SW 137

2015-005448

RB&G
ENGINEERING, INC.

April 30, 2015

Mr. Phil Burns
Department of Environmental Quality
Division of Solid and Hazardous Waste
P.O. Box 144880
Salt Lake City, Utah 84114-4880

Re: Juab Rural Development Agency (JRDA)
Evaluation of Evapotranspiration Cover for Class II and Class IV Landfill

Dear Mr. Burns:

Enclosed please find one copy of a report entitled "Evaluation of Evapotranspiration Cover for Juab Rural Development Agency Class II and Class IV Landfill." This analysis is being submitted in support of the permit renewal application for the JRDA facility located west of Nephi, Utah on Sheeplane Road, south of Highway 132.

The purpose of the study was to evaluate whether an evapotranspiration (ET) cover, using material found on adjacent property owned by JRDA, would fulfill the requirements of Utah Administrative Code R315-303-3(4) *Standards for Design*. The conclusion of the analysis is that use of the available material in an ET cover will achieve equivalent reduction in infiltration as compared to a standard cover.

We appreciate your review and consideration of the proposed ET cover for the JRDA facility. If there are any questions or concerns that need to be addressed, please let us know.

Sincerely,

RB&G Engineering, Inc.

Carl L. Cook, P.E.
Principal

cc: Mike Seely, Juab Rural Development Agency

1435 WEST 820 NORTH, PROVO, UTAH 84601-1343
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EVALUATION OF EVAPOTRANSPIRATION COVER

FOR

JUAB RURAL DEVELOPMENT AGENCY CLASS II AND CLASS IV LANDFILL

Prepared for:
Juab Rural Development Agency
21 East 100 North
Nephi, Utah 84648

April 2015

Prepared by:
RB&G Engineering, Inc.
1435 W. 820 N.
Provo, UT 84601

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APPENDIX

1.0 INTRODUCTION

The Juab Rural Development Agency (JRDA) operates a landfill west of Nephi, south of Highway 132, on Sheeplane Road. The subject property is located in Section 15, Township 13 South, Range 1 West, Salt Lake Base and Meridian. JRDA owns 300 acres within this section. The location of the landfill site is presented in the Appendix as Figure 1. The landfill is permitted as a Class II and IV landfill with a standard (clay) cover design. JRDA is proposing that an evapotranspiration cover be used to close the landfill. The materials available at the site are better suited for an evapotranspiration cover than a clay cover, and evapotranspiration covers are generally able to withstand the local climatic conditions without the desiccation cracking commonly observed with clay covers.

This study evaluates whether an evapotranspiration cover, using on-site materials, will fulfill the requirements of Utah Administrative Code (UAC) R315-303-3(4) *Standards for Design*. The UAC states that an alternative cover such as an evapotranspiration cover must achieve an equivalent reduction in infiltration as achieved by the standard design and must provide equivalent protection from wind and water erosion as achieved by the standard design.

To demonstrate the equivalent reduction in infiltration, the expected performance of an alternative final cover design is required to be documented by the use of an appropriate mathematical model. To evaluate whether an evapotranspiration cover at the JRDA landfill meets the performance standards, RB&G Engineering collected soil samples from the landfill site, obtained hydraulic analysis of the soil samples, and performed site-specific modeling comparing the evapotranspiration cover to the standard cover.

2.0 CLIMATIC CONDITIONS

The climate data used in this analysis is derived from actual historical daily precipitation and potential evaporation data for Nephi, Utah. The analysis requires the wettest year, driest year, and average/typical year to be determined. Monthly precipitation data for 1905 to 1908 and 1942 to 2013 (all available years) was obtained from Utah State University's Utah Climate Center, GHCN (Global Historical Climatology Network), Nephi Station (Station ID USC00426135, 39.7122 degrees latitude, -111.832 degrees longitude, elevation 1563 meters/5131 feet). Seventy years included full data for every month. Table 1 and Table 2 below show a summary of precipitation for Nephi and yearly ranked precipitation.

Table 1
Precipitation Summary for Nephi, Utah (1905-1908 and 1942-2013)

	Precipitation (inches/year)	Year
Average	14.4	(1987)
Maximum	26.5	1983
Minimum	6.8	1976

Table 2
Ranked Precipitation in Nephi, Utah (1905-1908 and 1942-2013)

Rank	Year	Precip. (in/yr)	Rank	Year	Precip. (in/yr)	Rank	Year	Precip. (in/yr)
1	1983	26.54	25	1971	15.22	48	1988	12.52
2	1906	22.37	26	1996	14.98	49	1989	12.50
3	1982	22.26	27	1947	14.93	50	1960	12.41
4	1981	20.67	28	1965	14.93	51	2011	12.39
5	1998	19.55	29	1970	14.91	52	1966	12.37
6	1980	18.04	30	1953	14.70	53	1979	12.14
7	2005	18.04	31	1905	14.65	54	1949	11.89
8	1907	18.00	32	1992	14.49	55	1962	11.87
9	1997	17.86	33	1943	14.33	56	2009	11.52
10	1985	17.73	34	1987	14.27	57	2008	11.45
11	1957	17.43	35	1999	14.15	58	2002	11.30
12	1993	17.34	36	1969	13.94	59	2007	11.26
13	1946	17.32	37	1952	13.73	60	2001	11.22
14	1994	17.30	38	2006	13.69	61	1959	11.20
15	1995	17.03	39	1990	13.59	62	1977	10.65
16	1968	16.93	40	1967	13.55	63	1975	10.54
17	1908	16.84	41	1955	13.37	64	1956	9.76
18	1986	16.80	42	1954	13.24	65	1950	9.60
19	2000	16.77	43	2003	13.17	66	1942	9.58
20	1945	16.52	44	2004	13.07	67	1974	9.24
21	1951	16.35	45	1972	12.97	68	1958	8.73
22	1984	16.27	46	1961	12.89	69	2013	8.43
23	1973	15.61	47	1991	12.65	70	1976	6.82
24	1944	15.55						

It was determined that the maximum precipitation year was 1983. The minimum precipitation year was 1976. Precipitation patterns were evaluated, and 1987 was chosen as the year that most closely represents an average precipitation year. Data from each of these years was used in the modeling analysis as described in Section 4.0 HYDRUS Model Design of this report.

3.0 SOIL INVESTIGATION AND HYDRAULIC PROPERTIES

Soil investigations were conducted within the property owned by the JRDA (see Vicinity Map, Figure 1, in the Appendix) with the intent of locating material that would be suitable for use as the primary layer in an evapotranspiration cover system as final cover for the landfill. The investigations were conducted by excavating test pits with a backhoe and obtaining soil samples for testing. Potential borrow sites were identified by reviewing soil survey maps prepared by the U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS), formerly the Soil Conservation Service. The maps are presented in Soil Survey of Fairfield-Nephi Area Utah (1984). The generalized soil information identified in the mapping is primarily provided for the purpose of land planning and potential hazard identification. The NRCS soil survey map with its accompanying legend is included for reference in the Appendix.

Soils that are most appropriate for use in evapotranspiration covers support native plant growth that can be used to reduce the moisture that may infiltrate through the cover into the underlying landfill materials. Most plants grow best in soils that have relatively balanced proportions of sand, silt and clay, such as loams, clay loams and sandy loams. Review of the generalized soils maps, shows that the area is predominated by soils with loamy characteristics.

Two areas were selected for investigation. The first is the area immediately uphill and to the south of the current landfill. The second is approximately 3,000 to 6,000 feet west of the active landfill, where there are several relatively flat areas between the surrounding hills.

A total of fourteen test pits were excavated within the two areas. The locations of the excavated test pits are shown on Figure 2 in the Appendix. It will be observed that Test pits 12-01, 12-02 and 12-03 were located at the south limits of the active landfill, and the remaining excavations were conducted in the second, westerly investigation area. Copies of the test pit logs for each excavation are attached in the Appendix.

Soil testing was conducted on samples from six of the test pits, 12-01, 12-02, 12-03, 12-04, 12-06 and 12-07. Test Pit 12-05 encountered bedrock at a depth of 6-inches below the ground surface, so no testing was performed on this material. Tests performed on the samples obtained from the identified excavations included permeability, gradations, bulk densities, and moisture content. The results of the tests are presented in the Summary of Test Data included in the Appendix. It will be observed from the results that samples from Test Pits 12-01, 12-02, 12-03 and 12-07 classify as gravelly sands with about 25% of the materials being silts and clays. These materials are generally unsuitable for evapotranspiration landfill covers.

Samples obtained from Test Pits 12-04 and 12-06 classify as loam and loam to clay-loam materials, respectively, in accordance with the NRCS soil texture criteria. These soils showed promise for use as the primary layer in an evapotranspiration cover. The remaining seven excavations, Test Pits 14-01 through 14-07, were performed in an attempt to determine the extent of the available soil material that might be used in the landfill cover.

Soil Hydraulic Parameters

Soil hydraulic parameters are required to model the evapotranspiration cover. The van Genuchten-Mualem model was used for this analysis. Q_r, Q_S, Alpha, n, and K_S are unsaturated hydraulic parameters used in the van Genuchten-Mualem model and are defined as follows (Šimůnek, 2013):

Q_r (θ_r) - residual volumetric soil water content
Q_S (θ_S) - saturated volumetric soil water content
Alpha (α) - van Genuchten fitting parameter, L^{-1}
n - van Genuchten fitting parameter, dimensionless
K_s - saturated hydraulic conductivity, LT^{-1}

These parameters are obtained from the soil water characteristic curve, which shows the relationship between the water content (θ) and the soil water potential (ψ). Material from Test Pit 12-04 was analyzed by the Daniel B. Stephens and Associates, Inc., Laboratory Testing Facility in Albuquerque, New Mexico using standard hydraulic tests and methods to determine the soil water characteristic curve and associated parameters. The soil sample was tested at two levels of compaction, 82% of maximum and 88% of maximum. The full results of the hydraulic conductivity analysis are shown in the Appendix. Hydraulic parameter values reported by Stephens & Associates are shown below in Table 3.

Table 3
Hydraulic Parameters for Soil from Test Pit 12-04

Sample and Compaction Level	θ_r (% vol)	θ_S (% vol)	α (cm^{-1})	N (-)	K_S (cm/sec)
Test Pit 12-04 (82%, 87.8pcf)	0.00	48.88	0.0459	1.2064	7.3E-04
Test Pit 12-04 (88%, 94.3pcf)	0.00	44.88	0.0194	1.2097	7.4E-05

It is estimated from previous calculations in the preparation of the JRDA landfill permit, that approximately 220,000 cubic yards of material will be needed in order to provide a 30-inch evapotranspiration cover depth over the final closed landfill area. Using the depth of potentially acceptable material from the test pit excavations as shown on the logs, and an approximate area where the material is available, it is estimated that 250,000 to 300,000+ cubic yards of material can be obtained. The approximate area where the material is located is shown on Figure 3 in the Appendix.

Soil for a standard clay cover is not available on-site at the JRDA landfill. The unsaturated hydraulic parameters shown in Table 4 are provided in the HYDRUS- 1D library (sourced from Carsel, 1988) as average parameters for clay (note that K_s is given in cm/day below instead of cm/sec as in the reported values above). This material was chosen as the closest approximation to the clay typically used in standard covers.

Table 4
Hydraulic Parameters for Clay from HYDRUS-1D Library

Material	θ_r (% vol)	θ_s (% vol)	α (cm^{-1})	N (-)	K_s (cm/day)
Clay	0.068	0.38	0.008	1.09	4.8

UAC R315-303-3(4) requires that the final lifts of clay used to construct a standard cover design have a permeability of 1 x 10^{-5} cm/sec or less. In order to match this permeability requirement, the library K_s value of 4.8 cm/day for clay was changed to 0.864 cm/day (the equivalent of 1 x 10^{-5} cm/sec) for the top 16 cm (approximately 6 inches) of the standard cover simulation.

Scaling factors of 1.3 for Alpha (α) and 1.1 for n were applied to these laboratory-obtained parameters to account for scaling effects, hysteresis, and alteration in soil structure caused by processes such as freeze-thaw and wet-dry cycling, root growth and death, and burrowing fauna. The final values used for each model are shown in Table 5.

Table 5
Hydraulic Parameters for All Soil Types Used

Model	θ_r (% vol)	θ_s (% vol)	α (cm^{-1})	N (-)	K_s (cm/day)
ET Cover, 82% compaction	0.00	0.4888	0.05967	1.32704	63.1
ET Cover, 88% compaction	0.00	0.4488	0.02522	1.33067	6.394
Standard cover (top 15 cm)	0.068	0.38	0.0104	1.199	0.864
Standard cover (bottom 31 cm)	0.068	0.38	0.0104	1.199	4.8

4.0 HYDRUS MODEL DESIGN

Model Selection

The HYDRUS-1D modeling package was selected to model the performance of the evapotranspiration cover and compare it to the performance of the standard design. Two-dimensional models are often used to model similar situations; however, the developers of the HYDRUS-1D and HYDRUS-2D packages recommend using HYDRUS-1D "for engineering problems, such as multi seasonal simulations of the recharge through landfill cover." (HYDRUS-1D FAQ).

Three scenarios were modeled:

1) evapotranspiration cover, 82% compaction
2) evapotranspiration cover, 88% compaction
3) standard (clay) cover

The optimum compaction level for the evapotranspiration cover is approximately 85% of maximum. The 82% of maximum and 88% of maximum compaction levels were modeled to bound the optimum 85% level.

Key model input and parameters used in each of the model scenarios are described briefly as follows.

Time

The models were run for 15 years (5480 days). This includes 5 years at average rainfall conditions (1987, 14.4 inches per year), 5 years representing the driest year (1976, 6.8 inches per year), and 5 years representing the wettest year (26.5 inches per year). UAC requires the model to be run until stable with average rainfall conditions, and then to be run for 5 years representing the wettest conditions. Per instruction from the Division of Solid and Hazardous Waste, five years of the driest year (drought conditions) were added to the model to simulate a worst-case scenario that could potentially kill off the vegetation of the evapotranspiration cover and compromise its performance.

Soil Hydraulic Parameters

The van Genuchten-Mualem single porosity model was used for all model scenarios. Soil hydraulic parameters were discussed in detail in Section 3.0 Soil Investigation and Hydraulic Properties of this report. See
Table 5 for a summary of the final values used for each model.

Boundary and Initial Conditions
An upper boundary condition of atmospheric with surface layer was used to allow up to 1 centimeter of water to pond at the landfill surface. A lower boundary condition of free drainage was used. A node spacing of 1 centimeter was used. The initial conditions for pressure head were set to -100 cm pressure (matric potential) at all depths in the profile. The pressure head at the surface node only was changed from -100 to 0 centimeters to simulate the boundary condition that water is ponding with no surface storage.

Transpiration Parameters
The Feddes root water uptake model was used for the evapotranspiration cover scenarios. Vegetation parameters (including root water uptake) were not included for the standard cover scenario. The local climate and growing conditions were considered in determining plant-related parameters.

