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Laboratory-Derived Hydraulic Properties of Selected Materials from Wells R-9, R-12, and R-25

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Produced by the Groundwater Investigations Focus Area

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TABLE OF CONTENTS

1.0 INTRODUCTION **1**

2.0 HYDROGEOLOGIC SETTING **1**

3.0 DRILLING PROGRAM **1**

4.0 SAMPLES TESTED **3**

5.0 ACKNOWLEDGEMENTS **4**

6.0 REFERENCES **4**

APPENDIX Test Results

Figure

Figure 3.0-1 Locations of wells from which samples were collected 2

Table

Table 4.0-1 Sources of the Samples Tested 3

1.0 INTRODUCTION

This document gives the results of laboratory testing of hydraulic properties of various geologic materials encountered in three deep wells (R-9, R-12, and R-25) drilled at Los Alamos National Laboratory (LANL). Such results are often filed by the one who requested the analyses and thus are not readily available to others who might benefit from their use. Therefore, the Groundwater Integration Team decided that binding the actual laboratory data sheets for these analyses into a LANL report was the best way not only to preserve the testing results but also to distribute them. More specifically, this report contains (1) a brief overview of the LANL hydrogeologic setting, (2) a short summary of LANL's sitewide drilling program, (3) a description of the samples tested, and (4) an appendix that contains the test results.

2.0 HYDROGEOLOGIC SETTING

LANL is located approximately 35 mi northwest of Santa Fe, New Mexico, on the Pajarito Plateau, a deeply dissected expanse of volcanic and sedimentary deposits situated between the Jemez Mountains and the Rio Grande. The geologic column includes, in descending order, the Bandelier Tuff, the Puye Formation and the Santa Fe Group, as well as the Cerros del Rio basalt and Tschicoma Formation, which are interbedded with the Puye and Santa Fe. The Bandelier Tuff is associated with the formation of the Valles caldera. The Puye Formation consists of fanglomerate that accumulated east of the Jemez Mountains. The Santa Fe Group represents sedimentary fill of the Española basin portion of the regional trough known as the Rio Grande rift.

Groundwater has been encountered beneath the plateau in shallow and intermediate-depth perched zones of saturation as well as in the deep regional zone of saturation. Perched water occurs in and between tuff subunits in the mesas as well as in alluvium and the basalts interbedded with the Puye Formation and Santa Fe Group beneath canyon floors. Groundwater associated with the deep zone of saturation occurs in different rock units making up the regional aquifer, depending on location.

