REPORT

UNITED STATES NATURAL RESOURCES (USNR) TEST PLOT –

ANNUAL REPORT NO. 1

LITTLE ROCK AND TYRONE MINES

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1.0 INTRODUCTION

The Little Rock Mine is permitted as an existing mine under Mining Act Permit No. GR007RE and Discharge Permit 1236 (DP-1236). The best available materials for reclamation at the Little Rock mine is overburden composed of Precambrian Granite. In early 2014, Freeport Mc-Moran Inc. (Tyrone) proposed to build test plots on a portion of the United States National Resource (USNR) reclamation area to evaluate the use of Precambrian Granite from the Little Rock pit. The test plot was tentatively approved by the New Mexico Mining and Minerals Division (MMD) and the New Mexico Environment Department (NMED) prior to construction with the understanding that formal approval was pending further consideration. The test plots were constructed starting in 2014 and seeded in the Spring of 2015.

In November 2014, Tyrone prepared a work plan for the USNR test plots to facilitate technical discussion with the MMD and NMED. The Agencies requested that Tyrone modify the work plan to include enhanced erosion and vegetation monitoring and consider the application of amendments. The USNR test plot work plan was conditionally approved and is intended to meet the requirements of Condition 8.P.1 (b) of Revision 14-1 to Permit GR007RE and Condition 33 of DP-1236. The intent of this submittal is to document the construction of the test plots and provide results of the erosion and vegetation monitoring.

1.1 Background

The Little Rock Test Plots were originally constructed on the 7A Stockpile at the Tyrone Mine using Precambrian Granite overburden from the Copper Mountain Pit. When the Little Rock Test Plot work plan was originally developed (2001 with major revisions in 2004) it was impractical to access the overburden from the Little Rock pit because mining had not started and the haul road to Tyrone was not constructed. Copper Mountain materials were used because of their similarity to the overburden from the Little Rock pit and the availability of materials and a test location (7A stockpile). Once mining at Little Rock commenced, it was possible to construct test plots using overburden from the Little Rock pit. The USNR reclamation area provided an opportunity to test the overburden material from the Little Rock pit and further refine and demonstrate material handling techniques and reclamation specifications.

1.2 Objectives

The primary goal for the USNR test plot program is to evaluate revegetation success for the Little Rock Precambrian granite. Tyrone hypothesized that multiple year delays in seeding the Precambrian Granite on the 7A test plots, combined with drought conditions, contributed to unacceptable vegetation establishment (Golder, 2014). Thus, the major performance criterion to be assessed at the USNR test plots is vegetation performance. These test plots will further inform Tyrone about the implications of surface armoring on seedling establishment over time. Because the vegetation establishment was delayed quantitative erosion measurement were not made on the 7A test plots. The establishment of quantitative erosion transects in the USNR cover materials will aid in quantifying erosion on the Precambrian Granite cover materials.

2.0 USNR TEST PLOT CHARACTERISTICS

Reclamation of the USNR Leach Stockpile area involved removal of the residual leached ore materials primarily from drainage areas, minor regrading of the site to tie into bedrock drainages, and installation of a nominal 3-foot thick cover of Precambrian Granite from the Little Rock Mine. The construction and material handling methods are described in Section 2.1. The layout and design of the test plot treatments are discussed in Section 2.2. The revegetation techniques are described in Section 2.3.

2.1 Construction and Materials Handling

Test plot construction included site grading, cover placement, and revegetation. Test plots were constructed using available mine equipment. Cover for the test plots was sourced from the Little Rock Open Pit Phase 4 mining area. As a normal course of operations, Tyrone follows the Material Characterization and Handling Plan (dated October 25, 2011) for its cover material segregation. This plan was implemented in segregating material for USNR reclamation and the test plots. In addition to the procedures outlined in the characterization and handling plan, Tyrone reclamation quality control personnel visually monitored the source material (in the Little Rock pit) and rejected materials that were too coarse for use as cover. The materials were hauled from the pit with large haul trucks (CAT 793) and staged near the test plots, prior to hauling with smaller trucks (CAT 730 Ejector) to the test plots; smaller truck were used to place cover materials as the roads were too narrow for larger haul trucks. Consistent with Tyrone's materials management practices, the materials on the temporary stockpile where managed to reduce the overall volume of rock fragments. Cover material was end-dumped on the test plots using ≈30 ton trucks and graded down slope with a dozer.

2.2 Test Plot Layout and Design

The two acre test plot included four treatments which were approximately a half acre each. A control and three treatments were proposed for the USNR test plots. The major treatments involve changes in the seed mix and the timing of mulching. The treatments are described below:

- Control (conventional seed mix and mulching)
- Mulch prior to seeding with conventional seed mix
- Conventional mulch with alternative seed mix
- Mulch prior to seeding with alternative seed mix

Figure 1 illustrates the layout and configuration of the USNR test plots. Typical cross-sections are shown in Figure 2. The finished slope gradients on the test plot ranged from about 3:1 to 4:1. Based on the final surveys, the slope lengths ranged from about 150 to 180 feet. The cover thickness exceeded three feet on the test plot (Section 3.2).

2.3 Revegetation

The plots were revegetated in a manner consistent with requirements of Appendix C of Permit GR007RE, with some minor variations related to the seed mix and the timing of the mulching, which are described below. The revegetation operations were performed by the Freeport-McMoRan seeding crew on June 4 and 5, 2015. Operationally, the revegetation procedures included: 1) scarification and seedbed preparation, 2) seeding, and 3) mulching and crimping.

2.3.1 Scarification and Seeding

Scarification was performed on the contour at a depth of 8-12 inches. The seed was drilled and broadcast simultaneously using a modified rangeland drill with depth control bands, packer wheels, agitators and augers, and picker wheels. The light and fluffy seeds were allowed to fall freely behind the drill and were covered using chain drags pulled behind the drill. Compact seeds were drilled to promote proper seed placement.

2.3.2 Seed Mix

Two seed mixes were applied on USNR test plots. The conventional seed mix was modified slightly from the primary seed mix in Appendix C of the MMD permit modification 06-3 to accommodate the availability of seed and included 4 warm season grass, 5 cool season grass, 3 forb, and 4 shrub species (Table 1). An alternative seed mix deviated from the typical seed mix in Appendix C of Permit GR007RE to include a number of experimental species native to the Desert Southwest region. The alternative seed mix was comprised of 10 warm season grass, 6 cool season grass, 10 forb, and 6 shrub species (Table 2). For reference the number of seeds per square foot were similar for both seed mixes, but the experimental mix contained some species with larger seeds.

2.3.3 Mulching

Conventionally, Tyrone has applied mulch after seed placement. At the USNR, the timing of seeding and mulching varied among the test plot treatments. Mulch was applied prior to seeding on half the area and after seeding on the other half. Mulch was applied at a rate of approximately 2-tons/ac. The mulch was then crimped 3 to 4 inches into the cover using a disc harrow with straight coulter discs spaced approximately 6 to 8 inches apart. The crimping operation was performed on the contour.

Table 1. Conventional Seed Mix used at the USNR Test Plots

Species	Common Name	lbs/ac
Warm Season Grass		
Bothriochloa barbinodis	Cane bluestem	0.3
Bouteloua curtipendula	Sideoats gramma	1.25
Bouteloua gracilis	Blue grama	0.25
Leptochloa dubia	Green sprangletop	0.40
Cool Season Grass		
Achnatherum hymenoides	Indian ricegrass	1.50
Agropyron dasystachyum	Streambank wheatgrass	1.00
Elymus elymoides	Bottlebrush squirreltail	1.25
Koeleria macrantha	Prairie Junegrass	0.10
Sporobolus cryptandrus	Sand dropseed	0.05
Shrubs		
Atriplex canescens	Fourwing saltbush	0.75
Chilopsis Linearis	Desert willow	0.75
Ericameria nauseosa	Rubber rabbit brush	0.30
Krascheninikovia lanata	Winterfat	0.50
Forbs		
Dalea candida	White prairie clover	0.4
Linum lewisii	Blue flax	0.12
Ratibida columnaris	Prairie coneflower	0.2
	PLS (lbs/acre)	**9.12**

Note: lbs/ac = pounds per acre, PLS = pure live seed

Table 2. Alternative Seed Mix used at the USNR Test Plots

Species	Common Name	lbs/ac
Warm Season Grass		
Aristida purpurea var. longiseta	Fendler threeawn	0.25
Bothriochloa barbinodis	Cane bluestem	0.10
Bouteloua curtipendula	Sideoats grama	1.00
Bouteloua rothrockii	Rothrock's grama	0.05
Eragrostis intermedia	Plains lovegrass	0.05
Heteropogon contortus	Tanglehead	0.25
Muhlenbergia montana	Mountain muhly	0.03
Schizachyrium scoparium	Little bluestem	0.90
Sporobolus airoides	Alkali sacaton	0.05
Sporobolus giganteus	Giant dropseed	0.05
Cool Season Grass		
Elymus elymoides	Bottlebrush squirreltail	1.00
Elymus glaucus	Blue wildrye	0.40
Hesperostipa neomexicana	New Mexico feathergrass	3.00
Poa secunda	Sandberg bluegrass	0.05
Sporobolus cryptandrus	Sand dropseed	0.02
Thinopyrum intermedium	Intermediate wheatgrass	1.00
Shrubs		
Acacia constricta	Whitethorn acacia	1.00
Acacia greggii	Catclaw acacia	2.00
Atriplex canescens	Fourwing saltbush	1.50
Encelia virginensis	Virgin River brittlebush	0.25
Ericameria nauseosa	Rubber rabbitbrush	0.20
Robinia neomexicana	New Mexico locust	2.50
Forbs		
Achillea millefolium var. occidentalis	Western yarrow	0.01
Artemisia ludoviciana	White sagebrush	0.05
Baileya multiradiata	Desert marigold	0.05
Erigeron speciosus	Aspen fleabane	0.05
Isocoma tenuisecta	Burroweed	0.05
Lotus rigidus	Deervetch	0.10
Oenothera pallida	Pale evening primrose	0.10
Penstemon palmeri	Palmer's penstemon	0.20
Senna covesii	Coues' cassia	0.25
Sphaeralcea coccinea	Scarlet globemallow	0.10
	PLS (lbs/acre)	**16.61**

Note: lbs/ac = pounds per acre, PLS = pure live seed

3.0 COVER CHARACTERISTICS

The configuration and physical and chemical characteristics of the cover materials were evaluated after placement on the test plots. The field and laboratory methods are discussed in Section 3.1. The results of the field observations are described in Section 3.2. Section 3.3 contains a summary of the chemical characteristics of the covers. The results of the physical and hydraulic testing are summarized in Sections 3.4 and 3.5. Section 3.6 provides information on the estimated water holding capacity for the cover materials and presents a generalized relationship for predicting water holding capacity based on material properties.

3.1 Methods

The field, laboratory, and computational methods associated with the cover material characterization are described in the following sections.

3.1.1 Field Methods

Five test pits were excavated and described on the test plots. The sample locations are shown on Figure 1. Five samples of the cover materials were also collected for physical and chemical analysis of the fine earth fraction (particles < 2mm in diameter). In addition, three samples were collected for soil hydraulic testing. The samples collected for fine-earth analysis were about 5 to 10 kg with the larger rock fragments (> 75 mm) removed. The samples collected for particle size analyses were placed directly in gallon-size plastic bags, while the samples for soil-hydraulic analyses were placed in 5-gallon airtight plastic buckets. The samples were shipped to the associated analytical laboratories at ambient temperature.

3.1.2 Laboratory

The soil hydraulic samples were analyzed at the Daniel B. Stephens & Associates (DBS&A) Laboratory in Albuquerque, NM. The chemical and particle size analyses were conducted at Energy Laboratories in Billings, MT. The bulk soil samples collected for fine-earth analysis were air-dried and passed through a 2 mm sieve at the laboratory. The analytical methods are listed in Table 3.

Because the cover materials contained rock fragments, the soil-hydraulic analyses were conducted on the fine-earth fraction. Column tests were performed on < 2mm subsamples packed to a specified target density based on established soil textural relationships (Soil Survey Division Staff, 1993). The target density for the laboratory samples was 1.4 g/cm^3. Paired suction and water content measurements were made using hanging-column, pressure plate, water activity meter, and relative humidity box methods. The soil samples were subjected to at least 5 suction points ranging from near saturation (≈ 0 cm) to about 850,000 cm. The saturated hydraulic conductivity (K_{sat}) of the fine earth fraction samples was determined by the constant-head method. Laboratory reports are in Appendix A.

Table 3. Soil Chemical, Physical and Hydraulic Test Methods

Test	Method
Saturated Paste pH	SLS 1954, Method 2 and 21a
Electrical Conductivity	SLS 1954, Method 3a and 4b
Particle Size Distribution	ASA 1982, Method 15-5
Saturation percentage	SLS 1954, Method 27a
N as Nitrate	ASA 1982, Method 33-8.1
Phosphorous (Olsen)	ASA 1982, Method 24-5.4
Dry Bulk Density:	ASTM D4531; ASTM D6836
Organic Matter	ASA 1982 Method 29-3.5.2
Moisture Content:	ASTM D2216; ASTM D6836
Calculated Porosity:	ASTM D2435; Klute, A. 1986. Porosity. Chp.18-2.1, pp. 444-445, in A. Klute (ed.), Methods of Soil Analysis, American Society of Agronomy, Madison, WI
Saturated Hydraulic Conductivity: Constant Head: (Rigid Wall)	ASTM D 2434 (modified apparatus)
Hanging Column	ASTM D6836; Klute, A. 1986. Porosity. Chp.26, in A. Klute (ed.), Methods of Soil Analysis, American Society of Agronomy, Madison, WI
Pressure Plate	ASTM D6836; ASTM D2325
Water Potential (Dewpoint Potentiometer)	ASTM D6836; Rawlins, S.L. and G.S. Campbell, 1986. Water Potential: Thermocouple Psychrometry. Chp.24, pp. 597-619, in A. Klute (ed.), Methods of Soil Analysis, Part 1. American Society of Agronomy, Madison, WI.
Relative Humidity (Box)	Karathanasis & Hajek. 1982. Quantitative Evaluation of Water Absorption on Soil Clays. SSSA Journal 46:1324-1325; Campbell, G. and Gee. 1986. Water Potential: Miscellaneous Methods. Ch. 25, pp. 631-632, in A. Klute (ed.), Methods of Soil Analysis, American Society of Agronomy, Madison, WI
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
Specific Gravity (Fine)	ASTM D854

Note:
SLS = Salinity Laboratory Staff
ASA = American Society of Agronomy

3.1.3 Soil Water Characteristic Curves

Soil water characteristic curves (SWCC) were developed using the RETC code (van Genuchten et al., 1991). The saturated water content (θ_S), residual water content (θ_r) and van Genuchten α and N parameters and relative hydraulic conductivity were estimated using the RETC code (van Genuchten et al., 1991). The SWCC's were developed for the fine-earth fraction and for the whole soils after correction of the fine-earth fraction data for rock fragments. The laboratory data were subsequently corrected to account for rock fragments representative of the whole soil. In particular, the volumetric water content of the fine-earth fraction at various matric suction values was proportionally reduced in accordance with the volume of rock fragments contained in the whole soil.

3.1.4 Water Holding Capacity Estimation

The water holding capacity was determined by subtracting the water held at the traditionally defined field capacity from water held at wilting point (USDA 2014). Field capacity was estimated as the water held at 100 cm (10 kPa) of suction and wilting point was estimated as the water held at 15,000 cm (1500 kPa) of suction (USDA, 2014). Because the cover materials are consistently sandy loams and generally contain between 40 and 60% rock fragments, they were considered coarse textured and field capacity was determined at 100 cm suction. The water content at field capacity and wilting point were determined numerically (rather than graphically) from the soil water characteristic curve functions developed for each sample.

3.2 Thickness and Structural Observations

Cover thickness and structure were assessed in 5 test pits distributed across the test plot area. The covers in the test pits all exceeded the 36 inch minimum requirement with range from 38 to 45 inches thick. Structurally, the covers were dominantly matrix supported with occasional and localized zones of clast supported. The cover materials were pushed in lifts and feathered down the slope to reduce clast supported zones and promotes gravity separation of the larger rock fragments, which were removed from the base of the slope.

3.3 Chemical Properties

The soil testing results indicate that there are no inherent chemical limitations for the growth of native plants. The cover materials are slightly alkaline (pH 7.6 to 7.7) and non-saline (EC < 2 dS/m). The organic matter, phosphorous, and nitrate nitrogen concentrations are considered adequate for the target plant species. The test results are summarized in the Table 4.

Table 4. Chemical Characteristics of the USNR Cover Materials

Sample ID	Paste pH	Paste Extract EC	Organic Carbon	Phosphorus	Nitrate-N
	s.u.	dS/m	%	t/ac-ft	
UTPQA-1	7.7	0.5	< 0.1	12	8
UTPQA-2	7.7	0.4	< 0.1	8	8
UTPQA-3	7.6	0.5	< 0.1	8	8
LTPQA-4	7.7	0.5	< 0.1	8	8
LTPQA-5	7.7	0.6	< 0.1	12	8

3.4 Particle Size Distribution

The range in particle size distribution for the fine-earth fractions was relatively narrow with all the samples classified as sandy loams (Table 5). The rock fragment content ranged from 40 to 60 percent by volume and sizes ranged from gravel to stones. The saturation percentage data was relatively consistent increasing with clay content, suggesting that the samples are mineralogically similar.

Table 5. Particle Size Distribution for the USNR Samples

Sample ID	USDA Texture Class¹	Particle Size Distribution (wt %)			Rock Fragments²	Saturation Percentage
		Sand	Silt	Clay	(vol %)	%
UTPQA-1	SL	73	20	7	60	25.4
UTPQA-2	SL	73	19	8	55	25.3
UTPQA-3	SL	71	21	8	40	24.2
LTPQA-4	SL	71	19	10	50	26.2
LTPQA-5	SL	67	23	10	55	26.5

Notes: 1) Texture = USDA texture class according to Soil Survey Division Staff (1993); SL = sandy loam
2) Rock fragments based on field volumetric estimates from test pits

3.5 Soil Hydraulic Properties

The saturated water content of the < 2 mm soil fraction was consistent among the samples, ranging between 0.48 and 0.51 cm^3/cm^3 (Table 6). The minor variations in saturated water content and other properties are not unexpected given the textural consistency of the materials (Section 4.1). The other soil hydrologic parameters (θ_r and van Genuchten α and N) compare well with standardized relationships among soil particle size and hydraulic properties of similarly textured soils (Rawls et al., 1982; Carsel and Parrish, 1988). The K_{sat} of the < 2 mm samples ranged from 8.9 x 10^{-2} to 2.6 x 10^{-2} cm/s (Table 6), which is the high end of the range expected for sandy loams when compared to typical published values (Klute and Dirksen, 1986). The post-consolidation bulk densities of the laboratory samples only increased slightly compared to the laboratory target densities indicating that the samples were near equilibrium levels at the target densities.

Table 6. Soil Hydraulic Properties of USNR Cover Materials Fine-Earth Fraction

Sample ID	Saturated Hydraulic Conductivity	van Genuchten Coefficients				Bulk Density
		θr	θs	α	N	
	(cm/s)	(cm^3/cm^3)		1/cm	Dimensionless	(g/cm^3)
UTPQA-2	8.9E-02	0.00	0.48	0.103	1.29	1.44
UTPQA-3	7.0E-02	0.00	0.50	0.097	1.31	1.53
LTPQA-4	3.2E-02	0.00	0.50	0.092	1.29	1.52
T7ALRLC	2.6E-02	0.05	0.51	0.078	1.39	1.51

Notes: 1) θr = residual water content; θs = saturated water content
2) cm/s = centimeters per second; mm = millimeters; cm^3 = cubic centimeters; g/cm^3 = grams per cubic centimeter

Table 7. Soil Hydraulic Properties of the USNR Cover Materials Whole Soil Fraction

Sample ID	Saturated Hydraulic Conductivity	van Genuchten Coefficients				Rock Fragments
		θr	θs	α	N	
	(cm/s)	(cm^3/cm^3)		1/cm	Dimensionless	(vol %)
UTPQA-2	1.6E-02	0.00	0.22	0.103	1.29	55
UTPQA-3	2.0E-02	0.00	0.30	0.098	1.31	40
LTPQA-4	1.0E-02	0.00	0.25	0.093	1.30	55
T7ALRLC	7.2E-03	0.00	0.28	0.115	1.27	45

Notes: 1) θ_r = residual water content; θ_s = saturated water content
2) cm/s = centimeters per second; mm = millimeters; cm^3 = cubic centimeters; g/cm^3 = grams per cubic centimeter

The SWCC's for each sample are provided in Appendix B. The SWCC graphs display the curves for the fine-earth fraction and for the whole soil assuming the rock fragment content for each test pit based on the field descriptions (Table 7).

3.6 Water Holding Capacity

The estimated water holding capacity of the fine-earth fraction ranged from about 2.1 to 2.4 in/ft (Table 8). The water holding capacity on a whole soil basis (corrected for the field rock fragment contents) ranged from about 1.0 to 1.4 in/ft reflecting the reduction of water holding capacity associated with the rock fragments. The average water holding capacity of the fine-earth fraction was 2.23 in/ft based on the 4 samples tested.

Table 8. Estimated Water Holding Capacity of USNR Cover Samples

Sample ID	Water Holding Capacity (in/ft)		Rock Fragment Content[2] (vol %)
	Fine Earth	Whole Soil[1]	
UTPQA-2	2.21	1.00	55
UTPQA-3	2.30	1.38	40
LTPQA-4	2.35	1.17	50
T7ALRLC	2.07	1.28	45

Notes: 1) Whole soil based on RETC adjusted for field rock fragments
2) Total rock fragments based on field estimates for profile

Because the water holding capacity of the cover is directly related to the quantity of rock fragments, a generalized relationship was developed using the average water holding capacity of the fine earth fraction corrected for various rock fragment concentrations (Figure 3). The line is described by the following equation;

$$\text{Field WHC} = (\text{FE WHC}) \times (1 - \text{VRF})$$

Where the FE WHC is the fine-earth water holding capacity, which is assumed to be 2.23 in/ft (average of materials tested), and VRF is the volumetric rock fragment content. This relationship will allow determination of the water holding capacity of the cover using soil textural (i.e., rock fragment) data, which is collected as part of the cover quality control process. For example, if the cover material in a reclamation area had an average rock fragment content of 45% (0.45) the field water holding capacity would be estimated to be 1.4 in/ft (i.e., 2.23 x 1-0.45).

This analysis indicates that the Little Rock cover materials will achieve the Copper Rule requirements (≈ 2.6 inches) with the 3-foot thick cover. The cover material on the test plots had an average rock fragment of about 48%. Thus, the cover materials on the test plots have a water holding capacity that exceeds the 20.6.7.F (2) requirements.

4.0 EROSION MONITORING

Erosion is the detachment and movement of soil by wind or water. Soil erosion rates vary temporally in response to a number of controlling factors. The major factors affecting erosion include the amount, duration, and intensity of rainfall, soil physical characteristics, nature of the soil surface, vegetation, litter, and rock cover, and the gradient, shape, and length of slope. Soil erosion at mine sites is typically predicted using models that incorporate these factors (Toy and Foster 1998). Because erosion is episodic, short-term measurements are typically poorly correlated to the long-term prediction provided by models (Weltz et al. 1998). For instance, erosion rates are expected to be highest during the vegetation establishment period and may not reflect long-term rates. Similarly, variations in weather events can strongly affect the erosion process. Because of the large size of the plots, sediment traps were considered impractical as a means to measure erosion. Soil erosion was measured using a portable erosion meter (McCool et al 1981; Kincaid and Williams 1966). The erosion measurements were made using the erosion meter described in Golder (2009).

The erosion transects were installed and baseline monitoring was conducted in June 2016. A subsequent monitoring episode was conducted in December 2016 to assess changes in surface topography. Figure 4 shows the location of the erosion monitoring stations. Cross-section plots of the relative changes in the ground surface from the baseline measurements in 2016 are included in Appendix C (Figures C-1 to C-2). Photographs of the monitoring locations compared to the baseline conditions are included in Appendix D.

4.1 Changes in Surface Elevation and Erosion

Changes in soil surface elevations were evaluated assuming each erosion meter station represented a separate sample. For each station, the average change in surface elevation from the initial measurement was calculated using points that intersected soil, rock fragments, and litter. Positive changes in surface elevation indicate degradation and negative changes indicate aggradation. The four individual stations on each transect were averaged to determine the change in elevation for each transect. The two transects were averaged to estimate the change in surface elevation for the test plot as a whole considering that the vegetation was not substantively different among the mulching treatments.

The relative changes in ground surface elevation were minimal considering that the test plots is still in the vegetation establishment phase. The relative change in ground surface from baseline was 1.7 mm on the south transect (1:2.98 gradient) and 0.9 mm on the north transect (1:3.2 gradient). The average for the test plot was 1.3 mm. This represents an estimated erosion rate of about 8.5 tons/ac for the first measurement period, which is within the measurement error of this method (Golder, 2009).

The erosion transects were constructed and baseline conditions were measured about 1 year after seeding and mulching. The amount of surface aggradation or degradation that occurred during the period between mulching and the baseline measurement (i.e., summer of 2015) is impossible to quantify. Thus, the erosion estimates provided in this section do not represent the entire period of reclamation. Because the straw mulch was largely intact through the summer of 2015 and persisted locally with diminishing effectiveness into 2016, we believe that the actual erosion is likely to be somewhat, but probably not substantially higher.

Examination of the station cross-sections suggests that rill erosion is more prevalent than sheet erosion on the slopes. The zone of apparent riling tends to occur near the mid-point of the slope, which is consistent with erosion processes on natural hillslopes.

Table 9. Average Change in Ground Surface Elevation of the USNR Erosion Transects

Station #	USNR-South	USNR-North	Average
1 (near crest)	1.5	0.5	1.0
2	0.2	2.6	1.4
3	5.0	1.6	3.3
4 (near toe)	0.0	-1.0	-0.5
Transect Average	**1.7**	**0.9**	
Test Plot Average			**1.3**

Notes:
Changes in elevation are from baseline in millimeters (mm)
Negative values indicate surface aggradation
Positive values indicate surface degradation

5.0 VEGETATION MONITORING

Vegetation attributes on the test plots were evaluated qualitatively in 2016 with emphasis on plant establishment. Because weather conditions have an important impact on plant establishment, the precipitation records from the Little Rock meteorological station are provide in this section. Table 10 lists the monthly and annual precipitation for 2015, and 2016. Compared to the long-term regional records (Ft Bayard with about 16 inches), annual precipitation was somewhat, but not drastically, below average for 2015 and slightly above normal for 2016. The daily distribution of precipitation is shown in Figure 5. Overall, the prevailing precipitation is considered favorable, but not exceptionally wet.

Table 10. Monthly and Annual Precipitation at the Little Rock Met Station

	2014	2015	2016
January	0.00	2.22	1.03
February	0.00	0.44	0.31
March	1.12	0.82	0.00
April	0.33	0.31	0.54
May	0.03	0.52	0.15
June	0.15	1.14	0.61
July	0.83	2.40	2.43
August	4.80	2.57	5.53
September	3.04	1.14	3.34
October	1.63	0.25	0.27
November	1.28	1.15	0.26
December	1.12	1.44	2.54
Annual	14.33	14.40	17.01

The status of the vegetation in 2016 is depicted in Figures 6 through 9 for the mulching and seeding variations. In general, the vegetation on all treatments is performing adequately for this stage of reclamation with average plant density exceeding 1 plant/square foot. There were no discernable differences in canopy cover on the plots that were seeded either before or after mulching. Species composition varied among the experimental and conventional seed mix treatments, although the early stage of reclamation made definitive identification of some species difficult. The future vegetation studies required by the work plan and Permit will be necessary to better define species response of the conventional and experimental seed mix treatments. Nonetheless, species with a notable response on the experimental seed mix plots included whitethorn and catclaw acacia, white sagebrush, Palmer's penstemon and deer vetch. Coues' senna, which was observed on the experimental seed mix treatment in the fall of 2015, was not present in 2016.