The Feddes' parameters for grass were used for the evapotranspiration cover simulations. The native vegetation at the JRDA landfill includes grasses, cedar trees, rabbitbrush, and sagebrush. When big sagebrush plants are removed prior to seeding grasses, the sagebrush often reinvades the grassed areas (Cook & Lewis, 1963, Hull & Klomp, 1974, and NRCS, 2011). Adequately maintained native shrubs and sagebrush can be appropriate vegetation for evapotranspiration covers if they are adequately maintained (Final Guidance, 2013 and Albright, 2010). These plants, particularly sagebrush, have many desirable features that may lead to better performance of the evapotranspiration cover, including greater rainfall interception, protection of grass understory, deeper and larger lateral spread of roots, and year-round transpiration from evergreen leaves. Invasive trees will be removed from the cover annually. If native grasses, shrubs, and sagebrush invade the landfill area, this will be accepted.

Climate Data
Daily temperature, precipitation, and evapotranspiration data for the years under consideration were obtained from Utah State University's Utah Climate Center, Nephi Station. Daily soil temperatures were obtained for the National Weather Service's Cooperative Network station in Salt Lake City (SLC NWSFO AP), which closely matched temperatures in Nephi. Precipitation data is discussed in more detail in Section 2.0 Climatic Conditions of this report. The total rainfall over the 15 years of the model simulation is 239 inches (606 cm). The daily potential transpiration was calculated using the leaf area index method. Calculated transpiration was subtracted from daily evapotranspiration to determine daily evaporation.

Relative humidity data for 2012-2014 was obtained from the USU Climate Center's AgMet/AgWeather network and used to calculate minimum allowed surface pressure head.

Parameters Comparison

Model input parameters that are different for the two cover types are summarized in Table 6.

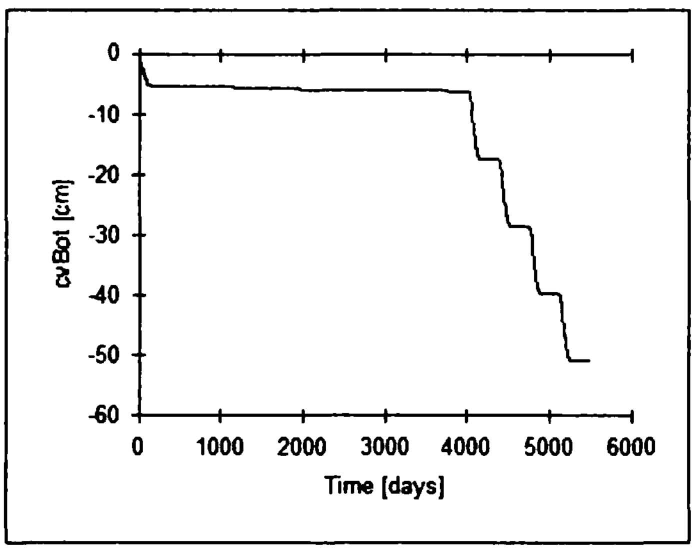
Table 6
Model Input Parameters Summary

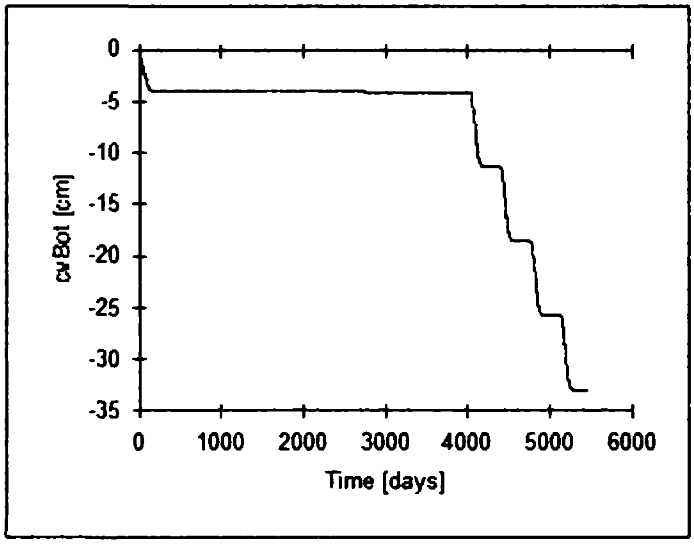
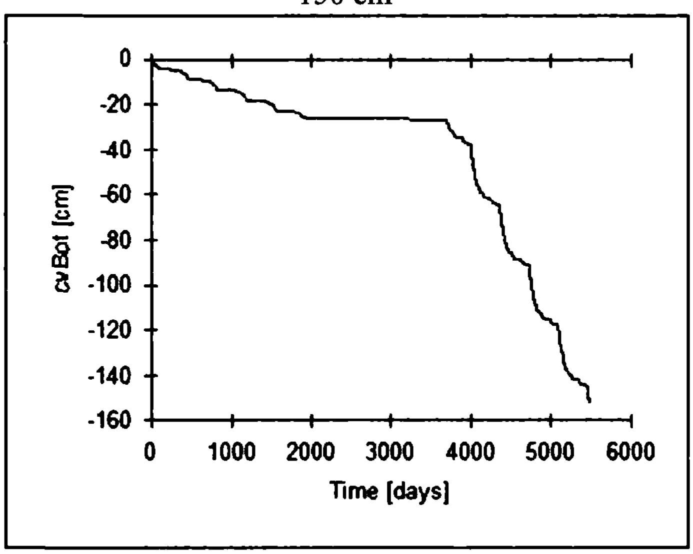
Model Input Parameter	Evapotranspiration Cover (82% compaction)	Evapotranspiration Cover (88% compaction)	Standard Clay Cover
Depth of soil profile	76 cm (30 inches)	76 cm (30 inches)	46 cm (18 inches)
Hydraulic model	van Genuchten-Mualem	van Genuchten-Mualem	van Genuchten-Mualem with air-entry value of -2 cm
Q_r, θ_r (% vol)	0.00	0.00	0.0068
Q_s, θ_s (% vol)	0.4888	0.4488	0.38
Alpha, α (cm^{-1})	0.05967	0.02522	0.0104
n (-)	1.32704	1.33067	1.199
K_s (cm/day)	63.1	6.394	0.864 (top 15 cm) 4.8 (bottom 31 cm)
Root water uptake	(see discussion)		not used

5.0 RESULTS

The results of each of the model simulations are shown in Table 7. The model output of cumulative flux through bottom of soil profile represents the cumulative infiltration through the landfill final cover. The model predicts a cumulative infiltration of 50 centimeters (19.7 inches) over 15 years for the evapotranspiration cover with 82% compaction, 33 centimeters (13.0 inches) for the evapotranspiration cover with 88% compaction, and 150 cm (59.1 inches) for the standard clay cover. Total rainfall over the 15-year model period is 606 cm (239 inches).

Table 7
HYDRUS-1D Model Simulation Results

Model	Cumulative Flux Through Bottom of Soil Profile (cm)	Cumulative Runoff (cm)
Evapotranspiration Cover (82% compaction)	50 cm 	0.2 cm

<table>
<tr><th>Model</th><th>Cumulative Flux Through Bottom of Soil Profile (cm)</th><th>Cumulative Runoff (cm)</th></tr>
<tr><td>Evapotranspiration Cover (88% compaction)</td><td>33 cm

</td><td>0.9 cm</td></tr>
<tr><td>Standard Clay Cover</td><td>150 cm

</td><td>0.2 cm</td></tr>
</table>

The ideal compaction of the cover lies midway between the modeled values, at 85%. Interpolating between the results of the two models gives a cumulative bottom flux of 41.5 centimeters for an evapotranspiration cover optimally compacted to 85% of maximum.

The model results show that the evapotranspiration cover achieves a significantly greater reduction in infiltration than is achieved by the standard design.

6.0 CONCLUSION

An evapotranspiration cover, constructed using soils similar to those tested from test pit 12-04 and compacted to 82-88% of the maximum laboratory density, achieves a greater reduction in infiltration than is achieved by the standard design. In addition, the evapotranspiration cover provides equivalent protection from wind and water erosion as achieved by the standard design. Standard clay covers in the arid climate of Utah are typically prone to desiccation cracking, allowing water to infiltrate into the landfill. This phenomenon is not shown in the modeled simulation. It is often difficult to maintain vegetation on standard covers, and they become prone to wind and water erosion. The evapotranspiration cover utilizes vegetation well-suited to native conditions, or native vegetation, and it is more easily maintained, allowing the evapotranspiration cover to provide superior protection from wind and water erosion.

The proposed evapotranspiration cover, constructed of materials from the JRDA landfill site, meets the requirements for the performance of the standard clay cover and therefore satisfies the requirements of the Utah Administrative Code and the Division of Solid and Hazardous Waste.

7.0 REFERENCES

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Utah Administrative Code (UAC) R315-303-3(4)

Utah State University Utah Climate Center, Global Historical Climatology Network.

Figures

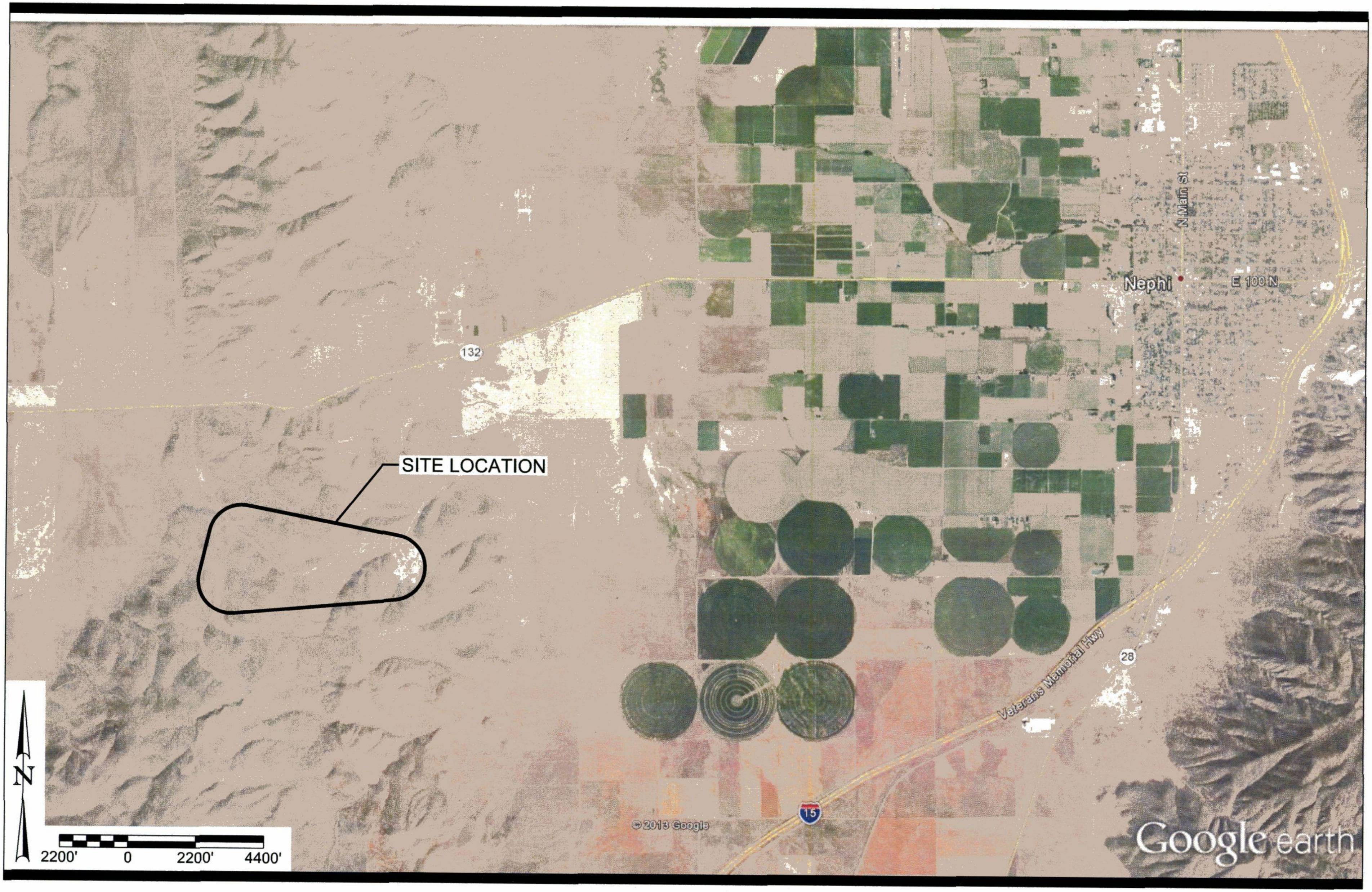

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Figure 1 VICINITY MAP

Juab RDA Landfill

Nephi, Juab County, Utah

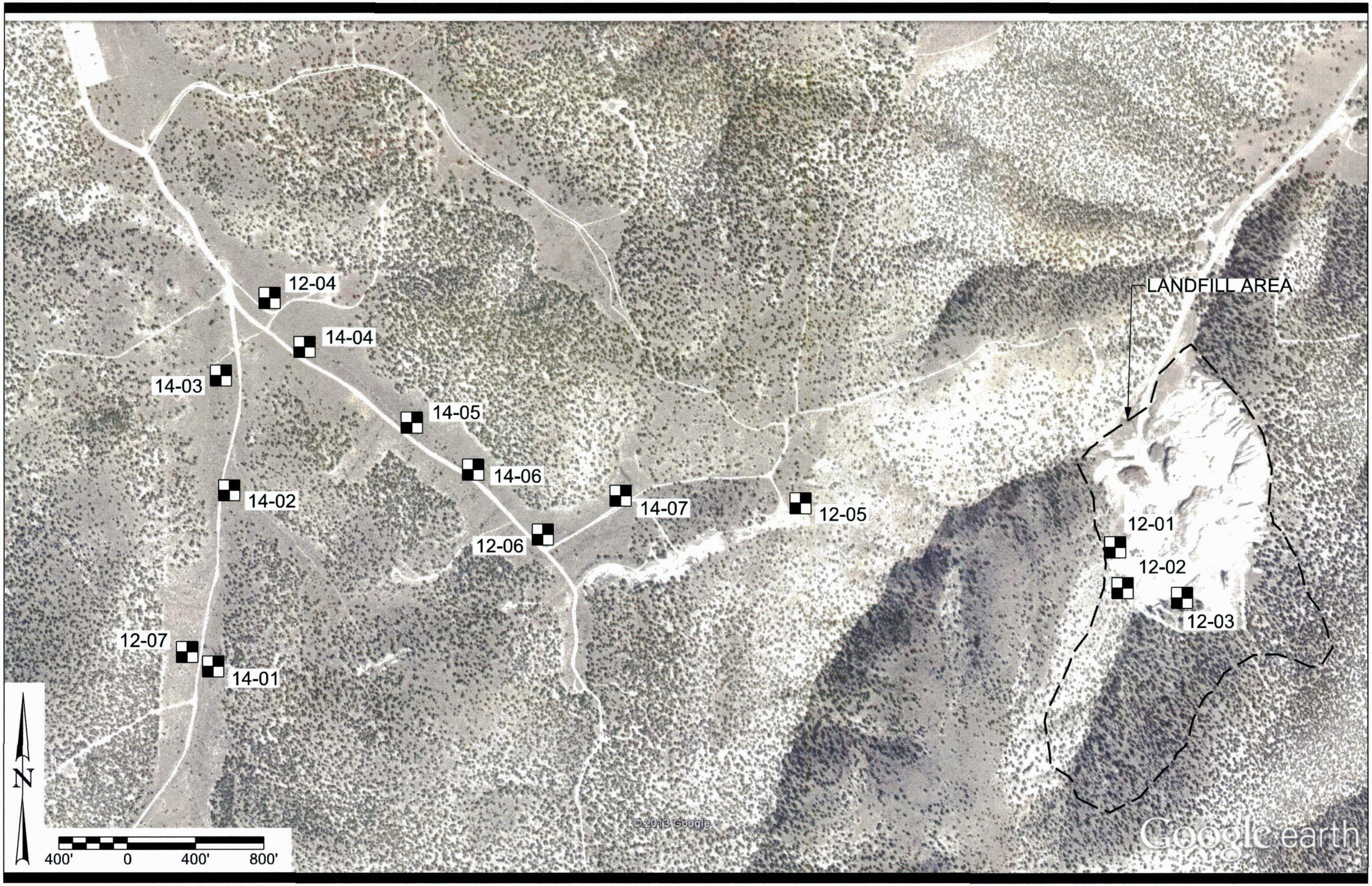

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Figure 2 SITE PLAN & TEST HOLE LOCATIONS

