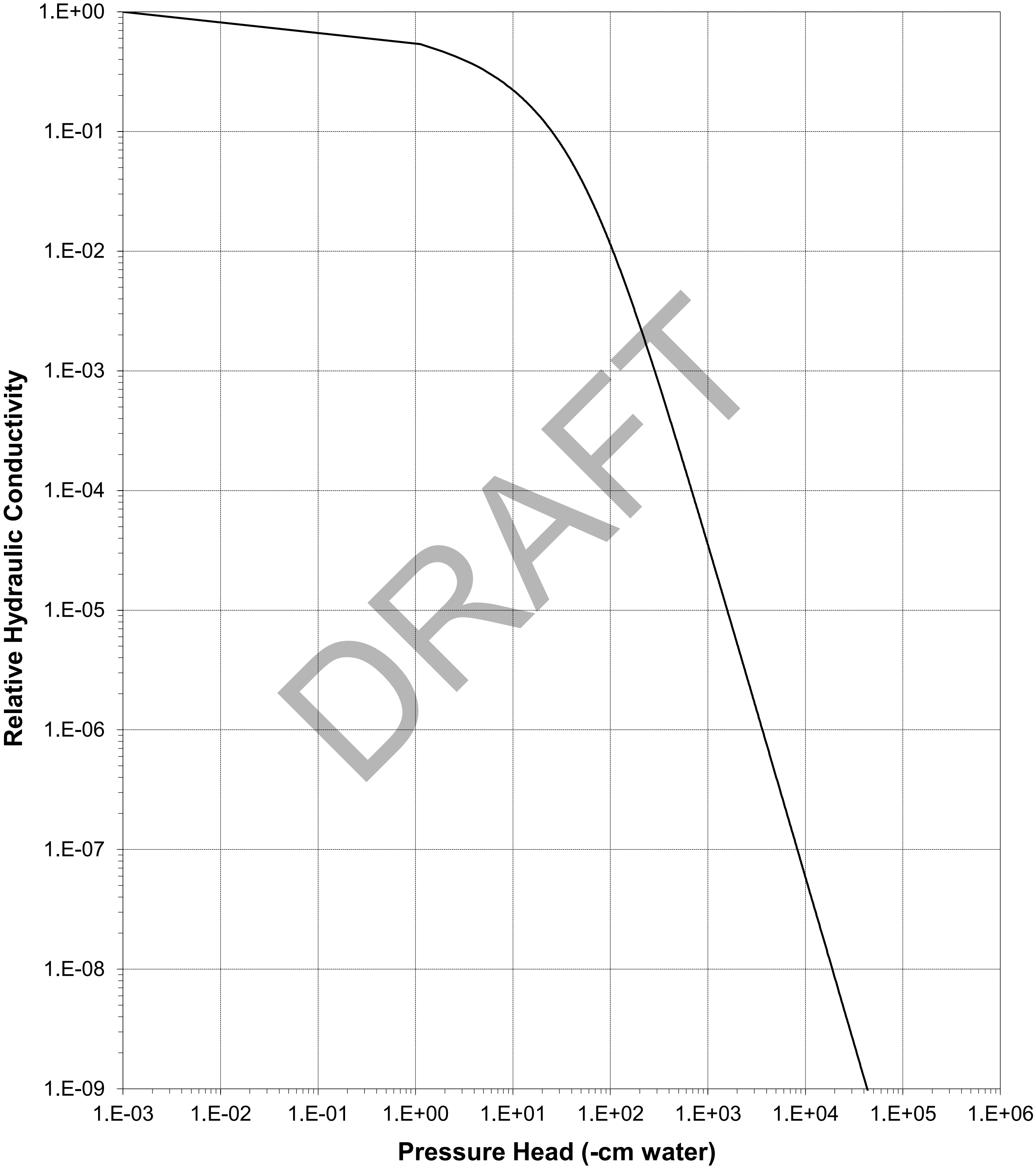
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite 11-15 (85%, 1.50)



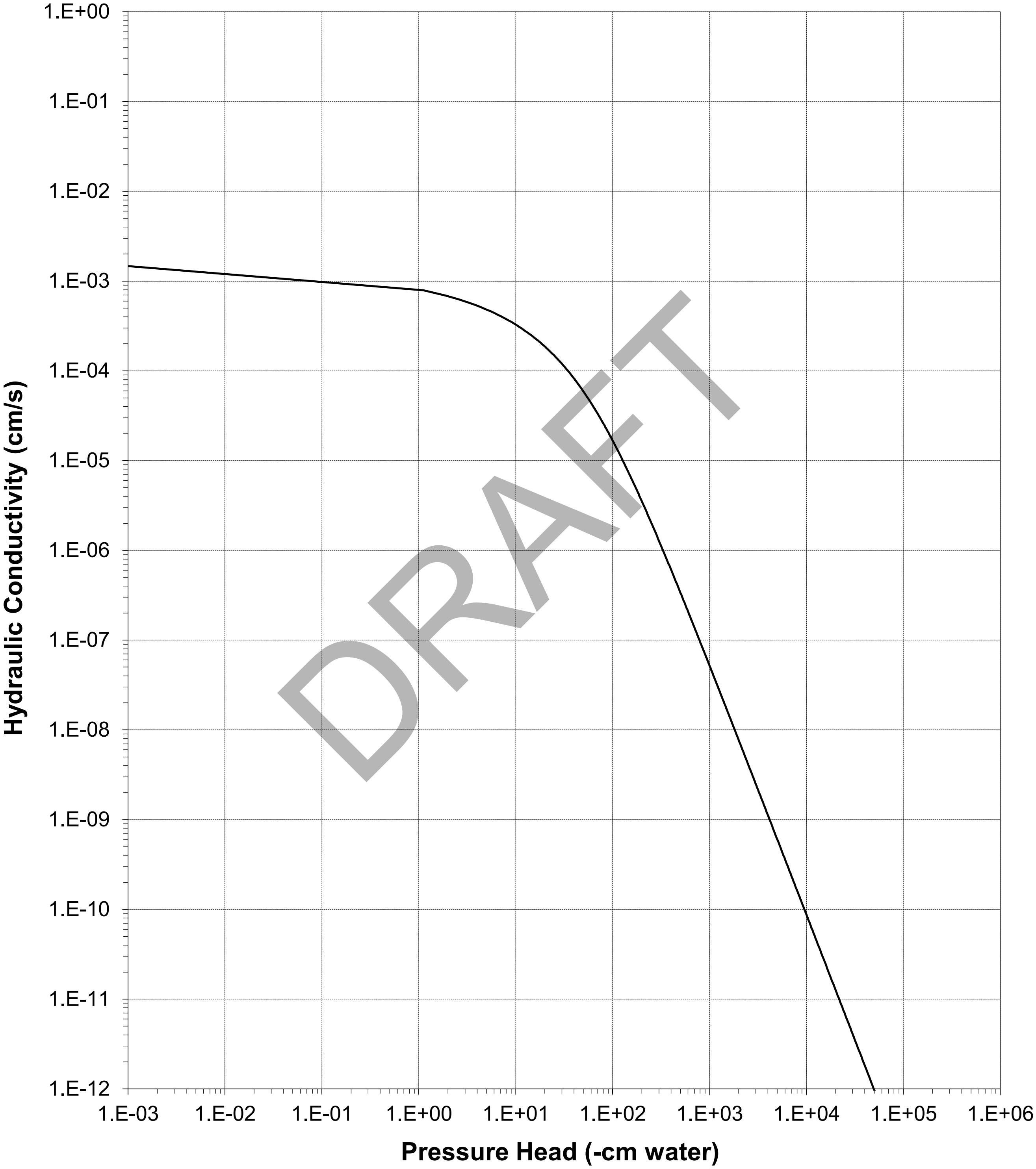
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 11-15 (85%, 1.50)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 11-15 (85%, 1.50)



Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 11-15 (85%, 1.50)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	18.97	81.03	100.00
Mass Fraction (%):	18.97	81.03	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.50	1.64
Calculated Porosity (% vol):	0.00	43.35	38.28
Volume of Solids (cm^3):	7.16	30.58	37.74
Volume of Voids (cm^3):	0.00	23.40	23.40
Total Volume (cm^3):	7.16	53.98	61.14
Volumetric Fraction (%):	11.71	88.29	100.00
Initial Moisture Content (% vol):	0.00	20.94	18.49
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.50	1.64
Calculated Porosity (% vol):	0.00	43.35	38.28
Volume of Solids (cm^3):	7.16	30.58	37.74
Volume of Voids (cm^3):	0.00	23.40	23.40
Total Volume (cm^3):	7.16	53.98	61.14
Volumetric Fraction (%):	11.71	88.29	100.00
Saturated Moisture Content (% vol):	0.00	42.99	37.96
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.52	1.65
Calculated Porosity (% vol):	0.00	42.68	37.63
Volume of Solids (cm^3):	7.16	30.58	37.74
Volume of Voids (cm^3):	0.00	22.77	22.77
Total Volume (cm^3):	7.16	53.34	60.50
Volumetric Fraction (%):	11.83	88.17	100.00
Residual Moisture Content (% vol):	0.00	0.27	0.23
Ksat (cm/sec):	NM	1.5E-03	1.2E-03

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Hanging Column / Pressure Plate
(Soil-Water Characteristic Curve)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3186.29
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	269.93
Sample Number:	VVL Composite 16-20 (85%, 1.45)	*Tare wt., screen & clamp* (g):	47.27
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2194.77
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.45
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	45.22

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	8-Sep-14	14:00	4539.10	0	47.19
	15-Sep-14	10:00	4534.19	12.5	46.96
	22-Sep-14	15:30	4472.40	34.5	44.15
	29-Sep-14	16:15	4356.73	107.5	38.88
Pressure plate:	8-Oct-14	13:00	4264.80	337	34.69

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	12.5	---	---	---	---
	34.5	---	---	---	---
	107.5	---	---	---	---
Pressure plate:	337	---	---	---	---

DRAFT

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: VVL Composite 16-20 (85%, 1.45)

Initial sample bulk density (g/cm^3)*:* 1.45
Fraction of test sample used (<2.00mm fraction) (%): 57.04

Dry weight of dew point potentiometer sample* (g)*:* 169.95
Tare weight, jar (g)*:* 118.36

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content [†] (% vol)
Dew point potentiometer:	10-Sep-14	13:20	176.88	18968	11.12
	10-Sep-14	10:50	175.41	60066	8.76
	9-Sep-14	15:30	173.75	285136	6.10

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	18968	---	---	---	---
	60066	---	---	---	---
	285136	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 75.66
Tare weight (g)*:* 40.73

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content [†] (% vol)
Relative humidity box:	9-Sep-14	11:00	77.46	851293	4.28

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

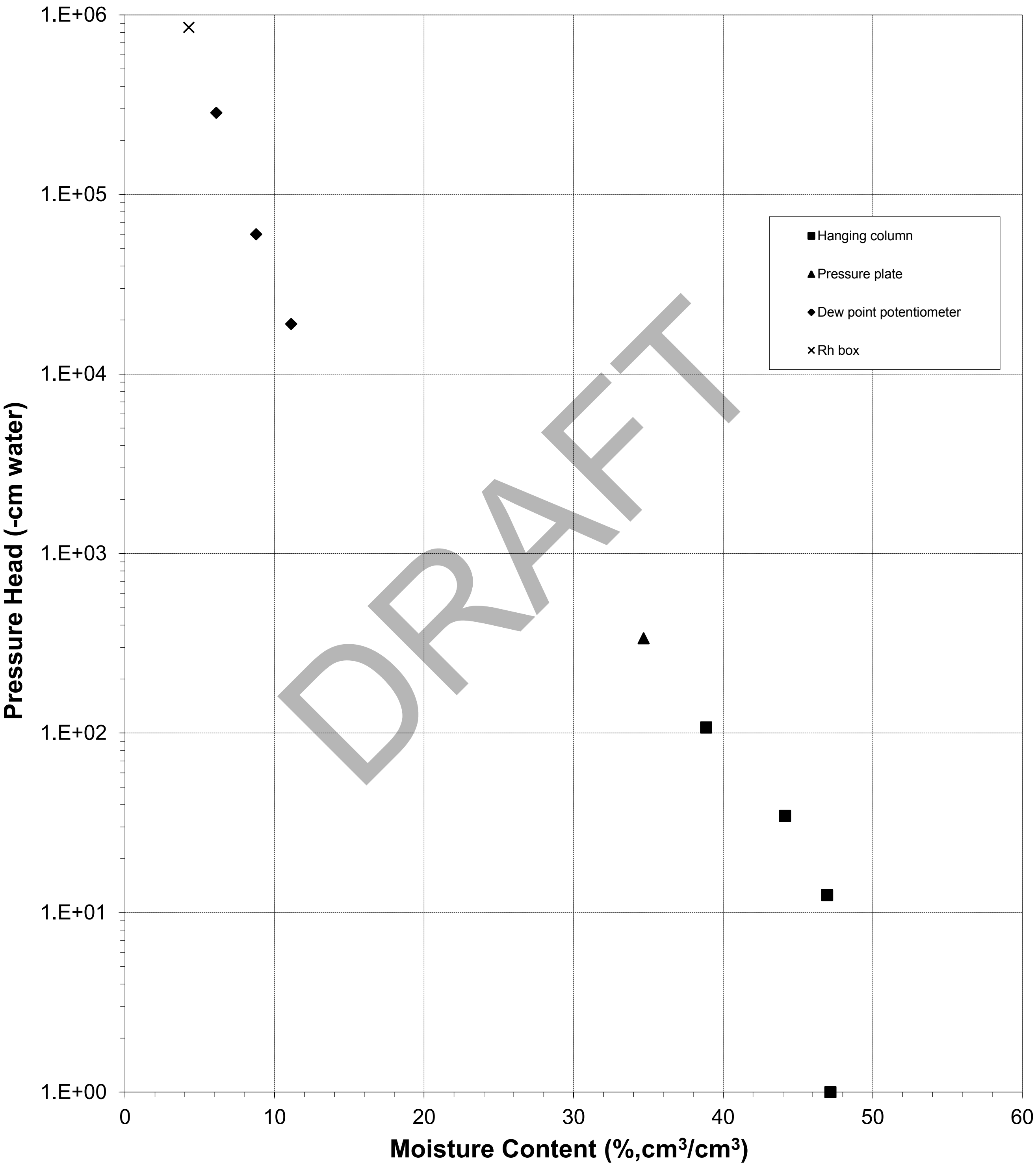
[†] Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

[‡‡] Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

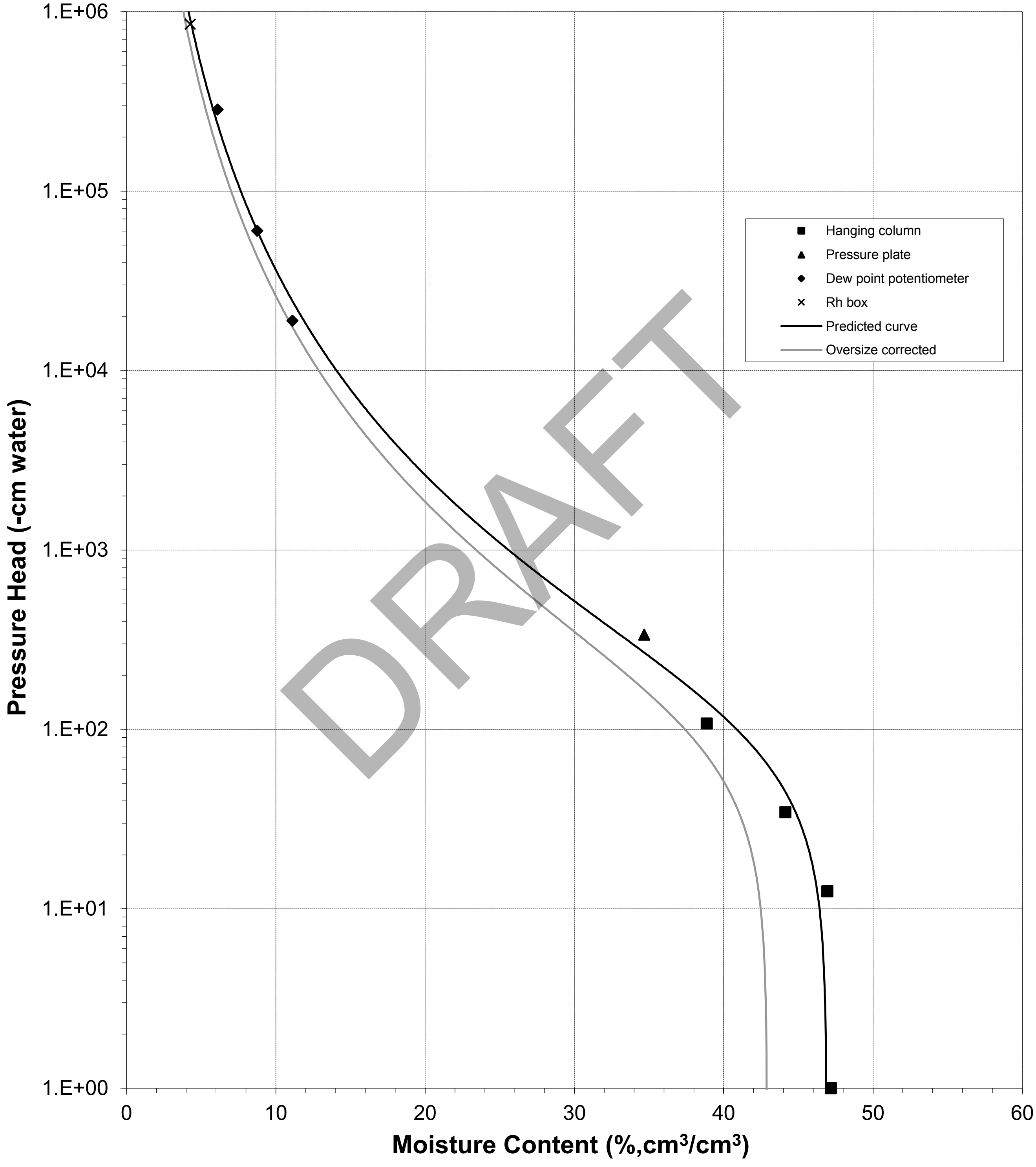
Water Retention Data Points

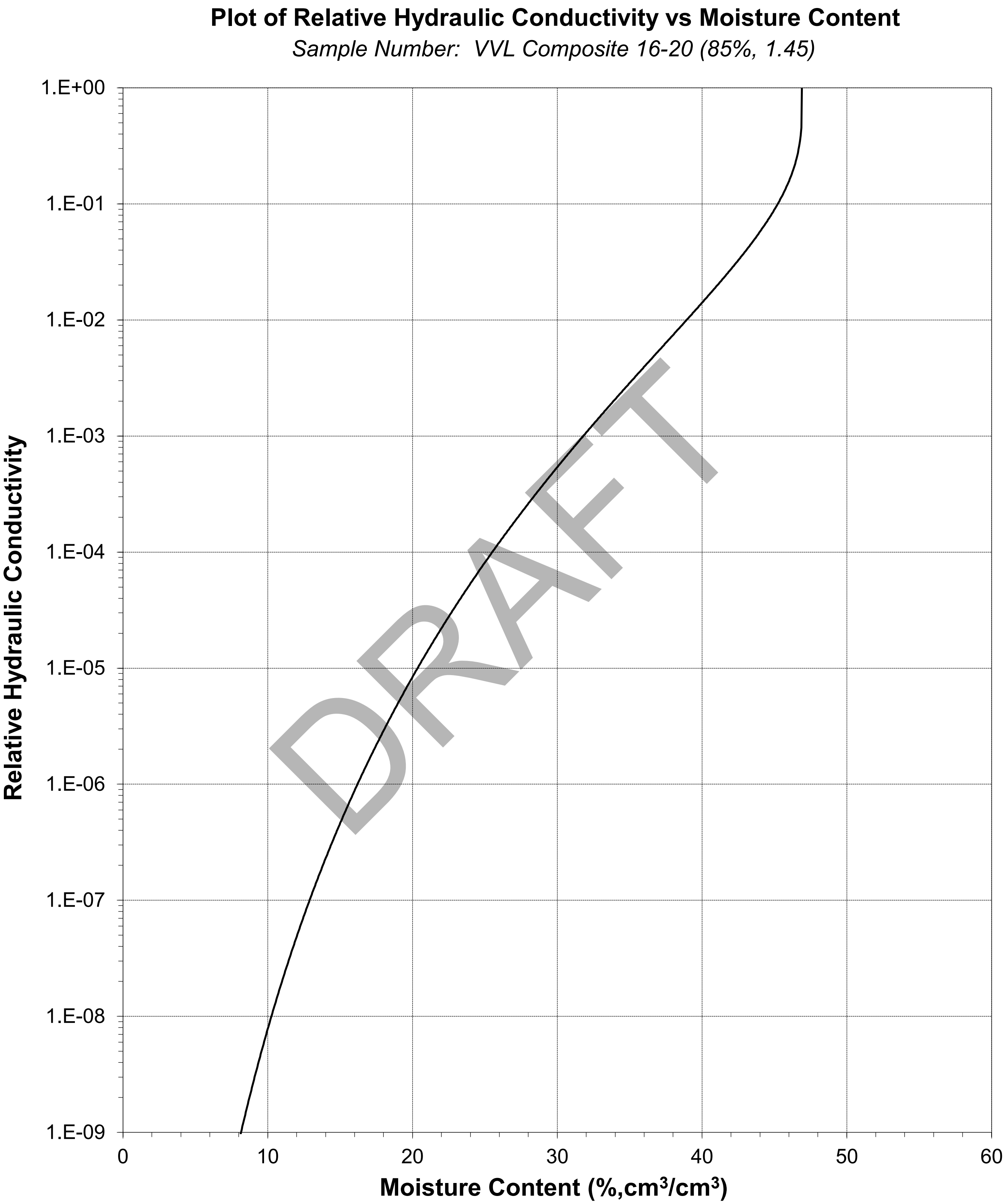
Sample Number: VVL Composite 16-20 (85%, 1.45)



Predicted Water Retention Curve and Data Points

Sample Number: VVL Composite 16-20 (85%, 1.45)

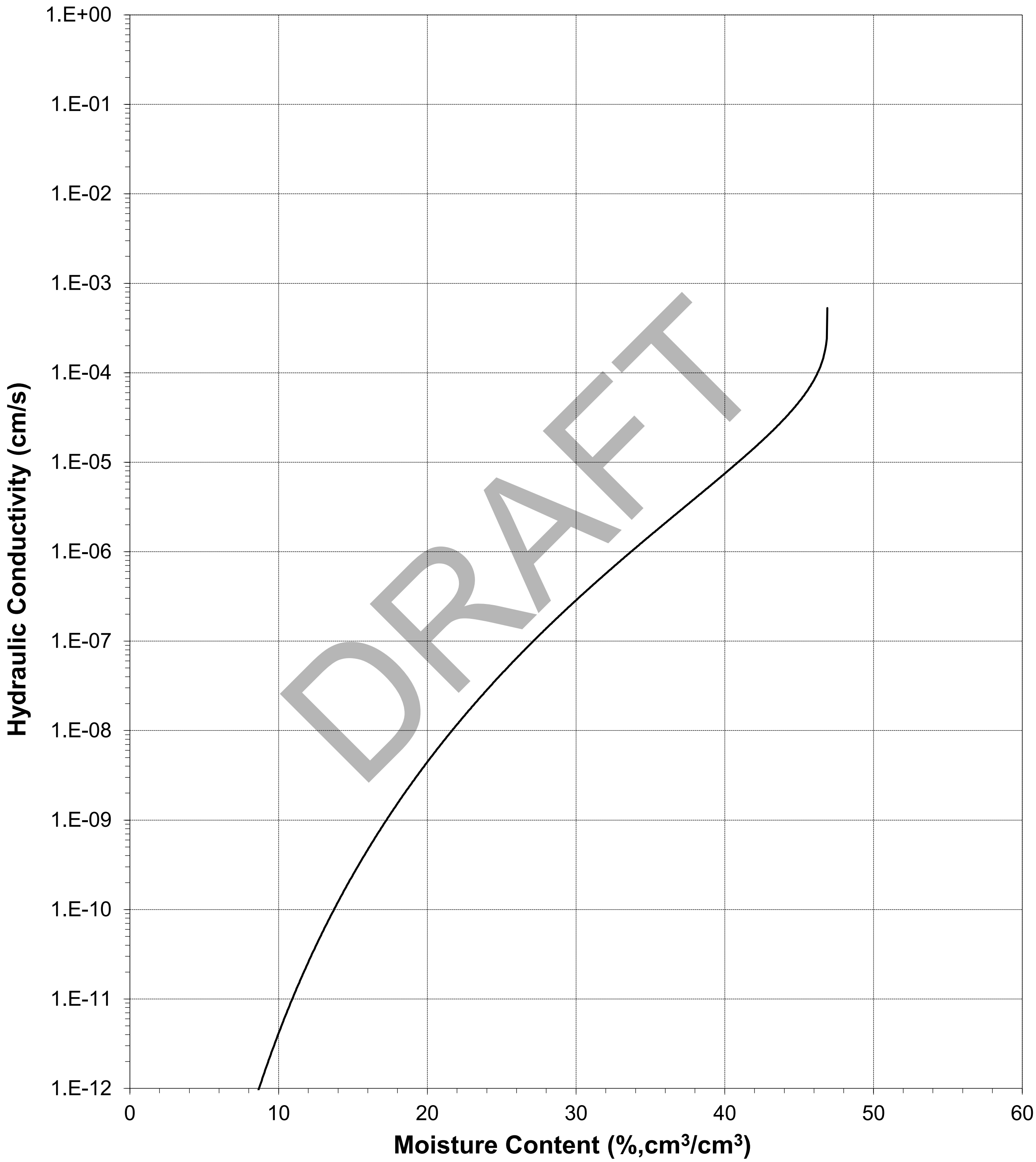




Plot of Relative Hydraulic Conductivity vs Moisture Content
Sample Number: VVL Composite 16-20 (85%, 1.45)
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
Relative Hydraulic Conductivity
0
10
20
30
40
50
60
Moisture Content (%,cm3/cm3)
DRAFT

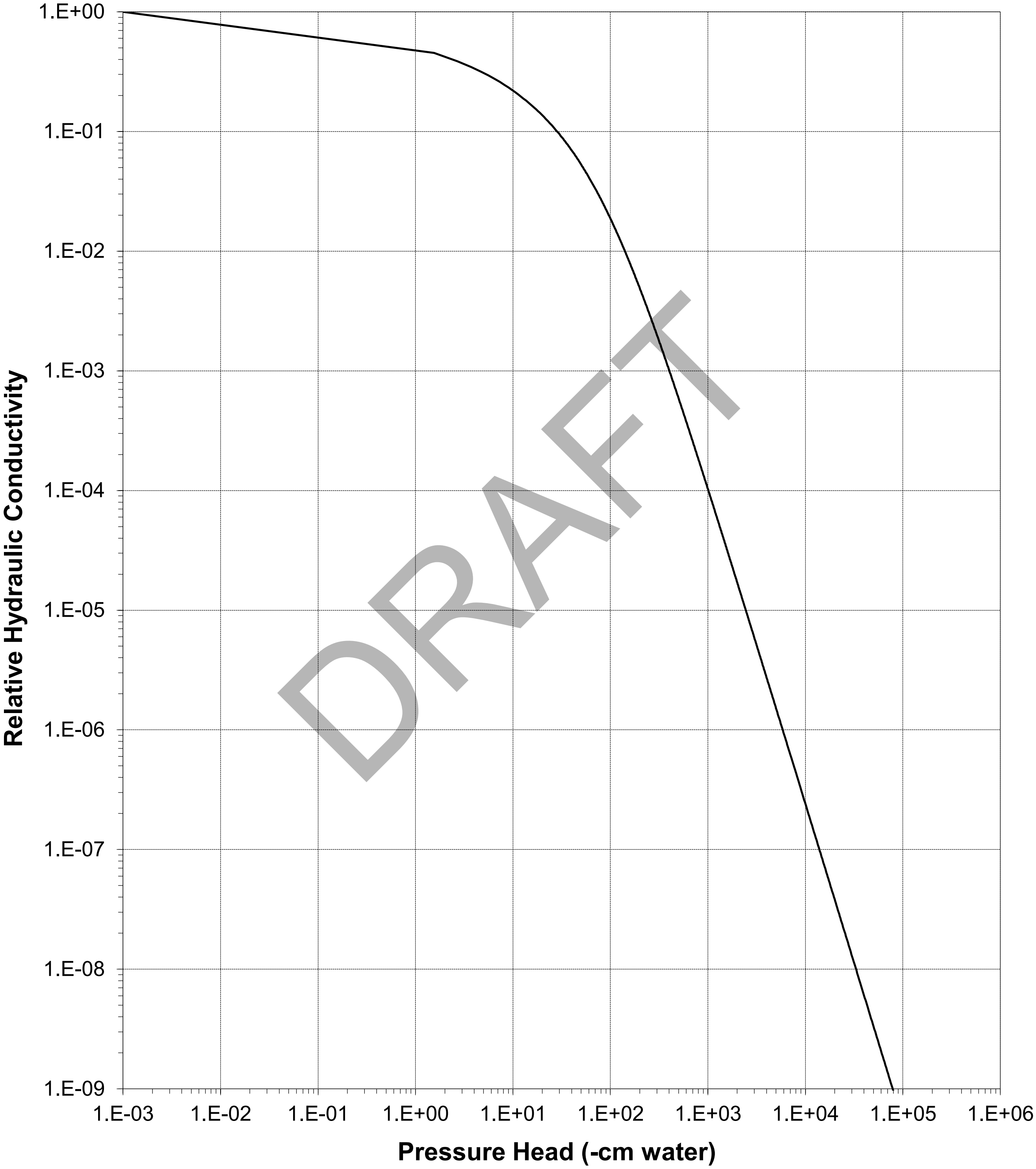
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite 16-20 (85%, 1.45)



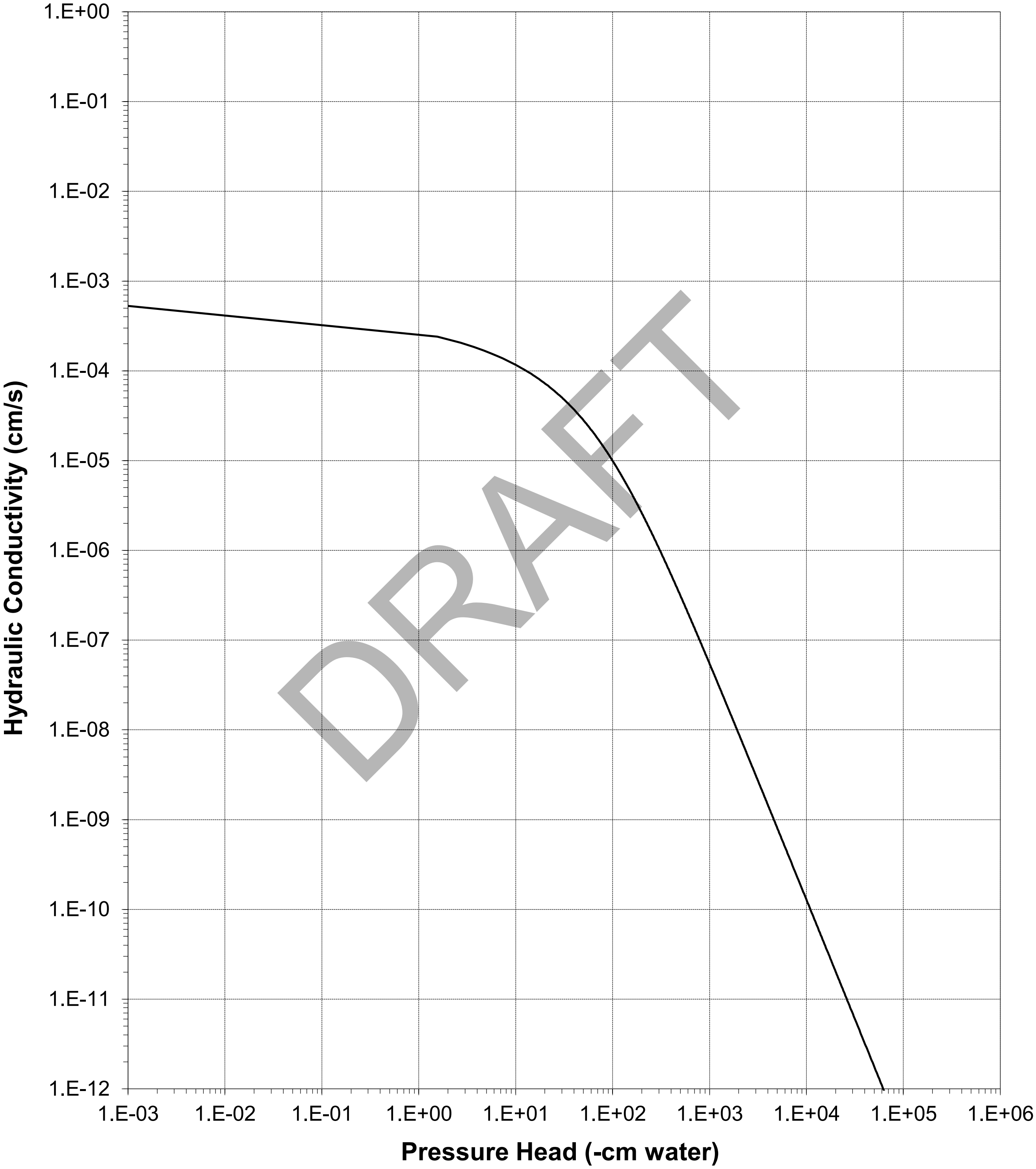
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 16-20 (85%, 1.45)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 16-20 (85%, 1.45)



Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 16-20 (85%, 1.45)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	14.48	85.52	100.00
Mass Fraction (%):	14.48	85.52	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.45	1.55
Calculated Porosity (% vol):	0.00	45.22	41.38
Volume of Solids (cm^3):	5.46	32.27	37.74
Volume of Voids (cm^3):	0.00	26.64	26.64
Total Volume (cm^3):	5.46	58.91	64.37
Volumetric Fraction (%):	8.49	91.51	100.00
Initial Moisture Content (% vol):	0.00	24.76	22.66
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.45	1.55
Calculated Porosity (% vol):	0.00	45.22	41.38
Volume of Solids (cm^3):	5.46	32.27	37.74
Volume of Voids (cm^3):	0.00	26.64	26.64
Total Volume (cm^3):	5.46	58.91	64.37
Volumetric Fraction (%):	8.49	91.51	100.00
Saturated Moisture Content (% vol):	0.00	46.90	42.92
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.45	1.55
Calculated Porosity (% vol):	0.00	45.22	41.38
Volume of Solids (cm^3):	5.46	32.27	37.74
Volume of Voids (cm^3):	0.00	26.64	26.64
Total Volume (cm^3):	5.46	58.91	64.37
Volumetric Fraction (%):	8.49	91.51	100.00
Residual Moisture Content (% vol):	0.00	0.00	0.00
Ksat (cm/sec):	NM	5.3E-04	4.5E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3048.84
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	271.14
Sample Number:	VVL Composite 21-30 (85%, 1.38)	*Tare wt., screen & clamp* (g):	60.30
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2201.91
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.38
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	47.75

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	8-Sep-14	14:00	4452.60	0	48.70
	15-Sep-14	9:30	4451.85	12.0	48.67
	22-Sep-14	15:15	4413.50	30.5	46.92
	29-Sep-14	13:45	4288.78	103.5	41.26
Pressure plate:	8-Oct-14	12:40	4172.90	337	36.00

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	12.0	---	---	---	---
	30.5	---	---	---	---
	103.5	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: VVL Composite 21-30 (85%, 1.38)

Initial sample bulk density (g/cm^3)*:* 1.38
Fraction of test sample used (<2.00mm fraction) (%): 56.28

Dry weight of dew point potentiometer sample* (g)*:* 161.19
Tare weight, jar (g)*:* 114.40

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	10-Sep-14	13:17	169.92	9076	14.54
	10-Sep-14	12:15	167.40	41506	10.34
	9-Sep-14	16:00	165.59	164596	7.33

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	9076	---	---	---	---
	41506	---	---	---	---
	164596	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 69.86
Tare weight (g)*:* 42.29

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	9-Sep-14	11:00	71.51	851293	4.66

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

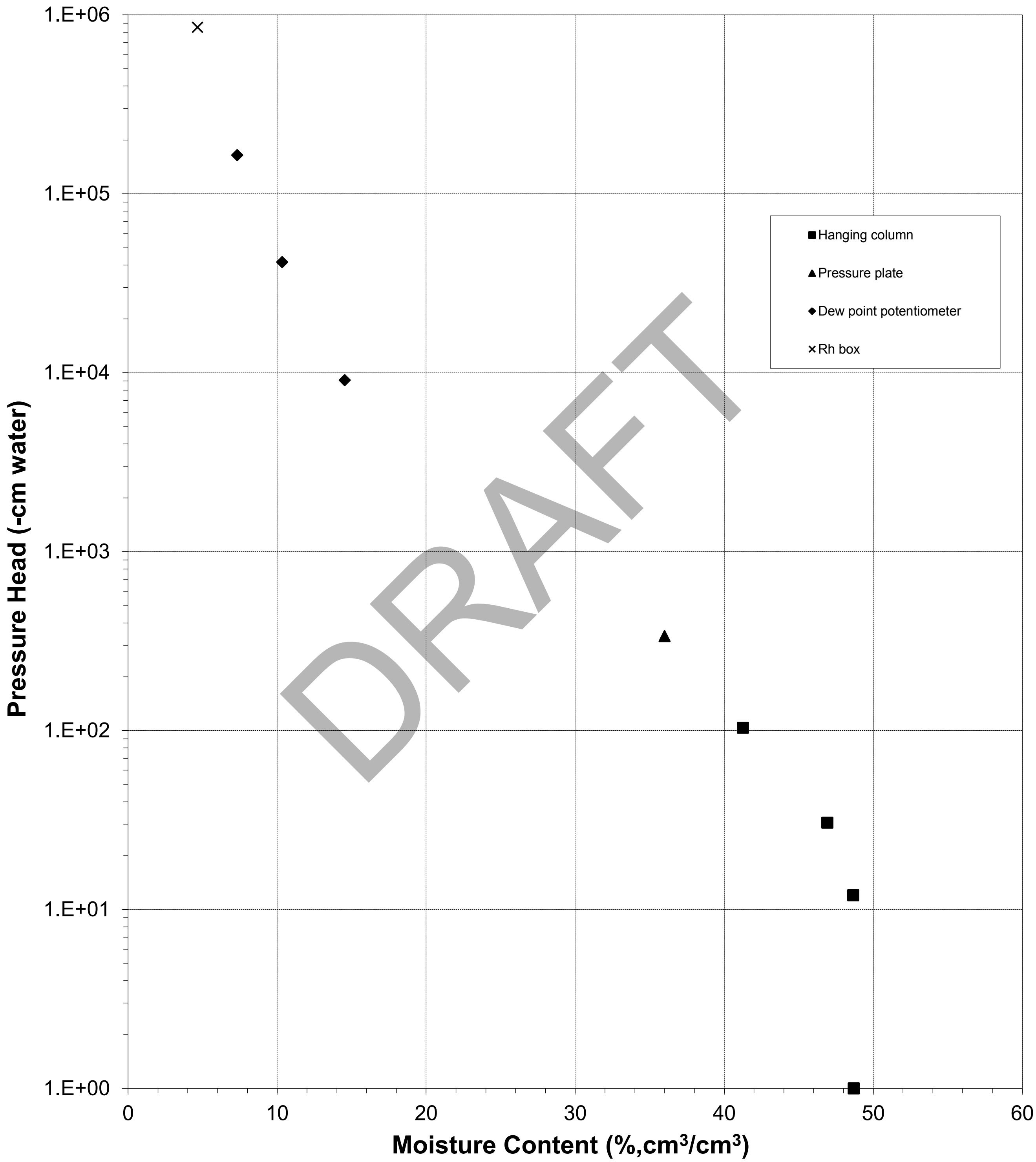
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

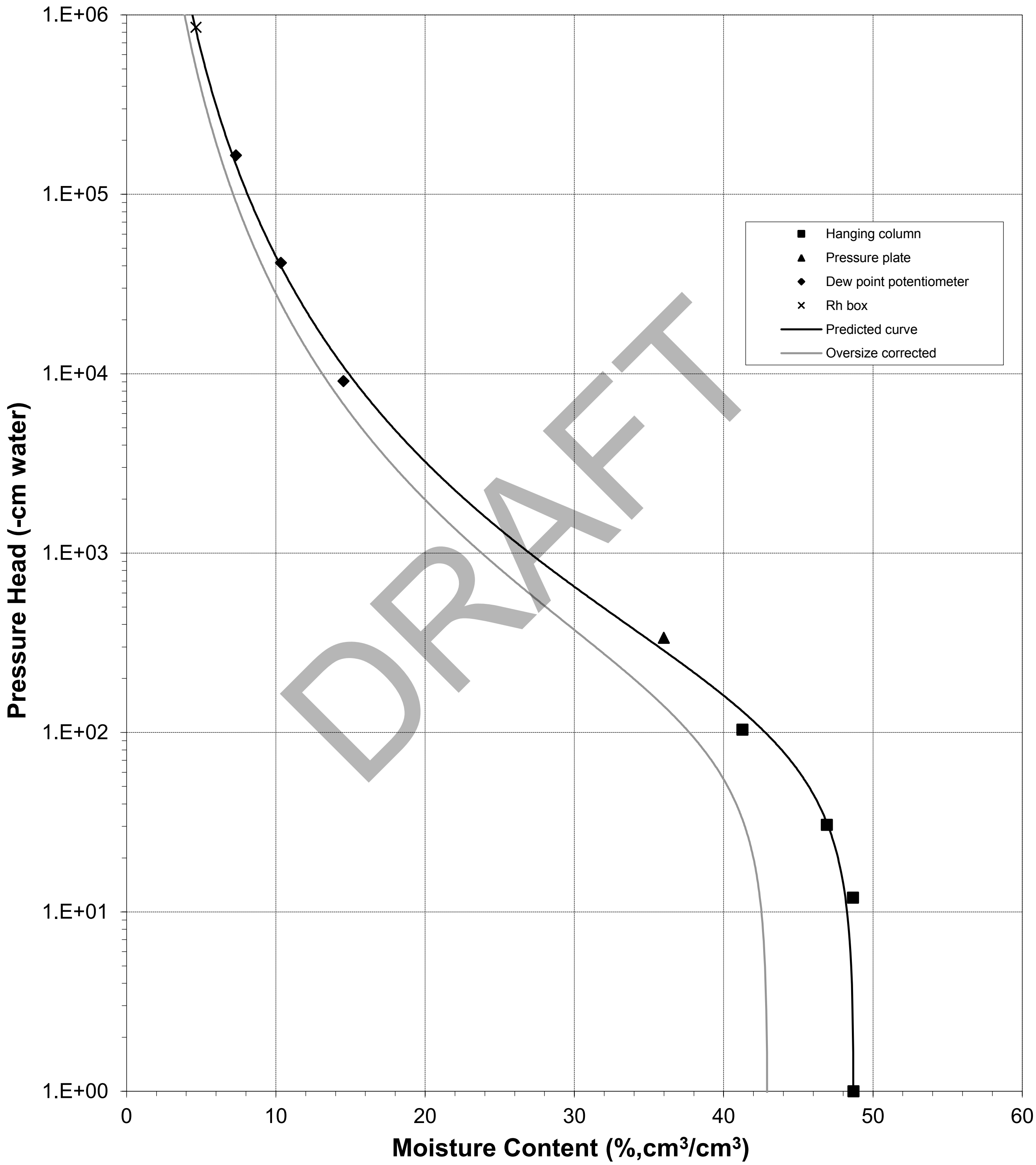
Water Retention Data Points

Sample Number: VVL Composite 21-30 (85%, 1.38)



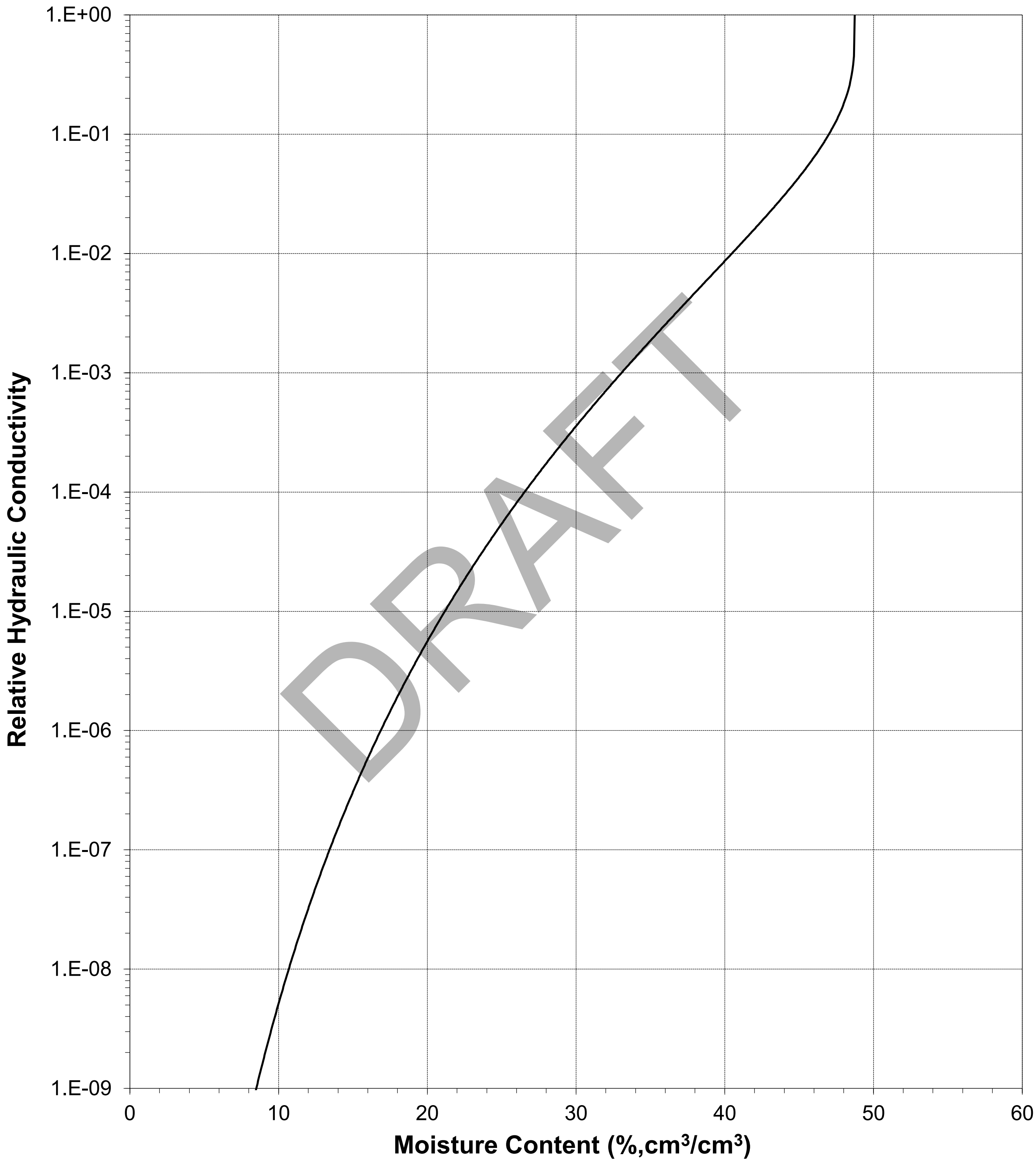
Predicted Water Retention Curve and Data Points

Sample Number: VVL Composite 21-30 (85%, 1.38)



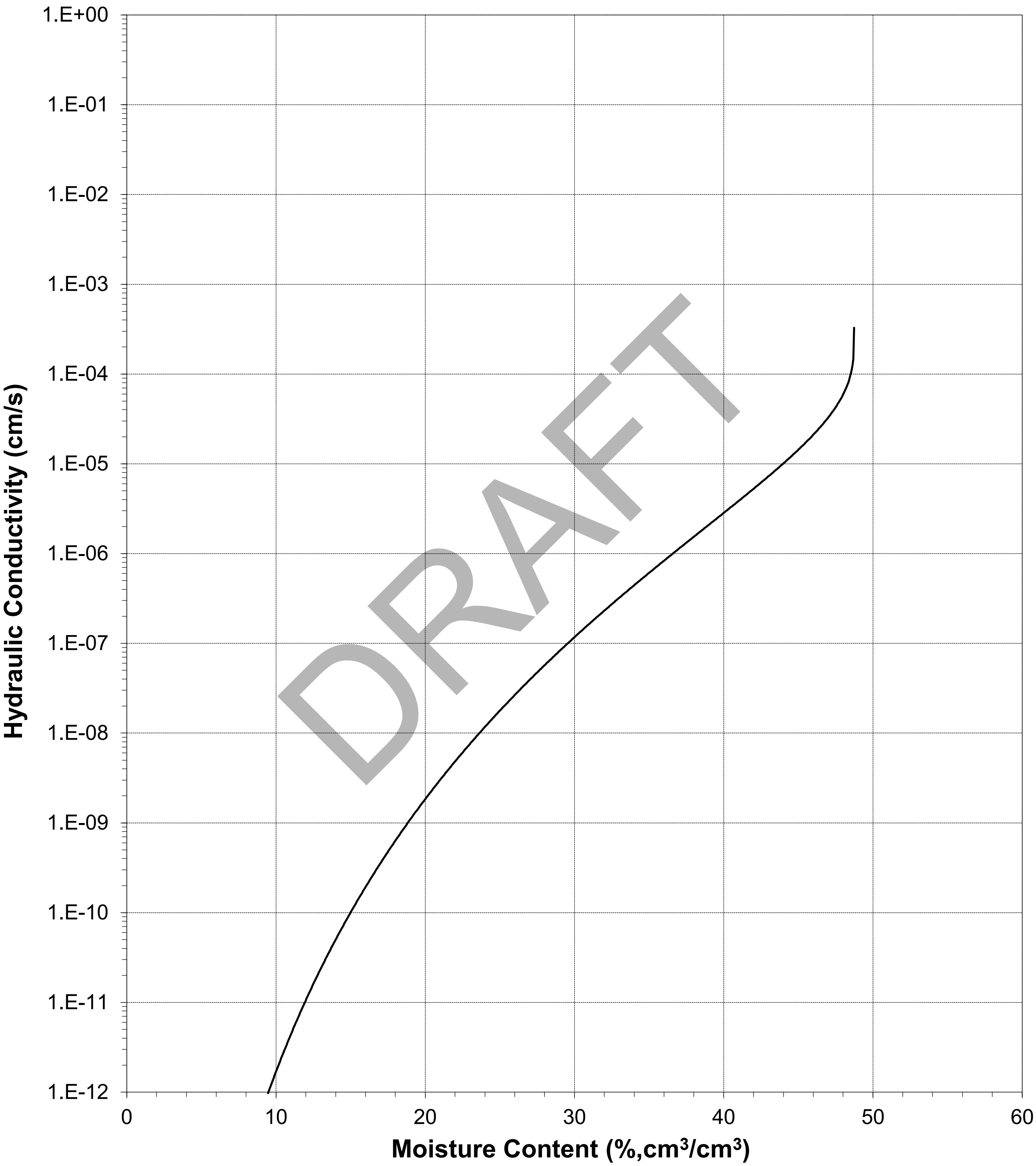
Plot of Relative Hydraulic Conductivity vs Moisture Content

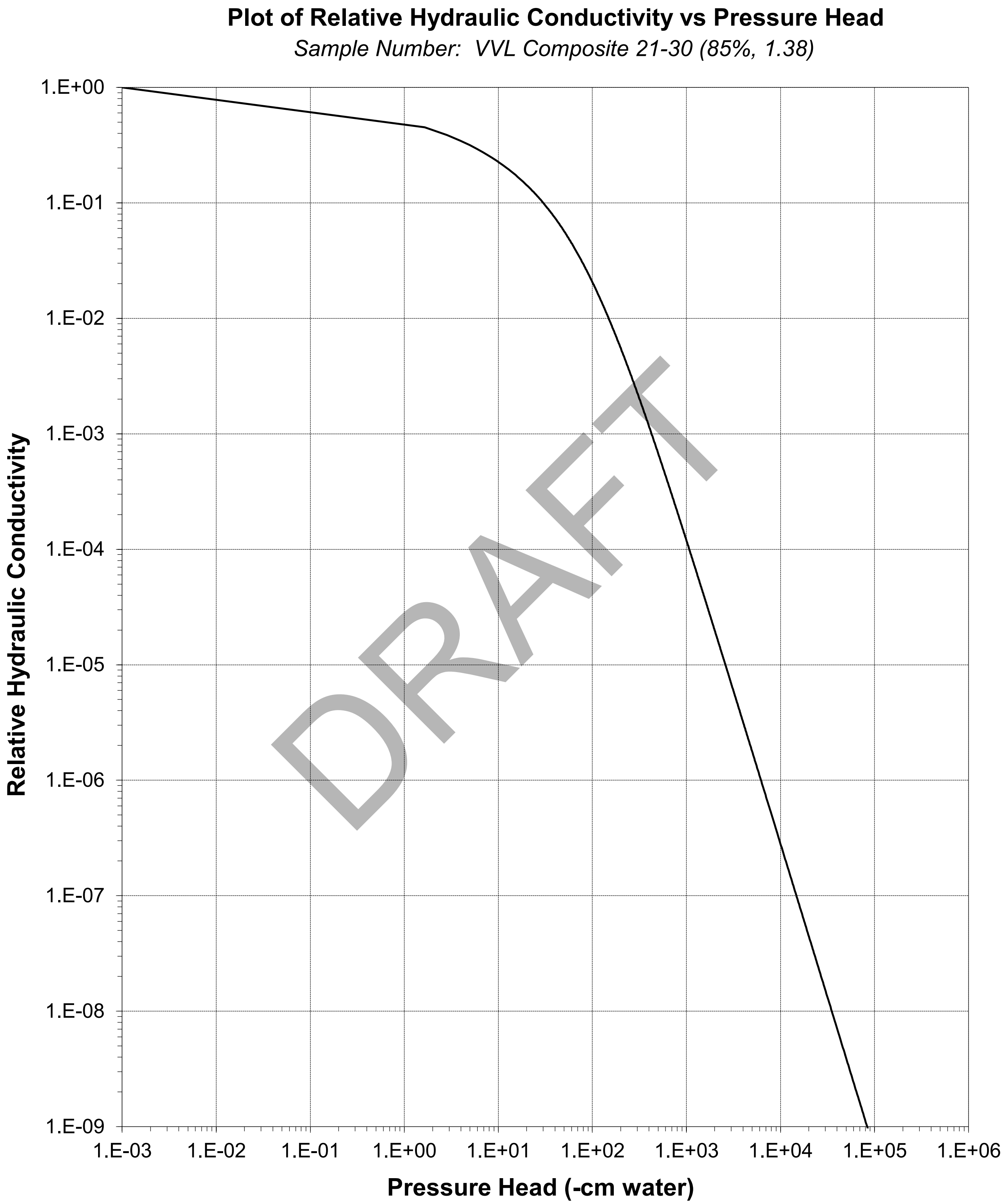
Sample Number: VVL Composite 21-30 (85%, 1.38)



Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite 21-30 (85%, 1.38)

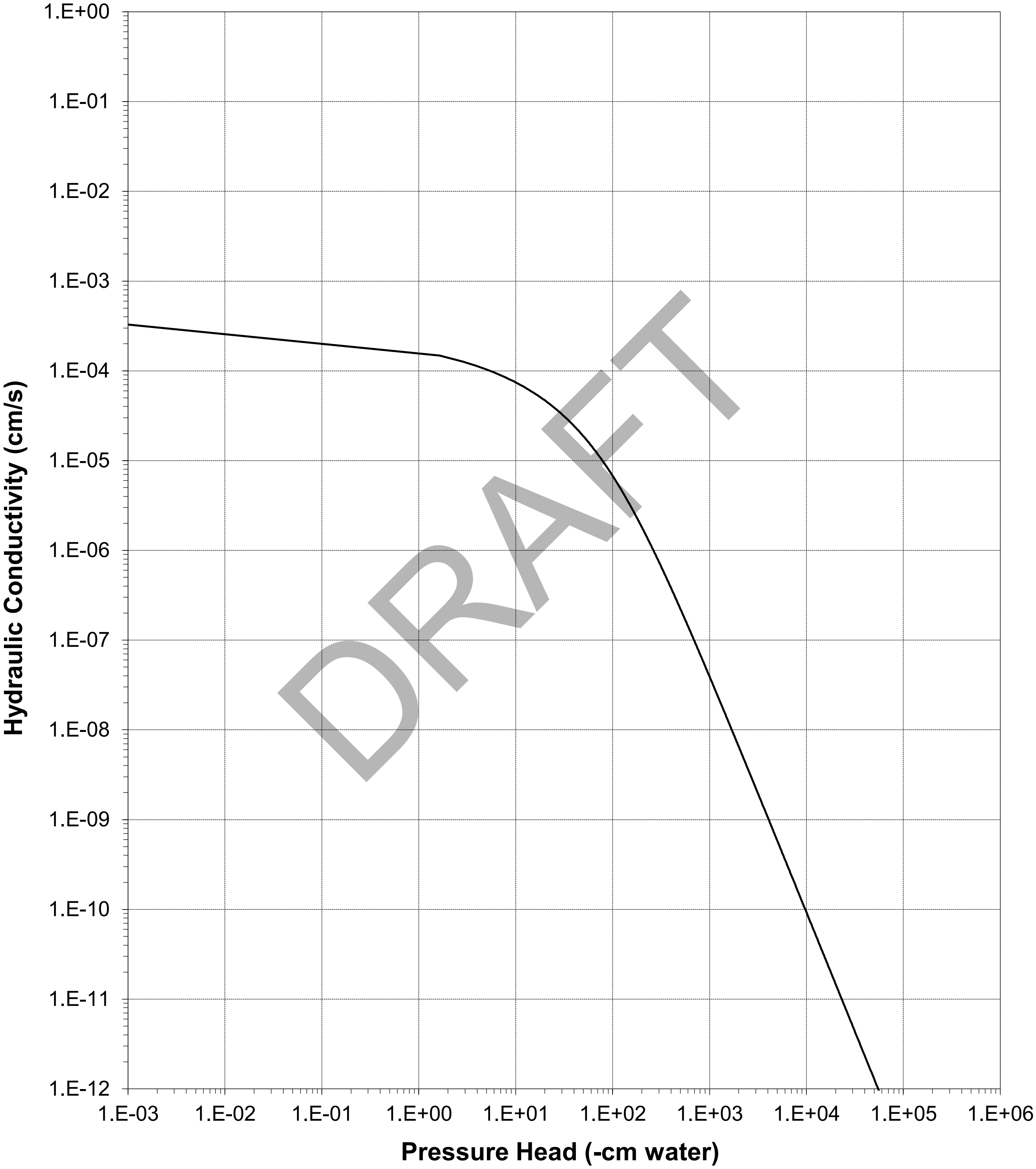




Plot of Relative Hydraulic Conductivity vs Pressure Head
Sample Number: VVL Composite 21-30 (85%, 1.38)
Relative Hydraulic Conductivity
Pressure Head (-cm water)
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
DRAFT

Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 21-30 (85%, 1.38)



Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 21-30 (85%, 1.38)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	20.52	79.48	100.00
Mass Fraction (%):	20.52	79.48	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.38	1.54
Calculated Porosity (% vol):	0.00	47.75	42.07
Volume of Solids (cm^3):	7.74	29.99	37.74
Volume of Voids (cm^3):	0.00	27.41	27.41
Total Volume (cm^3):	7.74	57.40	65.14
Volumetric Fraction (%):	11.89	88.11	100.00
Initial Moisture Content (% vol):	0.00	25.09	22.11
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.38	1.54
Calculated Porosity (% vol):	0.00	47.75	42.07
Volume of Solids (cm^3):	7.74	29.99	37.74
Volume of Voids (cm^3):	0.00	27.41	27.41
Total Volume (cm^3):	7.74	57.40	65.14
Volumetric Fraction (%):	11.89	88.11	100.00
Saturated Moisture Content (% vol):	0.00	48.73	42.94
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.38	1.54
Calculated Porosity (% vol):	0.00	47.75	42.07
Volume of Solids (cm^3):	7.74	29.99	37.74
Volume of Voids (cm^3):	0.00	27.41	27.41
Total Volume (cm^3):	7.74	57.40	65.14
Volumetric Fraction (%):	11.89	88.11	100.00
Residual Moisture Content (% vol):	0.00	0.00	0.00
Ksat (cm/sec):	NM	3.3E-04	2.6E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+ (85%, 1.22)
Project Name: VVL Composite Samples
PO Number: 12015