6.0 REFERENCES

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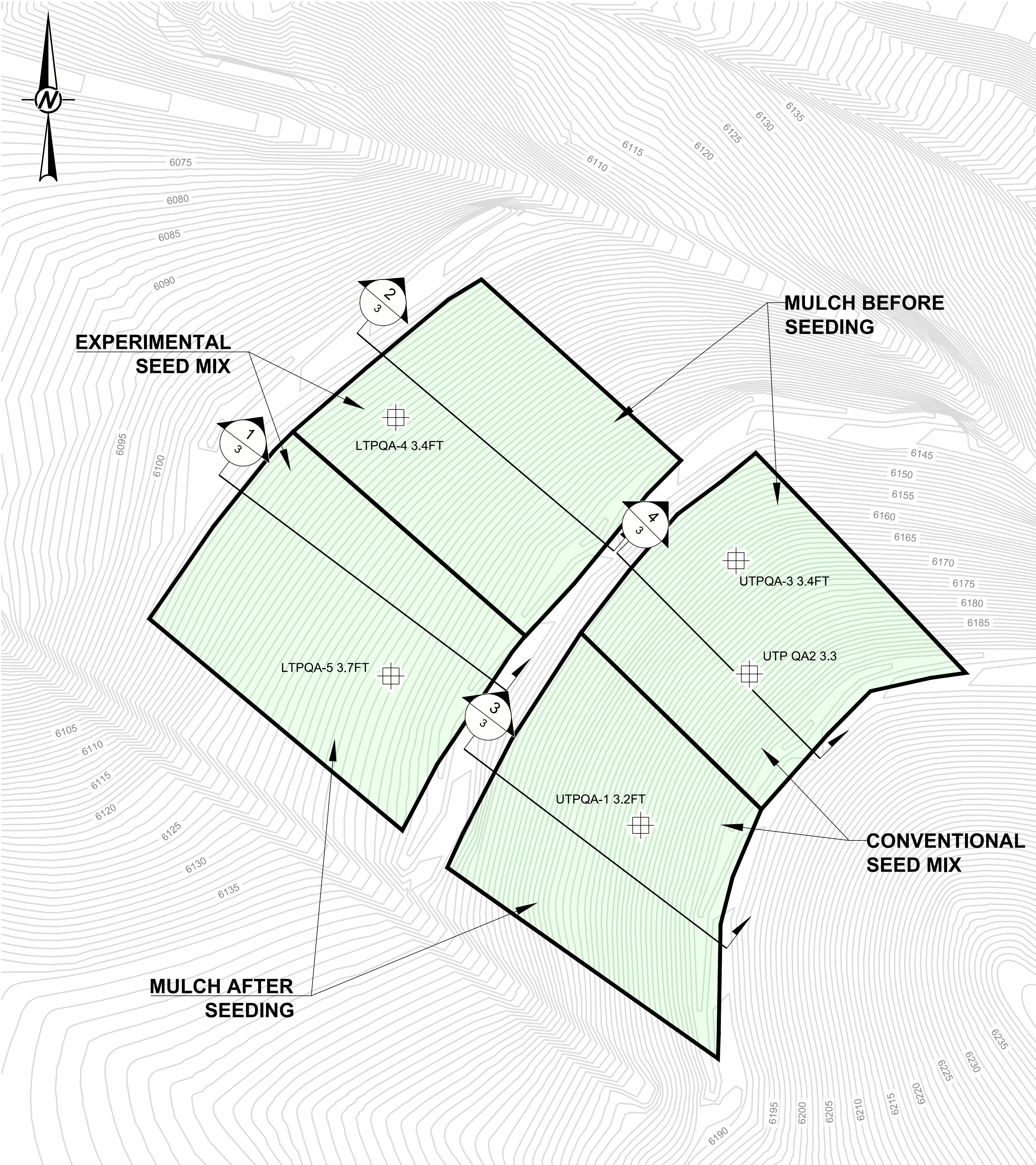
FIGURES



LEGEND

(thick line)	TEST PLOT BOUNDARY
UTPQA-1 3.2FT	TEST PIT LOCATION

REFERENCE(S)

TOPOGRAPHY PROVIDED BY FREEPORT McMoRan TYRONE INC.

0 40 80
1" = 80' FEET

CLIENT
FREEPORT McMoRan TYRONE INC.
GRANT COUNTY, NEW MEXICO

PROJECT
USNR AS-BUILT REPORT

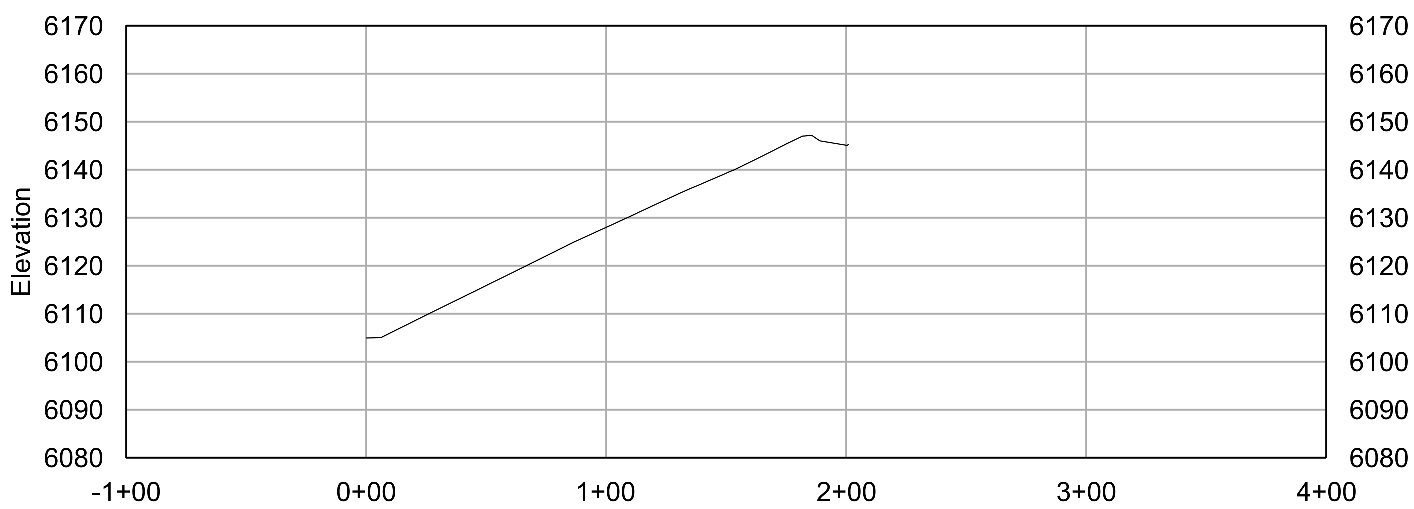
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-02-22
DESIGNED	LM
PREPARED	CM
REVIEWED	LM
APPROVED	LM

TITLE
TEST PLOT LAYOUT

PROJECT NO.	PHASE	REV.	FIGURE
123-80014	--	--	1



0 40 80
1" = 80' FEET
SCALE: H=80'
SCALE: V=40'
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1
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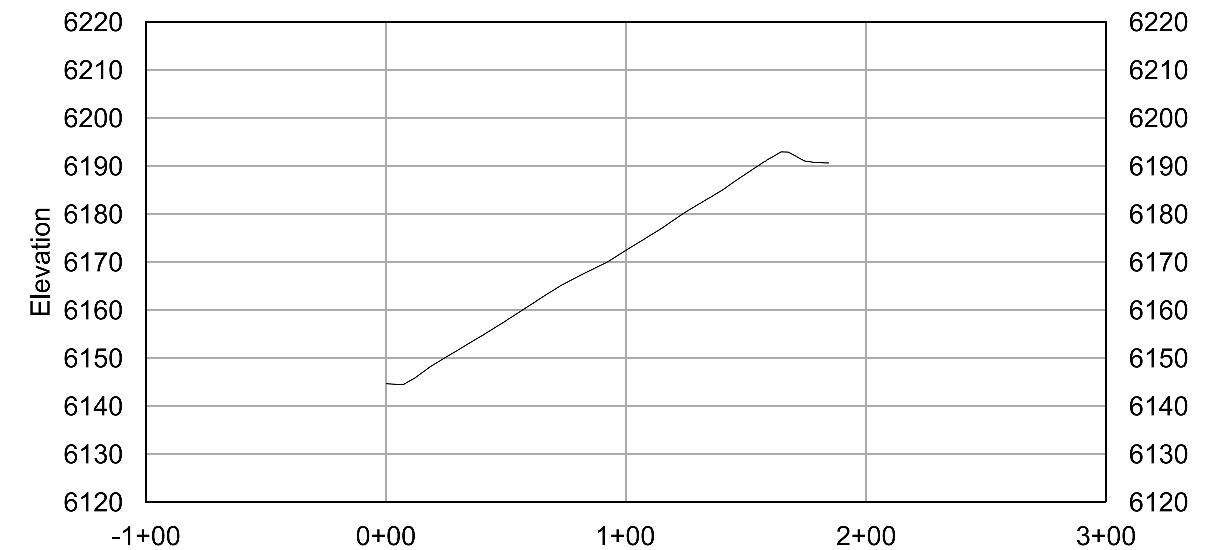

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1" = 80' FEET
SCALE: H=80'
SCALE: V=40'
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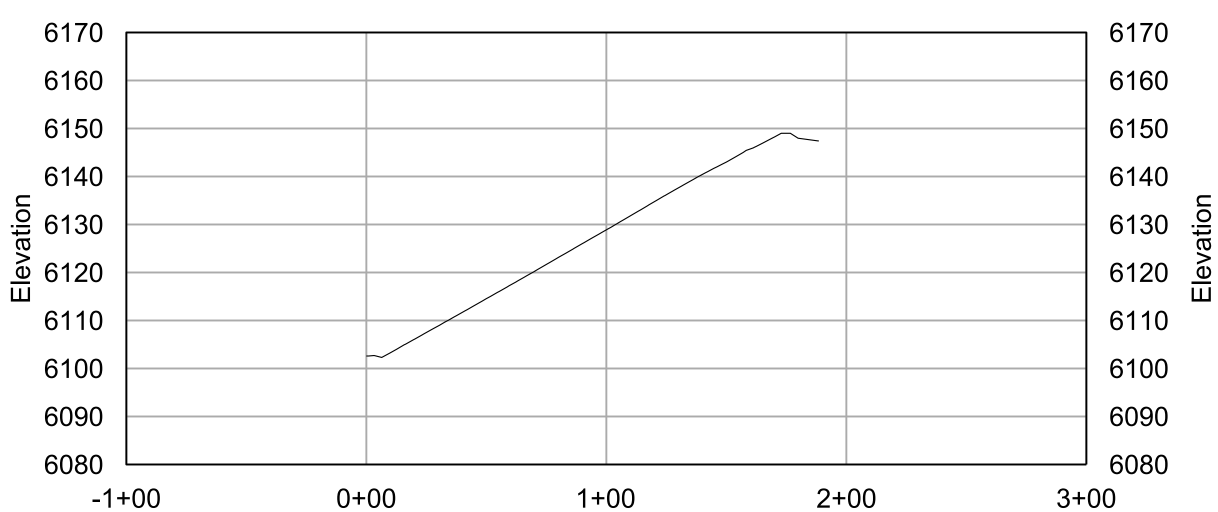
1
CONVENTIONAL SEED MIX TEST PLOT CROSS SECTION



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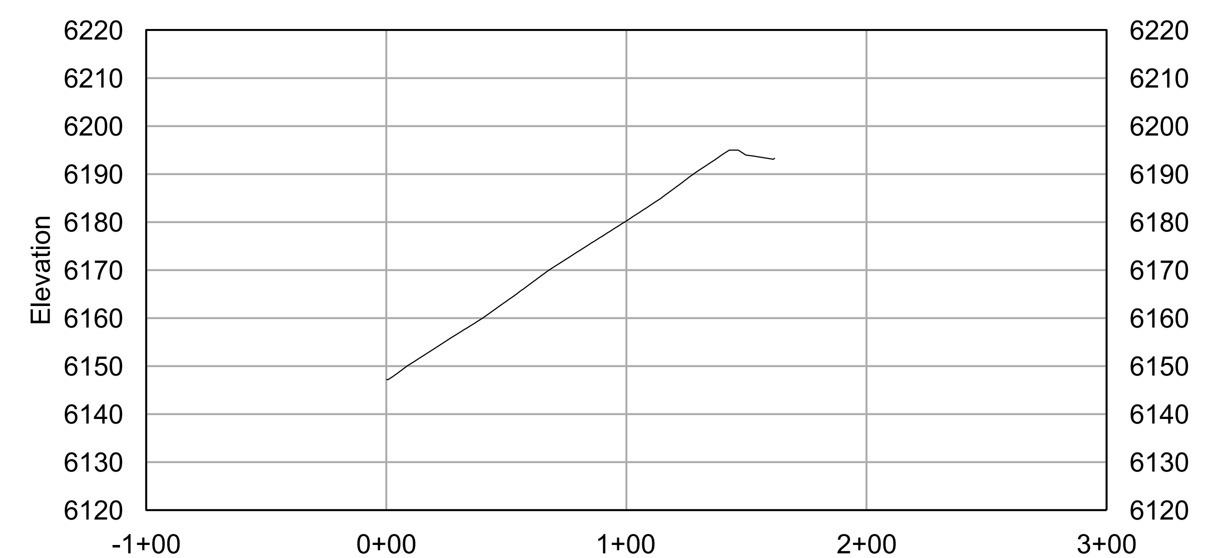
1" = 80' FEET
SCALE: H=80'
SCALE: V=40'
2
1
EXPERIMENTAL SEED MIX TEST PLOT CROSS SECTION



0 40 80
1" = 80' FEET
SCALE: H=80'
SCALE: V=40'
4
1
CONVENTIONAL SEED MIX TEST PLOT CROSS SECTION

CLIENT
FREEPORT McMoRan TYRONE INC.
GRANT COUNTY, NEW MEXICO

PROJECT
USNR AS-BUILT REPORT

CONSULTANT

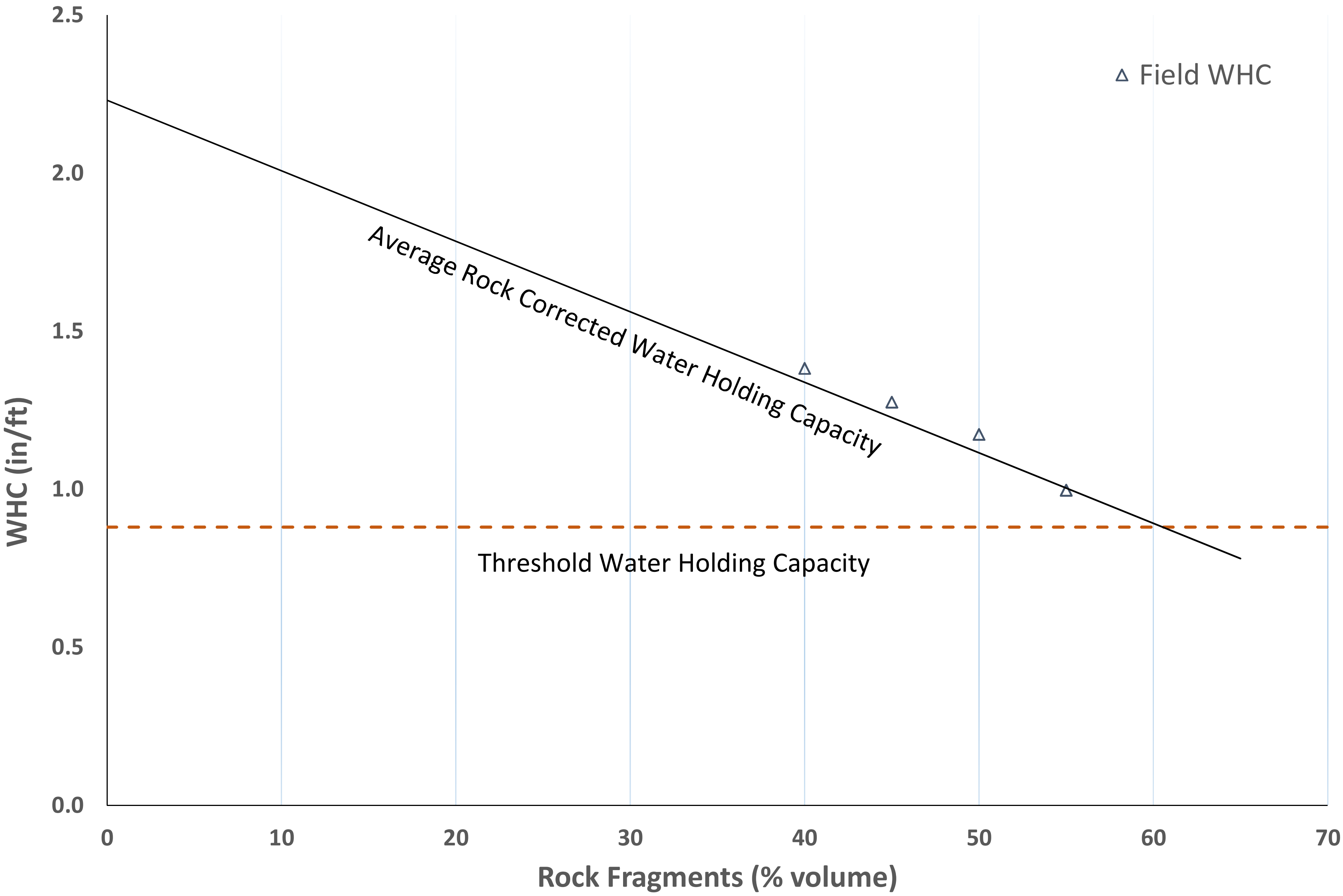
Golder Associates

YYYY-MM-DD	2017-02-22
DESIGNED	LM
PREPARED	CM
REVIEWED	LM
APPROVED	LM

TITLE
USNR TEST PLOT CROSS SECTIONS

PROJECT NO.	PHASE	REV.	FIGURE
123-80014	--	--	2

Figure 3:
Standardized Relationship for Water Holding Capacity and Volumetric Rock Fragment Content



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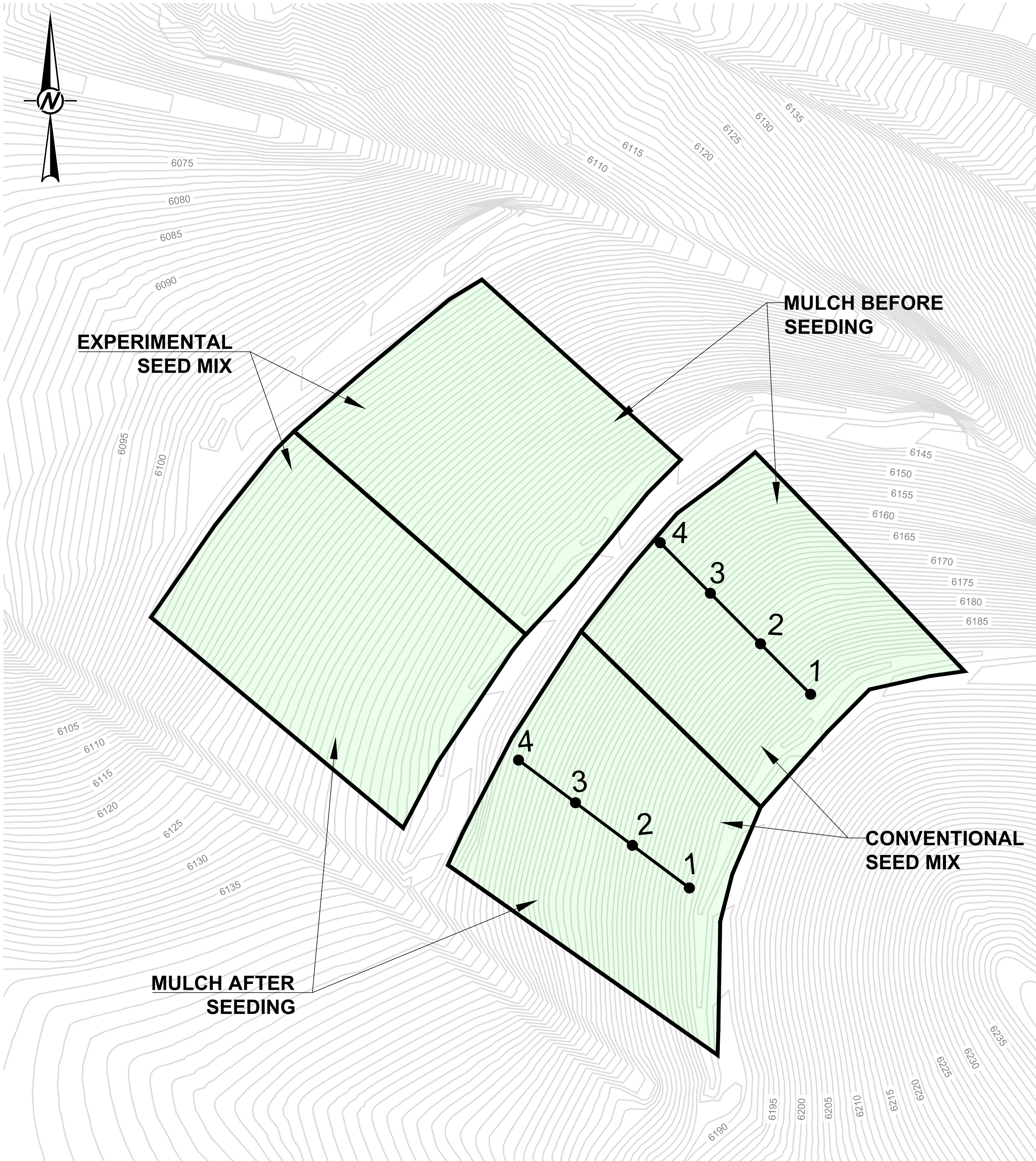


LEGEND

TEST PLOT BOUNDARY

4 3 2 1

TRANSECT LOCATION WITH STATIONS AT 40 FEET APART, STATION 1 AT 10 FEET FROM CREST OF SLOPE.

REFERENCE(S)

TOPOGRAPHY PROVIDED BY FREEPORT McMoRAN TYRONE INC.

0 40 80
1" = 80' FEET

CLIENT
FREEPORT McMoRan TYRONE INC.
GRANT COUNTY, NEW MEXICO

PROJECT
USNR AS-BUILT REPORT

CONSULTANT

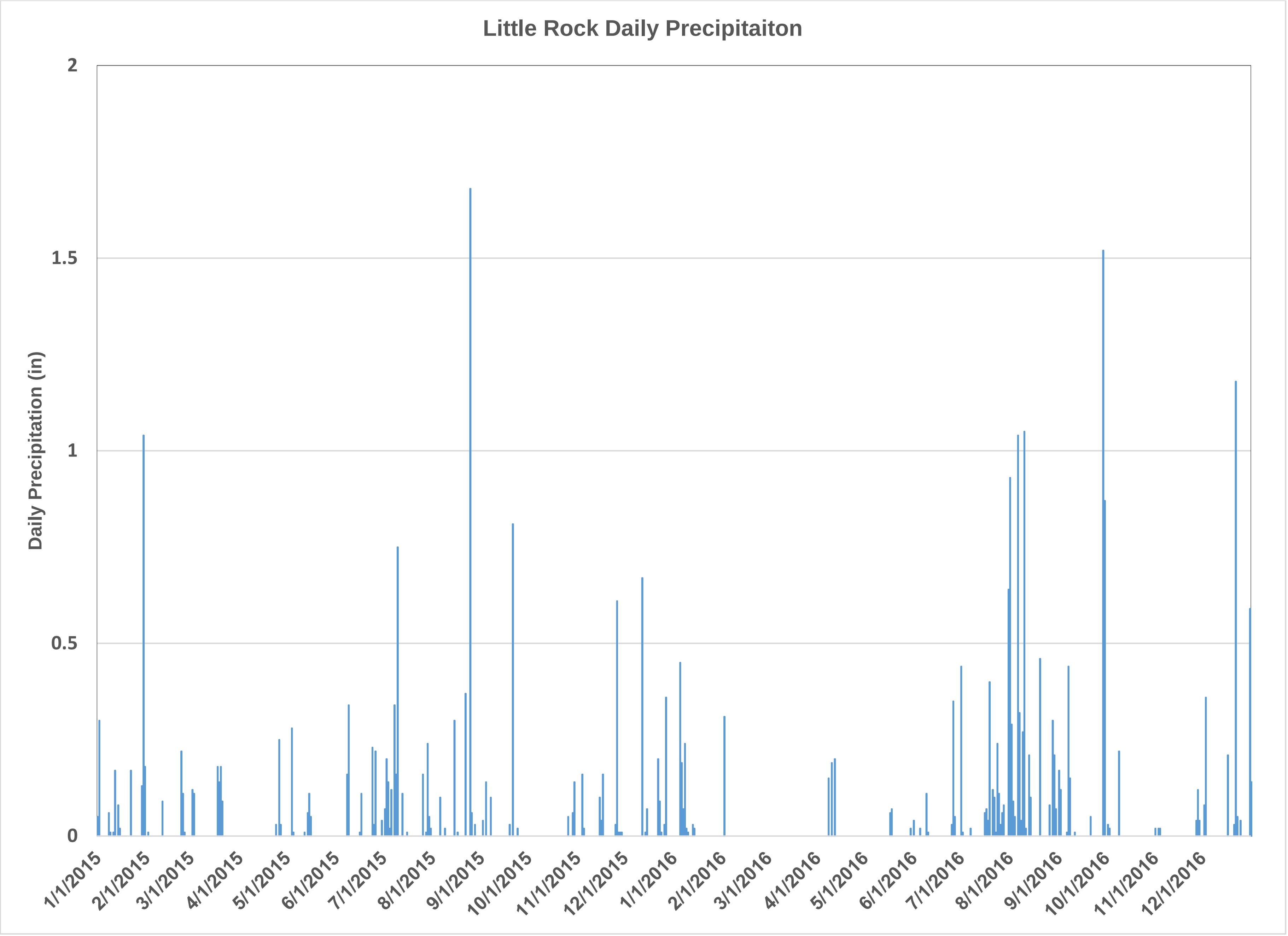
Golder Associates

YYYY-MM-DD	2017-02-22
DESIGNED	LM
PREPARED	CM
REVIEWED	LM
APPROVED	LM

TITLE
USNR EROSION TRANSECT LOCATIONS

PROJECT NO.	PHASE	REV.	FIGURE
123-80014	--	--	4

Figure 5:
Daily Precipitation at the Little Rock Met Station



Golder Associates

Figure 6. Status of vegetation on the seeding after mulching conventional treatment. (October 2016)

Figure 7. Status of vegetation on the seeding before mulching treatment. (Conventional mix. October 2016)

Figure 8. Status of vegetation on the seeding before mulching treatment. (Experimental mix. June 2016)

Figure 9. Status of vegetation on the seeding after mulching treatment. (Experimental mix. June 2016)

APPENDIX A
LABORATORY REPORTS

ENERGY LABORATORIES

ANALYTICAL SUMMARY REPORT

March 11, 2016

Golder Associates Inc
5200 Pasadena NE Ste C
Albuquerque, NM 87113

Work Order: B16030333

Project Name: USNR Test Plots

Energy Laboratories Inc Billings MT received the following 5 samples for Golder Associates Inc on 3/3/2016 for analysis.

Lab ID	Client Sample ID	Collect Date	Receive Date	Matrix	Test
B16030333-001	USNR UTPQA-1	05/28/15 0:00	03/03/16	Soil	Coarse Fragments Conductivity, Saturated Paste Extract Nitrate as N, KCL Extract Organic Carbon/Matter Walkley-Black pH, Saturated Paste Phosphorus-Olsen Saturated Paste Extraction Particle Size Analysis Saturation Percentage Texture
B16030333-002	USNR UTPQA-2	05/28/15 0:00	03/03/16	Soil	Same As Above
B16030333-003	USNR UTPQA-3	05/28/15 0:00	03/03/16	Soil	Same As Above
B16030333-004	USNR LTPQA-4	05/28/15 0:00	03/03/16	Soil	Same As Above
B16030333-005	USNR LTPQA-5	05/28/15 0:00	03/03/16	Soil	Same As Above

The analyses presented in this report were performed by Energy Laboratories, Inc., 1120 S 27th St., Billings, MT 59101, unless otherwise noted. Any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

If you have any questions regarding these test results, please call.