Juab RDA Landfill

Nephi, Juab County, Utah

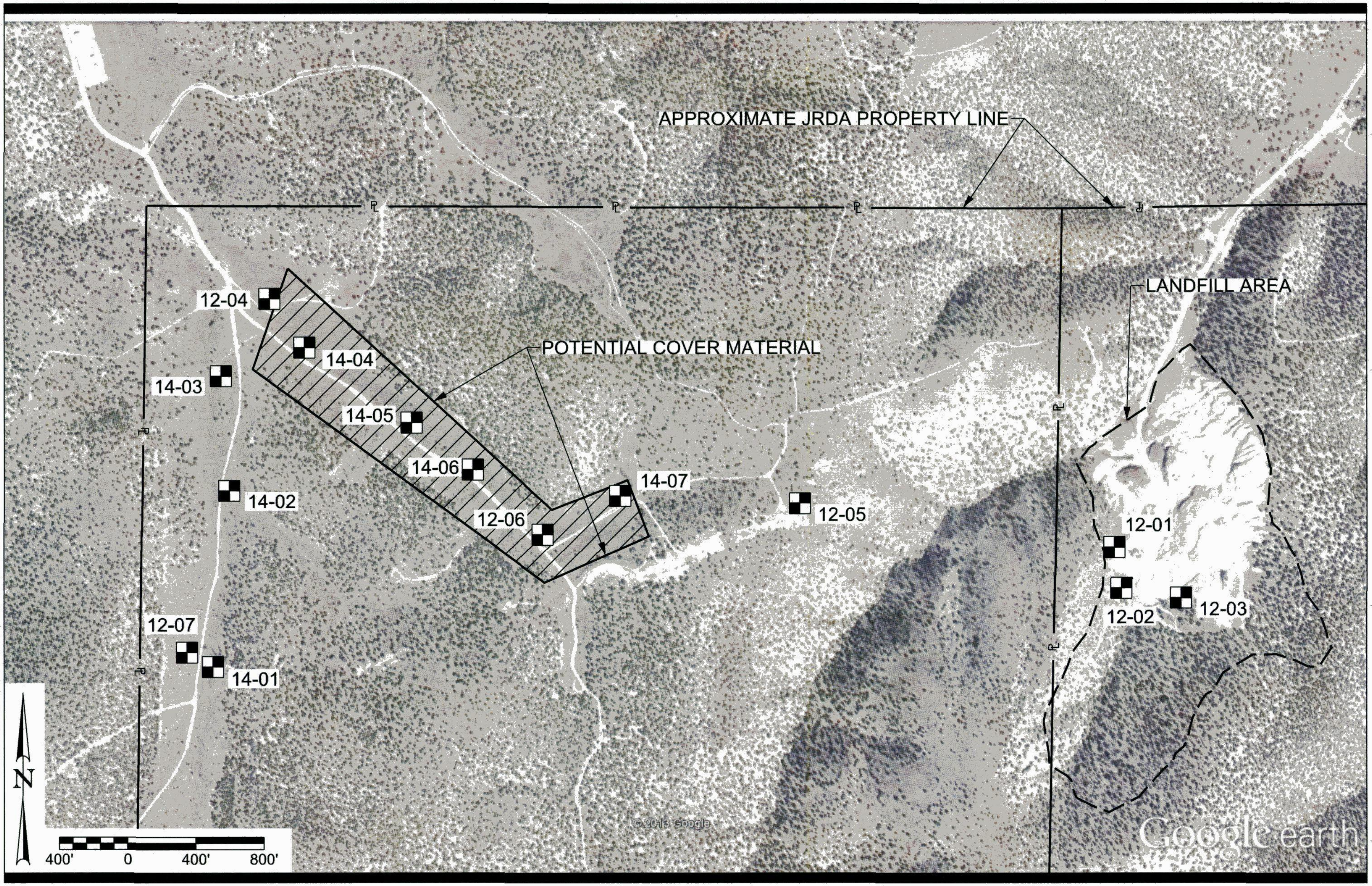

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Figure 3 LOCATION OF POTENTIAL COVER MATERIAL

Juab RDA Landfill

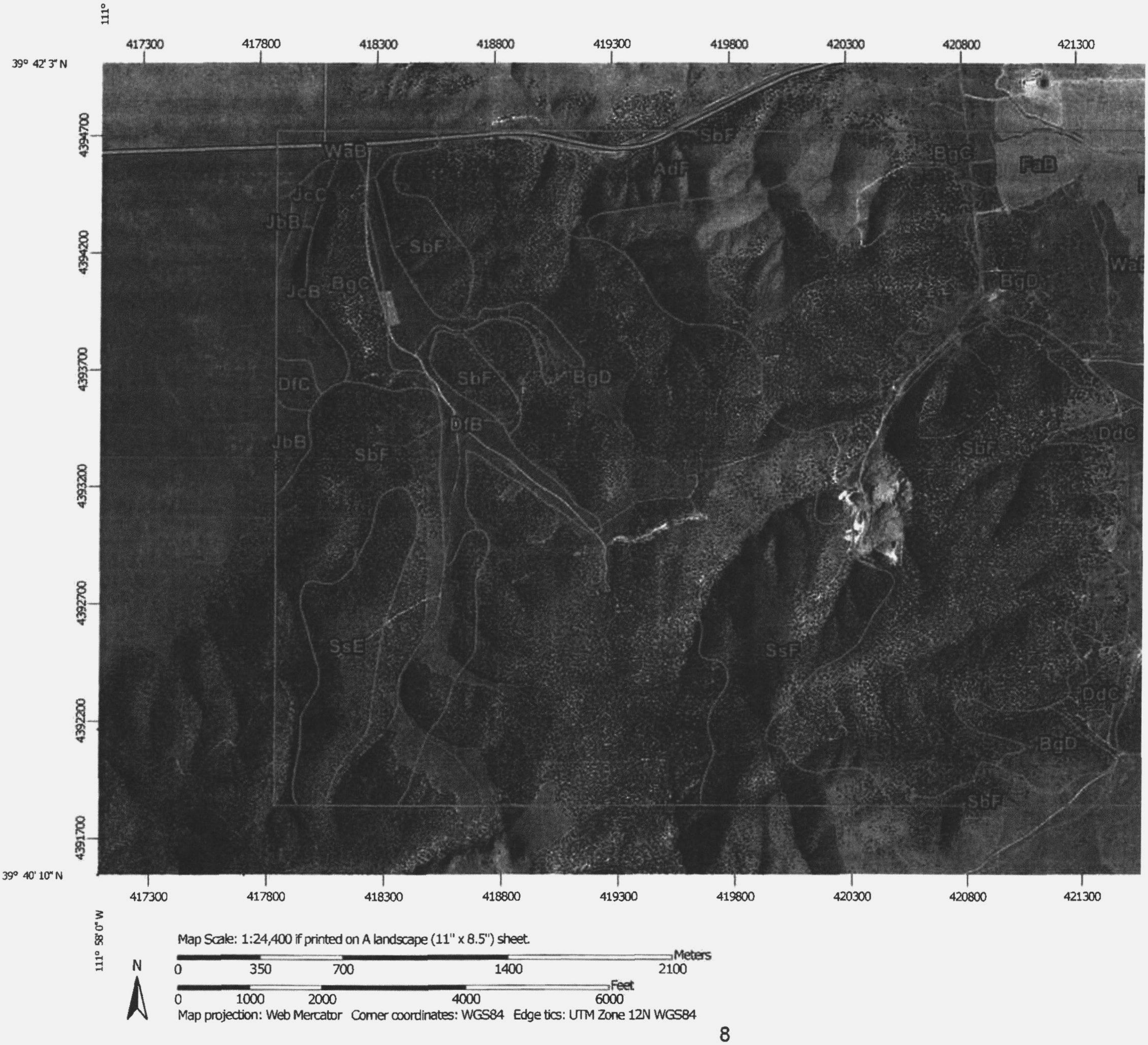
Nephi, Juab County, Utah

Appendix

NRCS Soil Map
Summary of Test Data
Test Pit Logs
Hydraulic Conductivity Testing Results

NRCS Soil Map

Soil Map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4391700
WaB
SbF
AdF
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FaB
JcC
JbB
SbF
BgC
JcB
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JbB
SbF
DdC
SsE
SsF
DdC
BgD
SbF
Map Scale: 1:24,400 if printed on A landscape (11" x 8.5") sheet.
Meters
0
350
700
1400
2100
Feet
0
1000
2000
4000
6000
N
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORM

The soil surveys that comprise your AC

Please rely on the bar scale on each m
measurements.

Source of Map: Natural Resources C
Web Soil Survey URL: http://websoil
Coordinate System: Web Mercator (

Maps from the Web Soil Survey are ba
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Albers equal-area conic projection, sho
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This product is generated from the USD
the version date(s) listed below.

Soil Survey Area: Fairfield-Nephi Are
Survey Area Data: Version 7, Dec 2:

Soil map units are labeled (as space allo
or larger.

Date(s) aerial images were photograph
13, 2011

The orthophoto or other base map on w
compiled and digitized probably differs
imagery displayed on these maps. As a
of map unit boundaries may be eviden

Map Unit Legend

Fairfield-Nephi Area, Utah (UT608)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
AdF	Amtoft, moist-Rock outcrop complex, 30 to 70 percent slopes	73.5	2.7%
BgC	Borvant cobbly loam, 2 to 8 percent slopes	79.4	2.9%
BgD	Borvant cobbly loam, 8 to 25 percent slopes	852.2	31.1%
DdC	Donnardo stony loam, 2 to 8 percent slopes	133.7	4.9%
DfB	Doyce loam, 2 to 4 percent slopes	82.0	3.0%
DfC	Doyce loam, 4 to 8 percent slopes	8.5	0.3%
FaB	Firmage gravelly loam, dry, 2 to 4 percent slopes	25.2	0.9%
JbB	Juab loam, 2 to 4 percent slopes	13.6	0.5%
JcB	Juab loam, gravelly substratum, 2 to 4 percent slopes	27.1	1.0%
JcC	Juab loam, gravelly substratum, 4 to 8 percent slopes	7.9	0.3%
McB	Manassa silt loam, moderately saline, 0 to 2 percent slopes	8.7	0.3%
SbF	Sandall very cobbly loam, 25 to 60 percent slopes	1,036.9	37.8%
SsE	Sumine-Reywat-Rock outcrop complex, 10 to 30 percent slopes	81.8	3.0%
SsF	Sumine-Reywat-Rock outcrop complex, 30 to 60 percent slopes	168.2	6.1%
WaB	Wales loam, 2 to 4 percent slopes	143.8	5.2%
Totals for Area of Interest		**2,742.4**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic

Summary of Test Data

RB&G ENGINEERING, INC.

Table 1

SUMMARY OF TEST DATA

PROJECT: Juab County Landfill
PROJECT NO.:
LOCATION: Nephi, UT
FEATURE: Test Pits

HOLE NO.	DEPTH BELOW GROUND SURFACE (ft)	IN-PLACE		Permeability @ Approx. 89% compaction of ASTM D-698	ATTERBERG LIMITS			MECHANICAL ANALYSIS			PERCENT FINER THAN 0.005 mm	UNIFIED SOIL CLASSIFICATION SYSTEM / (AASHTO CLASSIFICATION)
		DRY UNIT WEIGHT (pcf)	MOISTURE (%)		LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT & CLAY		
TP 12-01	1-3		8.8				NP	36	36	28		SM
TP 12-02	1-3		9.6				NP	26	61	13		SM
TP 12-03	1-3		8.4				NP	39	46	15		SM
TP 12-04	2-3		10.1	3.25 ft/yr 3.14 X 10e6 cm/sec	27	20	7	2	31	67	22.1	CL-ML
TP 12-06	2-3		10.5	2.03 ft/ yr 1.96 X 10e6 cm/ sec	29	19	10	1	28	71	28.1	CL
TP 12-07	2-3		10.2				NP	35	44	21		SM

NP=Non-Plastic

Test Pit Logs

TEST PIT LOG

TEST PIT NO. 12-01

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL

CLIENT: JUAB RDA

LOCATION: SEE SITE PLAN

EXCAVATION METHOD: DOZER

OPERATOR: -

DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000

DATE STARTED: 11/1/12

DATE COMPLETED: 11/1/12

GROUND ELEVATION: NOT MEASURED

LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–0.5					ML	brown, dry — SANDY SILT organics								
	0.5–4		Bucket (1–3 ft)			SM	lt. brown, moist — SILTY SAND W/GRAVEL becoming slightly cemented w/depth		8.8		NP	36	36	28	
	4						BOH								

LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

RB&G ENGINEERING, INC.

TEST PIT LOG

TEST PIT NO. 12-02

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL

CLIENT: JUAB RDA

LOCATION: SEE SITE PLAN

EXCAVATION METHOD: DOZER

OPERATOR: -

DEPTH TO WATER - INITIAL: ∇ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000

DATE STARTED: 11/1/12

DATE COMPLETED: 11/1/12

GROUND ELEVATION: NOT MEASURED

LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–0.5					ML	brown, dry — SANDY SILT organics								
	0.5–4 (1, 2, 3)		Bucket (≈1–3 ft)			SM	lt. brown, moist — SILTY SAND W/GRAVEL becoming slightly cemented w/depth		9.6		NP	26	61	13	
	4						BOH								

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LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS
- UC = Unconfined Compression
- CT = Consolidation
- DS = Direct Shear
- UU = Unconsolidated, Undrained
- CU = Consolidated, Undrained
- HYD = Hydrometer
- SS = Soluble Salt
- DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 12-03

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL

CLIENT: JUAB RDA

LOCATION: SEE SITE PLAN

EXCAVATION METHOD: DOZER

OPERATOR: -

DEPTH TO WATER - INITIAL: ∇ DRY' AFTER 24 HOURS: ▼ N.M.

PROJECT NUMBER: 200521.000

DATE STARTED: 11/1/12

DATE COMPLETED: 11/1/12

GROUND ELEVATION: NOT MEASURED

LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–5		Bucket (2–4 ft)			SM	SILTY SAND W/GRAVEL becoming slightly cemented w/depth lt. brown, moist		8.4		NP	39	46	15	
	5						BOH								

RB&G ENGINEERING, INC.

LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 12-04

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL
CLIENT: JUAB RDA
LOCATION: SEE SITE PLAN
EXCAVATION METHOD: RUBBER TIRE BACKHOE
OPERATOR: -
DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000
DATE STARTED: 11/1/12
DATE COMPLETED: 11/1/12
GROUND ELEVATION: NOT MEASURED
LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–1					CL	dk. brown, moist	LEAN CLAY W/SAND organics								
	1–3		Bucket (2–2.9)			CL-ML	brown, slightly moist	SANDY SILTY CLAY		10.1	27	7	2	31	67	
	3–4.25		Bucket (3.5–3.9)			CL-ML	lt. brown, slightly moist	SANDY SILTY CLAY W/GRAVEL gravels increasing w/depth								
	4.25–5					GM	lt. brown, slightly moist	SILTY GRAVEL W/SAND								
	5							BOH								

OT_LOGV1 NEPHILANDFILL.GPJ US EVAL.GDT 3/14/14

RB&G ENGINEERING, INC.

LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 12-05

PROJECT: JUAB RDA LANDFILL
CLIENT: JUAB RDA
LOCATION: SEE SITE PLAN
EXCAVATION METHOD: RUBBER TIRE BACKHOE
OPERATOR: -
DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000
DATE STARTED: 11/1/12
DATE COMPLETED: 11/1/12
GROUND ELEVATION: NOT MEASURED
LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
						SM	brown, slightly moist	SILTY SAND W/GRAVEL								
	1							BEDROCK								
								BOH								
	2															
	3															
	4															

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LEGEND:
DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)
UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 12-06

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL

CLIENT: JUAB RDA

LOCATION: SEE SITE PLAN

EXCAVATION METHOD: RUBBER TIRE BACKHOE

OPERATOR: -

DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000

DATE STARTED: 11/1/12

DATE COMPLETED: 11/1/12

GROUND ELEVATION: NOT MEASURED

LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–1					CL	dk. brown, moist	LEAN CLAY W/SAND organics								
	1–4		Bucket (2–3)			CL	brown, slightly moist	LEAN CLAY W/SAND		10.5	29	10	1	28	71	
	4–8.5		Bucket (5–6)			CL	lt. brown, slightly moist	SANDY LEAN CLAY								
			Bucket (7.5–8.5)			CL	lt. brown, slightly moist									
	8.5–9					GM	lt. brown, slightly moist	SILTY GRAVEL W/SAND								
	9							BOH								

JOT LOGV1 NEPHILANDFILL.GPJ US EVAL.GDT 3/14/14

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LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS

UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 12-07

PROJECT: JUAB RDA LANDFILL
CLIENT: JUAB RDA
LOCATION: SEE SITE PLAN
EXCAVATION METHOD: RUBBER TIRE BACKHOE
OPERATOR: -
DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000
DATE STARTED: 11/1/12
DATE COMPLETED: 11/1/12
GROUND ELEVATION: NOT MEASURED
LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–1					CL	dk. brown, moist — SANDY LEAN CLAY organics								
	1–3		Bucket (2–3)			SM	lt. brown, moist — SILTY SAND W/GRAVEL		10.3		NP	35	44	21	
	3						BOH								
	4														

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LEGEND:
DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)
UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 14-01

PROJECT: JUAB RDA LANDFILL
CLIENT: JUAB RDA
LOCATION: SEE SITE PLAN
EXCAVATION METHOD: 120 TRACKHOE
OPERATOR: -
DEPTH TO WATER - INITIAL: ∇ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000
DATE STARTED: 3/6/14
DATE COMPLETED: 3/6/14
GROUND ELEVATION: NOT MEASURED
LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample Type	Sample Rec. (in)	Sample See Legend	USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter. Liquid Limit	Atter. Plast. Index	Gradation Gravel (%)	Gradation Sand (%)	Gradation Silt/Clay (%)	Other Tests
	0–1					CL	dk. brown, moist	LEAN CLAY W/SAND organics								
	1–3.75		Bucket (2–3 ft)			CL	lt. brown, slightly moist	LEAN CLAY W/SAND								
	3.75–5					SM	lt. brown, slightly moist	SILTY SAND W/GRAVEL								
	5							BOH								

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LEGEND:
DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)
UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 14-02

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL	
CLIENT: JUAB RDA	PROJECT NUMBER: 200521.000
LOCATION: SEE SITE PLAN	DATE STARTED: 3/6/14
EXCAVATION METHOD: 120 TRACKHOE	DATE COMPLETED: 3/6/14
OPERATOR: -	GROUND ELEVATION: NOT MEASURED
DEPTH TO WATER - INITIAL: ▽ DRY' AFTER 24 HOURS: ▼ N.M.	LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–1.5					CL	dk. brown, moist — LEAN CLAY W/SAND organics								
	1.5–3		Bucket (approx. 2–2.9 ft)			CL	lt. brown, slightly moist — SANDY LEAN CLAY W/GRAVEL								
	3–4					GM	lt. brown, slightly moist — SILTY GRAVEL W/SAND								
	4						BOH								

OT_LOGV1 NEPHILANDFILL.GPJ US EVAL.GDT 3/14/14

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LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS
- UC = Unconfined Compression
- CT = Consolidation
- DS = Direct Shear
- UU = Unconsolidated, Undrained
- CU = Consolidated, Undrained
- HYD = Hydrometer
- SS = Soluble Salt
- DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 14-03

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL

CLIENT: JUAB RDA

LOCATION: SEE SITE PLAN

EXCAVATION METHOD: 120 TRACKHOE

OPERATOR: -

DEPTH TO WATER - INITIAL: ▽ DRY' AFTER 24 HOURS: ▼ N.M.

PROJECT NUMBER: 200521.000

DATE STARTED: 3/6/14

DATE COMPLETED: 3/6/14

GROUND ELEVATION: NOT MEASURED

LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–1.5					CL	dk. to lt. brown, moist to slightly moist — LEAN CLAY W/SAND organics in top 12"								
	1.5–2					GM	lt. brown, slightly moist — SILTY GRAVEL W/SAND								
	2						BOH								

Depth scale: 1, 2, 3, 4

LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; *0.45* ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

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DT_LOGV1 NEPHILANDFILL.GPJ US EVAL.GDT 3/14/14

TEST PIT LOG

TEST PIT NO. 14-04

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL

CLIENT: JUAB RDA

PROJECT NUMBER: 200521.000

LOCATION: SEE SITE PLAN

DATE STARTED: 3/6/14

EXCAVATION METHOD: 120 TRACKHOE

DATE COMPLETED: 3/6/14

OPERATOR: -

GROUND ELEVATION: NOT MEASURED

DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–1					CL	dk. brown, moist	LEAN CLAY W/SAND organics								
	1–4		Bucket (2–3)			CL	lt. brown, slightly moist	LEAN CLAY W/SAND								
	4–6		Bucket (5–6)			CL-ML	lt. brown, slightly moist	SANDY SILTY CLAY W/GRAVEL gravels increasing w/depth								
	6							BOH								

JT_LOGV1 NEPHILANDFILL.GPJ US EVAL.GDT 3/14/14

RB&G ENGINEERING, INC.

LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; *0.45* ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS

UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 14-05

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL

CLIENT: JUAB RDA

LOCATION: SEE SITE PLAN

EXCAVATION METHOD: 120 TRACKHOE

OPERATOR: -

DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000

DATE STARTED: 3/6/14

DATE COMPLETED: 3/6/14

GROUND ELEVATION: NOT MEASURED

LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–1.5					CL	dk. brown, moist	LEAN CLAY W/SAND organics								
	1.5–3.7		Bucket (2.0–2.9)			CL	brown, slightly moist	LEAN CLAY W/SAND								
	3.7–8.5		Bucket (5.0–5.9); Bucket (7.5–8.4)			CL	lt. brown, slightly moist	SANDY LEAN CLAY more sandy w/depth								
						CL	lt. brown, slightly moist									
	8.5–9					GM	lt. brown, slightly moist	SILTY GRAVEL W/SAND cobbles								
	9							BOH								

OT_LOGV1 NEPHILANDFILL.GPJ US EVAL.GDT 3/14/14

RB&G ENGINEERING, INC.

LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS

- UC = Unconfined Compression
- CT = Consolidation
- DS = Direct Shear
- UU = Unconsolidated, Undrained
- CU = Consolidated, Undrained
- HYD = Hydrometer
- SS = Soluble Salt
- DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 14-06

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL

CLIENT: JUAB RDA

LOCATION: SEE SITE PLAN

EXCAVATION METHOD: 120 TRACKHOE

OPERATOR: -

DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000

DATE STARTED: 3/6/14

DATE COMPLETED: 3/6/14

GROUND ELEVATION: NOT MEASURED

LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
	0–1.2					CL	dk. brown, moist — LEAN CLAY W/SAND organics								
	1.2–7.8		Bucket (2–2.9 ft)			CL	brown, slightly moist — SANDY LEAN CLAY								
			Bucket (6–6.9 ft)			CL	lt. brown, slightly moist								
	7.8–8.5					GM	lt. brown, slightly moist — SILTY GRAVEL W/SAND cobbles								
	8.5						BOH								

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9

RB&G ENGINEERING, INC.

LEGEND:

DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

TEST PIT LOG

TEST PIT NO. 14-07

SHEET 1 OF 1

PROJECT: JUAB RDA LANDFILL
CLIENT: JUAB RDA
LOCATION: SEE SITE PLAN
EXCAVATION METHOD: 120 TRACKHOE
OPERATOR: -
DEPTH TO WATER - INITIAL: ▽ DRY' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200521.000
DATE STARTED: 3/6/14
DATE COMPLETED: 3/6/14
GROUND ELEVATION: NOT MEASURED
LOGGED BY: J. BOONE

Elev. (ft)	Depth (ft)	Lithology	Sample Type	Sample Rec. (in)	Sample See Legend	USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter. Liquid Limit	Atter. Plast. Index	Gradation Gravel (%)	Gradation Sand (%)	Gradation Silt/Clay (%)	Other Tests
	0–1					CL	dk. brown, moist	SANDY LEAN CLAY organics								
	1–4.5		Bucket (2–3)			CL	lt. brown, slightly moist	SANDY LEAN CLAY								
	4.5–9		Bucket (7–8)			CL-ML	lt. brown, slightly moist	SANDY SILTY CLAY trace gravels								
	9–9.75					GM	lt. brown, slightly moist	SILTY GRAVEL W/SAND								
	9.75							BOH								

OT_LOGV1 NEPHILANDFILL.GPJ US EVAL.GDT 3/14/14

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LEGEND:
DISTURBED SAMPLE — Bucket ← Sample Type; 0.45 ← Torvane (tsf)
UNDISTURBED SAMPLE

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
UU = Unconsolidated, Undrained
CU = Consolidated, Undrained
HYD = Hydrometer
SS = Soluble Salt
DC = Dispersive Clay

Hydraulic Conductivity Testing Results

Laboratory Report for
RB&G Engineering, Inc.

JRDA Landfill Project

May 21, 2014

Daniel B. Stephens & Associates, Inc.

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

May 21, 2014

Carl Cook
RB&G Engineering, Inc.
1435 West 820 North
Provo, UT 84601
(801) 374-5771

Re: DBS&A Laboratory Report for the RB&G Engineering JRDA Landfill Project

Dear Mr. Cook:

Enclosed is the report for the RB&G Engineering JRDA Landfill project. 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 RB&G Engineering 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

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			
Test Pit 12-04 (82%, 87.8pcf)	X	X		X			X	X		X	X			X								
Test Pit 12-04 (88%, 94.3pcf)	X	X		X			X	X		X	X			X								

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

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

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

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

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

Notes

Sample Receipt:
One sample arrived on April 8, 2014, in two full 1-gallon Ziploc bags, double bagged. The bags arrived in a box with packing paper and were received in good order.

Sample Preparation and Testing Notes:
Two sub-samples were prepared for initial properties testing, saturated hydraulic conductivity testing, and the hanging column and pressure chamber portions of the moisture retention testing by remolding the material into testing rings to target 82% and 88% of the maximum dry bulk density, based on the client provided standard proctor compaction testing results. The density (in pcf) and the percent of maximum dry bulk density achieved were added to the sample ID's. Remaining bulk material was used to prepare sub-samples for the dewpoint potentiometer and relative humidity chamber portions of the moisture retention testing.

Total porosity calculations were performed using an assumed specific gravity value of 2.70.

Summary of Sample Preparation/Volume Changes (g/cm^3 and pcf)

	Proctor Data		Target Remold Parameters[1]			Actual Remold Data			Volume Change Post Saturation[2]			Volume Change Post Drying Curve[3]		
Sample Number	Opt. Moist. Cont. (%, g/g)	Max. Dry Density (g/cm^3)	Moist. Cont. (%, g/g)	Dry Bulk Density (g/cm^3)	% of Max. Density (%)	Moist. Cont. (%, g/g)	Dry Bulk Density (g/cm^3)	% of Max. Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Max. Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Max. Density (%)
Test Pit 12-04 (82%, 87.8pcf)	15.9	1.73	15.9	1.41	82%	16.7	1.41	81.5%	1.41	---	81.5%	1.41	---	81.5%
Test Pit 12-04 (88%, 94.3pcf)	15.9	1.73	15.9	1.52	88%	16.7	1.51	87.5%	1.51	---	87.5%	1.51	---	87.5%

	Proctor Data		Target Remold Parameters[1]			Actual Remold Data			Volume Change Post Saturation[2]			Volume Change Post Drying Curve[3]		
Sample Number	Opt. Moist. Cont. (%, g/g)	Max. Dry Density (pcf)	Moist. Cont. (%, g/g)	Dry Bulk Density (pcf)	% of Max. Density (%)	Moist. Cont. (%, g/g)	Dry Bulk Density (pcf)	% of Max. Density (%)	Dry Bulk Density (pcf)	% Volume Change (%)	% of Max. Density (%)	Dry Bulk Density (pcf)	% Volume Change (%)	% of Max. Density (%)
Test Pit 12-04 (82%, 87.8pcf)	15.9	107.7	15.9	88.3	82%	16.7	87.8	81.5%	87.8	---	81.5%	87.8	---	81.5%
Test Pit 12-04 (88%, 94.3pcf)	15.9	107.7	15.9	94.8	88%	16.7	94.3	87.5%	94.3	---	87.5%	94.3	---	87.5%

[1]Target Remold Parameters: Provided by the client.

[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 chamber testing. The 'Volume Change Post Drying Curve' values represent the final sample dimensions after the last hanging column or pressure chamber measurement.