Dry wt. of sample (g): 2700.23
Tare wt., ring (g): 272.82
Tare wt., screen & clamp (g): 67.12
Initial sample volume (cm^3): 2217.25
Initial dry bulk density (g/cm^3): 1.22
Assumed particle density (g/cm^3): 2.65
Initial calculated total porosity (%): 54.04

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	3-Sep-14	10:55	4309.20	0	57.23
	10-Sep-14	13:35	4308.96	12.0	57.22
	17-Sep-14	10:45	4295.60	32.0	56.62
	24-Sep-14	15:30	4188.20	93.0	51.78
Pressure plate:	4-Oct-14	10:45	4072.50	337	46.56

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	12.0	---	---	---	---
	32.0	---	---	---	---
	93.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: VVL Composite 31+ (85%, 1.22)

Initial sample bulk density (g/cm^3)*:* 1.22
Fraction of test sample used (<2.00mm fraction) (%): 78.45

Dry weight of dew point potentiometer sample* (g)*:* 147.15
Tare weight, jar (g)*:* 116.43

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	10-Sep-14	13:00	153.68	19070	20.31
	10-Sep-14	9:00	152.54	52112	16.76
	9-Sep-14	14:30	150.60	449630	10.73

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	19070	---	---	---	---
	52112	---	---	---	---
	449630	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 59.09
Tare weight (g)*:* 40.70

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	9-Sep-14	11:00	60.78	851293	8.81

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

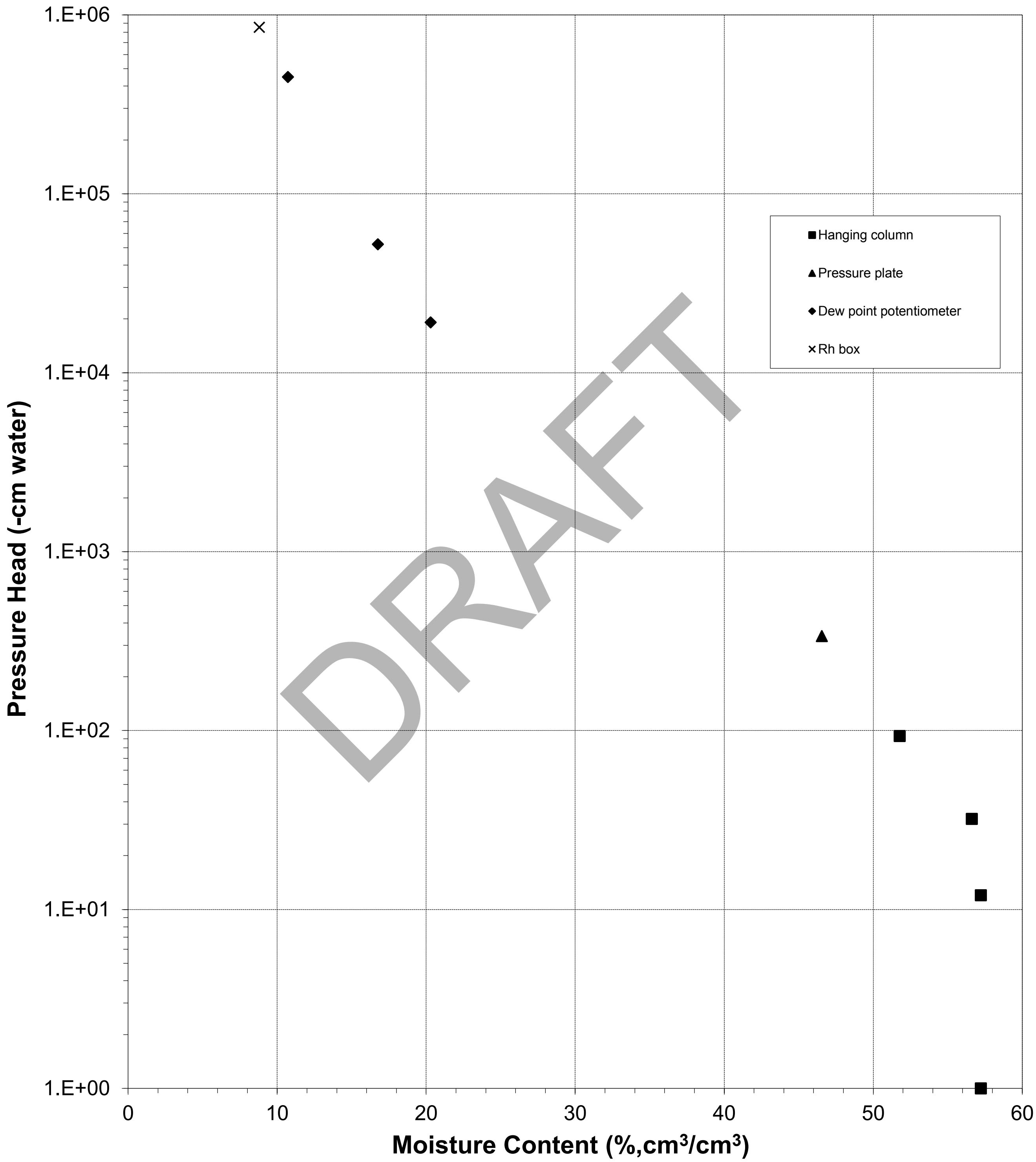
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

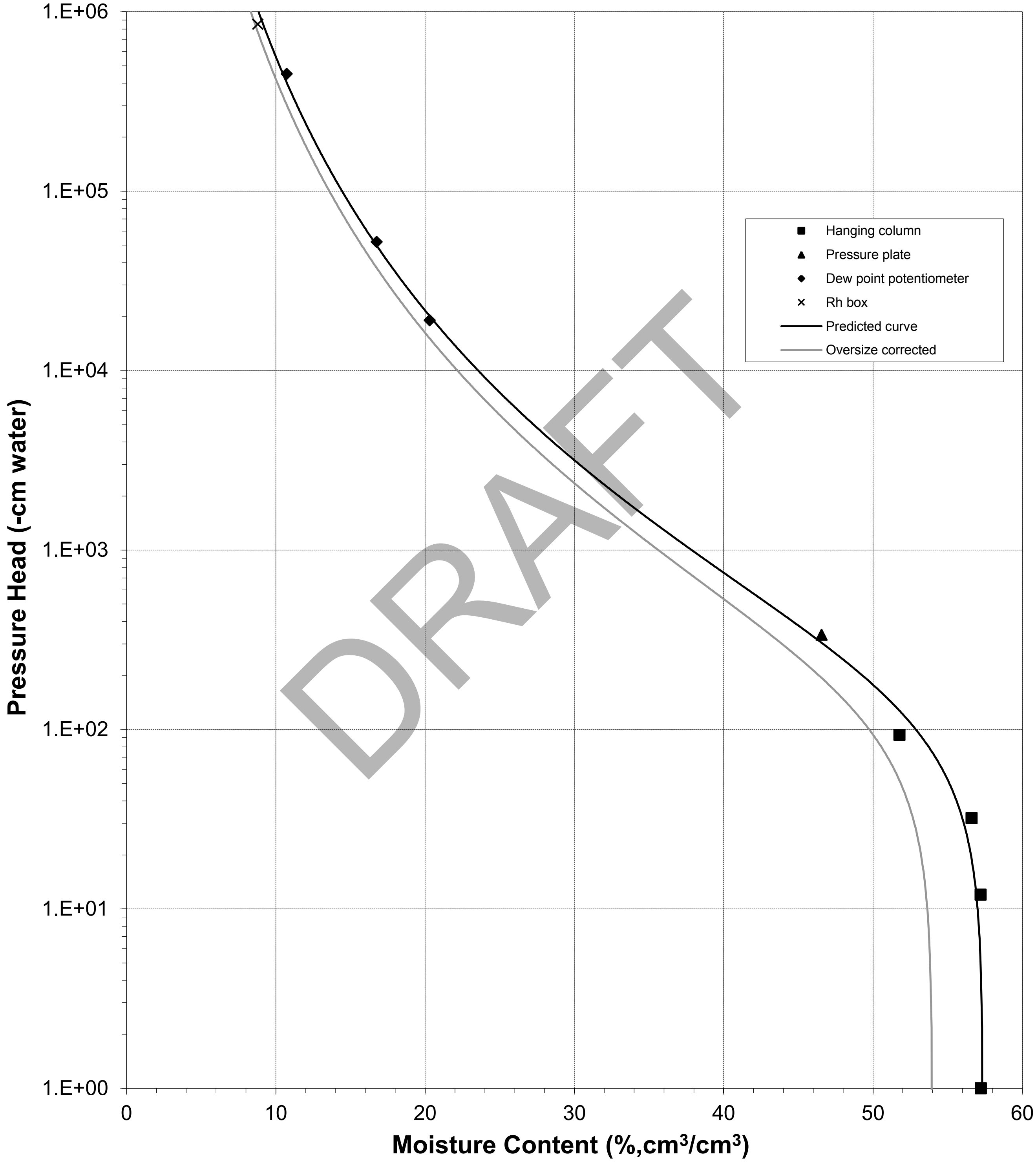
Water Retention Data Points

Sample Number: VVL Composite 31+ (85%, 1.22)



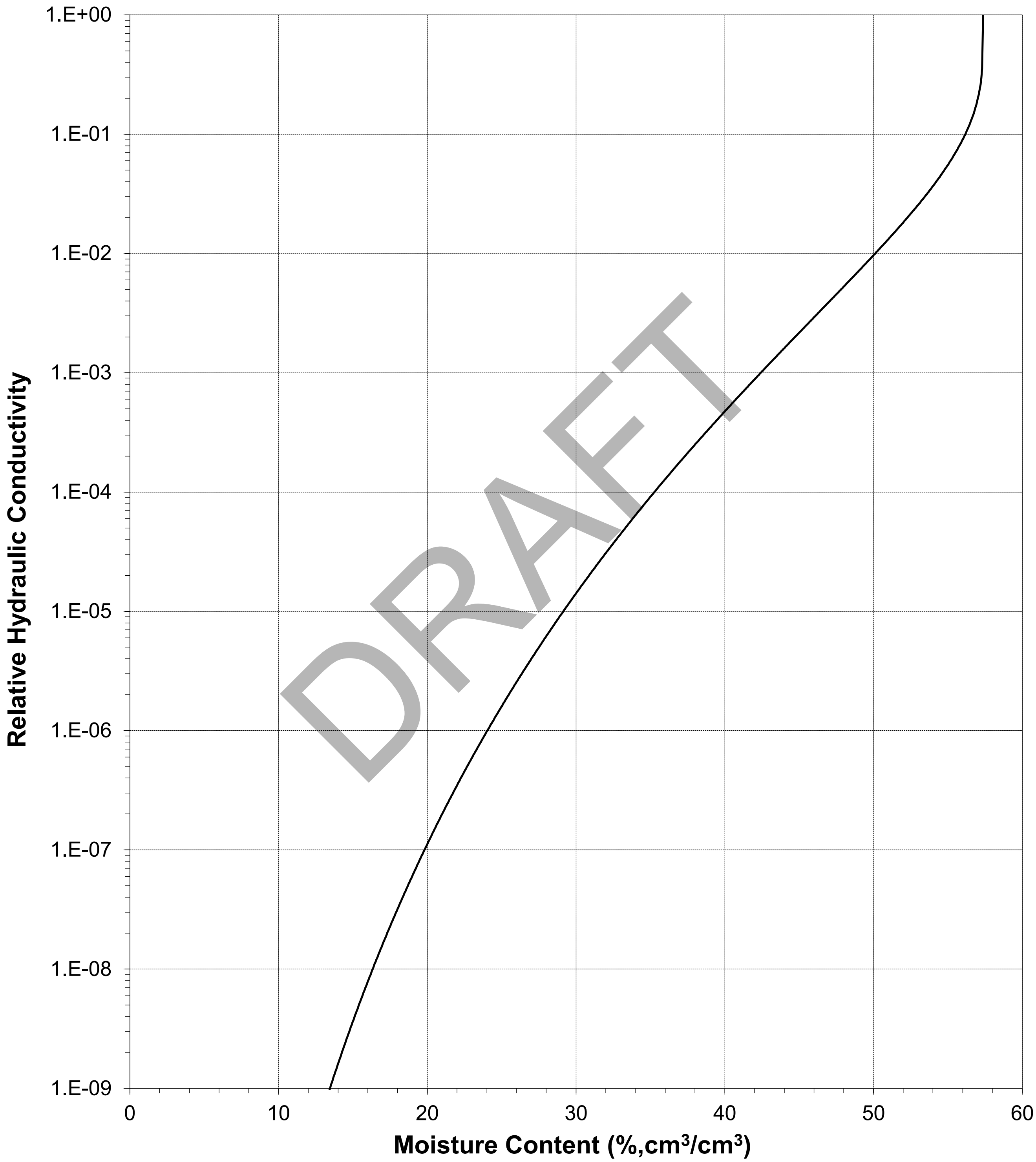
Predicted Water Retention Curve and Data Points

Sample Number: VVL Composite 31+ (85%, 1.22)



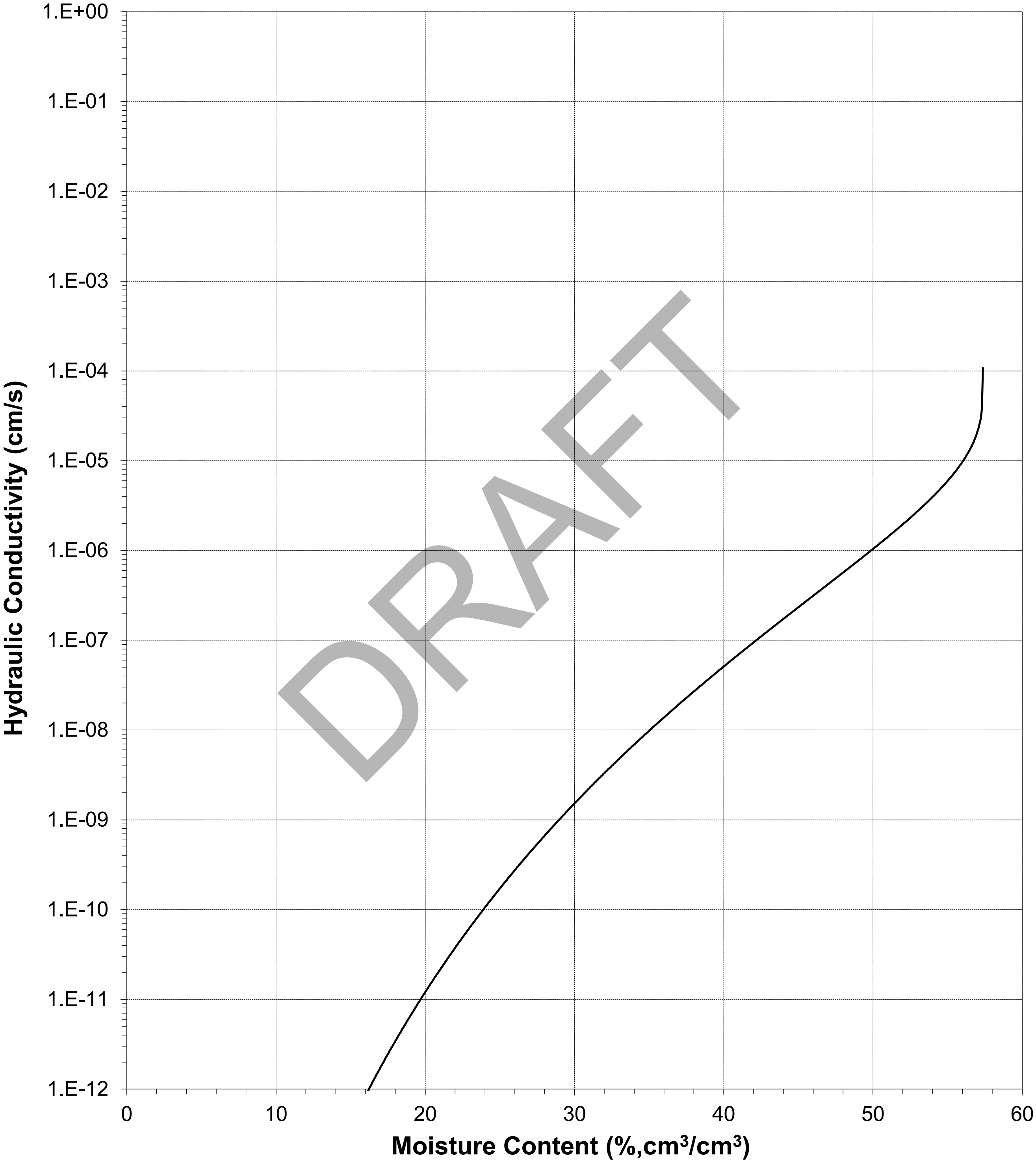
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite 31+ (85%, 1.22)



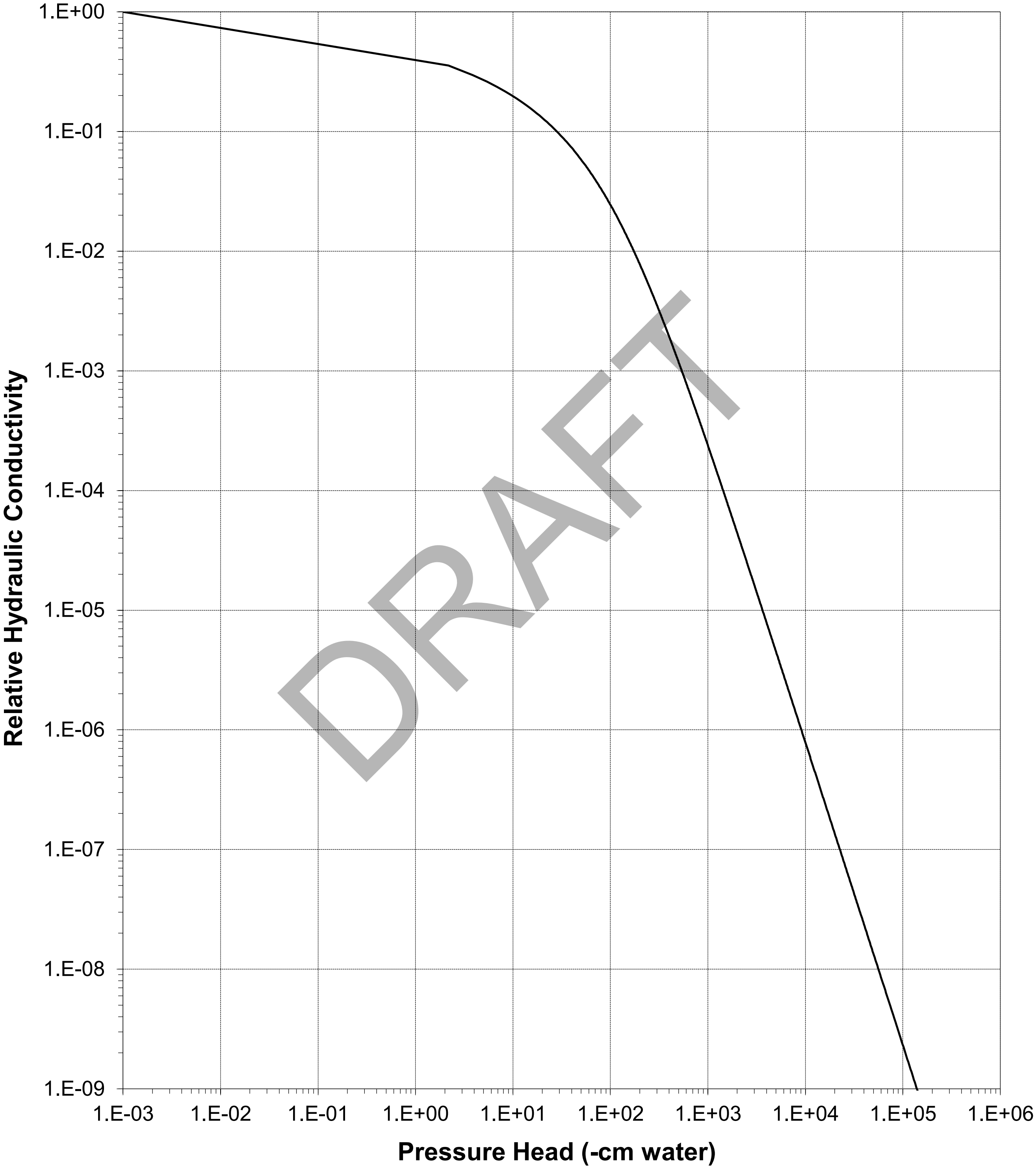
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite 31+ (85%, 1.22)



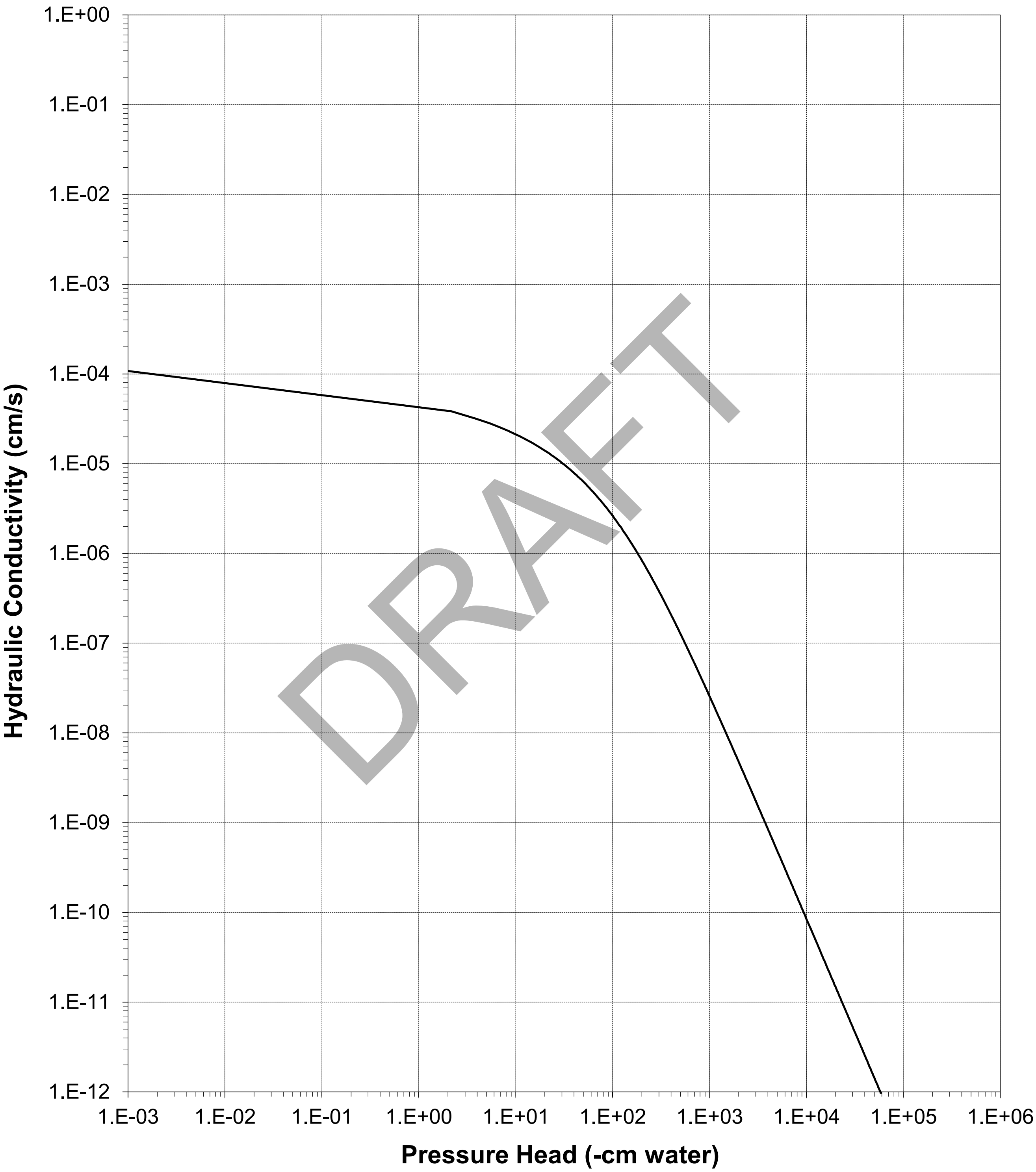
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 31+ (85%, 1.22)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite 31+ (85%, 1.22)



Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+ (85%, 1.22)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	12.02	87.98	100.00
Mass Fraction (%):	12.02	87.98	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.22	1.30
Calculated Porosity (% vol):	0.00	54.04	50.85
Volume of Solids (cm^3):	4.54	33.20	37.74
Volume of Voids (cm^3):	0.00	39.04	39.04
Total Volume (cm^3):	4.54	72.24	76.78
Volumetric Fraction (%):	5.91	94.09	100.00
Initial Moisture Content (% vol):	0.00	33.05	31.10
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.22	1.30
Calculated Porosity (% vol):	0.00	54.04	50.85
Volume of Solids (cm^3):	4.54	33.20	37.74
Volume of Voids (cm^3):	0.00	39.04	39.04
Total Volume (cm^3):	4.54	72.24	76.78
Volumetric Fraction (%):	5.91	94.09	100.00
Saturated Moisture Content (% vol):	0.00	57.37	53.98
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.22	1.30
Calculated Porosity (% vol):	0.00	54.04	50.85
Volume of Solids (cm^3):	4.54	33.20	37.74
Volume of Voids (cm^3):	0.00	39.04	39.04
Total Volume (cm^3):	4.54	72.24	76.78
Volumetric Fraction (%):	5.91	94.09	100.00
Residual Moisture Content (% vol):	0.00	0.00	0.00
Ksat (cm/sec):	NM	1.1E-04	9.5E-05

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10 (85%, 1.51)
Project Name: VVL Composite Samples
PO Number: 12015

Dry wt. of sample (g): 3342.18
Tare wt., ring (g): 272.60
Tare wt., screen & clamp (g): 53.78
Initial sample volume (cm^3): 2220.60
Initial dry bulk density (g/cm^3): 1.51
Assumed particle density (g/cm^3): 2.65
Initial calculated total porosity (%): 43.20

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	3-Sep-14	1:20	4630.70	0	43.33	
	10-Sep-14	13:25	4624.48	8.0	43.05	
	17-Sep-14	10:35	4595.60	20.5	41.75	
	24-Sep-14	15:15	4399.65	73.0	33.21	‡‡
Pressure plate:	4-Oct-14	10:30	4174.90	337	24.15	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	8.0	---	---	---	---
	20.5	---	---	---	---
	73.0	2201.16	-0.88%	1.52	42.70
Pressure plate:	337	2096.96	-5.57%	1.59	39.86

DRAFT

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: VVL Composite TP-10 (85%, 1.51)

Initial sample bulk density (g/cm^3)*:* 1.51
Fraction of test sample used (<2.00mm fraction) (%): 63.04

Dry weight of dew point potentiometer sample* (g)*:* 169.09
Tare weight, jar (g)*:* 112.27

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)	
Dew point potentiometer:	10-Sep-14	14:10	173.84	13971	8.40	‡‡
	10-Sep-14	12:35	172.45	54559	5.94	‡‡
	10-Sep-14	11:55	171.81	146545	4.81	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	13971	2096.96	-5.57%	1.59	39.86
	54559	2096.96	-5.57%	1.59	39.86
	146545	2096.96	-5.57%	1.59	39.86

Dry weight of relative humidity box sample* (g)*:* 72.86
Tare weight (g)*:* 47.61

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)	
Relative humidity box:	9-Sep-14	11:00	73.75	851293	3.57	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	2096.96	-5.57%	1.59	39.86

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

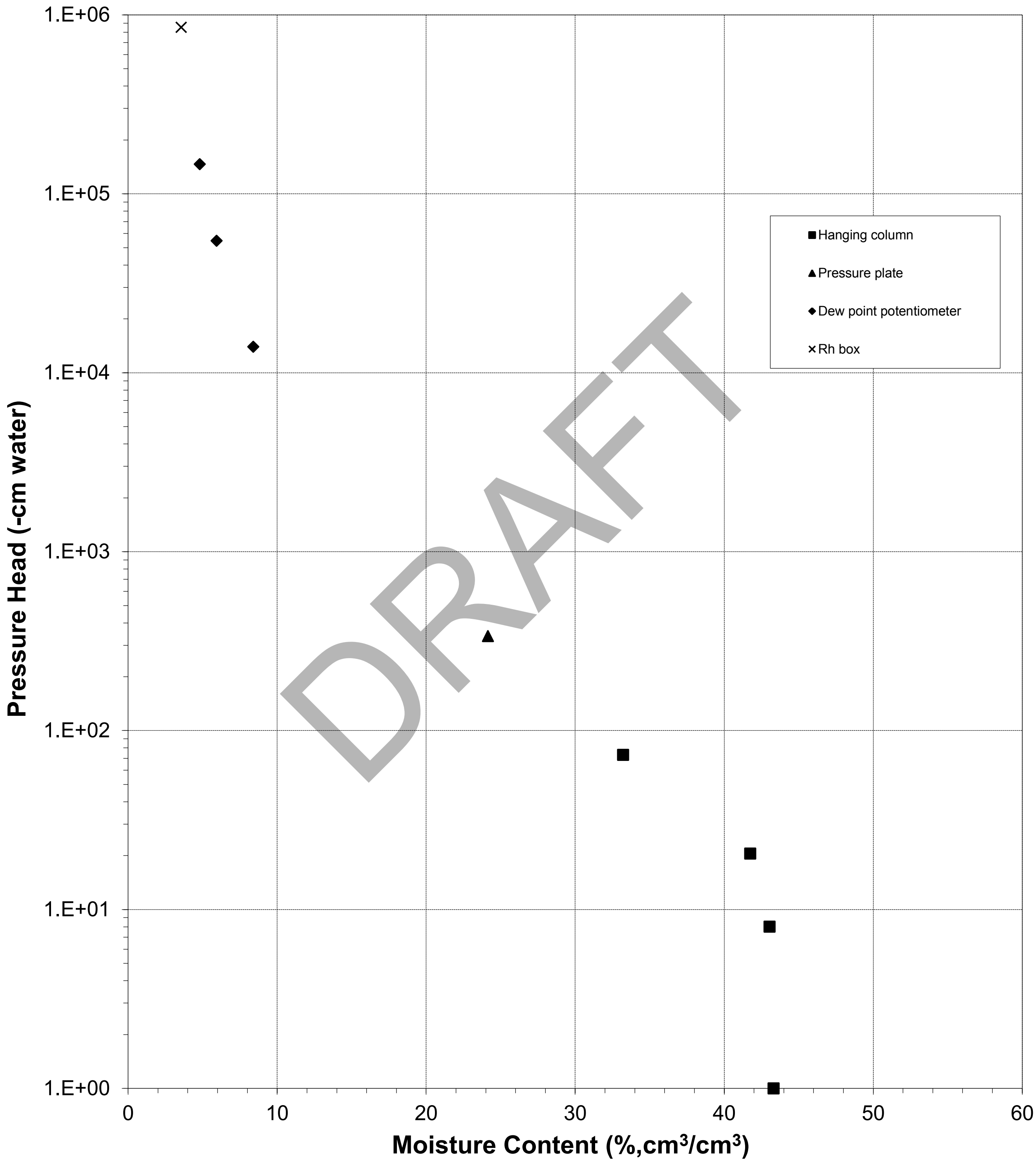
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

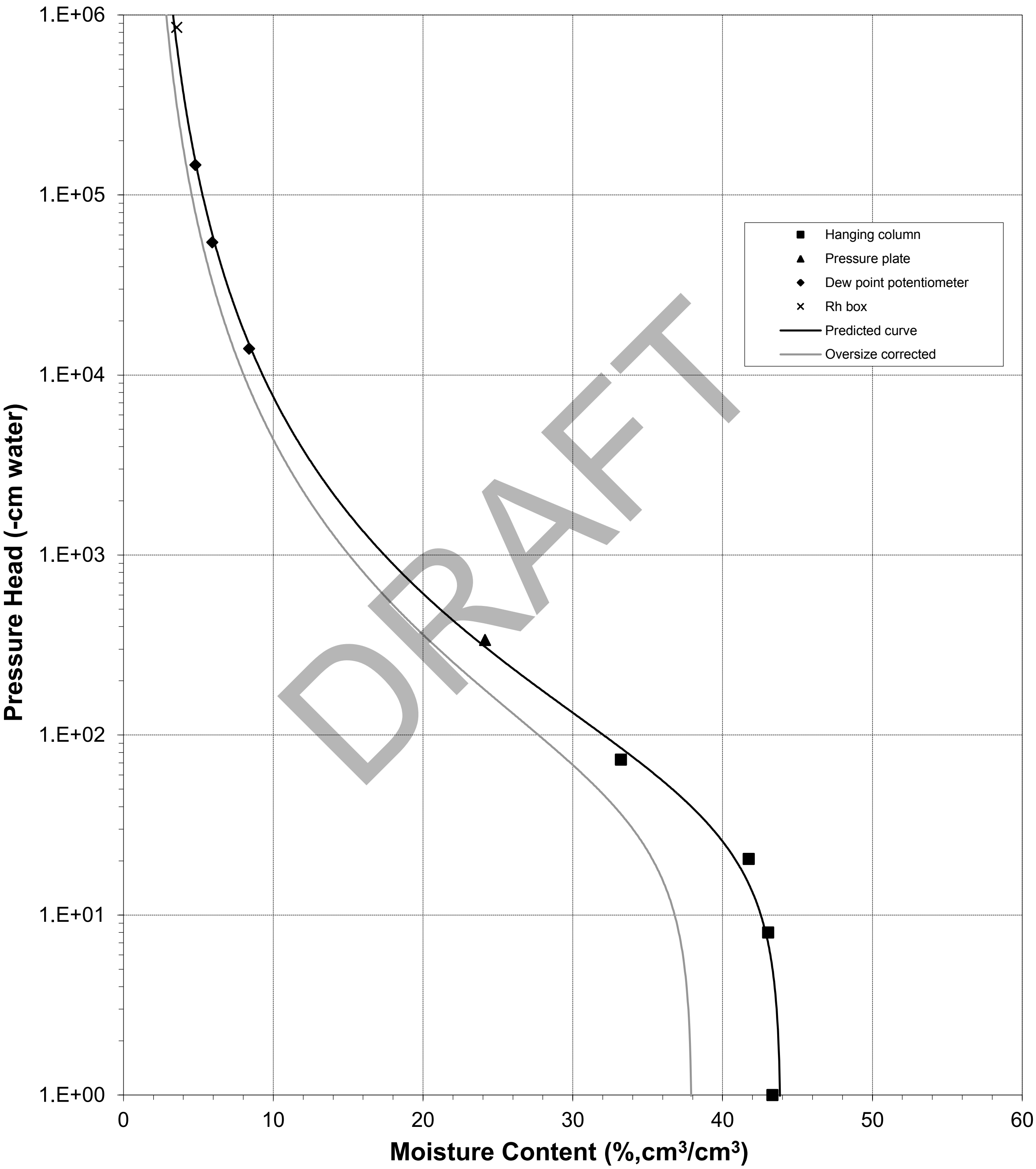
Water Retention Data Points

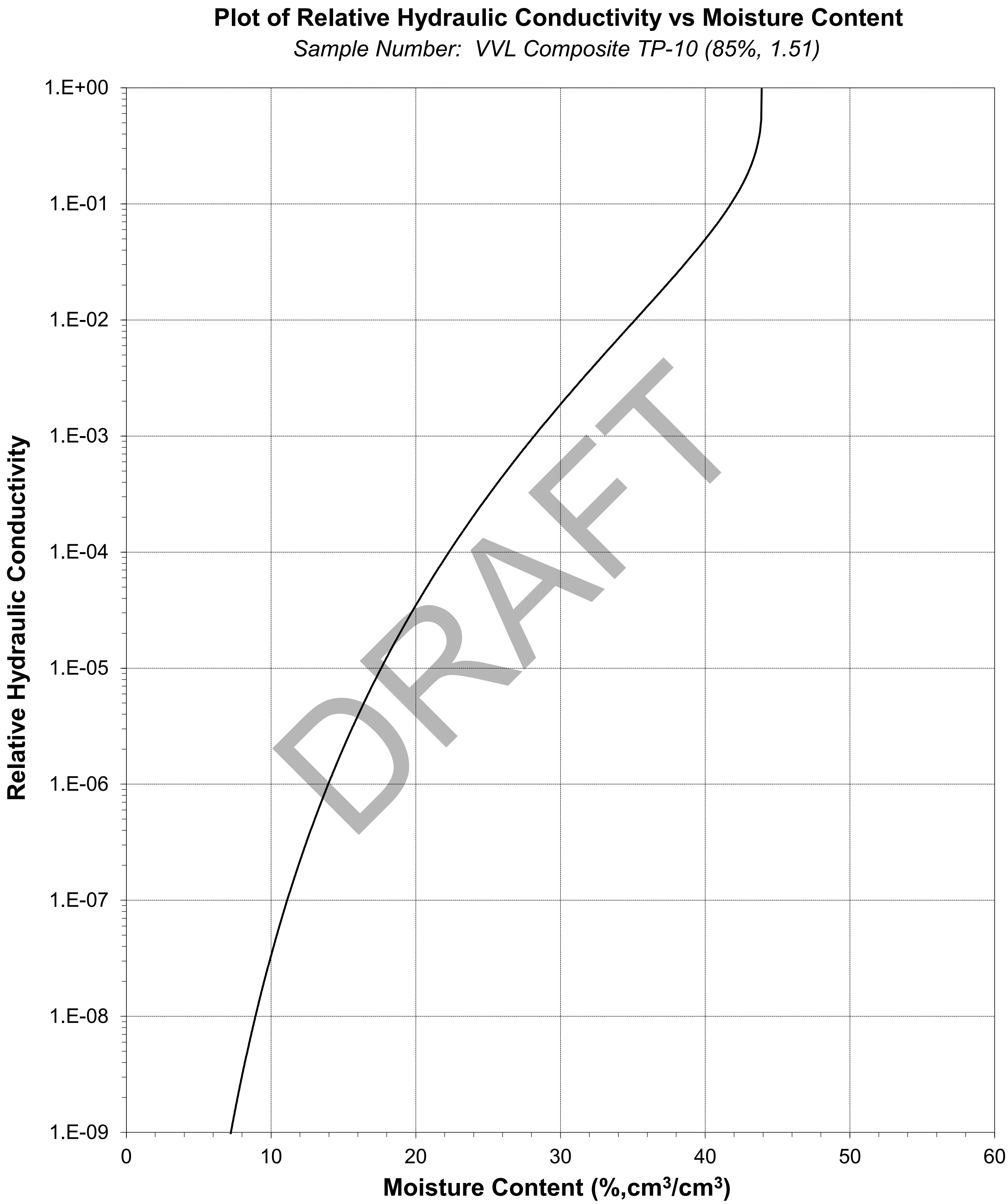
Sample Number: VVL Composite TP-10 (85%, 1.51)



Predicted Water Retention Curve and Data Points

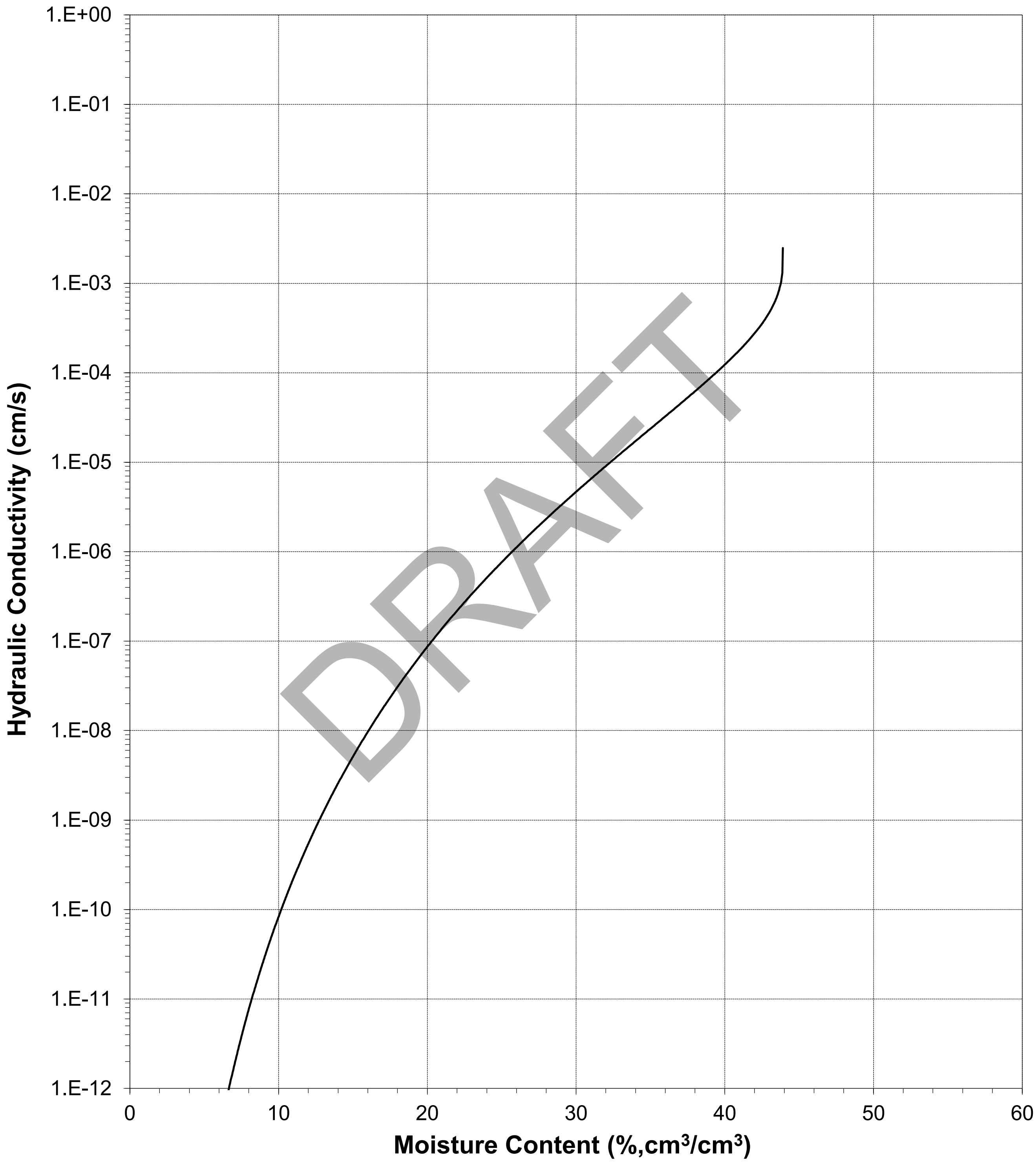
Sample Number: VVL Composite TP-10 (85%, 1.51)




Plot of Relative Hydraulic Conductivity vs Moisture Content
Sample Number: VVL Composite TP-10 (85%, 1.51)
Relative Hydraulic Conductivity
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
0
10
20
30
40
50
60
Moisture Content (%,cm3/cm3)
DRAFT

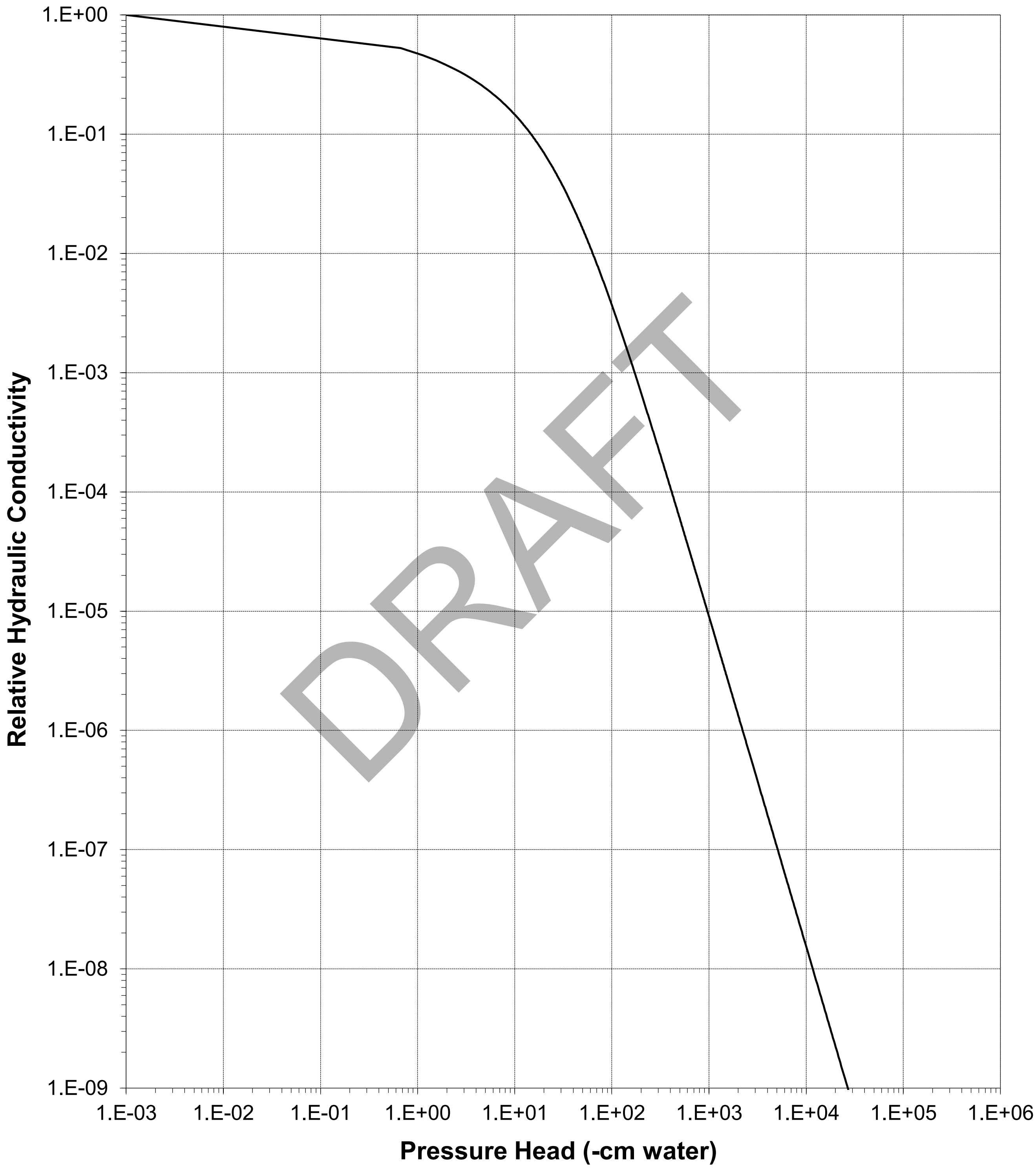
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite TP-10 (85%, 1.51)



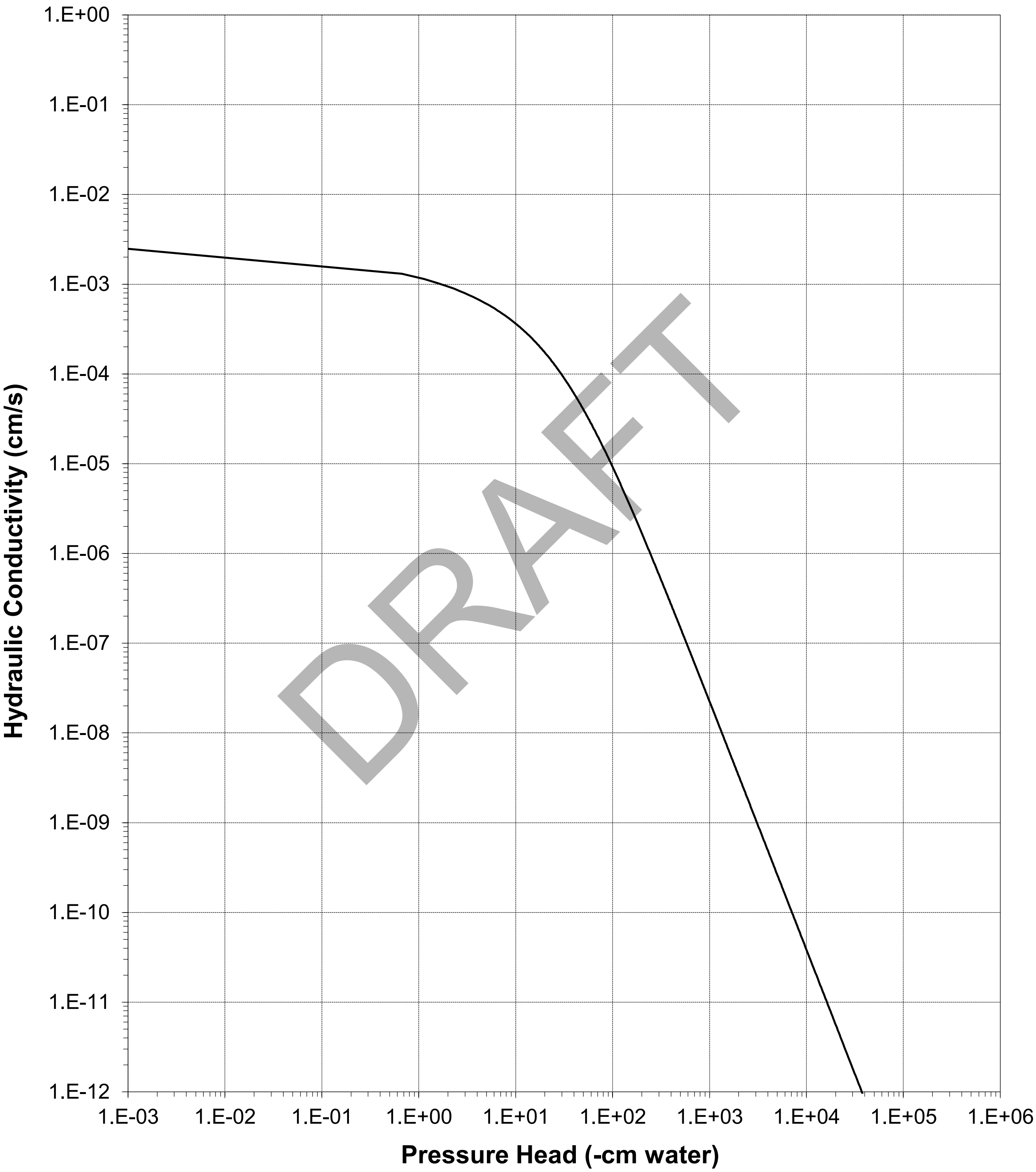
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite TP-10 (85%, 1.51)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite TP-10 (85%, 1.51)



Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10 (85%, 1.51)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	21.58	78.42	100.00
Mass Fraction (%):	21.58	78.42	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.51	1.66
Calculated Porosity (% vol):	0.00	43.20	37.36
Volume of Solids (cm^3):	8.14	29.59	37.74
Volume of Voids (cm^3):	0.00	22.51	22.51
Total Volume (cm^3):	8.14	52.10	60.25
Volumetric Fraction (%):	13.52	86.48	100.00
Initial Moisture Content (% vol):	0.00	23.65	20.46
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.51	1.66
Calculated Porosity (% vol):	0.00	43.20	37.36
Volume of Solids (cm^3):	8.14	29.59	37.74
Volume of Voids (cm^3):	0.00	22.51	22.51
Total Volume (cm^3):	8.14	52.10	60.25
Volumetric Fraction (%):	13.52	86.48	100.00
Saturated Moisture Content (% vol):	0.00	43.91	37.97
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.59	1.74
Calculated Porosity (% vol):	0.00	39.86	34.19
Volume of Solids (cm^3):	8.14	29.59	37.74
Volume of Voids (cm^3):	0.00	19.61	19.61
Total Volume (cm^3):	8.14	49.20	57.34
Volumetric Fraction (%):	14.20	85.80	100.00
Residual Moisture Content (% vol):	0.00	1.43	1.23
Ksat (cm/sec):	NM	2.5E-03	2.0E-03

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Moisture Retention Data
Hanging Column / Pressure Plate
(Soil-Water Characteristic Curve)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3091.19
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	270.01
Sample Number:	VVL Composite TP-12 (85%, 1.40)	*Tare wt., screen & clamp* (g):	56.79
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2203.81
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.40
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	47.07

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)	
Hanging column:	3-Sep-14	10:40	4446.30	0	46.66	
	10-Sep-14	13:30	4445.90	12.0	46.64	
	17-Sep-14	10:40	4437.06	32.0	46.24	
	24-Sep-14	15:20	4334.46	105.0	41.59	
Pressure plate:	4-Oct-14	10:37	4184.50	337	36.86	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	12.0	---	---	---	---
	32.0	---	---	---	---
	105.0	---	---	---	---
Pressure plate:	337	2079.65	-5.63%	1.49	43.91

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data
Dew Point Potentiometer / Relative Humidity Box
(Soil-Water Characteristic Curve)

Sample Number: VVL Composite TP-12 (85%, 1.40)

Initial sample bulk density (g/cm^3)*:* 1.40
Fraction of test sample used (<2.00mm fraction) (%): 60.23

Dry weight of dew point potentiometer sample* (g)*:* 136.31
Tare weight, jar (g)*:* 111.86

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Dew point potentiometer:	10-Sep-14	12:45	141.14	5303	17.69	‡‡
	10-Sep-14	8:46	140.15	22742	14.06	‡‡
	9-Sep-14	14:30	138.87	185502	9.37	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	5303	2079.65	-5.63%	1.49	43.91
	22742	2079.65	-5.63%	1.49	43.91
	185502	2079.65	-5.63%	1.49	43.91

Dry weight of relative humidity box sample* (g)*:* 60.11
Tare weight (g)*:* 38.03

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Relative humidity box:	9-Sep-14	11:00	61.63	851293	6.18	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	2079.65	-5.63%	1.49	43.91

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

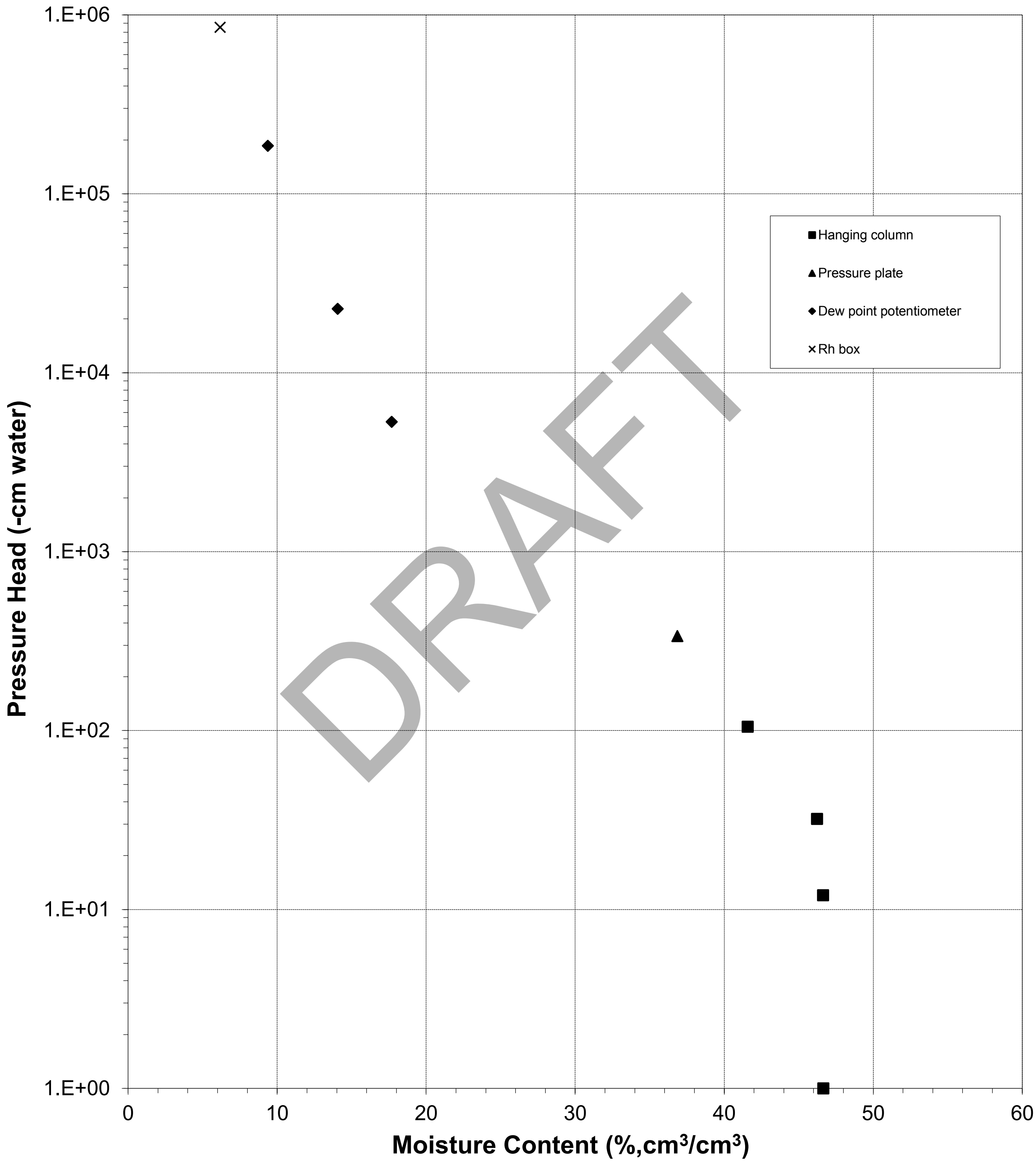
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

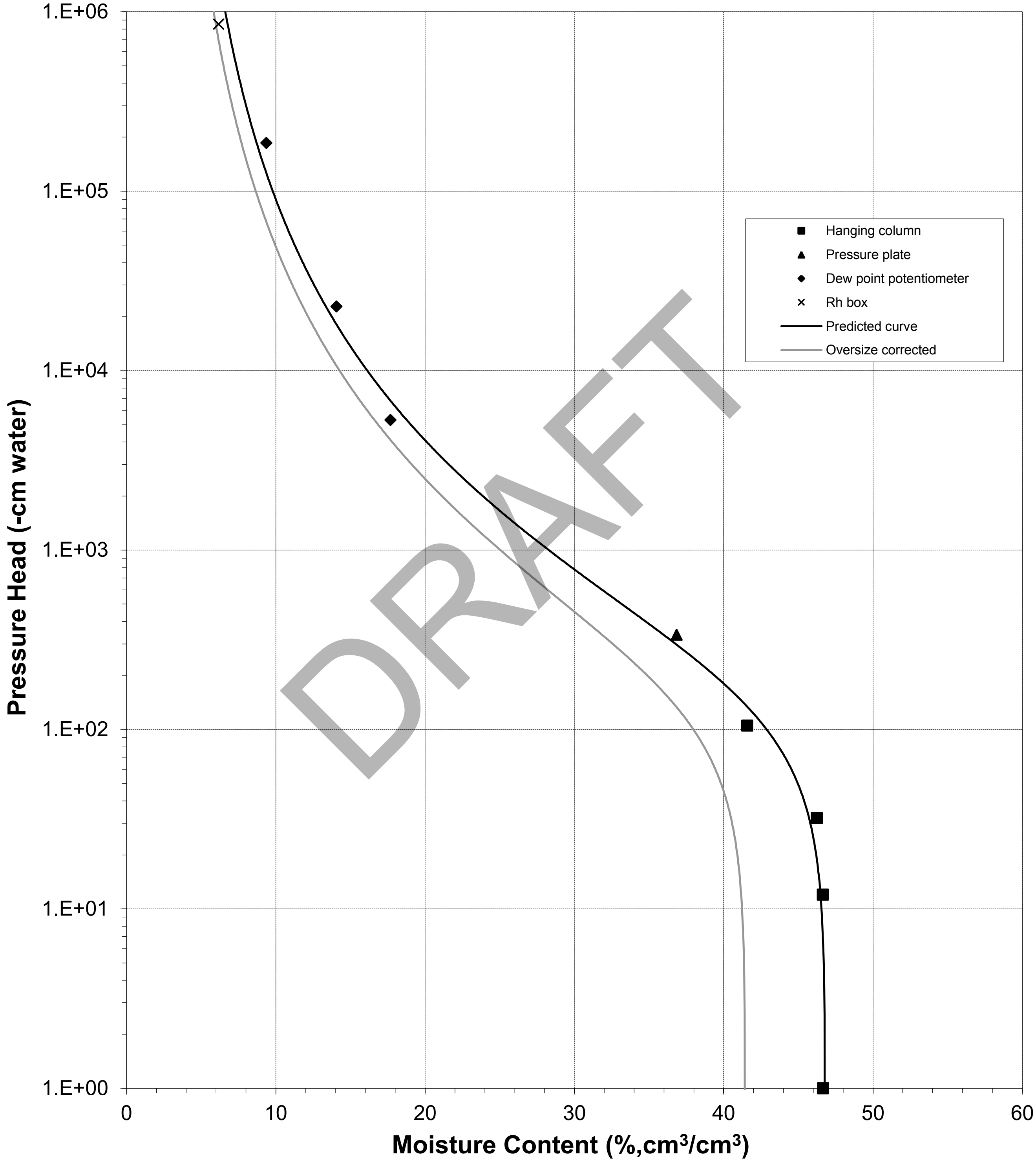
Water Retention Data Points

Sample Number: VVL Composite TP-12 (85%, 1.40)