Report Approved By:

LABORATORY ANALYTICAL REPORT

Prepared by Billings, MT Branch

Client: Golder Associates Inc
Project: USNR Test Plots
Workorder: B16030333

Report Date: 03/11/16
Date Received: 03/03/16

	Analysis	Coarse Frags	Sand	Silt	Clay	Texture	pH	COND	Saturation	Organic Carbon	Phos, Olsen	Nitrate as N
	Units	%	%	%	%		s_u_	mmhos/cm	%	%	mg/kg	mg/kg
Sample ID	**Client Sample ID**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
B16030333-001	USNR UTPQA-1	62	73	20	7	SL	7.7	0.5	25.4	< 0.1	3	2
B16030333-002	USNR UTPQA-2	55	73	19	8	SL	7.7	0.4	25.3	< 0.1	2	2
B16030333-003	USNR UTPQA-3	53	71	21	8	SL	76.0	0.5	24.2	< 0.1	2	2
B16030333-004	USNR LTPQA-4	55	71	19	10	SL	7.7	0.5	26.2	< 0.1	2	2
B16030333-005	USNR LTPQA-5	61	67	23	10	SL	7.7	0.6	26.5	< 0.1	3	2

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Golder Associates Inc

Project: USNR Test Plots

Report Date: 03/11/16

Work Order: B16030333

Analyte		Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**ASA15-5**								Batch: R257811	
Lab ID:	**B16030336-001A DUP**	Sample Duplicate				Run: MISC-SOIL_160311A			03/11/16 10:18	
Sand		74	%	1.0				1.4	30	
Silt		19	%	1.0				5.1	30	
Clay		7.0	%	1.0				0.0	30	
Lab ID:	**LCS-1603111018**	Laboratory Control Sample				Run: MISC-SOIL_160311A			03/11/16 10:18	
Sand		44	%	1.0	107	70	130			
Silt		37	%	1.0	106	70	130			
Clay		19	%	1.0	79	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Golder Associates Inc

Project: USNR Test Plots

Report Date: 03/11/16

Work Order: B16030333

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA24-5						Batch: OM_3-11-2016_07-54-09AM			
Lab ID: LCS	Laboratory Control Sample				Run: FIA205-B_160311A				03/11/16 07:55
Phosphorus, Olsen	7.4	mg/kg	1.0	111	70	130			
Lab ID: B16030333-001ADUP	Sample Duplicate				Run: FIA205-B_160311A				03/11/16 08:04
Phosphorus, Olsen	2.4	mg/kg	1.0				8.4	30	
Lab ID: B16030333-001AMS	Sample Matrix Spike				Run: FIA205-B_160311A				03/11/16 08:05
Phosphorus, Olsen	13	mg/kg	1.0	101	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Golder Associates Inc **Report Date:** 03/11/16
Project: USNR Test Plots **Work Order:** B16030333

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA29-3									Batch: R257811
Lab ID: B16030333-001A DUP	Sample Duplicate				Run: MISC-SOIL_160311A				03/11/16 10:12
Organic Carbon	0.0700	%	0.10					30	
Lab ID: LCS-1603111012	Laboratory Control Sample				Run: MISC-SOIL_160311A				03/11/16 10:12
Organic Carbon	1.26	%	0.10	79	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Golder Associates Inc **Report Date:** 03/11/16

Project: USNR Test Plots **Work Order:** B16030333

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASA33-8									Batch: OM_3-10-2016_11-41-30AM
Lab ID: LCS	Laboratory Control Sample				Run: FIA205-B_160310A				03/10/16 11:42
Nitrate as N, KCL Extract	8.10	mg/kg	1.0	109	70	130			
Lab ID: B16030336-005ADUP	Sample Duplicate				Run: FIA205-B_160310A				03/10/16 11:56
Nitrate as N, KCL Extract	2.68	mg/kg	1.0				9.4	30	
Lab ID: B16030336-005AMS	Sample Matrix Spike				Run: FIA205-B_160310A				03/10/16 11:56
Nitrate as N, KCL Extract	4.91	mg/kg	1.0	118	50	150			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Golder Associates Inc | **Report Date:** 03/11/16
Project: USNR Test Plots | **Work Order:** B16030333

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASAM10-3									Batch: R257811
Lab ID: B16030333-005A DUP	Sample Duplicate				Run: MISC-SOIL_160311A				03/11/16 10:10
Conductivity, sat. paste	0.540	mmhos/cm	0.10				1.8	30	
Lab ID: LCS-1603111010	Laboratory Control Sample				Run: MISC-SOIL_160311A				03/11/16 10:10
Conductivity, sat. paste	11.9	mmhos/cm	0.10	88	70	130			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Golder Associates Inc — **Report Date:** 03/11/16

Project: USNR Test Plots — **Work Order:** B16030333

Analyte	Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method: ASAM10-3.2									Batch: R257811
Lab ID: B16030333-005A DUP	Sample Duplicate				Run: MISC-SOIL_160311A				03/11/16 10:10
pH, sat. paste	7.60	s.u.	0.10				1.3	10	
Lab ID: LCS-1603111010	Laboratory Control Sample				Run: MISC-SOIL_160311A				03/11/16 10:10
pH, sat. paste	7.00	s.u.	0.10	99	90	110			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

QA/QC Summary Report

Prepared by Billings, MT Branch

Client: Golder Associates Inc **Report Date:** 03/11/16

Project: USNR Test Plots **Work Order:** B16030333

Analyte		Result	Units	RL	%REC	Low Limit	High Limit	RPD	RPDLimit	Qual
Method:	**USDA27a**									Batch: R257811
Lab ID:	**B16030333-005A DUP**	Sample Duplicate				Run: MISC-SOIL_160311A				03/11/16 10:10
Saturation		28.2	%	0.10				6.2	20	
Lab ID:	**LCS-1603111010**	Laboratory Control Sample				Run: MISC-SOIL_160311A				03/11/16 10:10
Saturation		36.9	%	0.10	97	50	150			

Qualifiers:

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

Work Order Receipt Checklist

Golder Associates Inc B16030333

Login completed by: Cindy Rohrer
Date Received: 3/3/2016
Reviewed by: BL2000\jmueller
Received by: car
Reviewed Date: 3/4/2016
Carrier name: FedEx Ground

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on all shipping container(s)/cooler(s)?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on all sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.)	Yes ☑	No ☐	
Temp Blank received in all shipping container(s)/cooler(s)?	Yes ☐	No ☐	Not Applicable ☑
Container/Temp Blank temperature:	11.0°C No Ice		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	Not Applicable ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as –dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

Contact and Corrective Action Comments:

None

ENERGY
Trust our People. Trust our Data.

Chain of Custody & Analytical Request Record

www.energylab.com

Account Information (Billing information)

Company/Name	Golder Associates
Contact	Doug Romig
Phone	(505) 821-3043
Mailing Address	5200 Pasadena NE, Ste. C
City, State, Zip	Albuquerque, NM 87113-2208
Email	Doug_Romig@Golder.com;Drichelle_Pierce@Golder.co
Receive Invoice	☒Hard Copy ☐Email
Receive Report	☐Hard Copy ☒Email
Purchase Order	
Quote	
Bottle Order	

Report Information (if different than Account Information)

Company/Name	
Contact	
Phone	
Mailing Address	
City, State, Zip	
Email	
Receive Report	☐Hard Copy ☐Email
Special Report/Formats:	☐ LEVEL IV ☐ NELAC ☐ EDD/EDT (contact laboratory) ☐ Other________

Comments

Bill To: 123-80014

Project Information

Project Name, PWSID, Permit, etc.	USNR Test Plots
Sampler Name	Doug Romig
Sampler Phone	(505) 821-3043
Sample Origin State	New Mexico
EPA/State Compliance	☐ Yes ☐ No

MINING CLIENTS, please indicate sample type.
*If ore has been processed or refined, call before sending.
☐ Byproduct 11 (e)2 material ☐ Unprocessed ore (NOT ground or refined)*

Matrix Codes
A - Air
W - Water
S - Soils/Solids
V - Vegetation
B - Bioassay
O - Other
DW - Drinking Water

All turnaround times are standard unless marked as RUSH.

Energy Laboratories MUST be contacted prior to RUSH sample submittal for charges and scheduling – See Instructions Page

Analysis Requested

	Sample Identification (Name, Location, Interval, etc.)	Collection Date	Collection Time	Number of Containers	Matrix (See Codes Above)	pH, Saturated Paste	Conductivity, sat. pasate	Particle Size Analysis: sand, silt, clay	Saturation Percentage	Organic Carbon - Walkley/Nlack	Phosphorus-Olsen	Nitrate as N, KCL Extract	Gravel Content >2mm		See Attached	RUSH TAT	ELI LAB ID Laboratory Use Only
1	USNR UTPQA-1	5/28/15		1	S	✓	✓	✓	✓	✓	✓	✓	✓				B16030333-001
2	USNR UTPQA-2	5/28/15		1	S	✓	✓	✓	✓	✓	✓	✓	✓				002
3	USNR UTPQA-3	5/28/15		1	S	✓	✓	✓	✓	✓	✓	✓	✓				003
4	USNR LTPQA-4	5/28/15		1	S	✓	✓	✓	✓	✓	✓	✓	✓				004
5	USNR LTPQA-5	5/28/15		1	S	✓	✓	✓	✓	✓	✓	✓	✓				005
6																	
7																	
8																	
9																	
10																	

Custody Record MUST be signed	Relinquished by (print)	Date/Time	Signature	Received by (print)	Date/Time	Signature
	Kyle Kirtley	2/29/16 15:16	[signature]			
	Relinquished by (print)	Date/Time	Signature	Received by Laboratory (print)	Date/Time 3-3-16 9:30	Signature Cindy Dohner

LABORATORY USE ONLY

Shipped By	Cooler ID(s)	Custody Seals	Intact	Receipt Temp	Temp Blank	On Ice	Payment Type	Amount	Receipt Number (cash/check only)
FedExGr		Y (N) C B	Y N	11.0 °C	Y (N)	Y (N)	CC Cash Check______	$	

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested. This serves as notice of this possibility. All subcontracted data will be clearly notated on your analytical report.

DANIEL B. STEPHENS & ASSOCIATES, INC.

Laboratory Report for

Golder Associates, Inc.

USNR, 1303098

April 13, 2016

Daniel B. Stephens & Associates, Inc.

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

April 13, 2016

Lewis Munk
Golder Associates, Inc.
5200 Pasadena NE, Suite C
Albuquerque, NM 87113
(505) 821-3043

Re: DBS&A Laboratory Report for the Golder Associates, Inc., USNR 1303098 Project

Dear Mr. Munk:

Enclosed is the report for the Golder Associates, Inc. USNR 1303098 project 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 Golder Associates, 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

Joleen Hines
Laboratory Supervising Manager

Enclosure

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Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	Atterberg Limits	Proctor Compaction
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
T7ALRLC-Comp (<2mm, 1.4g/cc)	X	X		X			X			X	X			X								
UTPQA-2 (<2mm, 1.4g/cc)	X	X		X			X			X	X			X								
UTPQA-3 (<2mm, 1.4g/cc)	X	X		X			X			X	X			X								
LTPQA-4 (<2mm, 1.4g/cc)	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:
Four samples, each in a full 5-gallon bucket sealed with a lid, were hand delivered on February 29, 2016. All samples were received in good order.

Sample Preparation and Testing Notes:
Particles larger than 2mm were removed from each sample by splitting the material over a #10 sieve after gently breaking up larger clods by hand. Sample T7ALRLC-Comp was processes at the as received moisture content, and the remaining three samples were processed after a short air drying period in order to facilitate the splitting process. The <2mm fraction from each sample was then remolded into a testing ring to target a dry bulk density of 1.40 g/cm^3, each at the respective as processed moisture content. Each remolded sub-sample ID was annotated with the actual remold density achieved (in g/cm^3), and with "<2mm" to indicate that the <2mm fraction was used for testing. The remolded <2mm sub-samples were subjected to initial properties analysis, saturated hydraulic conductivity testing, and the hanging column and pressure chamber portions of the moisture retention testing. Additional <2mm material was obtained for the dewpoint potentiometer and relative humidity chamber portions of the moisture retention testing.

Volumetric water contents were adjusted for changes in volume, where applicable. Due to the irregularities formed on the sample surfaces during settling, volume measurements obtained after the initial reading should be considered estimates.

Oversize correction calculations are presented since the >2mm fraction removed was greater than 5% of the bulk sample mass. The percentages of coarse (>2mm) and fine (<2mm) fractions used in the calculations are based on the initial splitting process. The percentage of <2mm material would be greater if the material had been soaked and washed during the splitting process.

Porosity calculations are based on the use of an assumed specific gravity value of 2.65.

Summary of Sample Preparation/Volume Changes

Sample Number	Target Remold Parameters[1] Dry Bulk Density (g/cm³)	Target Remold Parameters[1] Dry Bulk Density (pcf)	Actual Remold Data Moist. Cont. (%, g/g)	Actual Remold Data Dry Bulk Density (g/cm³)	Actual Remold Data Dry Bulk Density (pcf)	Actual Remold Data % of Target Density (%)	Volume Change Post Saturation[2] Dry Bulk Density (g/cm³)	Volume Change Post Saturation[2] Dry Bulk Density (pcf)	Volume Change Post Saturation[2] % Volume Change (%)	Volume Change Post Saturation[2] % of Initial Density (%)	Volume Change Post Drying Curve[3] Dry Bulk Density (g/cm³)	Volume Change Post Drying Curve[3] Dry Bulk Density (pcf)	Volume Change Post Drying Curve[3] % Volume Change (%)	Volume Change Post Drying Curve[3] % of Initial Density (%)
T7ALRLC-Comp (<2mm, 1.4g/cc)	1.40	87.4	2.6	1.40	87.44	100.1%	1.40	87.44	---	100.0%	1.44	90.07	-2.9%	103.0%
UTPQA-2 (<2mm, 1.4g/cc)	1.40	87.4	9.0	1.40	87.59	100.2%	1.40	87.59	---	100.0%	1.46	90.91	-3.7%	103.8%
UTPQA-3 (<2mm, 1.4g/cc)	1.40	87.4	8.2	1.40	87.68	100.3%	1.40	87.68	---	100.0%	1.45	90.50	-3.1%	103.2%
LTPQA-4 (<2mm, 1.4g/cc)	1.40	87.4	7.4	1.40	87.62	100.2%	1.40	87.62	---	100.0%	1.48	92.36	-5.1%	105.4%

[1]Target Remold Parameters: Provided by the client: Remold <2mm fraction to target 1.40 g/cm³.

[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		Dry Bulk	Wet Bulk	Calculated
	Gravimetric	Volumetric	Gravimetric	Volumetric	Density	Density	Porosity
Sample Number	(%, g/g)	(%, cm^3/cm^3)	(%, g/g)	(%, cm^3/cm^3)	(g/cm^3)	(g/cm^3)	(%)
T7ALRLC-Comp (<2mm, 1.4g/cc)	NA	NA	2.6	3.6	1.40	1.44	47.1
UTPQA-2 (<2mm, 1.4g/cc)	NA	NA	9.0	12.6	1.40	1.53	47.1
UTPQA-3 (<2mm, 1.4g/cc)	NA	NA	8.2	11.6	1.40	1.52	47.0
LTPQA-4 (<2mm, 1.4g/cc)	NA	NA	7.4	10.3	1.40	1.51	47.0

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

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis	
			Constant Head	Falling Head
T7ALRLC-Comp (<2mm, 1.4g/cc)	2.6E-02	7.2E-03	X	
UTPQA-2 (<2mm, 1.4g/cc)	8.9E-02	1.6E-02	X	
UTPQA-3 (<2mm, 1.4g/cc)	7.0E-02	2.0E-02	X	
LTPQA-4 (<2mm, 1.4g/cc)	3.2E-02	1.0E-02	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)
T7ALRLC-Comp (<2mm, 1.4g/cc)	0	48.9
	4	48.5 ‡‡
	11	48.0 ‡‡
	28	31.8 ‡‡
	157	21.5 ‡‡
	816	14.2 ‡‡
	2550	12.0 ‡‡
	36815	7.2 ‡‡
	214872	5.1 ‡‡
	845560	4.3 ‡‡
UTPQA-2 (<2mm, 1.4g/cc)	0	46.2
	4	46.2
	9	43.4 ‡‡
	32	32.3 ‡‡
	168	18.0 ‡‡
	1836	10.3 ‡‡
	12034	7.4 ‡‡
	43647	5.9 ‡‡
	191314	4.2 ‡‡
	845560	3.3 ‡‡
UTPQA-3 (<2mm, 1.4g/cc)	0	48.7
	4	47.1 ‡‡
	11	45.9 ‡‡
	23	35.0 ‡‡
	161	18.4 ‡‡
	612	12.6 ‡‡
	3977	9.5 ‡‡
	57211	5.7 ‡‡
	219155	4.5 ‡‡
	845560	3.4 ‡‡

‡‡ 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)
LTPQA-4 (<2mm, 1.4g/cc)	0	47.8
	4	47.6 ‡‡
	12	46.6 ‡‡
	26	33.5 ‡‡
	157	19.8 ‡‡
	918	12.3 ‡‡
	10504	8.3 ‡‡
	69142	5.8 ‡‡
	722120	3.6 ‡‡
	845560	3.6 ‡‡

‡‡ 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)
T7ALRLC-Comp (<2mm, 1.4g/cc)	0.0784	1.3933	4.76	50.56	1.97	21.34
UTPQA-2 (<2mm, 1.4g/cc)	0.0641	1.4448	4.12	47.26	1.18	13.93
UTPQA-3 (<2mm, 1.4g/cc)	0.0650	1.4700	4.39	49.37	1.83	20.91
LTPQA-4 (<2mm, 1.4g/cc)	0.0610	1.4543	4.31	49.19	1.99	23.37

--- = 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 (%)
T7ALRLC-Comp (<2mm, 1.4g/cc)	NA	NA	2.6	3.6	1.40	1.44	47.1
UTPQA-2 (<2mm, 1.4g/cc)	NA	NA	9.0	12.6	1.40	1.53	47.1
UTPQA-3 (<2mm, 1.4g/cc)	NA	NA	8.2	11.6	1.40	1.52	47.0
LTPQA-4 (<2mm, 1.4g/cc)	NA	NA	7.4	10.3	1.40	1.51	47.0

NA = Not analyzed

--- = This sample was not remolded

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

Job Name:	Golder Associates, Inc.
Job Number:	NM16.0055.00
Sample Number:	T7ALRLC-Comp (<2mm, 1.4g/cc)
Date Sampled:	5/18/2013
Project:	USNR, 1303098

	As Received	Remolded
Test Date:	NA	10-Mar-16
Field weight of sample* (g):		453.11
Tare weight, ring (g):		133.37
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		311.66
Sample volume (cm^3):		222.50
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		2.6
Volumetric Moisture Content (% vol):		3.6
Dry bulk density (g/cm^3):		1.40
Wet bulk density (g/cm^3):		1.44
Calculated Porosity (% vol):		47.1
Percent Saturation:		7.7

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:	Golder Associates, Inc.
Job Number:	NM16.0055.00
Sample Number:	UTPQA-2 (<2mm, 1.4g/cc)
Date Sampled:	5/28/2015
Project:	USNR, 1303098

	As Received	Remolded
Test Date:	NA	10-Mar-16
Field weight of sample* (g):		468.48
Tare weight, ring (g):		125.40
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		314.72
Sample volume (cm^3):		224.31
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		9.0
Volumetric Moisture Content (% vol):		12.6
Dry bulk density (g/cm^3):		1.40
Wet bulk density (g/cm^3):		1.53
Calculated Porosity (% vol):		47.1
Percent Saturation:		26.9

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: Golder Associates, Inc.
Job Number: NM16.0055.00
Sample Number: UTPQA-3 (<2mm, 1.4g/cc)
Date Sampled: 5/28/2015
Project: USNR, 1303098

	As Received	Remolded
Test Date:	NA	10-Mar-16
Field weight of sample* (g):		468.35
Tare weight, ring (g):		126.74
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		315.62
Sample volume (cm^3):		224.72
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		8.2
Volumetric Moisture Content (% vol):		11.6
Dry bulk density (g/cm^3):		1.40
Wet bulk density (g/cm^3):		1.52
Calculated Porosity (% vol):		47.0
Percent Saturation:		24.6

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

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

Job Name:	Golder Associates, Inc.
Job Number:	NM16.0055.00
Sample Number:	LTPQA-4 (<2mm, 1.4g/cc)
Date Sampled:	5/28/2015
Project:	USNR, 1303098

	As Received	Remolded
Test Date:	NA	10-Mar-16
Field weight of sample* (g):		467.21
Tare weight, ring (g):		127.87
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		316.08
Sample volume (cm^3):		225.21
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		7.4
Volumetric Moisture Content (% vol):		10.3
Dry bulk density (g/cm^3):		1.40
Wet bulk density (g/cm^3):		1.51
Calculated Porosity (% vol):		47.0
Percent Saturation:		22.0

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

Comments:

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

Saturated Hydraulic Conductivity

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis: Constant Head	Method of Analysis: Falling Head
T7ALRLC-Comp (<2mm, 1.4g/cc)	2.6E-02	7.2E-03	X	
UTPQA-2 (<2mm, 1.4g/cc)	8.9E-02	1.6E-02	X	
UTPQA-3 (<2mm, 1.4g/cc)	7.0E-02	2.0E-02	X	
LTPQA-4 (<2mm, 1.4g/cc)	3.2E-02	1.0E-02	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:	Golder Associates, Inc.	*Type of water used:*	TAP
Job Number:	NM16.0055.00	*Collection vessel tare* (g)*:*	10.99
Sample Number:	T7ALRLC-Comp (<2mm, 1.4g/cc)	*Sample length* (cm)*:*	7.59
Date Sampled:	5/18/2013	*Sample diameter* (cm)*:*	6.11
Project:	USNR, 1303098	*Sample x-sectional area* (cm^2)*:*	29.31

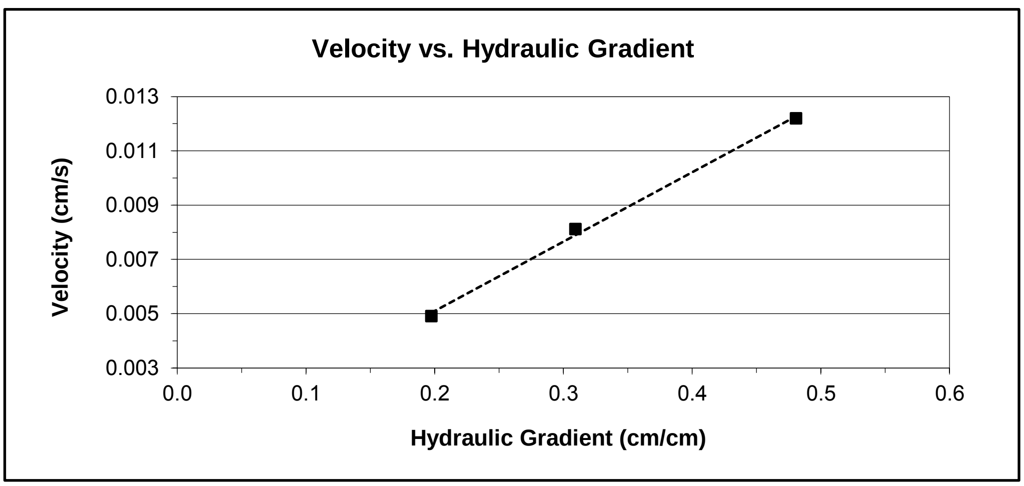
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
11-Mar-16	9:09:30	19.5	3.65	21.71	10.7	30	2.5E-02	2.6E-02
11-Mar-16	9:10:00							
Test # 2:								
11-Mar-16	9:31:00	19.5	2.35	18.12	7.1	30	2.6E-02	2.7E-02
11-Mar-16	9:31:30							
Test # 3:								
11-Mar-16	9:41:00	19.5	1.5	15.30	4.3	30	2.5E-02	2.5E-02
11-Mar-16	9:41:30							

***Average Ksat* (cm/sec):** **2.6E-02**

***Oversize Corrected Ksat* (cm/sec):** **7.2E-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: Golder Associates, Inc.
Job Number: NM16.0055.00
Sample Number: T7ALRLC-Comp (<2mm, 1.4g/cc)
Date Sampled: 5/18/2013
Project: USNR, 1303098

Split (3/4", 3/8", #4): #10
Calculated Porosity of Fines (% vol): 47.1

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	8137.70	3142.11	11279.81
Bulk Density (g/cm^3):	2.65	1.40	2.12
Volume of Solids (cm^3):	3070.83	1185.70	4256.53
Volume of Voids (cm^3):	0.00	1057.51	1057.51
Total Volume (cm^3):	3070.83	2243.21	5314.04
Volumetric Fraction (%):	57.79	42.21	100.00
Mass Fraction (%):	72.14	27.86	100.00
Ksat (cm/sec):	NM	2.6E-02	7.2E-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:	Golder Associates, Inc.	*Type of water used:*	TAP
Job Number:	NM16.0055.00	*Collection vessel tare* (g)*:*	10.97
Sample Number:	UTPQA-2 (<2mm, 1.4g/cc)	*Sample length* (cm)*:*	7.60
Date Sampled:	5/28/2015	*Sample diameter* (cm)*:*	6.13
Project:	USNR, 1303098	*Sample x-sectional area* (cm^2)*:*	29.50

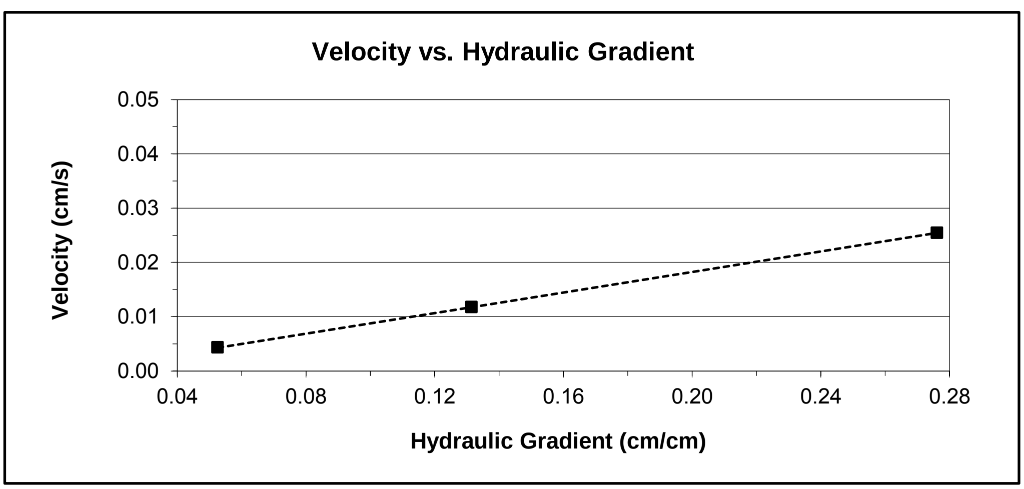
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
11-Mar-16	9:21:00	19.5	2.1	33.48	22.5	30	9.2E-02	9.3E-02
11-Mar-16	9:21:30							
Test # 2:								
11-Mar-16	9:32:00	19.5	1	21.34	10.4	30	8.9E-02	9.0E-02
11-Mar-16	9:32:30							
Test # 3:								
11-Mar-16	9:42:00	19.5	0.4	14.78	3.8	30	8.2E-02	8.3E-02
11-Mar-16	9:42:30							

***Average Ksat* (cm/sec): 8.9E-02**

***Oversize Corrected Ksat* (cm/sec): 1.6E-02**

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:	Golder Associates, Inc.
Job Number:	NM16.0055.00
Sample Number:	UTPQA-2 (<2mm, 1.4g/cc)
Date Sampled:	5/28/2015
Project:	USNR, 1303098
Split (3/4", 3/8", #4):	#10
Calculated Porosity of Fines (% vol):	47.1

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	4912.19	1087.57	5999.76
Bulk Density (g/cm^3):	2.65	1.40	2.28
Volume of Solids (cm^3):	1853.66	410.40	2264.06
Volume of Voids (cm^3):	0.00	364.75	364.75
Total Volume (cm^3):	1853.66	775.15	2628.81
Volumetric Fraction (%):	70.51	29.49	100.00
Mass Fraction (%):	81.87	18.13	100.00
Ksat (cm/sec):	NM	8.9E-02	1.6E-02

* = 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

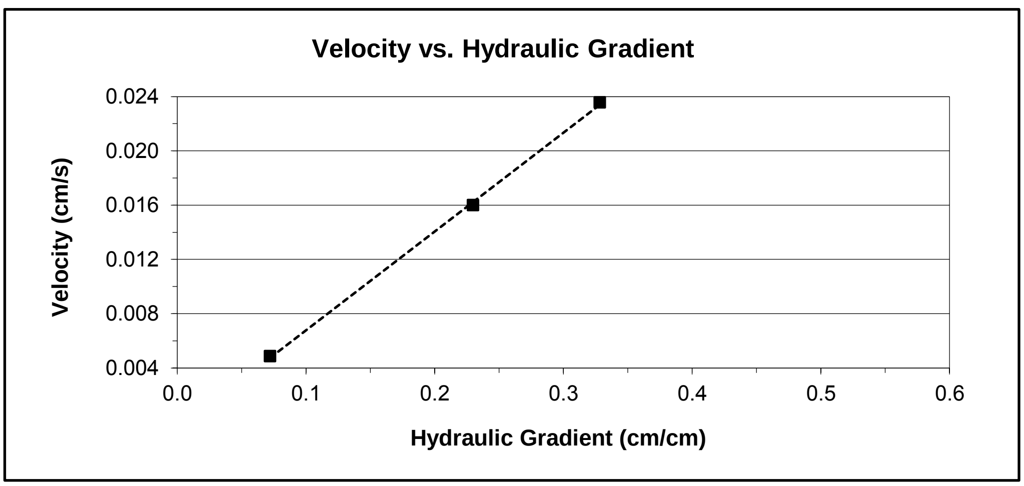
Job Name: Golder Associates, Inc.
Job Number: NM16.0055.00
Sample Number: UTPQA-3 (<2mm, 1.4g/cc)
Date Sampled: 5/28/2015
Project: USNR, 1303098