Notes:

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

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

	Moisture Content						
	As Received		Remolded				
Sample Number	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
Test Pit 12-04 (82%, 87.8pcf)	16.7	23.5	---	---	1.41	1.64	47.9
Test Pit 12-04 (88%, 94.3pcf)	16.7	25.2	---	---	1.51	1.76	44.1

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

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis: Constant Head	Method of Analysis: Falling Head
Test Pit 12-04 (82%, 87.8pcf)	7.3E-04	---	X	
Test Pit 12-04 (88%, 94.3pcf)	7.4E-05	---	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)
Test Pit 12-04 (82%, 87.8pcf)	0	48.0
	15	47.3
	29	41.2
	86	34.0
	337	28.7
	17643	12.9
	64145	9.3
	245466	6.7
	848426	5.1
Test Pit 12-04 (88%, 94.3pcf)	0	44.5
	18	43.7
	53	39.8
	126	34.2
	337	30.5
	13053	15.1
	41608	11.0
	141548	8.1
	376306	6.5
	848426	5.4

‡‡ 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)
Test Pit 12-04 (82%, 87.8pcf)	0.0459	1.2064	0.00	48.88	---	---
Test Pit 12-04 (88%, 94.3pcf)	0.0194	1.2097	0.00	44.88	---	---

--- = 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 (%)
Test Pit 12-04 (82%, 87.8pcf)	16.7	23.5	---	---	1.41	1.64	47.9
Test Pit 12-04 (88%, 94.3pcf)	16.7	25.2	---	---	1.51	1.76	44.1

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

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

Job Name: RB&G Engineering, Inc.
Job Number: LB14.0073.00
Sample Number: Test Pit 12-04 (82%, 87.8pcf)
Project: JRDA Landfill Project
Location: NA

	As Received	Remolded
Test Date:	11-Apr-14	---
Field weight of sample* (g):	498.17	
Tare weight, ring (g):	132.87	
Tare weight, pan/plate (g):	0.00	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	312.97	
Sample volume (cm^3):	222.48	
Assumed particle density (g/cm^3):	2.70	
Gravimetric Moisture Content (% g/g):	16.7	
Volumetric Moisture Content (% vol):	23.5	
Dry bulk density (g/cm^3):	1.41	
Wet bulk density (g/cm^3):	1.64	
Calculated Porosity (% vol):	47.9	
Percent Saturation:	49.1	

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

Comments:

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

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

Job Name: RB&G Engineering, Inc.
Job Number: LB14.0073.00
Sample Number: Test Pit 12-04 (88%, 94.3pcf)
Project: JRDA Landfill Project
Location: NA

	As Received	Remolded
Test Date:	11-Apr-14	---
Field weight of sample* (g):	529.07	
Tare weight, ring (g):	133.72	
Tare weight, pan/plate (g):	0.00	
Tare weight, other (g):	0.00	
Dry weight of sample (g):	338.91	
Sample volume (cm^3):	224.39	
Assumed particle density (g/cm^3):	2.70	
Gravimetric Moisture Content (% g/g):	16.7	
Volumetric Moisture Content (% vol):	25.2	
Dry bulk density (g/cm^3):	1.51	
Wet bulk density (g/cm^3):	1.76	
Calculated Porosity (% vol):	44.1	
Percent Saturation:	57.1	

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

Comments:

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

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
Test Pit 12-04 (82%, 87.8pcf)	7.3E-04	---	X	
Test Pit 12-04 (88%, 94.3pcf)	7.4E-05	---	X	

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

Saturated Hydraulic Conductivity
Constant Head Method

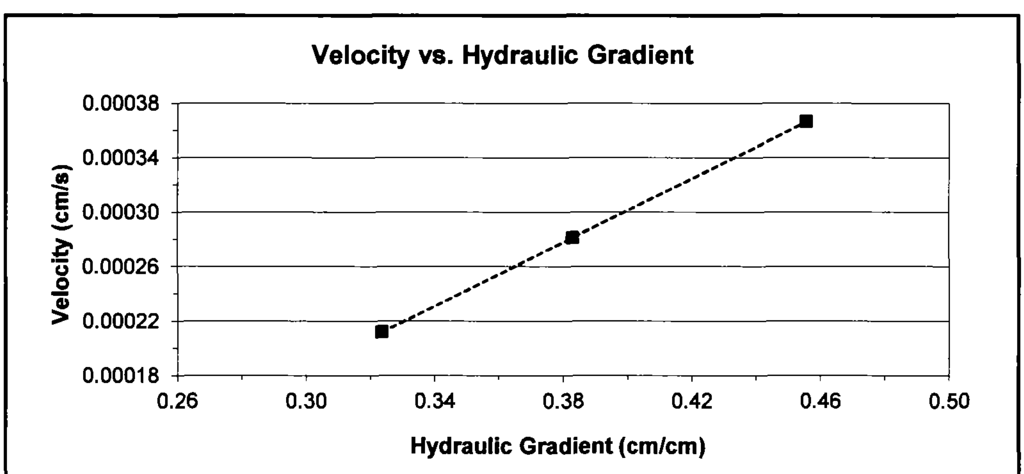
Job Name: RB&G Engineering, Inc.
Job Number: LB14.0073.00
Sample Number: Test Pit 12-04 (82%, 87.8pcf)
Project: JRDA Landfill Project
Location: NA

Type of water used: TAP
Collection vessel tare (g): 10.98
Sample length (cm): 7.57
Sample diameter (cm): 6.12
Sample x-sectional area (cm^2): 29.38

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:								
16-Apr-14	13:19:30	20.1	3.45	14.48	3.5	325	8.0E-04	8.1E-04
16-Apr-14	13:24:55							
Test # 2:								
16-Apr-14	14:43:41	20.1	2.9	37.97	27.0	3268	7.3E-04	7.4E-04
16-Apr-14	15:38:09							
Test # 3:								
16-Apr-14	15:53:01	20.1	2.45	13.28	2.3	369	6.6E-04	6.6E-04
16-Apr-14	15:59:10							

***Average Ksat* (cm/sec):** **7.3E-04**
***Oversize Corrected Ksat* (cm/sec):** **---**

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



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

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job Name:	RB&G Engineering, Inc.	*Type of water used:*	TAP
Job Number:	LB14.0073.00	*Collection vessel tare* (g):	11.05
Sample Number:	Test Pit 12-04 (88%, 94.3pcf)	*Sample length* (cm):	7.62
Project:	JRDA Landfill Project	*Sample diameter* (cm):	6.12
Location:	NA	*Sample x-sectional area* (cm^2):	29.46

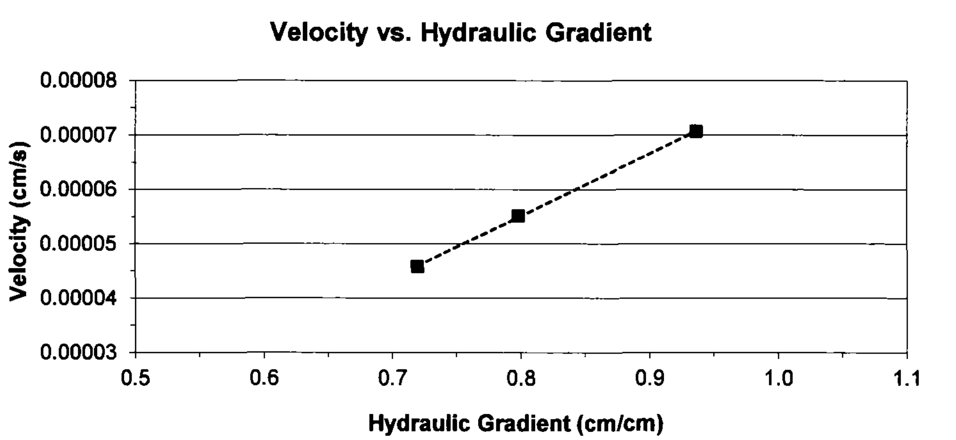
Date	Time	Temp (°C)	Head (cm)	Q + Tare (g)	Q (cm^3)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:								
16-Apr-14	13:19:40	20.1	6.75	11.66	0.6	293	8.0E-05	8.0E-05
16-Apr-14	13:24:33							
Test # 2:								
16-Apr-14	14:43:25	20.1	5.7	16.35	5.3	3259	7.4E-05	7.4E-05
16-Apr-14	15:37:44							
Test # 3:								
16-Apr-14	15:52:38	20.1	5.1	12.11	1.1	786	6.8E-05	6.9E-05
16-Apr-14	16:05:44							

***Average Ksat* (cm/sec):** **7.4E-05**

***Oversize Corrected Ksat* (cm/sec):** **---**

Comments:

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



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

Moisture Retention Characteristics

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
Test Pit 12-04 (82%, 87.8pcf)	0	48.0
	15	47.3
	29	41.2
	86	34.0
	337	28.7
	17643	12.9
	64145	9.3
	245466	6.7
	848426	5.1
Test Pit 12-04 (88%, 94.3pcf)	0	44.5
	18	43.7
	53	39.8
	126	34.2
	337	30.5
	13053	15.1
	41608	11.0
	141548	8.1
	376306	6.5
	848426	5.4

‡‡ 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)
Test Pit 12-04 (82%, 87.8pcf)	0.0459	1.2064	0.00	48.88	---	---
Test Pit 12-04 (88%, 94.3pcf)	0.0194	1.2097	0.00	44.88	---	---

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

Moisture Retention Data
Hanging Column / Pressure Plate
(Soil-Water Characteristic Curve)

Job Name: RB&G Engineering, Inc.
Job Number: LB14.0073.00
Sample Number: Test Pit 12-04 (82%, 87.8pcf)
Project: JRDA Landfill Project
Location: NA

Dry wt. of sample (g): 312.97
Tare wt., ring (g): 132.87
Tare wt., screen & clamp (g): 28.27
Initial sample volume (cm^3): 222.48
Initial dry bulk density (g/cm^3): 1.41
Assumed particle density (g/cm^3): 2.70
Initial calculated total porosity (%): 47.90

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	17-Apr-14	8:30	580.95	0	48.02
	24-Apr-14	13:15	579.33	14.5	47.29
	2-May-14	10:10	565.88	29.0	41.25
	9-May-14	14:30	549.73	86.0	33.99
Pressure plate:	19-May-14	8:15	537.89	337	28.67

Volume Adjusted Data[1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change[2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	---	---	---	---
	14.5	---	---	---	---
	29.0	---	---	---	---
	86.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

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

Technician Notes:

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

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Dew Point Potentiometer / Relative Humidity Box
(Soil-Water Characteristic Curve)

Sample Number: Test Pit 12-04 (82%, 87.8pcf)

Initial sample bulk density (g/cm³): 1.41
Fraction of test sample used (<2.00mm fraction) (%): 91.43

Dry weight of dew point potentiometer sample* (g): 164.69
Tare weight, jar (g): 117.21

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)
Dew point potentiometer:	25-Apr-14	11:39	169.47	17643	12.94
	24-Apr-14	9:54	168.13	64145	9.32
	23-Apr-14	10:45	167.18	245466	6.74

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm³)	% Volume Change [2] (%)	Adjusted Density (g/cm³)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	17643	---	---	---	---
	64145	---	---	---	---
	245466	---	---	---	---

Dry weight of relative humidity box sample* (g): 62.59
Tare weight (g): 42.28

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	25-Apr-14	12:20	63.39	848426	5.07

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm³)	% Volume Change [2] (%)	Adjusted Density (g/cm³)	Adjusted Calc. Porosity (%)
Relative humidity box:	848426	---	---	---	---

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

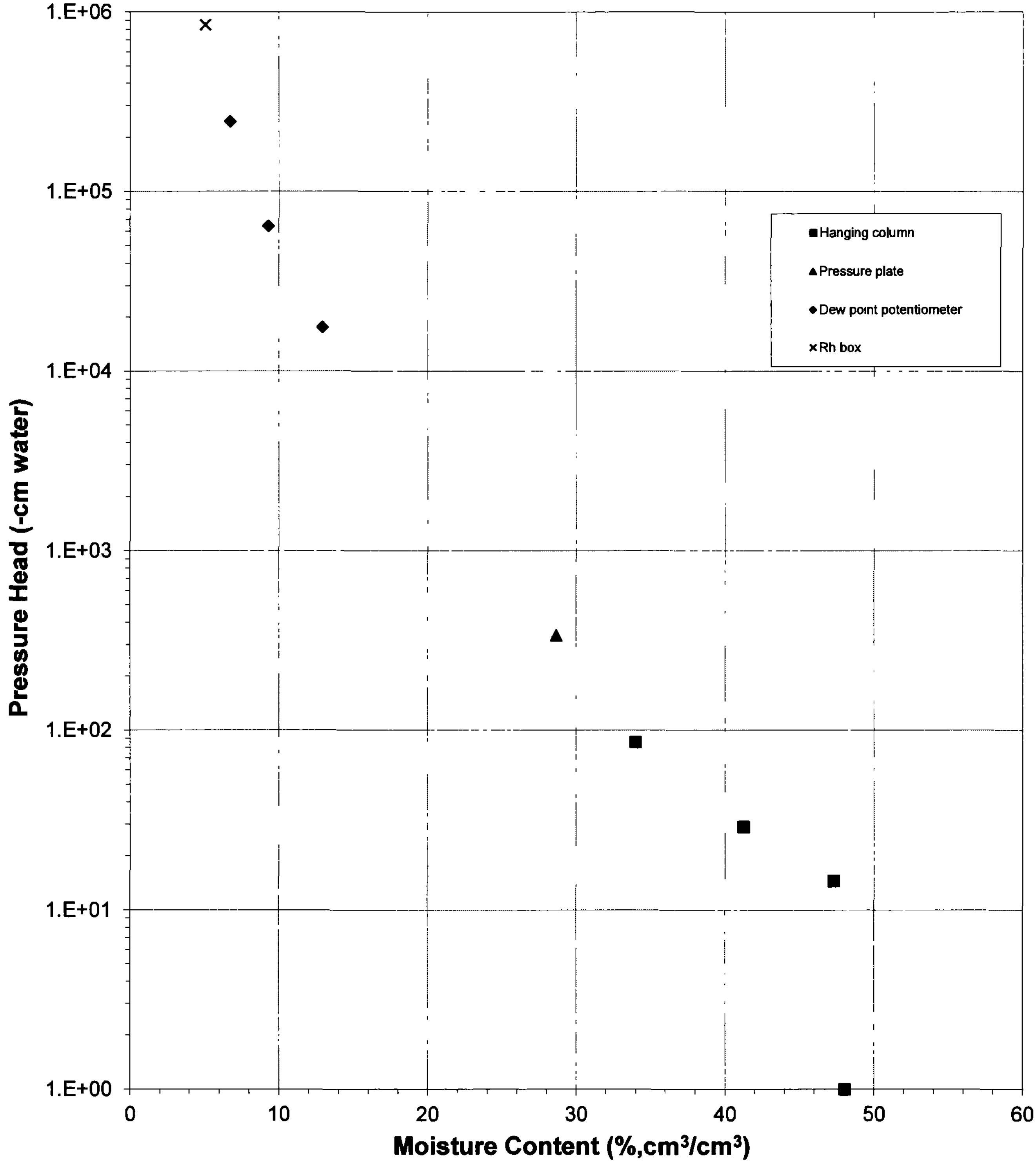
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm³.