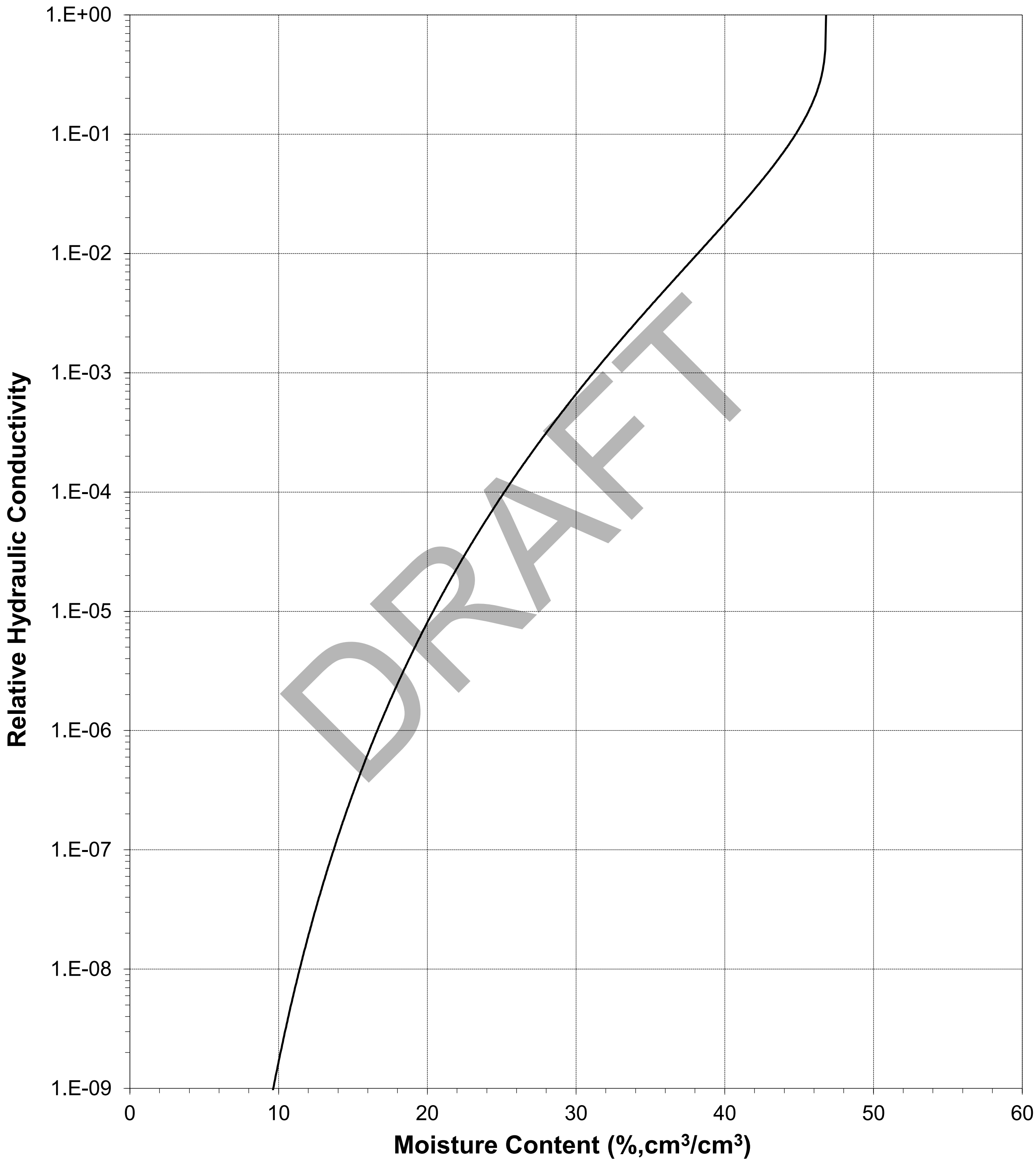
Predicted Water Retention Curve and Data Points

Sample Number: VVL Composite TP-12 (85%, 1.40)



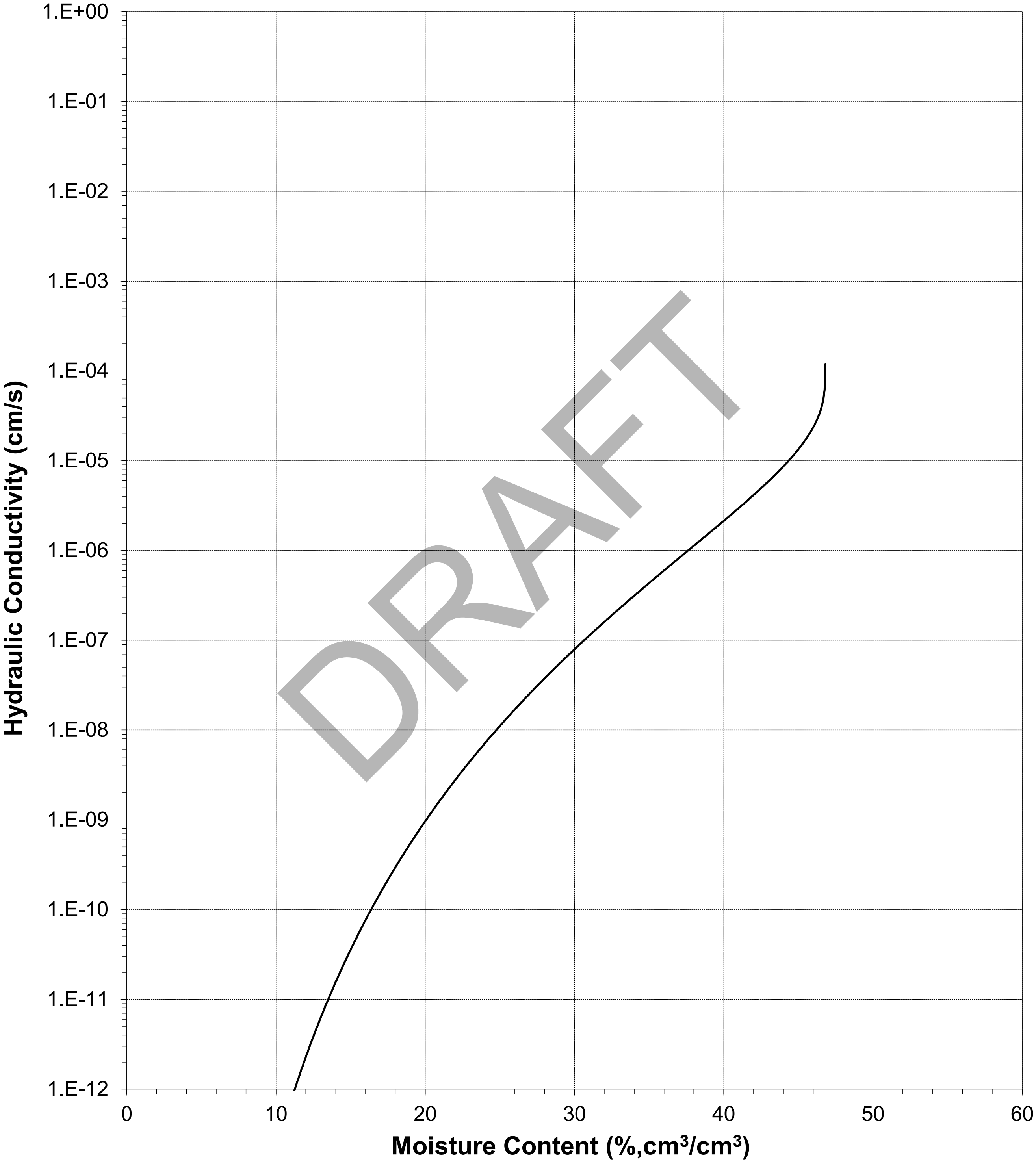
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite TP-12 (85%, 1.40)



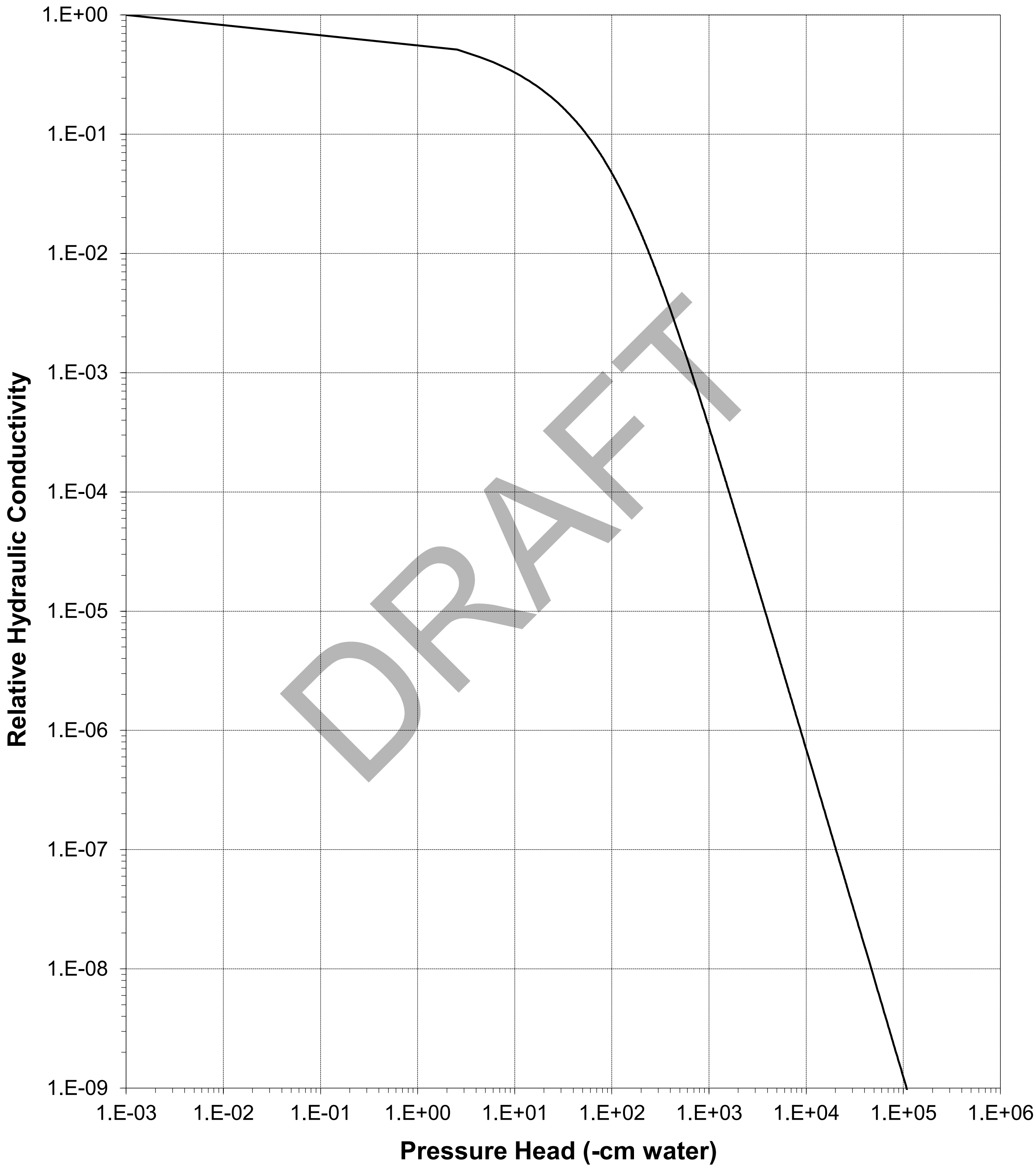
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite TP-12 (85%, 1.40)



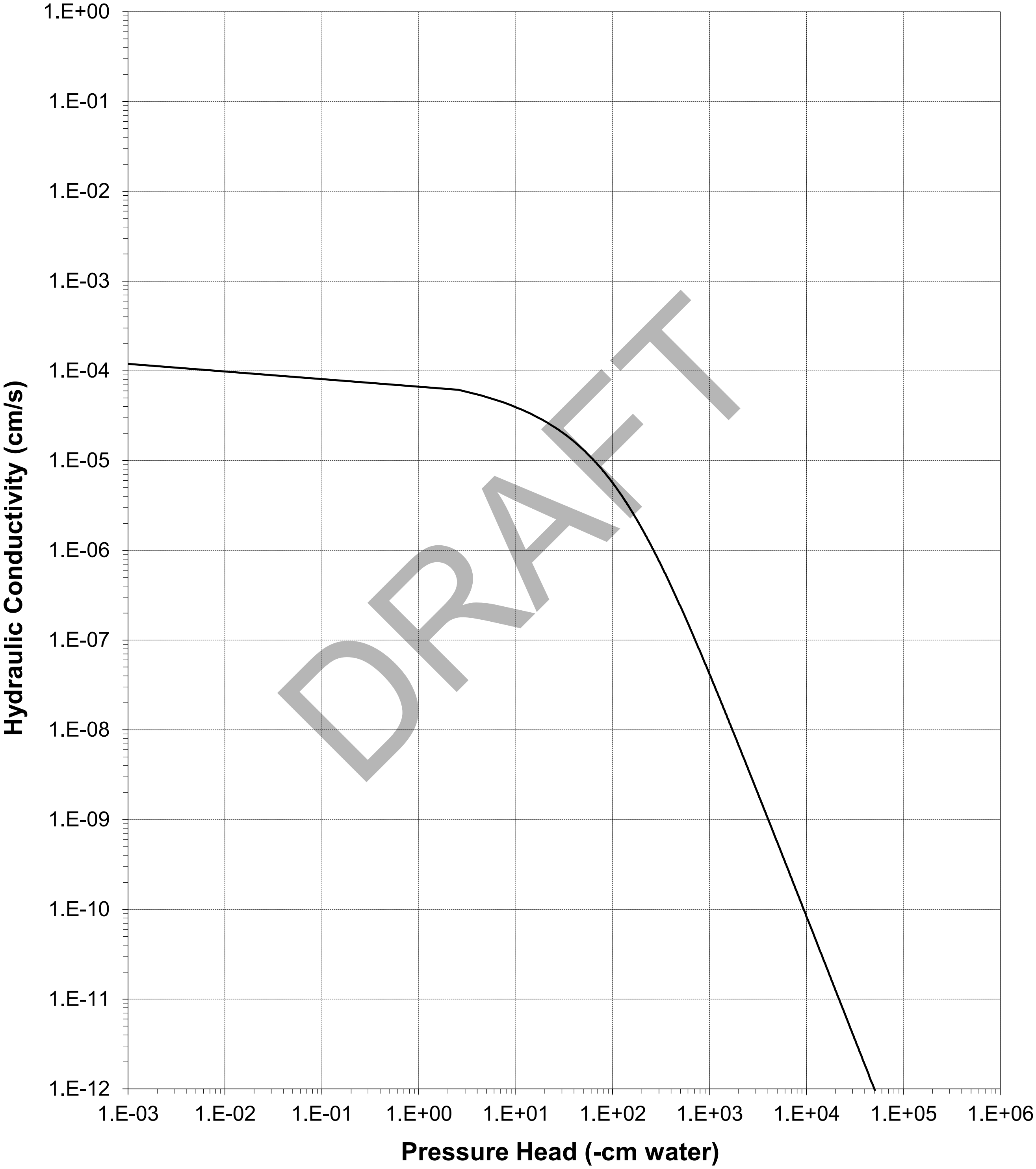
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite TP-12 (85%, 1.40)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite TP-12 (85%, 1.40)



Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12 (85%, 1.40)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	19.61	80.39	100.00
Mass Fraction (%):	19.61	80.39	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.40	1.55
Calculated Porosity (% vol):	0.00	47.07	41.69
Volume of Solids (cm^3):	7.40	30.33	37.74
Volume of Voids (cm^3):	0.00	26.98	26.98
Total Volume (cm^3):	7.40	57.31	64.71
Volumetric Fraction (%):	11.44	88.56	100.00
Initial Moisture Content (% vol):	0.00	26.07	23.09
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.40	1.55
Calculated Porosity (% vol):	0.00	47.07	41.69
Volume of Solids (cm^3):	7.40	30.33	37.74
Volume of Voids (cm^3):	0.00	26.98	26.98
Total Volume (cm^3):	7.40	57.31	64.71
Volumetric Fraction (%):	11.44	88.56	100.00
Saturated Moisture Content (% vol):	0.00	46.81	41.45
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.49	1.63
Calculated Porosity (% vol):	0.00	43.91	38.62
Volume of Solids (cm^3):	7.40	30.33	37.74
Volume of Voids (cm^3):	0.00	23.75	23.75
Total Volume (cm^3):	7.40	54.08	61.48
Volumetric Fraction (%):	12.04	87.96	100.00
Residual Moisture Content (% vol):	0.00	3.43	3.02
Ksat (cm/sec):	NM	1.2E-04	9.6E-05

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-13 (85%, 1.37)
Project Name: VVL Composite Samples
PO Number: 12015

Dry wt. of sample (g): 3086.05
Tare wt., ring (g): 275.53
Tare wt., screen & clamp (g): 55.27
Initial sample volume (cm^3): 2250.16
Initial dry bulk density (g/cm^3): 1.37
Assumed particle density (g/cm^3): 2.65
Initial calculated total porosity (%): 48.25

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	8-Sep-14	14:00	4536.42	0	49.76	
	15-Sep-14	9:33	4547.12	13.0	49.33	‡‡
	22-Sep-14	15:25	4501.30	34.0	47.33	‡‡
	29-Sep-14	16:05	4381.16	103.0	42.09	‡‡
Pressure plate:	8-Oct-14	12:48	4289.80	337	38.10	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	13.0	2291.03	+1.82%	1.35	49.17
	34.0	2291.03	+1.82%	1.35	49.17
	103.0	2291.03	+1.82%	1.35	49.17
Pressure plate:	337	2291.03	+1.82%	1.35	49.17

DRAFT

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: VVL Composite TP-13 (85%, 1.37)

Initial sample bulk density (g/cm^3)*:* 1.37
Fraction of test sample used (<2.00mm fraction) (%): 65.88

Dry weight of dew point potentiometer sample* (g)*:* 160.83
Tare weight, jar (g)*:* 114.94

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Dew point potentiometer:	10-Sep-14	9:55	167.82	20090	13.52	‡‡
	9-Sep-14	15:30	166.04	82196	10.07	‡‡
	9-Sep-14	14:32	165.31	148381	8.66	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	20090	2291.03	+1.82%	1.35	49.17
	82196	2291.03	+1.82%	1.35	49.17
	148381	2291.03	+1.82%	1.35	49.17

Dry weight of relative humidity box sample* (g)*:* 83.17
Tare weight (g)*:* 44.10

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Relative humidity box:	9-Sep-14	11:00	85.66	851293	5.66	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	2291.03	+1.82%	1.35	49.17

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

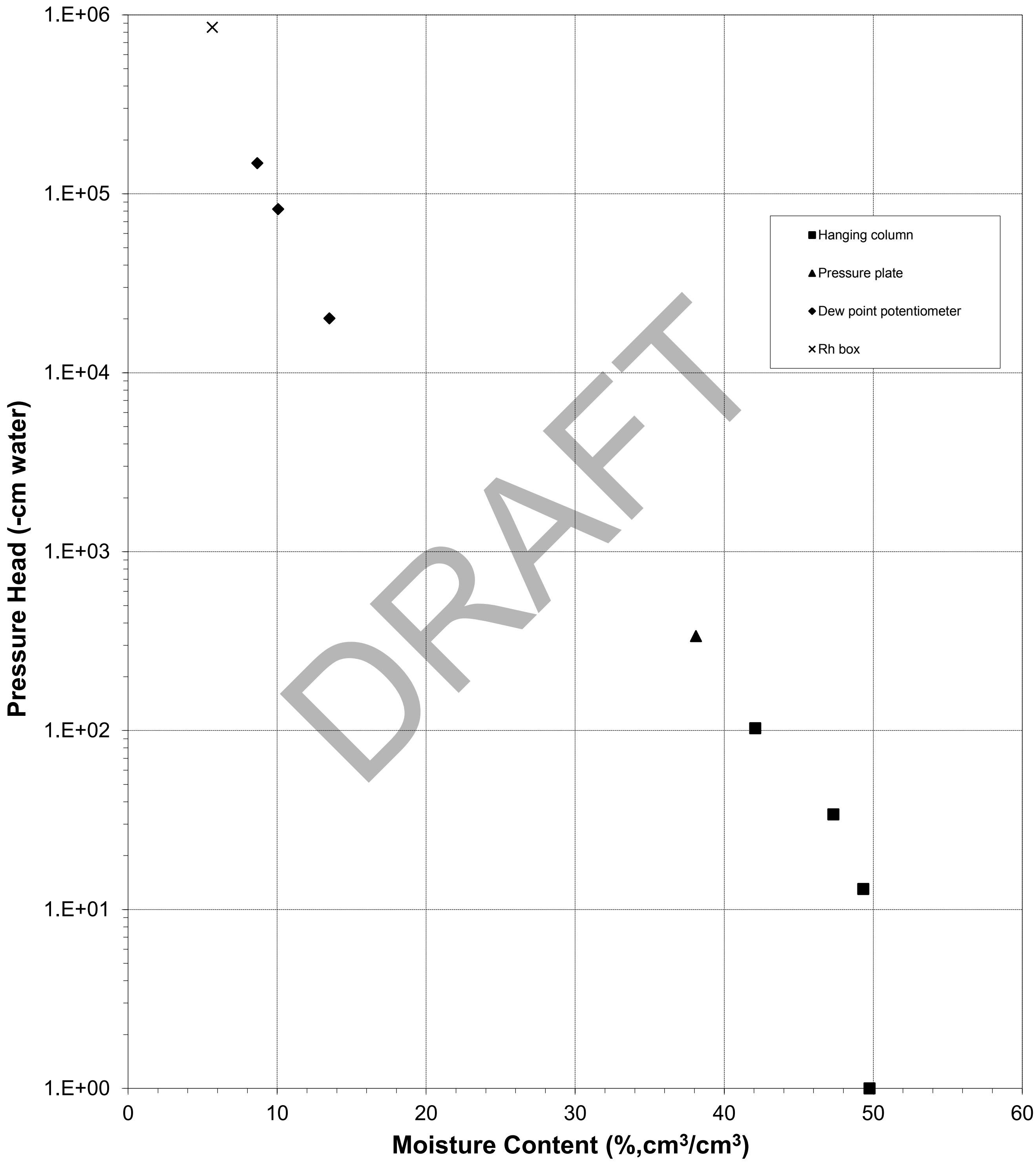
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

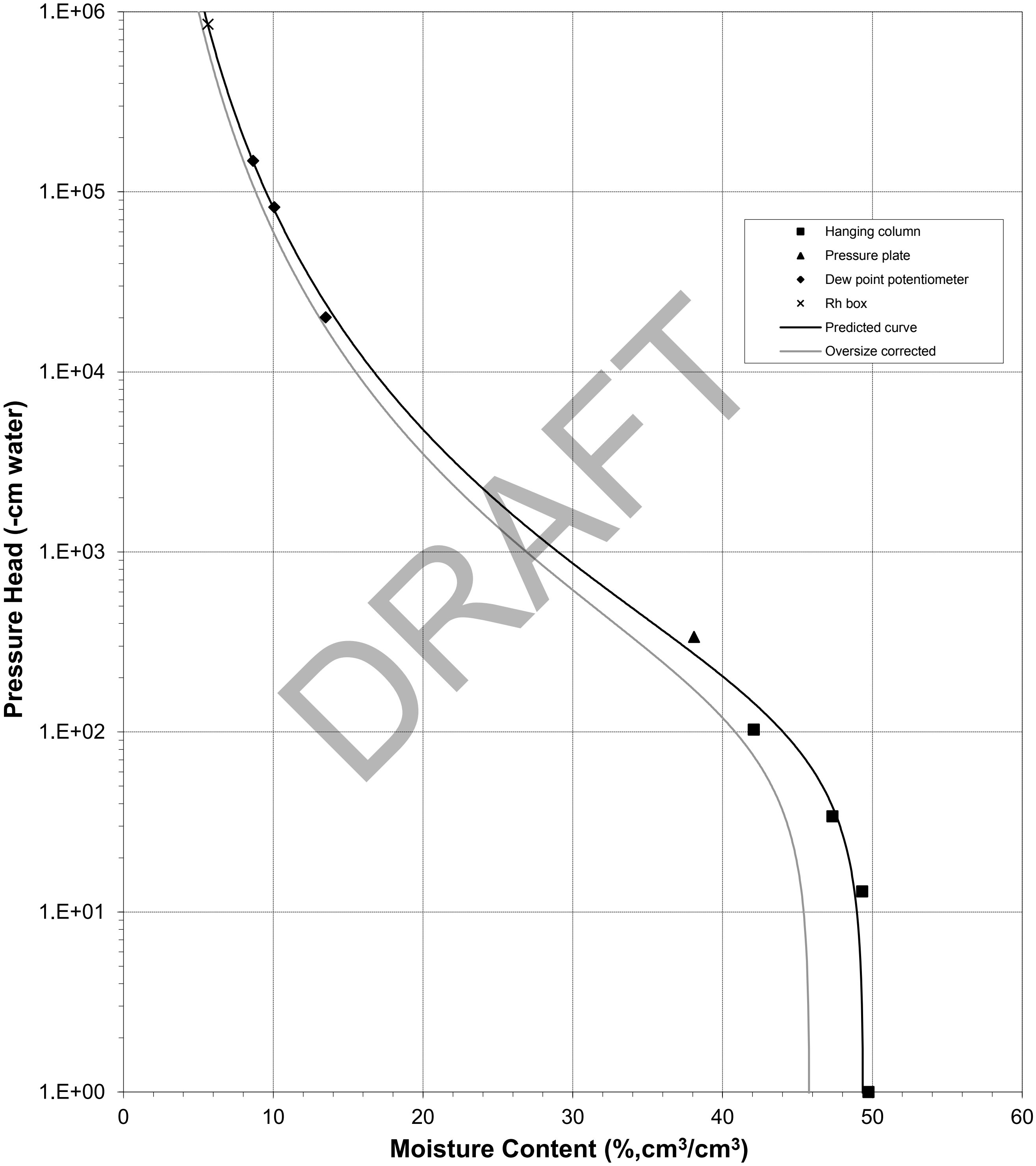
Water Retention Data Points

Sample Number: VVL Composite TP-13 (85%, 1.37)



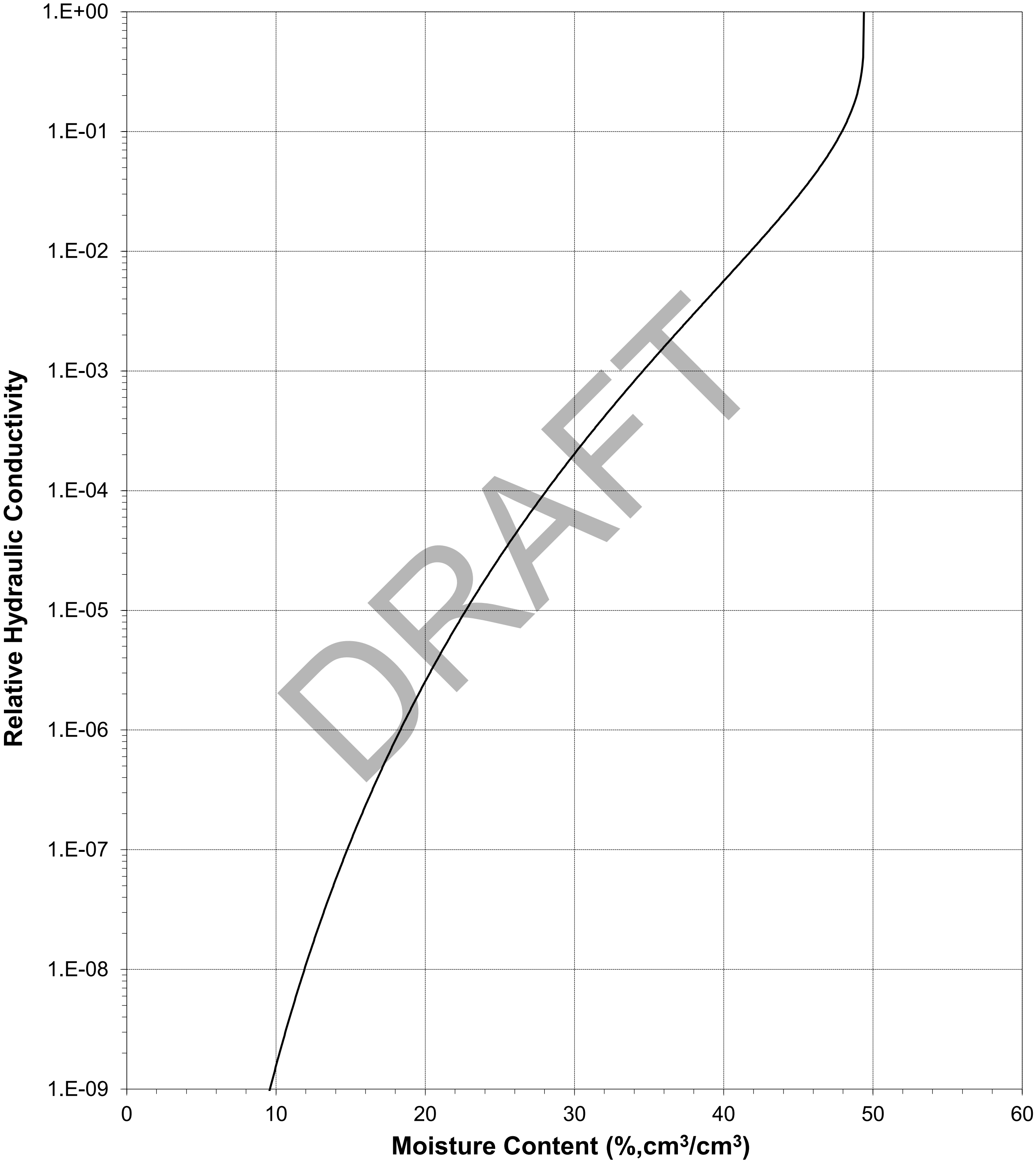
Predicted Water Retention Curve and Data Points

Sample Number: VVL Composite TP-13 (85%, 1.37)



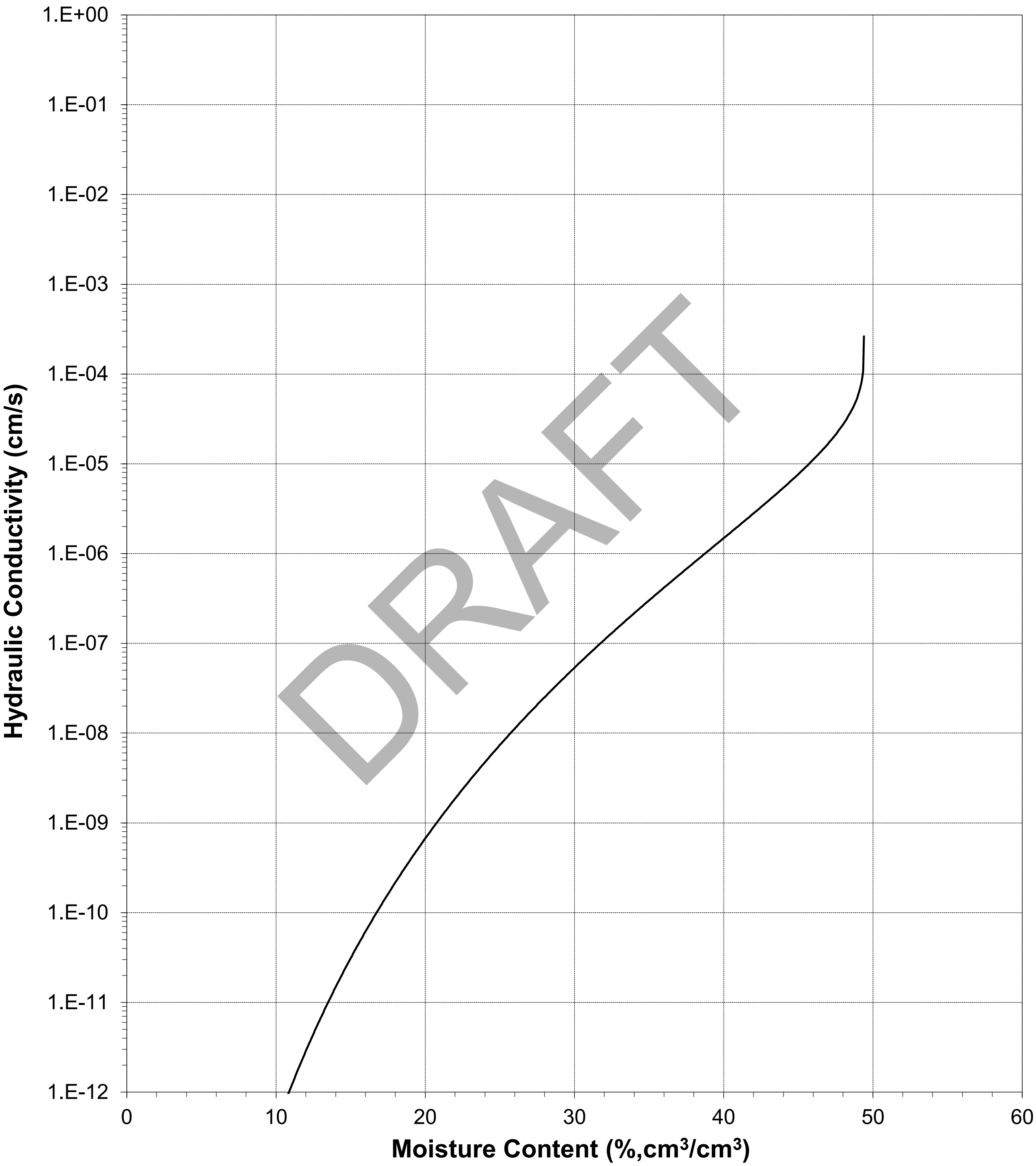
Plot of Relative Hydraulic Conductivity vs Moisture Content

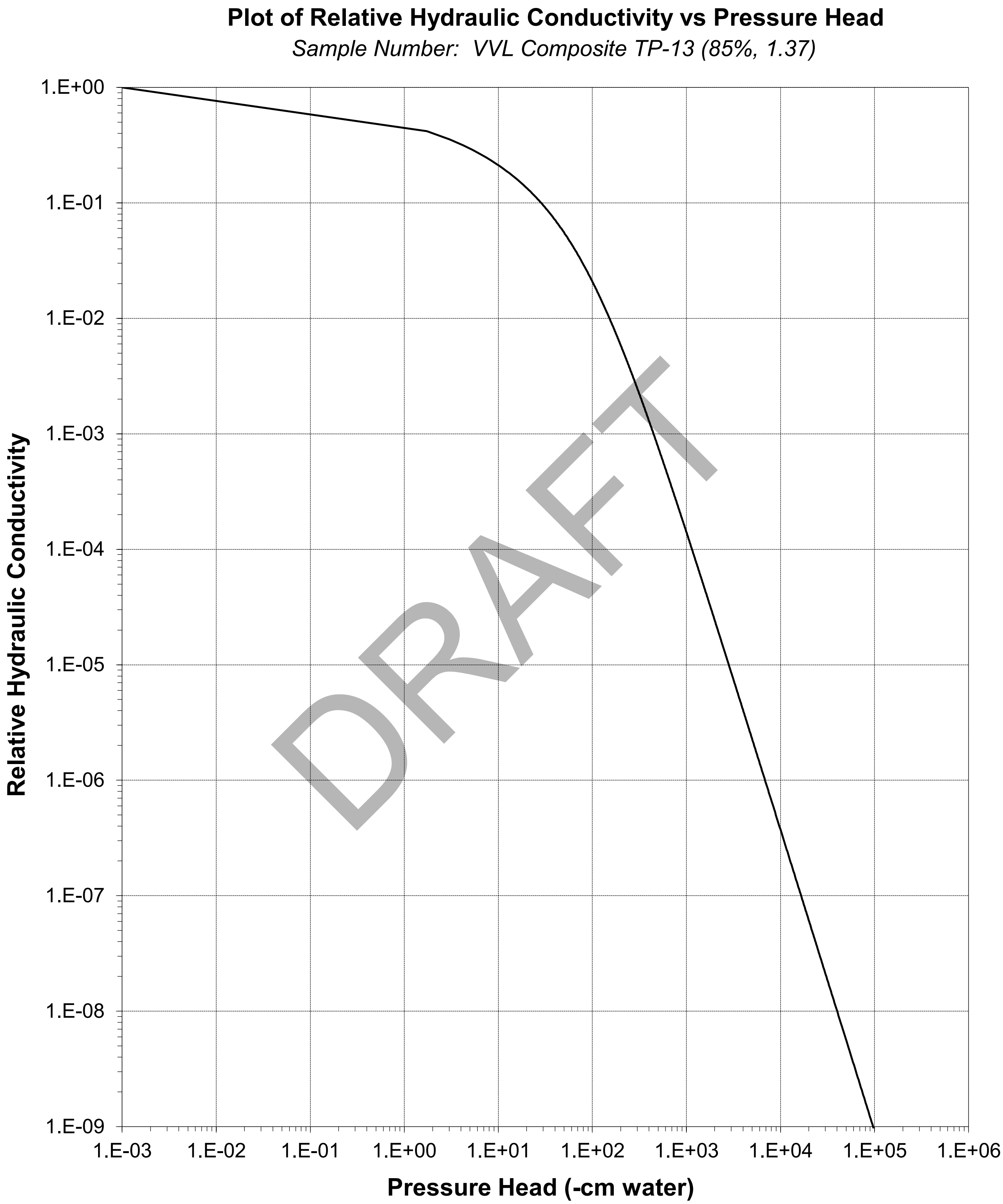
Sample Number: VVL Composite TP-13 (85%, 1.37)



Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: VVL Composite TP-13 (85%, 1.37)

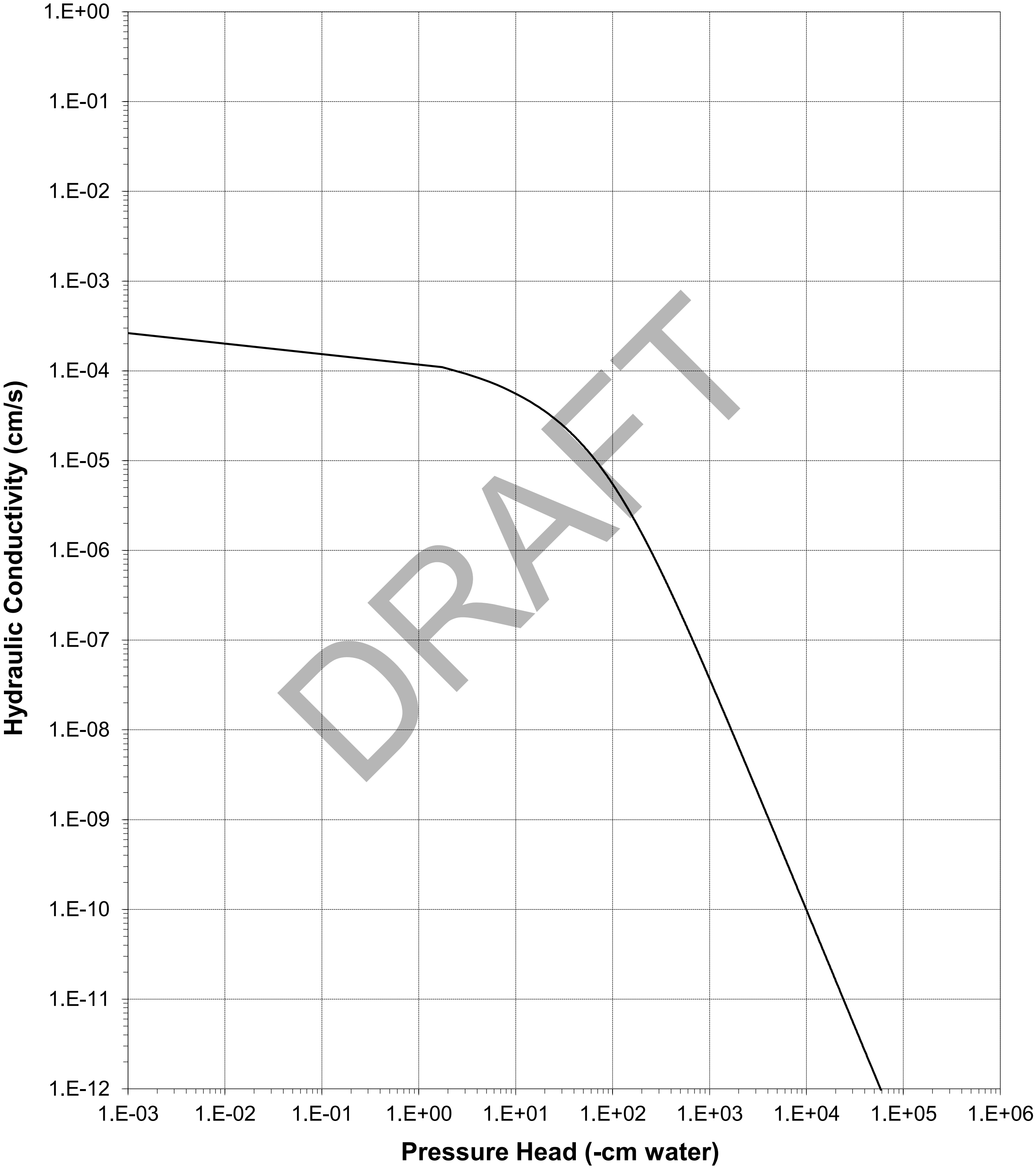




Plot of Relative Hydraulic Conductivity vs Pressure Head
Sample Number: VVL Composite TP-13 (85%, 1.37)
Relative Hydraulic Conductivity
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
Pressure Head (-cm water)
DRAFT

Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: VVL Composite TP-13 (85%, 1.37)



Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-13 (85%, 1.37)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	13.14	86.86	100.00
Mass Fraction (%):	13.14	86.86	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.37	1.46
Calculated Porosity (% vol):	0.00	48.25	44.74
Volume of Solids (cm^3):	4.96	32.78	37.74
Volume of Voids (cm^3):	0.00	30.56	30.56
Total Volume (cm^3):	4.96	63.33	68.29
Volumetric Fraction (%):	7.26	92.74	100.00
Initial Moisture Content (% vol):	0.00	28.91	26.81
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.37	1.46
Calculated Porosity (% vol):	0.00	48.25	44.74
Volume of Solids (cm^3):	4.96	32.78	37.74
Volume of Voids (cm^3):	0.00	30.56	30.56
Total Volume (cm^3):	4.96	63.33	68.29
Volumetric Fraction (%):	7.26	92.74	100.00
Saturated Moisture Content (% vol):	0.00	49.39	45.81
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.35	1.44
Calculated Porosity (% vol):	0.00	49.17	45.66
Volume of Solids (cm^3):	4.96	32.78	37.74
Volume of Voids (cm^3):	0.00	31.71	31.71
Total Volume (cm^3):	4.96	64.49	69.44
Volumetric Fraction (%):	7.14	92.86	100.00
Residual Moisture Content (% vol):	0.00	0.00	0.00
Ksat (cm/sec):	NM	2.6E-04	2.3E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Hanging Column / Pressure Plate
(Soil-Water Characteristic Curve)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	164.29
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	53.27
Sample Number:	WB Borrow-1 (85%, 1.42)	*Tare wt., screen & clamp* (g):	25.51
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	115.77
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.42
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	46.45

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	3-Sep-14	11:45	297.09	0	46.66
	10-Sep-14	13:30	296.54	7.0	46.19
	17-Sep-14	10:30	296.15	29.0	45.85
	24-Sep-14	15:22	286.73	102.0	37.71
Pressure plate:	3-Oct-14	16:25	273.63	337	26.40

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	7.0	---	---	---	---
	29.0	---	---	---	---
	102.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: WB Borrow-1 (85%, 1.42)

Initial sample bulk density (g/cm^3)*:* 1.42
Fraction of test sample used (<2.00mm fraction) (%): 82.87

Dry weight of dew point potentiometer sample* (g)*:* 156.79
Tare weight, jar (g)*:* 117.49

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	10-Sep-14	9:00	160.72	23251	11.76
	9-Sep-14	16:00	159.74	67307	8.83
	9-Sep-14	14:08	158.69	220379	5.69

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	23251	---	---	---	---
	67307	---	---	---	---
	220379	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 59.40
Tare weight (g)*:* 36.82

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	9-Sep-14	11:00	60.07	851293	3.49

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

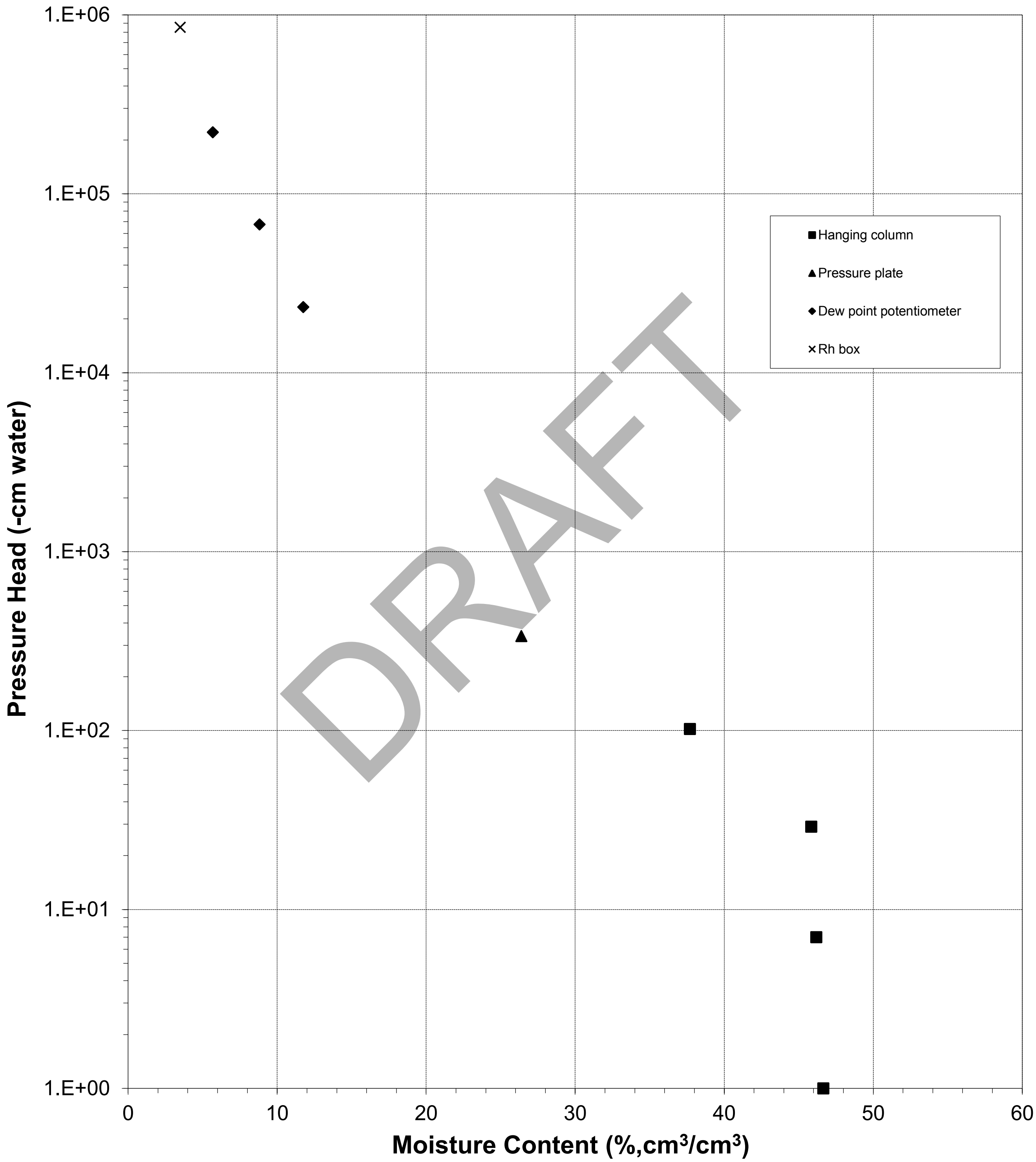
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

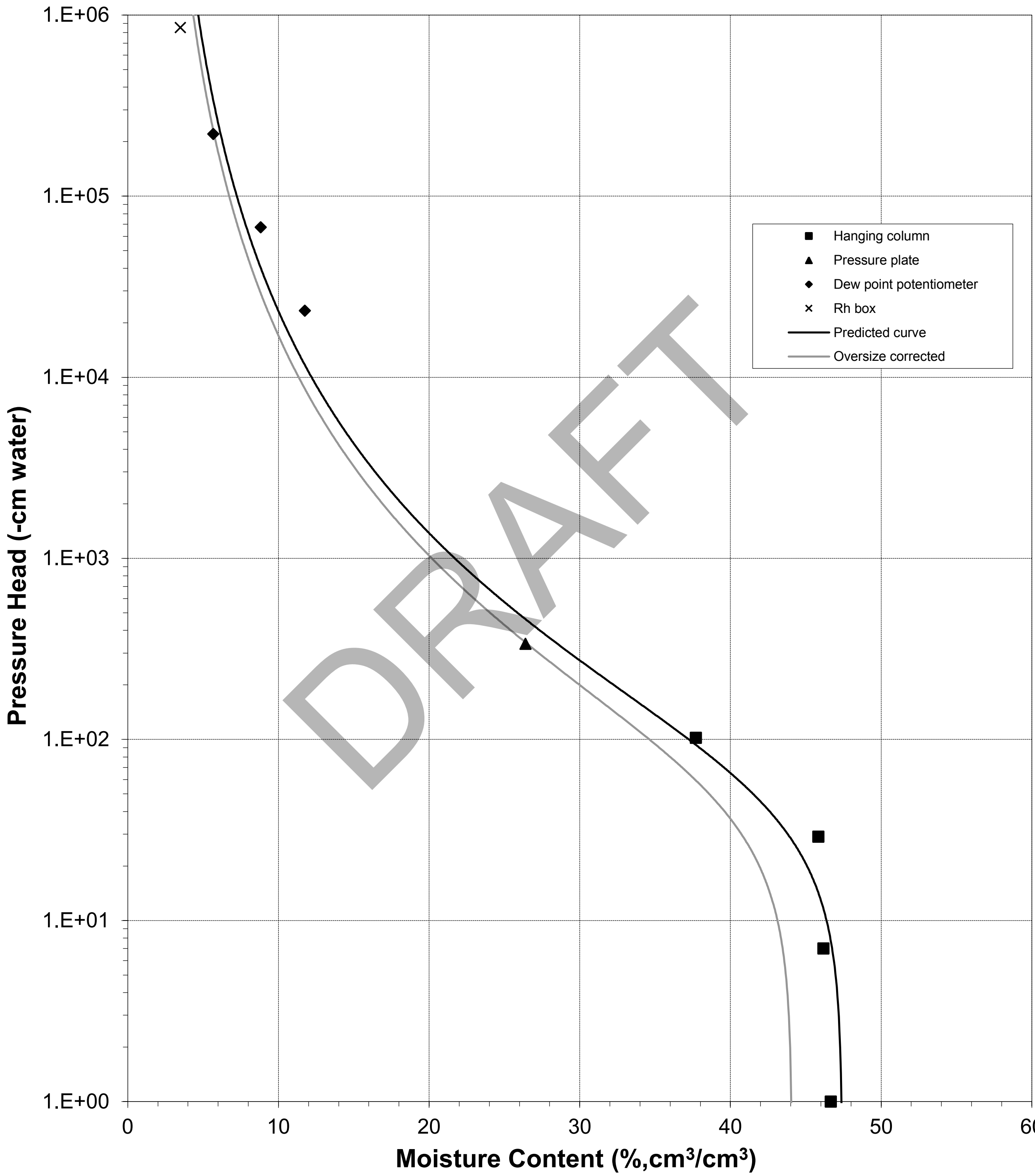
Water Retention Data Points

Sample Number: WB Borrow-1 (85%, 1.42)



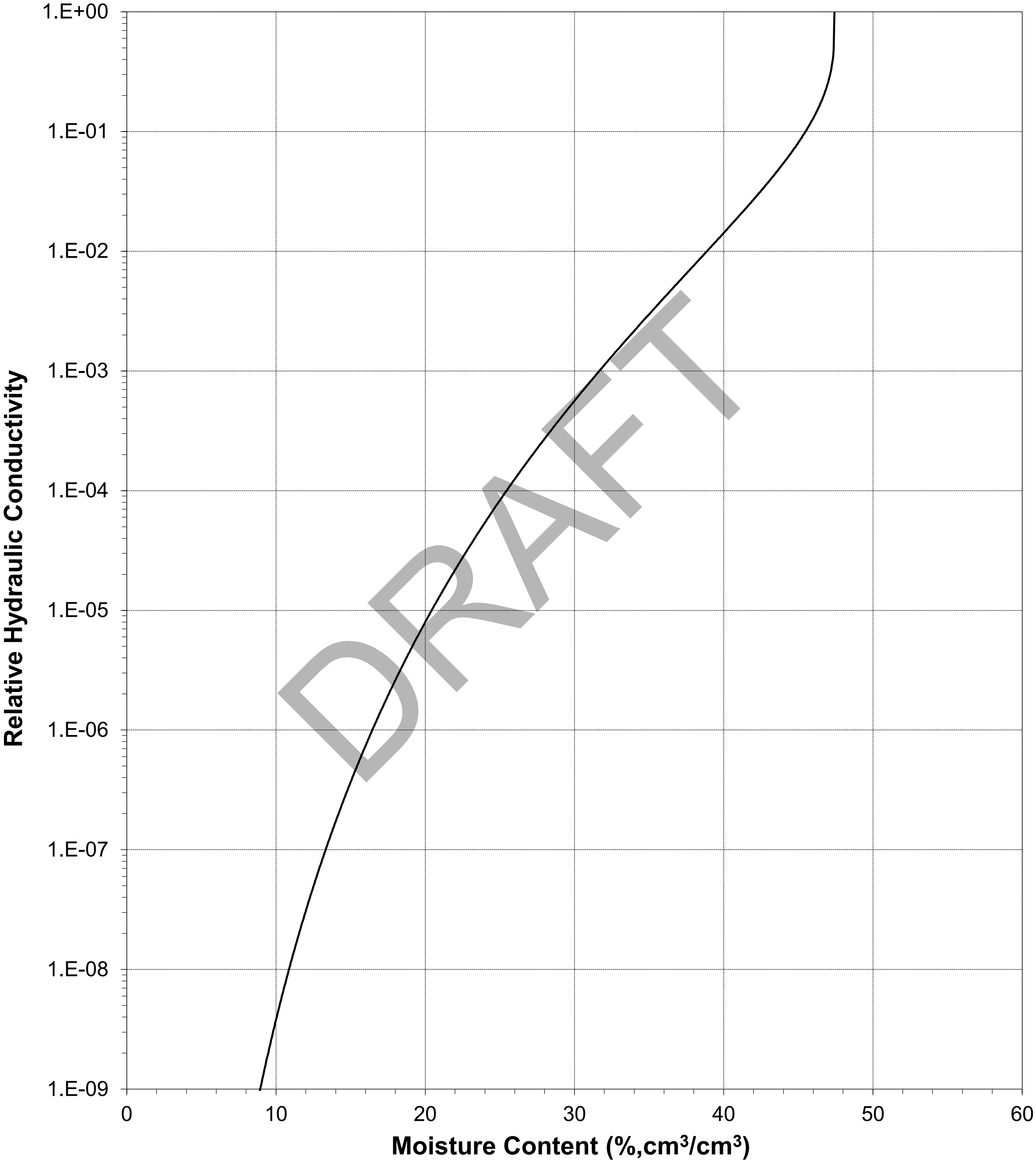
Predicted Water Retention Curve and Data Points

Sample Number: WB Borrow-1 (85%, 1.42)



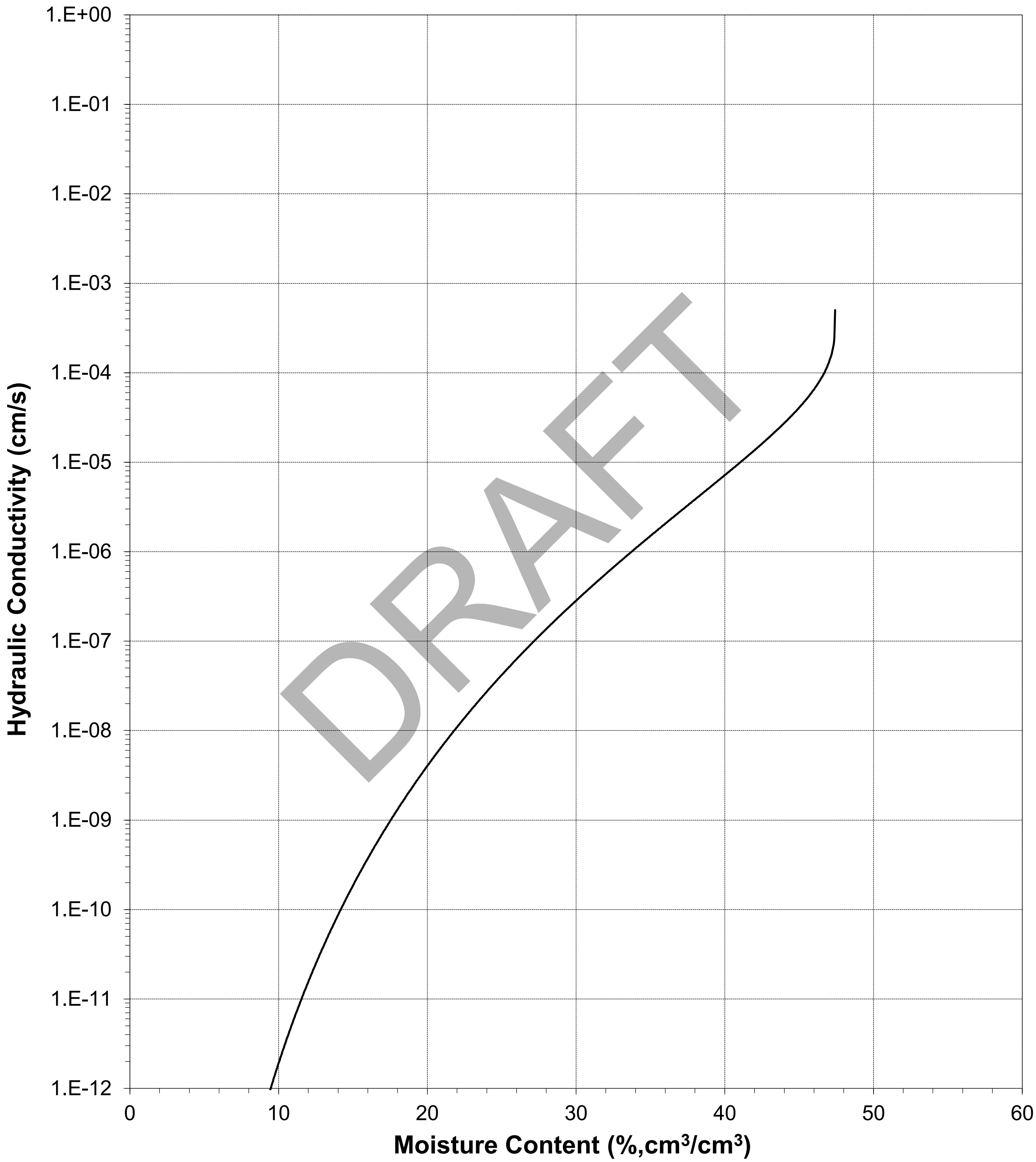
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: WB Borrow-1 (85%, 1.42)