Type of water used: TAP
Collection vessel tare (g)*:* 11.00
Sample length (cm)*:* 7.61
Sample diameter (cm)*:* 6.13
Sample x-sectional area (cm^2)*:* 29.52

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:								
11-Mar-16	9:22:00	19.5	2.5	31.87	20.9	30	7.2E-02	7.3E-02
11-Mar-16	9:22:30							
Test # 2:								
11-Mar-16	9:33:00	19.5	1.75	25.15	14.2	30	6.9E-02	7.1E-02
11-Mar-16	9:33:30							
Test # 3:								
11-Mar-16	9:43:00	19.5	0.55	15.30	4.3	30	6.7E-02	6.8E-02
11-Mar-16	9:43:30							

***Average Ksat* (cm/sec):** **7.0E-02**
***Oversize Corrected Ksat* (cm/sec):** **2.0E-02**

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: Golder Associates, Inc.
Job Number: NM16.0055.00
Sample Number: UTPQA-3 (<2mm, 1.4g/cc)
Date Sampled: 5/28/2015
Project: USNR, 1303098

Split (3/4", 3/8", #4): #10
Calculated Porosity of Fines (% vol)*:* 47.0

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g)*:*	4561.39	1776.38	6337.77
Bulk Density (g/cm^3)*:*	2.65	1.40	2.12
Volume of Solids (cm^3)*:*	1721.28	670.33	2391.61
Volume of Voids (cm^3)*:*	0.00	594.47	594.47
Total Volume (cm^3)*:*	1721.28	1264.80	2986.08
Volumetric Fraction (%)*:*	57.64	42.36	100.00
Mass Fraction (%)*:*	71.97	28.03	100.00
Ksat (cm/sec)*:*	NM	7.0E-02	2.0E-02

* = 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:	Golder Associates, Inc.	*Type of water used:*	TAP
Job Number:	NM16.0055.00	*Collection vessel tare* (g)*:*	11.04
Sample Number:	LTPQA-4 (<2mm, 1.4g/cc)	*Sample length* (cm)*:*	7.62
Date Sampled:	5/28/2015	*Sample diameter* (cm)*:*	6.14
Project:	USNR, 1303098	*Sample x-sectional area* (cm^2)*:*	29.57

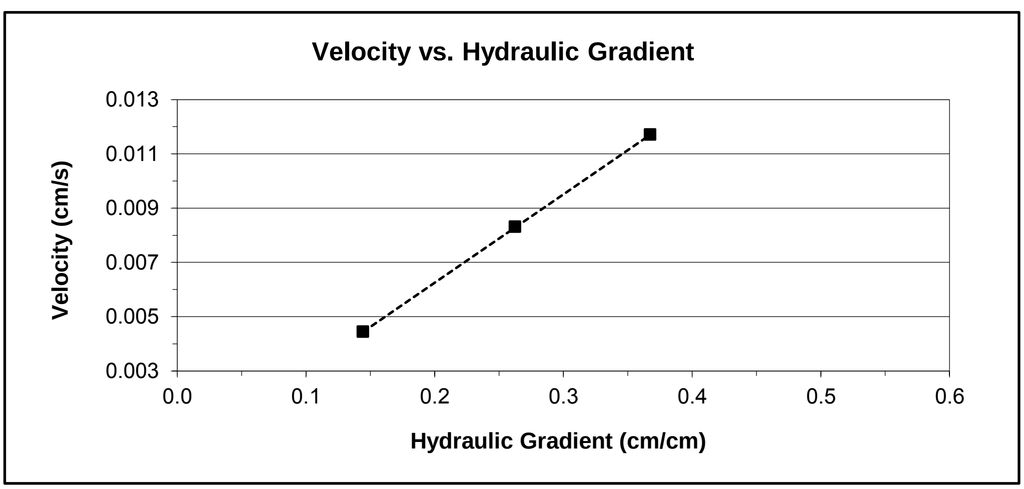
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
11-Mar-16	9:23:00	19.5	2.8	21.42	10.4	30	3.2E-02	3.2E-02
11-Mar-16	9:23:30							
Test # 2:								
11-Mar-16	9:34:00	19.5	2	18.41	7.4	30	3.2E-02	3.2E-02
11-Mar-16	9:34:30							
Test # 3:								
11-Mar-16	9:44:00	19.5	1.1	14.98	3.9	30	3.1E-02	3.1E-02
11-Mar-16	9:44:30							

***Average Ksat* (cm/sec): 3.2E-02**

***Oversize Corrected Ksat* (cm/sec): 1.0E-02**

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: Golder Associates, Inc.
Job Number: NM16.0055.00
Sample Number: LTPQA-4 (<2mm, 1.4g/cc)
Date Sampled: 5/28/2015
Project: USNR, 1303098

Split (3/4", 3/8", #4): #10
Calculated Porosity of Fines (% vol): 47.0

	Coarse Fraction*	Fines Fraction	Composite
Subsample Mass (g):	5018.47	2406.12	7424.59
Bulk Density (g/cm^3):	2.65	1.40	2.06
Volume of Solids (cm^3):	1893.76	907.97	2801.73
Volume of Voids (cm^3):	0.00	806.41	806.41
Total Volume (cm^3):	1893.76	1714.38	3608.15
Volumetric Fraction (%):	52.49	47.51	100.00
Mass Fraction (%):	67.59	32.41	100.00
Ksat (cm/sec):	NM	3.2E-02	1.0E-02

* = 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

Moisture Retention Characteristics

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
T7ALRLC-Comp (<2mm, 1.4g/cc)	0	48.9
	4	48.5 ‡‡
	11	48.0 ‡‡
	28	31.8 ‡‡
	157	21.5 ‡‡
	816	14.2 ‡‡
	2550	12.0 ‡‡
	36815	7.2 ‡‡
	214872	5.1 ‡‡
	845560	4.3 ‡‡
UTPQA-2 (<2mm, 1.4g/cc)	0	46.2
	4	46.2
	9	43.4 ‡‡
	32	32.3 ‡‡
	168	18.0 ‡‡
	1836	10.3 ‡‡
	12034	7.4 ‡‡
	43647	5.9 ‡‡
	191314	4.2 ‡‡
	845560	3.3 ‡‡
UTPQA-3 (<2mm, 1.4g/cc)	0	48.7
	4	47.1 ‡‡
	11	45.9 ‡‡
	23	35.0 ‡‡
	161	18.4 ‡‡
	612	12.6 ‡‡
	3977	9.5 ‡‡
	57211	5.7 ‡‡
	219155	4.5 ‡‡
	845560	3.4 ‡‡

‡‡ 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)
LTPQA-4 (<2mm, 1.4g/cc)	0	47.8
	4	47.6 ‡‡
	12	46.6 ‡‡
	26	33.5 ‡‡
	157	19.8 ‡‡
	918	12.3 ‡‡
	10504	8.3 ‡‡
	69142	5.8 ‡‡
	722120	3.6 ‡‡
	845560	3.6 ‡‡

‡‡ 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)
T7ALRLC-Comp (<2mm, 1.4g/cc)	0.0784	1.3933	4.76	50.56	1.97	21.34
UTPQA-2 (<2mm, 1.4g/cc)	0.0641	1.4448	4.12	47.26	1.18	13.93
UTPQA-3 (<2mm, 1.4g/cc)	0.0650	1.4700	4.39	49.37	1.83	20.91
LTPQA-4 (<2mm, 1.4g/cc)	0.0610	1.4543	4.31	49.19	1.99	23.37

--- = 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:	Golder Associates, Inc.	*Dry wt. of sample* (g):	311.66
Job Number:	NM16.0055.00	*Tare wt., ring* (g):	133.37
Sample Number:	T7ALRLC-Comp (<2mm, 1.4g/cc)	*Tare wt., screen & clamp* (g):	27.44
Date Sampled:	5/18/2013	*Initial sample volume* (cm^3):	222.50
Project:	USNR, 1303098	*Initial dry bulk density* (g/cm^3):	1.40
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	47.14

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	11-Mar-16	12:05	581.35	0	48.93	
	18-Mar-16	10:05	578.60	4.0	48.50	‡‡
	25-Mar-16	12:10	576.20	11.0	48.02	‡‡
	1-Apr-16	16:00	541.10	28.0	31.77	‡‡
	8-Apr-16	9:30	519.00	157.0	21.54	‡‡

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	---	---	---	---
	4.0	218.84	-1.65%	1.42	46.26
	11.0	216.02	-2.91%	1.44	45.56
	28.0	216.02	-2.91%	1.44	45.56
	157.0	216.02	-2.91%	1.44	45.56

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: T7ALRLC-Comp (<2mm, 1.4g/cc)

Initial sample bulk density (g/cm^3)*:* 1.40

Dry weight of dew point potentiometer sample* (g)*:* 170.62

Tare weight, jar (g)*:* 115.79

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content (% vol)	
Dew point potentiometer:	29-Mar-16	10:50	176.03	816	14.24	‡‡
	24-Mar-16	9:10	175.19	2550	12.02	‡‡
	21-Mar-16	10:20	173.37	36815	7.24	‡‡
	17-Mar-16	8:15	172.56	214872	5.10	‡‡

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:	816	216.02	-2.91%	1.44	45.56
	2550	216.02	-2.91%	1.44	45.56
	36815	216.02	-2.91%	1.44	45.56
	214872	216.02	-2.91%	1.44	45.56

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

‡‡ Volume adjustments are applicable at this matric potential (see comment #1).

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: T7ALRLC-Comp (<2mm, 1.4g/cc)

Initial sample bulk density (g/cm^3)*:* 1.40

Dry weight of relative humidity box sample* (g)*:* 79.16

Tare weight (g)*:* 38.82

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content (% vol)	
Relative humidity box:	15-Mar-16	10:40	80.37	845560	4.33	‡

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:	845560	216.02	-2.91%	1.44	45.56

Comments:

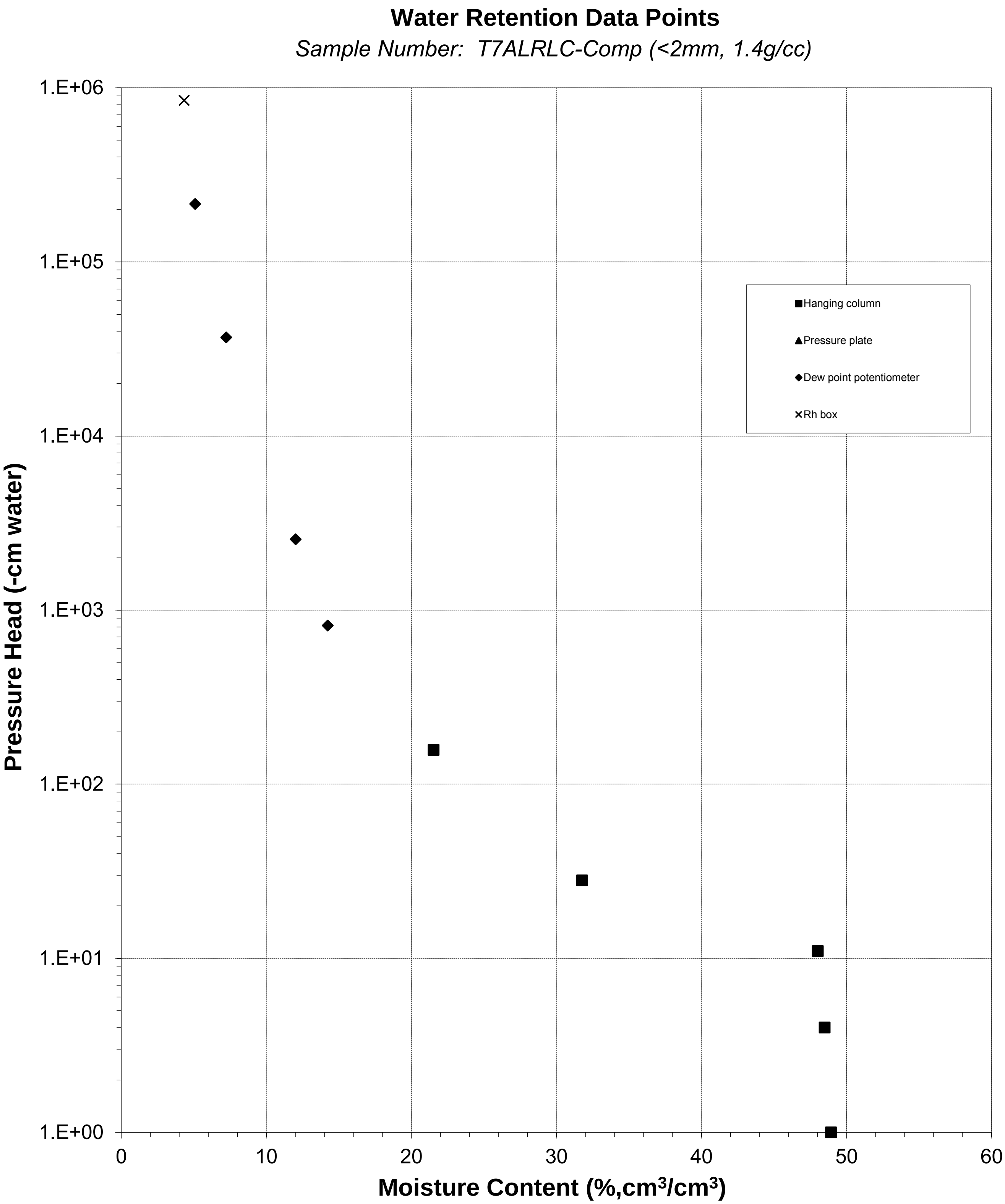
1 Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

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

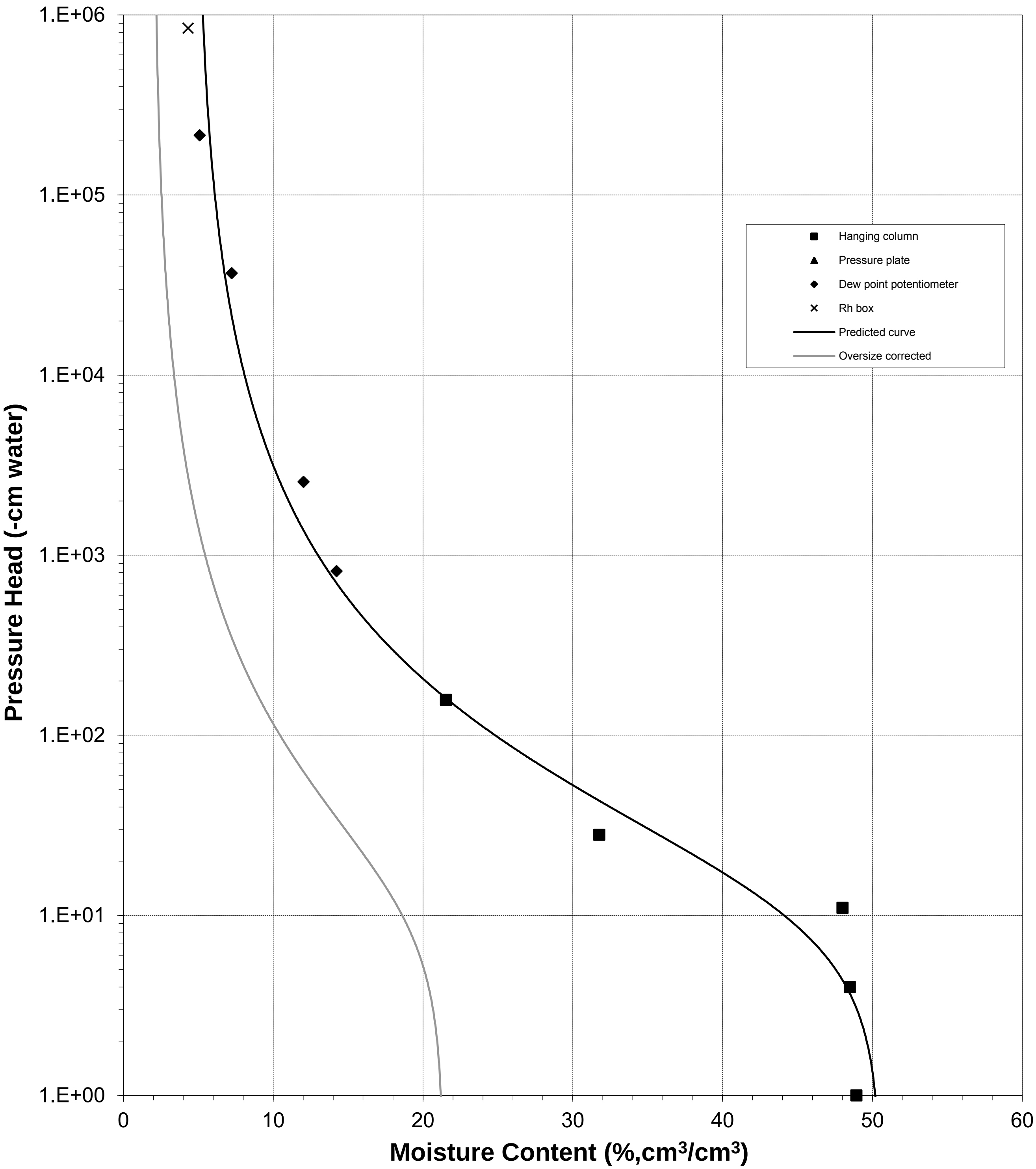
‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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


Water Retention Data Points
Sample Number: T7ALRLC-Comp (<2mm, 1.4g/cc)
Pressure Head (-cm water)
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
0
10
20
30
40
50
60
Moisture Content (%,cm³/cm³)
Hanging column
Pressure plate
Dew point potentiometer
Rh box

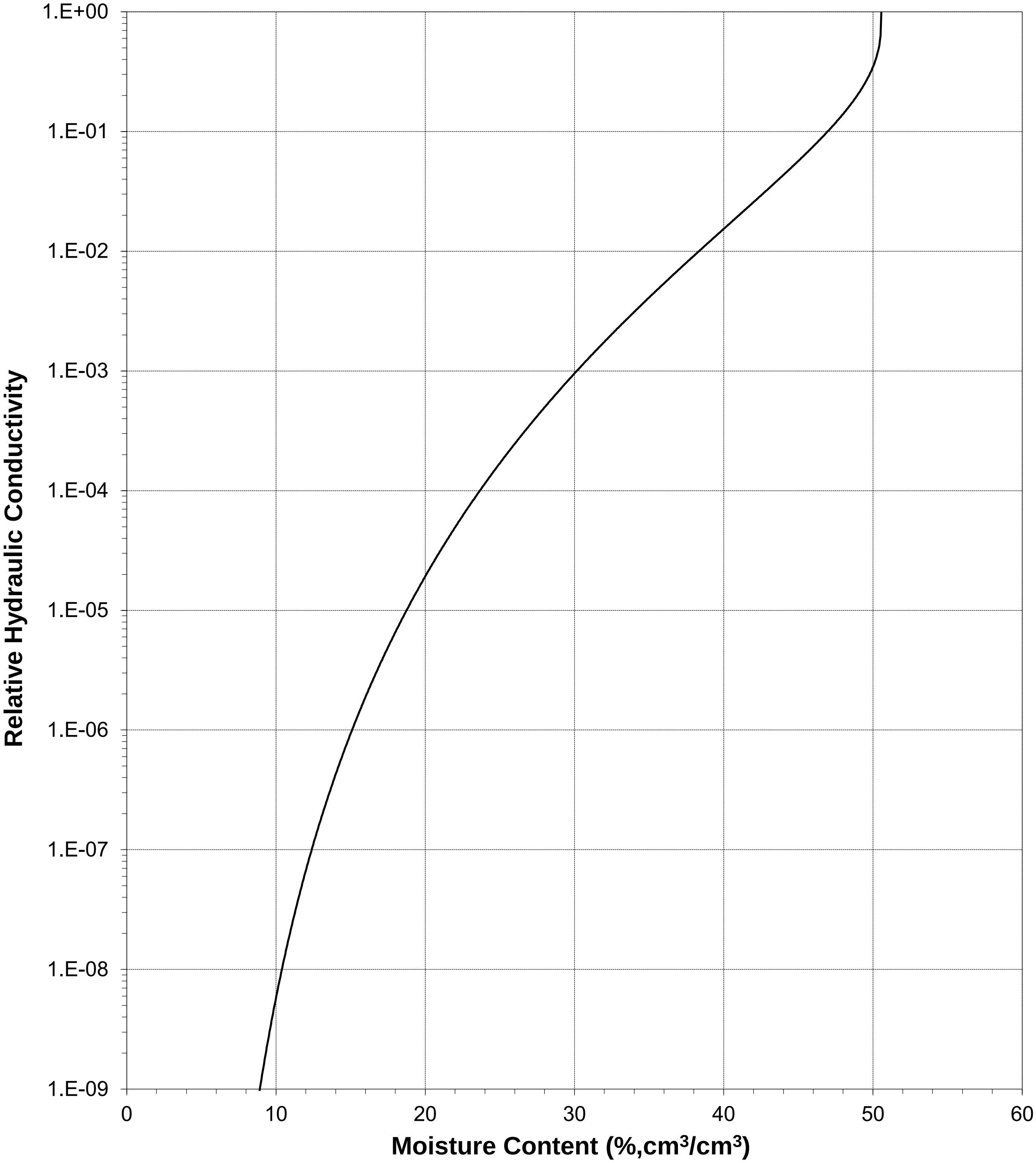
Predicted Water Retention Curve and Data Points

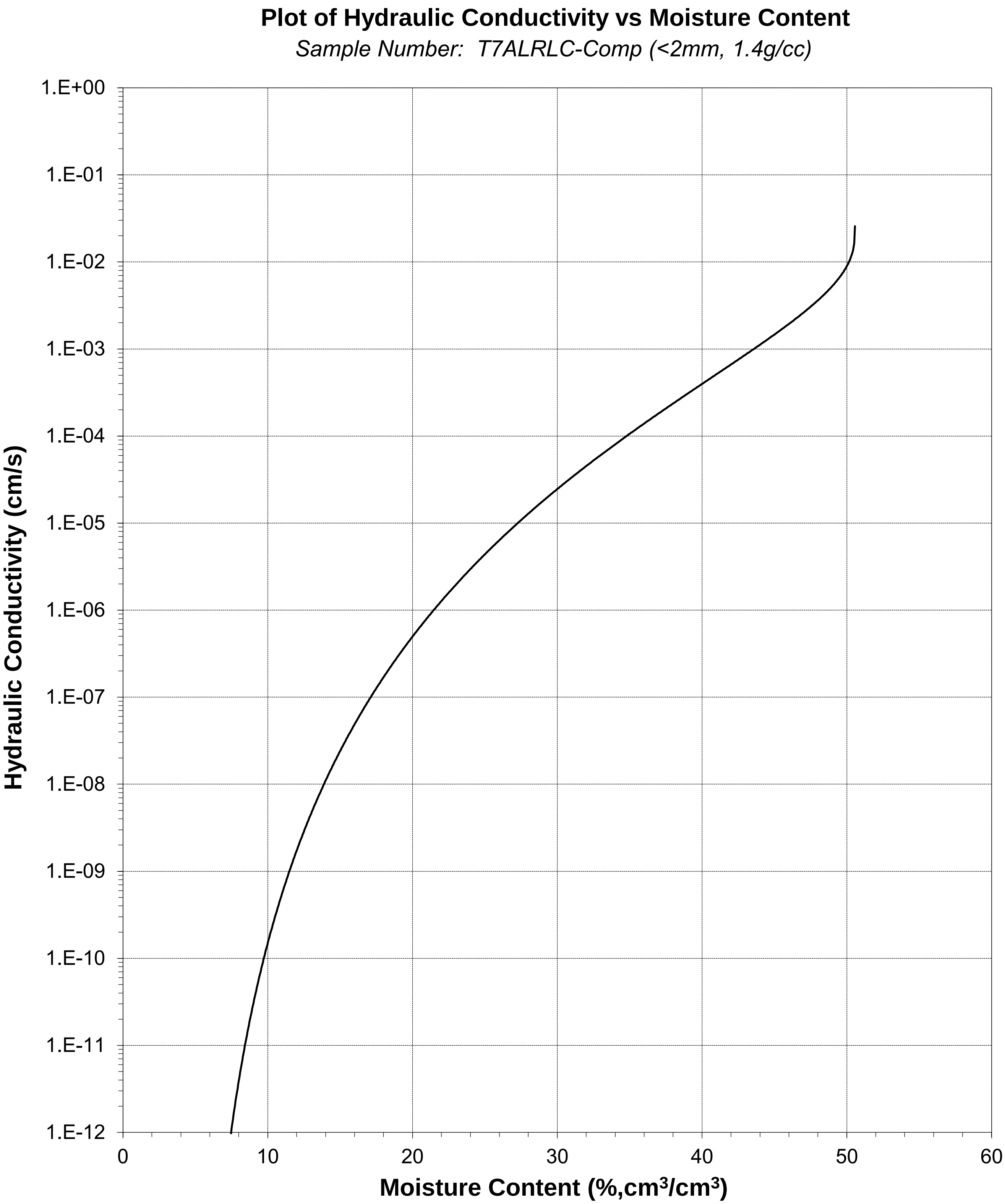
Sample Number: T7ALRLC-Comp (<2mm, 1.4g/cc)



Plot of Relative Hydraulic Conductivity vs Moisture Content

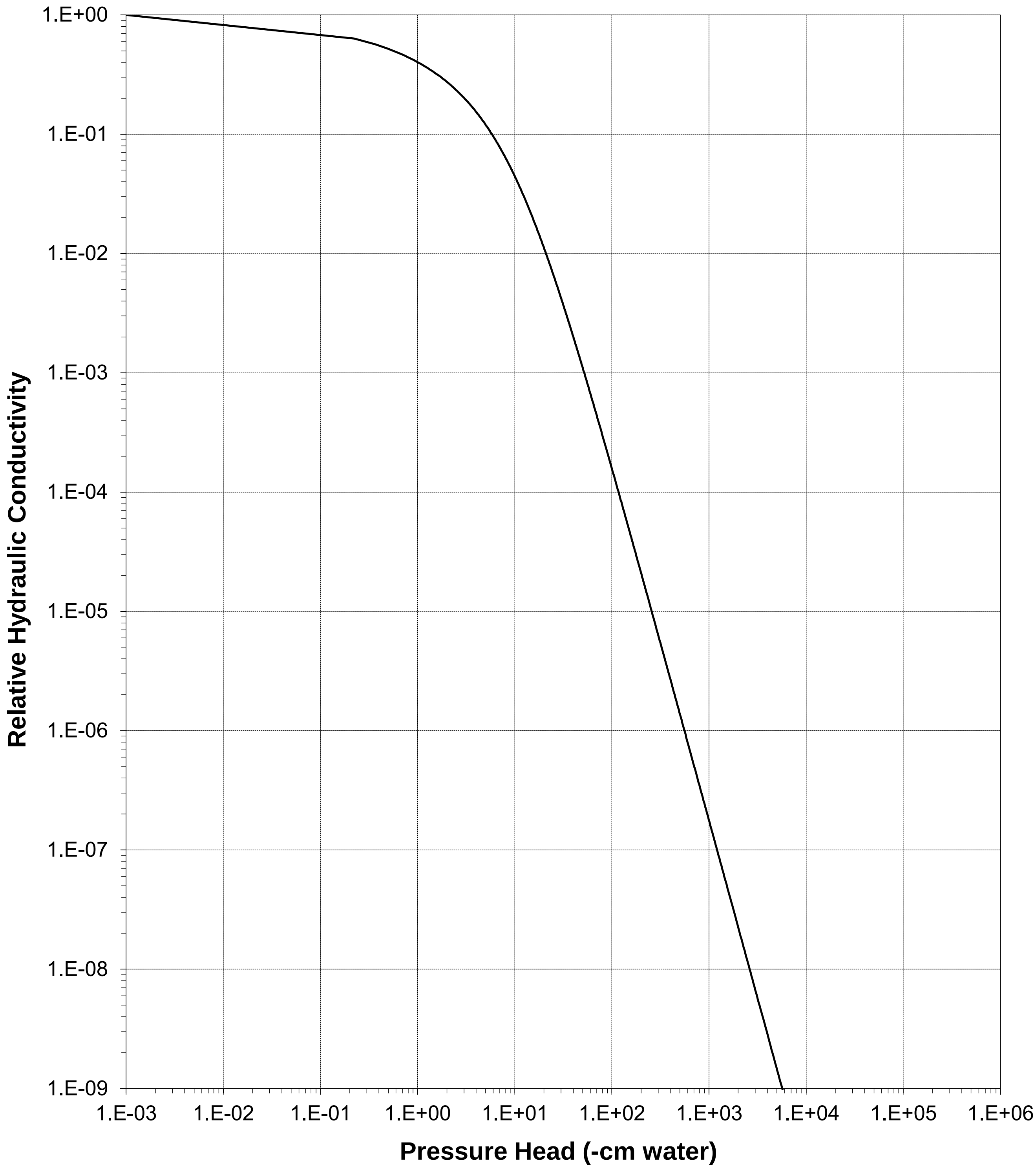
Sample Number: T7ALRLC-Comp (<2mm, 1.4g/cc)