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

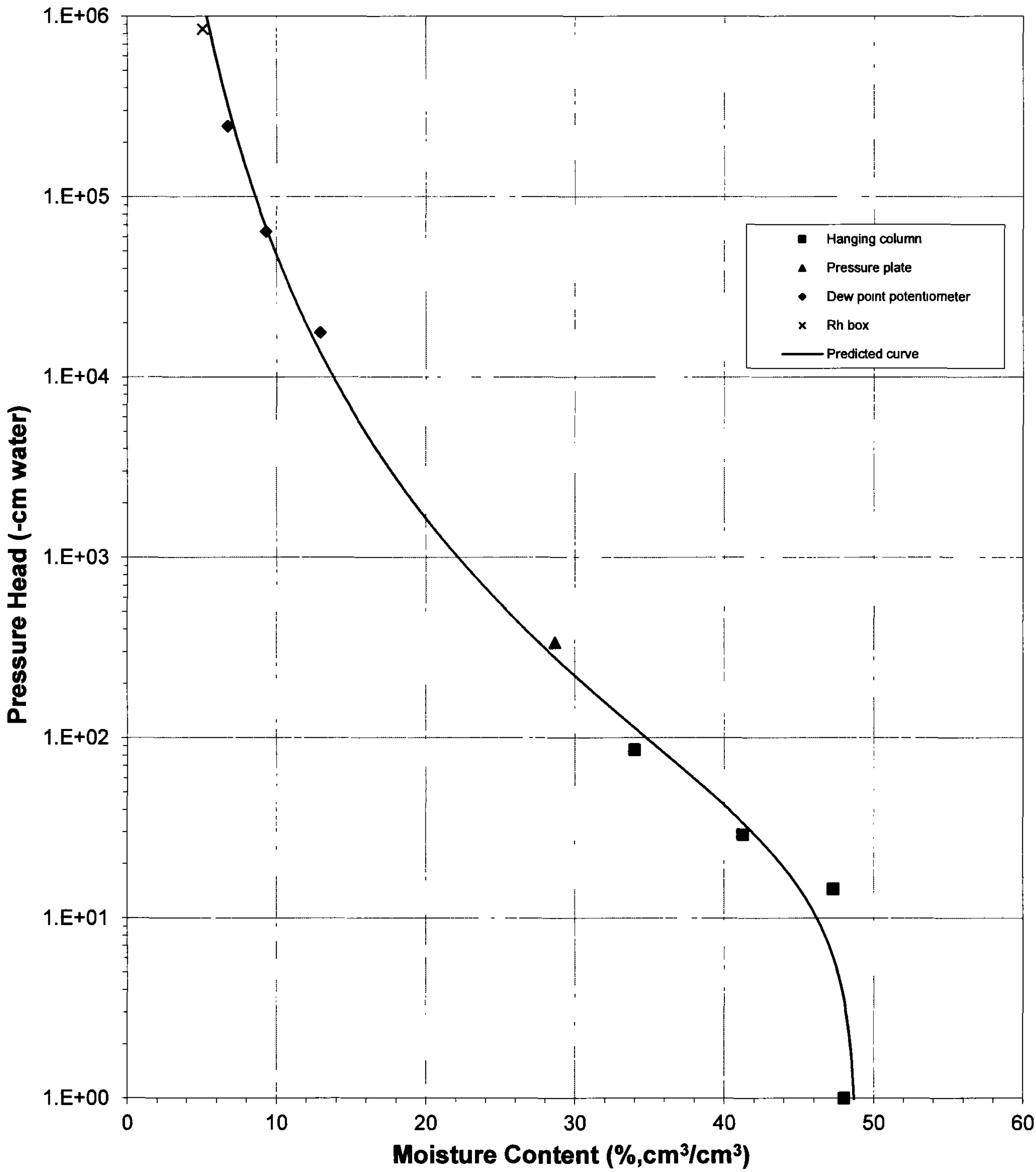
Water Retention Data Points

Sample Number: Test Pit 12-04 (82%, 87.8pcf)



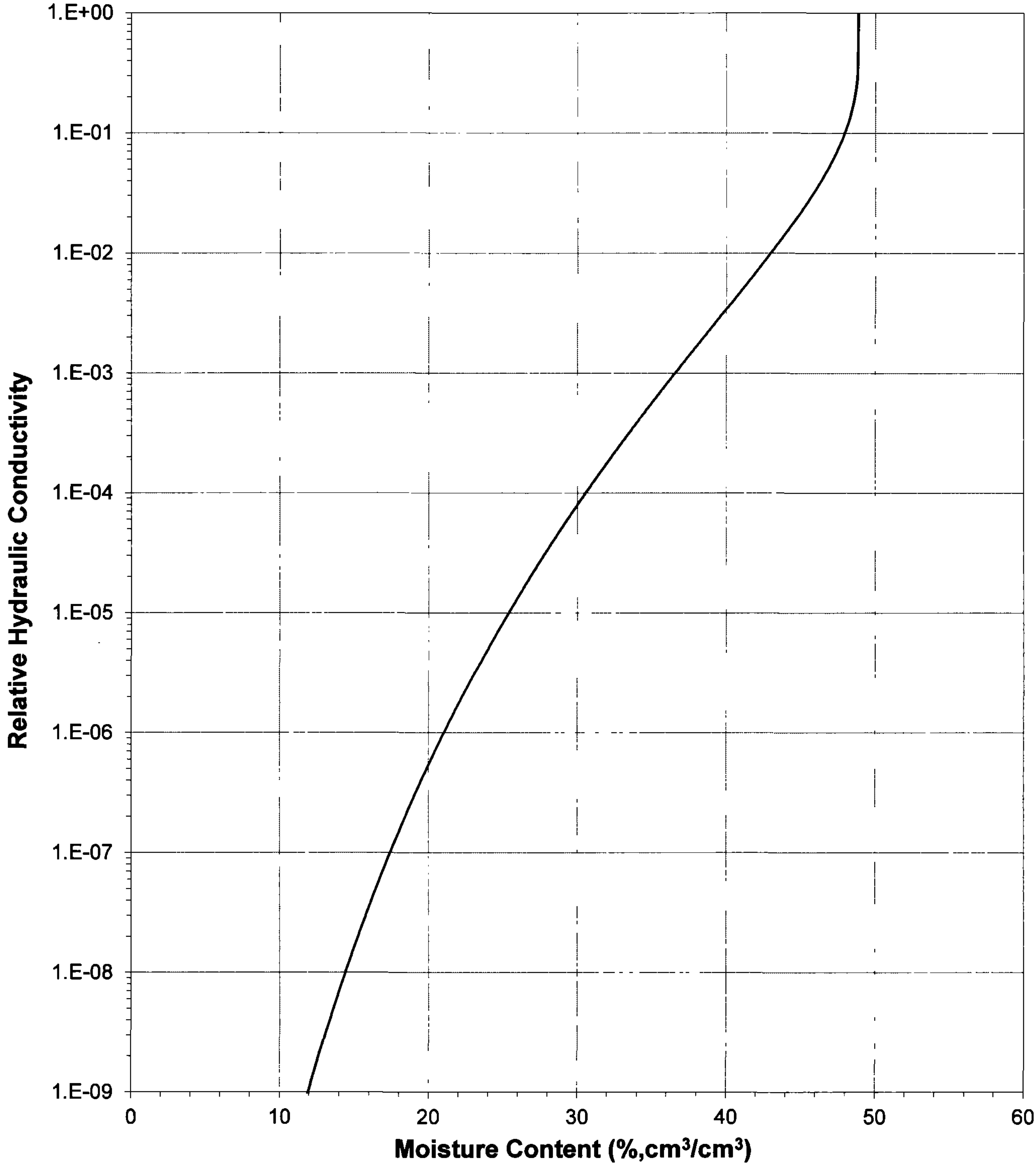
Predicted Water Retention Curve and Data Points

Sample Number: Test Pit 12-04 (82%, 87.8pcf)



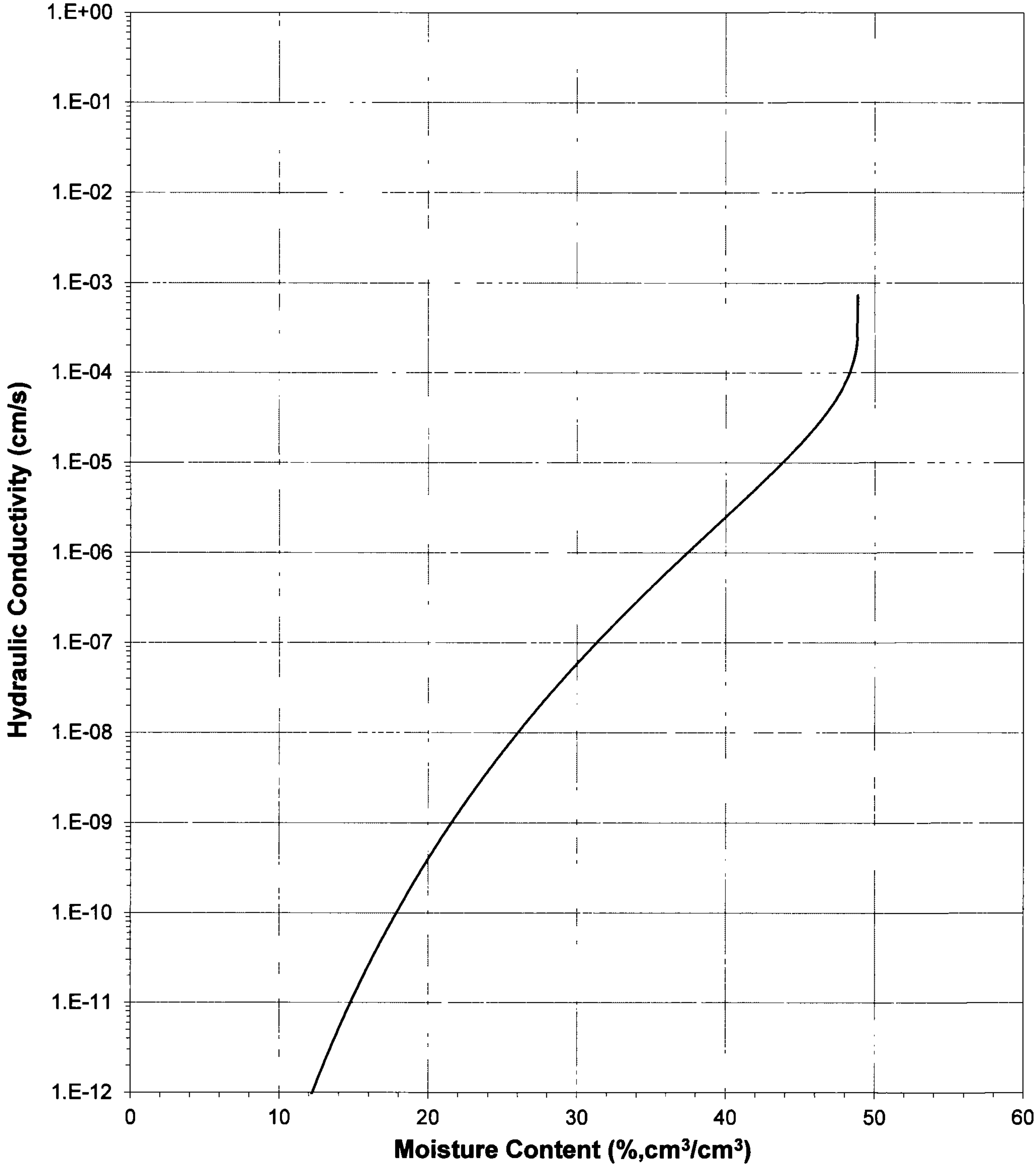
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: Test Pit 12-04 (82%, 87.8pcf)



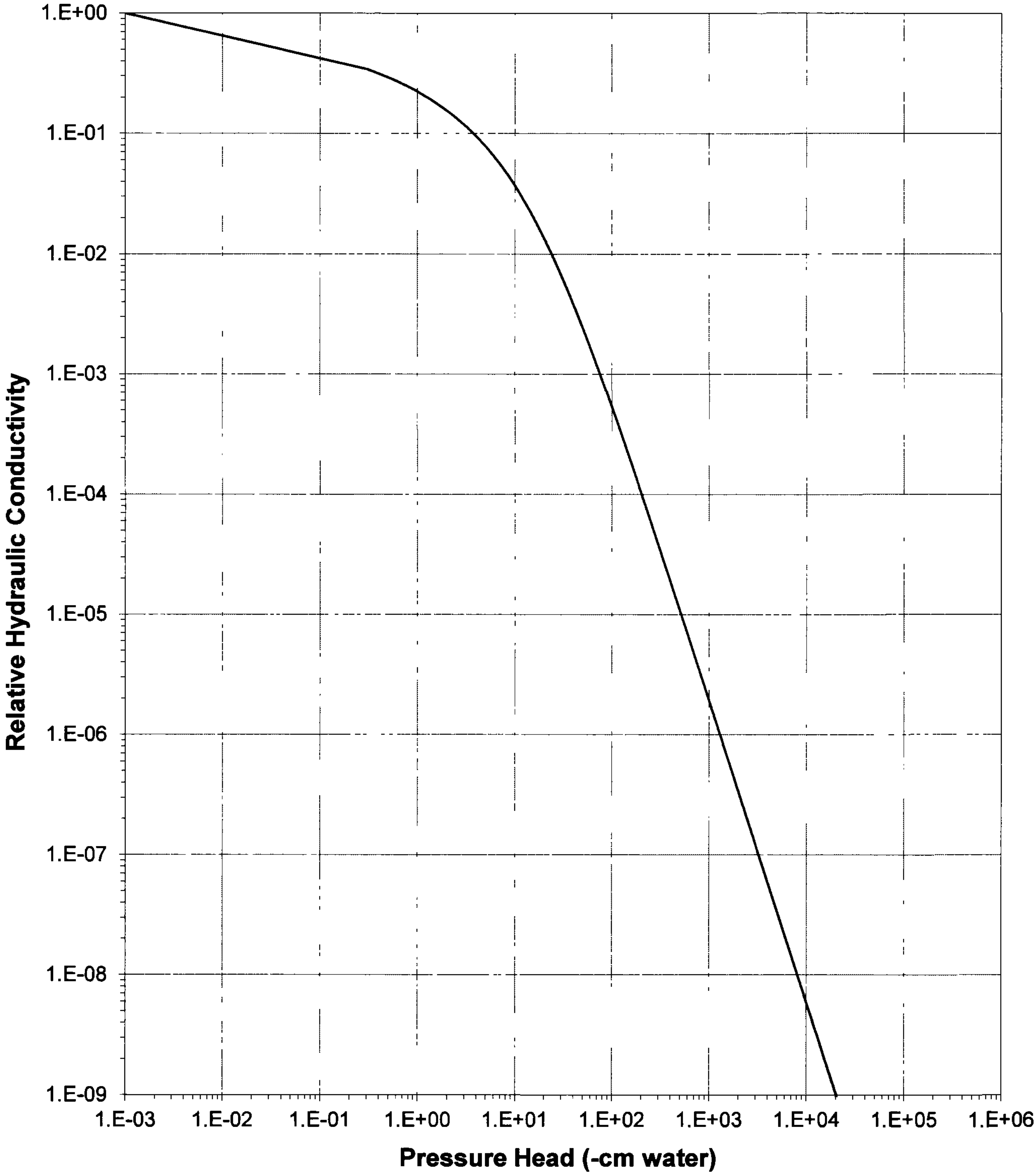
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: Test Pit 12-04 (82%, 87.8pcf)