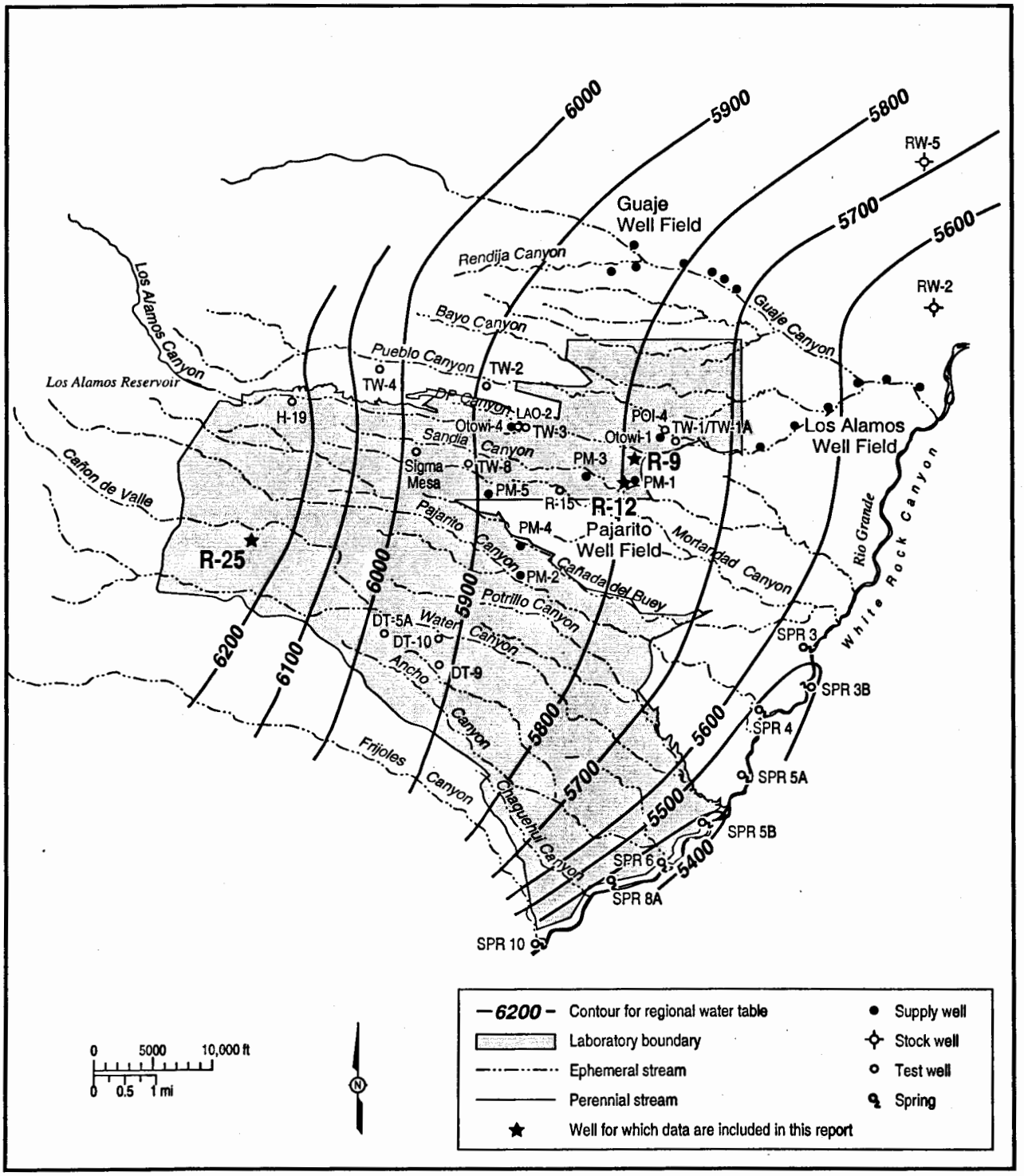
3.0 DRILLING PROGRAM

LANL is endeavoring to improve the conceptual hydrogeologic model for the Pajarito Plateau by characterizing the geology, hydrology and water quality of all underlying saturated zones by means of 32 wells to be drilled to the regional aquifer. This effort is being conducted under the facility's hydrogeologic work plan (LANL 1998, 59599). That document describes the wells to be installed, the rationale for their location and characterization activities planned.

The samples for which data are presented in this document come from wells R-9, R-12, and R-25 (Figure 3.0-1). The final completion reports for R-9, R-12, and R-25 will give details of the geology, hydrology, and water quality encountered in these wells (in preparation). Nonetheless, a few brief remarks on these wells are presented for background.

R-9 is located in lower Los Alamos Canyon and has a total depth of 771 ft. The well penetrated three perched zones of saturation: two in the Cerros del Rio basalt between the depths of 236 and 264 ft and between 275 and 282 ft as well as one in the Puye Formation between the depths of 524 and 627 ft. R-9 encountered the regional water table at a depth of 688 ft in basalt at the top of the Santa Fe Group.

R-12 is located south of R-9 in lower Sandia Canyon and has a total depth of 886 ft. Like R-9, it penetrated perched water in the Cerros del Rio basalt. However, at R-12 perched water occurred between the depths of 424 and 520 ft. R-12 also encountered the regional water table in basalt at the top of the Santa Fe Group, but at a depth of 805 ft.



Source: Purtymun 1984, 6513.

F3.0-1 / LAB-DER HYDRAUL PROP R-9, R-12, R-25 / 073100

Figure 3.0-1. Locations of wells from which samples were collected

R-25 is located on a mesa south of Canon de Valle and has a total depth of 1942 ft. The well penetrated a thick zone of apparently perched water in the Bandelier Tuff between the depths of 711 and 1132 ft. The regional water table was encountered at a depth of 1286 ft in the Puye Formation.

4.0 SAMPLES TESTED

Hydrologic characterization in the LANL deep-well program includes the determination of hydraulic properties of major geologic materials. Although various hydraulic properties of materials in phreatic (saturated) zones may be tested by either field or laboratory methods, only laboratory testing of core is practical for materials in vadose (unsaturated) zones.