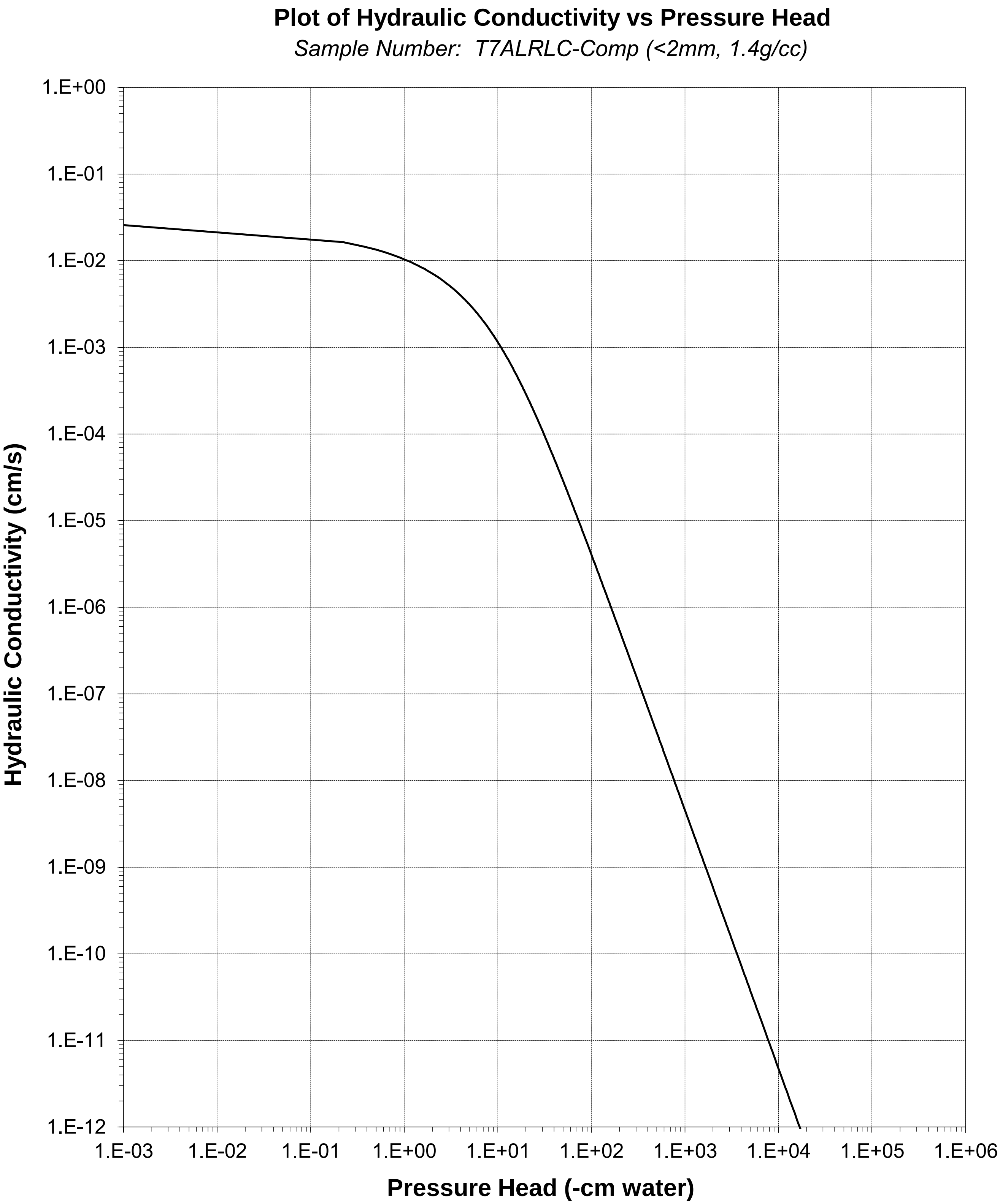



Plot of Hydraulic Conductivity vs Moisture Content
Sample Number: T7ALRLC-Comp (<2mm, 1.4g/cc)
Hydraulic Conductivity (cm/s)
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
0
10
20
30
40
50
60
Moisture Content (%,cm³/cm³)

Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: T7ALRLC-Comp (<2mm, 1.4g/cc)




Plot of Hydraulic Conductivity vs Pressure Head
Sample Number: T7ALRLC-Comp (<2mm, 1.4g/cc)
Hydraulic Conductivity (cm/s)
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-10
1.E-11
1.E-12
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)

Oversize Correction Data Sheet

Job Name: Golder Associates, Inc.
Job Number: NM16.0055.00
Sample Number: T7ALRLC-Comp (<2mm, 1.4g/cc)
Date Sampled: 5/18/2013
Project: USNR, 1303098

Split (3/4", 3/8", #4): #10

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	8137.70	3142.11	11279.81
Mass Fraction (%):	72.14	27.86	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.40	2.12
Calculated Porosity (% vol):	0.00	47.14	19.90
Volume of Solids (cm^3):	3070.83	1185.70	4256.53
Volume of Voids (cm^3):	0.00	1057.51	1057.51
Total Volume (cm^3):	3070.83	2243.21	5314.04
Volumetric Fraction (%):	57.79	42.21	100.00
Initial Moisture Content (% vol):	0.00	3.63	1.53
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.40	2.12
Calculated Porosity (% vol):	0.00	47.14	19.90
Volume of Solids (cm^3):	3070.83	1185.70	4256.53
Volume of Voids (cm^3):	0.00	1057.51	1057.51
Total Volume (cm^3):	3070.83	2243.21	5314.04
Volumetric Fraction (%):	57.79	42.21	100.00
Saturated Moisture Content (% vol):	0.00	50.56	21.34
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.44	2.15
Calculated Porosity (% vol):	0.00	45.56	18.90
Volume of Solids (cm^3):	3070.83	1185.70	4256.53
Volume of Voids (cm^3):	0.00	992.20	992.20
Total Volume (cm^3):	3070.83	2177.90	5248.73
Volumetric Fraction (%):	58.51	41.49	100.00
Residual Moisture Content (% vol):	0.00	4.76	1.97
Ksat (cm/sec):	NM	2.6E-02	7.2E-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:	Golder Associates, Inc.	*Dry wt. of sample* (g):	314.72
Job Number:	NM16.0055.00	*Tare wt., ring* (g):	125.40
Sample Number:	UTPQA-2 (<2mm, 1.4g/cc)	*Tare wt., screen & clamp* (g):	27.89
Date Sampled:	5/28/2015	*Initial sample volume* (cm^3):	224.31
Project:	USNR, 1303098	*Initial dry bulk density* (g/cm^3):	1.40
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	47.06

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	11-Mar-16	12:12	571.74	0	46.24	
	18-Mar-16	10:10	571.70	4.0	46.23	
	25-Mar-16	12:12	563.10	8.5	43.42	‡
	1-Apr-16	16:05	538.30	31.5	32.34	‡
	8-Apr-16	9:33	506.90	168.0	18.00	‡

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	---	---	---	---
	4.0	---	---	---	---
	8.5	219.00	-2.37%	1.44	45.77
	31.5	217.38	-3.09%	1.45	45.37
	168.0	216.11	-3.66%	1.46	45.05

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: UTPQA-2 (<2mm, 1.4g/cc)

Initial sample bulk density (g/cm^3)*:* 1.40

Dry weight of dew point potentiometer sample* (g)*:* 162.72

Tare weight, jar (g)*:* 113.19

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content (% vol)	
Dew point potentiometer:	24-Mar-16	9:17	166.22	1836	10.29	‡‡
	22-Mar-16	12:40	165.24	12034	7.41	‡‡
	21-Mar-16	10:30	164.72	43647	5.88	‡‡
	17-Mar-16	8:21	164.16	191314	4.23	‡‡

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:	1836	216.11	-3.66%	1.46	45.05
	12034	216.11	-3.66%	1.46	45.05
	43647	216.11	-3.66%	1.46	45.05
	191314	216.11	-3.66%	1.46	45.05

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

‡‡ Volume adjustments are applicable at this matric potential (see comment #1).

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: UTPQA-2 (<2mm, 1.4g/cc)

Initial sample bulk density (g/cm^3)*:* 1.40

Dry weight of relative humidity box sample* (g)*:* 82.06

Tare weight (g)*:* 47.61

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content (% vol)	
Relative humidity box:	15-Mar-16	10:40	82.83	845560	3.27	‡

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:	845560	216.11	-3.66%	1.46	45.05

Comments:

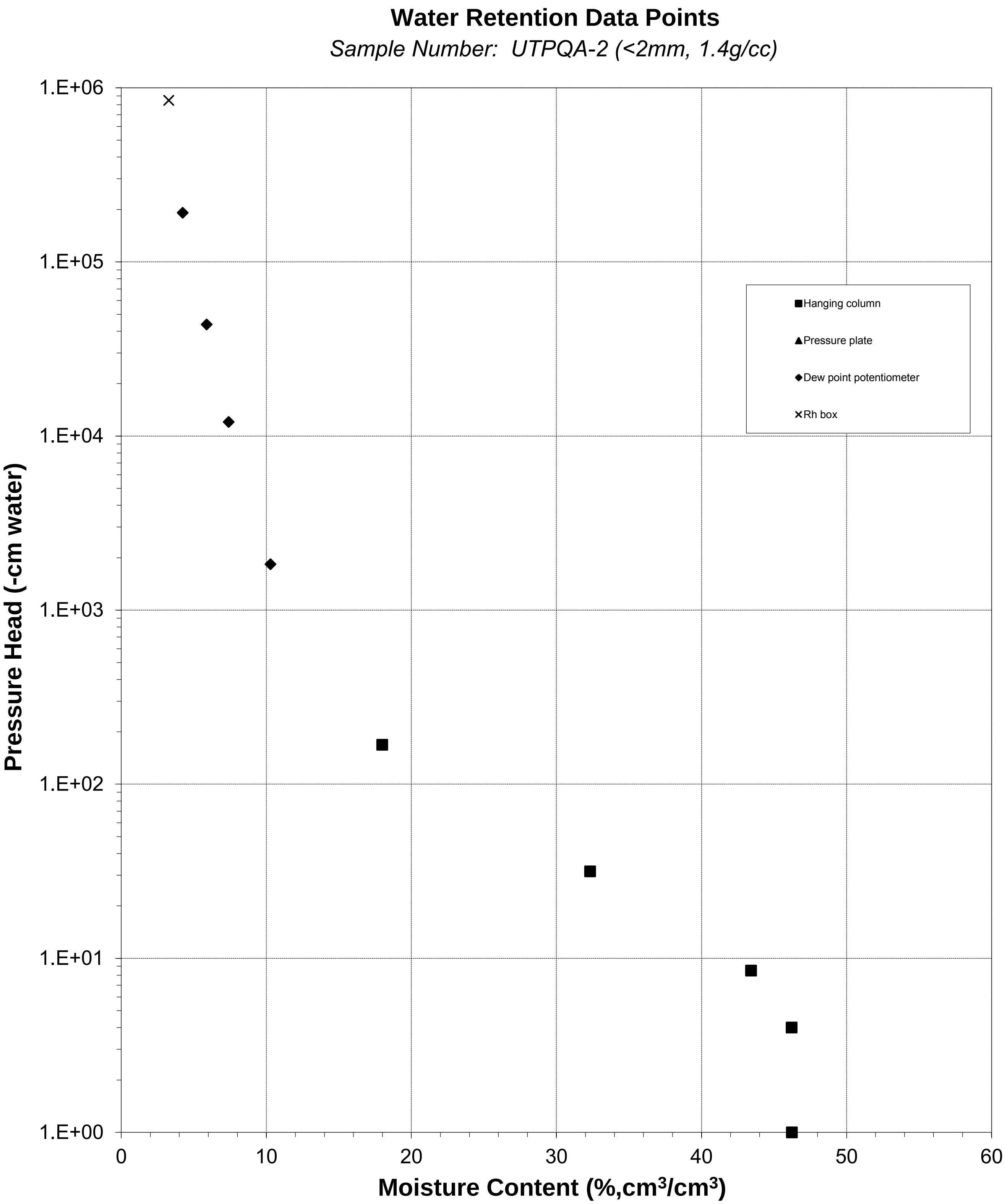
[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[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

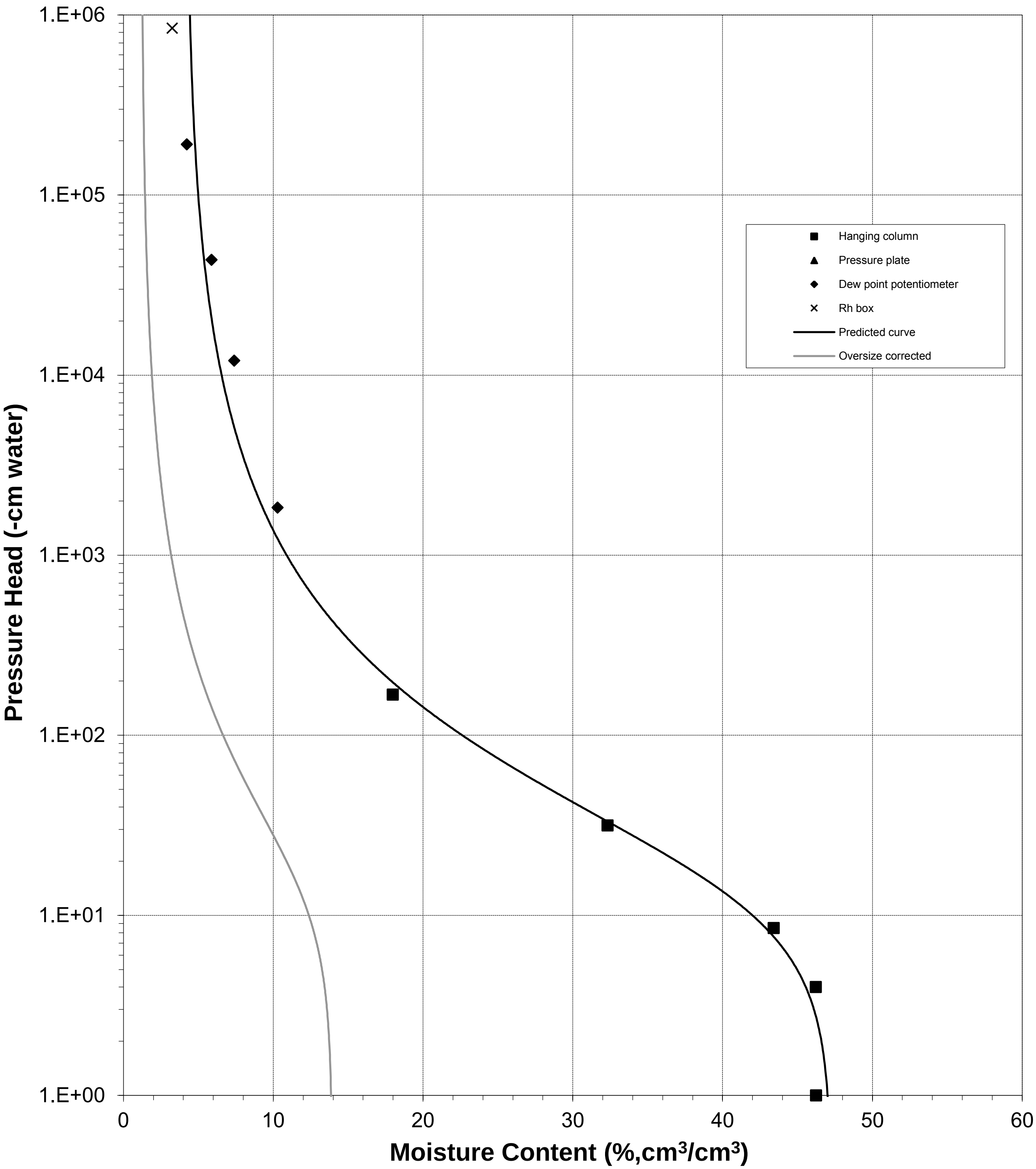
‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

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


Water Retention Data Points
Sample Number: UTPQA-2 (<2mm, 1.4g/cc)
Pressure Head (-cm water)
Moisture Content (%,cm³/cm³)
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
0
10
20
30
40
50
60
Hanging column
Pressure plate
Dew point potentiometer
Rh box

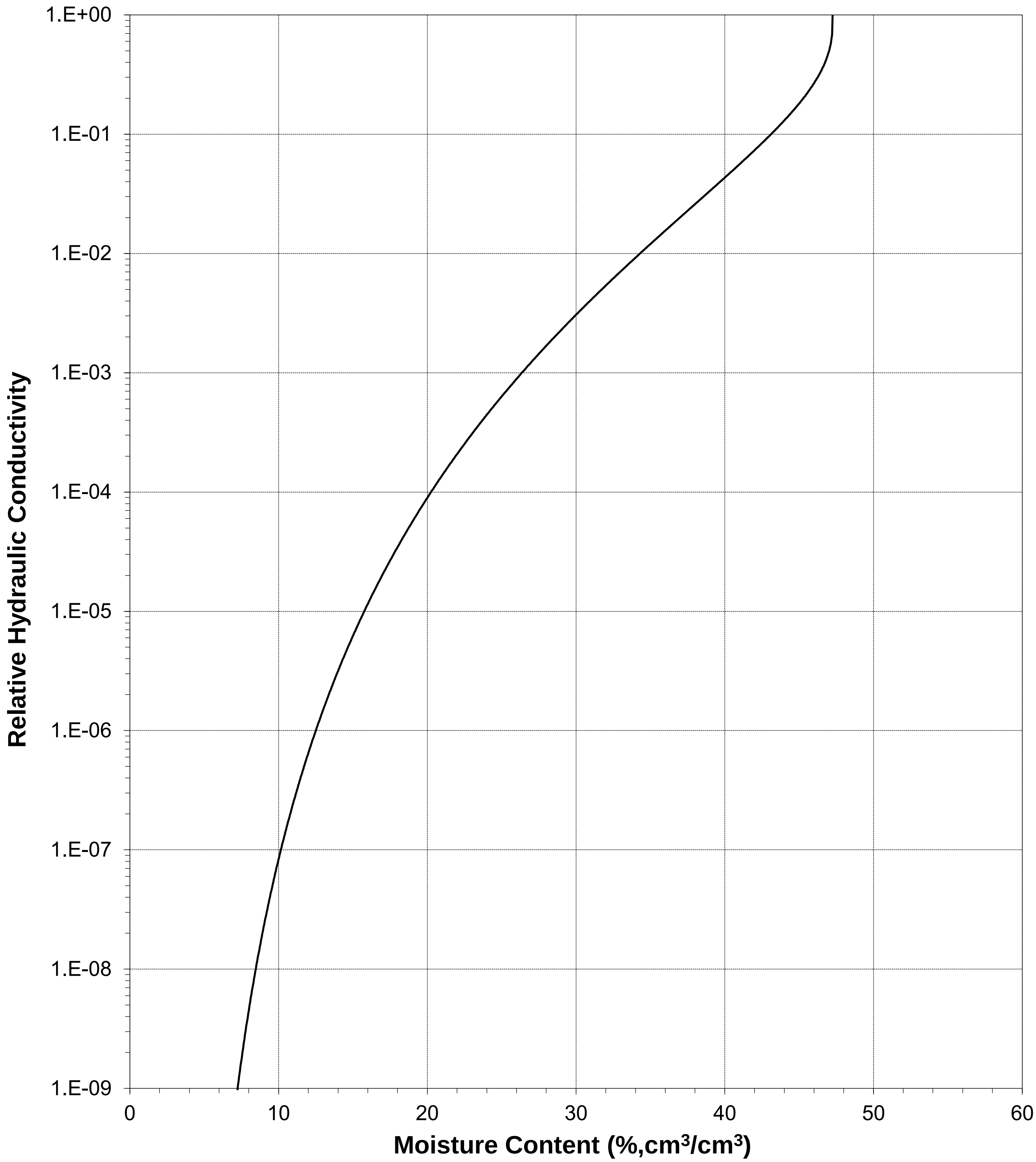
Predicted Water Retention Curve and Data Points

Sample Number: UTPQA-2 (<2mm, 1.4g/cc)



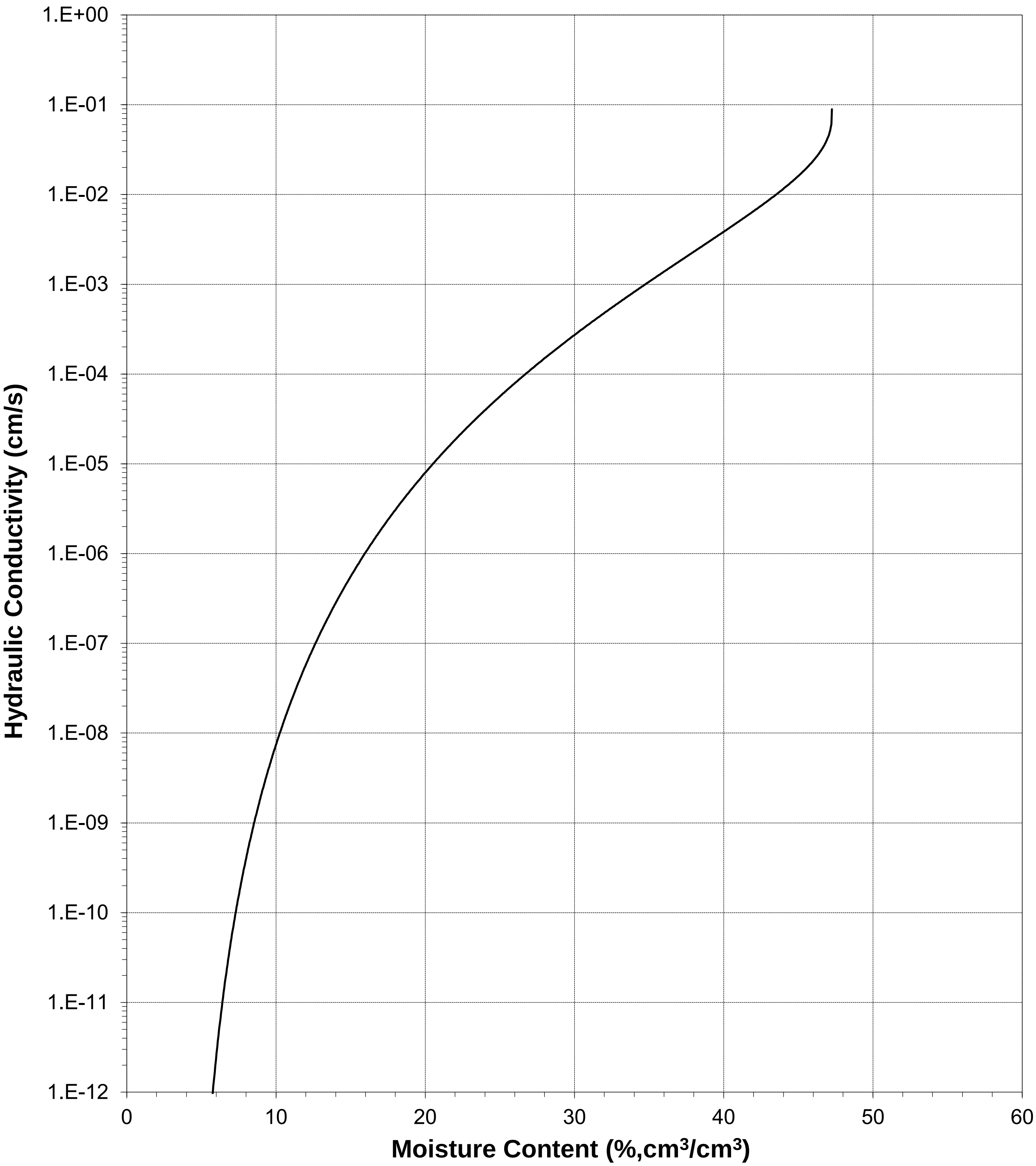
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: UTPQA-2 (<2mm, 1.4g/cc)



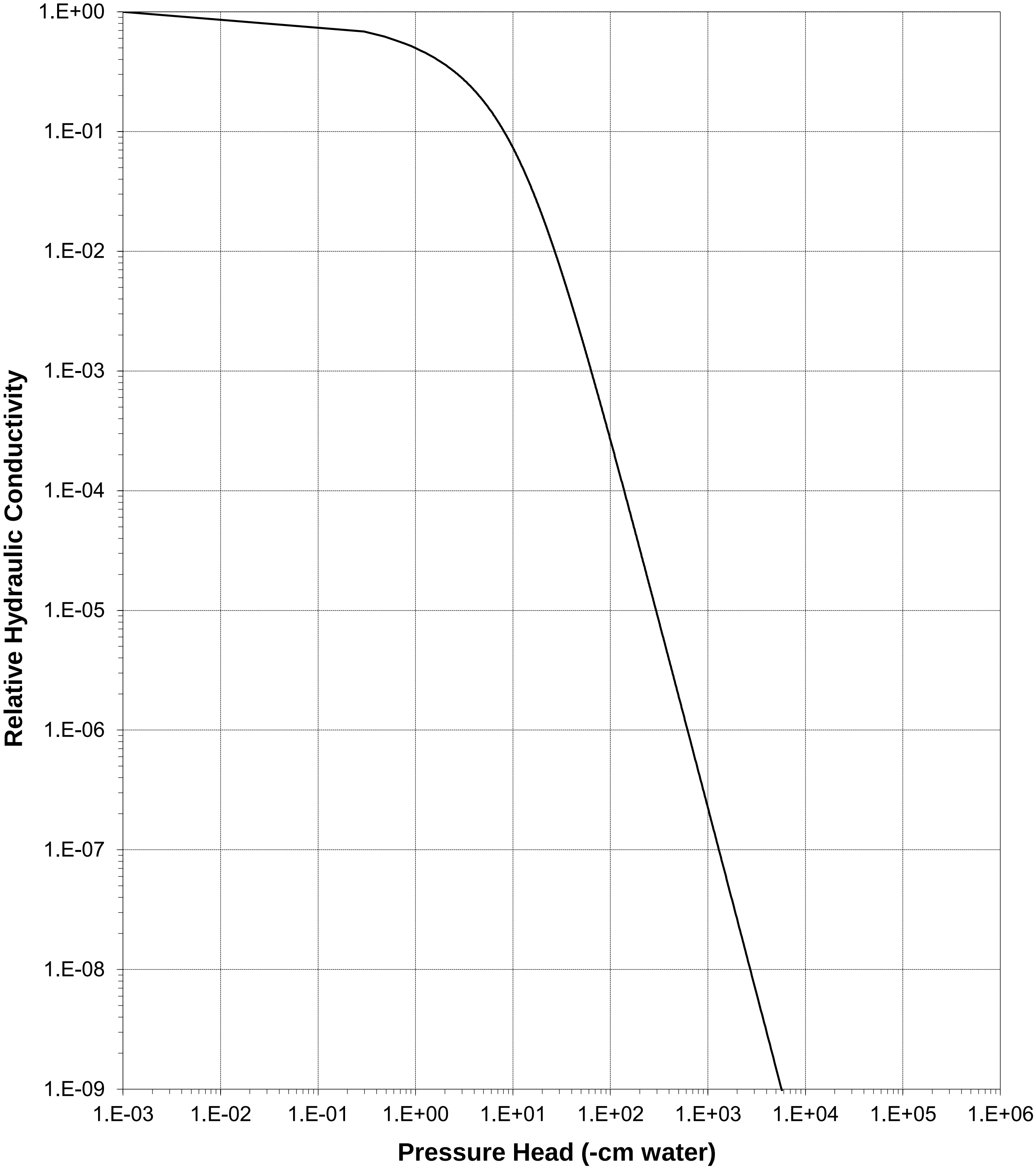
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: UTPQA-2 (<2mm, 1.4g/cc)