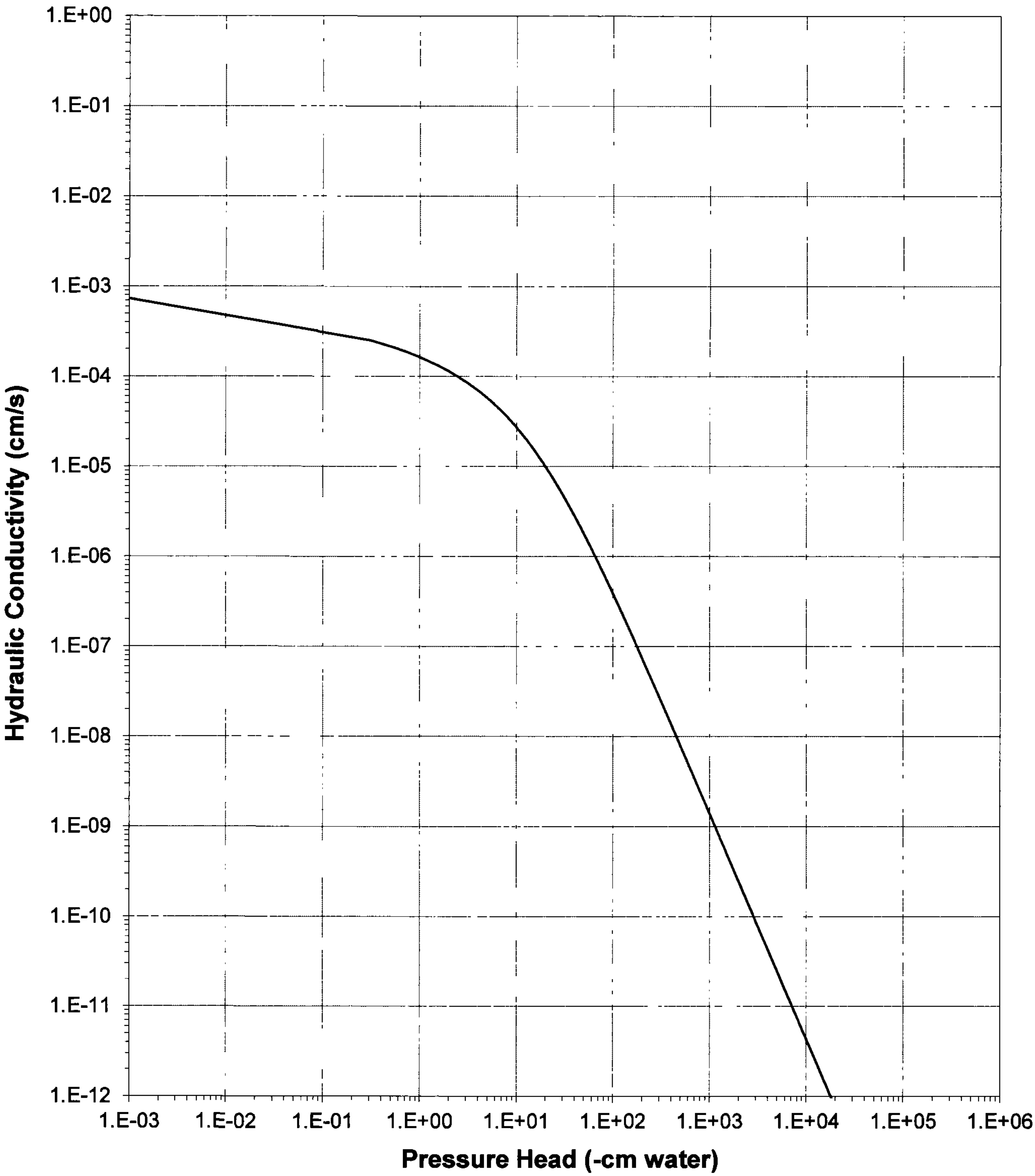
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: Test Pit 12-04 (82%, 87.8pcf)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: Test Pit 12-04 (82%, 87.8pcf)



Moisture Retention Data

Hanging Column / Pressure Plate

(Soil-Water Characteristic Curve)

Job Name: RB&G Engineering, Inc.
Job Number: LB14.0073.00
Sample Number: Test Pit 12-04 (88%, 94.3pcf)
Project: JRDA Landfill Project
Location: NA

Dry wt. of sample (g): 338.91
Tare wt., ring (g): 133.72
Tare wt., screen & clamp (g): 26.58
Initial sample volume (cm^3): 224.39
Initial dry bulk density (g/cm^3): 1.51
Assumed particle density (g/cm^3): 2.70
Initial calculated total porosity (%): 44.06

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	17-Apr-14	8:30	599.12	0	44.53
	24-Apr-14	15:00	597.23	18.0	43.68
	2-May-14	10:00	588.49	53.0	39.79
	9-May-14	14:30	575.85	126.0	34.15
Pressure plate:	19-May-14	8:15	567.54	337	30.45

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	---	---	---	---
	18.0	---	---	---	---
	53.0	---	---	---	---
	126.0	---	---	---	---
Pressure plate:	337	---	---	---	---

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

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

Technician Notes:

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: Test Pit 12-04 (88%, 94.3pcf)

Initial sample bulk density (g/cm³): 1.51

Fraction of test sample used (<2.00mm fraction) (%): 91.43

Dry weight of dew point potentiometer sample* (g): 163.25

Tare weight, jar (g): 116.24

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)
Dew point potentiometer:	24-Apr-14	11:45	168.38	13053	15.08
	24-Apr-14	10:36	167.01	41608	11.03
	23-Apr-14	14:46	166.01	141548	8.11
	23-Apr-14	10:55	165.47	376306	6.51

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm³)	% Volume Change [2] (%)	Adjusted Density (g/cm³)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	13053	---	---	---	---
	41608	---	---	---	---
	141548	---	---	---	---
	376306	---	---	---	---

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/cm³.

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

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

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: Test Pit 12-04 (88%, 94.3pcf)

Initial sample bulk density (g/cm^3): 1.51

Fraction of test sample used (<2.00mm fraction) (%): 91.43

Dry weight of relative humidity box sample* (g): 60.91

Tare weight (g): 39.93

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	25-Apr-14	12:20	61.73	848426	5.44

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:	848426	---	---	---	---

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

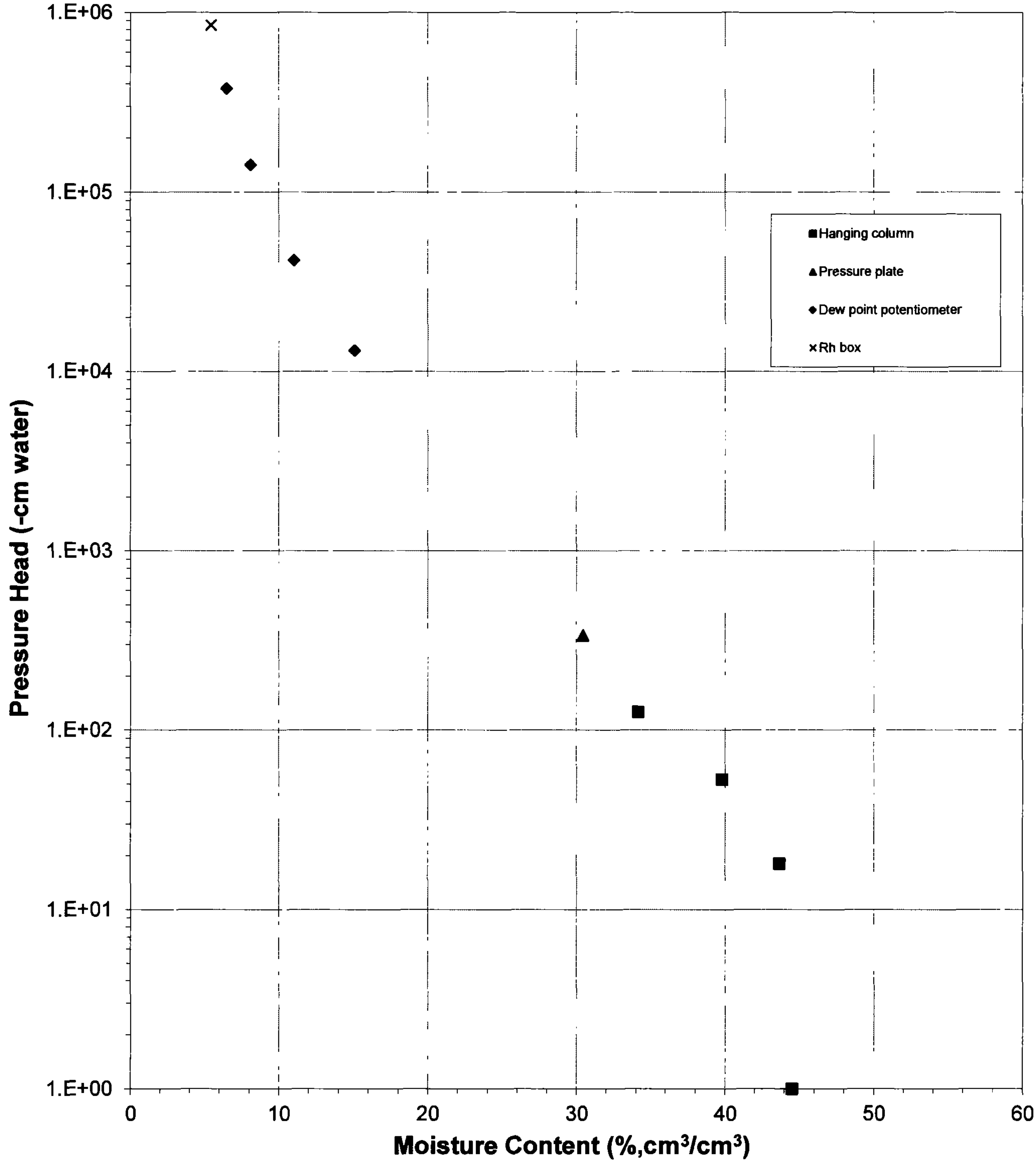
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

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

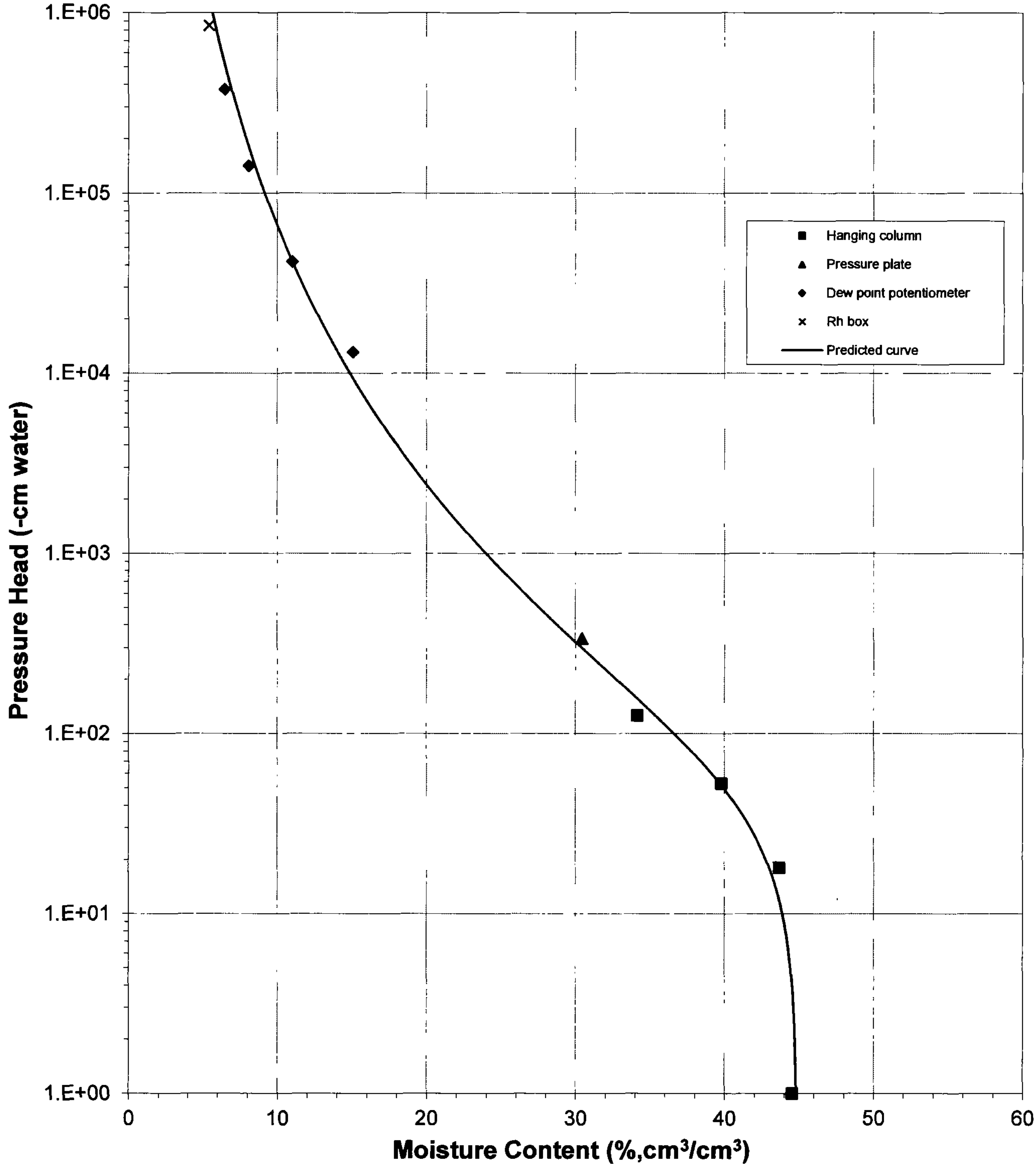
Water Retention Data Points

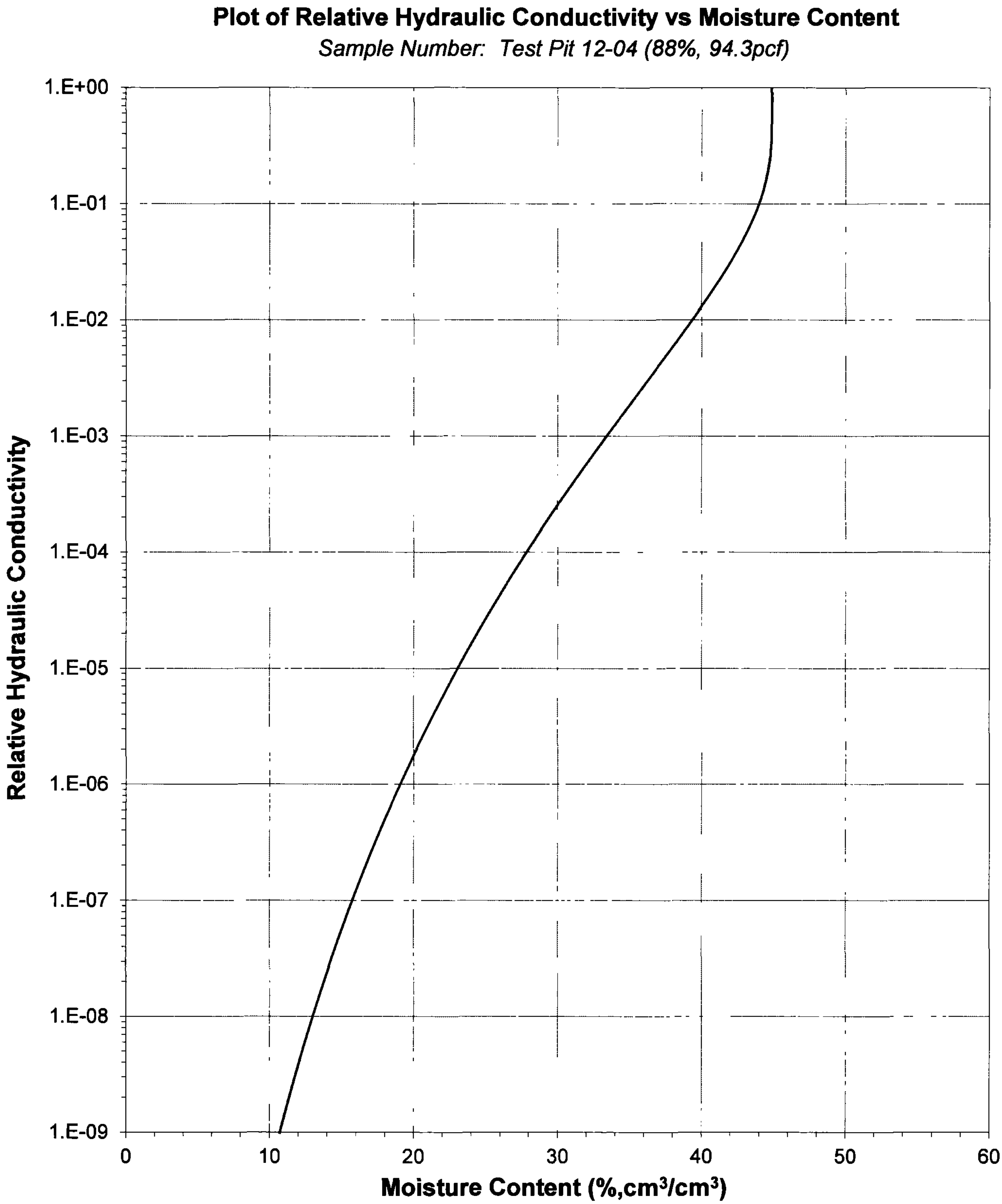
Sample Number: Test Pit 12-04 (88%, 94.3pcf)