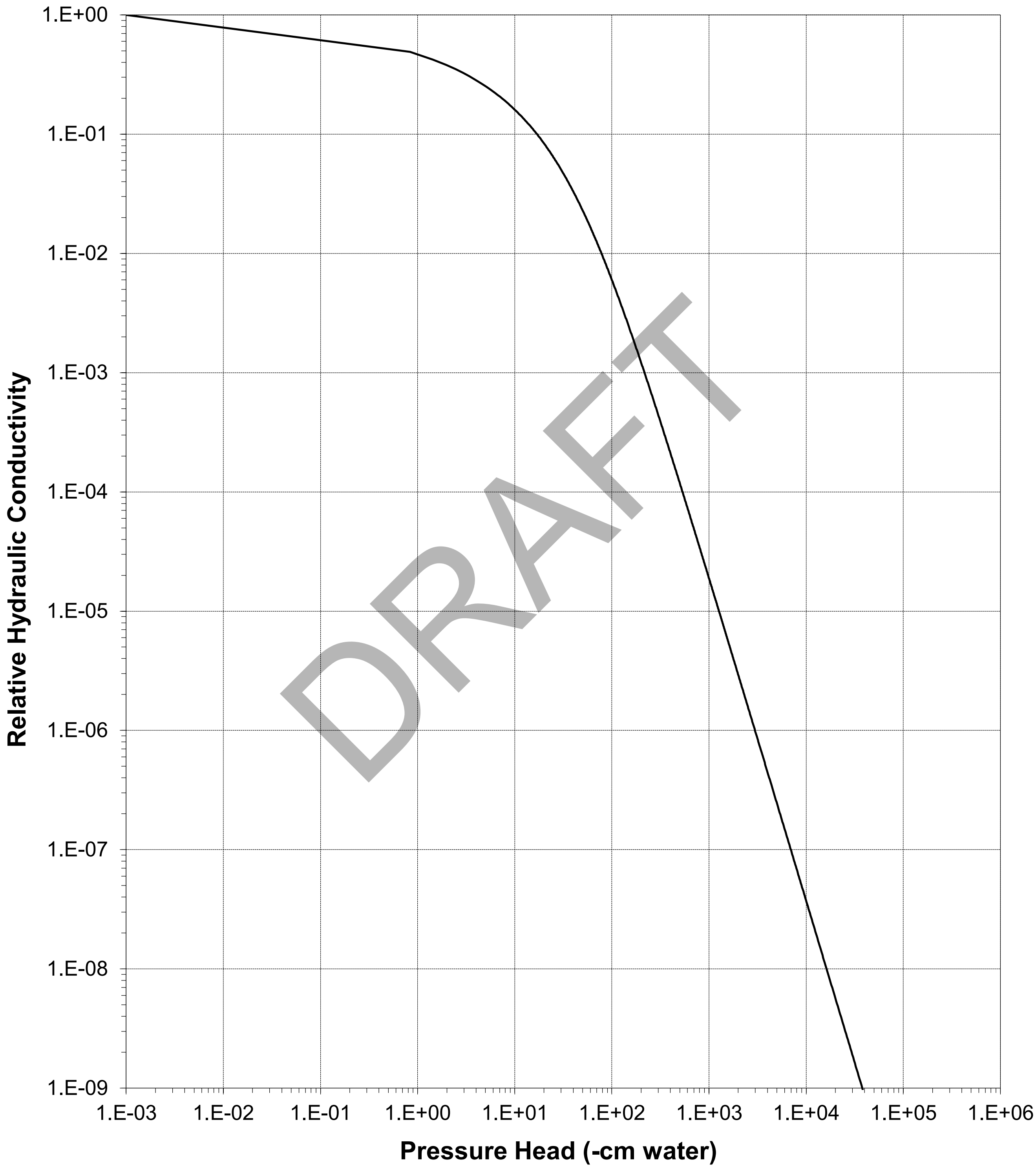
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: WB Borrow-1 (85%, 1.42)



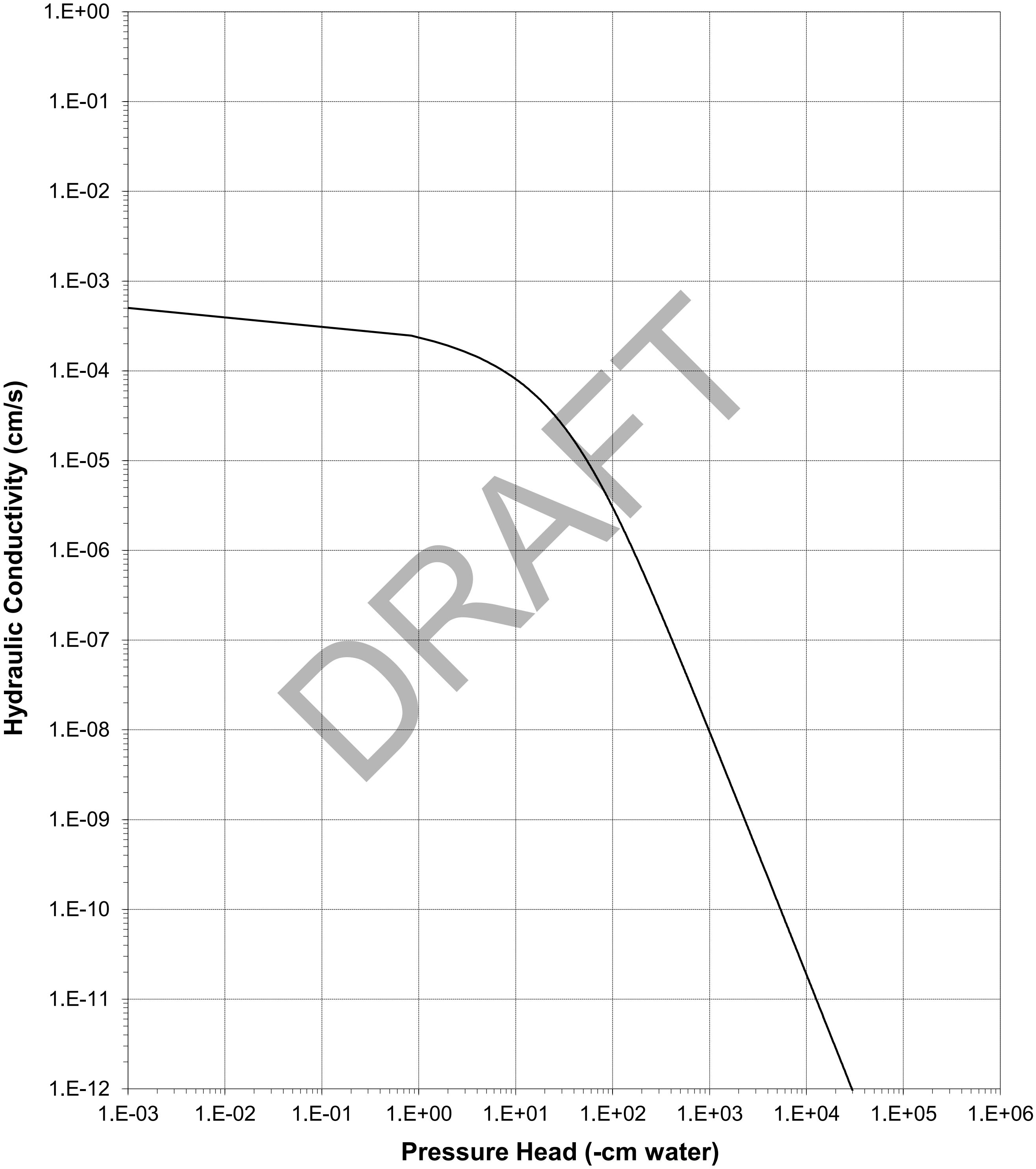
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: WB Borrow-1 (85%, 1.42)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: WB Borrow-1 (85%, 1.42)



Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Borrow-1 (85%, 1.42)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	12.36	87.64	100.00
Mass Fraction (%):	12.36	87.64	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.42	1.51
Calculated Porosity (% vol):	0.00	46.45	43.19
Volume of Solids (cm^3):	4.66	33.07	37.74
Volume of Voids (cm^3):	0.00	28.68	28.68
Total Volume (cm^3):	4.66	61.76	66.42
Volumetric Fraction (%):	7.02	92.98	100.00
Initial Moisture Content (% vol):	0.00	25.97	24.15
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.42	1.51
Calculated Porosity (% vol):	0.00	46.45	43.19
Volume of Solids (cm^3):	4.66	33.07	37.74
Volume of Voids (cm^3):	0.00	28.68	28.68
Total Volume (cm^3):	4.66	61.76	66.42
Volumetric Fraction (%):	7.02	92.98	100.00
Saturated Moisture Content (% vol):	0.00	47.42	44.09
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.42	1.51
Calculated Porosity (% vol):	0.00	46.45	43.19
Volume of Solids (cm^3):	4.66	33.07	37.74
Volume of Voids (cm^3):	0.00	28.68	28.68
Total Volume (cm^3):	4.66	61.76	66.42
Volumetric Fraction (%):	7.02	92.98	100.00
Residual Moisture Content (% vol):	0.00	1.94	1.80
Ksat (cm/sec):	NM	5.0E-04	4.4E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Moisture Retention Data
Hanging Column / Pressure Plate
(Soil-Water Characteristic Curve)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	181.10
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	55.22
Sample Number:	WB Stockpile-1 (85%, 1.52)	*Tare wt., screen & clamp* (g):	27.82
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	119.42
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.52
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	42.77

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	3-Sep-14	11:55	316.20	0	43.60
	10-Sep-14	13:35	316.18	8.0	43.58
	17-Sep-14	10:45	315.76	27.0	43.23
	24-Sep-14	15:30	310.12	91.0	38.50
Pressure plate:	4-Oct-14	10:45	297.78	337	28.17

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	8.0	---	---	---	---
	27.0	---	---	---	---
	91.0	---	---	---	---
Pressure plate:	337	---	---	---	---

DRAFT

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: WB Stockpile-1 (85%, 1.52)

Initial sample bulk density (g/cm^3)*:* 1.52

Fraction of test sample used (<2.00mm fraction) (%): 88.43

Dry weight of dew point potentiometer sample* (g)*:* 157.01

Tare weight, jar (g)*:* 115.17

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	10-Sep-14	9:30	160.19	32430	10.19
	9-Sep-14	15:07	159.04	164494	6.51
	9-Sep-14	13:50	158.51	510308	4.81

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	32430	---	---	---	---
	164494	---	---	---	---
	510308	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 60.35

Tare weight (g)*:* 36.87

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	9-Sep-14	11:00	61.03	851293	3.90

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

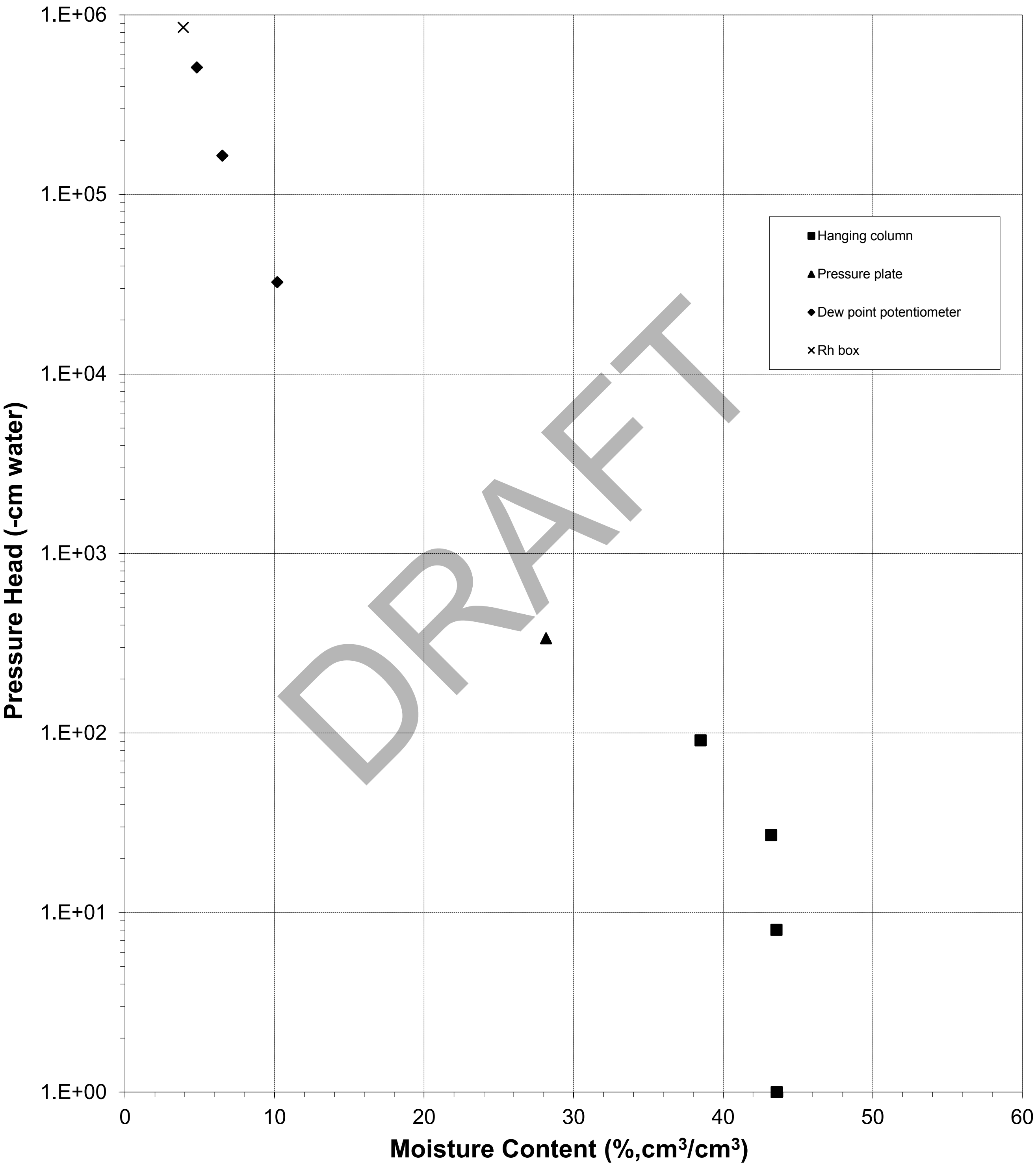
Laboratory analysis by: D. O' Dowd/D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

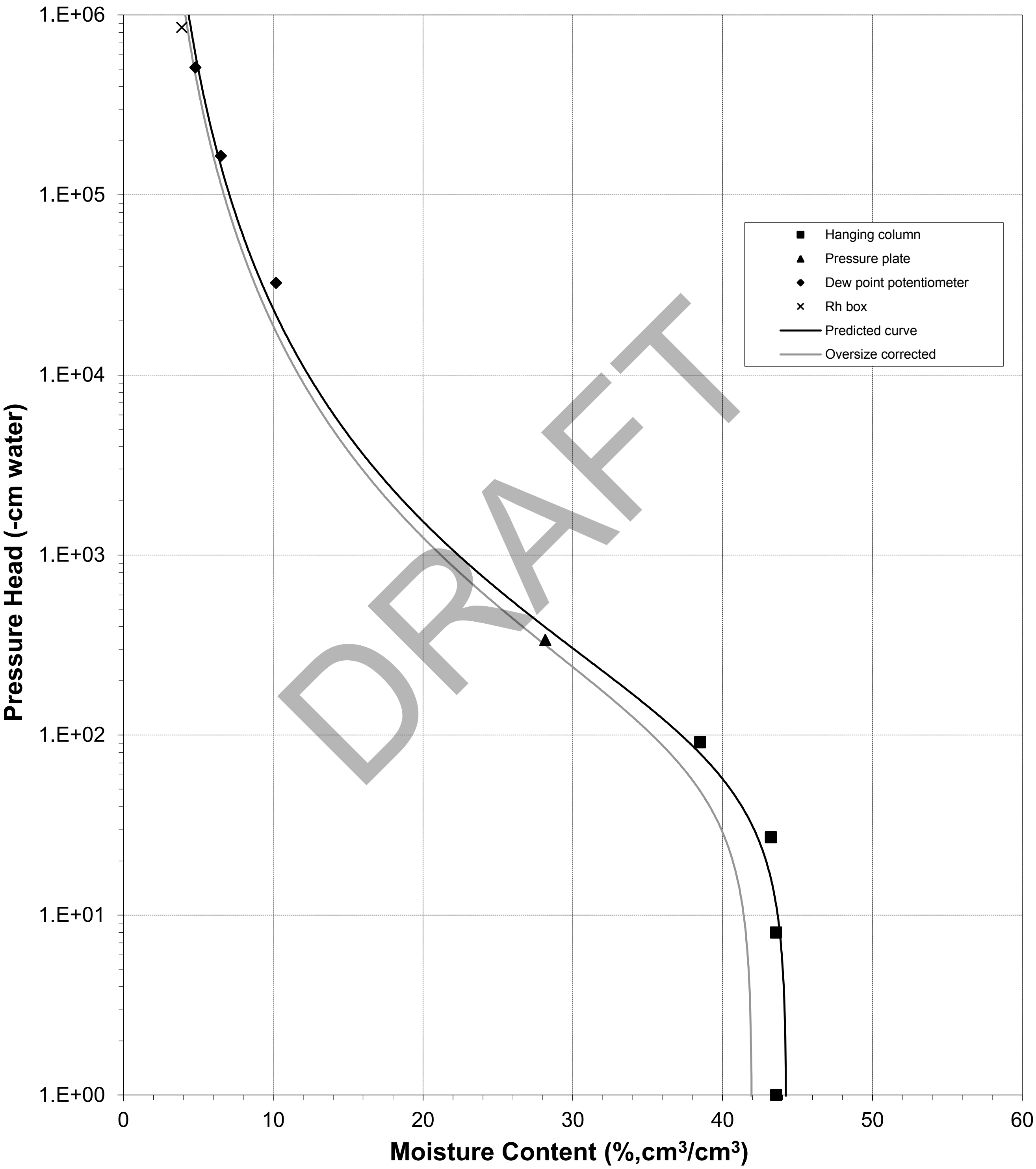
Water Retention Data Points

Sample Number: WB Stockpile-1 (85%, 1.52)



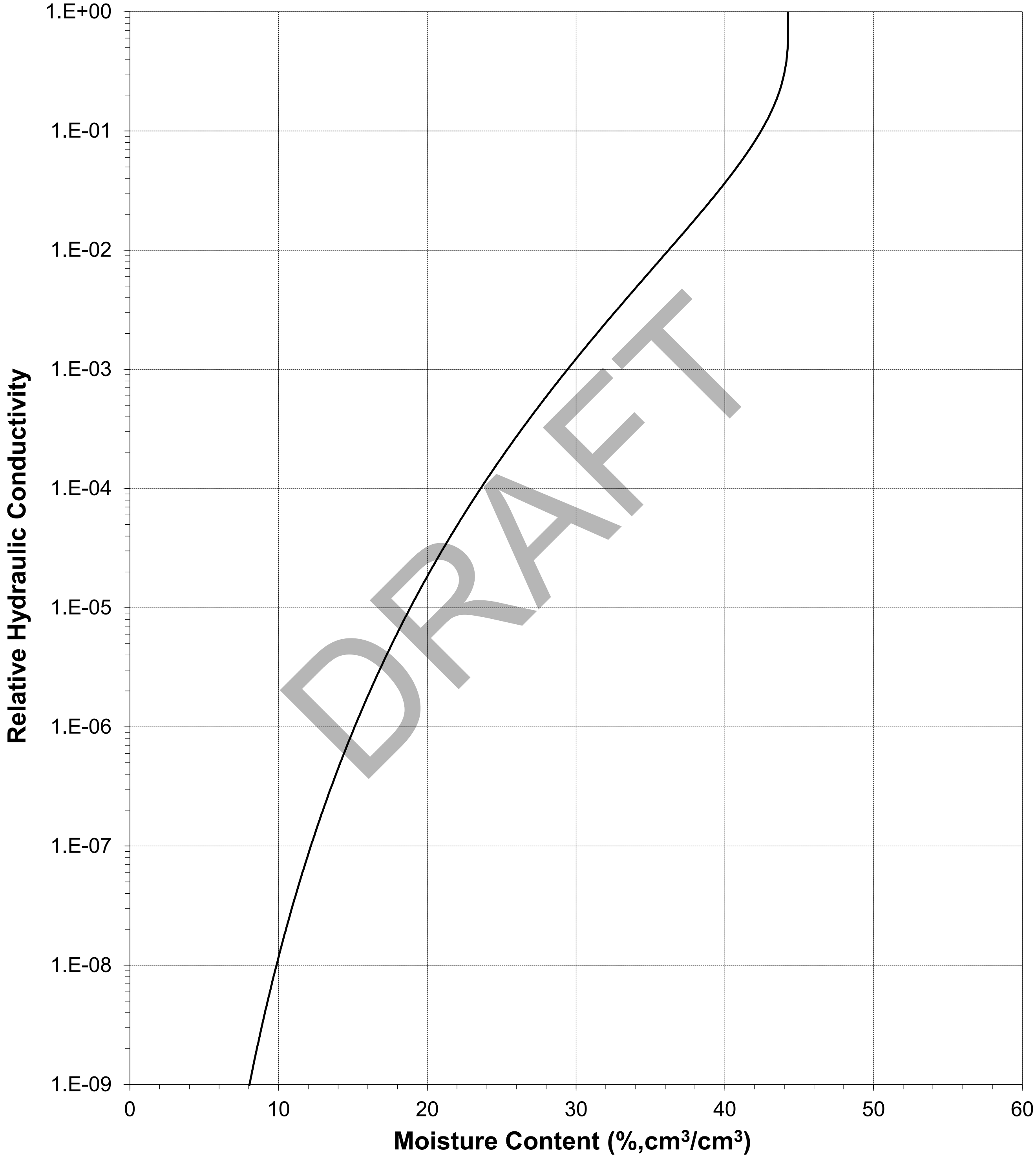
Predicted Water Retention Curve and Data Points

Sample Number: WB Stockpile-1 (85%, 1.52)



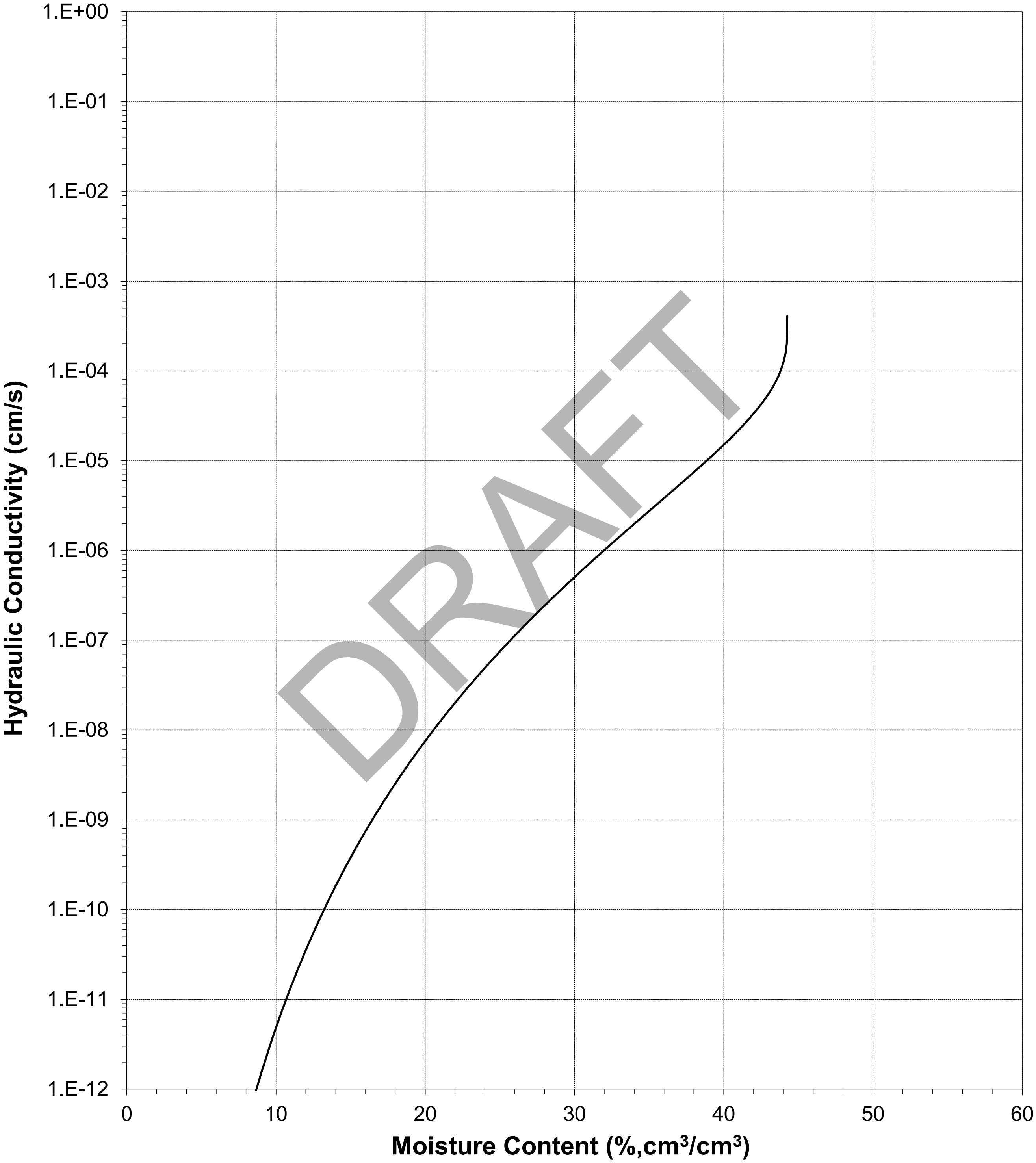
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: WB Stockpile-1 (85%, 1.52)



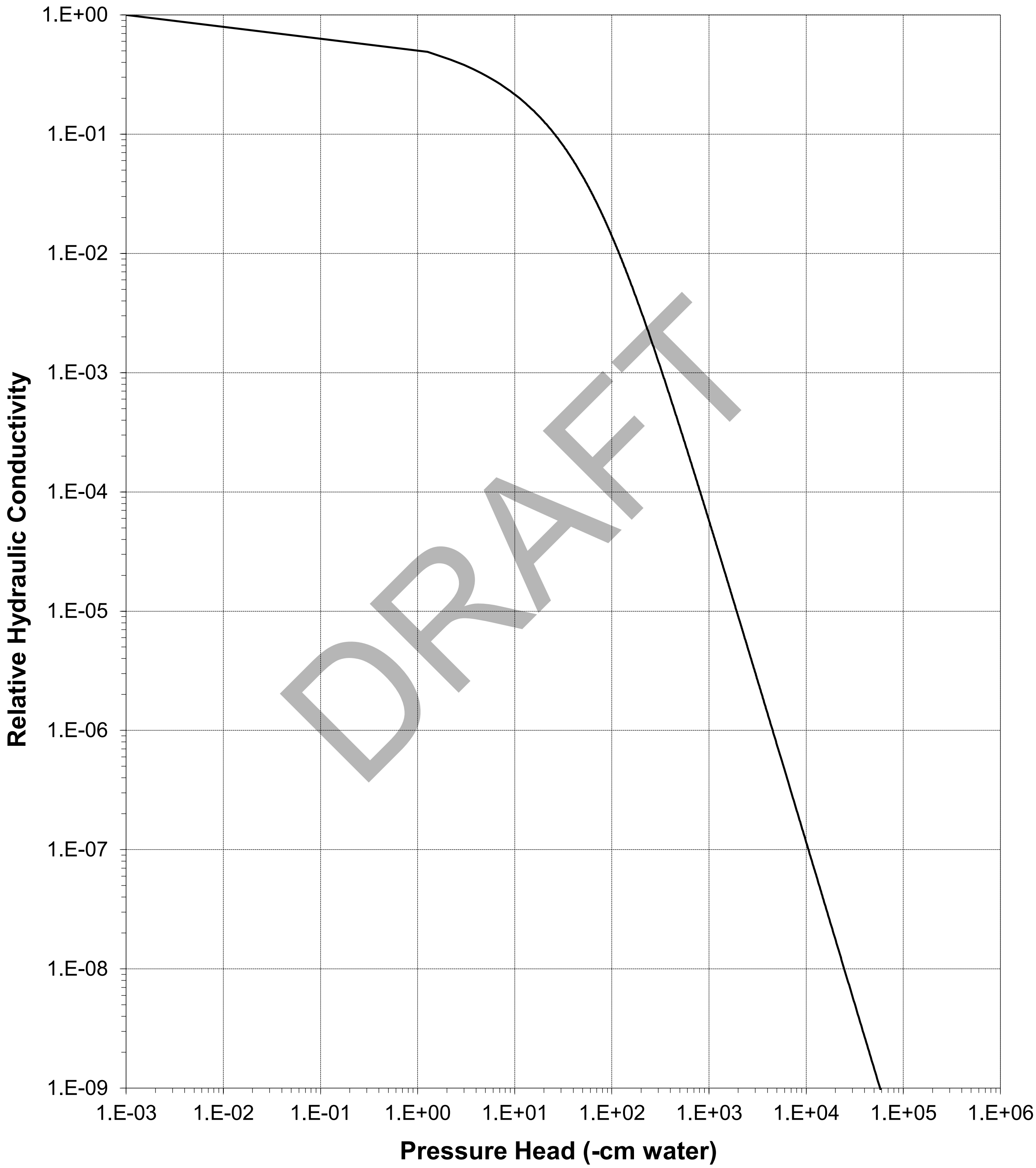
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: WB Stockpile-1 (85%, 1.52)



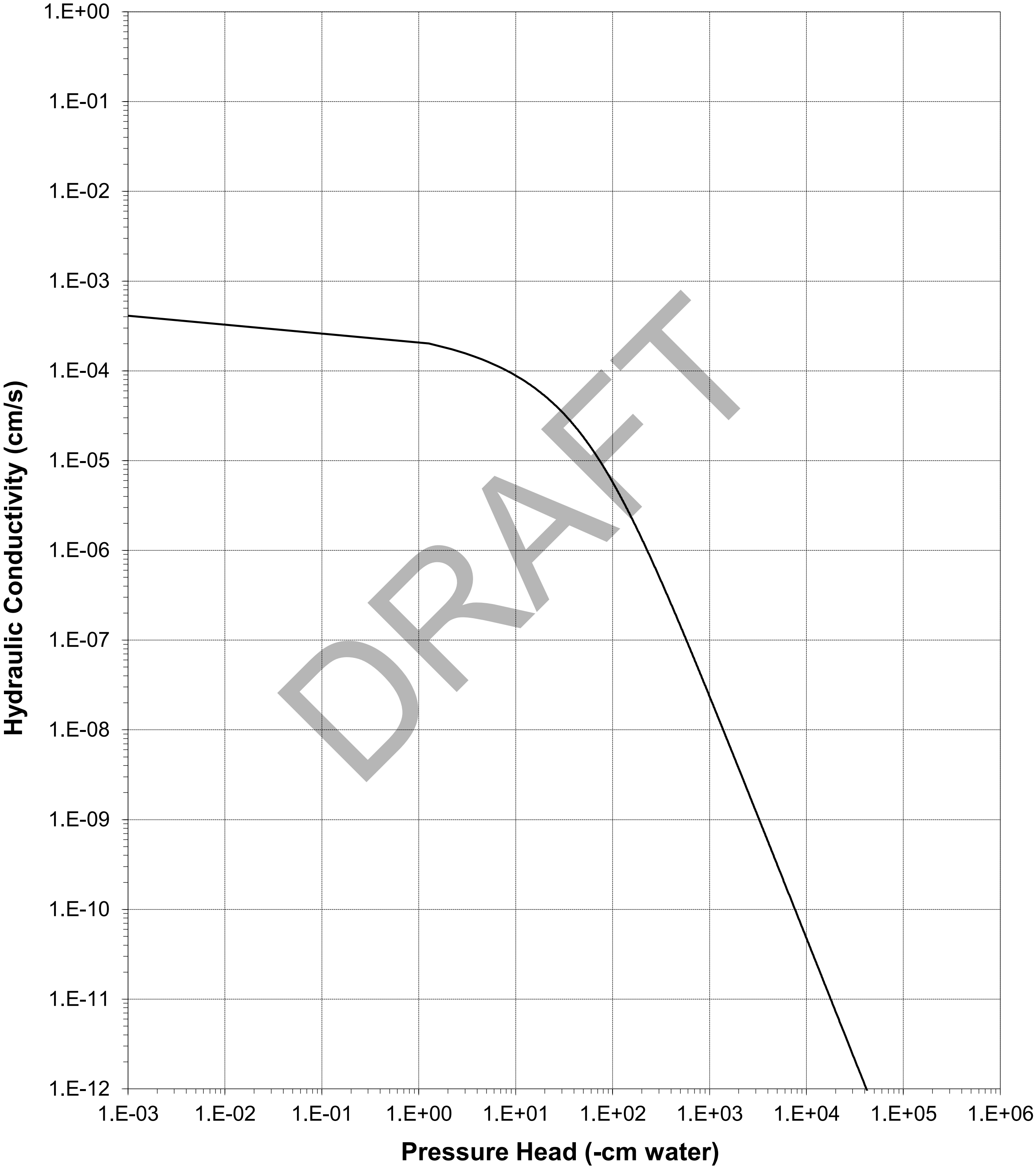
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: WB Stockpile-1 (85%, 1.52)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: WB Stockpile-1 (85%, 1.52)



Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-1 (85%, 1.52)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	8.73	91.27	100.00
Mass Fraction (%):	8.73	91.27	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.52	1.58
Calculated Porosity (% vol):	0.00	42.77	40.55
Volume of Solids (cm^3):	3.30	34.44	37.74
Volume of Voids (cm^3):	0.00	25.74	25.74
Total Volume (cm^3):	3.30	60.18	63.48
Volumetric Fraction (%):	5.19	94.81	100.00
Initial Moisture Content (% vol):	0.00	22.40	21.24
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.52	1.58
Calculated Porosity (% vol):	0.00	42.77	40.55
Volume of Solids (cm^3):	3.30	34.44	37.74
Volume of Voids (cm^3):	0.00	25.74	25.74
Total Volume (cm^3):	3.30	60.18	63.48
Volumetric Fraction (%):	5.19	94.81	100.00
Saturated Moisture Content (% vol):	0.00	44.26	41.97
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.52	1.58
Calculated Porosity (% vol):	0.00	42.77	40.55
Volume of Solids (cm^3):	3.30	34.44	37.74
Volume of Voids (cm^3):	0.00	25.74	25.74
Total Volume (cm^3):	3.30	60.18	63.48
Volumetric Fraction (%):	5.19	94.81	100.00
Residual Moisture Content (% vol):	0.00	1.45	1.38
Ksat (cm/sec):	NM	4.1E-04	3.8E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2 (85%, 1.48)
Project Name: VVL Composite Samples
PO Number: 12015

Dry wt. of sample (g): 167.66
Tare wt., ring (g): 72.21
Tare wt., screen & clamp (g): 28.05
Initial sample volume (cm^3): 113.33
Initial dry bulk density (g/cm^3): 1.48
Assumed particle density (g/cm^3): 2.65
Initial calculated total porosity (%): 44.17

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	3-Sep-14	11:50	320.31	0	46.23
	10-Sep-14	13:40	320.22	8.0	46.15
	17-Sep-14	10:45	319.64	29.0	45.64
	24-Sep-14	15:30	310.13	91.0	37.25
Pressure plate:	4-Oct-14	10:45	297.10	337	25.75

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Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	8.0	---	---	---	---
	29.0	---	---	---	---
	91.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: WB Stockpile-2 (85%, 1.48)

Initial sample bulk density (g/cm^3)*:* 1.48
Fraction of test sample used (<2.00mm fraction) (%): 73.14

Dry weight of dew point potentiometer sample* (g)*:* 155.61
Tare weight, jar (g)*:* 115.27

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	10-Sep-14	9:05	159.14	24883	9.47
	10-Sep-14	8:20	158.50	64961	7.75
	9-Sep-14	14:15	157.52	285646	5.12

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	24883	---	---	---	---
	64961	---	---	---	---
	285646	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 64.63
Tare weight (g)*:* 41.90

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	9-Sep-14	11:00	65.37	851293	3.53

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

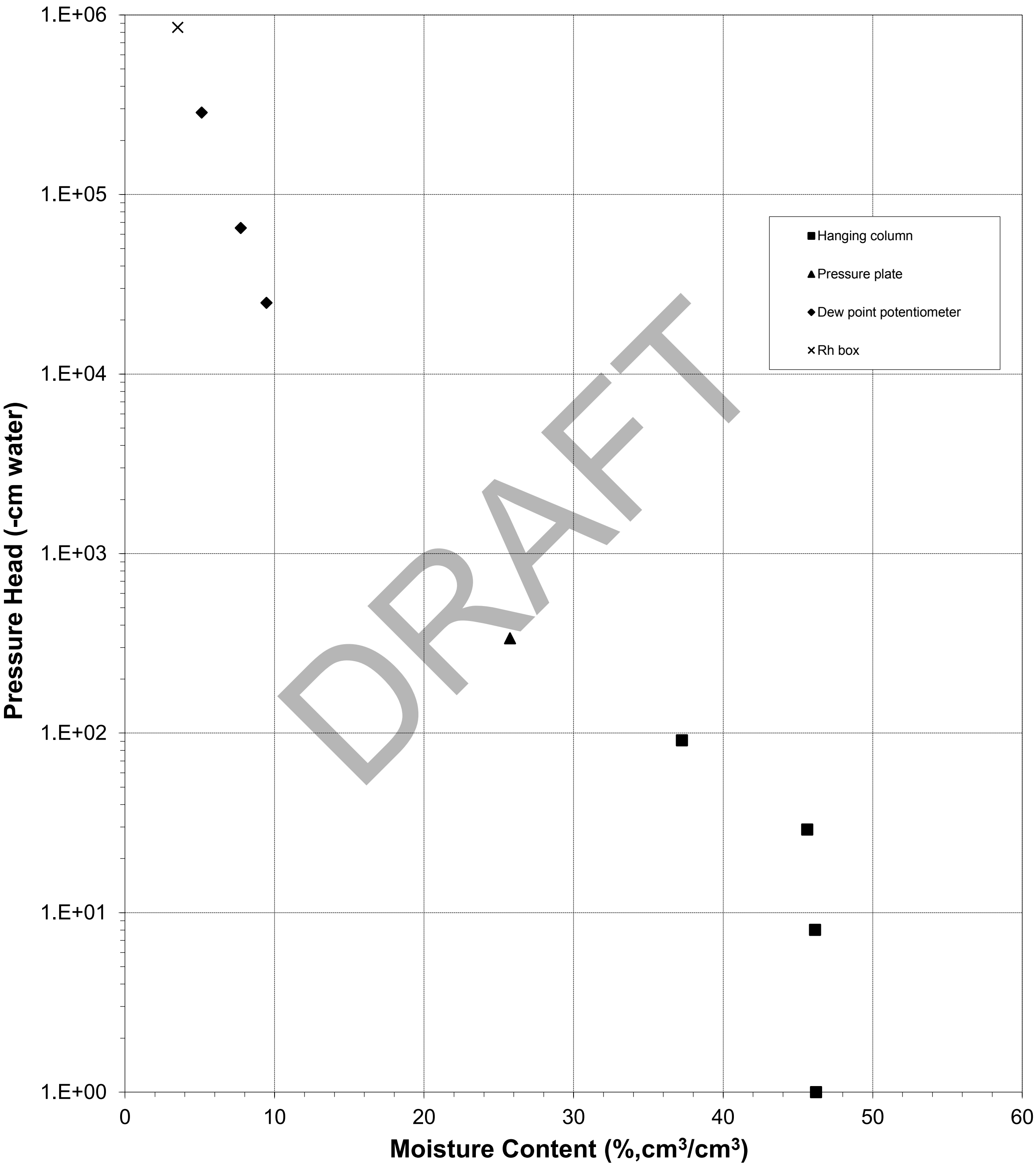
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

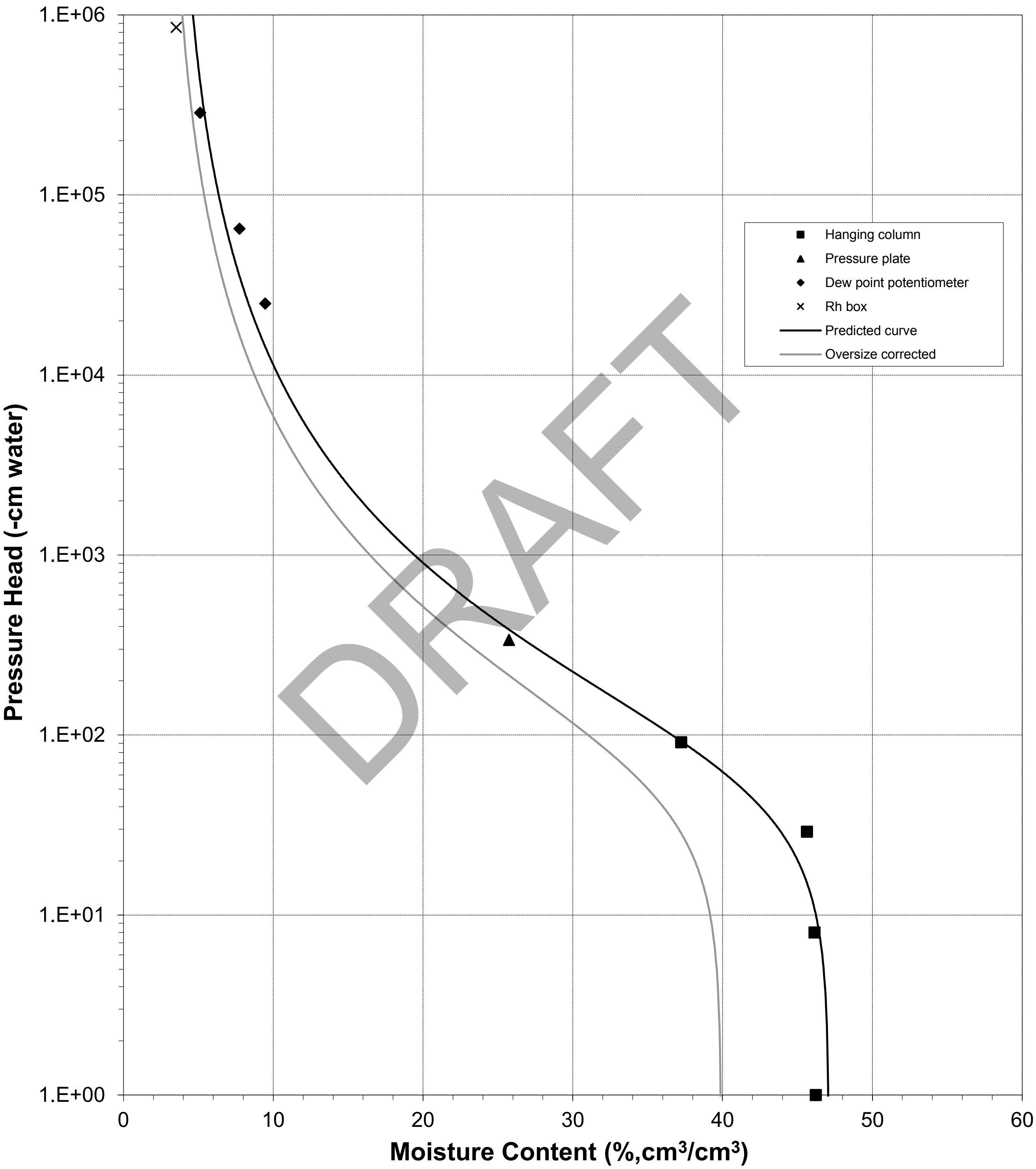
Water Retention Data Points

Sample Number: WB Stockpile-2 (85%, 1.48)



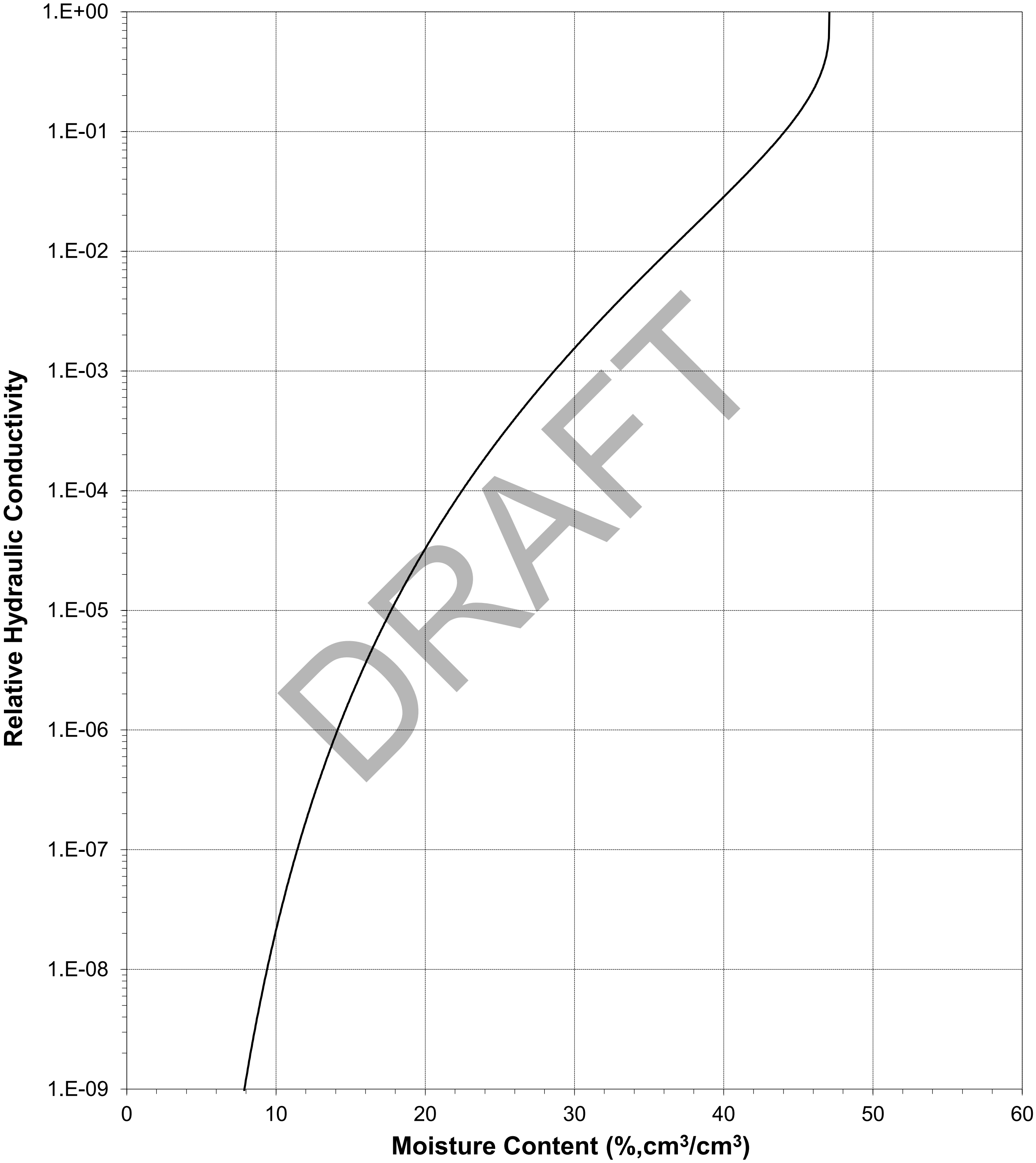
Predicted Water Retention Curve and Data Points

Sample Number: WB Stockpile-2 (85%, 1.48)



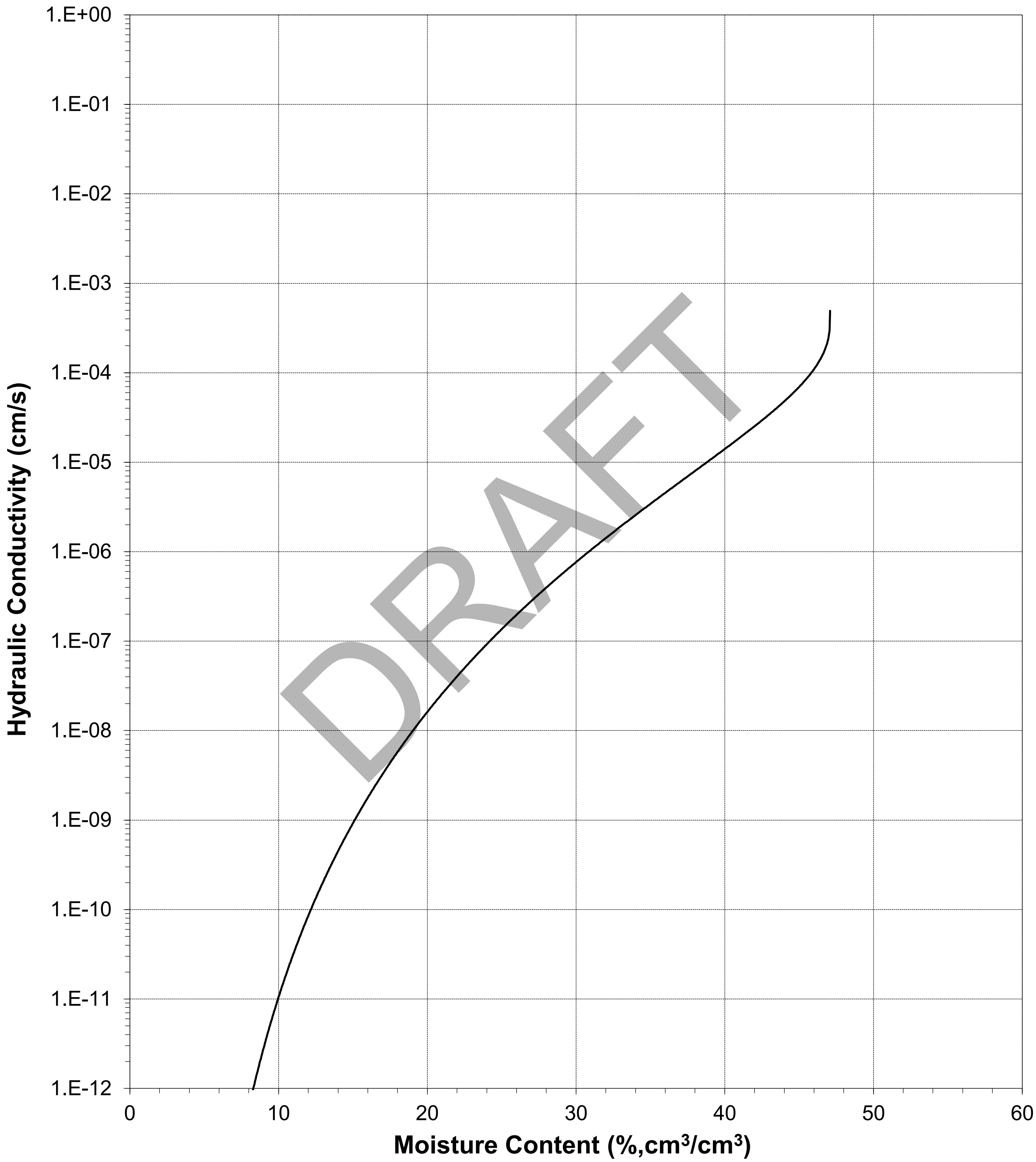
Plot of Relative Hydraulic Conductivity vs Moisture Content

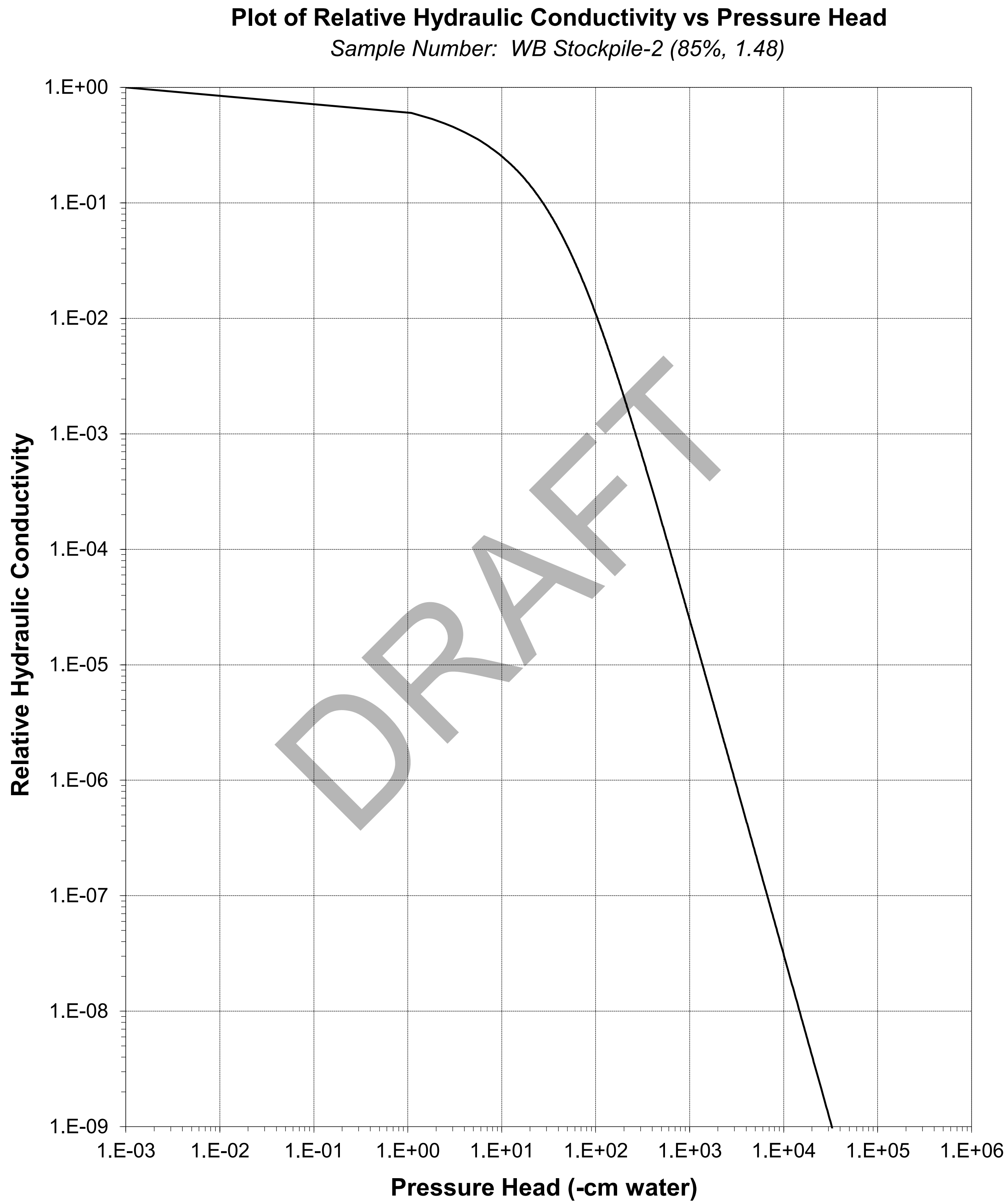
Sample Number: WB Stockpile-2 (85%, 1.48)



Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: WB Stockpile-2 (85%, 1.48)

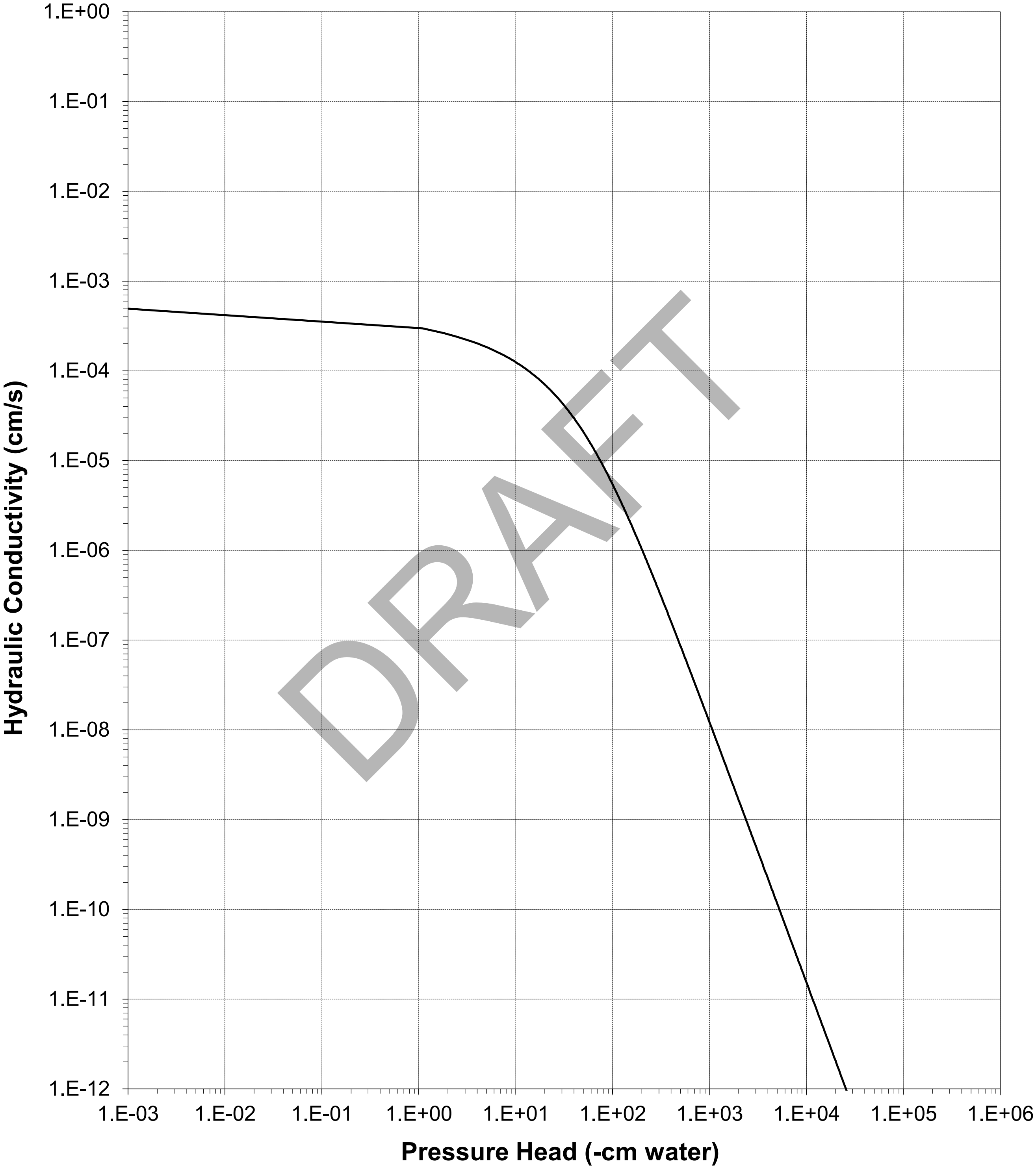




Plot of Relative Hydraulic Conductivity vs Pressure Head
Sample Number: WB Stockpile-2 (85%, 1.48)
Relative Hydraulic Conductivity
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
Pressure Head (-cm water)
DRAFT

Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: WB Stockpile-2 (85%, 1.48)



Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2 (85%, 1.48)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	24.42	75.58	100.00
Mass Fraction (%):	24.42	75.58	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.48	1.66
Calculated Porosity (% vol):	0.00	44.17	37.42
Volume of Solids (cm^3):	9.21	28.52	37.74
Volume of Voids (cm^3):	0.00	22.57	22.57
Total Volume (cm^3):	9.21	51.09	60.30
Volumetric Fraction (%):	15.28	84.72	100.00
Initial Moisture Content (% vol):	0.00	24.52	20.77
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.48	1.66
Calculated Porosity (% vol):	0.00	44.17	37.42
Volume of Solids (cm^3):	9.21	28.52	37.74
Volume of Voids (cm^3):	0.00	22.57	22.57
Total Volume (cm^3):	9.21	51.09	60.30
Volumetric Fraction (%):	15.28	84.72	100.00
Saturated Moisture Content (% vol):	0.00	47.09	39.90
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.48	1.66
Calculated Porosity (% vol):	0.00	44.17	37.42
Volume of Solids (cm^3):	9.21	28.52	37.74
Volume of Voids (cm^3):	0.00	22.57	22.57
Total Volume (cm^3):	9.21	51.09	60.30
Volumetric Fraction (%):	15.28	84.72	100.00
Residual Moisture Content (% vol):	0.00	3.35	2.83
Ksat (cm/sec):	NM	4.9E-04	3.7E-04

* = Porosity and moisture content of coarse fraction assumed to be zero.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.
NM = Not measured

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

Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	247.04
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	133.75
Sample Number:	Topsoil-1 (85%, 1.10)	*Tare wt., screen & clamp* (g):	27.21
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	224.14
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.10
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	58.41

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Hanging column:	3-Sep-14	12:00	539.82	0	58.81
	10-Sep-14	13:30	538.50	9.0	58.22
	17-Sep-14	10:30	538.08	30.0	58.04
	24-Sep-14	15:20	512.10	103.0	46.45
Pressure plate:	3-Oct-14	16:25	481.65	337	32.86