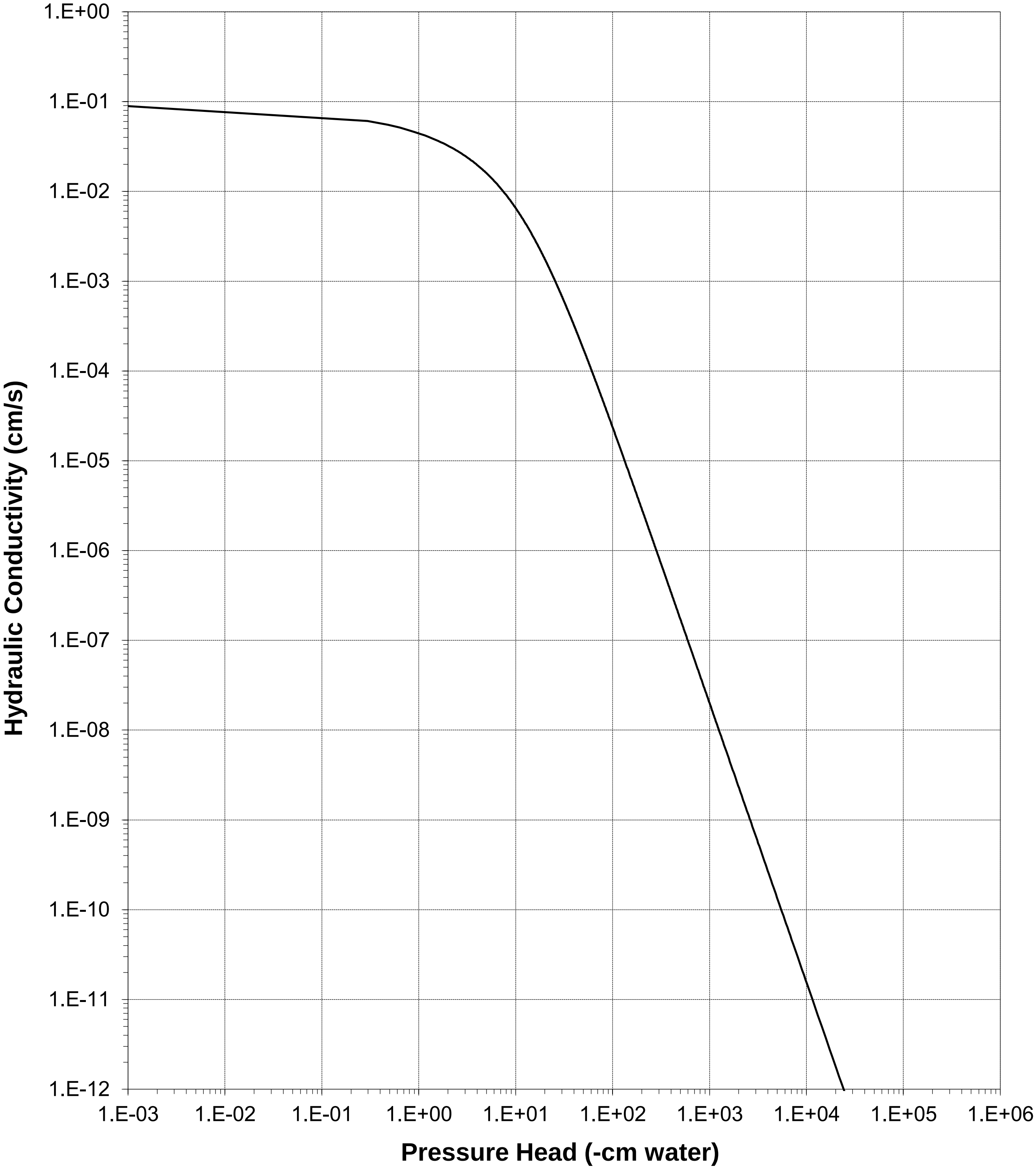
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: UTPQA-2 (<2mm, 1.4g/cc)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: UTPQA-2 (<2mm, 1.4g/cc)



Oversize Correction Data Sheet

Job Name: Golder Associates, Inc.
Job Number: NM16.0055.00
Sample Number: UTPQA-2 (<2mm, 1.4g/cc)
Date Sampled: 5/28/2015
Project: USNR, 1303098

Split (3/4", 3/8", #4): #10

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	4912.19	1087.57	5999.76
Mass Fraction (%):	81.87	18.13	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.40	2.28
Calculated Porosity (% vol):	0.00	47.06	13.88
Volume of Solids (cm^3):	1853.66	410.40	2264.06
Volume of Voids (cm^3):	0.00	364.75	364.75
Total Volume (cm^3):	1853.66	775.15	2628.81
Volumetric Fraction (%):	70.51	29.49	100.00
Initial Moisture Content (% vol):	0.00	12.64	3.73
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.40	2.28
Calculated Porosity (% vol):	0.00	47.06	13.88
Volume of Solids (cm^3):	1853.66	410.40	2264.06
Volume of Voids (cm^3):	0.00	364.75	364.75
Total Volume (cm^3):	1853.66	775.15	2628.81
Volumetric Fraction (%):	70.51	29.49	100.00
Saturated Moisture Content (% vol):	0.00	47.26	13.93
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.46	2.31
Calculated Porosity (% vol):	0.00	45.05	12.94
Volume of Solids (cm^3):	1853.66	410.40	2264.06
Volume of Voids (cm^3):	0.00	336.41	336.41
Total Volume (cm^3):	1853.66	746.81	2600.47
Volumetric Fraction (%):	71.28	28.72	100.00
Residual Moisture Content (% vol):	0.00	4.12	1.18
Ksat (cm/sec):	NM	8.9E-02	1.6E-02

* = 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:	Golder Associates, Inc.	*Dry wt. of sample* (g):	315.62
Job Number:	NM16.0055.00	*Tare wt., ring* (g):	126.74
Sample Number:	UTPQA-3 (<2mm, 1.4g/cc)	*Tare wt., screen & clamp* (g):	28.19
Date Sampled:	5/28/2015	*Initial sample volume* (cm^3):	224.72
Project:	USNR, 1303098	*Initial dry bulk density* (g/cm^3):	1.40
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	47.00

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	11-Mar-16	12:17	579.90	0	48.66	
	18-Mar-16	10:12	575.00	4.0	47.14	‡‡
	25-Mar-16	12:20	570.40	10.5	45.86	‡‡
	1-Apr-16	16:10	546.70	22.5	34.97	‡‡
	8-Apr-16	9:35	510.70	161.0	18.44	‡‡

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	---	---	---	---
	4.0	221.60	-1.39%	1.42	46.25
	10.5	217.73	-3.11%	1.45	45.30
	22.5	217.73	-3.11%	1.45	45.30
	161.0	217.73	-3.11%	1.45	45.30

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: UTPQA-3 (<2mm, 1.4g/cc)

Initial sample bulk density (g/cm^3)*:* 1.40

Dry weight of dew point potentiometer sample* (g)*:* 170.92

Tare weight, jar (g)*:* 115.29

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content (% vol)	
Dew point potentiometer:	29-Mar-16	11:50	175.75	612	12.59	‡‡
	24-Mar-16	9:35	174.57	3977	9.51	‡‡
	21-Mar-16	10:37	173.11	57211	5.71	‡‡
	17-Mar-16	8:30	172.64	219155	4.48	‡‡

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:	612	217.73	-3.11%	1.45	45.30
	3977	217.73	-3.11%	1.45	45.30
	57211	217.73	-3.11%	1.45	45.30
	219155	217.73	-3.11%	1.45	45.30

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

‡‡ Volume adjustments are applicable at this matric potential (see comment #1).

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: UTPQA-3 (<2mm, 1.4g/cc)

Initial sample bulk density (g/cm^3)*:* 1.40

Dry weight of relative humidity box sample* (g)*:* 71.93

Tare weight (g)*:* 39.38

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content (% vol)	
Relative humidity box:	15-Mar-16	10:40	72.69	845560	3.41	‡‡

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:	845560	217.73	-3.11%	1.45	45.30

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.

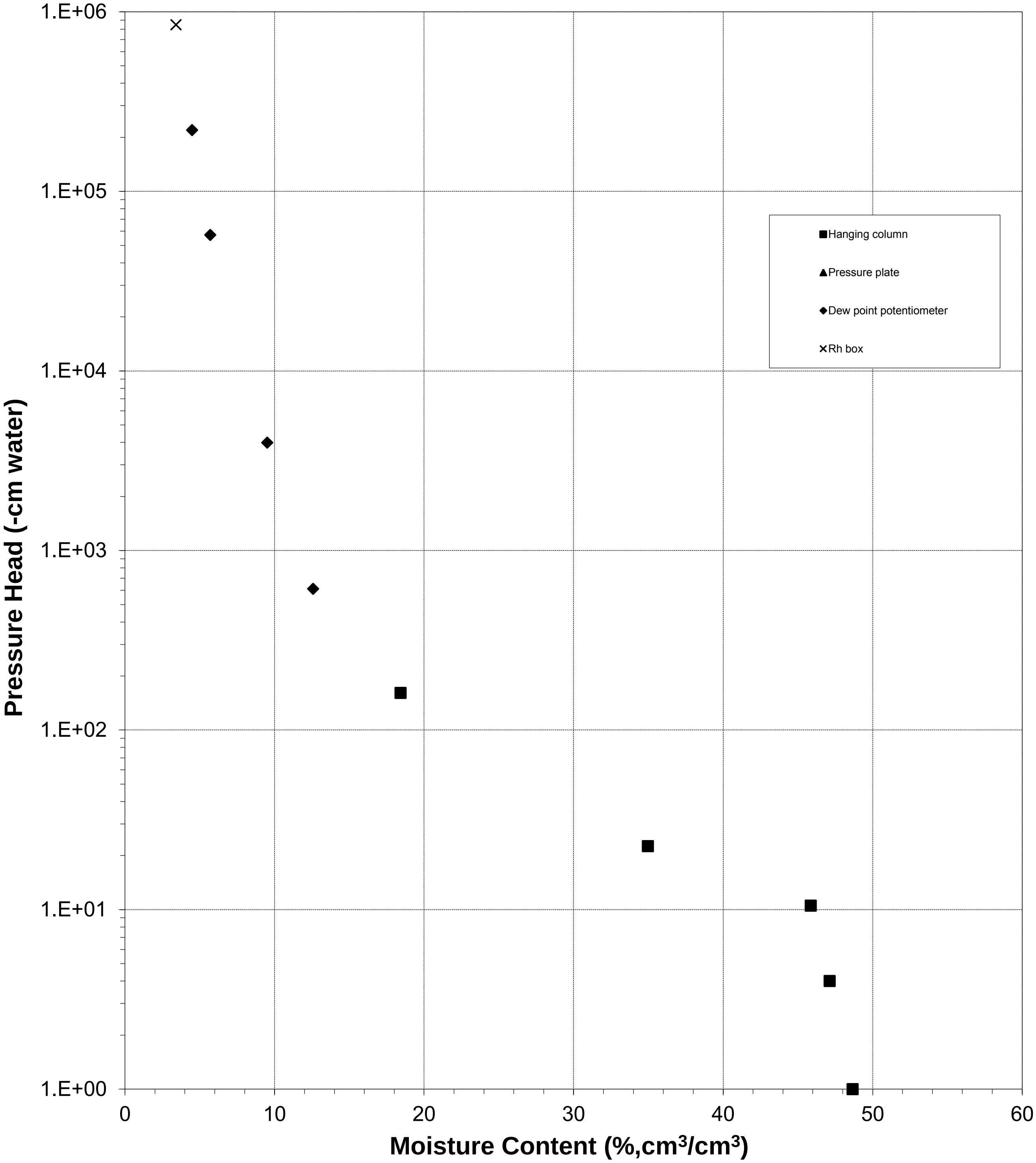
* Weight including tares

‡‡ 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: D. O'Dowd
Checked by: J. Hines

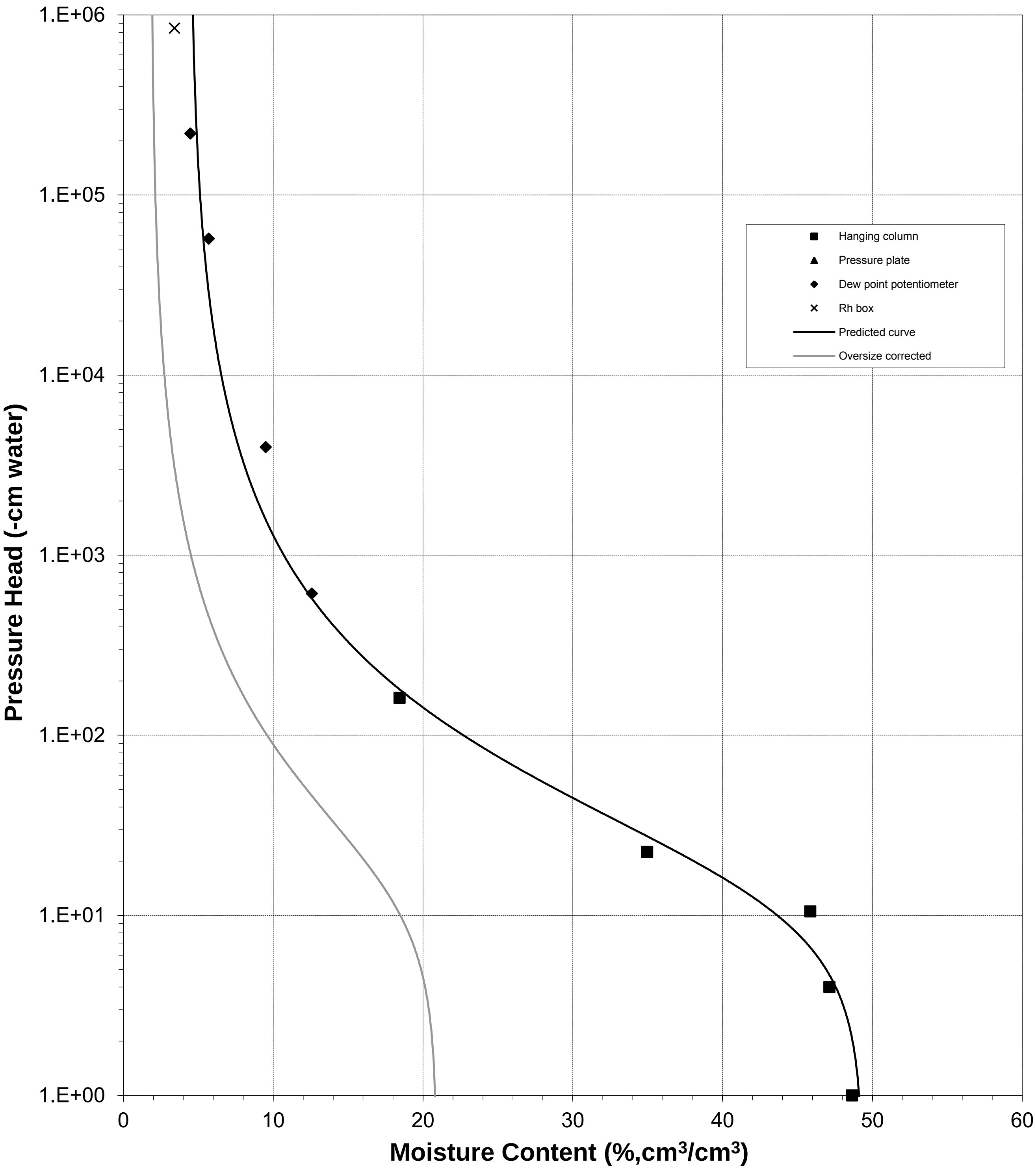
Water Retention Data Points

Sample Number: UTPQA-3 (<2mm, 1.4g/cc)



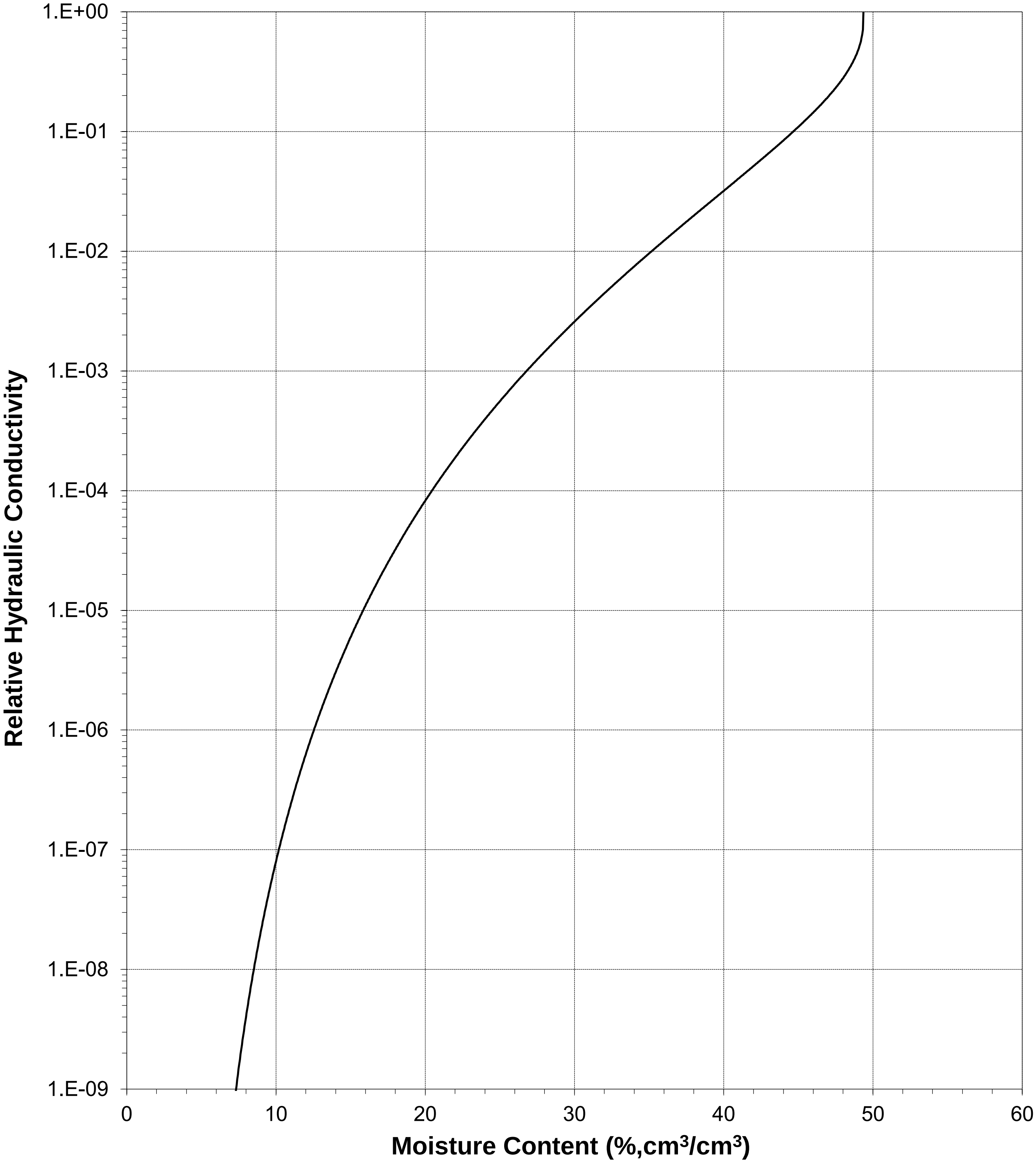
Predicted Water Retention Curve and Data Points

Sample Number: UTPQA-3 (<2mm, 1.4g/cc)



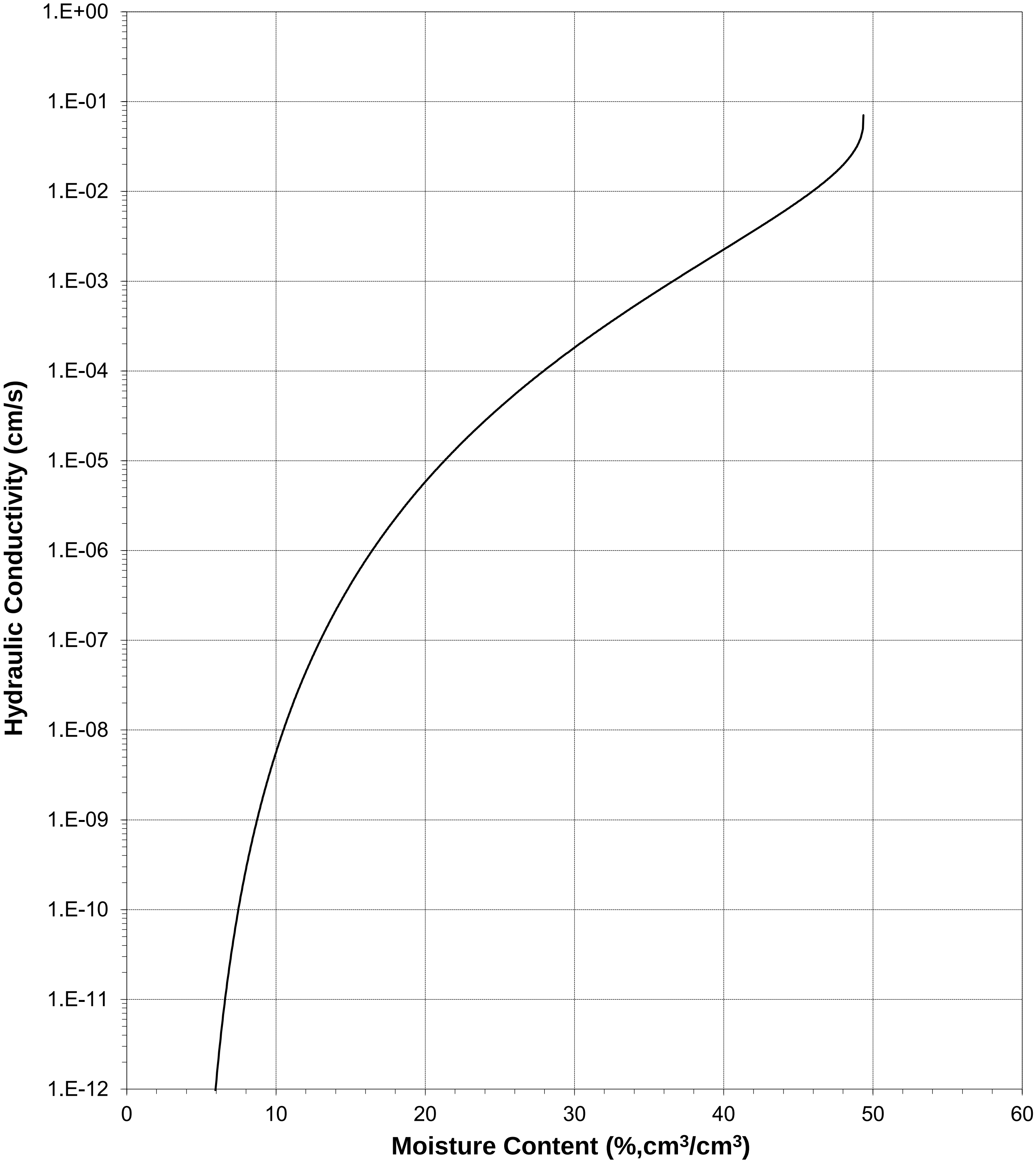
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: UTPQA-3 (<2mm, 1.4g/cc)



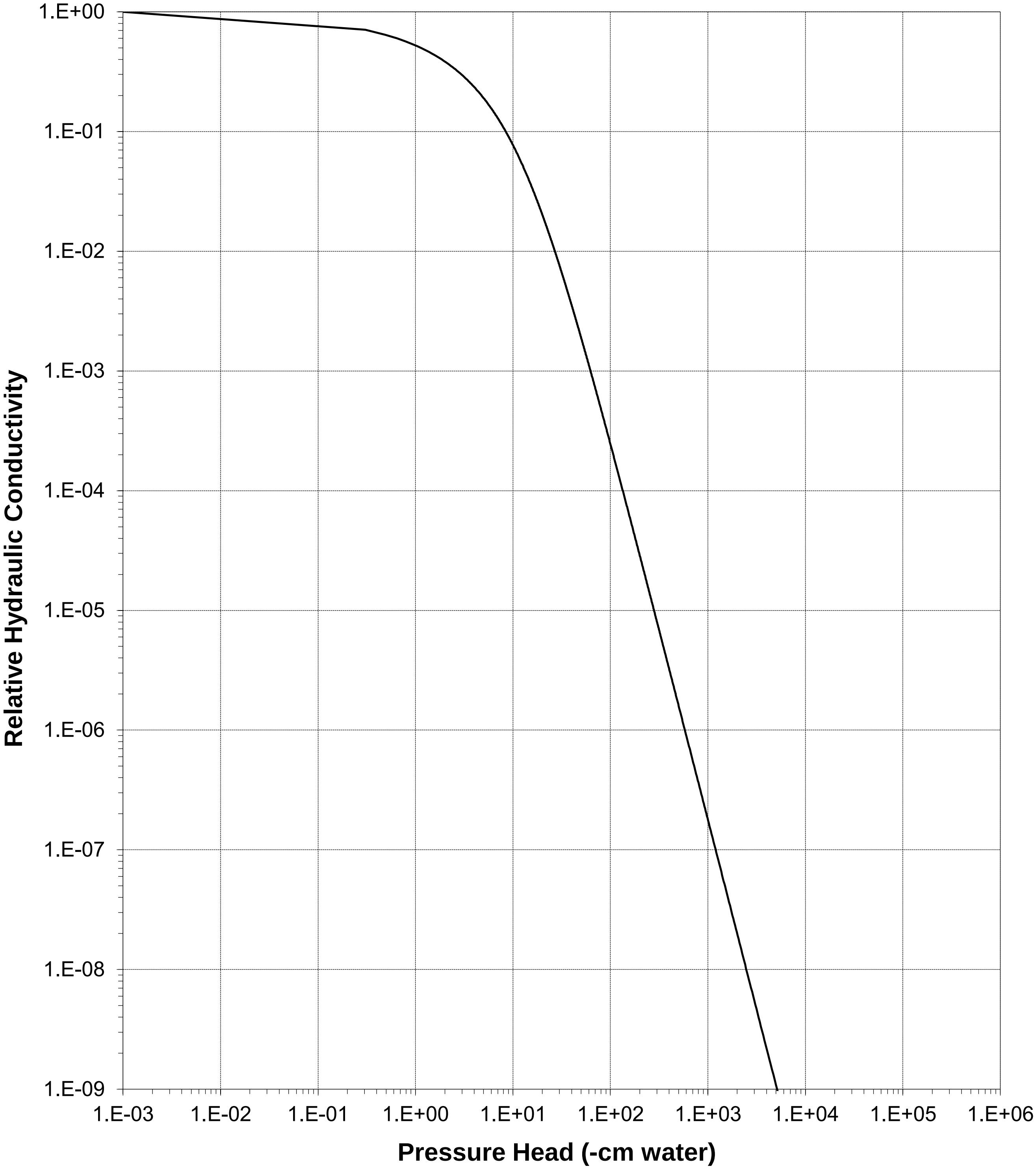
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: UTPQA-3 (<2mm, 1.4g/cc)