Predicted Water Retention Curve and Data Points

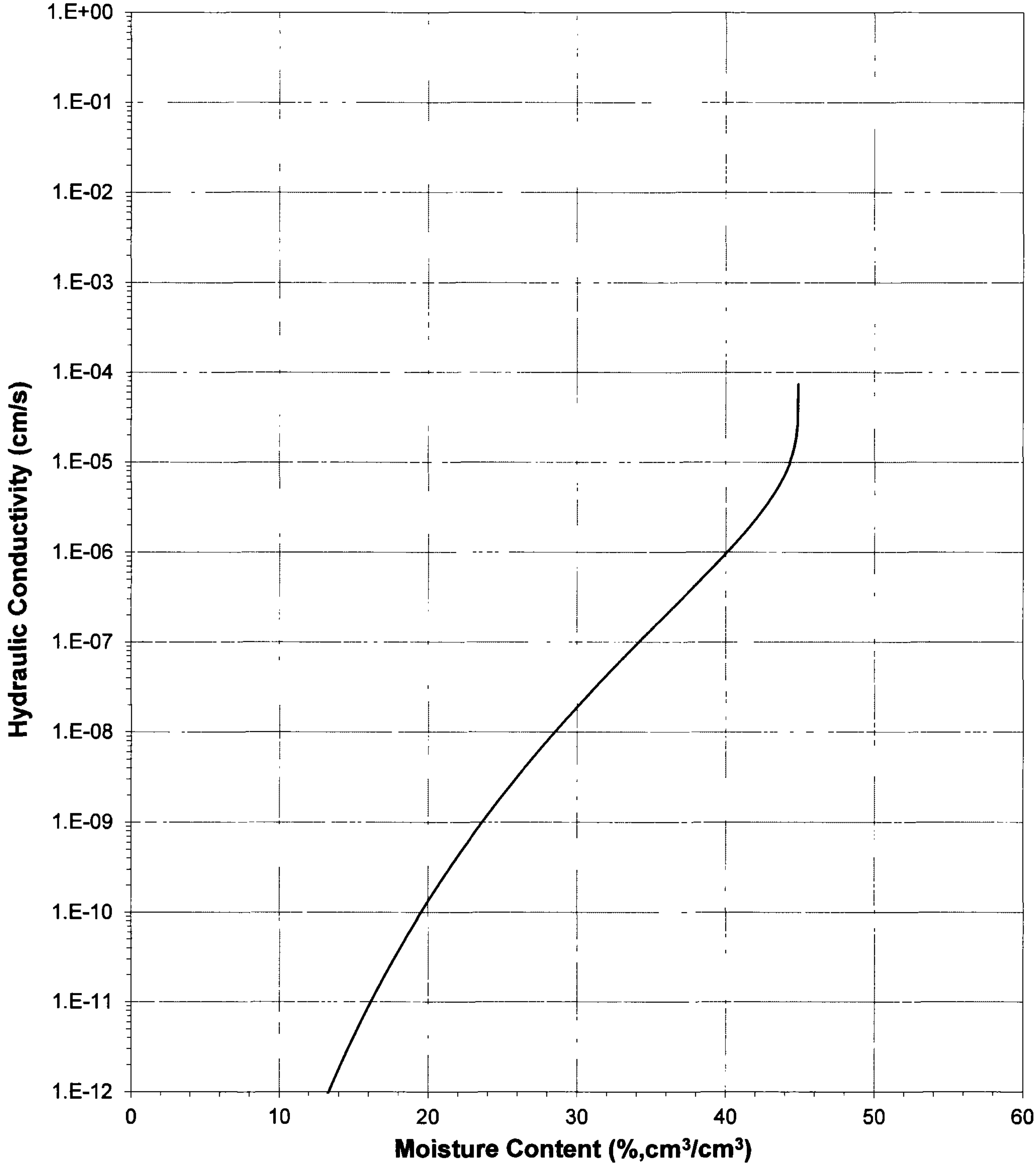
Sample Number: Test Pit 12-04 (88%, 94.3pcf)




Plot of Relative Hydraulic Conductivity vs Moisture Content
Sample Number: Test Pit 12-04 (88%, 94.3pcf)
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
Relative Hydraulic Conductivity
0
10
20
30
40
50
60
Moisture Content (%,cm3/cm3)

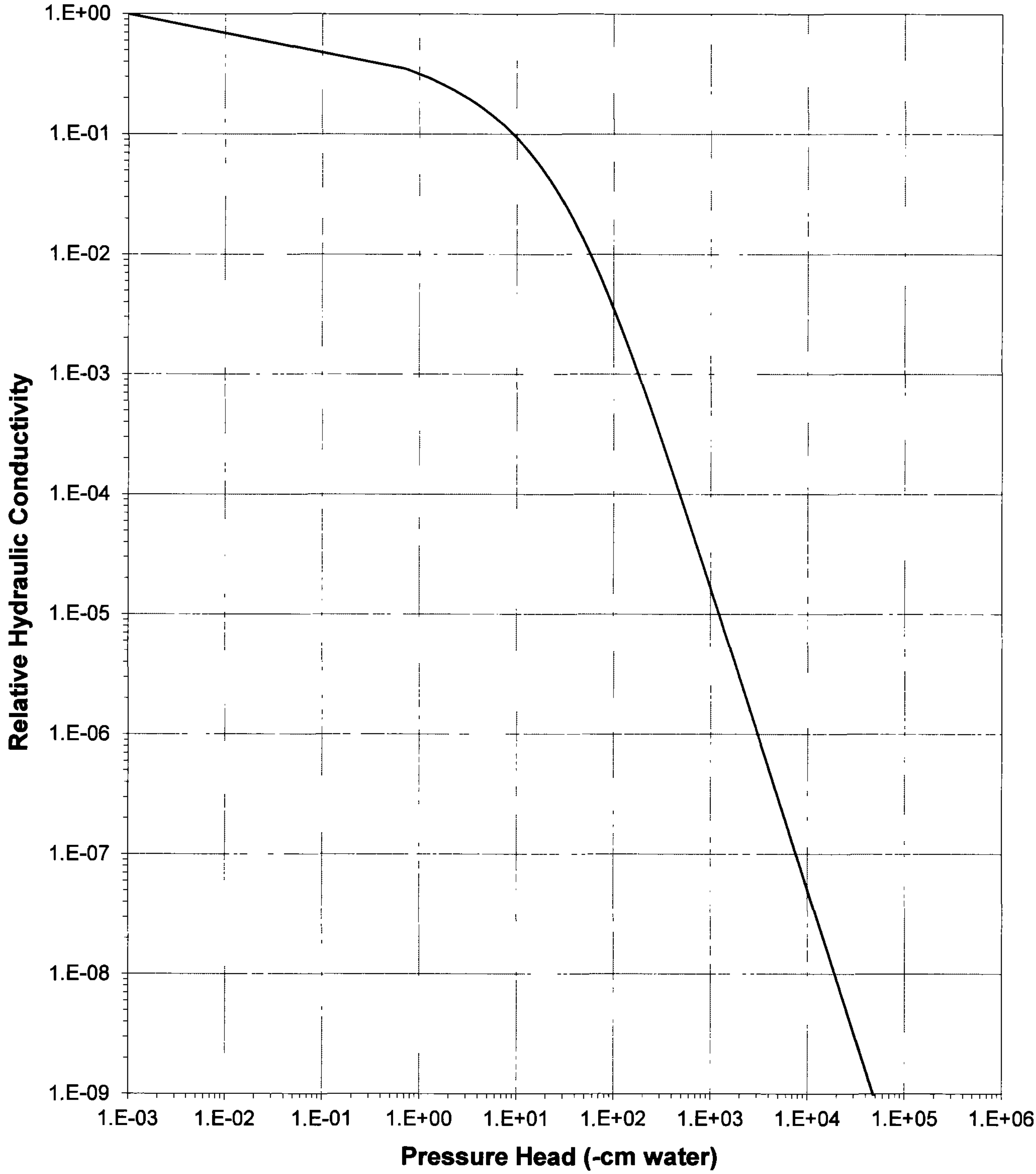
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: Test Pit 12-04 (88%, 94.3pcf)



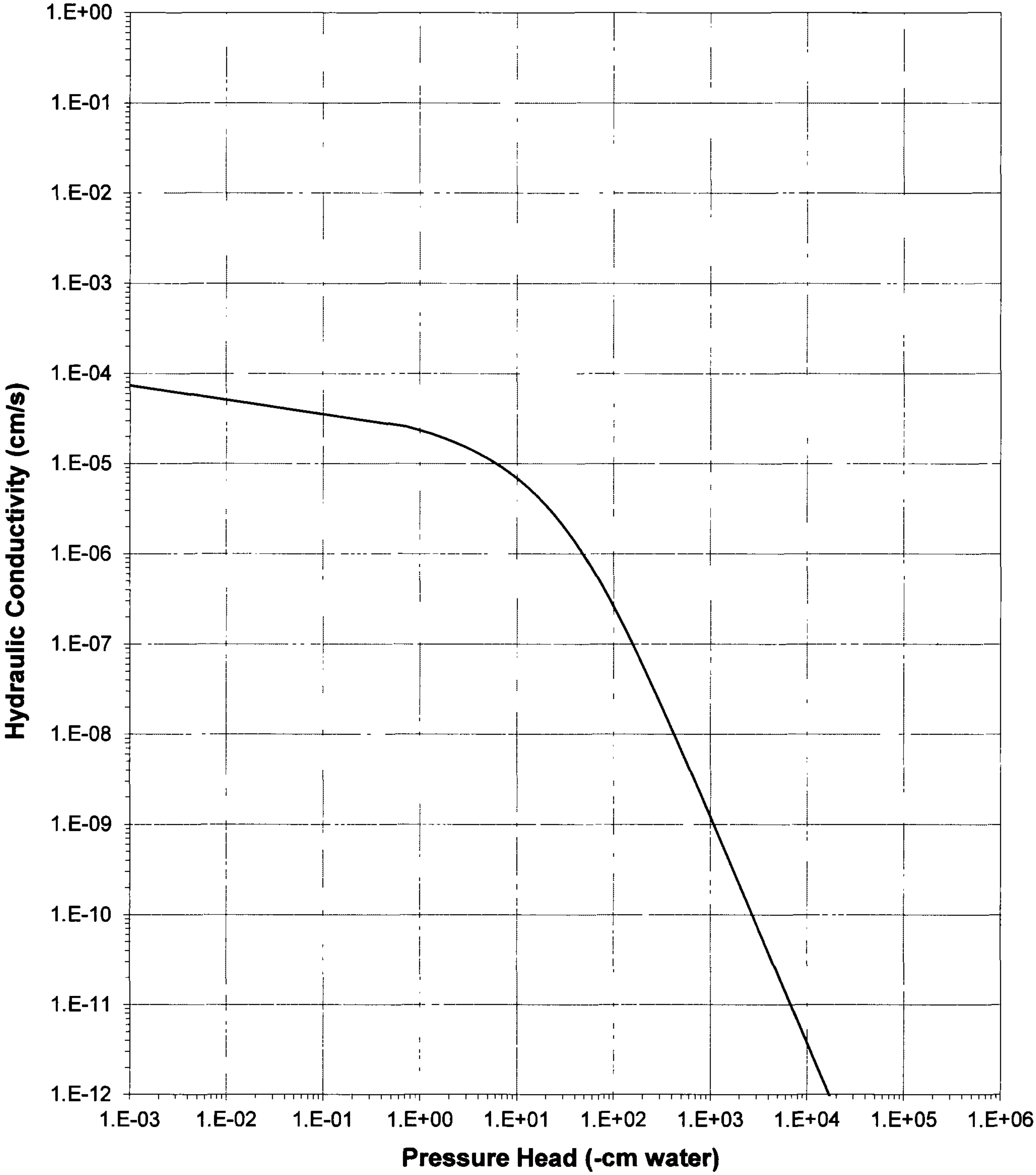
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: Test Pit 12-04 (88%, 94.3pcf)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: Test Pit 12-04 (88%, 94.3pcf)



Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263
Calculated Porosity:	ASTM D7263
Saturated Hydraulic Conductivity:	
Constant Head: (Rigid Wall)	ASTM D 2434 (modified apparatus)
Hanging Column Method:	ASTM D6836 (modified apparatus)
Pressure Plate Method:	ASTM D6836 (modified apparatus)
Water Potential (Dewpoint Potentiometer) Method:	ASTM D6836
Relative Humidity (Box) Method:	Campbell, G. and G. Gee. 1986. Water Potential: Miscellaneous Methods. Chp. 25, pp. 631-632, in A. Klute (ed.), Methods of Soil Analysis. Part 1. American Society of Agronomy, Madison, WI; Karathanasis & Hajek. 1982. Quantitative Evaluation of Water Adsorption on Soil Clays. SSA Journal 46:1321-1325
Moisture Retention Characteristics & Calculated Unsaturated Hydraulic Conductivity:	ASTM D6836; van Genuchten, M.T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. SSSAJ 44:892-898; van Genuchten, M.T., F.J. Leij, and S.R. Yates. 1991. The RETC code for quantifying the hydraulic functions of unsaturated soils. Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma. EPA/600/2091/065. December 1991