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	9.0	---	---	---	---
	30.0	---	---	---	---
	103.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: Topsoil-1 (85%, 1.10)

Initial sample bulk density (g/cm^3)*:* 1.10
Fraction of test sample used (<2.00mm fraction) (%): 96.44

Dry weight of dew point potentiometer sample* (g)*:* 143.78
Tare weight, jar (g)*:* 112.67

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Dew point potentiometer:	10-Sep-14	9:55	147.47	12646	12.61
	9-Sep-14	15:07	146.28	78729	8.54
	9-Sep-14	13:33	145.43	412101	5.64

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	12646	---	---	---	---
	78729	---	---	---	---
	412101	---	---	---	---

Dry weight of relative humidity box sample* (g)*:* 62.95
Tare weight (g)*:* 41.74

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
Relative humidity box:	9-Sep-14	11:00	63.82	851293	4.34

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	851293	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

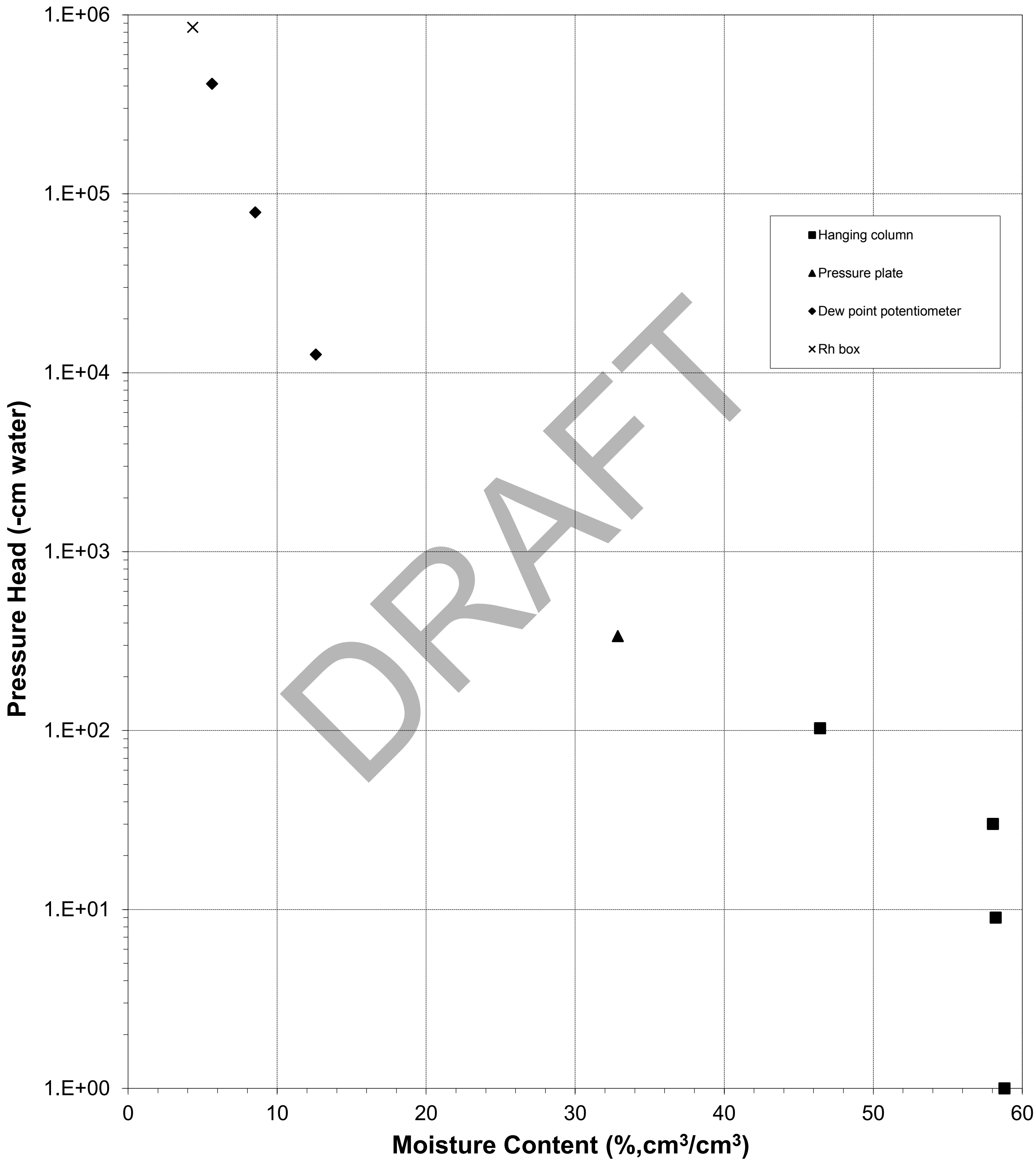
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

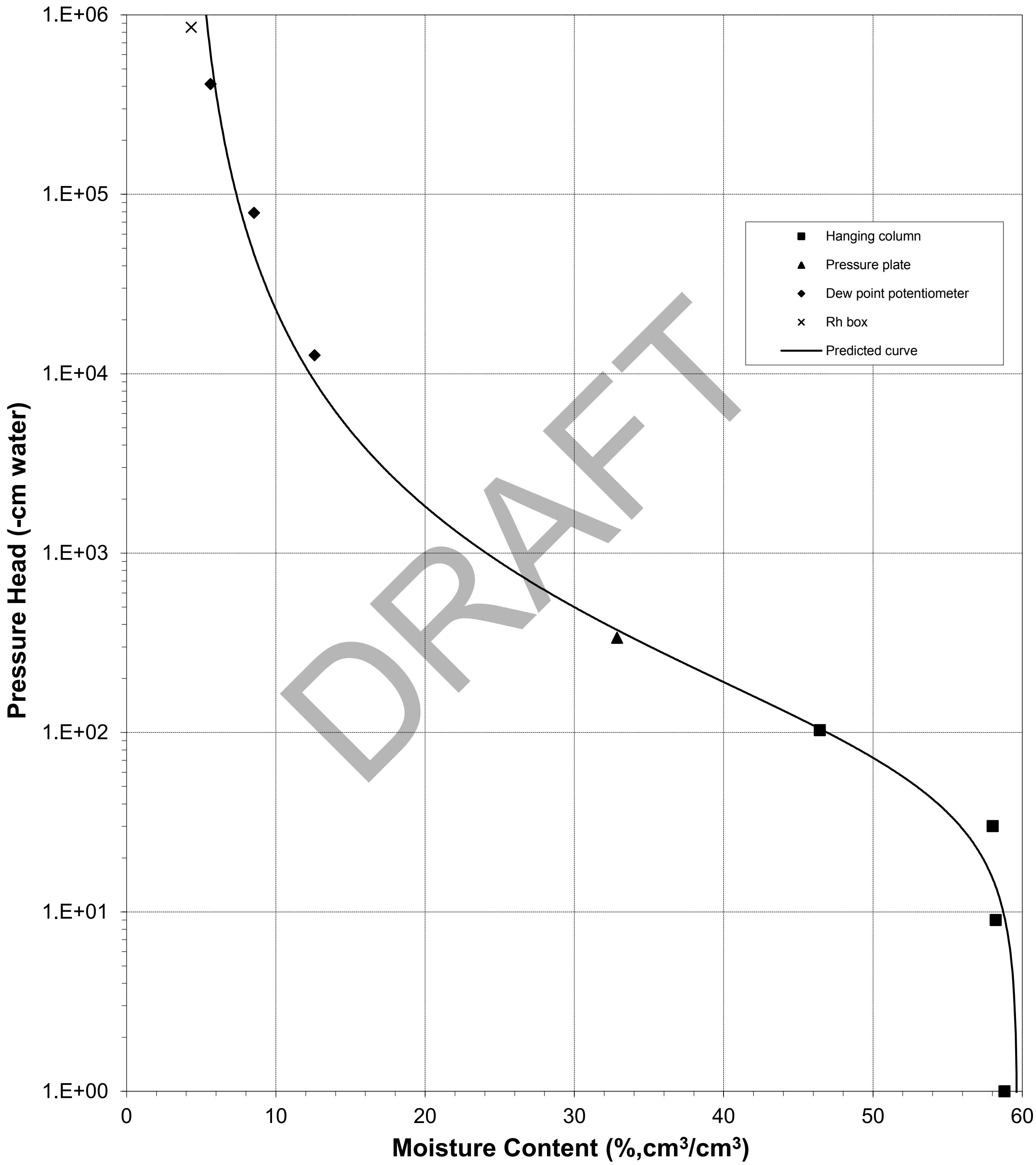
Water Retention Data Points

Sample Number: Topsoil-1 (85%, 1.10)



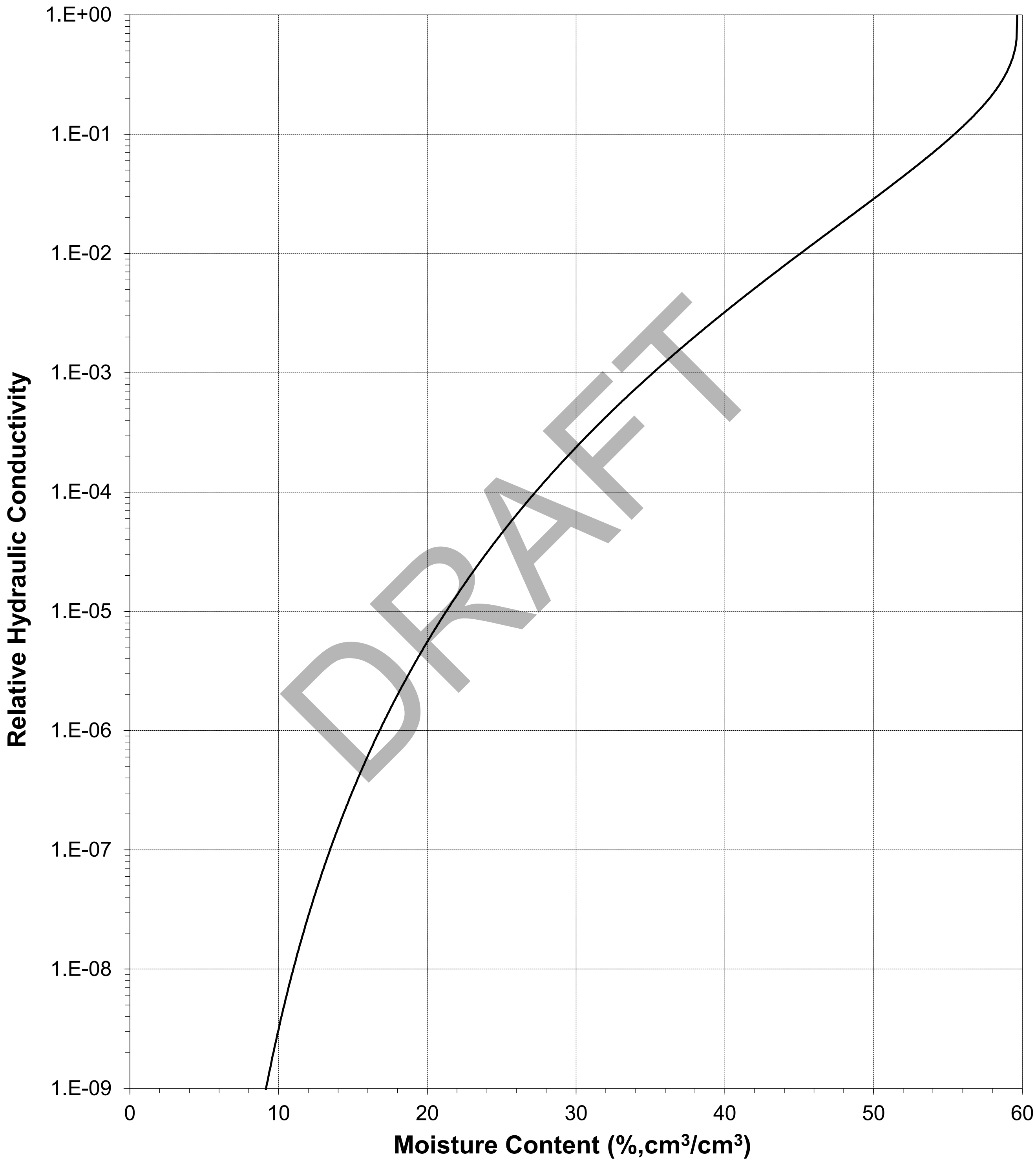
Predicted Water Retention Curve and Data Points

Sample Number: Topsoil-1 (85%, 1.10)



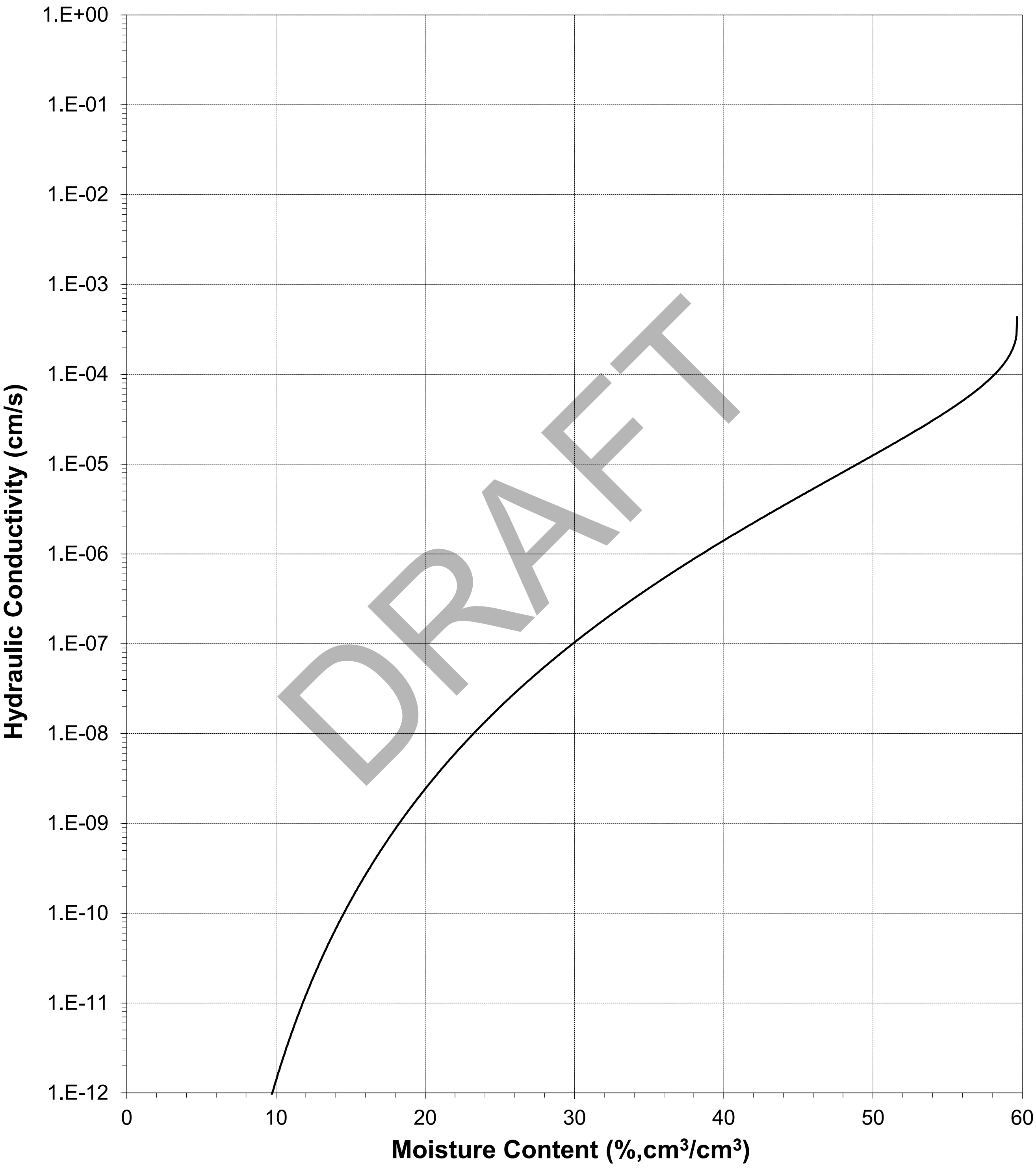
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: Topsoil-1 (85%, 1.10)



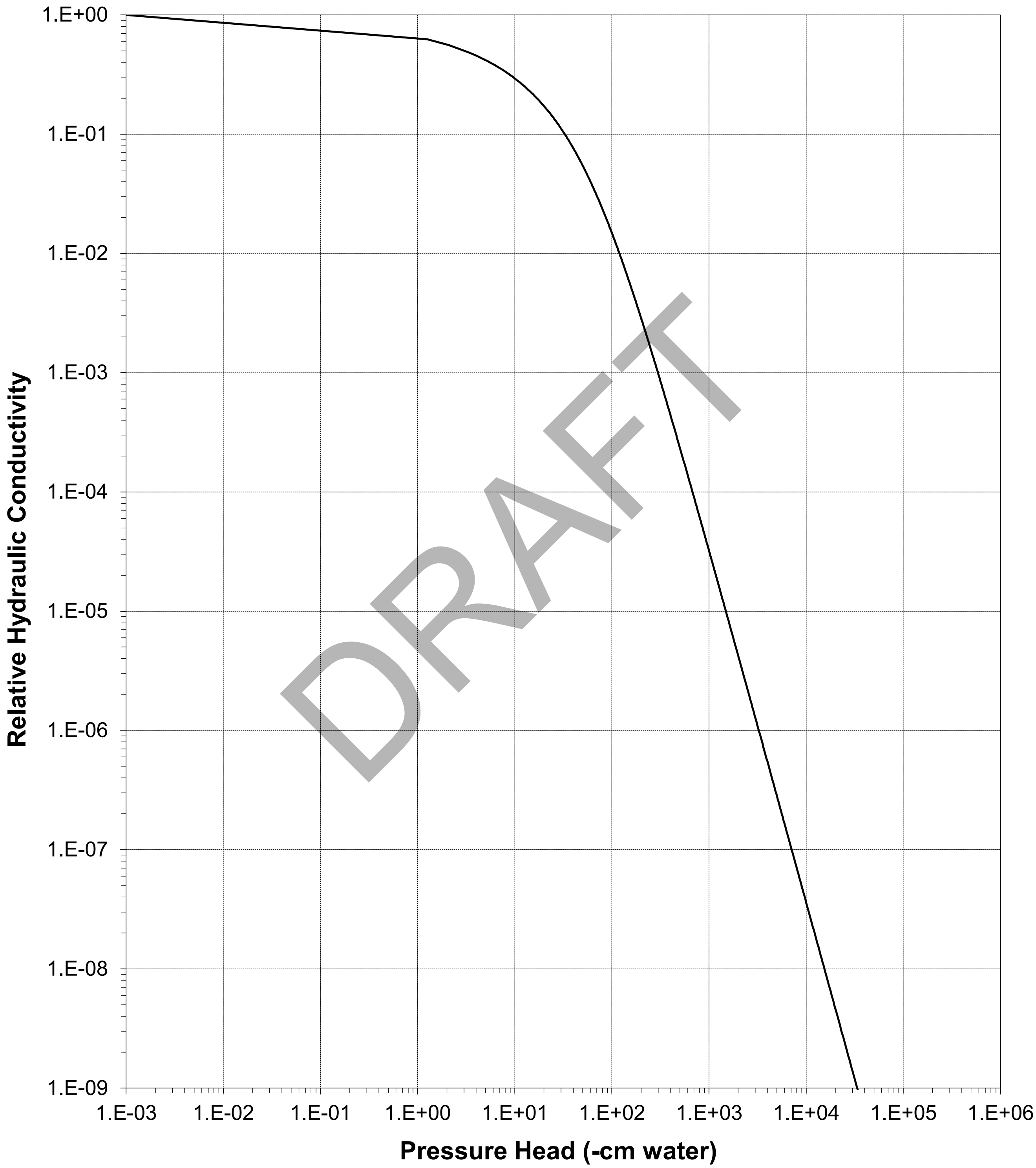
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: Topsoil-1 (85%, 1.10)



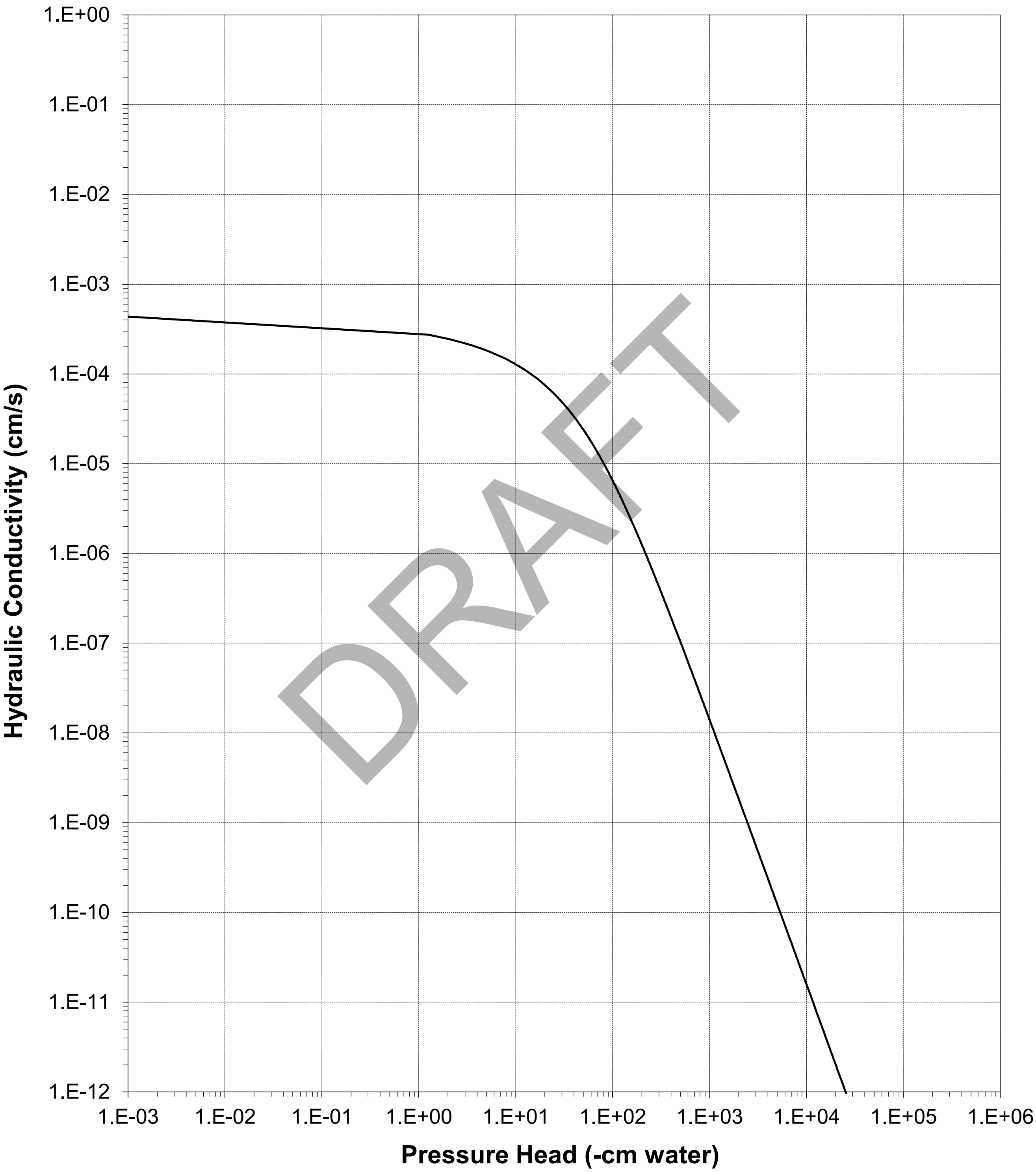
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: Topsoil-1 (85%, 1.10)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: Topsoil-1 (85%, 1.10)



Water Holding Capacity

Summary of Moisture Retention (-1/3 Bar, -15 Bar, and Water Holding Capacity*)

				Oversize Corrected		
Sample Number	-1/3 Bar Point Volumetric (%, cm^3/cm^3)	-15 Bar Point Volumetric (%, cm^3/cm^3)	Water Holding Capacity (%, cm^3/cm^3)	-1/3 Bar Point Volumetric (%, cm^3/cm^3)	-15 Bar Point Volumetric (%, cm^3/cm^3)	Water Holding Capacity (%, cm^3/cm^3)
VVL Composite 0-10 (85%, 1.46)	34.7	12.2	22.5	29.8	10.5	19.4
VVL Composite 11-15 (85%, 1.50)	27.2	8.1	19.2	24.0	7.1	16.9
VVL Composite 16-20 (85%, 1.45)	34.7	12.6	22.1	31.7	11.5	20.2
VVL Composite 21-30 (85%, 1.38)	36.0	13.3	22.7	31.7	11.7	20.0
VVL Composite 31+ (85%, 1.22)	46.6	21.5	25.0	43.8	20.2	23.6
VVL Composite TP-10 (85%, 1.51)	24.1	8.3	15.8	20.7	7.1	13.6
VVL Composite TP-12 (85%, 1.40)	36.9	14.6	22.2	32.4	12.9	19.6
VVL Composite TP-13 (85%, 1.37)	38.1	15.1	23.0	35.4	14.0	21.4
WB Borrow-1 (85%, 1.42)	26.4	11.0	15.4	24.5	10.3	14.3
WB Stockpile-1 (85%, 1.52)	28.2	11.1	17.1	26.7	10.5	16.2
WB Stockpile-2 (85%, 1.48)	25.7	9.3	16.4	21.8	7.9	13.9
Topsoil-1 (85%, 1.10)	32.9	11.0	21.9	---	---	---

*Water Holding Capacity (WHC) is defined here as the difference in the moisture content of the sample at -1/3 bar of water potential (commonly referred to as 'Field Capacity') and the moisture content of the sample at -15 bars of water potential (commonly referred to as 'Wilting Point').

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Pressure Plate
(-1/3 Bar)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3181.06
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	265.08
Sample Number:	VVL Composite 0-10 (85%, 1.46)	*Tare wt., screen & clamp* (g):	48.27
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2175.34
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.46
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	44.82

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Pressure plate:	8-Oct-14	13:05	4248.60	337	34.67

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	---	---	---	---

Moisture content at -1/3 bar (% cm^3/cm^3): 34.7

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 29.8

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer

(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10 (85%, 1.46)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.46
Fraction of test sample used (<2.00mm fraction) (%): 52.36

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)
-15 bar[3] :	NA	NA	NA	15297	12.17

Volume Adjusted Data[1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change[2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar[3] :	15297	---	---	---	---

Moisture content at -15 bars (% cm^3/cm^3): 12.2

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): 10.5

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10 (85%, 1.46)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	22.66	77.34	100.00
Mass Fraction (%):	22.66	77.34	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.46	1.63
Calculated Porosity (% vol):	0.00	44.82	38.58
Volume of Solids (cm^3):	8.55	29.19	37.74
Volume of Voids (cm^3):	0.00	23.70	23.70
Total Volume (cm^3):	8.55	52.89	61.44
Volumetric Fraction (%):	13.91	86.09	100.00
Initial Moisture Content (% vol):	0.00	24.10	20.75
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.46	1.63
Calculated Porosity (% vol):	0.00	44.82	44.82
Volume of Solids (cm^3):	8.55	29.19	37.74
Volume of Voids (cm^3):	0.00	23.70	23.70
Total Volume (cm^3):	8.55	52.89	61.44
Volumetric Fraction (%):	13.91	86.09	100.00
Moisture Content (% vol):	0.00	34.67	29.85
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.46	1.63
Calculated Porosity (% vol):	0.00	44.82	44.82
Volume of Solids (cm^3):	8.55	29.19	37.74
Volume of Voids (cm^3):	0.00	23.70	23.70
Total Volume (cm^3):	8.55	52.89	61.44
Volumetric Fraction (%):	13.91	86.09	100.00
Moisture Content (% vol):	0.00	12.17	10.47
Ksat (cm/sec):	NA	2.9E-04	2.2E-04

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3332.92
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	270.65
Sample Number:	VVL Composite 11-15 (85%, 1.50)	*Tare wt., screen & clamp* (g):	57.66
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2220.20
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.50
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	43.35

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)	
Pressure plate:	9-Oct-14	7:40	4259.00	337	27.24	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	2194.13	-1.17%	1.52	42.68

Moisture content at -1/3 bar (% cm^3/cm^3): 27.2

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 24.0

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Dew Point Potentiometer

(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 11-15 (85%, 1.50)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.50
Fraction of test sample used (<2.00mm fraction) (%): 56.44

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
-15 bar [3] *:*	NA	NA	NA	15297	8.08	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar [3] *:*	15297	2194.13	-1.17%	1.52	42.68

Moisture content at -15 bars (% cm^3/cm^3): **8.1**

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): **7.1**

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 11-15 (85%, 1.50)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	18.97	81.03	100.00
Mass Fraction (%):	18.97	81.03	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.50	1.64
Calculated Porosity (% vol):	0.00	43.35	38.28
Volume of Solids (cm^3):	7.16	30.58	37.74
Volume of Voids (cm^3):	0.00	23.40	23.40
Total Volume (cm^3):	7.16	53.98	61.14
Volumetric Fraction (%):	11.71	88.29	100.00
Initial Moisture Content (% vol):	0.00	20.94	18.49
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.52	1.65
Calculated Porosity (% vol):	0.00	42.68	42.68
Volume of Solids (cm^3):	7.16	30.58	37.74
Volume of Voids (cm^3):	0.00	22.77	22.77
Total Volume (cm^3):	7.16	53.34	60.50
Volumetric Fraction (%):	11.83	88.17	100.00
Moisture Content (% vol):	0.00	27.24	24.02
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.52	1.65
Calculated Porosity (% vol):	0.00	42.68	42.68
Volume of Solids (cm^3):	7.16	30.58	37.74
Volume of Voids (cm^3):	0.00	22.77	22.77
Total Volume (cm^3):	7.16	53.34	60.50
Volumetric Fraction (%):	11.83	88.17	100.00
Moisture Content (% vol):	0.00	8.08	7.13
Ksat (cm/sec):	NA	1.5E-03	1.2E-03

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite 16-20 (85%, 1.45)
Project Name:	VVL Composite Samples
PO Number:	12015

Dry wt. of sample (g):	3186.29
Tare wt., ring (g):	269.93
Tare wt., screen & clamp (g):	47.27
Initial sample volume (cm^3):	2194.77
Initial dry bulk density (g/cm^3):	1.45
Assumed particle density (g/cm^3):	2.65
Initial calculated total porosity (%):	45.22

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Pressure plate:	8-Oct-14	13:00	4264.80	337	34.69

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	---	---	---	---

Moisture content at -1/3 bar (% cm^3/cm^3): 34.7

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 31.7

Comments:

1 Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

2 Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data
Dew Point Potentiometer
(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 16-20 (85%, 1.45)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.45
Fraction of test sample used (<2.00mm fraction) (%): 57.04

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)
-15 bar[3] :	NA	NA	NA	15297	12.57

Volume Adjusted Data[1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change[2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar[3] :	15297	---	---	---	---

Moisture content at -15 bars (% cm^3/cm^3): 12.6

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): 11.5

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 16-20 (85%, 1.45)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	14.48	85.52	100.00
Mass Fraction (%):	14.48	85.52	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.45	1.55
Calculated Porosity (% vol):	0.00	45.22	41.38
Volume of Solids (cm^3):	5.46	32.27	37.74
Volume of Voids (cm^3):	0.00	26.64	26.64
Total Volume (cm^3):	5.46	58.91	64.37
Volumetric Fraction (%):	8.49	91.51	100.00
Initial Moisture Content (% vol):	0.00	24.76	22.66
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.45	1.55
Calculated Porosity (% vol):	0.00	45.22	45.22
Volume of Solids (cm^3):	5.46	32.27	37.74
Volume of Voids (cm^3):	0.00	26.64	26.64
Total Volume (cm^3):	5.46	58.91	64.37
Volumetric Fraction (%):	8.49	91.51	100.00
Moisture Content (% vol):	0.00	34.69	31.74
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.45	1.55
Calculated Porosity (% vol):	0.00	45.22	45.22
Volume of Solids (cm^3):	5.46	32.27	37.74
Volume of Voids (cm^3):	0.00	26.64	26.64
Total Volume (cm^3):	5.46	58.91	64.37
Volumetric Fraction (%):	8.49	91.51	100.00
Moisture Content (% vol):	0.00	12.57	11.50
Ksat (cm/sec):	NA	5.3E-04	4.5E-04

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3048.84
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	271.14
Sample Number:	VVL Composite 21-30 (85%, 1.38)	*Tare wt., screen & clamp* (g):	60.30
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2201.91
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.38
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	47.75

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Pressure plate:	8-Oct-14	12:40	4172.90	337	36.00

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	---	---	---	---

Moisture content at -1/3 bar (% cm^3/cm^3): 36.0

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 31.7

Comments:

1 Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

2 Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer

(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 21-30 (85%, 1.38)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.38
Fraction of test sample used (<2.00mm fraction) (%): 56.28

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
-15 bar [3] :	NA	NA	NA	15297	13.30

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar [3] :	15297	---	---	---	---

Moisture content at -15 bars (% cm^3/cm^3): **13.3**

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): **11.7**

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 21-30 (85%, 1.38)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	20.52	79.48	100.00
Mass Fraction (%):	20.52	79.48	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.38	1.54
Calculated Porosity (% vol):	0.00	47.75	42.07
Volume of Solids (cm^3):	7.74	29.99	37.74
Volume of Voids (cm^3):	0.00	27.41	27.41
Total Volume (cm^3):	7.74	57.40	65.14
Volumetric Fraction (%):	11.89	88.11	100.00
Initial Moisture Content (% vol):	0.00	25.09	22.11
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.38	1.54
Calculated Porosity (% vol):	0.00	47.75	47.75
Volume of Solids (cm^3):	7.74	29.99	37.74
Volume of Voids (cm^3):	0.00	27.41	27.41
Total Volume (cm^3):	7.74	57.40	65.14
Volumetric Fraction (%):	11.89	88.11	100.00
Moisture Content (% vol):	0.00	36.00	31.72
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.38	1.54
Calculated Porosity (% vol):	0.00	47.75	47.75
Volume of Solids (cm^3):	7.74	29.99	37.74
Volume of Voids (cm^3):	0.00	27.41	27.41
Total Volume (cm^3):	7.74	57.40	65.14
Volumetric Fraction (%):	11.89	88.11	100.00
Moisture Content (% vol):	0.00	13.30	11.72
Ksat (cm/sec):	NA	3.3E-04	2.6E-04

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+ (85%, 1.22)
Project Name: VVL Composite Samples
PO Number: 12015

Dry wt. of sample (g): 2700.23
Tare wt., ring (g): 272.82
Tare wt., screen & clamp (g): 67.12
Initial sample volume (cm^3): 2217.25
Initial dry bulk density (g/cm^3): 1.22
Assumed particle density (g/cm^3): 2.65
Initial calculated total porosity (%): 54.04

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Pressure plate:	4-Oct-14	10:45	4072.50	337	46.56

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	---	---	---	---

Moisture content at -1/3 bar (% cm^3/cm^3): 46.6

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 43.8

DRAFT

Comments:

1 Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

2 Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Dew Point Potentiometer
(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+ (85%, 1.22)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.22
Fraction of test sample used (<2.00mm fraction) (%): 78.45

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
-15 bar [3] *:*	NA	NA	NA	15297	21.51

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar [3] *:*	15297	---	---	---	---

Moisture content at -15 bars (% cm^3/cm^3): **21.5**

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): **20.2**

DRAFT

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+ (85%, 1.22)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	12.02	87.98	100.00
Mass Fraction (%):	12.02	87.98	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.22	1.30
Calculated Porosity (% vol):	0.00	54.04	50.85
Volume of Solids (cm^3):	4.54	33.20	37.74
Volume of Voids (cm^3):	0.00	39.04	39.04
Total Volume (cm^3):	4.54	72.24	76.78
Volumetric Fraction (%):	5.91	94.09	100.00
Initial Moisture Content (% vol):	0.00	33.05	31.10
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.22	1.30
Calculated Porosity (% vol):	0.00	54.04	54.04
Volume of Solids (cm^3):	4.54	33.20	37.74
Volume of Voids (cm^3):	0.00	39.04	39.04
Total Volume (cm^3):	4.54	72.24	76.78
Volumetric Fraction (%):	5.91	94.09	100.00
Moisture Content (% vol):	0.00	46.56	43.81
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.22	1.30
Calculated Porosity (% vol):	0.00	54.04	54.04
Volume of Solids (cm^3):	4.54	33.20	37.74
Volume of Voids (cm^3):	0.00	39.04	39.04
Total Volume (cm^3):	4.54	72.24	76.78
Volumetric Fraction (%):	5.91	94.09	100.00
Moisture Content (% vol):	0.00	21.51	20.24
Ksat (cm/sec):	NA	1.1E-04	9.5E-05

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3342.18
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	272.60
Sample Number:	VVL Composite TP-10 (85%, 1.51)	*Tare wt., screen & clamp* (g):	53.78
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2220.60
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.51
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	43.20

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)	
Pressure plate:	4-Oct-14	10:30	4174.90	337	24.15	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	2096.96	-5.57%	1.59	39.86

Moisture content at -1/3 bar (% cm^3/cm^3): 24.1

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 20.7

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Dew Point Potentiometer
(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10 (85%, 1.51)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.51
Fraction of test sample used (<2.00mm fraction) (%): 63.04

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
-15 bar [3] *:*	NA	NA	NA	15297	8.31	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar [3] *:*	15297	2096.96	-5.57%	1.59	39.86

Moisture content at -15 bars (% cm^3/cm^3): **8.3**

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): **7.1**

DRAFT

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10 (85%, 1.51)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	21.58	78.42	100.00
Mass Fraction (%):	21.58	78.42	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.51	1.66
Calculated Porosity (% vol):	0.00	43.20	37.36
Volume of Solids (cm^3):	8.14	29.59	37.74
Volume of Voids (cm^3):	0.00	22.51	22.51
Total Volume (cm^3):	8.14	52.10	60.25
Volumetric Fraction (%):	13.52	86.48	100.00
Initial Moisture Content (% vol):	0.00	23.65	20.46
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.59	1.74
Calculated Porosity (% vol):	0.00	39.86	39.86
Volume of Solids (cm^3):	8.14	29.59	37.74
Volume of Voids (cm^3):	0.00	19.61	19.61
Total Volume (cm^3):	8.14	49.20	57.34
Volumetric Fraction (%):	14.20	85.80	100.00
Moisture Content (% vol):	0.00	24.15	20.72
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.59	1.74
Calculated Porosity (% vol):	0.00	39.86	39.86
Volume of Solids (cm^3):	8.14	29.59	37.74
Volume of Voids (cm^3):	0.00	19.61	19.61
Total Volume (cm^3):	8.14	49.20	57.34
Volumetric Fraction (%):	14.20	85.80	100.00
Moisture Content (% vol):	0.00	8.31	7.13
Ksat (cm/sec):	NA	2.5E-03	2.0E-03

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12 (85%, 1.40)
Project Name: VVL Composite Samples
PO Number: 12015

Dry wt. of sample (g): 3091.19
Tare wt., ring (g): 270.01
Tare wt., screen & clamp (g): 56.79
Initial sample volume (cm^3): 2203.81
Initial dry bulk density (g/cm^3): 1.40
Assumed particle density (g/cm^3): 2.65
Initial calculated total porosity (%): 47.07

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)	
Pressure plate:	4-Oct-14	10:37	4184.50	337	36.86	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	2079.65	-5.63%	1.49	43.91

Moisture content at -1/3 bar (% cm^3/cm^3): 36.9

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 32.4

DRAFT

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Dew Point Potentiometer

(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12 (85%, 1.40)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.40
Fraction of test sample used (<2.00mm fraction) (%): 60.23

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content[†] (% vol)	
-15 bar[3] :	NA	NA	NA	15297	14.62	‡‡

Volume Adjusted Data[1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change[2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar[3] :	15297	2079.65	-5.63%	1.49	43.91

Moisture content at -15 bars (% cm^3/cm^3): 14.6

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): 12.9

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12 (85%, 1.40)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	19.61	80.39	100.00
Mass Fraction (%):	19.61	80.39	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.40	1.55
Calculated Porosity (% vol):	0.00	47.07	41.69
Volume of Solids (cm^3):	7.40	30.33	37.74
Volume of Voids (cm^3):	0.00	26.98	26.98
Total Volume (cm^3):	7.40	57.31	64.71
Volumetric Fraction (%):	11.44	88.56	100.00
Initial Moisture Content (% vol):	0.00	26.07	23.09
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.49	1.63
Calculated Porosity (% vol):	0.00	43.91	43.91
Volume of Solids (cm^3):	7.40	30.33	37.74
Volume of Voids (cm^3):	0.00	23.75	23.75
Total Volume (cm^3):	7.40	54.08	61.48
Volumetric Fraction (%):	12.04	87.96	100.00
Moisture Content (% vol):	0.00	36.86	32.42
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.49	1.63
Calculated Porosity (% vol):	0.00	43.91	43.91
Volume of Solids (cm^3):	7.40	30.33	37.74
Volume of Voids (cm^3):	0.00	23.75	23.75
Total Volume (cm^3):	7.40	54.08	61.48
Volumetric Fraction (%):	12.04	87.96	100.00
Moisture Content (% vol):	0.00	14.62	12.86
Ksat (cm/sec):	NA	1.2E-04	9.6E-05

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	3086.05
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	275.53
Sample Number:	VVL Composite TP-13 (85%, 1.37)	*Tare wt., screen & clamp* (g):	55.27
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	2250.16
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.37
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	48.25

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Pressure plate:	8-Oct-14	12:48	4289.80	337	38.10	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	2291.03	+1.82%	1.35	49.17

Moisture content at -1/3 bar (% cm^3/cm^3): **38.1**

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): **35.4**

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer

(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-13 (85%, 1.37)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.37
Fraction of test sample used (<2.00mm fraction) (%): 65.88

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
-15 bar[3] :	NA	NA	NA	15297	15.07	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar[3] :	15297	2291.03	+1.82%	1.35	49.17

Moisture content at -15 bars (% cm^3/cm^3): **15.1**

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): **14.0**

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-13 (85%, 1.37)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): 3/4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	13.14	86.86	100.00
Mass Fraction (%):	13.14	86.86	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.37	1.46
Calculated Porosity (% vol):	0.00	48.25	44.74
Volume of Solids (cm^3):	4.96	32.78	37.74
Volume of Voids (cm^3):	0.00	30.56	30.56
Total Volume (cm^3):	4.96	63.33	68.29
Volumetric Fraction (%):	7.26	92.74	100.00
Initial Moisture Content (% vol):	0.00	28.91	26.81
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.35	1.44
Calculated Porosity (% vol):	0.00	49.17	49.17
Volume of Solids (cm^3):	4.96	32.78	37.74
Volume of Voids (cm^3):	0.00	31.71	31.71
Total Volume (cm^3):	4.96	64.49	69.44
Volumetric Fraction (%):	7.14	92.86	100.00
Moisture Content (% vol):	0.00	38.10	35.38
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.35	1.44
Calculated Porosity (% vol):	0.00	49.17	49.17
Volume of Solids (cm^3):	4.96	32.78	37.74
Volume of Voids (cm^3):	0.00	31.71	31.71
Total Volume (cm^3):	4.96	64.49	69.44
Volumetric Fraction (%):	7.14	92.86	100.00
Moisture Content (% vol):	0.00	15.07	13.99
Ksat (cm/sec):	NA	2.6E-04	2.3E-04

DRAFT

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Moisture Retention Data
Pressure Plate
(-1/3 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Borrow-1 (85%, 1.42)
Project Name: VVL Composite Samples
PO Number: 12015

Dry wt. of sample (g): 164.29
Tare wt., ring (g): 53.27
Tare wt., screen & clamp (g): 25.51
Initial sample volume (cm^3): 115.77
Initial dry bulk density (g/cm^3): 1.42
Assumed particle density (g/cm^3): 2.65
Initial calculated total porosity (%): 46.45

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Pressure plate:	3-Oct-14	16:25	273.63	337	26.40

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	---	---	---	---

Moisture content at -1/3 bar (% cm^3/cm^3): 26.4

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 24.5

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data
Dew Point Potentiometer
(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Borrow-1 (85%, 1.42)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.42
Fraction of test sample used (<2.00mm fraction) (%): 82.87

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
-15 bar [3] :	NA	NA	NA	15297	11.03

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar [3] :	15297	---	---	---	---

Moisture content at -15 bars (% cm^3/cm^3): 11.0

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): 10.3

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Daniel B. Stephens & Associates, Inc.

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Borrow-1 (85%, 1.42)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	12.36	87.64	100.00
Mass Fraction (%):	12.36	87.64	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.42	1.51
Calculated Porosity (% vol):	0.00	46.45	43.19
Volume of Solids (cm^3):	4.66	33.07	37.74
Volume of Voids (cm^3):	0.00	28.68	28.68
Total Volume (cm^3):	4.66	61.76	66.42
Volumetric Fraction (%):	7.02	92.98	100.00
Initial Moisture Content (% vol):	0.00	25.97	24.15
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.42	1.51
Calculated Porosity (% vol):	0.00	46.45	46.45
Volume of Solids (cm^3):	4.66	33.07	37.74
Volume of Voids (cm^3):	0.00	28.68	28.68
Total Volume (cm^3):	4.66	61.76	66.42
Volumetric Fraction (%):	7.02	92.98	100.00
Moisture Content (% vol):	0.00	26.40	24.54
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.42	1.51
Calculated Porosity (% vol):	0.00	46.45	46.45
Volume of Solids (cm^3):	4.66	33.07	37.74
Volume of Voids (cm^3):	0.00	28.68	28.68
Total Volume (cm^3):	4.66	61.76	66.42
Volumetric Fraction (%):	7.02	92.98	100.00
Moisture Content (% vol):	0.00	11.03	10.26
Ksat (cm/sec):	NA	5.0E-04	4.4E-04

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	181.10
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	55.22
Sample Number:	WB Stockpile-1 (85%, 1.52)	*Tare wt., screen & clamp* (g):	27.82
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	119.42
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.52
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	42.77

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content † (% vol)
Pressure plate:	4-Oct-14	10:45	297.78	337	28.17

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	---	---	---	---

Moisture content at -1/3 bar (% cm^3/cm^3): 28.2

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 26.7

Comments:

1 Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

2 Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Dew Point Potentiometer
(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-1 (85%, 1.52)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.52
Fraction of test sample used (<2.00mm fraction) (%): 88.43

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
-15 bar[3] :	NA	NA	NA	15297	11.08

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar[3] :	15297	---	---	---	---

Moisture content at -15 bars (% cm^3/cm^3): 11.1

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): 10.5

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-1 (85%, 1.52)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	8.73	91.27	100.00
Mass Fraction (%):	8.73	91.27	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.52	1.58
Calculated Porosity (% vol):	0.00	42.77	40.55
Volume of Solids (cm^3):	3.30	34.44	37.74
Volume of Voids (cm^3):	0.00	25.74	25.74
Total Volume (cm^3):	3.30	60.18	63.48
Volumetric Fraction (%):	5.19	94.81	100.00
Initial Moisture Content (% vol):	0.00	22.40	21.24
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.52	1.58
Calculated Porosity (% vol):	0.00	42.77	42.77
Volume of Solids (cm^3):	3.30	34.44	37.74
Volume of Voids (cm^3):	0.00	25.74	25.74
Total Volume (cm^3):	3.30	60.18	63.48
Volumetric Fraction (%):	5.19	94.81	100.00
Moisture Content (% vol):	0.00	28.17	26.71
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.52	1.58
Calculated Porosity (% vol):	0.00	42.77	42.77
Volume of Solids (cm^3):	3.30	34.44	37.74
Volume of Voids (cm^3):	0.00	25.74	25.74
Total Volume (cm^3):	3.30	60.18	63.48
Volumetric Fraction (%):	5.19	94.81	100.00
Moisture Content (% vol):	0.00	11.08	10.51
Ksat (cm/sec):	NA	4.1E-04	3.8E-04

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Pressure Plate
(-1/3 Bar)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	167.66
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	72.21
Sample Number:	WB Stockpile-2 (85%, 1.48)	*Tare wt., screen & clamp* (g):	28.05
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	113.33
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.48
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	44.17

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Pressure plate:	4-Oct-14	10:45	297.10	337	25.75

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	---	---	---	---

Moisture content at -1/3 bar (% cm^3/cm^3): 25.7

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): 21.8

DRAFT

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer

(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2 (85%, 1.48)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.48
Fraction of test sample used (<2.00mm fraction) (%): 73.14

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
-15 bar [3] :	NA	NA	NA	15297	9.34

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar [3] :	15297	---	---	---	---

Moisture content at -15 bars (% cm^3/cm^3): 9.3

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): 7.9

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Oversize Correction Data Sheet

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2 (85%, 1.48)
Project Name: VVL Composite Samples
PO Number: 12015

Split (3/4", 3/8", #4): #4

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	24.42	75.58	100.00
Mass Fraction (%):	24.42	75.58	100.00
Initial Sample			
Bulk Density (g/cm^3):	2.65	1.48	1.66
Calculated Porosity (% vol):	0.00	44.17	37.42
Volume of Solids (cm^3):	9.21	28.52	37.74
Volume of Voids (cm^3):	0.00	22.57	22.57
Total Volume (cm^3):	9.21	51.09	60.30
Volumetric Fraction (%):	15.28	84.72	100.00
Initial Moisture Content (% vol):	0.00	24.52	20.77
Sample at -1/3 Bar			
Bulk Density (g/cm^3):	2.65	1.48	1.66
Calculated Porosity (% vol):	0.00	44.17	44.17
Volume of Solids (cm^3):	9.21	28.52	37.74
Volume of Voids (cm^3):	0.00	22.57	22.57
Total Volume (cm^3):	9.21	51.09	60.30
Volumetric Fraction (%):	15.28	84.72	100.00
Moisture Content (% vol):	0.00	25.75	21.81
Sample at -15 Bar			
Bulk Density (g/cm^3):	2.65	1.48	1.66
Calculated Porosity (% vol):	0.00	44.17	44.17
Volume of Solids (cm^3):	9.21	28.52	37.74
Volume of Voids (cm^3):	0.00	22.57	22.57
Total Volume (cm^3):	9.21	51.09	60.30
Volumetric Fraction (%):	15.28	84.72	100.00
Moisture Content (% vol):	0.00	9.34	7.91
Ksat (cm/sec):	NA	4.9E-04	3.7E-04

DRAFT

NA = Not analyzed
* = Porosity and moisture content of coarse fraction assumed to be zero, and coarse fraction bulk density assumed to be equal to particle density.
** = Volume adjusted, if applicable. See notes on Moisture Retention Data pages.

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Pressure Plate

(-1/3 Bar)

Job Name:	Hydrometrics, Inc.	*Dry wt. of sample* (g):	247.04
Job Number:	LB14.0168.00	*Tare wt., ring* (g):	133.75
Sample Number:	Topsoil-1 (85%, 1.10)	*Tare wt., screen & clamp* (g):	27.21
Project Name:	VVL Composite Samples	*Initial sample volume* (cm^3):	224.14
PO Number:	12015	*Initial dry bulk density* (g/cm^3):	1.10
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	58.41

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Pressure plate:	3-Oct-14	16:25	481.65	337	32.86

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Pressure plate:	337	---	---	---	---

Moisture content at -1/3 bar (% cm^3/cm^3): 32.9

Oversize corrected moisture content at -1/3 bar (% cm^3/cm^3): NA

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent volume change measurements obtained after the pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

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

Moisture Retention Data
Dew Point Potentiometer
(-15 Bar)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: Topsoil-1 (85%, 1.10)
Project Name: VVL Composite Samples
PO Number: 12015

Initial sample bulk density (g/cm^3)*:* 1.10
Fraction of test sample used (<2.00mm fraction) (%): 96.44

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)
-15 bar [3] :	NA	NA	NA	15297	11.00

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
-15 bar [3] :	15297	---	---	---	---

Moisture content at -15 bars (% cm^3/cm^3): **11.0**

Oversize corrected moisture content at -15 bars (% cm^3/cm^3): **NA**

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

[3] The moisture content of the sample at -15 bars of water potential was interpolated from the predicted water retention curve.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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

Particle Size Analysis

Summary of Particle Size Characteristics

Sample Number	d_{10} (mm)	d_{50} (mm)	d_{60} (mm)	C_u	C_c	Method	ASTM Classification	USDA Classification
VVL Composite 0-10	0.00024	1.6	4.4	1.8E+04	50	WS/H	Clayey gravel with sand (GC)s	Sandy Clay Loam † (Est)
VVL Composite 11-15	0.0069	1.1	3.4	493	2.1	WS/H	Silty sand with gravel (SM)g	Sandy Loam †
VVL Composite 16-20	2.8E-05	0.81	4.2	1.5E+05	103	WS/H	Clayey gravel with sand (GC)s	Sandy Clay Loam † (Est)
VVL Composite 21-30	0.00020	0.89	4.8	2.4E+04	9.2	WS/H	Clayey gravel with sand (GC)s	Sandy Clay Loam † (Est)
VVL Composite 31+	2.3E-10	0.021	0.058	2.5E+08	5877	WS/H	Sandy fat clay with gravel s(CH)g	Clay † (Est)
VVL Composite TP-10	0.0082	0.64	1.5	183	2.3	WS/H	Clayey sand with gravel (SC)g	Sandy Loam †
VVL Composite TP-12	1.2E-06	0.63	1.9	1.6E+06	2274	WS/H	Clayey gravel with sand (GC)s	Sandy Clay Loam † (Est)
VVL Composite TP-13	0.00038	0.49	1.1	2895	4.4	WS/H	Clayey sand with gravel (SC)g	Sandy Clay Loam † (Est)
WB Borrow-1	0.0013	0.095	0.22	169	3.1	WS/H	Clayey sand (SC)	Sandy Loam † (Est)
WB Stockpile-1	0.00028	0.035	0.063	225	9.6	WS/H	Sandy lean clay s(CL)	Loam † (Est)
WB Stockpile-2	0.0011	0.091	0.31	282	2.0	WS/H	Clayey sand with gravel (SC)g	Loam † (Est)
Topsoil-1	0.0036	0.047	0.070	19	1.3	WS/H	Sandy silt s(ML)	Loam

d_{50} = Median particle diameter

Est = Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

$$C_u = \frac{d_{60}}{d_{10}}$$

$$C_c = \frac{(d_{30})^2}{(d_{10})(d_{60})}$$

DS = Dry sieve

H = Hydrometer

WS = Wet sieve

† Greater than 10% of sample is coarse material

DRAFT

Percent Gravel, Sand, Silt and Clay*

Sample Number	% Gravel (>4.75mm)	% Sand (<4.75mm, >0.075mm)	% Silt (<0.075mm, >0.002mm)	% Clay (<0.002mm)
VVL Composite 0-10	39.3	35.6	11.4	13.7
VVL Composite 11-15	37.8	42.0	12.7	7.5
VVL Composite 16-20	39.6	32.3	14.7	13.4
VVL Composite 21-30	40.1	31.0	13.4	15.5
VVL Composite 31+	18.2	21.4	27.6	32.8
VVL Composite TP-10	34.1	44.3	15.1	6.5
VVL Composite TP-12	36.4	33.5	13.8	16.3
VVL Composite TP-13	28.9	37.8	15.6	17.6
WB Borrow-1	12.4	40.3	35.7	11.6
WB Stockpile-1	8.7	29.1	46.9	15.3
WB Stockpile-2	24.4	27.1	35.3	13.1
Topsoil-1	0.4	37.9	53.6	8.0

*USCS classification does not classify clay fraction based on particle size. USDA definition of clay (<0.002mm) used in this table.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 46048.20
Weight Passing #4 (g): 27973.21
Weight Retained #4 (g): 18074.99
Weight of Hydrometer Sample (g): 58.78
Calculated Weight of Sieve Sample (g): 96.76

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	46048.20	100.00
	2"	50	1282.51	1282.51	44765.69	97.21
	1.5"	38.1	3282.85	4565.36	41482.84	90.09
	1"	25	3756.91	8322.27	37725.93	81.93
	3/4"	19.0	2110.31	10432.58	35615.62	77.34
	3/8"	9.5	2484.86	12917.44	33130.76	71.95
	4	4.75	5157.55	18074.99	27973.21	60.75
-4			(Based on calculated sieve wt.)			
	10	2.00	8.12	46.10	50.66	52.36
	20	0.85	8.83	54.93	41.83	43.23
	40	0.425	8.31	63.24	33.52	34.64
	60	0.250	4.02	67.26	29.50	30.49
	140	0.106	4.12	71.38	25.38	26.23
	200	0.075	1.06	72.44	24.32	25.13
	dry pan		0.46	72.90	23.86	
	wet pan			23.86	0.00	

d_{10} (mm): 0.00024 d_{50} (mm): 1.6
d_{16} (mm): 0.0060 d_{60} (mm): 4.4
d_{30} (mm): 0.23 d_{84} (mm): 28

Median Particle Diameter --d_{50} (mm): 1.6
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 1.8E+04
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 50
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 9.9

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CH

ASTM Soil Classification: Clayey gravel with sand (GC)s
USDA Soil Classification: Sandy Clay Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

DRAFT

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 27-Aug-14
Start Time: 9:54

Type of Water Used: DISTILLED
Reaction with H_2O_2*:* NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

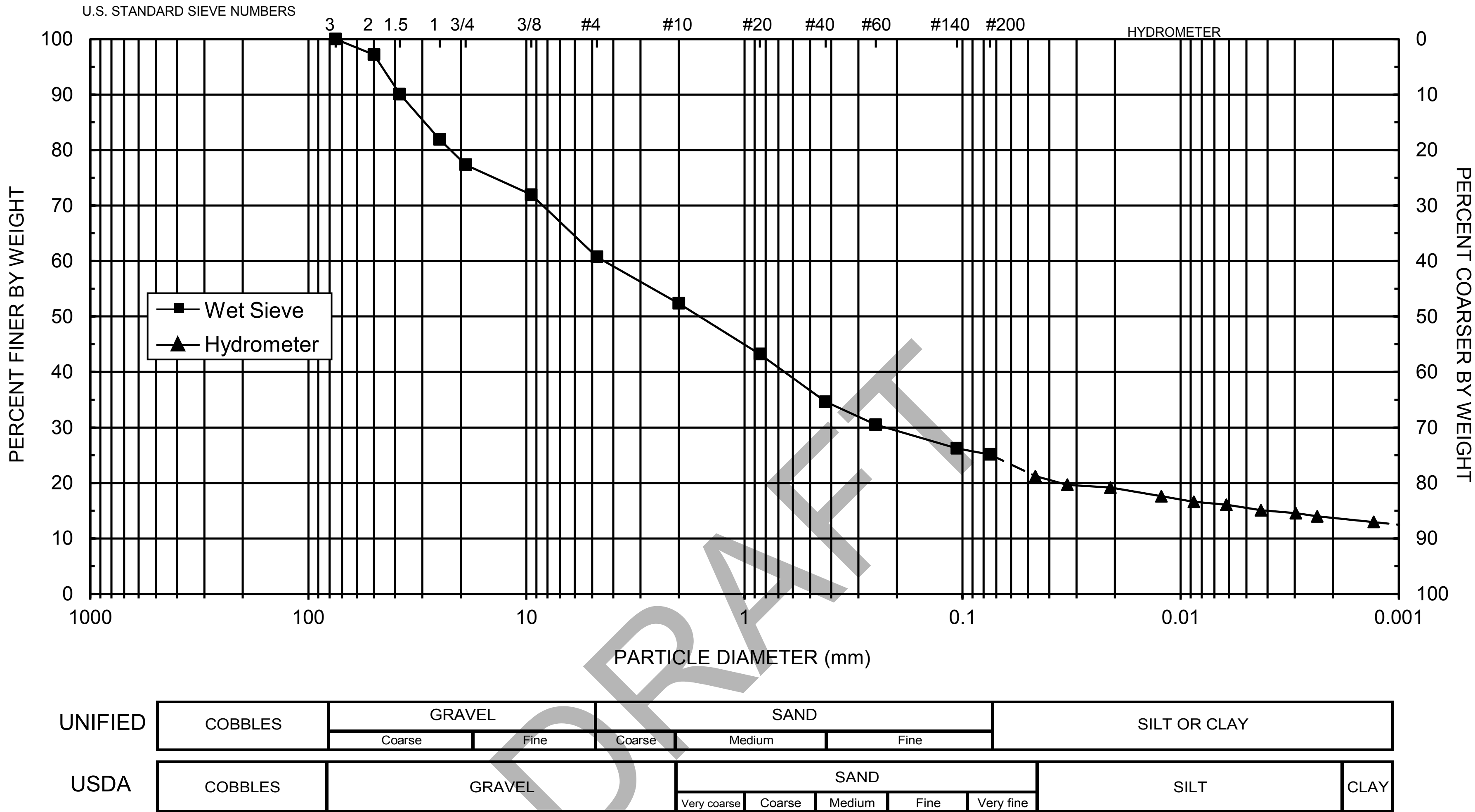
Initial Wt. (g)*:* 58.78
Total Sample Wt. (g)*:* 46048.20
Wt. Passing #4 (g): 27973.21