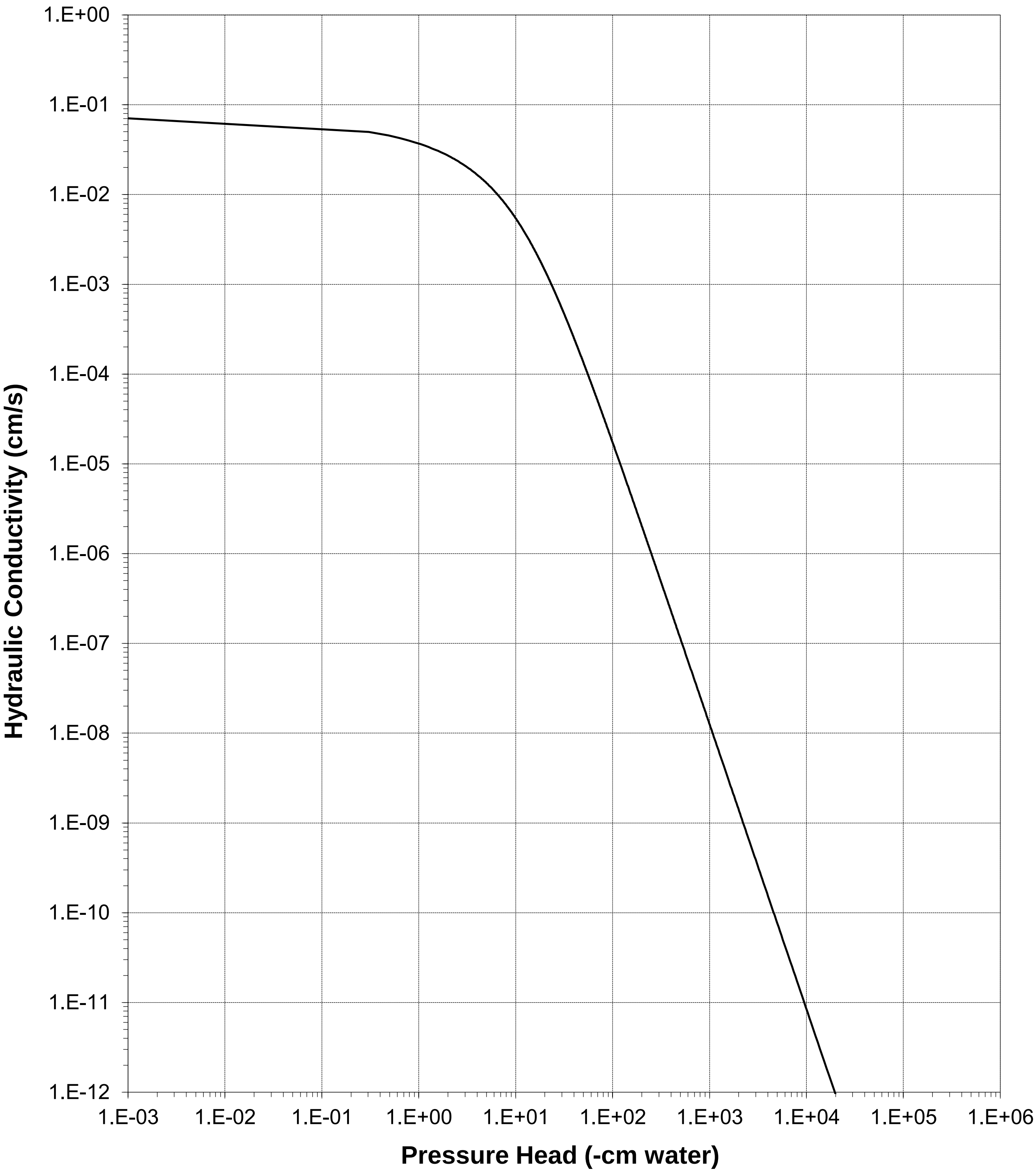
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: UTPQA-3 (<2mm, 1.4g/cc)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: UTPQA-3 (<2mm, 1.4g/cc)



Oversize Correction Data Sheet

Job Name:	Golder Associates, Inc.
Job Number:	NM16.0055.00
Sample Number:	UTPQA-3 (<2mm, 1.4g/cc)
Date Sampled:	5/28/2015
Project:	USNR, 1303098
Split (3/4", 3/8", #4):	#10

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	4561.39	1776.38	6337.77
Mass Fraction (%):	71.97	28.03	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.40	2.12
Calculated Porosity (% vol):	0.00	47.00	19.91
Volume of Solids (cm^3):	1721.28	670.33	2391.61
Volume of Voids (cm^3):	0.00	594.47	594.47
Total Volume (cm^3):	1721.28	1264.80	2986.08
Volumetric Fraction (%):	57.64	42.36	100.00
Initial Moisture Content (% vol):	0.00	11.57	4.90
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.40	2.12
Calculated Porosity (% vol):	0.00	47.00	19.91
Volume of Solids (cm^3):	1721.28	670.33	2391.61
Volume of Voids (cm^3):	0.00	594.47	594.47
Total Volume (cm^3):	1721.28	1264.80	2986.08
Volumetric Fraction (%):	57.64	42.36	100.00
Saturated Moisture Content (% vol):	0.00	49.37	20.91
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.45	2.15
Calculated Porosity (% vol):	0.00	45.30	18.84
Volume of Solids (cm^3):	1721.28	670.33	2391.61
Volume of Voids (cm^3):	0.00	555.09	555.09
Total Volume (cm^3):	1721.28	1225.42	2946.70
Volumetric Fraction (%):	58.41	41.59	100.00
Residual Moisture Content (% vol):	0.00	4.39	1.83
Ksat (cm/sec):	NM	7.0E-02	2.0E-02

* = 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:	Golder Associates, Inc.	*Dry wt. of sample* (g):	316.08
Job Number:	NM16.0055.00	*Tare wt., ring* (g):	127.87
Sample Number:	LTPQA-4 (<2mm, 1.4g/cc)	*Tare wt., screen & clamp* (g):	27.73
Date Sampled:	5/28/2015	*Initial sample volume* (cm^3):	225.21
Project:	USNR, 1303098	*Initial dry bulk density* (g/cm^3):	1.40
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	47.04

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	11-Mar-16	12:25	579.31	0	47.79	
	18-Mar-16	10:17	575.70	4.0	47.62	‡‡
	25-Mar-16	12:25	572.80	11.5	46.63	‡‡
	1-Apr-16	16:11	543.60	26.0	33.48	‡‡
	8-Apr-16	9:38	513.90	157.0	19.76	‡‡

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	---	---	---	---
	4.0	218.44	-3.01%	1.45	45.40
	11.5	216.87	-3.70%	1.46	45.00
	26.0	214.80	-4.62%	1.47	44.47
	157.0	213.65	-5.13%	1.48	44.17

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: LTPQA-4 (<2mm, 1.4g/cc)

Initial sample bulk density (g/cm^3)*:* 1.40
Fraction of test sample used (<2.00mm fraction) (%): 100.00

Dry weight of dew point potentiometer sample* (g)*:* 164.55
Tare weight, jar (g)*:* 115.28

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Dew point potentiometer:	25-Mar-16	12:33	168.63	918	12.25	‡‡
	22-Mar-16	13:10	167.31	10504	8.29	‡‡
	18-Mar-16	9:30	166.47	69142	5.77	‡‡
	15-Mar-16	10:10	165.75	722120	3.60	‡‡

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:	918	213.65	-5.13%	1.48	44.17
	10504	213.65	-5.13%	1.48	44.17
	69142	213.65	-5.13%	1.48	44.17
	722120	213.65	-5.13%	1.48	44.17

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).

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: LTPQA-4 (<2mm, 1.4g/cc)

Initial sample bulk density (g/cm^3): 1.40
Fraction of test sample used (<2.00mm fraction) (%): 100.00

Dry weight of relative humidity box sample* (g): 81.61
Tare weight (g): 44.09

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Relative humidity box:	15-Mar-16	10:40	82.53	845560	3.65	‡‡

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:	845560	213.65	-5.13%	1.48	44.17

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

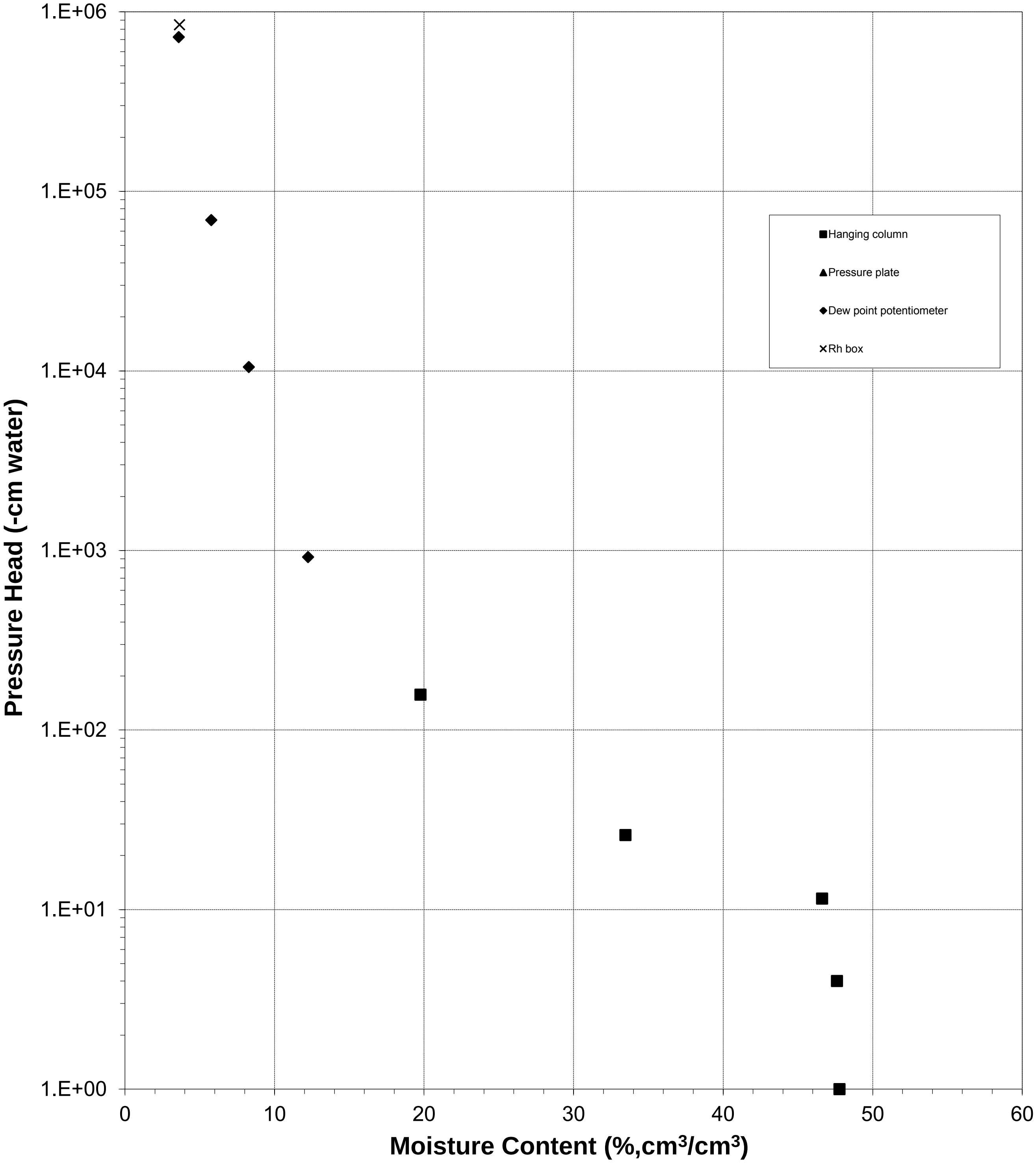
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

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

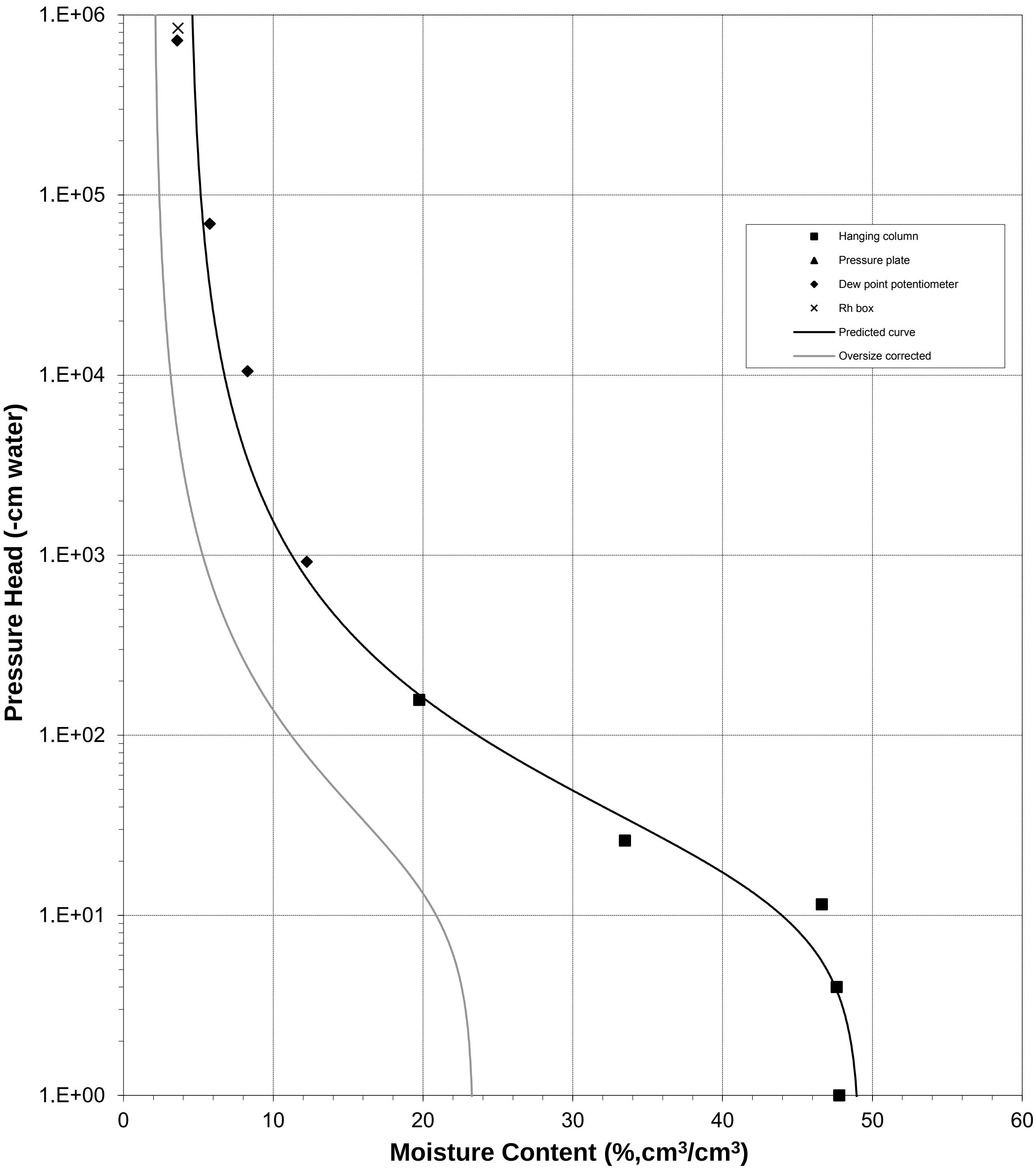
Water Retention Data Points

Sample Number: LTPQA-4 (<2mm, 1.4g/cc)



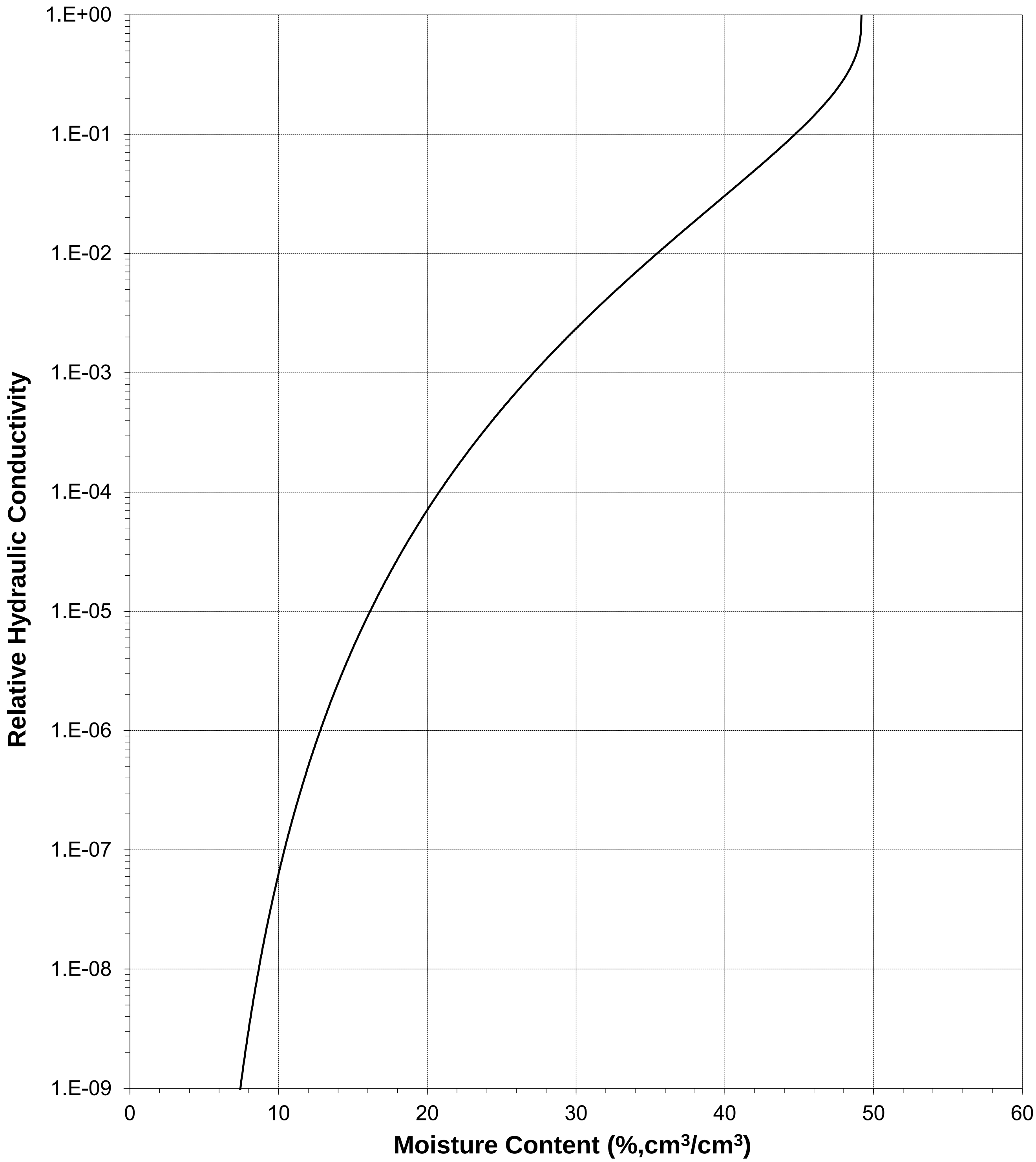
Predicted Water Retention Curve and Data Points

Sample Number: LTPQA-4 (<2mm, 1.4g/cc)



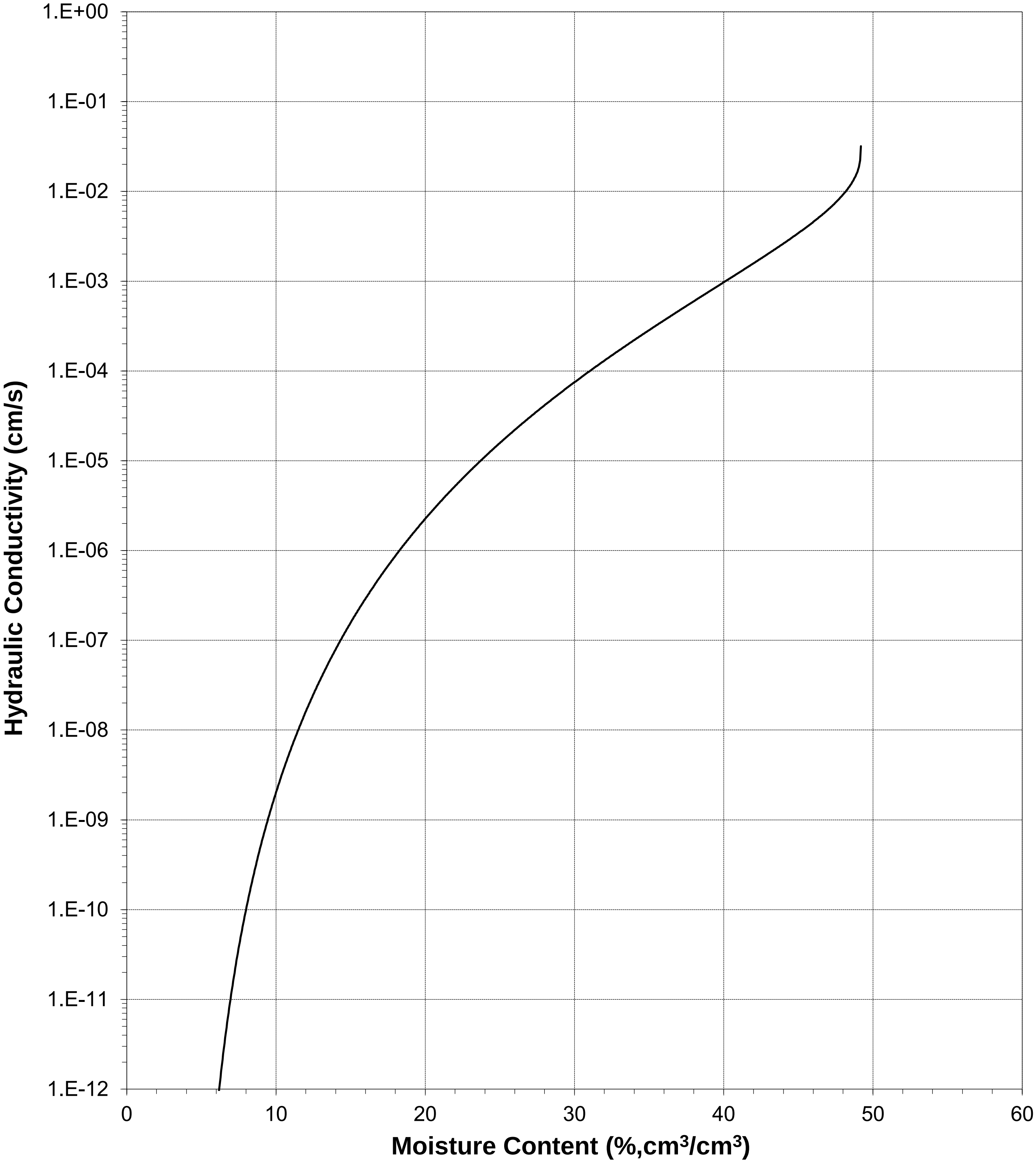
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: LTPQA-4 (<2mm, 1.4g/cc)



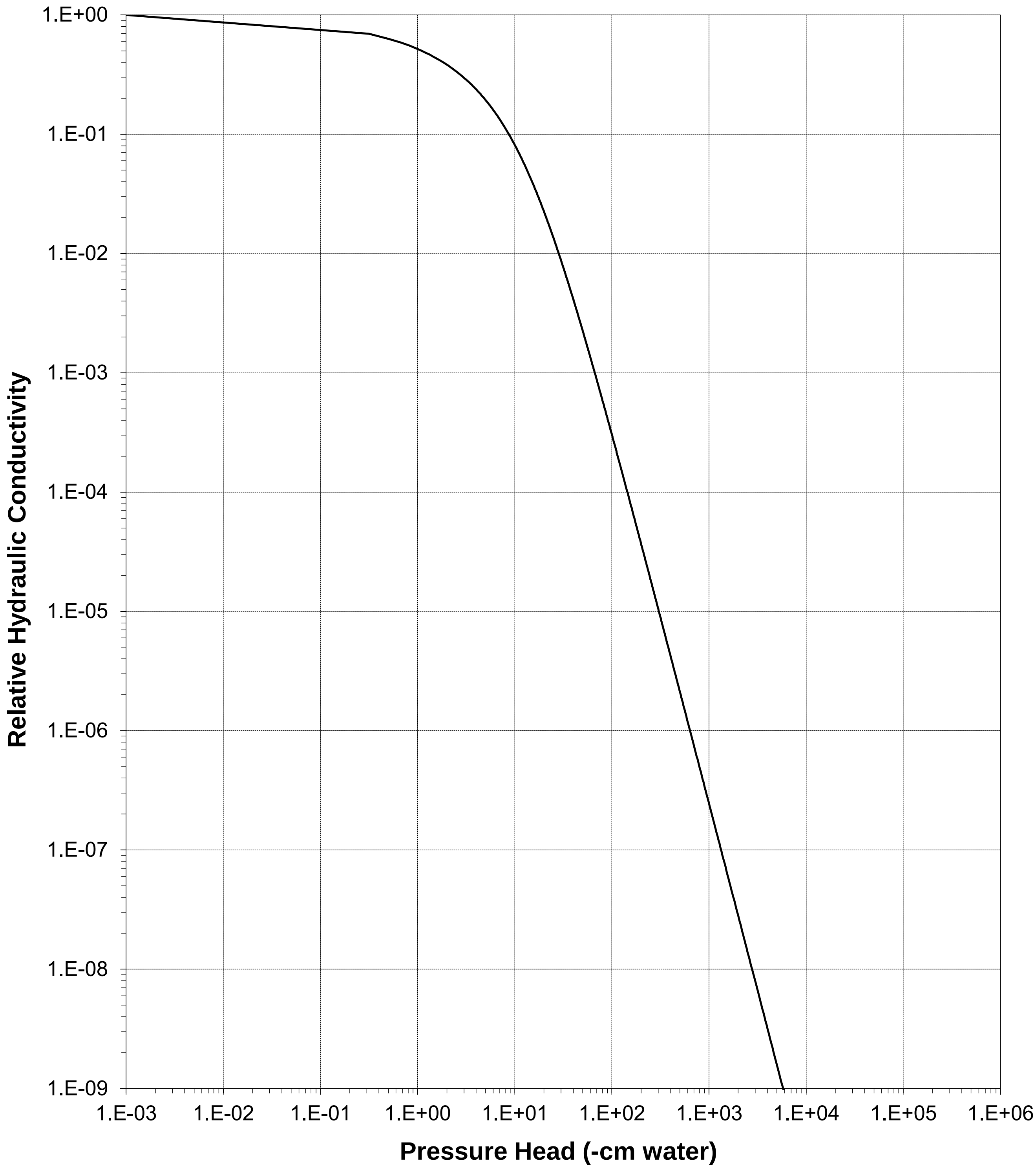
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: LTPQA-4 (<2mm, 1.4g/cc)



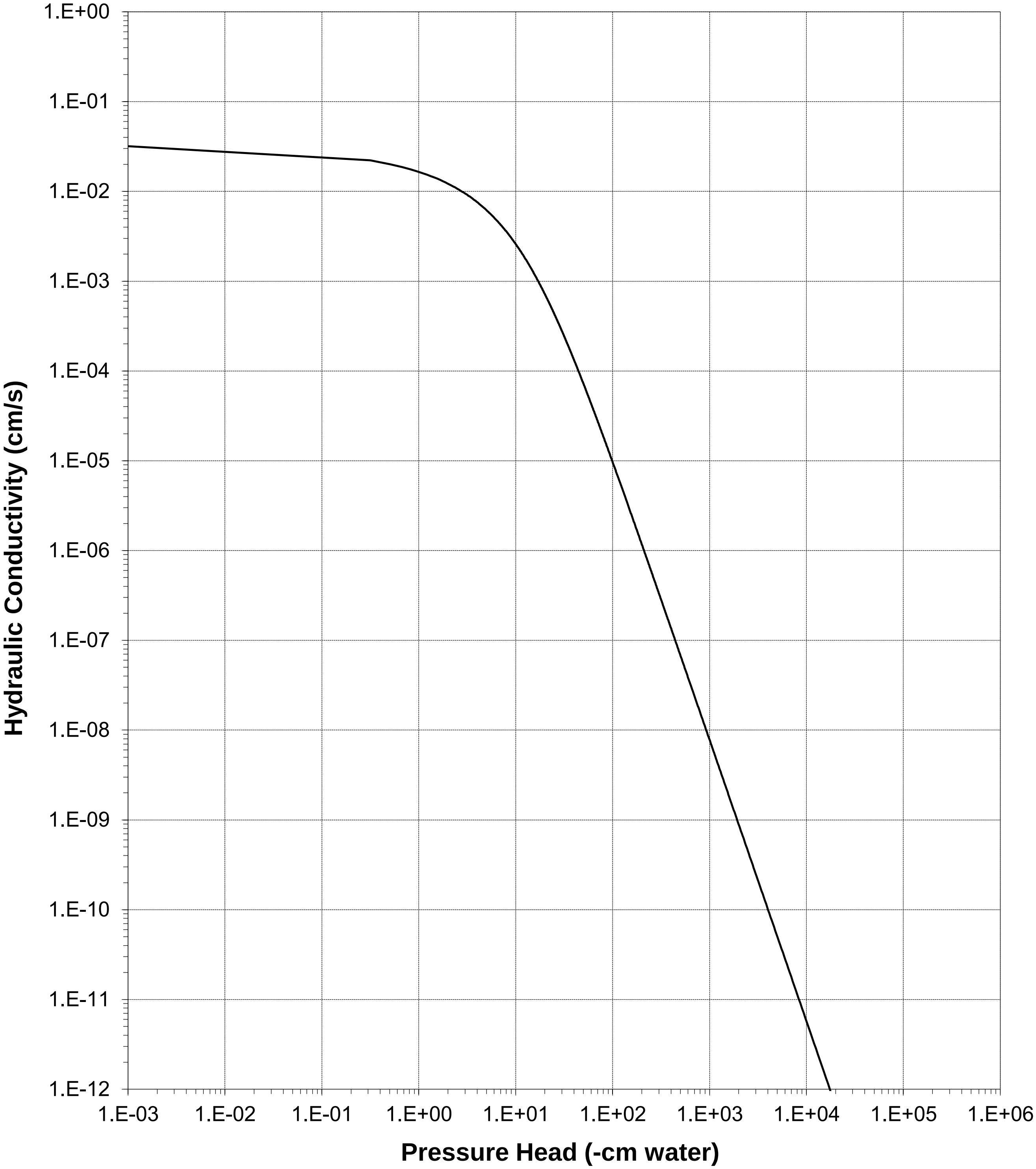
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: LTPQA-4 (<2mm, 1.4g/cc)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: LTPQA-4 (<2mm, 1.4g/cc)



Oversize Correction Data Sheet

Job Name: Golder Associates, Inc.
Job Number: NM16.0055.00
Sample Number: LTPQA-4 (<2mm, 1.4g/cc)
Date Sampled: 5/28/2015
Project: USNR, 1303098

Split (3/4", 3/8", #4): #10

	Coarse Fraction*	Fines Fraction**	Composite
Subsample Mass (g):	5018.47	2406.12	7424.59
Mass Fraction (%):	67.59	32.41	100.00
Initial Sample θ_i			
Bulk Density (g/cm^3):	2.65	1.40	2.06
Calculated Porosity (% vol):	0.00	47.04	22.35
Volume of Solids (cm^3):	1893.76	907.97	2801.73
Volume of Voids (cm^3):	0.00	806.41	806.41
Total Volume (cm^3):	1893.76	1714.38	3608.15
Volumetric Fraction (%):	52.49	47.51	100.00
Initial Moisture Content (% vol):	0.00	10.33	4.91
Saturated Sample θ_s			
Bulk Density (g/cm^3):	2.65	1.40	2.06
Calculated Porosity (% vol):	0.00	47.04	22.35
Volume of Solids (cm^3):	1893.76	907.97	2801.73
Volume of Voids (cm^3):	0.00	806.41	806.41
Total Volume (cm^3):	1893.76	1714.38	3608.15
Volumetric Fraction (%):	52.49	47.51	100.00
Saturated Moisture Content (% vol):	0.00	49.19	23.37
Residual Sample θ_r			
Bulk Density (g/cm^3):	2.65	1.48	2.11
Calculated Porosity (% vol):	0.00	44.17	20.41
Volume of Solids (cm^3):	1893.76	907.97	2801.73
Volume of Voids (cm^3):	0.00	718.40	718.40
Total Volume (cm^3):	1893.76	1626.37	3520.13
Volumetric Fraction (%):	53.80	46.20	100.00
Residual Moisture Content (% vol):	0.00	4.31	1.99
Ksat (cm/sec):	NM	3.2E-02	1.0E-02

* = 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

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263, ASTM D2216
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
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

APPENDIX B
SOIL WATER CHARACTERISTICS CURVES

Figure B-1:
USNR Soil Water Characteristic Curve
SAMPLE: UPTQA-2

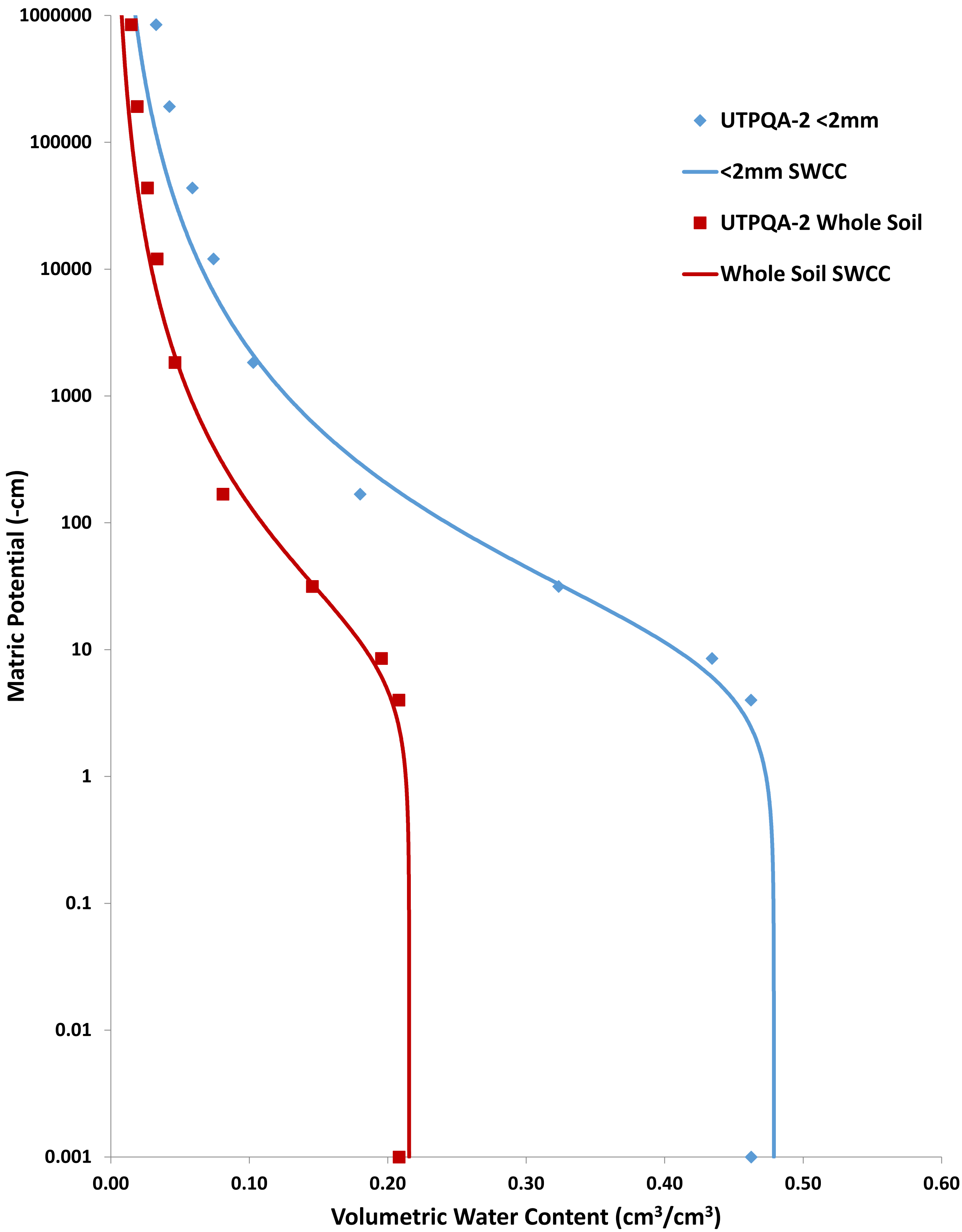


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Figure B-2:
USNR Soil Water Characteristic Curve
SAMPLE: UPTQA-3

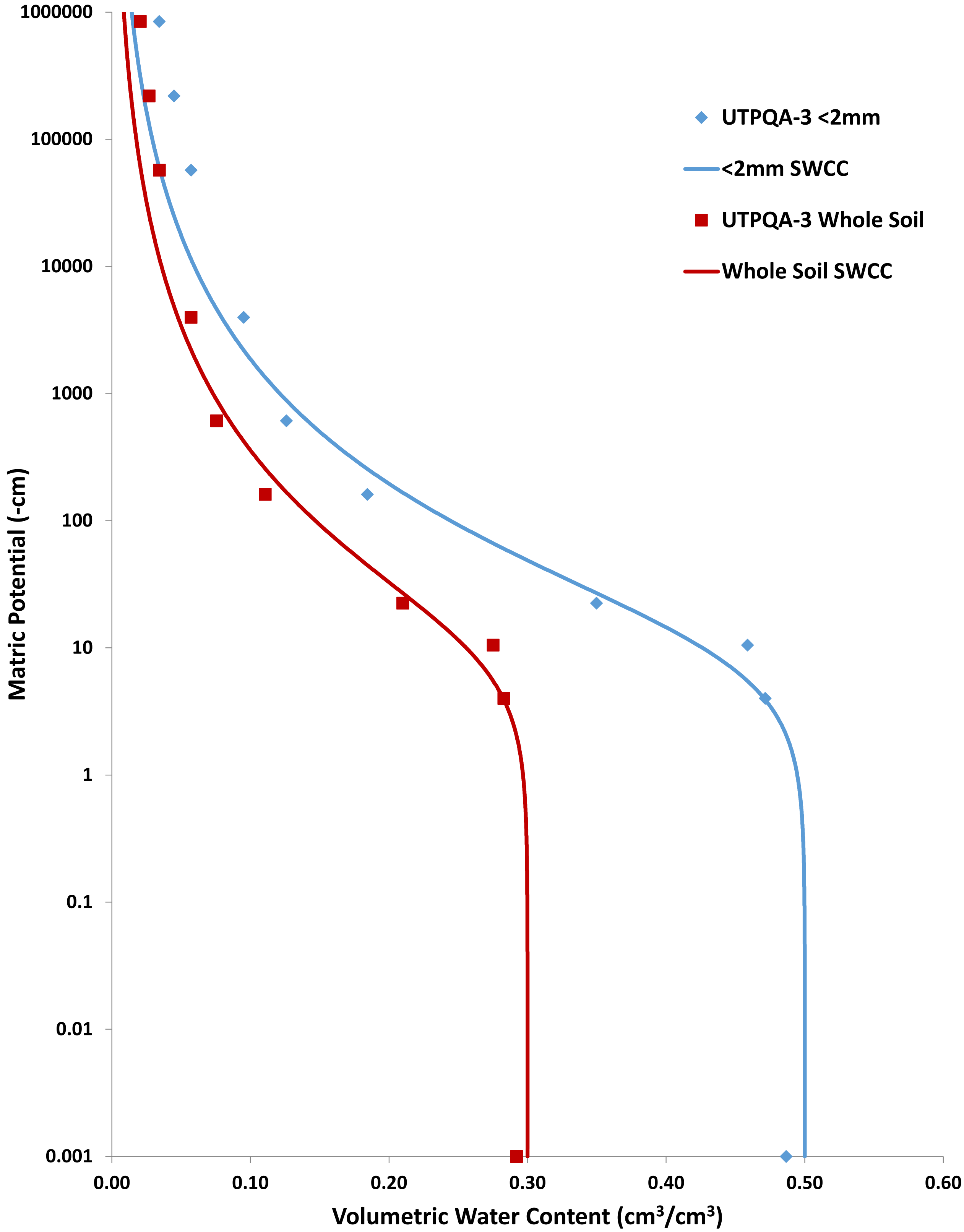

Figure B-3:
USNR Soil Water Characteristic Curve
SAMPLE: LPTQA-4

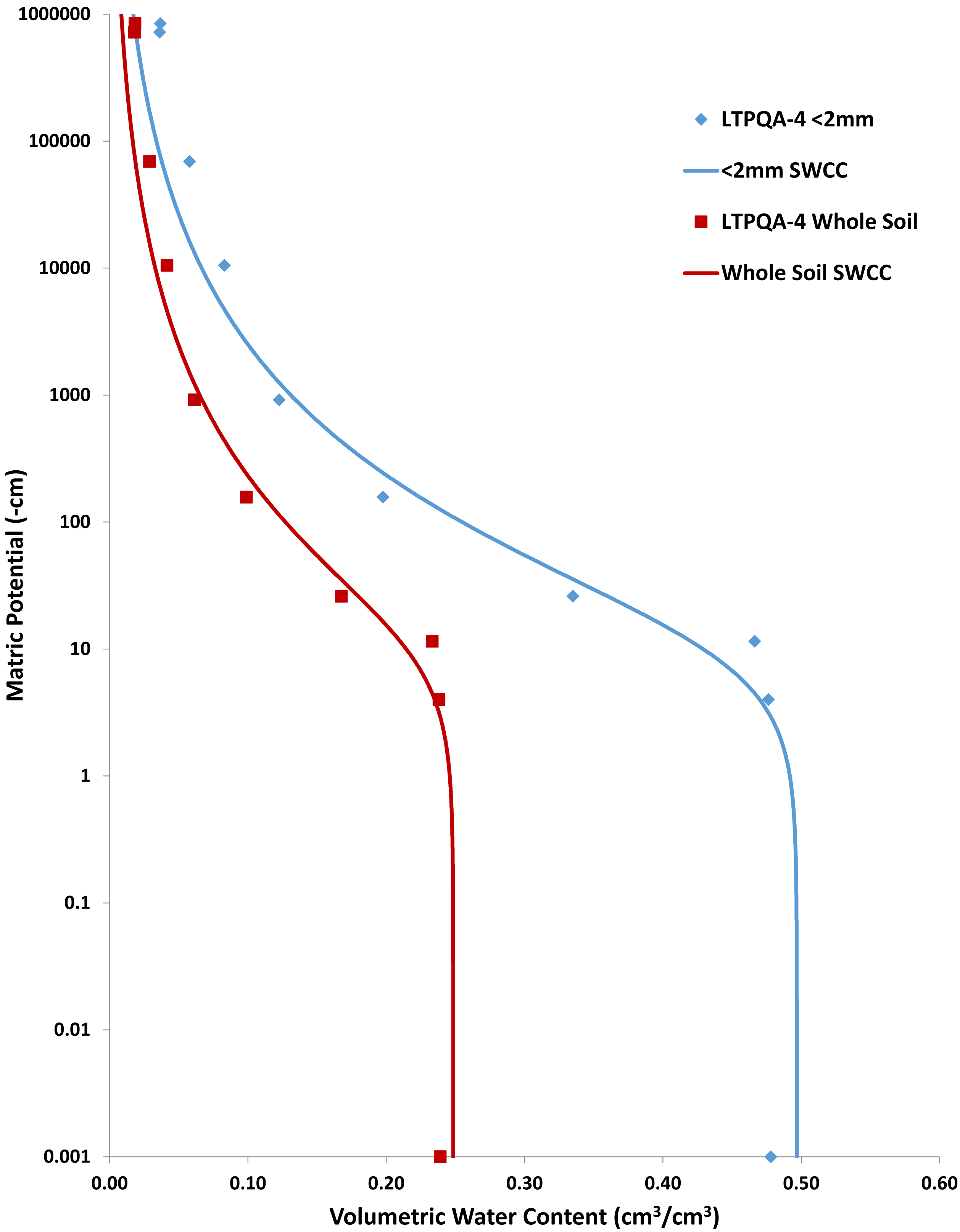

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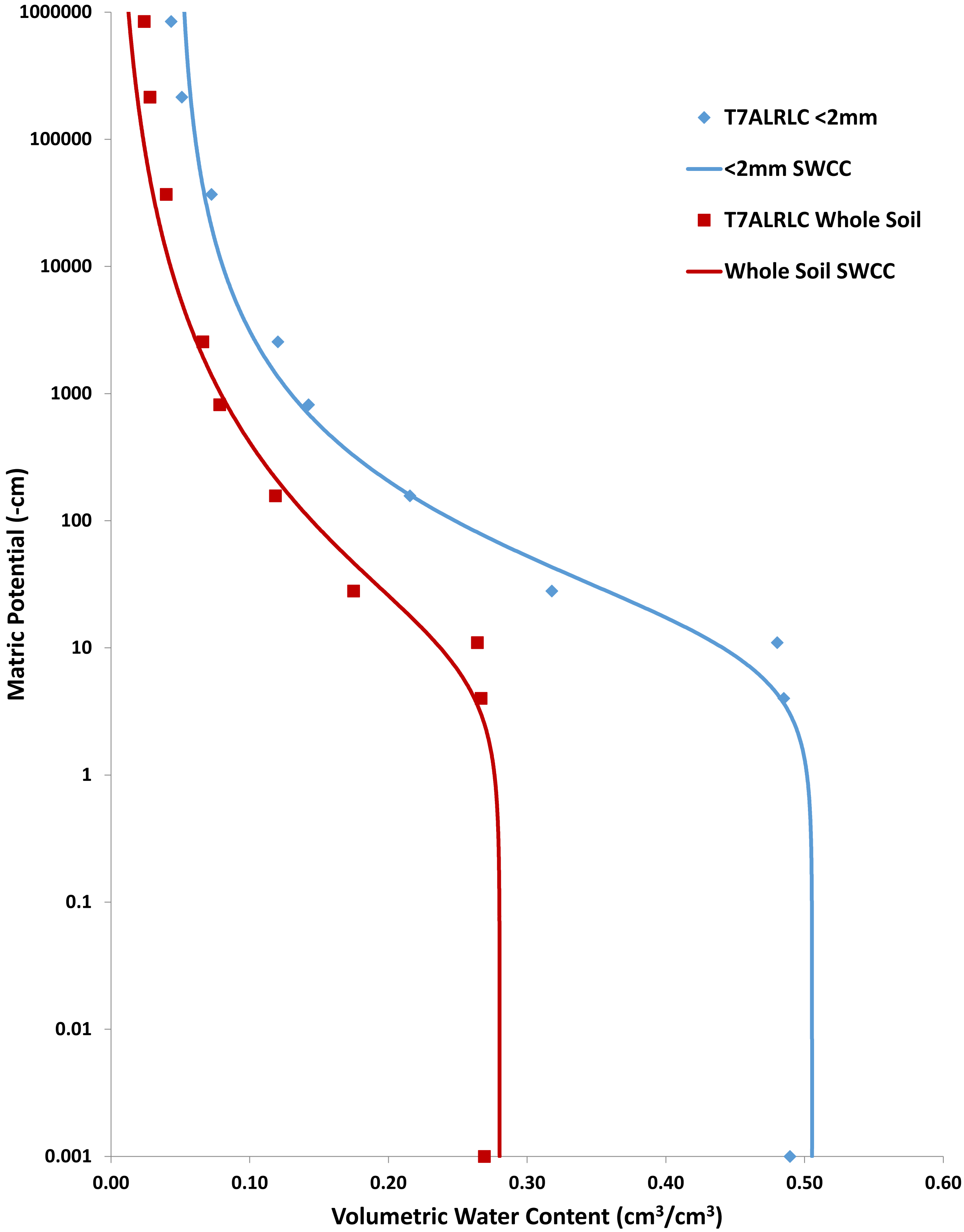
Figure B-4:
USNR Soil Water Characteristic Curve
SAMPLE: T7ALRLC



APPENDIX C
EROSION STATION CROSS-SECTIONS

Figure C-1:
USNR South Transect

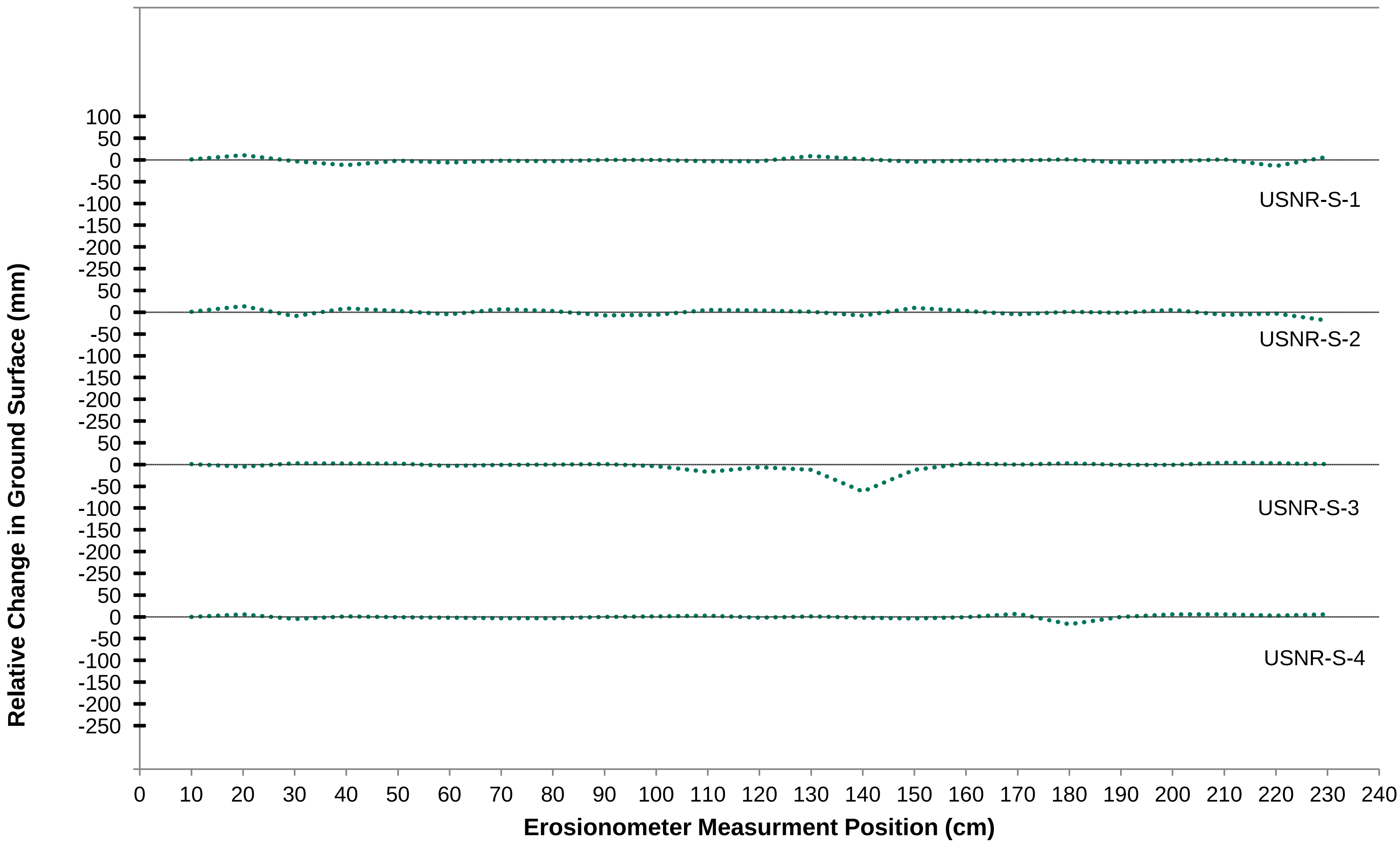


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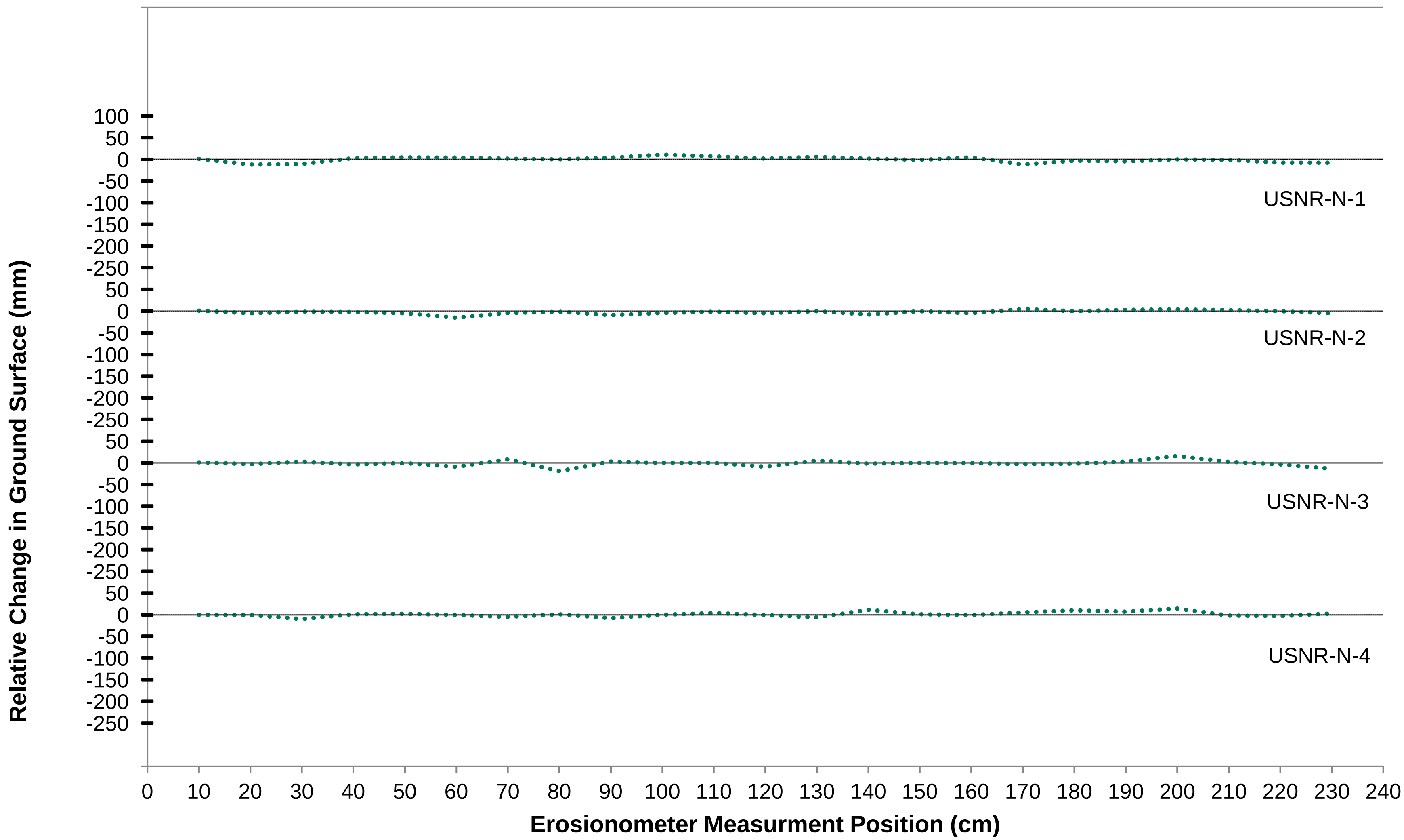
Figure C-2:
USNR North Transect



APPENDIX D
EROSION TRANSECT PHOTOGRAPHS

Transect Location:
USNR-N-1 Date: 6/13/16

Transect Location:
USNR-N-1 Date: 12/23/16

Transect Location:
USNR-N-2 Date: 6/13/16

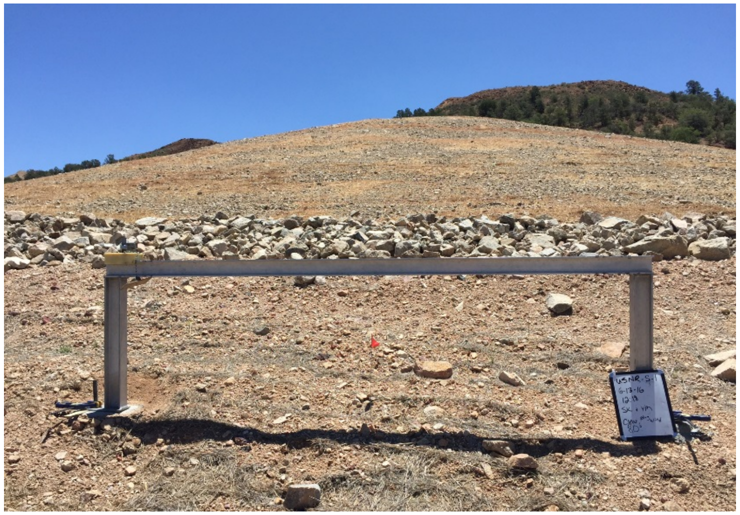
Transect Location:
USNR-N-2 Date: 12/23/16

Transect Location:
USNR-N-3 Date: 6/13/16

Transect Location:
USNR-N-3 Date: 12/23/16

Transect Location:
USNR-N-4 Date: 6/13/16

Transect Location:
USNR-N-4 Date: 12/23/16



Transect Location:
USNR-S-1 Date: 6/13/16

Transect Location:
USNR-S-1 Date: 12/23/16

Transect Location:
USNR-S-2 Date: 6/13/16

Transect Location:
USNR-S-2 Date: 12/23/16

Transect Location:
USNR-S-3 Date: 6/13/16

Transect Location:
USNR-S-3 Date: 12/23/16

Transect Location:
USNR-S-4 Date: 6/13/16

Transect Location:
USNR-S-4 Date: 12/23/16

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