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
27-Aug-14	1	21.5	26.5	6.0	20.5	12.0	0.04625	34.9	21.2
	2	21.5	25.0	6.0	19.0	12.2	0.03304	32.4	19.7
	5	21.5	24.5	6.0	18.5	12.3	0.02097	31.5	19.2
	15	21.5	23.0	6.0	17.0	12.5	0.01223	29.0	17.6
	30	21.6	22.0	6.0	16.1	12.7	0.00869	27.3	16.6
	60	21.6	21.5	6.0	15.6	12.8	0.00617	26.5	16.1
	126	21.7	20.5	5.9	14.6	12.9	0.00428	24.8	15.1
	264	21.7	20.0	5.9	14.1	13.0	0.00296	23.9	14.5
	421	21.5	19.5	6.0	13.5	13.1	0.00236	23.0	14.0
28-Aug-14	1404	21.4	18.5	6.0	12.5	13.3	0.00130	21.3	12.9

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: C. Krous
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.00024**	d_{30} = **0.23**	d_{50} = **1.6**	d_{60} = **4.4**	C_u = **1.8E+04**	C_c = **50**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
VVL Composite 0-10	**12015**	**Clayey gravel with sand (GC)s**	**Sandy Clay Loam †**

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 11-15
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 46786.10
Weight Passing #4 (g): 29099.72
Weight Retained #4 (g): 17686.38
Weight of Hydrometer Sample (g): 78.23
Calculated Weight of Sieve Sample (g): 125.78

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	46786.10	100.00
	2"	50	1977.56	1977.56	44808.54	95.77
	1.5"	38.1	2330.19	4307.75	42478.35	90.79
	1"	25	2770.31	7078.06	39708.04	84.87
	3/4"	19.0	1796.78	8874.84	37911.26	81.03
	3/8"	9.5	3816.83	12691.67	34094.43	72.87
	4	4.75	4994.71	17686.38	29099.72	62.20
-4			(Based on calculated sieve wt.)			
	10	2.00	7.24	54.79	70.99	56.44
	20	0.85	10.95	65.74	60.04	47.74
	40	0.425	10.15	75.89	49.89	39.67
	60	0.250	10.66	86.55	39.23	31.19
	140	0.106	11.19	97.74	28.04	22.29
	200	0.075	2.68	100.42	25.36	20.16
	dry pan		0.57	100.99	24.79	
	wet pan			24.79	0.00	

d_{10} (mm): 0.0069 d_{50} (mm): 1.1
d_{16} (mm): 0.036 d_{60} (mm): 3.4
d_{30} (mm): 0.22 d_{84} (mm): 23

Median Particle Diameter --d_{50} (mm): 1.1
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 493
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 2.1
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 8.0

Classification of fines: ML

ASTM Soil Classification: Silty sand with gravel (SM)g
USDA Soil Classification: Sandy Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 11-15
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:00

Type of Water Used: DISTILLED
Reaction with H_2O_2: NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

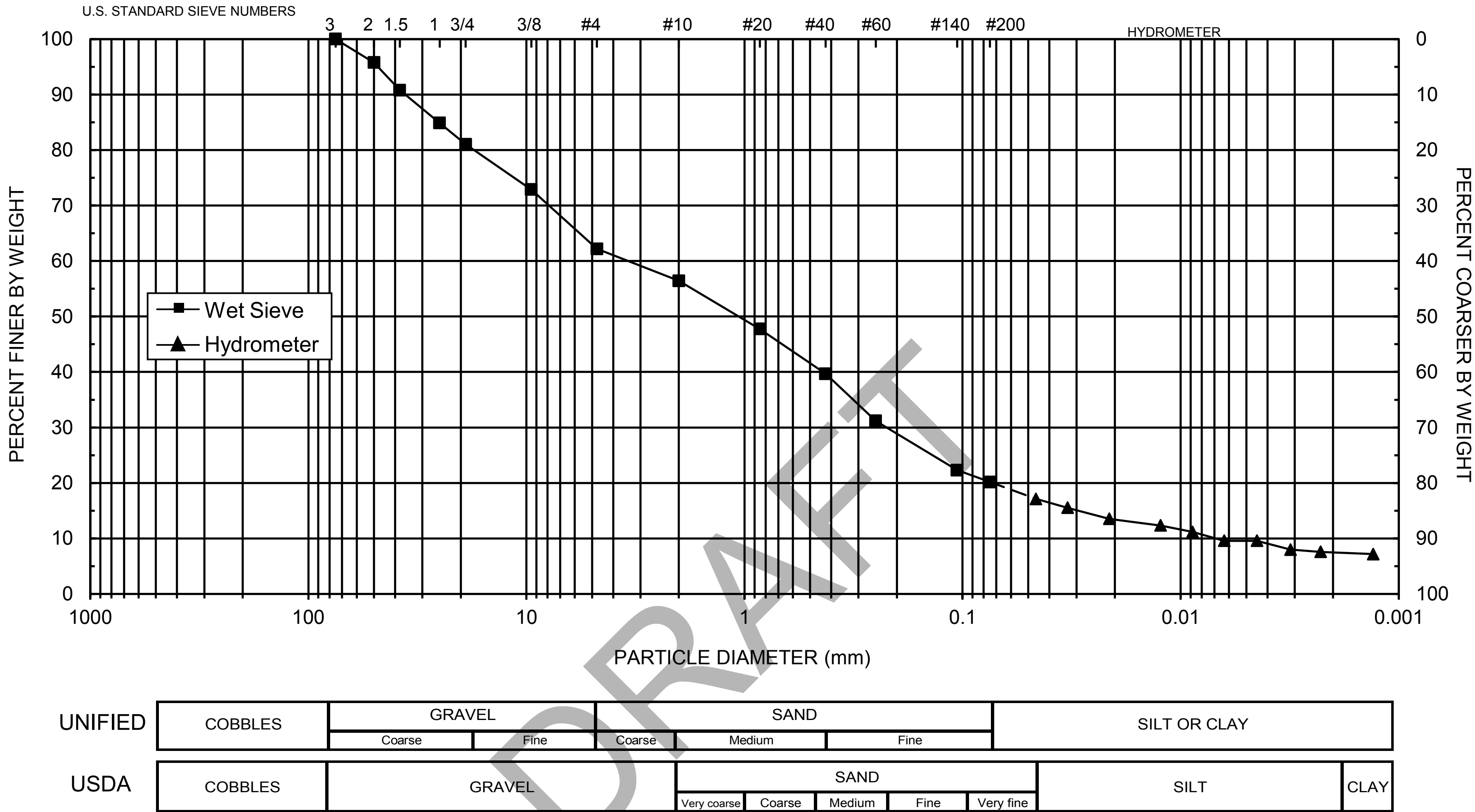
Initial Wt. (g): 78.23
Total Sample Wt. (g): 46786.10
Wt. Passing #4 (g): 29099.72

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.4	27.5	6.0	21.5	11.8	0.04599	27.5	17.1
	2	21.4	25.5	6.0	19.5	12.1	0.03297	25.0	15.5
	5	21.4	23.0	6.0	17.0	12.5	0.02120	21.8	13.5
	15	21.4	21.5	6.0	15.5	12.8	0.01236	19.8	12.3
	30	21.5	20.0	6.0	14.0	13.0	0.00881	17.9	11.2
	60	21.5	18.0	6.0	12.0	13.3	0.00631	15.4	9.6
	120	21.5	18.0	6.0	12.0	13.3	0.00446	15.4	9.6
	250	21.4	16.0	6.0	10.0	13.7	0.00313	12.8	8.0
	476	21.4	15.5	6.0	9.5	13.8	0.00228	12.2	7.6
27-Aug-14	1454	21.4	15.0	6.0	9.0	13.8	0.00131	11.5	7.2

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.0069**	d_{30} = **0.22**	d_{50} = **1.1**	d_{60} = **3.4**	C_u = **493**	C_c = **2.1**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
VVL Composite 11-15	**12015**	**Silty sand with gravel (SM)g**	**Sandy Loam †**

† Greater than 10% of sample is coarse material

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 16-20
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 46745.40
Weight Passing #4 (g): 28253.52
Weight Retained #4 (g): 18491.88
Weight of Hydrometer Sample (g): 67.19
Calculated Weight of Sieve Sample (g): 111.17

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	46745.40	100.00
	2"	50	242.97	242.97	46502.43	99.48
	1.5"	38.1	1258.91	1501.88	45243.52	96.79
	1"	25	3527.46	5029.34	41716.06	89.24
	3/4"	19.0	1739.24	6768.58	39976.82	85.52
	3/8"	9.5	5820.55	12589.13	34156.27	73.07
	4	4.75	5902.75	18491.88	28253.52	60.44
-4			(Based on calculated sieve wt.)			
	10	2.00	3.78	47.76	63.41	57.04
	20	0.85	7.15	54.91	56.26	50.61
	40	0.425	8.83	63.74	47.43	42.67
	60	0.250	6.78	70.52	40.65	36.57
	140	0.106	7.51	78.03	33.14	29.81
	200	0.075	1.82	79.85	31.32	28.17
	dry pan		0.45	80.30	30.87	
	wet pan			30.87	0.00	

DRAFT

d_{10} (mm): 2.8E-05 d_{50} (mm): 0.81
d_{16} (mm): 0.0065 d_{60} (mm): 4.2
d_{30} (mm): 0.11 d_{84} (mm): 17

Median Particle Diameter --d_{50} (mm): 0.81
Uniformity Coefficient, Cu --[d_{60}/d_{10}] (mm): 1.5E+05
Coefficient of Curvature, Cc --[$(d_{30})^2/(d_{10}*d_{60})$] (mm): 103
Mean Particle Diameter --[$(d_{16}+d_{50}+d_{84})/3$] (mm): 5.9

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CH

ASTM Soil Classification: Clayey gravel with sand (GC)s
USDA Soil Classification: Sandy Clay Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 16-20
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:06

Type of Water Used: DISTILLED
Reaction with H_2O_2: NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

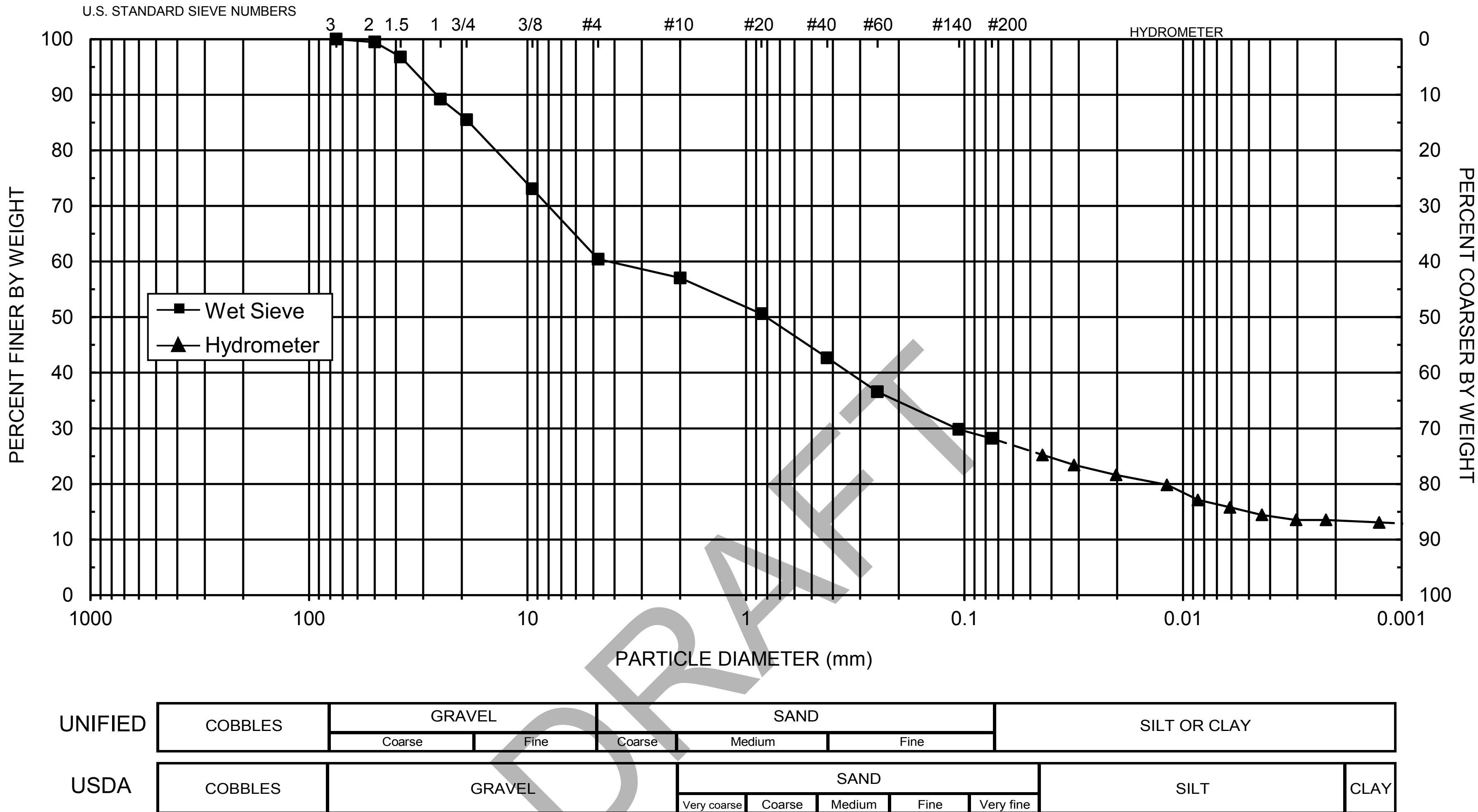
Initial Wt. (g): 67.19
Total Sample Wt. (g): 46745.40
Wt. Passing #4 (g): 28253.52

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.4	34.0	6.0	28.0	10.7	0.04386	41.7	25.2
	2	21.4	32.0	6.0	26.0	11.1	0.03149	38.7	23.4
	5	21.4	30.0	6.0	24.0	11.4	0.02021	35.7	21.6
	15	21.5	28.0	6.0	22.0	11.7	0.01183	32.8	19.8
	30	21.5	25.0	6.0	19.0	12.2	0.00853	28.3	17.1
	60	21.5	23.5	6.0	17.5	12.4	0.00609	26.1	15.8
	120	21.5	22.0	6.0	16.0	12.7	0.00435	23.9	14.4
	250	21.4	21.0	6.0	15.0	12.9	0.00304	22.4	13.5
	471	21.4	21.0	6.0	15.0	12.9	0.00221	22.4	13.5
27-Aug-14	1449	21.4	20.5	6.0	14.5	12.9	0.00127	21.6	13.1

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **2.8E-05**	d_{30} = **0.11**	d_{50} = **0.81**	d_{60} = **4.2**	C_u = **1.5E+05**	C_c = **103**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
VVL Composite 16-20	**12015**	**Clayey gravel with sand (GC)s**	**Sandy Clay Loam †**

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 21-30
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 45742.40
Weight Passing #4 (g): 27411.98
Weight Retained #4 (g): 18330.42
Weight of Hydrometer Sample (g): 64.42
Calculated Weight of Sieve Sample (g): 107.50

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	45742.40	100.00
	2"	50	2331.12	2331.12	43411.28	94.90
	1.5"	38.1	1923.92	4255.04	41487.36	90.70
	1"	25	3223.75	7478.79	38263.61	83.65
	3/4"	19.0	1907.88	9386.67	36355.73	79.48
	3/8"	9.5	5658.41	15045.08	30697.32	67.11
	4	4.75	3285.34	18330.42	27411.98	59.93
-4			(Based on calculated sieve wt.)			
	10	2.00	3.92	47.00	60.50	56.28
	20	0.85	7.13	54.13	53.37	49.65
	40	0.425	7.82	61.95	45.55	42.37
	60	0.250	6.06	68.01	39.49	36.74
	140	0.106	6.64	74.65	32.85	30.56
	200	0.075	1.74	76.39	31.11	28.94
	dry pan		0.36	76.75	30.75	
	wet pan			30.75	0.00	

d_{10} (mm): 0.00020 d_{50} (mm): 0.89
d_{16} (mm): 0.0032 d_{60} (mm): 4.8
d_{30} (mm): 0.094 d_{84} (mm): 26

Median Particle Diameter --d_{50} (mm): 0.89
Uniformity Coefficient, Cu --[d_{60}/d_{10}] (mm): 2.4E+04
Coefficient of Curvature, Cc --[$(d_{30})^2/(d_{10} * d_{60})$] (mm): 9.2
Mean Particle Diameter --[$(d_{16}+d_{50}+d_{84})/3$] (mm): 9.0

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CH

ASTM Soil Classification: Clayey gravel with sand (GC)s
USDA Soil Classification: Sandy Clay Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 21-30
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:54

Type of Water Used: DISTILLED
Reaction with H_2O_2: NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

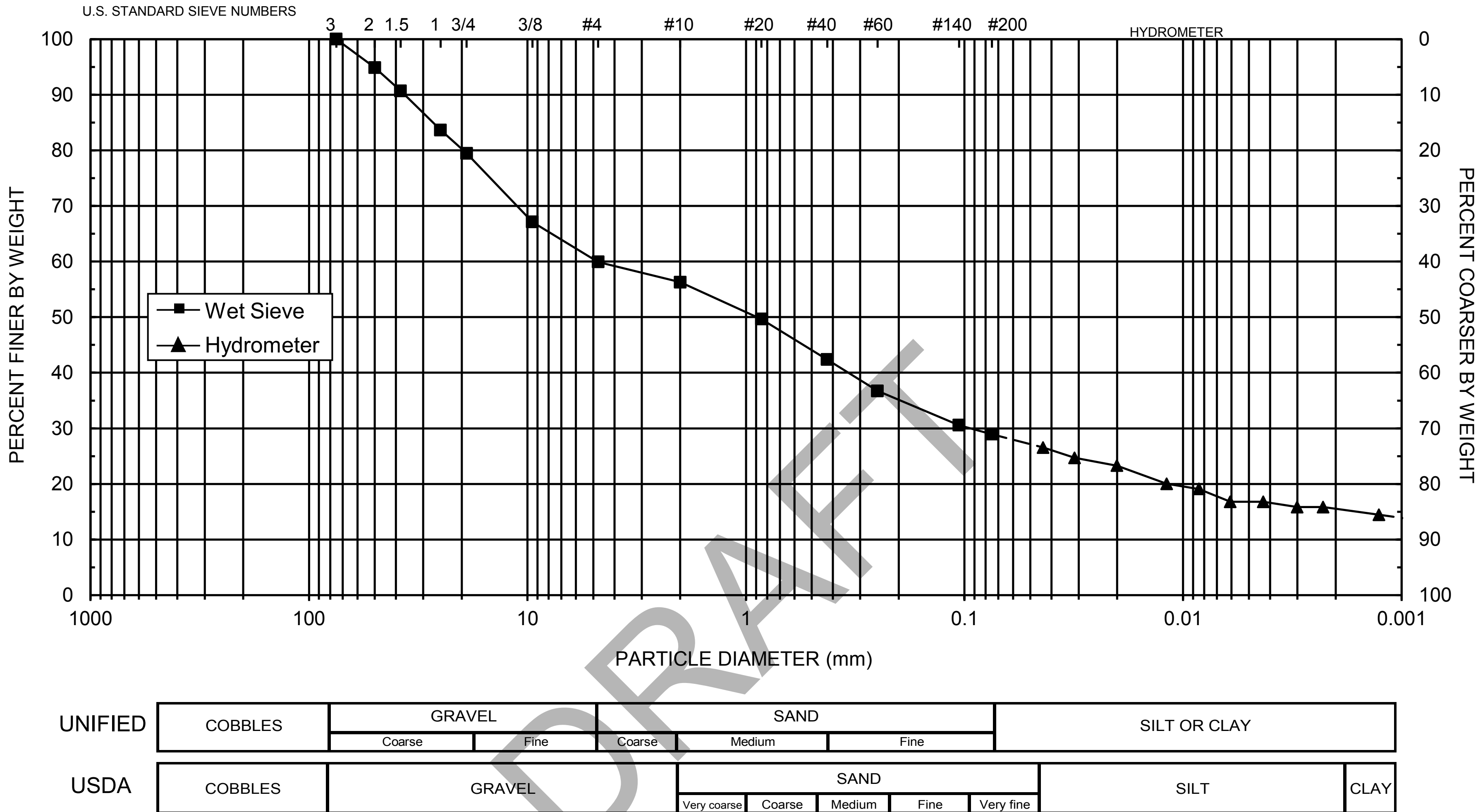
Initial Wt. (g): 64.42
Total Sample Wt. (g): 45742.40
Wt. Passing #4 (g): 27411.98

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.5	34.5	6.0	28.5	10.6	0.04364	44.3	26.5
	2	21.5	32.5	6.0	26.5	11.0	0.03133	41.2	24.7
	5	21.5	31.0	6.0	25.0	11.2	0.02005	38.9	23.3
	15	21.4	27.5	6.0	21.5	11.8	0.01187	33.4	20.0
	30	21.4	26.5	6.0	20.5	12.0	0.00845	31.9	19.1
	60	21.5	24.0	6.0	18.0	12.4	0.00607	28.0	16.8
	120	21.5	24.0	6.0	18.0	12.4	0.00429	28.0	16.8
	250	21.4	23.0	6.0	17.0	12.5	0.00300	26.4	15.8
	431	21.4	23.0	6.0	17.0	12.5	0.00228	26.4	15.8
27-Aug-14	1423	21.4	21.5	6.0	15.5	12.8	0.00127	24.1	14.4

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.00020**	d_{30} = **0.094**	d_{50} = **0.89**	d_{60} = **4.8**	C_u = **2.4E+04**	C_c = **9.2**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
VVL Composite 21-30	**12015**	**Clayey gravel with sand (GC)s**	**Sandy Clay Loam †**

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 38759.70
Weight Passing #4 (g): 31712.72
Weight Retained #4 (g): 7046.98
Weight of Hydrometer Sample (g): 51.03
Calculated Weight of Sieve Sample (g): 62.37

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	38759.70	100.00
	2"	50	741.04	741.04	38018.66	98.09
	1.5"	38.1	1188.51	1929.55	36830.15	95.02
	1"	25	1814.33	3743.88	35015.82	90.34
	3/4"	19.0	915.68	4659.56	34100.14	87.98
	3/8"	9.5	1605.74	6265.30	32494.40	83.84
	4	4.75	781.68	7046.98	31712.72	81.82
-4			(Based on calculated sieve wt.)			
	10	2.00	2.10	13.44	48.93	78.45
	20	0.85	2.07	15.51	46.86	75.13
	40	0.425	2.01	17.52	44.85	71.91
	60	0.250	2.00	19.52	42.85	68.70
	140	0.106	3.54	23.06	39.31	63.03
	200	0.075	1.61	24.67	37.70	60.45
	dry pan		0.29	24.96	37.41	
	wet pan			37.41	0.00	

DRAFT

d_{10} (mm): 2.3E-10 d_{50} (mm): 0.021
d_{16} (mm): 1.5E-08 d_{60} (mm): 0.058
d_{30} (mm): 0.00028 d_{84} (mm): 9.8

Median Particle Diameter --d_{50} (mm): 0.021
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 2.5E+08
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 5877
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 3.3

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CH

ASTM Soil Classification: Sandy fat clay with gravel s(CH)g
USDA Soil Classification: Clay †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:12

Type of Water Used: DISTILLED
Reaction with H_2O_2*:* NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

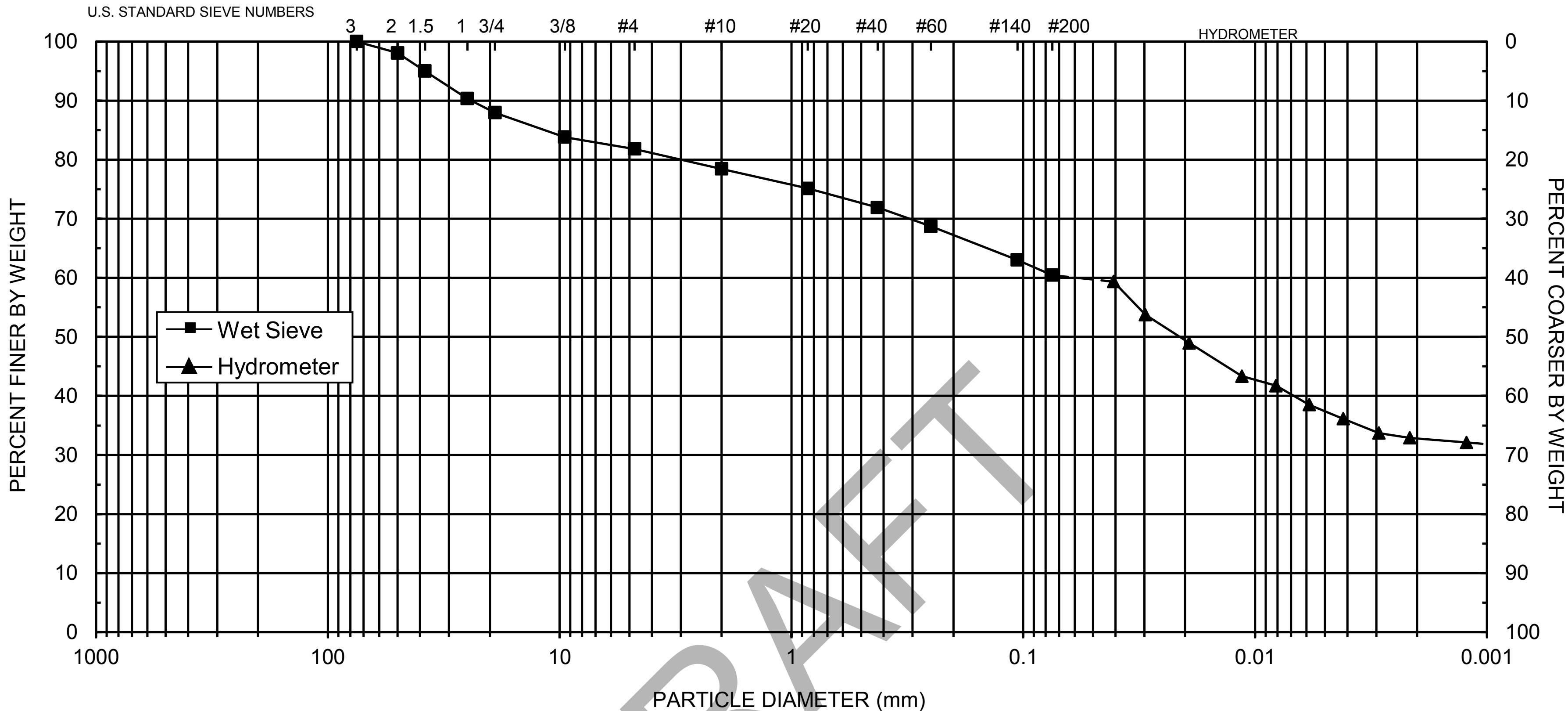
Initial Wt. (g)*:* 51.03
Total Sample Wt. (g)*:* 38759.70
Wt. Passing #4 (g): 31712.72

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.4	43.0	6.0	37.0	9.3	0.04073	72.5	59.4
	2	21.4	39.5	6.0	33.5	9.8	0.02968	65.7	53.7
	5	21.5	36.5	6.0	30.5	10.3	0.01923	59.8	49.0
	15	21.5	33.0	6.0	27.0	10.9	0.01140	53.0	43.3
	30	21.5	32.0	6.0	26.0	11.1	0.00812	51.0	41.7
	60	21.4	30.0	6.0	24.0	11.4	0.00583	47.1	38.5
	120	21.5	28.5	6.0	22.5	11.6	0.00416	44.2	36.1
	250	21.4	27.0	6.0	21.0	11.9	0.00292	41.2	33.7
	466	21.4	26.5	6.0	20.5	12.0	0.00215	40.2	32.9
27-Aug-14	1444	21.4	26.0	6.0	20.0	12.0	0.00122	39.2	32.1

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



UNIFIED	COBBLES	GRAVEL		SAND			SILT OR CLAY		
		Coarse	Fine	Coarse	Medium	Fine			

USDA	COBBLES	GRAVEL	SAND					SILT	CLAY
			Very coarse	Coarse	Medium	Fine	Very fine		

d_{10} = **2.3E-10**	d_{30} = **0.00028**	d_{50} = **0.021**	d_{60} = **0.058**	C_u = **2.5E+08**	C_c = **5877**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
VVL Composite 31+	**12015**	**Sandy fat clay with gravel s(CH)g**	**Clay** †

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 49431.50
Weight Passing #4 (g): 32599.59
Weight Retained #4 (g): 16831.91
Weight of Hydrometer Sample (g): 50.78
Calculated Weight of Sieve Sample (g): 77.00

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	49431.50	100.00
	2"	50	2970.88	2970.88	46460.62	93.99
	1.5"	38.1	2128.74	5099.62	44331.88	89.68
	1"	25	3658.05	8757.67	40673.83	82.28
	3/4"	19.0	1911.54	10669.21	38762.29	78.42
	3/8"	9.5	2319.17	12988.38	36443.12	73.72
	4	4.75	3843.53	16831.91	32599.59	65.95
-4			(Based on calculated sieve wt.)			
	10	2.00	2.24	28.46	48.54	63.04
	20	0.85	6.36	34.82	42.18	54.78
	40	0.425	8.93	43.75	33.25	43.18
	60	0.250	6.58	50.33	26.67	34.64
	140	0.106	7.92	58.25	18.75	24.35
	200	0.075	2.10	60.35	16.65	21.62
	dry pan		0.74	61.09	15.91	
	wet pan			15.91	0.00	

d_{10} (mm): 0.0082 d_{50} (mm): 0.64
d_{16} (mm): 0.036 d_{60} (mm): 1.5
d_{30} (mm): 0.17 d_{84} (mm): 28

Median Particle Diameter --d_{50} (mm): 0.64
Uniformity Coefficient, Cu --[d_{60}/d_{10}] (mm): 183
Coefficient of Curvature, Cc --[$(d_{30})^2/(d_{10}*d_{60})$] (mm): 2.3
Mean Particle Diameter --[$(d_{16}+d_{50}+d_{84})/3$] (mm): 9.6

Classification of fines: CL

ASTM Soil Classification: Clayey sand with gravel (SC)g
USDA Soil Classification: Sandy Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:18

Type of Water Used: DISTILLED
Reaction with H_2O_2: NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

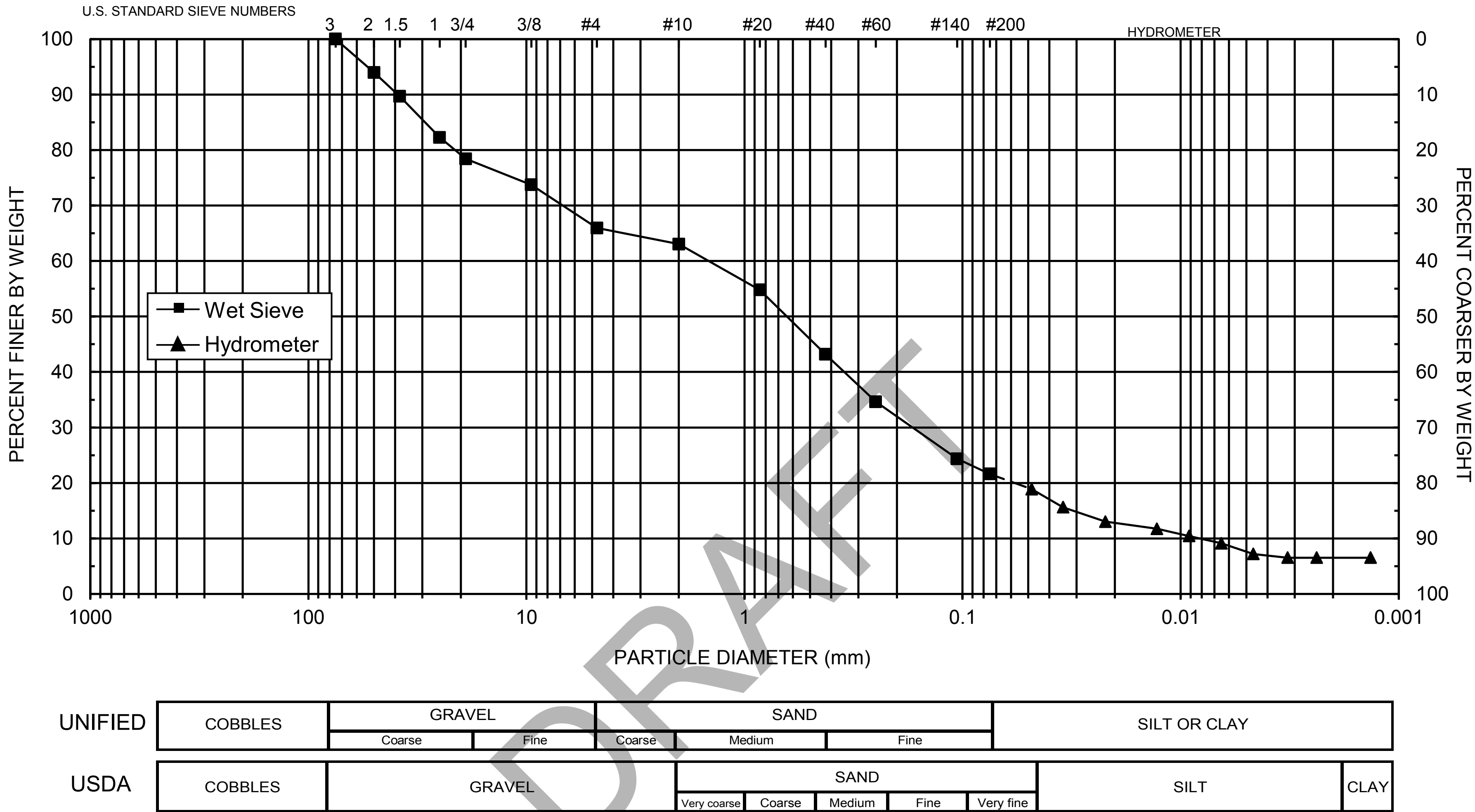
Initial Wt. (g): 50.78
Total Sample Wt. (g): 49431.50
Wt. Passing #4 (g): 32599.59

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.5	20.5	6.0	14.5	12.9	0.04815	28.6	18.9
	2	21.5	18.0	6.0	12.0	13.3	0.03458	23.7	15.6
	5	21.5	16.0	6.0	10.0	13.7	0.02214	19.8	13.0
	15	21.5	15.0	6.0	9.0	13.8	0.01285	17.8	11.7
	30	21.5	14.0	6.0	8.0	14.0	0.00914	15.8	10.4
	60	21.4	13.0	6.0	7.0	14.2	0.00651	13.8	9.1
	120	21.5	11.5	6.0	5.5	14.4	0.00464	10.9	7.2
	250	21.4	11.0	6.0	5.0	14.5	0.00323	9.9	6.5
	461	21.4	11.0	6.0	5.0	14.5	0.00237	9.9	6.5
27-Aug-14	1439	21.4	11.0	6.0	5.0	14.5	0.00134	9.9	6.5

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.0082**	d_{30} = **0.17**	d_{50} = **0.64**	d_{60} = **1.5**	C_u = **183**	C_c = **2.3**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
VVL Composite TP-10	**12015**	**Clayey sand with gravel (SC)g**	**Sandy Loam** †

† Greater than 10% of sample is coarse material

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 50102.30
Weight Passing #4 (g): 31847.26
Weight Retained #4 (g): 18255.04
Weight of Hydrometer Sample (g): 66.12
Calculated Weight of Sieve Sample (g): 104.02

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	50102.30	100.00
	2"	50	464.09	464.09	49638.21	99.07
	1.5"	38.1	2822.07	3286.16	46816.14	93.44
	1"	25	4675.36	7961.52	42140.78	84.11
	3/4"	19.0	1865.31	9826.83	40275.47	80.39
	3/8"	9.5	4844.84	14671.67	35430.63	70.72
	4	4.75	3583.37	18255.04	31847.26	63.56
-4			(Based on calculated sieve wt.)			
	10	2.00	3.47	41.37	62.65	60.23
	20	0.85	7.07	48.44	55.58	53.43
	40	0.425	8.35	56.79	47.23	45.40
	60	0.250	7.18	63.97	40.05	38.50
	140	0.106	6.94	70.91	33.11	31.83
	200	0.075	1.82	72.73	31.29	30.08
	dry pan		0.30	73.03	30.99	
	wet pan			30.99	0.00	

d_{10} (mm): 1.2E-06
d_{16} (mm): 0.0014
d_{30} (mm): 0.072
d_{50} (mm): 0.63
d_{60} (mm): 1.9
d_{84} (mm): 25

Median Particle Diameter --d_{50} (mm): 0.63
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 1.6E+06
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 2274
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 8.5

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CH

ASTM Soil Classification: Clayey gravel with sand (GC)s
USDA Soil Classification: Sandy Clay Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:24

Type of Water Used: DISTILLED
Reaction with H_2O_2: NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

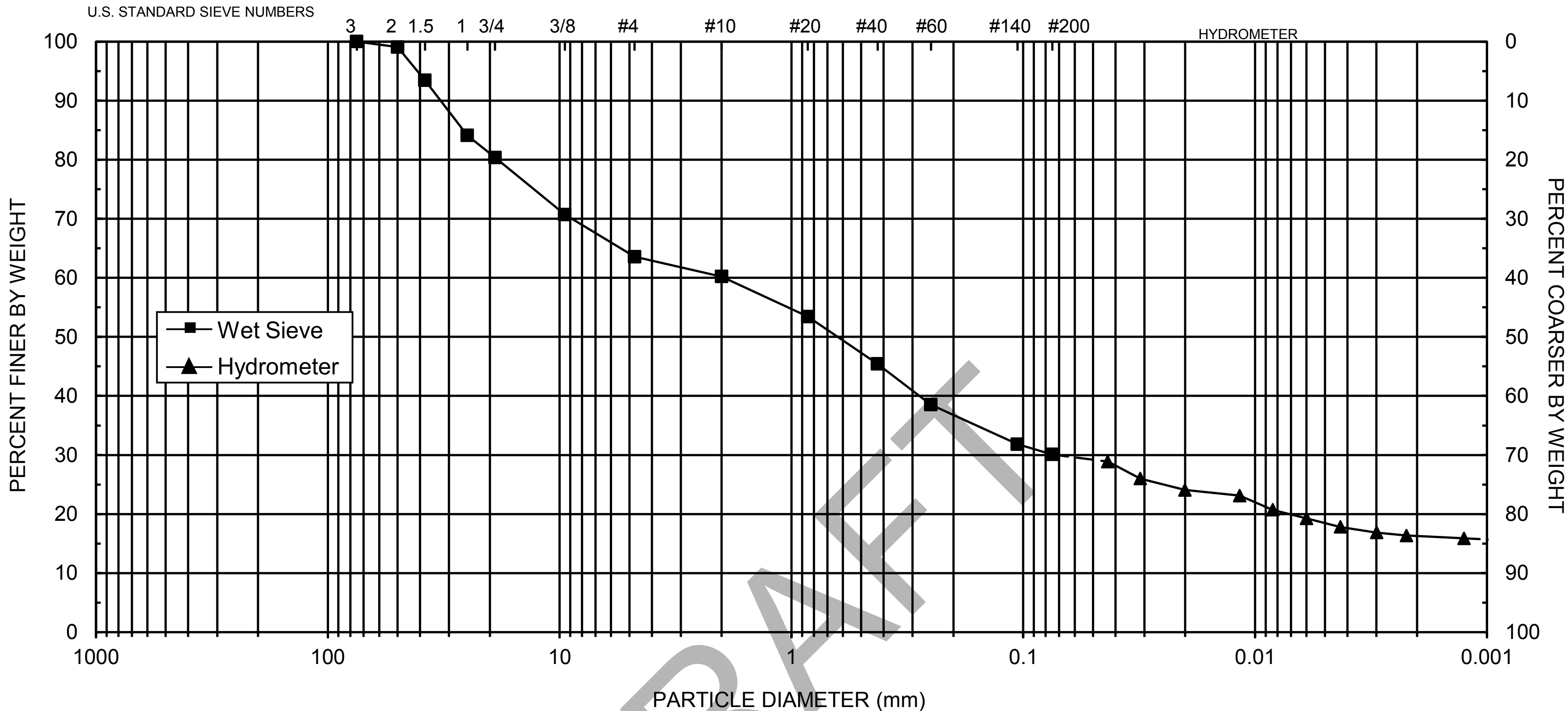
Initial Wt. (g): 66.12
Total Sample Wt. (g): 50102.30
Wt. Passing #4 (g): 31847.26

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.5	36.0	6.0	30.0	10.4	0.04314	45.4	28.9
	2	21.5	33.0	6.0	27.0	10.9	0.03121	40.9	26.0
	5	21.5	31.0	6.0	25.0	11.2	0.02004	37.9	24.1
	15	21.5	30.0	6.0	24.0	11.4	0.01165	36.3	23.1
	30	21.5	27.5	6.0	21.5	11.8	0.00839	32.6	20.7
	60	21.4	26.0	6.0	20.0	12.0	0.00600	30.3	19.2
	120	21.5	24.5	6.0	18.5	12.3	0.00428	28.0	17.8
	250	21.5	23.5	6.0	17.5	12.4	0.00298	26.5	16.8
	456	21.4	23.0	6.0	17.0	12.5	0.00222	25.7	16.4
27-Aug-14	1435	21.4	22.5	6.0	16.5	12.6	0.00126	25.0	15.9

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



UNIFIED	COBBLES	GRAVEL		SAND			SILT OR CLAY
		Coarse	Fine	Coarse	Medium	Fine	

USDA	COBBLES	GRAVEL	SAND					SILT	CLAY
			Very coarse	Coarse	Medium	Fine	Very fine		

d_{10} = **1.2E-06**	d_{30} = **0.072**	d_{50} = **0.63**	d_{60} = **1.9**	C_u = **1.6E+06**	C_c = **2274**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
VVL Composite TP-12	**12015**	**Clayey gravel with sand (GC)s**	**Sandy Clay Loam †**

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-13
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 40176.50
Weight Passing #4 (g): 28546.92
Weight Retained #4 (g): 11629.58
Weight of Hydrometer Sample (g): 54.65
Calculated Weight of Sieve Sample (g): 76.91

Shape: Rounded
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	40176.50	100.00
	2"	50	808.64	808.64	39367.86	97.99
	1.5"	38.1	1303.26	2111.90	38064.60	94.74
	1"	25	2175.67	4287.57	35888.93	89.33
	3/4"	19.0	990.64	5278.21	34898.29	86.86
	3/8"	9.5	3730.51	9008.72	31167.78	77.58
	4	4.75	2620.86	11629.58	28546.92	71.05
-4			(Based on calculated sieve wt.)			
	10	2.00	3.98	26.24	50.67	65.88
	20	0.85	6.39	32.63	44.28	57.57
	40	0.425	7.26	39.89	37.02	48.13
	60	0.250	5.03	44.92	31.99	41.59
	140	0.106	5.13	50.05	26.86	34.92
	200	0.075	1.29	51.34	25.57	33.25
	dry pan		0.34	51.68	25.23	
	wet pan			25.23	0.00	

d_{10} (mm): 0.00038 d_{50} (mm): 0.49
d_{16} (mm): 0.0014 d_{60} (mm): 1.1
d_{30} (mm): 0.043 d_{84} (mm): 15

Median Particle Diameter --d_{50} (mm): 0.49
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 2895
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 4.4
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 5.2

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CH

ASTM Soil Classification: Clayey sand with gravel (SC)g
USDA Soil Classification: Sandy Clay Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

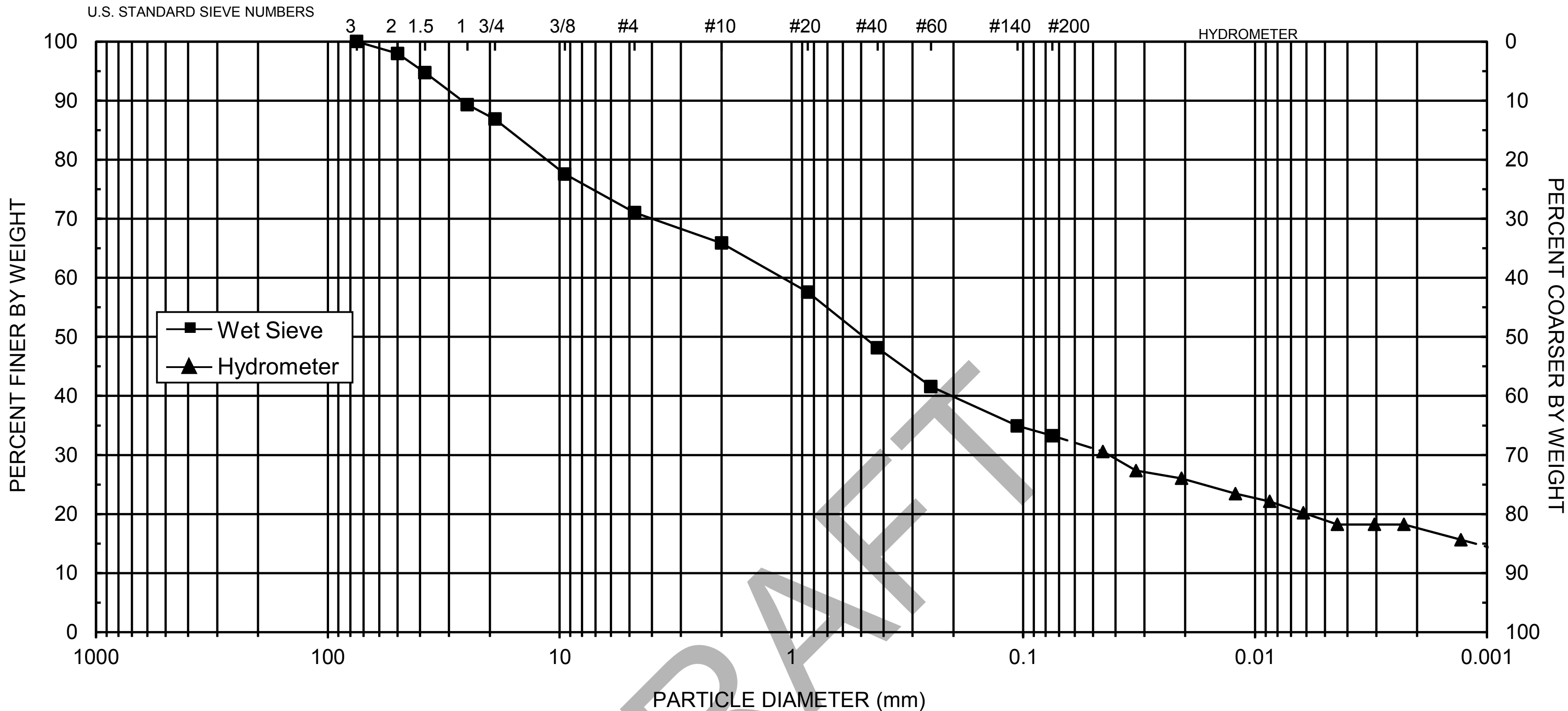
Job Name:	Hydrometrics, Inc.	*Type of Water Used:*	DISTILLED
Job Number:	LB14.0168.00	*Reaction with* H_2O_2*:*	NA
Sample Number:	VVL Composite TP-13	*Dispersant*:*	$(NaPO_3)_6$
Project Name:	VVL Composite Samples	*Assumed particle density:*	2.65
PO Number:	12015	*Initial Wt. (g):*	54.65
Test Date:	26-Aug-14	*Total Sample Wt. (g):*	40176.50
Start Time:	9:30	*Wt. Passing #4 (g):*	28546.92

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.5	29.5	6.0	23.5	11.5	0.04529	43.1	30.6
	2	21.5	27.0	6.0	21.0	11.9	0.03259	38.5	27.3
	5	21.5	26.0	6.0	20.0	12.0	0.02076	36.7	26.0
	15	21.5	24.0	6.0	18.0	12.4	0.01215	33.0	23.4
	30	21.5	23.0	6.0	17.0	12.5	0.00865	31.2	22.1
	60	21.4	21.5	6.0	15.5	12.8	0.00618	28.4	20.2
	120	21.5	20.0	6.0	14.0	13.0	0.00441	25.7	18.2
	250	21.5	20.0	6.0	14.0	13.0	0.00305	25.7	18.2
	451	21.4	20.0	6.0	14.0	13.0	0.00228	25.7	18.2
27-Aug-14	1430	21.4	18.0	6.0	12.0	13.3	0.00129	22.0	15.6

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



UNIFIED	COBBLES	GRAVEL		SAND			SILT OR CLAY
		Coarse	Fine	Coarse	Medium	Fine	

USDA	COBBLES	GRAVEL	SAND					SILT	CLAY
			Very coarse	Coarse	Medium	Fine	Very fine		

d_{10} = **0.00038**	d_{30} = **0.043**	d_{50} = **0.49**	d_{60} = **1.1**	C_u = **2895**	C_c = **4.4**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
VVL Composite TP-13	**12015**	**Clayey sand with gravel (SC)g**	**Sandy Clay Loam †**

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Borrow-1
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 21015.60
Weight Passing #4 (g): 18417.80
Weight Retained #4 (g): 2597.80
Weight of Hydrometer Sample (g): 60.40
Calculated Weight of Sieve Sample (g): 68.92

Shape: Angular
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	21015.60	100.00
	2"	50	0.00	0.00	21015.60	100.00
	1.5"	38.1	83.67	83.67	20931.93	99.60
	1"	25	782.19	865.86	20149.74	95.88
	3/4"	19.0	227.82	1093.68	19921.92	94.80
	3/8"	9.5	748.95	1842.63	19172.97	91.23
	4	4.75	755.17	2597.80	18417.80	87.64
-4			(Based on calculated sieve wt.)			
	10	2.00	3.29	11.81	57.11	82.87
	20	0.85	4.18	15.99	52.93	76.80
	40	0.425	5.35	21.34	47.58	69.04
	60	0.250	5.34	26.68	42.24	61.29
	140	0.106	6.91	33.59	35.33	51.26
	200	0.075	2.69	36.28	32.64	47.36
	dry pan		0.50	36.78	32.14	
	wet pan			32.14	0.00	

d_{10} (mm): 0.0013 — d_{50} (mm): 0.095
d_{16} (mm): 0.0044 — d_{60} (mm): 0.22
d_{30} (mm): 0.030 — d_{84} (mm): 2.5

Median Particle Diameter --d_{50} (mm): 0.095
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 169
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 3.1
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 0.87

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CL

ASTM Soil Classification: Clayey sand (SC)
USDA Soil Classification: Sandy Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Particle Size Analysis
Hydrometer Data

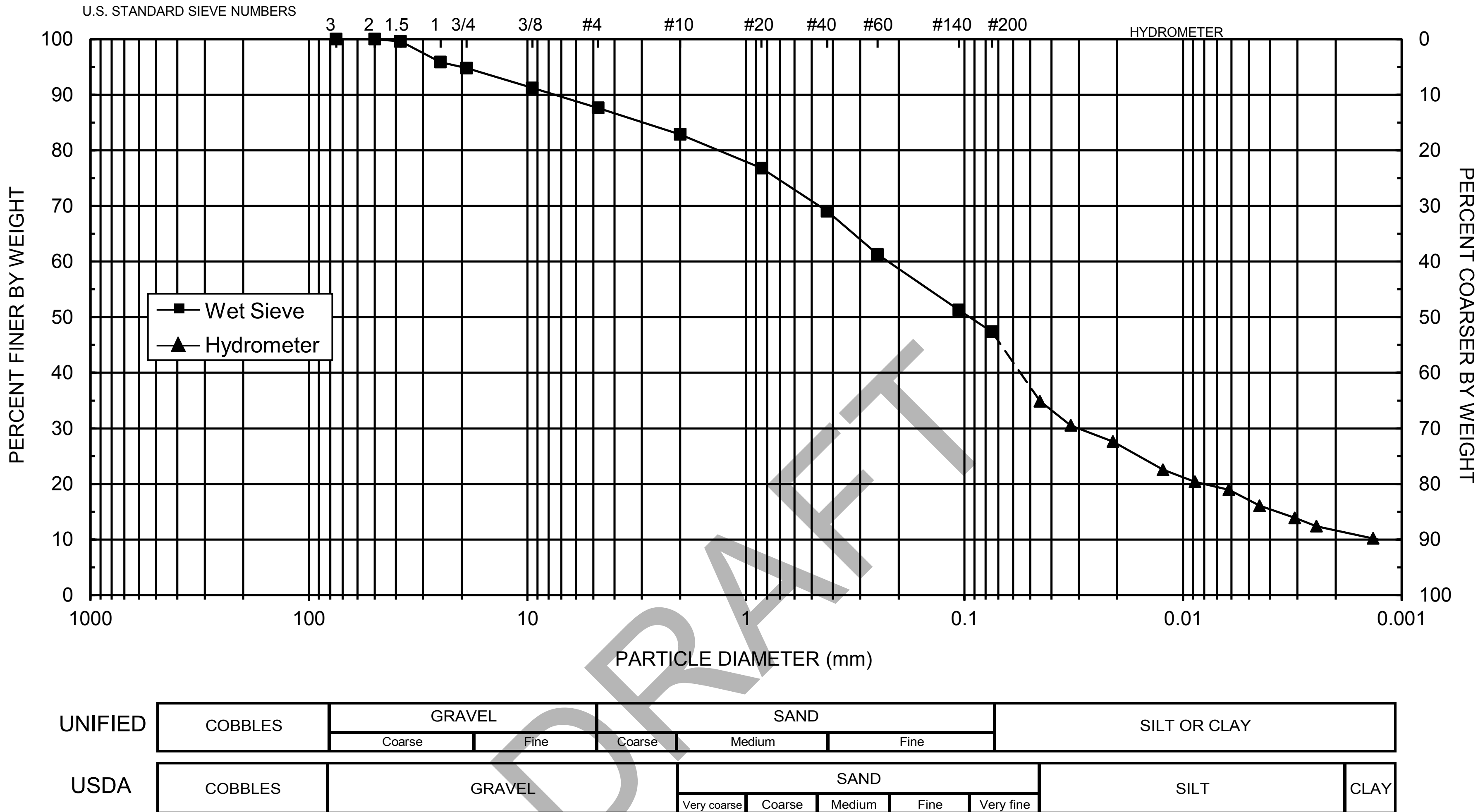
Job Name:	Hydrometrics, Inc.	*Type of Water Used:*	DISTILLED
Job Number:	LB14.0168.00	*Reaction with* H_2O_2*:*	NA
Sample Number:	WB Borrow-1	*Dispersant*:*	$(NaPO_3)_6$
Project Name:	VVL Composite Samples	*Assumed particle density:*	2.65
PO Number:	12015	*Initial Wt.* (g)*:*	60.40
Test Date:	27-Aug-14	*Total Sample Wt.* (g)*:*	21015.60
Start Time:	10:00	*Wt. Passing #4 (g):*	18417.80

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
27-Aug-14	1	21.5	30.0	6.0	24.0	11.4	0.04513	39.8	34.9
	2	21.5	27.0	6.0	21.0	11.9	0.03259	34.8	30.5
	5	21.5	25.0	6.0	19.0	12.2	0.02090	31.5	27.6
	15	21.6	21.5	6.0	15.5	12.8	0.01234	25.7	22.5
	30	21.6	20.0	6.0	14.1	13.0	0.00880	23.3	20.4
	62	21.6	19.0	6.0	13.1	13.2	0.00616	21.6	18.9
	121	21.7	17.0	5.9	11.1	13.5	0.00446	18.3	16.1
	259	21.7	15.5	5.9	9.6	13.8	0.00308	15.8	13.9
	416	21.5	14.5	6.0	8.5	13.9	0.00245	14.1	12.4
28-Aug-14	1399	21.4	13.0	6.0	7.0	14.2	0.00135	11.6	10.2

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: C. Krous
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.0013**	d_{30} = **0.030**	d_{50} = **0.095**	d_{60} = **0.22**	C_u = **169**	C_c = **3.1**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
WB Borrow-1	**12015**	**Clayey sand (SC)**	**Sandy Loam †**

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-1
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 19965.00
Weight Passing #4 (g): 18221.55
Weight Retained #4 (g): 1743.45
Weight of Hydrometer Sample (g): 58.16
Calculated Weight of Sieve Sample (g): 63.72

Shape: Angular
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	19965.00	100.00
	2"	50	0.00	0.00	19965.00	100.00
	1.5"	38.1	110.93	110.93	19854.07	99.44
	1"	25	287.18	398.11	19566.89	98.01
	3/4"	19.0	318.60	716.71	19248.29	96.41
	3/8"	9.5	495.43	1212.14	18752.86	93.93
	4	4.75	531.31	1743.45	18221.55	91.27
-4			(Based on calculated sieve wt.)			
	10	2.00	1.81	7.37	56.35	88.43
	20	0.85	2.64	10.01	53.71	84.28
	40	0.425	3.75	13.76	49.96	78.40
	60	0.250	3.45	17.21	46.51	72.99
	140	0.106	4.80	22.01	41.71	65.45
	200	0.075	2.07	24.08	39.64	62.20
	dry pan		0.68	24.76	38.96	
	wet pan			38.96	0.00	

d_{10} (mm): 0.00028 d_{50} (mm): 0.035
d_{16} (mm): 0.0025 d_{60} (mm): 0.063
d_{30} (mm): 0.013 d_{84} (mm): 0.82

Median Particle Diameter --d_{50} (mm): 0.035
Uniformity Coefficient, Cu --[d_{60}/d_{10}] (mm): 225
Coefficient of Curvature, Cc --[$(d_{30})^2/(d_{10}*d_{60})$] (mm): 9.6
Mean Particle Diameter --[$(d_{16}+d_{50}+d_{84})/3$] (mm): 0.29

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CL

ASTM Soil Classification: Sandy lean clay s(CL)
USDA Soil Classification: Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-1
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:42

Type of Water Used: DISTILLED
Reaction with H_2O_2*:* NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

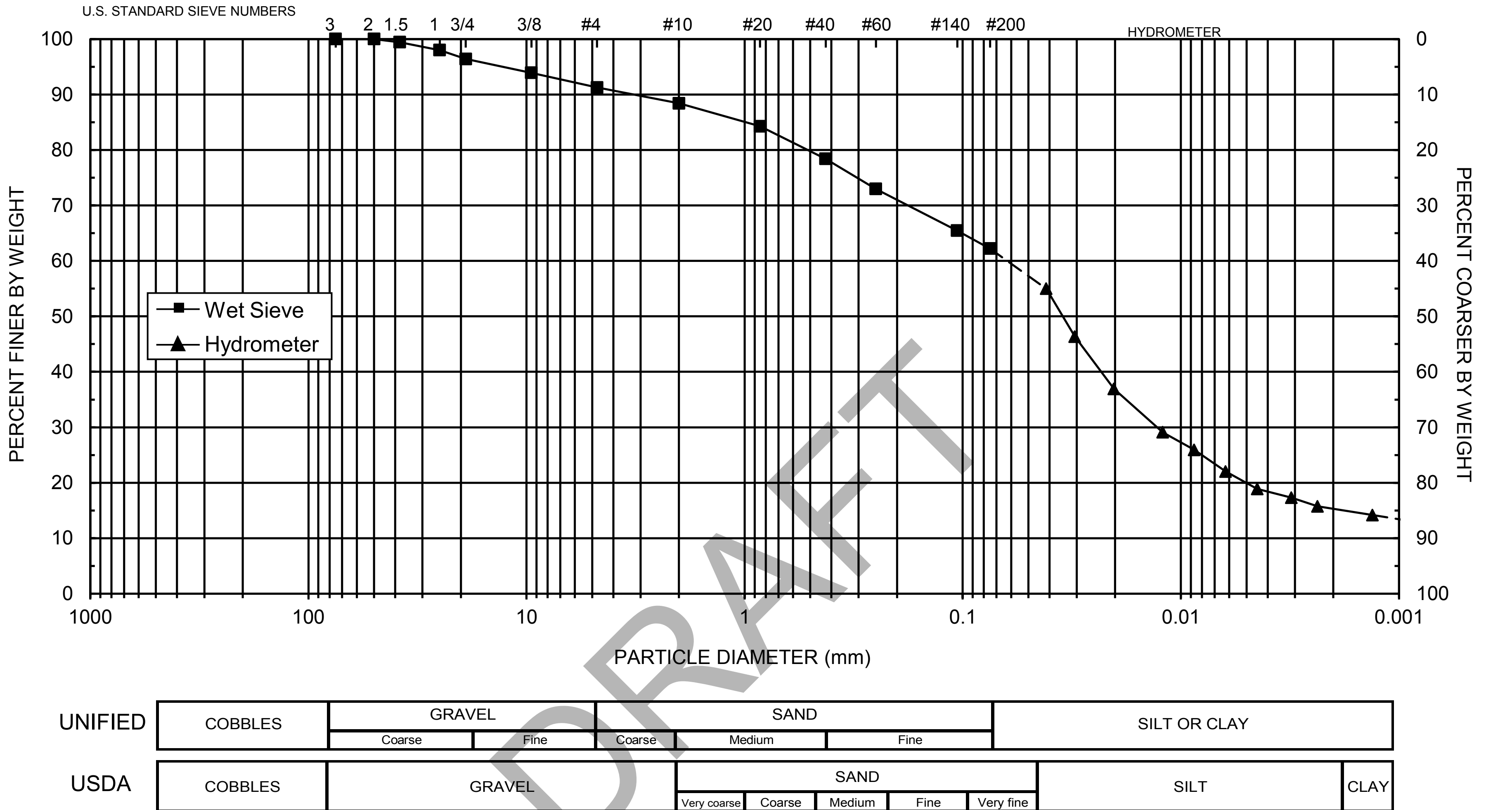
Initial Wt. (g)*:* 58.16
Total Sample Wt. (g)*:* 19965.00
Wt. Passing #4 (g): 18221.55

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.5	41.0	6.0	35.0	9.6	0.04140	60.2	55.0
	2	21.5	35.5	6.0	29.5	10.5	0.03062	50.8	46.3
	5	21.5	29.5	6.0	23.5	11.5	0.02026	40.5	36.9
	15	21.5	24.5	6.0	18.5	12.3	0.01211	31.9	29.1
	30	21.4	22.5	6.0	16.5	12.6	0.00868	28.4	25.9
	60	21.5	20.0	6.0	14.0	13.0	0.00623	24.1	22.0
	120	21.5	18.0	6.0	12.0	13.3	0.00446	20.7	18.9
	250	21.4	17.0	6.0	11.0	13.5	0.00311	18.9	17.3
	441	21.4	16.0	6.0	10.0	13.7	0.00236	17.2	15.7
27-Aug-14	1422	21.4	15.0	6.0	9.0	13.8	0.00132	15.5	14.2

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.00028**	d_{30} = **0.013**	d_{50} = **0.035**	d_{60} = **0.063**	C_u = **225**	C_c = **9.6**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
WB Stockpile-1	**12015**	**Sandy lean clay s(CL)**	**Loam †**

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 23971.00
Weight Passing #4 (g): 18117.64
Weight Retained #4 (g): 5853.36
Weight of Hydrometer Sample (g): 59.40
Calculated Weight of Sieve Sample (g): 78.59

Shape: Angular
Hardness: Hard and durable

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	23971.00	100.00
	2"	50	187.62	187.62	23783.38	99.22
	1.5"	38.1	867.05	1054.67	22916.33	95.60
	1"	25	2498.89	3553.56	20417.44	85.18
	3/4"	19.0	1357.89	4911.45	19059.55	79.51
	3/8"	9.5	493.55	5405.00	18566.00	77.45
	4	4.75	448.36	5853.36	18117.64	75.58
-4			(Based on calculated sieve wt.)			
	10	2.00	1.92	21.11	57.48	73.14
	20	0.85	3.79	24.90	53.69	68.32
	40	0.425	4.39	29.29	49.30	62.73
	60	0.250	3.65	32.94	45.65	58.09
	140	0.106	5.36	38.30	40.29	51.27
	200	0.075	2.21	40.51	38.08	48.45
	dry pan		0.65	41.16	37.43	
	wet pan			37.43	0.00	

d_{10} (mm): 0.0011 d_{50} (mm): 0.091
d_{16} (mm): 0.0049 d_{60} (mm): 0.31
d_{30} (mm): 0.026 d_{84} (mm): 24

Median Particle Diameter --d_{50} (mm): 0.091
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 282
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 2.0
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 8.0

Note: Reported values for d_{10}, C_u, C_c, and soil classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Classification of fines: CL

ASTM Soil Classification: Clayey sand with gravel (SC)g
USDA Soil Classification: Loam †

† Greater than 10% of sample is coarse material

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:48

Type of Water Used: DISTILLED
Reaction with H_2O_2*:* NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

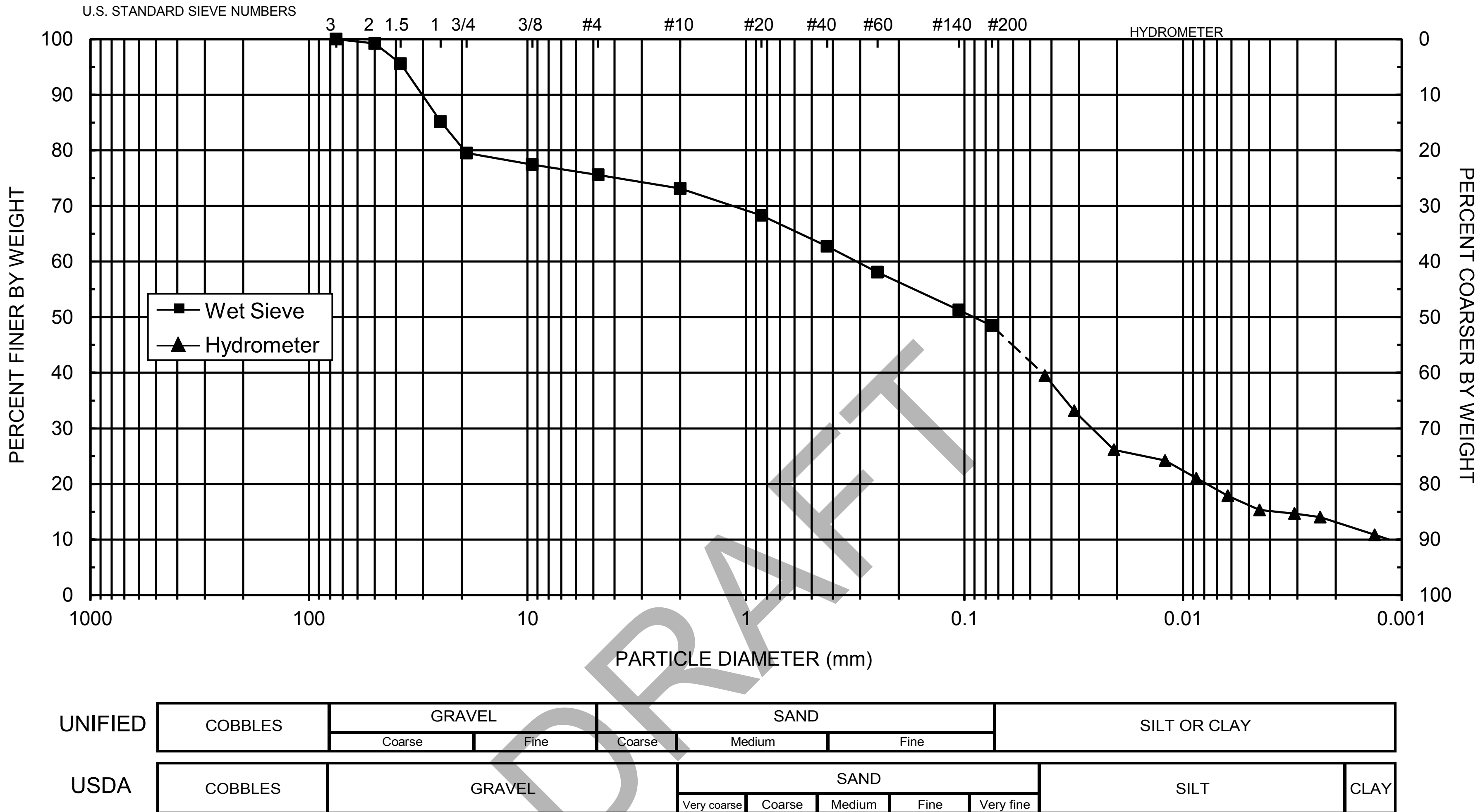
Initial Wt. (g): 59.40
Total Sample Wt. (g): 23971.00
Wt. Passing #4 (g): 18117.64

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.5	37.0	6.0	31.0	10.2	0.04279	52.2	39.5
	2	21.5	32.0	6.0	26.0	11.1	0.03145	43.8	33.1
	5	21.5	26.5	6.0	20.5	12.0	0.02069	34.6	26.1
	15	21.4	25.0	6.0	19.0	12.2	0.01208	32.0	24.2
	30	21.4	22.5	6.0	16.5	12.6	0.00868	27.8	21.0
	60	21.5	20.0	6.0	14.0	13.0	0.00623	23.6	17.9
	120	21.5	18.0	6.0	12.0	13.3	0.00446	20.3	15.3
	253	21.4	17.5	6.0	11.5	13.4	0.00309	19.4	14.7
	436	21.4	17.0	6.0	11.0	13.5	0.00236	18.6	14.0
27-Aug-14	1423	21.4	14.5	6.0	8.5	13.9	0.00132	14.3	10.8

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.0011**	d_{30} = **0.026**	d_{50} = **0.091**	d_{60} = **0.31**	C_u = **282**	C_c = **2.0**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
WB Stockpile-2	**12015**	**Clayey sand with gravel (SC)g**	**Loam †**

† Greater than 10% of sample is coarse material

Note: Reported values for d_{10}, C_u, C_c, and ASTM classification are estimates, since extrapolation was required to obtain the d_{10} diameter

Daniel B. Stephens & Associates, Inc.

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Wet Sieve Data (#4 Split)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: Topsoil-1
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 3-Sep-14

Initial Dry Weight of Sample (g): 13376.20
Weight Passing #4 (g): 13316.24
Weight Retained #4 (g): 59.96
Weight of Hydrometer Sample (g): 60.44
Calculated Weight of Sieve Sample (g): 60.71

Shape: Rounded
Hardness: Soft

Test Fraction	Sieve Number	Diameter (mm)	Wt. Retained	Cum Wt. Retained	Wt. Passing	% Passing
+4						
	3"	75	0.00	0.00	13376.20	100.00
	2"	50	0.00	0.00	13376.20	100.00
	1.5"	38.1	0.00	0.00	13376.20	100.00
	1"	25	0.00	0.00	13376.20	100.00
	3/4"	19.0	0.00	0.00	13376.20	100.00
	3/8"	9.5	12.81	12.81	13363.39	99.90
	4	4.75	47.15	59.96	13316.24	99.55
-4			(Based on calculated sieve wt.)			
	10	2.00	1.89	2.16	58.55	96.44
	20	0.85	2.12	4.28	56.43	92.95
	40	0.425	2.02	6.30	54.41	89.62
	60	0.250	3.19	9.49	51.22	84.37
	140	0.106	10.06	19.55	41.16	67.80
	200	0.075	3.75	23.30	37.41	61.62
	dry pan		0.89	24.19	36.52	
	wet pan			36.52	0.00	

d_{10} (mm): 0.0036 d_{50} (mm): 0.047
d_{16} (mm): 0.0059 d_{60} (mm): 0.070
d_{30} (mm): 0.018 d_{84} (mm): 0.25

Median Particle Diameter --d_{50} (mm): 0.047
Uniformity Coefficient, Cu --$[d_{60}/d_{10}]$ (mm): 19
Coefficient of Curvature, Cc --$[(d_{30})^2/(d_{10}*d_{60})]$ (mm): 1.3
Mean Particle Diameter --$[(d_{16}+d_{50}+d_{84})/3]$ (mm): 0.10

Classification of fines (visual method): ML

ASTM Soil Classification: Sandy silt s(ML)
USDA Soil Classification: Loam

Laboratory analysis by: J. Fisher
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Particle Size Analysis
Hydrometer Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: Topsoil-1
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 26-Aug-14
Start Time: 9:36

Type of Water Used: DISTILLED
Reaction with H_2O_2*:* NA
Dispersant:* $(NaPO_3)_6$
Assumed particle density: 2.65

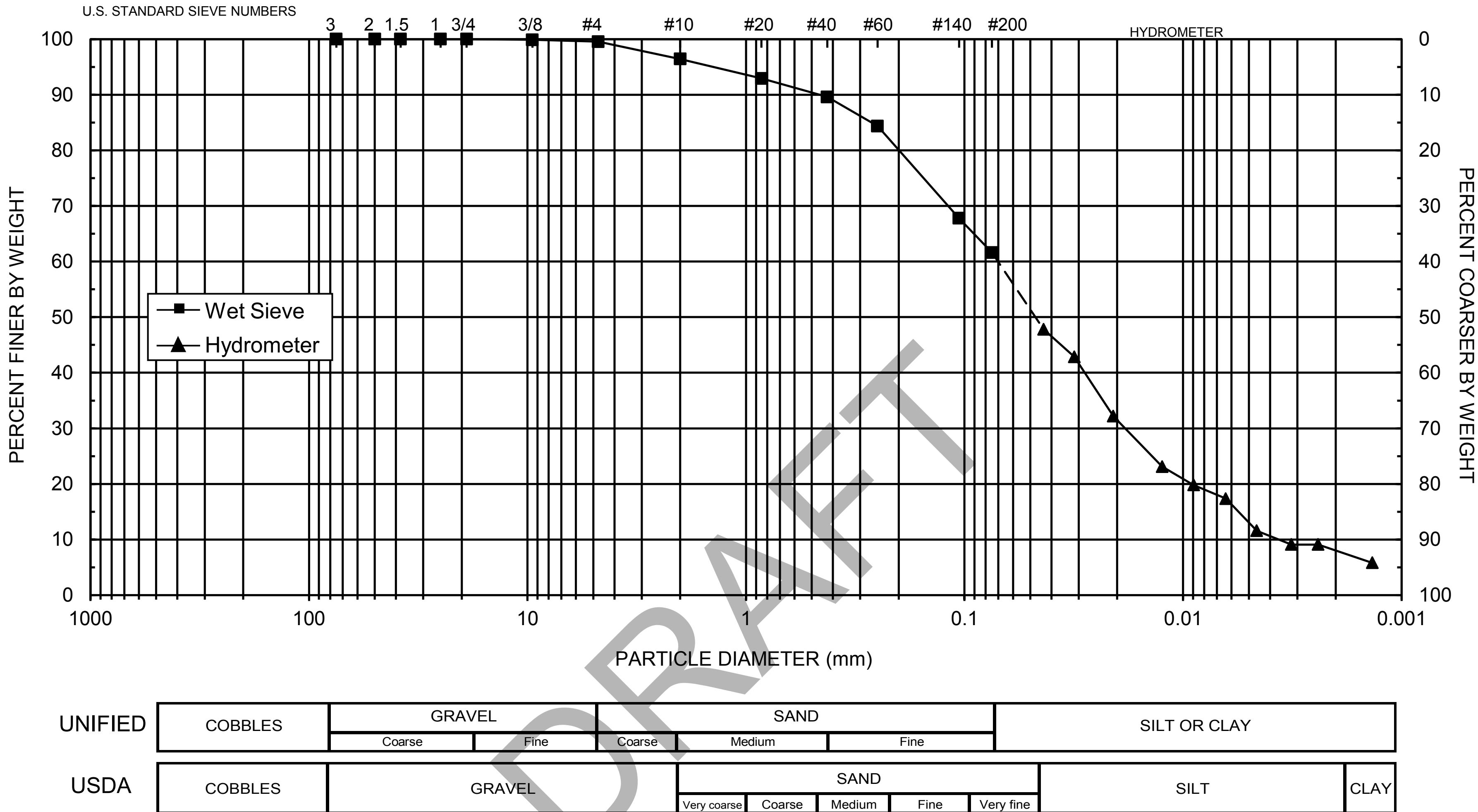
Initial Wt. (g)*:* 60.44
Total Sample Wt. (g)*:* 13376.20
Wt. Passing #4 (g): 13316.24

Date	Time (min)	Temp (°C)	R (g/L)	R_L (g/L)	R_{corr} (g/L)	L (cm)	D (mm)	P (%)	% Finer
26-Aug-14	1	21.5	35.0	6.0	29.0	10.6	0.04347	48.0	47.8
	2	21.5	32.0	6.0	26.0	11.1	0.03145	43.1	42.9
	5	21.5	25.5	6.0	19.5	12.1	0.02083	32.3	32.2
	15	21.5	20.0	6.0	14.0	13.0	0.01246	23.2	23.1
	30	21.4	18.0	6.0	12.0	13.3	0.00893	19.9	19.8
	60	21.5	16.5	6.0	10.5	13.6	0.00637	17.4	17.3
	120	21.5	13.0	6.0	7.0	14.2	0.00460	11.6	11.6
	254	21.4	11.5	6.0	5.5	14.4	0.00319	9.1	9.1
	446	21.4	11.5	6.0	5.5	14.4	0.00241	9.1	9.1
27-Aug-14	1427	21.4	9.5	6.0	3.5	14.7	0.00136	5.8	5.8

Comments:

* Dispersion device: mechanically operated stirring device

Laboratory analysis by: S. Hanhardt
Data entered by: C. Krous
Checked by: J. Hines



d_{10} = **0.0036**	d_{30} = **0.018**	d_{50} = **0.047**	d_{60} = **0.070**	C_u = **19**	C_c = **1.3**

SAMPLE NUMBER	PO NUMBER	ASTM CLASSIFICATION	USDA CLASSIFICATION
Topsoil-1	**12015**	**Sandy silt s(ML)**	**Loam**

Daniel B. Stephens & Associates, Inc.

Atterberg Limits/ Identification of Fines

Summary of Atterberg Tests

Sample Number	Liquid Limit	Plastic Limit	Plasticity Index	Classification
VVL Composite 0-10	75	25	50	CH
VVL Composite 11-15	33	27	6	ML
VVL Composite 16-20	54	24	30	CH
VVL Composite 21-30	68	25	43	CH
VVL Composite 31+	65	30	35	CH
VVL Composite TP-10	38	24	14	CL
VVL Composite TP-12	72	25	47	CH
VVL Composite TP-13	66	26	40	CH
WB Borrow-1	34	23	11	CL
WB Stockpile-1	31	19	12	CL
WB Stockpile-2	32	21	11	CL
Topsoil-1	---	---	---	ML

--- = Soil requires visual-manual classification due to non-plasticity

Daniel B. Stephens & Associates, Inc.

Atterberg Limits

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	38	29	18
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	125.24	128.04	123.86
Weight of pan plus dry soil (g)	121.13	123.60	119.76
Weight of pan (g):	115.27	117.57	114.55
Gravimetric moisture content (% g/g):	70.14	73.63	78.69
Liquid Limit:	75		

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	122.76	118.35
Weight of pan plus dry soil (g)	121.47	117.08
Weight of pan (g):	116.43	112.07
Gravimetric moisture content (% g/g):	25.60	25.35
Plastic Limit:	25	

Results

Percent of Sample Retained on #40 Sieve: See Sieve

Liquid Limit: 75
Plastic Limit: 25
Plasticity Index: 50

Classification: CH

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

D a n i e l B . S t e p h e n s & A s s o c i a t e s , I n c .

Atterberg Limits

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 11-15
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	31	23	16
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	127.88	123.40	124.43
Weight of pan plus dry soil (g)	124.91	120.20	121.35
Weight of pan (g):	115.62	110.85	112.67
Gravimetric moisture content (% g/g):	31.97	34.22	35.48
Liquid Limit:	33		

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	120.24	123.10
Weight of pan plus dry soil (g)	118.66	121.70
Weight of pan (g):	112.69	116.48
Gravimetric moisture content (% g/g):	26.47	26.82
Plastic Limit:	27	

Results

Percent of Sample Retained on #40 Sieve: See Sieve

Liquid Limit: 33
Plastic Limit: 27
Plasticity Index: 6

Classification: ML

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Daniel B. Stephens & Associates, Inc.

Atterberg Limits

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite 16-20
Project Name:	VVL Composite Samples
PO Number:	12015
Test Date:	28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	33	26	18
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	128.15	130.81	130.75
Weight of pan plus dry soil (g)	124.54	126.16	127.49
Weight of pan (g):	117.50	117.45	121.84
Gravimetric moisture content (% g/g):	51.28	53.39	57.70
Liquid Limit:	54		

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	121.56	118.60
Weight of pan plus dry soil (g)	120.45	117.48
Weight of pan (g):	115.78	112.70
Gravimetric moisture content (% g/g):	23.77	23.43
Plastic Limit:	24	

Results

Percent of Sample Retained on #40 Sieve:	See Sieve
Liquid Limit:	54
Plastic Limit:	24
Plasticity Index:	30
Classification:	CH

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Daniel B. Stephens & Associates, Inc.

Atterberg Limits

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 21-30
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	37	29	17
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	122.68	128.07	123.11
Weight of pan plus dry soil (g)	119.77	123.39	118.34
Weight of pan (g):	115.16	116.46	111.63
Gravimetric moisture content (% g/g):	63.12	67.53	71.09

Liquid Limit: 68

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	117.97	117.74
Weight of pan plus dry soil (g)	116.88	116.63
Weight of pan (g):	112.58	112.27
Gravimetric moisture content (% g/g):	25.35	25.46

Plastic Limit: 25

Results

Percent of Sample Retained on #40 Sieve: See Sieve

Liquid Limit: 68
Plastic Limit: 25
Plasticity Index: 43

Classification: CH

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Daniel B. Stephens & Associates, Inc.

Atterberg Limits

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite 31+
Project Name:	VVL Composite Samples
PO Number:	12015
Test Date:	28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	34	26	17
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	125.02	120.06	126.62
Weight of pan plus dry soil (g)	121.86	117.36	123.29
Weight of pan (g):	116.80	113.15	118.40
Gravimetric moisture content (% g/g):	62.45	64.13	68.10
Liquid Limit:	65		

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Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	116.83	115.29
Weight of pan plus dry soil (g)	115.82	114.30
Weight of pan (g):	112.50	110.99
Gravimetric moisture content (% g/g):	30.42	29.91
Plastic Limit:	30	

Results

Percent of Sample Retained on #40 Sieve:	See Sieve
Liquid Limit:	65
Plastic Limit:	30
Plasticity Index:	35
Classification:	CH

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Atterberg Limits

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	34	25	17
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	122.13	120.28	127.26
Weight of pan plus dry soil (g)	119.79	117.92	124.28
Weight of pan (g):	113.15	111.65	116.87
Gravimetric moisture content (% g/g):	35.24	37.64	40.22

Liquid Limit: 38

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	119.47	124.67
Weight of pan plus dry soil (g)	118.23	123.39
Weight of pan (g):	113.24	118.05
Gravimetric moisture content (% g/g):	24.85	23.97

Plastic Limit: 24

Results

Percent of Sample Retained on #40 Sieve: See Sieve

Liquid Limit: 38
Plastic Limit: 24
Plasticity Index: 14

Classification: CL

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Daniel B. Stephens & Associates, Inc.

Atterberg Limits

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite TP-12
Project Name:	VVL Composite Samples
PO Number:	12015
Test Date:	28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	36	27	16
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	123.57	126.48	129.17
Weight of pan plus dry soil (g)	118.90	122.32	123.22
Weight of pan (g):	112.01	116.50	115.32
Gravimetric moisture content (% g/g):	67.78	71.48	75.32

Liquid Limit: 72

DRAFT

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	120.39	123.08
Weight of pan plus dry soil (g)	119.14	121.52
Weight of pan (g):	114.22	115.17
Gravimetric moisture content (% g/g):	25.41	24.57

Plastic Limit: 25

Results

Percent of Sample Retained on #40 Sieve:	See Sieve
Liquid Limit:	72
Plastic Limit:	25
Plasticity Index:	47
Classification:	CH

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Daniel B. Stephens & Associates, Inc.

Atterberg Limits

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	VVL Composite TP-13
Project Name:	VVL Composite Samples
PO Number:	12015
Test Date:	28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	35	24	16
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	123.88	130.58	126.31
Weight of pan plus dry soil (g)	120.50	125.25	120.74
Weight of pan (g):	115.14	117.17	112.62
Gravimetric moisture content (% g/g):	63.06	65.97	68.60
Liquid Limit:	66		

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	123.03	123.36
Weight of pan plus dry soil (g)	121.84	121.95
Weight of pan (g):	117.20	116.43
Gravimetric moisture content (% g/g):	25.65	25.54
Plastic Limit:	26	

Results

Percent of Sample Retained on #40 Sieve:	See Sieve
Liquid Limit:	66
Plastic Limit:	26
Plasticity Index:	40
Classification:	CH

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Atterberg Limits

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Borrow-1
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	35	25	15
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	123.38	129.04	131.33
Weight of pan plus dry soil (g)	120.86	125.55	127.80
Weight of pan (g):	113.25	115.28	117.68
Gravimetric moisture content (% g/g):	33.11	33.98	34.88

Liquid Limit: 34

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	124.05	123.75
Weight of pan plus dry soil (g)	122.82	122.37
Weight of pan (g):	117.45	116.40
Gravimetric moisture content (% g/g):	22.91	23.12

Plastic Limit: 23

Results

Percent of Sample Retained on #40 Sieve: See Sieve

Liquid Limit: 34
Plastic Limit: 23
Plasticity Index: 11

Classification: CL

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Atterberg Limits

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	WB Stockpile-1
Project Name:	VVL Composite Samples
PO Number:	12015
Test Date:	28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	35	23	15
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	129.45	125.98	128.64
Weight of pan plus dry soil (g)	126.43	123.72	125.41
Weight of pan (g):	116.30	116.29	115.32
Gravimetric moisture content (% g/g):	29.81	30.42	32.01
Liquid Limit:	31		

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	122.02	125.40
Weight of pan plus dry soil (g)	120.73	123.94
Weight of pan (g):	114.03	116.43
Gravimetric moisture content (% g/g):	19.25	19.44
Plastic Limit:	19	

Results

Percent of Sample Retained on #40 Sieve:	See Sieve
Liquid Limit:	31
Plastic Limit:	19
Plasticity Index:	12
Classification:	CL

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Daniel B. Stephens & Associates, Inc.

Atterberg Limits

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	WB Stockpile-2
Project Name:	VVL Composite Samples
PO Number:	12015
Test Date:	28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:	37	24	15
Pan number:	LL1	LL2	LL3
Weight of pan plus moist soil (g):	123.81	120.88	126.63
Weight of pan plus dry soil (g)	120.98	118.52	123.03
Weight of pan (g):	111.87	111.22	112.63
Gravimetric moisture content (% g/g):	31.06	32.33	34.62
Liquid Limit:	32		

Plastic Limit

	Trial 1	Trial 2
Pan number:	PL1	PL2
Weight of pan plus moist soil (g):	132.30	123.91
Weight of pan plus dry soil (g)	130.86	122.42
Weight of pan (g):	124.11	115.37
Gravimetric moisture content (% g/g):	21.33	21.13
Plastic Limit:	21	

Results

Percent of Sample Retained on #40 Sieve:	See Sieve
Liquid Limit:	32
Plastic Limit:	21
Plasticity Index:	11
Classification:	CL

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Daniel B. Stephens & Associates, Inc.

Atterberg Limits

Job Name:	Hydrometrics, Inc.
Job Number:	LB14.0168.00
Sample Number:	Topsoil-1
Project Name:	VVL Composite Samples
PO Number:	12015
Test Date:	28-Aug-14

Liquid Limit

	Trial 1	Trial 2	Trial 3
Number of drops:			
Pan number:			
Weight of pan plus moist soil (g):			
Weight of pan plus dry soil (g)			
Weight of pan (g):			
Gravimetric moisture content (% g/g):	---	---	---
Liquid Limit:	---		

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Plastic Limit

	Trial 1	Trial 2
Pan number:		
Weight of pan plus moist soil (g):		
Weight of pan plus dry soil (g)		
Weight of pan (g):		
Gravimetric moisture content (% g/g):	---	---
Plastic Limit:	---	

Results

Percent of Sample Retained on #40 Sieve:	See Sieve
Liquid Limit:	---
Plastic Limit:	---
Plasticity Index:	---
Classification (Visual Method):	ML

Comments:

--- = Soil requires visual-manual classification due to non-plasticity
* = 1-point method requested by client

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

Data for Description and Identification of Fines
(Visual-Manual Procedure)

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: Topsoil-1
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 28-Aug-14

Visual-manual classification of material passing the #40 sieve in lieu of Atterberg analysis due to non-plasticity:

Descriptive Information:

Color of Moist Sample: Black (10YR 2/1)
Odor: None
Moisture Condition: Moist
HCl Reaction: None

Preliminary Identification:

Dry Strength: Low
Dilatency: Rapid
Toughness: Low
Plasticity: Non-plastic

Identification of Inorganic Fine Grained Soils:

Silt (ML)

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)
VVL Composite 0-10	17.6	1.72	13.6	1.87
VVL Composite 11-15	15.0	1.76	12.2	1.88
VVL Composite 16-20	17.9	1.71	15.3	1.80
VVL Composite 21-30	19.5	1.62	15.5	1.76
VVL Composite 31+	27.5	1.44	24.2	1.52
VVL Composite TP-10	16.7	1.77	13.1	1.90
VVL Composite TP-12	19.5	1.65	15.7	1.78
VVL Composite TP-13	22.2	1.61	19.3	1.69
WB Borrow-1	18.9	1.67	16.6	1.75
WB Stockpile-1	15.8	1.79	14.4	1.84
WB Stockpile-2	17.3	1.74	13.0	1.89
Topsoil-1	29.2	1.30	---	---

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

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 0-10
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 28-Aug-14

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

Split (3/4", 3/8", #4): 3/4
Mass of coarse material (g): 22.65578242
Mass of fines material (g): 77.34421758
Mold weight (g): 5573
Mold volume (cm^3): 2123.94

Compaction Method: Standard C
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	9653	820.83	747.66	283.83	1.66	15.78
2	9835	759.30	688.16	270.63	1.71	17.04
3	9877	769.95	688.56	283.91	1.69	20.11
4	9837	788.91	702.86	298.48	1.66	21.28
5	9888	710.02	644.20	289.72	1.71	18.57

Soil Fractions
Coarse Fraction (% g/g): 22.7
Fines Fraction (% g/g): 77.3

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	1.81	12.20
2	1.86	13.18
3	1.84	15.56
4	1.81	16.46
5	1.86	14.36

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

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

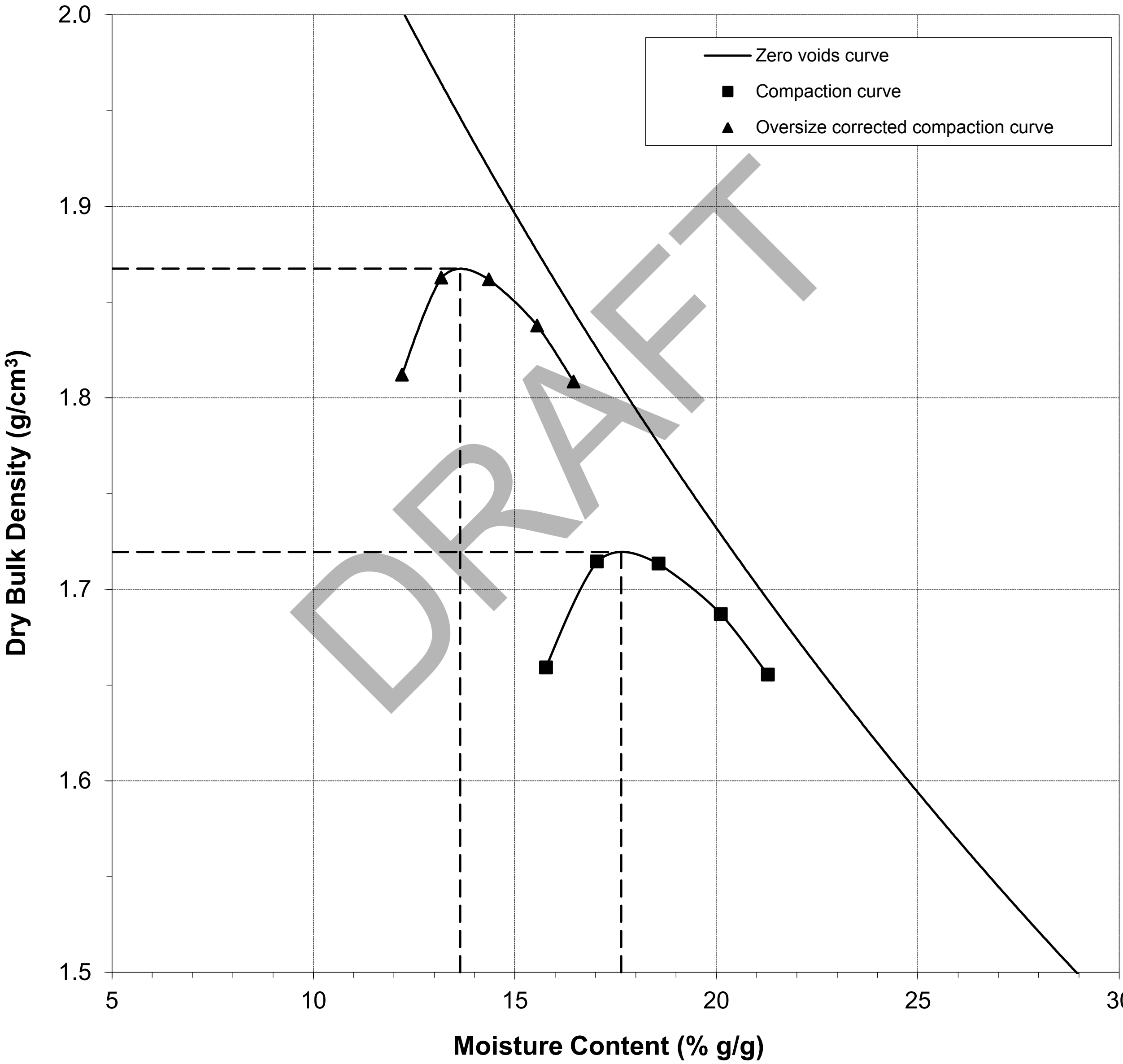
Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data Points with Fitted Curve

Sample Number: VVL Composite 0-10

	Measured	Corrected
Optimum Moisture Content (% g/g):	17.6	13.6
Maximum Dry Bulk Density (g/cm^3):	1.72	1.87

Test Date: 28-Aug-14



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

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

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 11-15
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 27-Aug-14

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

Split (3/4", 3/8", #4): 3/4
Mass of coarse material (g)*:* 18.96896728
Mass of fines material (g)*:* 81.03103272
Mold weight (g): 5573
Mold volume (cm^3)*:* 2123.94

Compaction Method: Standard C
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	9635	759.53	717.50	296.54	1.74	9.98
2	9790	797.27	736.22	263.78	1.76	12.92
3	9916	951.47	859.39	287.01	1.76	16.09
4	9916	960.93	855.36	297.88	1.72	18.94
5	9868	820.15	732.17	301.51	1.68	20.43

Soil Fractions

Coarse Fraction (% g/g): 19.0
Fines Fraction (% g/g): 81.0

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	1.86	8.09
2	1.88	10.47
3	1.88	13.04
4	1.84	15.34
5	1.80	16.55

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

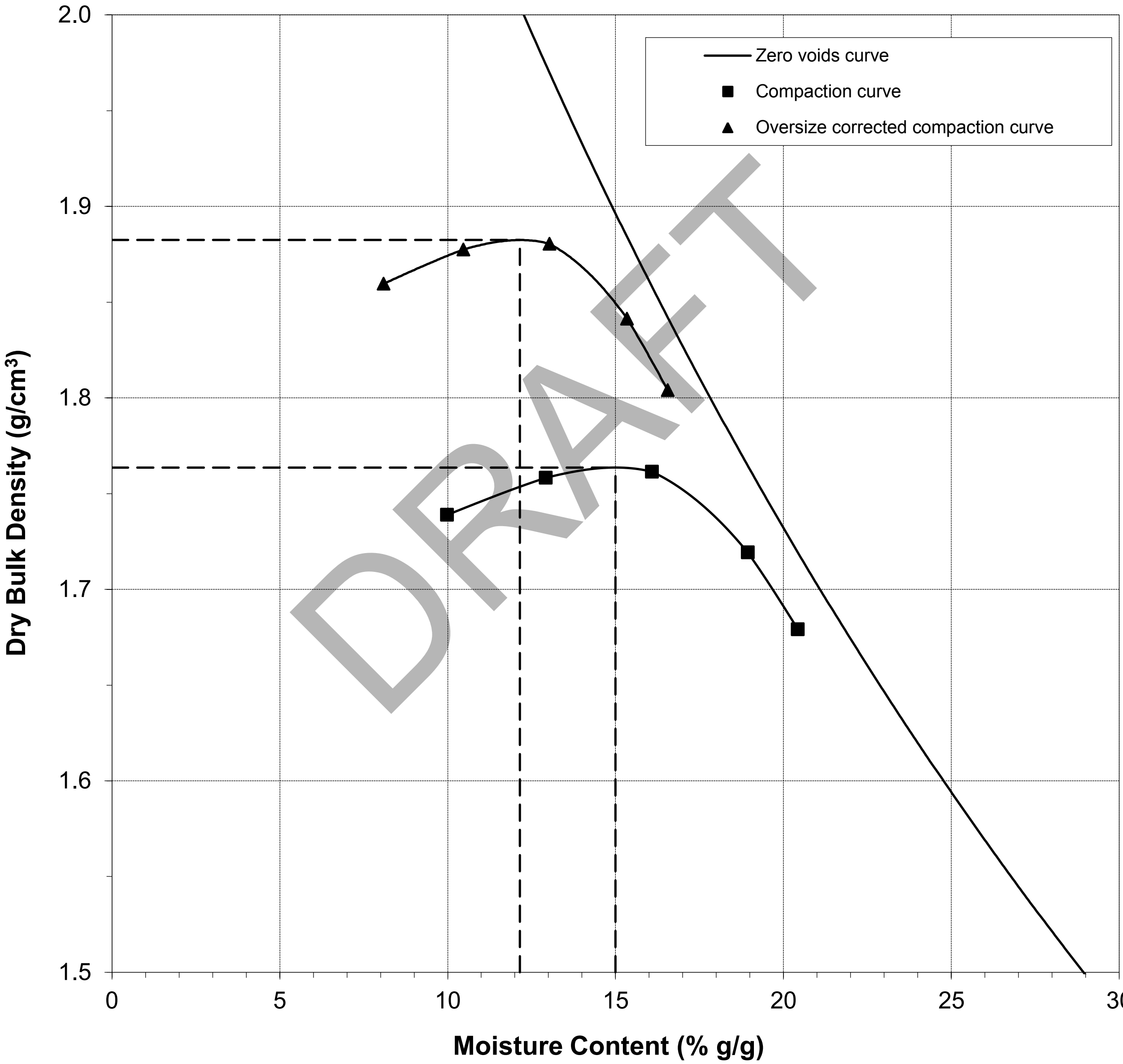
Laboratory analysis by: N. Candelaria
Data entered by: D. O'Dowd
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: VVL Composite 11-15

	Measured	Corrected
Optimum Moisture Content (% g/g):	15.0	12.2
Maximum Dry Bulk Density (g/cm^3):	1.76	1.88

Test Date: 27-Aug-14



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

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

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 16-20
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 29-Aug-14

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

Split (3/4", 3/8", #4): 3/4
Mass of coarse material (g): 14.47967073
Mass of fines material (g): 85.52032927
Mold weight (g): 5573
Mold volume (cm^3): 2123.94

Compaction Method: Standard C
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	9490	808.77	748.56	284.74	1.63	12.98
2	9602	662.50	605.49	207.42	1.66	14.32
3	9846	785.87	711.57	297.45	1.71	17.94
4	9835	746.56	661.05	268.94	1.65	21.81
5	9845	744.09	668.31	296.82	1.67	20.40

Soil Fractions
Coarse Fraction (% g/g): 14.5
Fines Fraction (% g/g): 85.5

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	1.73	11.10
2	1.75	12.25
3	1.80	15.34
4	1.74	18.65
5	1.76	17.45

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

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

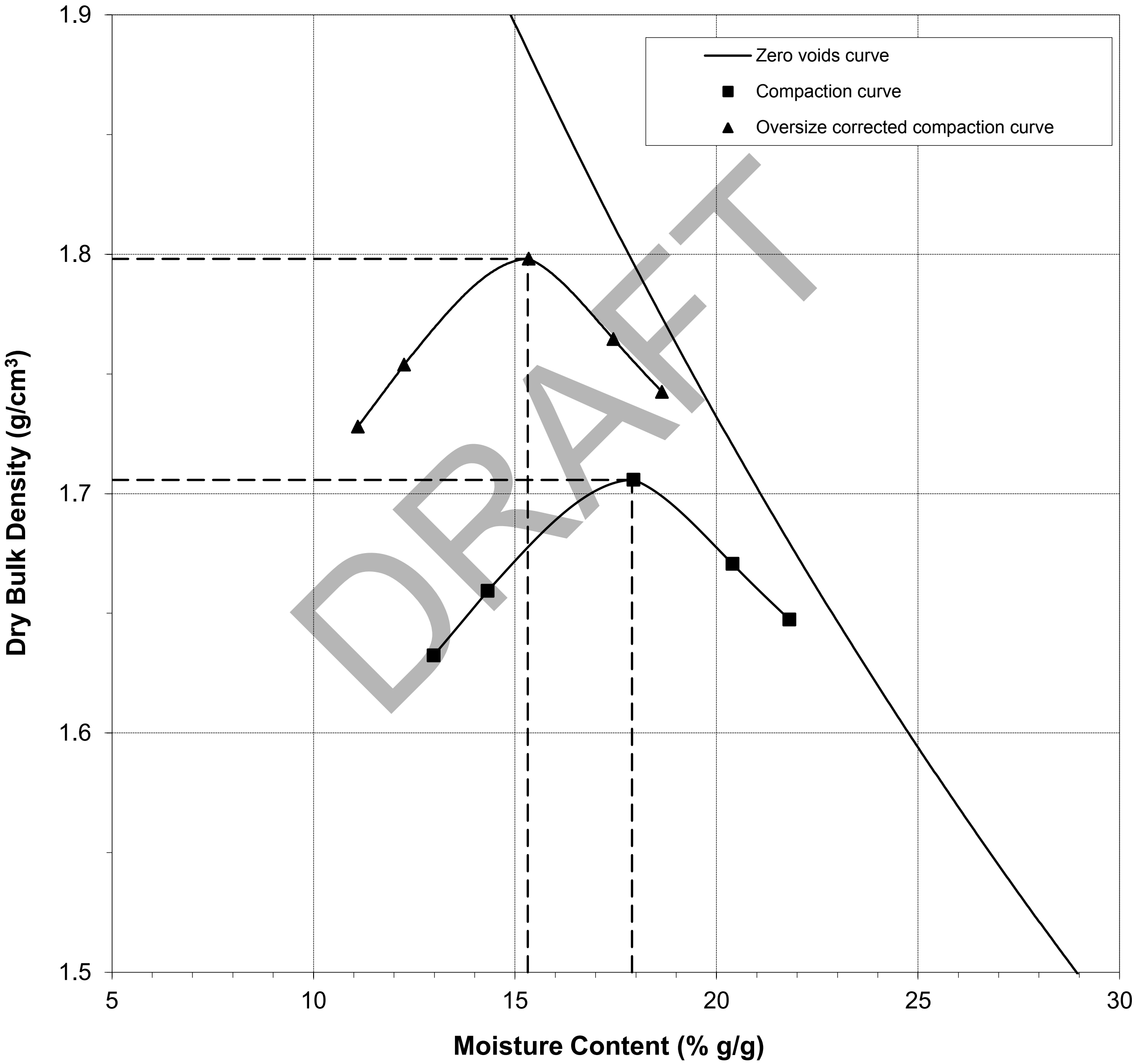
Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data Points with Fitted Curve

Sample Number: VVL Composite 16-20

	Measured	Corrected
Optimum Moisture Content (% g/g):	17.9	15.3
Maximum Dry Bulk Density (g/cm^3):	1.71	1.80

Test Date: 29-Aug-14



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

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

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 21-30
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 27-Aug-14

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

Split (3/4", 3/8", #4): 3/4
Mass of coarse material (g): 20.52072038
Mass of fines material (g): 79.47927962
Mold weight (g): 5573
Mold volume (cm^3): 2123.94

Compaction Method: Standard C
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	9463	831.71	756.65	289.61	1.58	16.07
2	9671	891.57	794.90	283.08	1.62	18.89
3	9735	703.94	632.46	298.93	1.61	21.43
4	9714	743.70	653.29	283.51	1.57	24.45
5	9625	748.27	647.80	298.48	1.48	28.76

Soil Fractions
Coarse Fraction (% g/g): 20.5
Fines Fraction (% g/g): 79.5

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	1.72	12.77
2	1.76	15.01
3	1.75	17.03
4	1.71	19.43
5	1.63	22.86

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

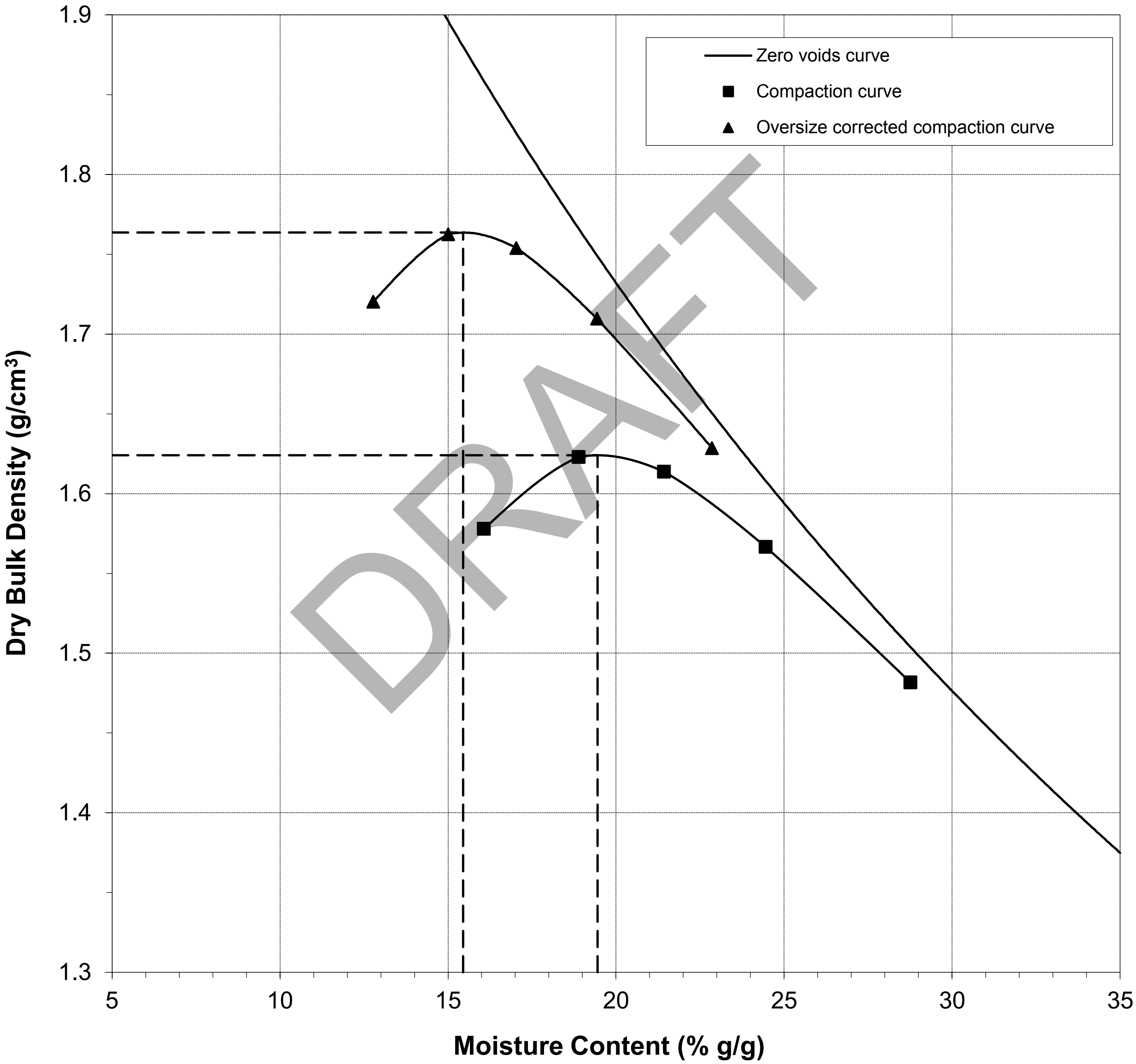
Laboratory analysis by: N. Candelaria
Data entered by: D. O'Dowd
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: VVL Composite 21-30

	Measured	Corrected
Optimum Moisture Content (% g/g):	19.5	15.5
Maximum Dry Bulk Density (g/cm^3):	1.62	1.76

Test Date: 27-Aug-14



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

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

Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite 31+
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 25-Aug-14

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

Split (3/4", 3/8", #4): 3/4
Mass of coarse material (g): 12.02166167
Mass of fines material (g): 87.97833833
Mold weight (g): 5573
Mold volume (cm^3): 2123.94

Compaction Method: Standard C
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	9178	809.35	721.54	289.58	1.41	20.33
2	9377	797.94	696.92	293.65	1.43	25.05
3	9500	693.05	585.64	212.71	1.44	28.80
4	9485	776.19	656.97	269.82	1.41	30.79
5	9495	806.02	679.15	282.81	1.40	32.01

Soil Fractions

Coarse Fraction (% g/g): 12.0
Fines Fraction (% g/g): 88.0

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	1.49	17.88
2	1.52	22.04
3	1.52	25.34
4	1.49	27.09
5	1.48	28.16

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

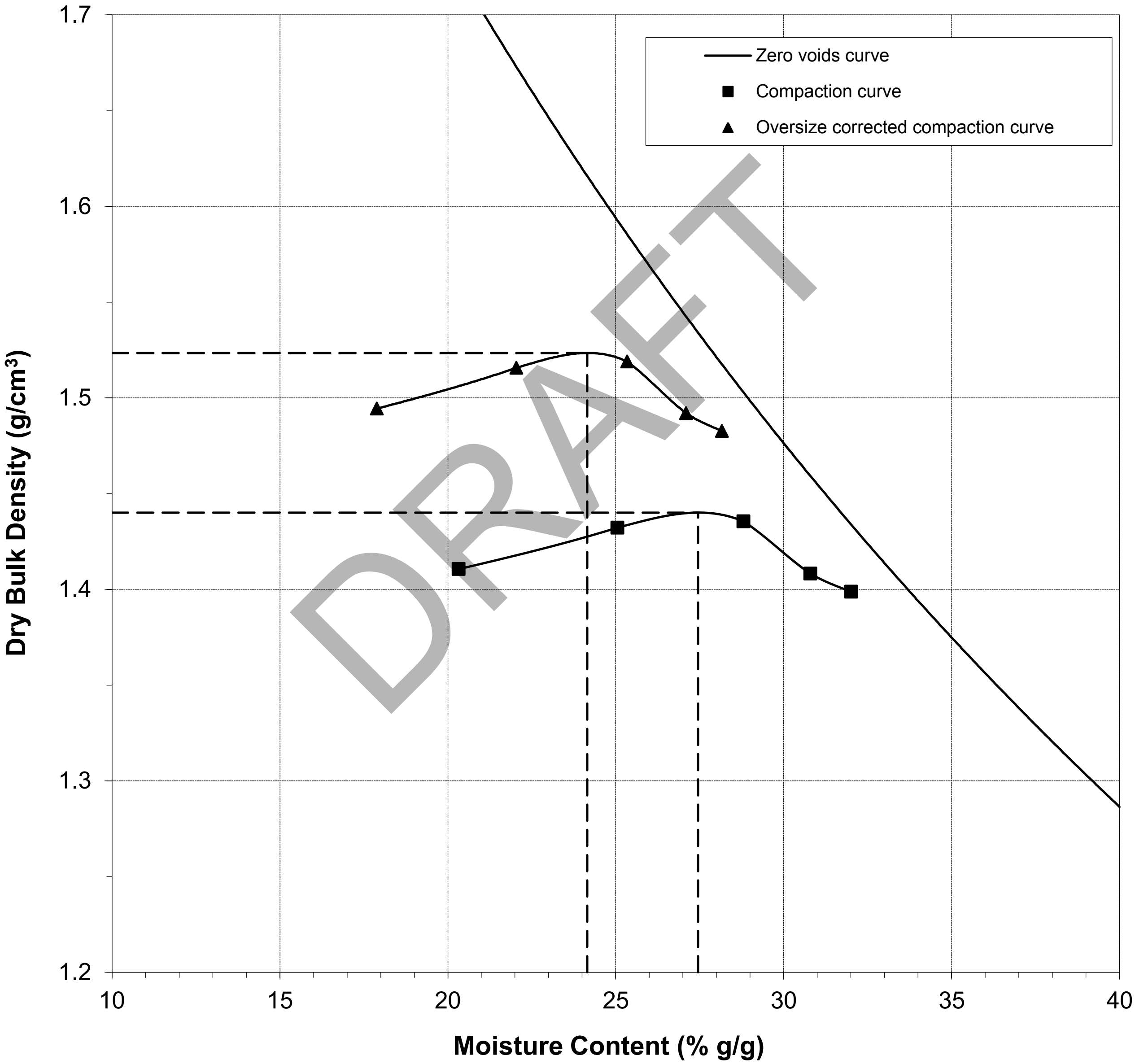
Laboratory analysis by: N. Candelaria
Data entered by: C. Krous
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: VVL Composite 31+

	Measured	Corrected
Optimum Moisture Content (% g/g):	27.5	24.2
Maximum Dry Bulk Density (g/cm^3):	1.44	1.52

Test Date: 25-Aug-14



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

Laboratory analysis by: N. Candelaria
Data entered by: C. Krous
Checked by: J. Hines

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-10
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 25-Aug-14

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

Split (3/4", 3/8", #4): 3/4
Mass of coarse material (g)*:* 21.58382813
Mass of fines material (g)*:* 78.41617187
Mold weight (g): 5573
Mold volume (cm^3)*:* 2123.94

Compaction Method: Standard C
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	9738	877.42	815.53	297.96	1.75	11.96
2	9860	872.01	795.83	284.26	1.76	14.89
3	9963	881.31	792.81	268.40	1.77	16.88
4	9903	889.17	792.26	287.76	1.71	19.21
5	9826	897.08	792.53	283.37	1.66	20.53

Soil Fractions

Coarse Fraction (% g/g): 21.6
Fines Fraction (% g/g): 78.4

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	1.89	9.38
2	1.89	11.68
3	1.90	13.23
4	1.85	15.06
5	1.81	16.10

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

Laboratory analysis by: N. Candelaria
Data entered by: C. Krous
Checked by: J. Hines

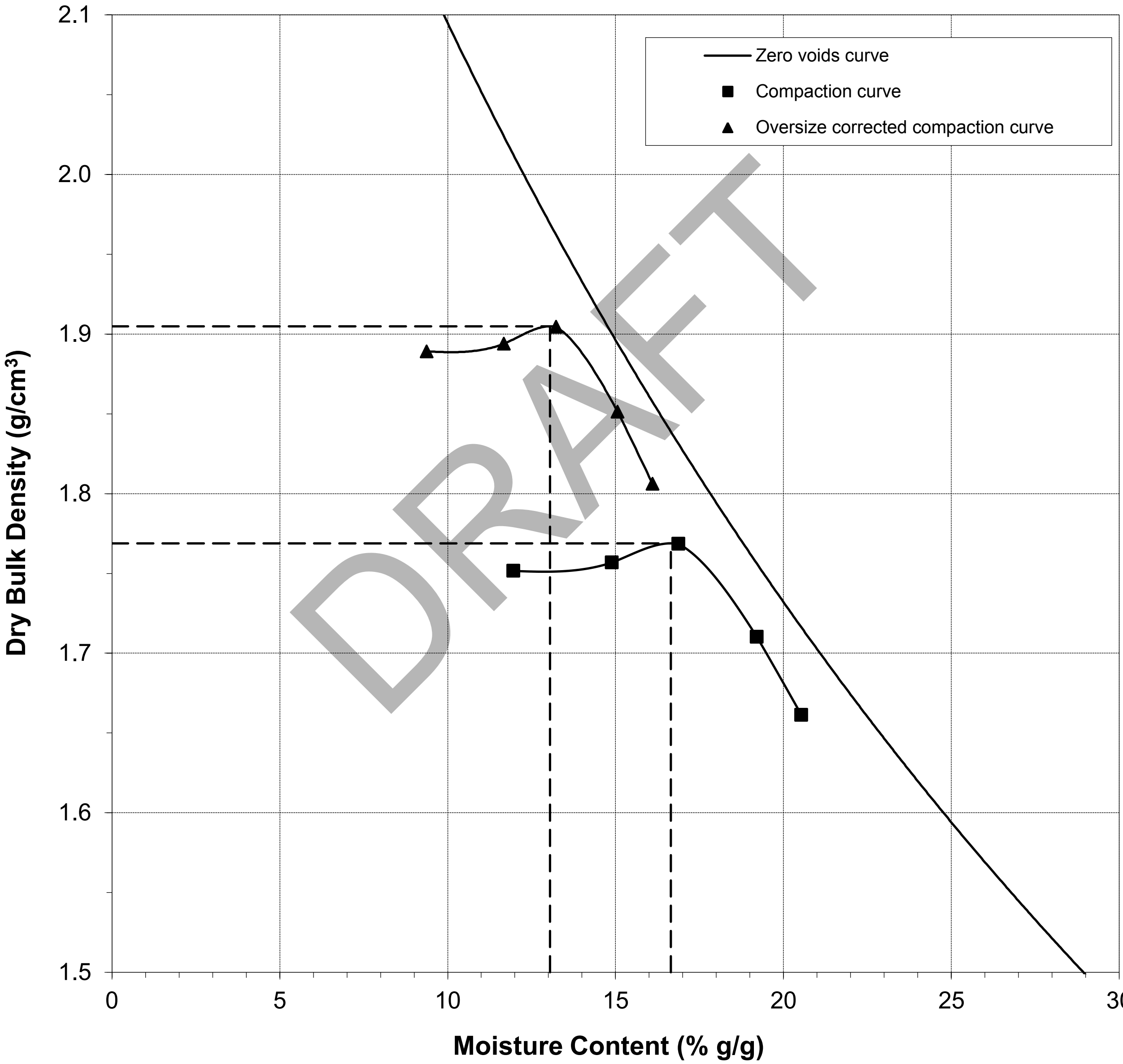
Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data Points with Fitted Curve

Sample Number: VVL Composite TP-10

	Measured	Corrected
Optimum Moisture Content (% g/g):	16.7	13.1
Maximum Dry Bulk Density (g/cm^3):	1.77	1.90

Test Date: 25-Aug-14



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

Laboratory analysis by: N. Candelaria
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-12
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 25-Aug-14

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

Split (3/4", 3/8", #4): 3/4
Mass of coarse material (g): 19.61353072
Mass of fines material (g): 80.38646928
Mold weight (g): 5573
Mold volume (cm^3): 2123.94

Compaction Method: Standard C
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	9492	915.22	834.08	292.88	1.60	14.99
2	9609	824.82	742.57	269.39	1.62	17.38
3	9757	838.90	748.21	282.26	1.65	19.46
4	9764	785.82	693.99	282.98	1.61	22.34
5	9741	792.02	697.66	298.97	1.59	23.67

Soil Fractions

Coarse Fraction (% g/g): 19.6
Fines Fraction (% g/g): 80.4

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	1.74	12.05
2	1.75	13.97
3	1.78	15.65
4	1.75	17.96
5	1.72	19.03

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

Laboratory analysis by: N. Candelaria
Data entered by: C. Krous
Checked by: J. Hines

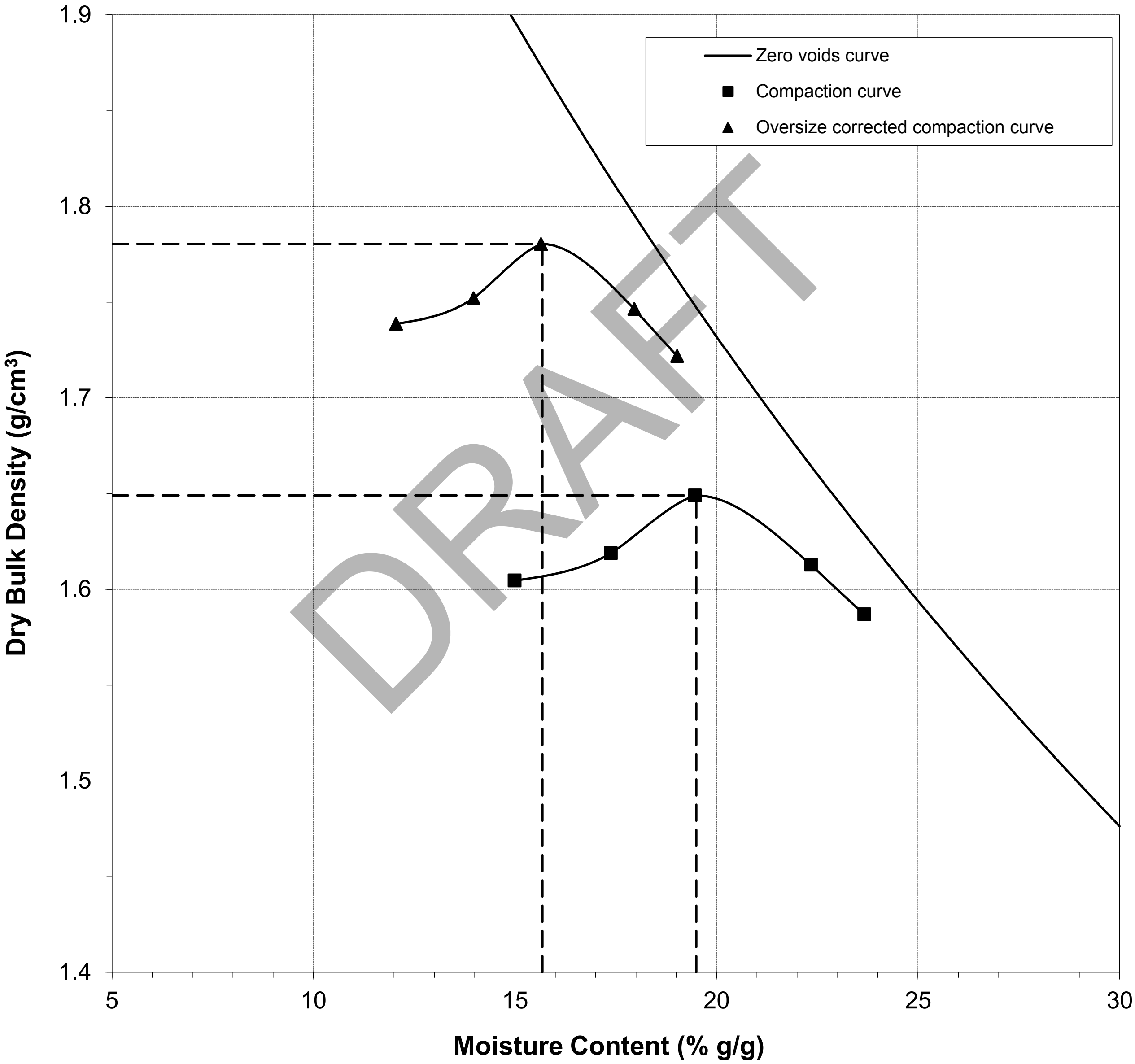
Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data Points with Fitted Curve

Sample Number: VVL Composite TP-12

	Measured	Corrected
Optimum Moisture Content (% g/g):	19.5	15.7
Maximum Dry Bulk Density (g/cm^3):	1.65	1.78

Test Date: 25-Aug-14



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

Laboratory analysis by: N. Candelaria
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: VVL Composite TP-13
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 28-Aug-14

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

Split (3/4", 3/8", #4): 3/4
Mass of coarse material (g): 13.13755554
Mass of fines material (g): 86.86244446
Mold weight (g): 5573
Mold volume (cm^3): 2123.94

Compaction Method: Standard C
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	9411	861.24	774.20	291.07	1.53	18.02
2	9561	803.80	713.95	269.71	1.56	20.23
3	9740	702.11	628.21	294.40	1.61	22.14
4	9728	816.59	710.13	267.89	1.58	24.07
5	9686	677.50	583.39	210.09	1.55	25.21

<u>Soil Fractions</u>
Coarse Fraction (% g/g): 13.1
Fines Fraction (% g/g): 86.9

<u>Properties of Coarse Material</u>
Assumed particle density (g/cm^3): 2.65
Assumed Initial Moisture Content (% g/g): 0.0

<u>Oversize Corrected Values for Dry Bulk Density and Moisture Content</u>

Trial	Dry Bulk Density of Composite (g/cm^3)	Moisture Content of Composite (% g/g)
1	1.62	15.65
2	1.65	17.57
3	1.69	19.23
4	1.66	20.91
5	1.64	21.90

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

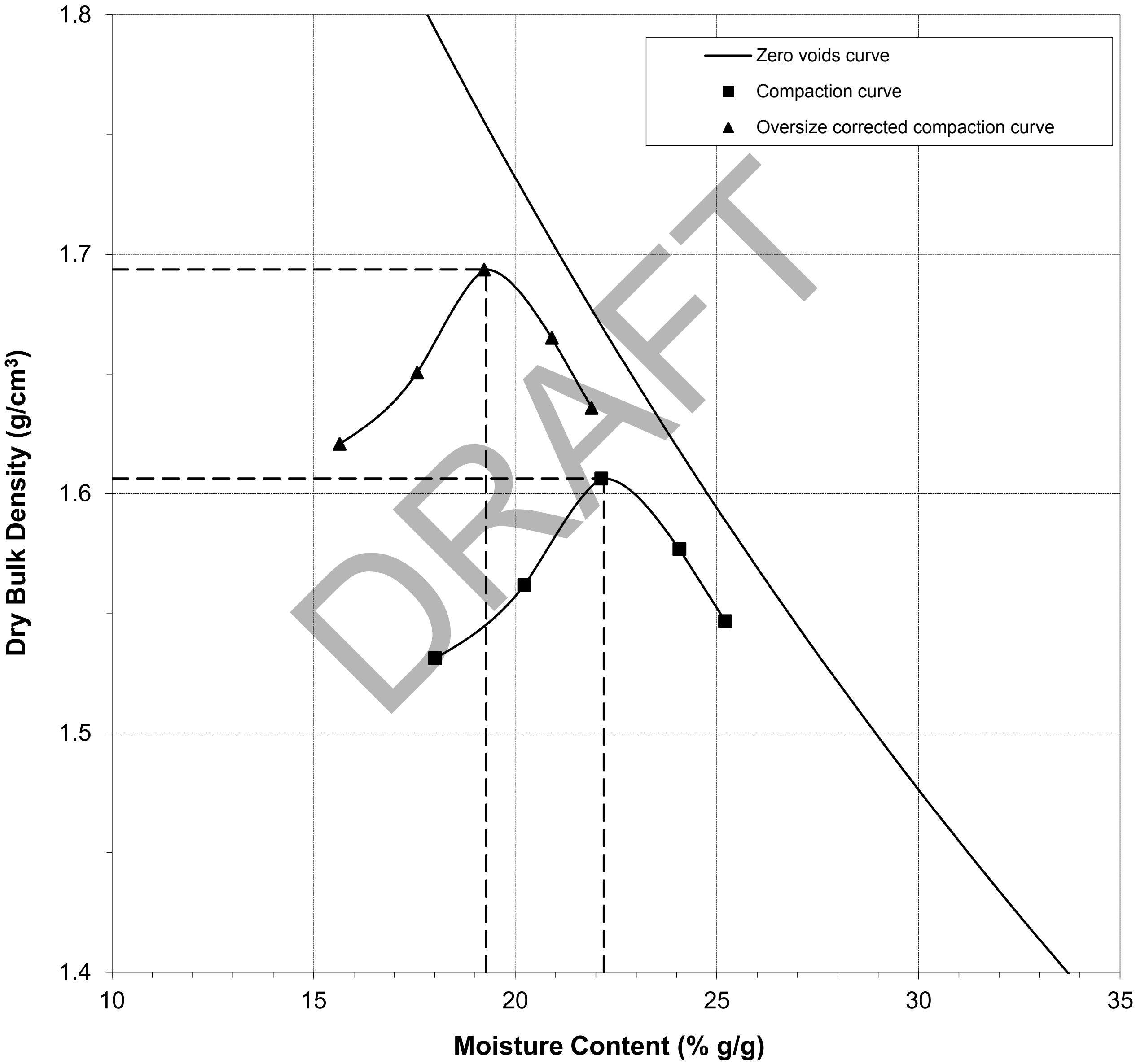
Laboratory analysis by: N. Candelaria
Data entered by: D. O'Dowd
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: VVL Composite TP-13

	Measured	Corrected
Optimum Moisture Content (% g/g):	22.2	19.3
Maximum Dry Bulk Density (g/cm^3):	1.61	1.69

Test Date: 28-Aug-14



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

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

Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Borrow-1
Project Name: VVL Composite Samples
PO Number: 12015
Test Date: 18-Aug-14
As Received Moisture Content (% g/g): NA

Split (3/4", 3/8", #4): #4
Mass of coarse material (g): 12.36129352
Mass of fines material (g): 87.63870648
Mold weight (g): 4202
Mold volume (cm^3): 943.95
Compaction Method: Standard A
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	5957	893.63	815.95	298.92	1.62	15.02
2	6023	869.88	785.66	283.53	1.65	16.77
3	6081	946.46	841.82	289.70	1.67	18.95
4	6073	896.77	789.99	284.53	1.64	21.13
5	6057	859.69	749.87	268.23	1.60	22.80

Soil Fractions

Coarse Fraction (% g/g): 12.4
Fines Fraction (% g/g): 87.6

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	13.17
2	1.73	14.70
3	1.75	16.61
4	1.72	18.51
5	1.68	19.98

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

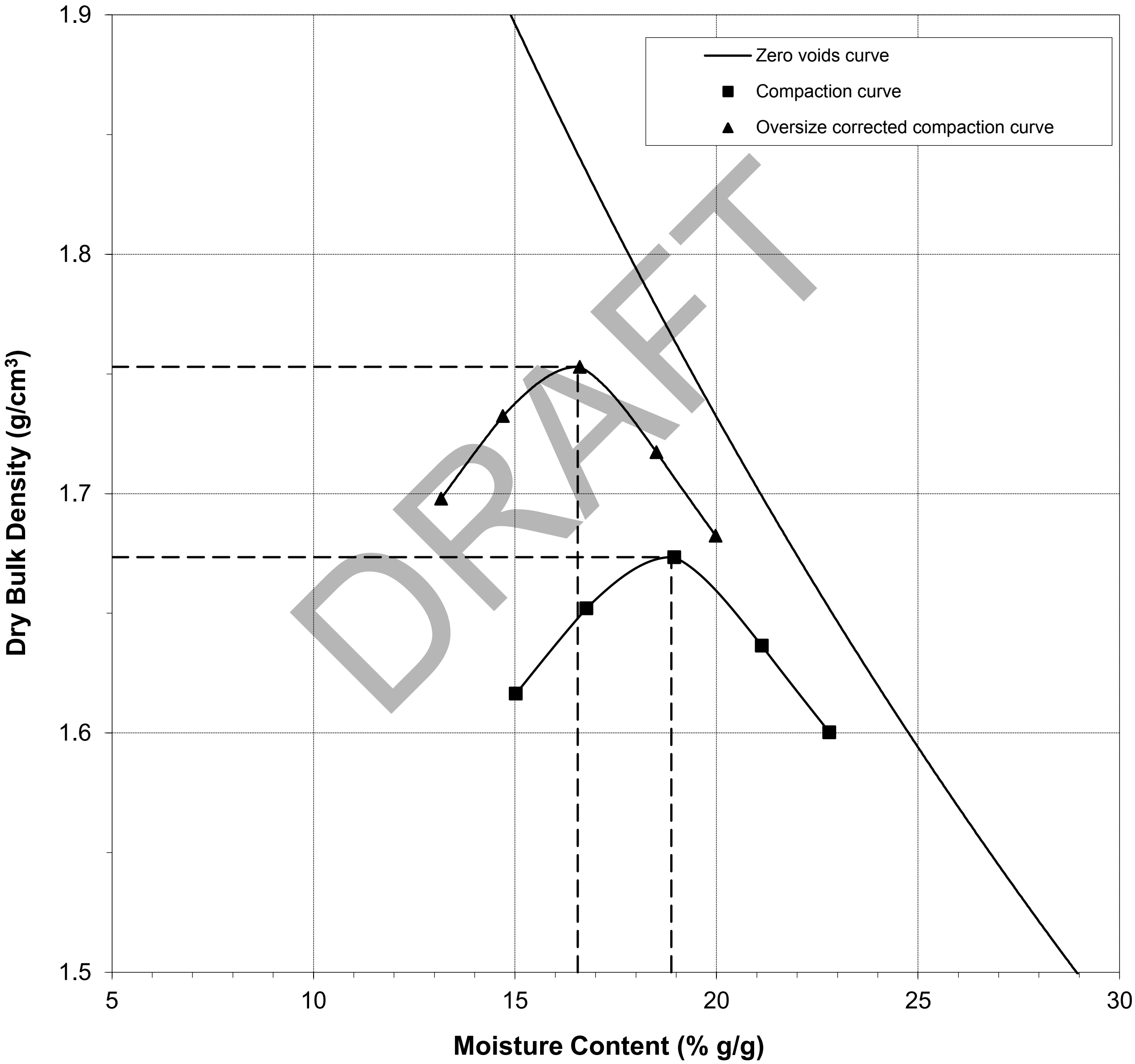
Laboratory analysis by: N. Canelaria
Data entered by: C. Krous
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: WB Borrow-1

	Measured	Corrected
Optimum Moisture Content (% g/g):	18.9	16.6
Maximum Dry Bulk Density (g/cm^3):	1.67	1.75

Test Date: 18-Aug-14



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

Laboratory analysis by: N. Canelaria
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data

Job Name:	Hydrometrics, Inc.	*Split (3/4", 3/8", #4):*	#4
Job Number:	LB14.0168.00	*Mass of coarse material* (g):	8.732531931
Sample Number:	WB Stockpile-1	*Mass of fines material* (g):	91.26746807
Project Name:	VVL Composite Samples	*Mold weight (g):*	4202
PO Number:	12015	*Mold volume* (cm^3):	943.95
Test Date:	18-Aug-14	*Compaction Method:*	Standard A
		Preparation Method:	Dry
As Received Moisture Content (% g/g):	NA	*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	5931	899.16	837.35	268.45	1.65	10.86
2	6063	890.36	818.88	291.60	1.74	13.56
3	6152	975.79	884.42	292.25	1.79	15.43
4	6163	911.60	816.97	269.40	1.77	17.28
5	6124	828.59	741.84	284.28	1.71	18.96

Soil Fractions

Coarse Fraction (% g/g): 8.7
Fines Fraction (% g/g): 91.3

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	1.71	9.92
2	1.79	12.37
3	1.84	14.08
4	1.82	15.77
5	1.77	17.30

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

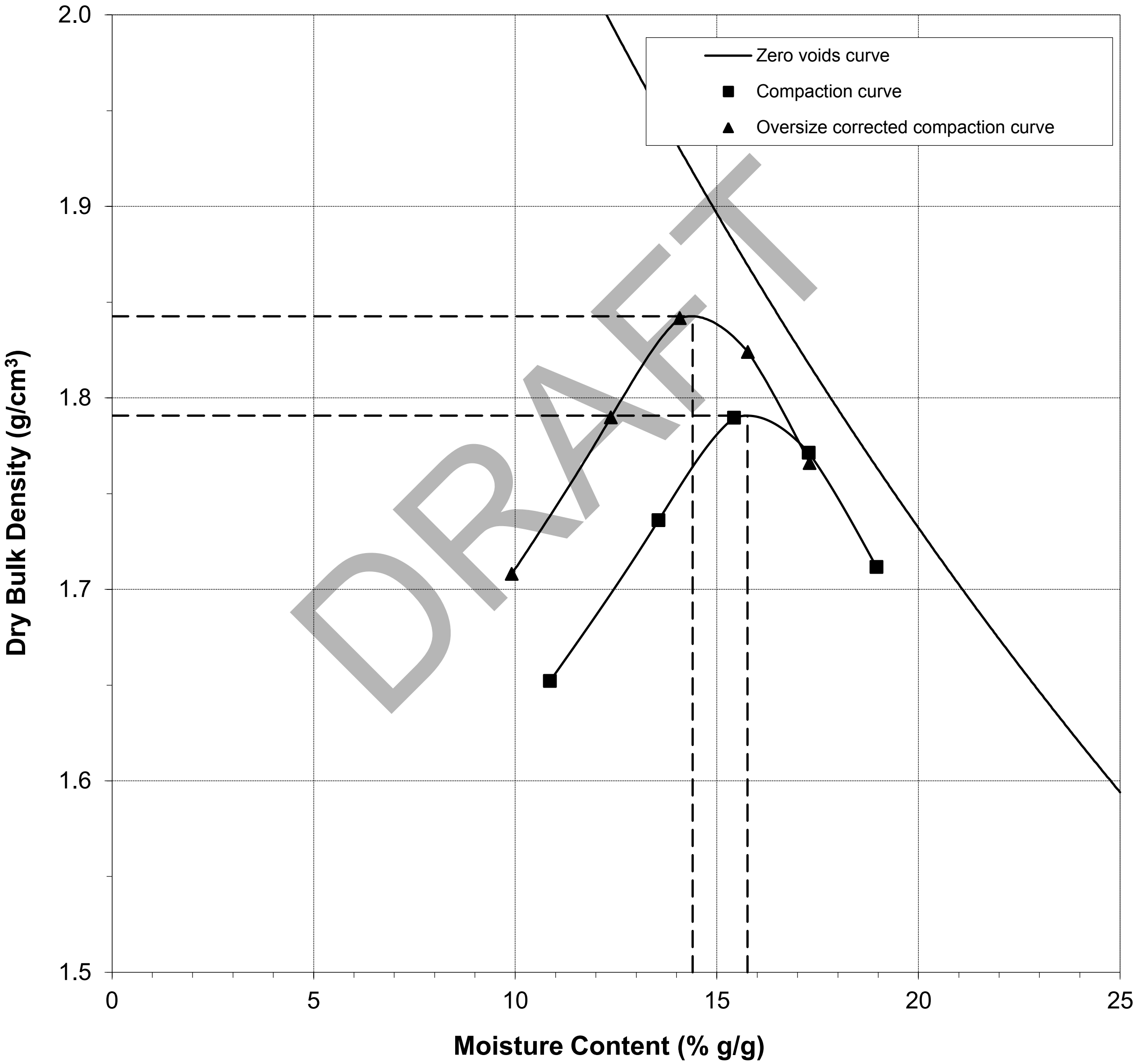
Laboratory analysis by: N. Canelaria
Data entered by: C. Krous
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: WB Stockpile-1

	Measured	Corrected
Optimum Moisture Content (% g/g):	15.8	14.4
Maximum Dry Bulk Density (g/cm^3):	1.79	1.84

Test Date: 18-Aug-14



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

Laboratory analysis by: N. Canelaria
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: WB Stockpile-2
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 18-Aug-14

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

Split (3/4", 3/8", #4): #4
Mass of coarse material (g): 24.41850569
Mass of fines material (g): 75.58149431
Mold weight (g): 4202
Mold volume (cm^3): 943.95

Compaction Method: Standard A
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	5947	915.75	844.89	282.91	1.64	12.61
2	6012	870.38	795.77	296.98	1.67	14.96
3	6115	901.64	809.03	260.81	1.73	16.89
4	6123	885.81	788.45	269.39	1.71	18.76
5	6082	901.93	795.56	286.96	1.65	20.91

Soil Fractions

Coarse Fraction (% g/g): 24.4
Fines Fraction (% g/g): 75.6

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	1.81	9.53
2	1.83	11.31
3	1.89	12.77
4	1.87	14.18
5	1.81	15.81

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

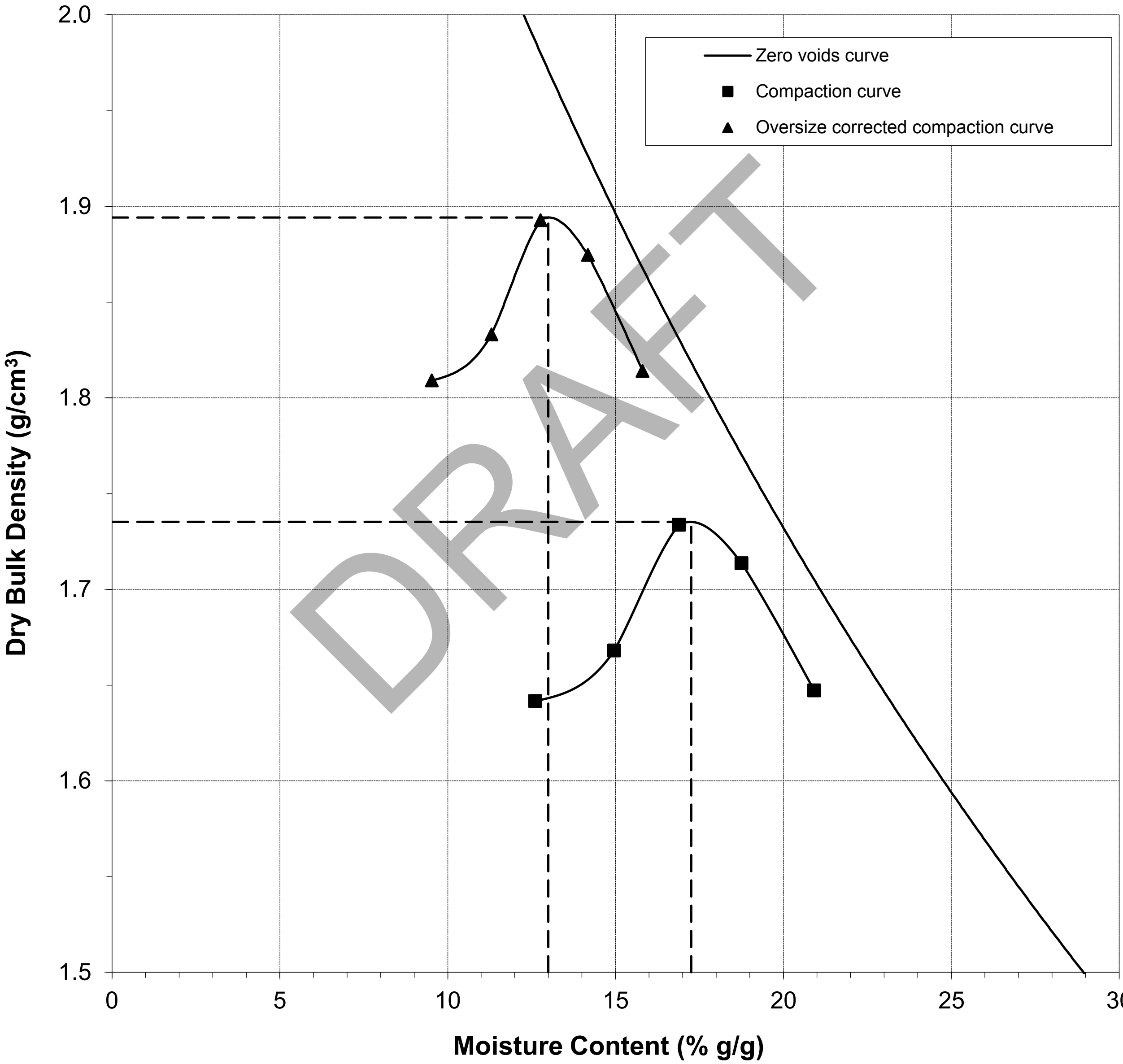
Laboratory analysis by: N. Canelaria
Data entered by: C. Krous
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: WB Stockpile-2

	Measured	Corrected
Optimum Moisture Content (% g/g):	17.3	13.0
Maximum Dry Bulk Density (g/cm^3):	1.74	1.89

Test Date: 18-Aug-14



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

Laboratory analysis by: N. Canelaria
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Proctor Compaction Data

Job Name: Hydrometrics, Inc.
Job Number: LB14.0168.00
Sample Number: Topsoil-1
Project Name: VVL Composite Samples
PO Number: 12015

Test Date: 18-Aug-14

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

Split (3/4", 3/8", #4): #4
Mass of coarse material (g): 0.448258848
Mass of fines material (g): 99.55174115
Mold weight (g): 4202
Mold volume (cm³): 943.95

Compaction Method: Standard A
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	5647	694.32	610.48	267.63	1.23	24.45
2	5692	722.05	629.50	284.32	1.24	26.81
3	5785	729.90	629.86	284.77	1.30	28.99
4	5786	693.11	593.03	271.92	1.28	31.17
5	5803	772.55	644.43	269.55	1.26	34.18

DRAFT

Soil Fractions

Coarse Fraction (% g/g): 0.4
Fines Fraction (% g/g): 99.6

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	---	---
2	---	---
3	---	---
4	---	---
5	---	---

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

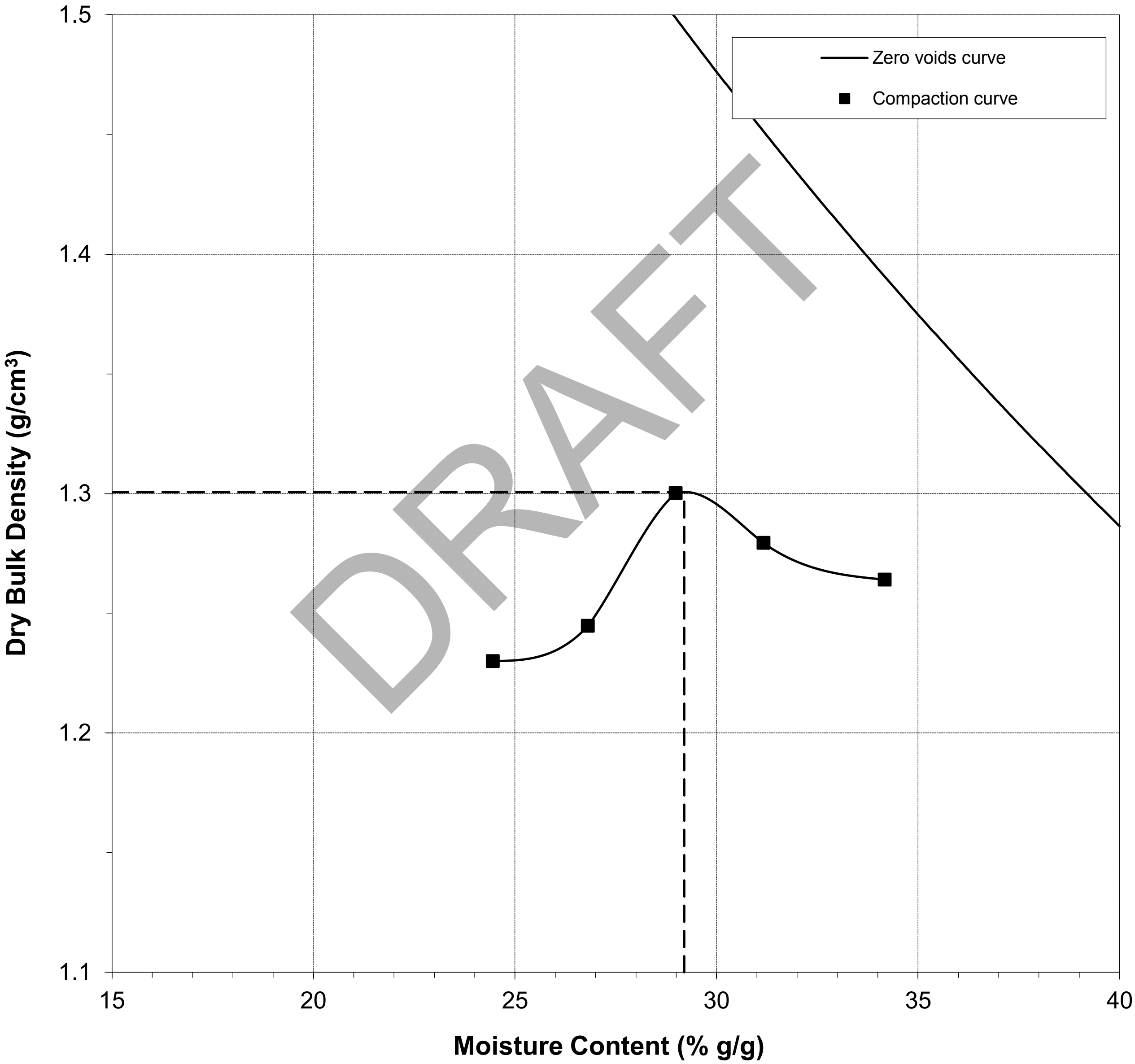
Laboratory analysis by: N. Canelaria
Data entered by: C. Krous
Checked by: J. Hines

Proctor Compaction Data Points with Fitted Curve

Sample Number: Topsoil-1

	Measured	Corrected
Optimum Moisture Content (% g/g):	29.2	---
Maximum Dry Bulk Density (g/cm^3):	1.30	---

Test Date: 18-Aug-14



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

Laboratory analysis by: N. Canelaria
Data entered by: C. Krous
Checked by: J. Hines

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263
Calculated Porosity:	ASTM D7263
Saturated Hydraulic Conductivity: Constant Head: (Rigid Wall)	ASTM D 2434 (modified apparatus)
Hanging Column Method:	ASTM D6836 (modified apparatus)
Pressure Plate Method:	ASTM D6836 (modified apparatus)
Water Potential (Dewpoint Potentiometer) Method:	ASTM D6836
Relative Humidity (Box) Method:	Campbell, G. and G. Gee. 1986. Water Potential: Miscellaneous Methods. Chp. 25, pp. 631-632, in A. Klute (ed.), Methods of Soil Analysis. Part 1. American Society of Agronomy, Madison, WI; Karathanasis & Hajek. 1982. Quantitative Evaluation of Water Adsorption on Soil Clays. SSA Journal 46:1321-1325
Moisture Retention Characteristics & Calculated Unsaturated Hydraulic Conductivity:	ASTM D6836; van Genuchten, M.T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. SSSAJ 44:892-898; van Genuchten, M.T., F.J. Leij, and S.R. Yates. 1991. The RETC code for quantifying the hydraulic functions of unsaturated soils. Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma. EPA/600/2091/065. December 1991
Particle Size Analysis:	ASTM D422
USCS (ASTM) Classification:	ASTM D422, ASTM D2487
USDA Classification:	ASTM D422, USDA Soil Textural Triangle
Atterberg Limits:	ASTM D4318
Visual-Manual Description:	ASTM D2488
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
Water Holding Capacity (calc):	ASTM D6836; Stephens, D. B. 1996, pp.11-12, Vadose Zone Hydrology. CRC Press, Inc., Boca Raton, FL

Attachment 2
Estimated Performance of an Evapotranspiration Cover for the Former ASARCO Smelter Site

Estimated performance of an evapotranspiration cover for the Former ASARCO Smelter Site

William H Albright, PhD

This report summarizes estimates of required and available water storage relative to design of an evapotranspiration final cover for the Former ASARCO Smelter Site near East Helena, MT.

Evapotranspiration (ET), or water balance, covers for final closure of waste sites function by providing water storage in the cover soils for periods when precipitation exceeds evapotranspiration. The available storage capacity in a soil profile can be calculated and is a product of the soil hydraulic properties and the cover thickness. The required storage capacity for an effective ET cover for a specific site can be difficult to estimate and requires consideration of temporal variation in precipitation, evaporation, and transpiration. The required storage method employed in this technical memorandum provides a preliminary calculation of storage required and required layer thickness to provide adequate available storage based on empirical results from large-scale field tests, monthly summaries of precipitation, evaporation, and transpiration, and soil properties of selected borrow soils.

The required storage is based on results from the Alternative Cover Assessment Program (ACAP) funded by the USEPA and is described in *Water Balance Covers for Waste Containment: Principles and Practice* (Albright, Benson, Waugh, ASTM Press, 2010). Estimates of required storage by the ACAP method are based on methods and coefficients derived from data collected in a nation-wide network of large-scale field tests of covers. Although semi-empirical, the required storage method has general applicability because of the large database (28 final cover test sections in 11 states monitored for 4-8 years) used to create the method.

Required Storage: Method

The required storage (S_r) is the design amount of water to be stored in the cover profile for a given site. Regression analysis of the ACAP data was used to identify two important factors: (1) monthly thresholds for the ratio of precipitation (P) to potential evapotranspiration (PET) beyond which water accumulates in an ET cover; and (2) the amount of water that accumulates in the soil profile in months with threshold exceedance. The ACAP data were segregated for sites with snow and frozen ground vs. sites without freezing conditions and by the warm and cool seasons in North America (fall-winter vs. spring-summer). At “cold” sites water accumulates when the monthly threshold for P/PET exceeds 0.51 (fall/winter) and 0.32 (spring/summer). The method assumes that during months when P/PET falls below these thresholds, water does not accumulate.

When the monthly threshold is exceeded the monthly accumulation of soil water storage (ΔS) can be computed using the water balance equation:

$$\Delta S = P - R - ET - L - P_r \quad (1)$$

where P is monthly precipitation, R is monthly runoff, ET is monthly evapotranspiration, L is monthly internal lateral drainage, and P_r is monthly percolation. Of the quantities on the right-hand side of Eq. 1, only P is available for design. However, ET can be assumed to be a fraction (β) of PET, L is usually very small and can be ignored (Albright et al. 2004). The remaining components, R and P_r, are combined into a loss term (Λ) to simplify Eq. 1 as:

$$\Delta S = P - \beta\, PET - \Lambda \quad (2)$$

Values for β and Λ were obtained by fitting Eq. 2 to the ACAP data set (Apiwantragoon 2007). Thus, given defined values for β and Λ, Eq. 2 can be used to estimate the monthly accumulation in soil water storage using precipitation and PET data which are available for the former ASARCO site. For Montana ("cold" sites) β = 0.37 (fall/winter) and 1.00 (spring/summer) and Λ = 0.0 mm (fall/winter) and 167.8 mm (spring/summer).

Using the monthly thresholds for water accumulation and the β and Λ parameters for "cold sites", the required storage (S_r) in a design year can be estimated by summing the monthly ΔS for all fall/winter months and all spring/summer months:

$$S_r = \sum_{i=1}^{6} \Delta S_{i,FW} + \sum_{i=7}^{12} \Delta S_{i,SS} \quad (3)$$

where $\Delta S_{i,FW}$ is the change in storage during the i^{th} month of fall and winter and $\Delta S_{i,SS}$ is the change in storage during the i^{th} month of spring and summer. Both $\Delta S_{i,FW}$ and $\Delta S_{i,SS}$ are computed with Eq. 2 using monthly data and the β and Λ parameters. The terms $\Delta S_{i,FW}$ and $\Delta S_{i,SS}$ are included in Eq. 3 only for those months when the monthly P/PET exceeds the thresholds, and in only those cases where either term is greater than or equal to zero (i.e., terms less than zero are not included). Additional detail of this method is in (Albright et al. 2010).

Available storage: Method

Available storage is the product of the plant-available water storage capacity of the soil and the thickness of the cover. The plant-available water storage capacity of a cover can be calculated from the soil water characteristic curve (SWCC). The SWCC is typically analyzed in the lab (ASTM D6836) and produces data which may be fit with a least-squares method to the van Genuchten equation to describe a continuous relationship between soil water suction and volumetric soil water content. From that relationship two important points are calculated - the water contents of the soil at field capacity (33 kPa) and at wilting point (1500 kPa). The difference between these two points is called the "plant-available water holding capacity". This inherent storage characteristic of the soil (given in mm of stored water per unit depth of soil) multiplied by the thickness of the cover gives the storage capacity of a cover soil profile.

Results for Former ASARCO Smelter Site

Required storage for the Former ASARCO Smelter Site

Required storage was computed using P and PET data from the Western Regional Climate Center (WRCC), results are shown in Table 1. Free access to the National Land Data Assimilation System (NLDAS) (Mitchell et al., 2004) gridded weather data on the Google Earth Engine (GEE) cloud computing platform, has provided a unique opportunity to develop a complete historical time series of reference evapotranspiration (ETo) from 1979 to present. The Desert Research Institute has developed Python and JavaScript programs that are executed on the GEE cloud computing platform to rapidly process NLDAS gridded weather data for estimating ETo. Bias corrected and spatially disaggregated (BCSD) NLDAS gridded weather data of daily maximum and minimum air temperature (Tmax and Tmin), daily maximum and minimum relative humidity (RHmax and RHmin), solar radiation (Rs) and daily average windspeed at 2m height (u2) were utilized to estimate daily and monthly ETo. Daily NLDAS weather data available on the GEE were spatially disaggregated to a 4 km spatial resolution by Abatzoglou (2011) based on Parameter Regression on Independent Slopes Model (PRISM) (Daly, 2008) 4 km spatial resolution monthly temperature and precipitation data. Because a finer spatial resolution (<12 km) product of Rs and u2 does not exist, simple bilinear interpolation was performed to resample from 12 km to 4 km (Abatzoglou, 2011).

Available storage for the Former ASARCO Smelter Site

The soil thickness required to store the maximum required storage (49 mm, Table 1) is shown in Table 2 and was calculated for each soil sample using soil hydraulic property data supplied by Daniel B Stephens and Associates. The required soil layer thickness ranges between 0.21 and 0.80 m for as constructed conditions. The laboratory soil hydraulic property data were modified to reflect anticipated changes due to natural pedogenic processes including wet-dry and freeze-thaw cycles and biointrusion and required soil layer thickness ranges between 0.24 and 1.17 m. These natural processes typically increase porosity and introduce larger pores resulting in changes to soil storage properties. The effects of these processes were investigated at the ACAP research sites, results are reported in Benson et al. (2011) along with recommendations for adjustment factors for laboratory data. Soil layer thicknesses reflecting these recommendations required for storage of the maximum required storage value (49 mm) are also reported in Table 2. These required and available storage figures provide sufficient basis for a preliminary design of an ET cover for the smelter site. The calculated soil layer thicknesses to provide adequate soil water storage should be evaluated with regard to the thickness required to support the vegetative cover.

Table 1. Annual precipitation, PET, winter precipitation and required storage estimated from climate data for the Former ASARCO Smelter Site.

Year	Annual Precipitation (mm)	Annual PET (mm)	Annual Winter* Precipitation (mm)	Annual Required Storage (mm)
1979-80	335	1167	62	17
1980-81	393	1126	112	0
1981-82	310	1136	90	6
1982-83	265	1128	103	27
1983-84	364	1149	85	5
1984-85	168	1213	70	4
1985-86	304	1155	132	49
1986-87	301	1144	83	27
1987-88	269	1210	39	0
1988-89	262	1163	128	28
1989-90	276	1145	73	0
1990-91	287	1204	32	0
1991-92	230	1253	82	9
1992-93	331	1080	99	40
1992-94	372	1080	76	0
1994-95	266	1107	61	0
1995-96	297	1076	100	7
1996-97	264	1110	71	27
1997-98	353	1046	77	17
1998-99	268	1122	71	18
1999-00	202	1224	47	0
2000-01	249	1172	98	35
2001-02	36	201	60	0
2002-03	307	1130	79	0
2003-04	227	1241	53	0
2004-05	380	1129	78	0
2005-06	315	1288	93	16
2006-07	278	1283	107	20
2007-08	248	1258	96	0
2008-09	223	1232	84	8
2009-10	325	1179	71	4
2010-11	432	1148	111	41

* Winter precipitation is defined for this method as September through February.

Table 2. Unsaturated soil hydraulic parameters and the thickness of a layer of each soil required to store the maximum required storage (49 mm of water). Numbers in parentheses are corrected by the method described in the NRC report (Benson et al. 2011).

Soil sample	α (cm^{-1})	N	Volumetric water content (%)					Soil thickness (m) required to store 49 mm of water
			Residual	Saturated	Field capacity	Wilting point	Plant available	
EB-ET-1	0.0441 (0.0573)	1.29 (1.42)	0	20.2	9.1 (5.8)	3.0 (1.2)	6.1 (4.6)	0.80 (1.07)
EB-ET-2	0.0164 (0.0213)	1.34 (1.48)	0	25.2	13.6 (9.6)	3.8 (1.6)	9.8 (8.0)	0.50 (0.61)
EB-ET-3	0.0155 (0.0202)	1.31 (1.45)	1.42	39.9	23.8 (17.4)	8.4 (4.3)	15.4 (13.1)	0.32 (0.37)
VV-ET-1	0.0090 (0.0117)	1.20 (1.33)	0	45.2	34.7 (27.8)	16.5 (8.2)	18.2 (19.6)	0.27 (0.25)
VV-ET-2	0.0095 (0.0124)	1.23 (1.36)	1.81	38.8	28.9 (23.2)	13.4 (7.4)	15.5 (15.8)	0.32 (0.31)
VV-ET-3	0.0121 (0.0157)	1.28 (1.41)	1.83	35.6	23.9 (18.5)	9.6 (5.4	14.3 (13.1)	0.34 (0.37)
VVL Comp 0-10	0.0061 (0.0079)	1.30 (1.43)	1.12	44.6	28.9 (24.1)	10.5 (5.8)	18.4 (18.3)	0.27 (0.27)
VVL Comp 11-15	0.0140 (0.0181)	1.32 (1.45)	0.27	43.0	22.7 (16.7)	7.2 (3.3)	15.5 (13.4)	0.32 (0.37)
VVL Comp 16-20	0.0094 (0.0123)	1.26 (1.39	0.00	46.9	30.3 (23.9)	11.6 (5.6)	18.7 (18.3)	0.26 (0.27)
VVL Comp 21-30	0.0089 (0.0116)	1.26 (1.39)	0.00	48.7	30.7 (24.4)	11.8 (5.7)	18.9 (18.7)	0.26 (0.26)
VVL Comp 31+	0.0065 (0.0837)	1.21 (1.46)	0.00	57.4	43.2 (11.7)	20.3 (2.0)	22.9 (9.7)	0.21 (0.51)
VVL Comp TP-10	0.0231 (0.0300)	1.31 (1.44)	1.43	43.9	20.4 (14.4)	7.2 (3.7)	13.2 (10.7)	0.37 (0.46)
VVL Comp TP-12	0.0059 (0.0077)	1.30 (1.43)	3.43	46.8	32.0 (26.9)	13.0 (8.0)	19.0 (18.9)	0.26 (0.26)
VVL Comp TP-13	0.0083 (0.0108)	1.25 (1.37)	0.00	49.4	34.0 (27.3)	14.0 (7.0)	20.0 (20.3)	0.25 (0.24)
WB Borrow-1	0.0179 (0.0233)	1.29 (1.42)	1.94	47.4	26.6 (19.4)	10.3 (5.4)	16.3 (14.0)	0.30 (0.35)
WB Stockpile-1	0.0118 (0.1522)	1.29 (1.54)	1.45	44.3	27.8 (6.2	10.6 (2.0)	17.3 (4.2)	0.28 (1.17)
WB Stockpile-2	0.0153 (0.0199)	1.36 (1.50)	3.35	47.1	22.7 (17.0)	7.9 (5.0)	14.8 (12.0)	0.33 (0.41)
Topsoil-1	0.0137 (0.0177)	1.39 (1.52)	3.92	59.7	34.0 (25.6)	11.1 (7.0)	22.9 (18.6)	0.21 (0.26)

References

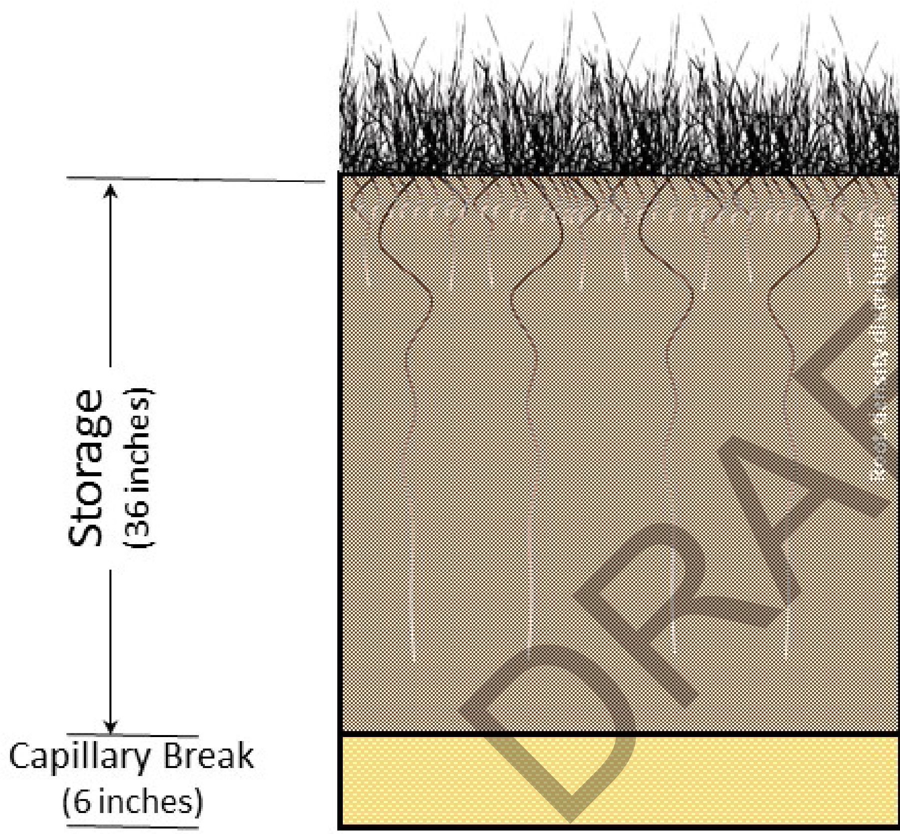
Albright, W.H., Benson, C.H., and Waugh, W.J., 2010. Water Balance Covers for Waste Containment: Principles and Practice. ASCE Press, Reston VA.

Albright, W., Benson, C., Gee, G., Roesler, A., Abichou, T., Apiwantragoon, P., Lyles, B., and Rock, S. (2004). "Field water balance of landfill final covers". *J. Environ. Qual*. 33(6), 2317-2332.

Apiwantragoon, P. (2007). "Field hydrologic evaluation of final covers for waste containment." Ph.D. dissertation, University of Wisconsin, Madison, Wisc.

Benson, C., Albright, W., Fratta, D., Tinjum, J., Kucukkirca, E., Lee, S., Scalia, J., Schlicht, P., Wang, X. 2011. Engineered Covers for Waste Containment: Changes in Engineering Properties & Implications for Long-Term Performance Assessment, NUREG/CR-7028, Office of Research, U.S. Nuclear Regulatory Commission, Washington.

Attachment 3
HYDRUS Model Inputs Conceptual Diagram



Upper Boundary -Atmospheric Conditions

Daily Precipitation 1979 – 2013 Helena Airport Station
Meteorological data from Helena, MT AgriMet station and NLDAS data used to develop reference evapotranspiration.

Vegetation – PET Conditions

Total potential evapotranspiration calculated using grass as a reference crop and the reference evapotranspiration.
End of month average leaf area index values used for western wheatgrass to calculate potential transpiration and remainder potential evaporation.
Rooting depth distribution 32 inches and based on grassland plant communities test site near Helena, MT.
Plant water stress parameters used for wheatgrass-dominated vegetation community.

Storage Layer – Soil Hydraulic Model

Single porosity model, van Genuchten – Mualem water retention curve without hysteresis.
Soil type specific parameters including van Genuchten soil parameters, saturated hydraulic conductivity, residual and saturated soil water content.

Capillary Break– Soil Hydraulic Model

Coarse grained soil type used for every simulation

Lower Boundary –Free Drainage

Free draining below capillary break layer considered percolation

Attachment 4
HYDRUS Model Results Summary

Sim9 VV-ET-3

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	107.6	198.5	-0.0044	-16.0070	-1.6007	303.2	30.3	0	Sim9	10/22/14	36" - VV-ET-3; Corrected	6" - EB-ET-2; Corrected	0.490	
2nd	7306	79-88	214.3	645.8	105.1	195.9	-0.0001	-0.3270	-0.0327	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	92.2	197.4	-0.0001	-0.2660	-0.0266	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	88.5	179.3	0.0000	-0.0040	-0.0004	270.4	27.0	0						
<5th	16345	09-13	107.7	336.5	46.3	95.6	0.0000	-0.0410	-0.0086	144.1	30.3	0						

Sim10 VV-ET-2

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	106.4	201.9	-0.0039	-14.4110	-1.4411	303.2	30.3	0	Sim10	10/22/14	36" - VV-ET-2; Corrected	6" - EB-ET-2; Corrected	0.429	
2nd	7306	79-88	214.3	645.8	102.3	199.2	0.0000	-0.0450	-0.0045	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	89.0	201.1	0.0000	-0.0440	-0.0044	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	85.2	182.9	0.0000	-0.0020	-0.0002	270.4	27.0	0						
<5th	16345	09-13	107.7	336.5	44.9	97.3	0.0000	-0.0030	-0.0006	144.1	30.3	0						

Sim11 VV-ET-1

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.1	111.0	201.5	-0.0036	-13.3220	-1.3322	302.5	30.2	0.53859	Sim11	10/23/14	36" - VV-ET-1; Corrected	6" - EB-ET-2; UnCorrected	0.340	Would not converge with water content & pressure head tolerance at 0.001 & 0.1 respecti
2nd	7306	79-88	214.3	645.1	102.4	199.1	0.0000	-0.0020	-0.0002	302.5	30.3	0.52401						
3rd	10958	89-98	203.0	626.1	88.2	202.1	0.0000	-0.0020	-0.0002	288.9	28.9	0.53859						
4th	14611	99-08	217.7	698.9	85.5	183.1	0.0000	-0.0020	-0.0002	270.4	27.0	0.52401						
<5th	16345	09-13	107.7	336.5	45.5	97.1	0.0000	-0.0010	-0.0002	144.1	30.3	0.53869						

Sim12 WB Borrow-1

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	112.8	197.1	-0.0049	-17.7950	-1.7795	303.2	30.3	0	Sim12	10/22/14	36" - WB Borrow 1; Corrected	6" - EB-ET-2; Corrected	0.318	
2nd	7306	79-88	214.3	645.8	107.1	194.9	0.0000	-0.0030	-0.0003	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	93.2	197.2	0.0000	-0.0030	-0.0003	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	89.9	178.8	0.0000	0.0000	0.0000	270.4	27.0	0						
<5th	16345	09-13	107.6	336.5	47.7	95.1	0.0000	0.0000	0.0000	144.1	30.3	0						

Sim23 WB Borrow-1 (uncorrected K for Cap Break)

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	112.6	197.0	-0.0049	-18.0590	-1.8059	303.2	30.3	0	Sim23	10/22/14	36" - WB Borrow 1; Corrected	6" - EB-ET-2; Uncorrected	0.316	Same as Sim12 but with uncorrected K for CB.
2nd	7306	79-88	214.3	645.8	107.1	194.9	0.0000	-0.0030	-0.0003	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	93.2	197.2	0.0000	-0.0040	-0.0004	288.9	28.9	0						
4th	14611	99-08	217.7	698.9	89.9	178.8	0.0000	-0.0030	-0.0003	270.4	27.0	0						
<5th	16345	09-13	107.6	336.5	47.7	95.1	0.0000	-0.0010	-0.0002	144.1	30.3	0						

Sim13 WB Stockpile-1

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	109.6	199.9	-0.0048	-17.5460	-1.7546	303.2	30.3	0	Sim13	10/22/14	36" - WB Stockpile-1; Corrected	6" - EB-ET-2; Corrected	0.388	
2nd	7306	79-88	214.3	645.8	104.4	197.3	0.0000	-0.0110	-0.0011	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	91.1	199.1	0.0000	-0.0170	-0.0017	288.8	28.9	0						
4th	14611	99-08	217.7	698.8	87.4	181.0	0.0000	0.0000	0.0000	270.4	27.0	0						
<5th	16345	09-13	107.6	336.6	46.2	96.2	0.0000	0.0000	0.0000	144.1	30.3	0						

Sim24 WB Stockpile-1 (uncorrected K for Cap. Break)

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	109.4	199.8	-0.0049	-17.9180	-1.7918	303.2	30.3	0	Sim24	10/22/14	36" - WB Stockpile-1; Corrected	6" - EB-ET-2; Uncorrected	0.389	Same as Sim13 but with uncorrected K for CB.
2nd	7306	79-88	214.3	645.8	104.4	197.3	0.0000	-0.0140	-0.0014	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	91.1	199.1	0.0000	-0.0210	-0.0021	288.8	28.9	0						
4th	14611	99-08	217.7	698.8	87.4	181.0	0.0000	-0.0040	-0.0004	270.4	27.0	0						
<5th	16345	09-13	107.6	336.6	46.2	96.2	0.0000	-0.0010	-0.0002	144.1	30.3	0						

Sim14 WB Stockpile-2

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	114.2	193.0	-0.0051	-18.4720	-1.8472	303.2	30.3	0	Sim14	10/22/14	36" - WB Stockpile-2; Corrected	6" - EB-ET-2; Corrected	0.379	
2nd	7306	79-88	214.3	645.8	110.5	191.3	0.0000	-0.0220	-0.0022	303.2	30.3	0						

3rd	10958	89-98	203.0	626.1	97.0	193.3	0.0000	-0.0520	-0.0052	288.8	28.9	0
4th	14611	99-08	217.7	698.8	93.4	175.1	0.0000	-0.0030	-0.0003	270.4	27.0	0
<5th	16345	09-13	107.6	336.6	49.3	93.3	0.0000	0.0000	0.0000	144.1	30.3	0

Sim25 WB Stockpile-2 (uncorrected K for Cap. Break)

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	113.9	193.0	-0.0051	-18.7450	-1.8745	303.2	30.3	0	Sim25	10/22/14	36" - WB Stockpile-2; Corrected	6" - EB-ET-2; Uncorrected	0.382	Same as Sim14 but with uncorrected K for CB.
2nd	7306	79-88	214.3	645.8	110.5	191.3	0.0000	-0.0280	-0.0028	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	97.0	193.3	0.0000	-0.0660	-0.0066	288.8	28.9	0						
4th	14611	99-08	217.7	698.8	93.4	175.1	0.0000	-0.0030	-0.0003	270.4	27.0	0						
<5th	16345	09-13	107.6	336.6	49.3	93.3	0.0000	-0.0020	-0.0004	144.1	30.3	0						

Sim15 VV-L Comp 0-10

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	104.3	206.0	-0.0043	-15.5410	-1.5541	303.2	30.3	0	Sim15	10/22/14	36" - VV-L Comp 0-10; Corrected	6" - EB-ET-2; Corrected	0.431	
2nd	7306	79-88	214.3	645.8	99.6	201.9	0.0000	-0.0610	-0.0061	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	86.7	203.1	0.0000	-0.0510	-0.0051	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	82.9	185.2	0.0000	-0.0030	-0.0003	270.4	27.0	0						
<5th	16345	09-13	107.7	336.5	43.6	98.4	0.0000	-0.0070	-0.0015	144.1	30.3	0						

Sim16 VV-L Comp 11-15

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	108.9	198.0	-0.0051	-18.5130	-1.8513	303.2	30.3	0	Sim16	10/22/14	36" - VV-L Comp 11-15; Corrected	6" - EB-ET-2; Corrected	0.472	
2nd	7306	79-88	214.3	645.8	106.0	195.2	-0.0001	-0.2300	-0.0230	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	93.1	196.6	-0.0001	-0.2020	-0.0202	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	89.2	178.6	0.0000	-0.0030	-0.0003	270.4	27.0	0						
<5th	16345	09-13	107.7	336.5	46.8	95.2	0.0000	-0.0240	-0.0051	144.1	30.3	0						

Sim17 VV-L Comp 16-20

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	104.6	206.3	-0.0047	-17.2050	-1.7205	303.2	30.3	0	Sim17	10/22/14	36" - VV-L Comp 16-20; Corrected	6" - EB-ET-2; Corrected	0.395	
2nd	7306	79-88	214.3	645.8	99.1	202.6	0.0000	-0.0220	-0.0022	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	86.0	204.0	0.0000	-0.0200	-0.0020	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	82.2	186.1	0.0000	-0.0010	-0.0001	270.4	27.0	0						
<5th	16345	09-13	107.6	336.5	43.4	98.8	0.0000	-0.0010	-0.0002	144.1	30.3	0						

Sim18 VV-L Comp 21-30

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	106.6	204.8	-0.0046	-16.7980	-1.6798	303.2	30.3	0	Sim18	10/22/14	36" - VV-L Comp 21-30; Corrected	6" - EB-ET-2; Corrected	0.369	
2nd	7306	79-88	214.3	645.8	100.4	201.5	0.0000	-0.0070	-0.0007	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	87.0	203.2	0.0000	-0.0080	-0.0008	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	83.4	185.0	0.0000	0.0000	0.0000	270.4	27.0	0						
<5th	16345	09-13	107.7	336.5	44.2	98.3	0.0000	-0.0010	-0.0002	144.1	30.3	0						

Sim 19 VV-L Comp 31+

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	104.4	212.1	-0.0043	-15.7130	-1.5713	303.2	30.3	0	Sim19	10/22/14	36" - VV-L Comp 31+; Corrected	6" - EB-ET-2; Corrected	0.285	
2nd	7306	79-88	214.3	645.8	94.0	208.2	0.0000	-0.0020	-0.0002	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	80.3	210.0	0.0000	-0.0020	-0.0002	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	77.3	191.5	0.0000	-0.0020	-0.0002	270.4	27.0	0						
<5th	16345	09-13	107.7	336.5	41.2	101.4	0.0000	-0.0010	-0.0002	144.1	30.3	0						

Sim20 VV-L Comp TP-10

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	112.0	192.8	-0.0050	-18.2410	-1.8241	303.2	30.3	0	Sim20	10/22/14	36" - VV-L Comp TP-10; Corrected	6" - EB-ET-2; Corrected	0.476	
2nd	7306	79-88	214.3	645.8	109.9	191.1	-0.0001	-0.4040	-0.0404	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	96.9	192.8	-0.0001	-0.3750	-0.0375	288.9	28.9	0						
4th	14611	99-08	217.7	698.8	93.2	174.8	0.0000	-0.0030	-0.0003	270.3	27.0	0						
<5th	16345	09-13	107.7	336.5	48.6	93.2	0.0000	-0.0240	-0.0051	144.1	30.3	0						

Sim21 VV-L Comp TP-12

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes

1st	3653	79-88	214.3	645.8	107.7	203.5	-0.0042	-15.3380	-1.5338	303.2	30.3	0	Sim21	10/22/14	36" - VV-L Comp TP-12; Corrected	6" - EB-ET-2; Corrected	0.370	
2nd	7306	79-88	214.3	645.8	101.6	200.1	0.0000	-0.0100	-0.0010	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	88.5	201.8	0.0000	-0.0120	-0.0012	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	84.8	183.7	0.0000	-0.0020	-0.0002	270.4	27.0	0						
<5th	16345	09-13	107.7	336.5	44.8	97.6	0.0000	-0.0010	-0.0002	144.1	30.3	0						

Sim22 VV-L Comp TP-13

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	105.0	207.6	-0.0045	-16.5740	-1.6574	303.2	30.3	0	Sim22	10/22/14	36" - VV-L Comp TP-13; Corrected	6" - EB-ET-2; Corrected	0.348	
2nd	7306	79-88	214.3	645.8	97.9	204.0	0.0000	-0.0050	-0.0005	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	84.6	205.7	0.0000	-0.0040	-0.0004	288.8	28.9	0						
4th	14611	99-08	217.7	698.9	81.0	187.5	0.0000	0.0000	0.0000	270.4	27.0	0						
<5th	16345	09-13	107.7	336.5	43.0	99.5	0.0000	-0.0010	-0.0002	144.1	30.3	0						

Sim26 SENSITIVITY RUN - CAPILLARY BREAK VALUES USED FOR BOTH ET LAYER AND CAP BREAK FULL PROFILE THICKNESS

decade	days	year	decadal sum pot. Transp. (cm)	decadal sum pot. Evap (cm)	decadal sum actual transp. (cm)	decadal sum actual evap. (cm)	avg. daily bottom percolation rate (cm/day)	Total decadal bottom percolation (cm)	average annual bottom percoloation rate (cm/year)	decadal precip. (cm)	average annual precip (cm/year)	Decadal Runoff (cm)	Sim#	Date	ET Thick & K	CB Thick & K	Water Balance (%)	Notes
1st	3653	79-88	214.3	645.8	96.9	201.7	-0.0048	-17.6640	-1.7664	303.2	30.3	0	Sim26	10/22/14	36" - EB-ET-2; UnCorrected	6" - EB-ET-2; UnCorrected	0.340	Trial run - used soil values for Cap. Break for entire 42" profile
2nd	7306	79-88	214.3	645.8	96.7	200.3	-0.0009	-3.4670	-0.3467	303.2	30.3	0						
3rd	10958	89-98	203.0	626.1	88.6	197.4	-0.0007	-2.5570	-0.2557	288.9	28.9	0						
4th	14611	99-08	217.7	698.8	90.3	176.3	-0.0001	-0.5300	-0.0530	270.4	27.0	0						
<5th	16345	09-13	107.7	336.6	45.0	96.2	-0.0006	-1.1130	-0.2343	144.1	30.3	0						

Note: last "period" only represents 4.75 years (09 to 2013); others are decades

Appendix C
Public Comments Received on the 2015/2016 Interim Measures Work Plan with U.S. Environmental Protection Agency Responses and Conditional Letter of Approval

To be inserted.