Eleven core samples from the three wells have been tested for hydraulic properties. Although funds for testing were limited, the intention was to test selected materials from both unsaturated and saturated zones in each well. Table 4.0-1 shows their distribution by well, geologic unit, depth interval, and type of test.

Table 4.0-1
Sources of the Samples Tested

Well	Sample Number	Geologic Unit	Depth Interval (ft)	Test
R-9	8808	Cerros del Rio basalt	187.5–188.2	Ksat[a]
	8814	Puye Formation (calcareous sandstone)	642.3–642.8	H Pkg[b]
R-12	8802	Cerros del Rio basalt	489.1–489.8	Ksat
	8806A	old alluvium (lake beds)	520.0–520.4	H Pkg
	8807	Puye Formation (pumiceous sandstone)	721.0–721.5	H Pkg
	8805	Puye Formation (sandstone/conglomerate)	753.0–753.4	H Pkg
R-25	CACV-98-0039	Qbt 2 (very welded tuff)[c]	239.2–239.5	H Pkg
	CACV-98-0043	Qbt 1g (poorly welded tuff)[d]	371.2–371.5	H Pkg
	CACV-98-0046	Tsankawi Pumice Bed	383.5–384	H Pkg
	CACV-98-0049	Qbo (nonwelded tuff)[e]	546.8–547.5	H Pkg
	CACV-99-0021	Qbo (nonwelded tuff)	767.5–768	Ksat

[a] Ksat = saturated hydraulic conductivity only.

[b] H Pkg = hydraulic package (full range of unsaturated-zone characteristics).

[c] Qbt 2 = Unit 2, Tshirege Member, Bandelier Tuff.

[d] Qbt 1g = Unit 1 glassy, Tshirege Member, Bandelier Tuff.

[e] Qbo = Otowi Member, Bandelier Tuff.

Materials from vadose zones were tested for the full suite of unsaturated hydraulic parameters: initial moisture content, bulk density, calculated porosity, saturation, saturated hydraulic conductivity, moisture characteristics (by hanging column, pressure plate, thermocouple psychrometer, and relative humidity box), and unsaturated hydraulic conductivity. Materials from phreatic zones were tested only for saturated hydraulic conductivity.

5.0 ACKNOWLEDGEMENTS

A special thanks goes to Diana Hollis of the Analysis and Assessments Focus Area, LANL Environmental Restoration (ER) Project, for providing funding for the tests. David Rogers (ESH-18) helped select samples for analysis. Daniel B. Stephens and Associates, Inc., performed the tests. The assistance of Mark Ankeny and Roxanne Smith of that company in various tasks throughout the testing and reporting was especially helpful. Pam Maestas (ER Project) was the compositor for the document and Jan Torline (ER Project) was the editor.

6.0 REFERENCES

LANL (Los Alamos National Laboratory), May 22, 1998. "Hydrogeologic Workplan," Los Alamos, New Mexico. (LANL 1998, 59599)

Purtymun, W. D., January 1984. "Hydrologic Characteristics of the Main Aquifer in the Los Alamos Area: Development of Ground Water Supplies," Los Alamos National Laboratory Report LA-9957-MS, Los Alamos, New Mexico. (Purtymun 1984, 6513)

Appendix

Test Results

A few notes are in order regarding the materials presented in the appendix and their use:

1. The following pages were reproduced directly from those submitted by the testing laboratory and have not been reworked for inclusion in this document.

2. The first page in this appendix shows which parameters were analyzed for each sample.

3. On these lab sheets, cores are identified only by the number assigned at LANL's Sample Management Office. Users must therefore refer to Table 4.0-1 in the text of this document to relate these sample numbers to the specific wells, geologic units, and depth intervals from which they came.

4. Results are arranged by test type rather than sample number. Thus, data for a given sample may be found in more than one place in the appendix.

Daniel B. Stephens & Associates, Inc.

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1] (θ, ρ_d, ϕ)	Saturated Hydraulic Conductivity[2]		Moisture Characteristics[3]					Unsaturated Hydraulic Conductivity	Particle Size[4]			Effective Porosity	Particle Density	Air Permeability	1/3, 15 Bar Points and Water Holding Capacity	Atterberg Limits	Proctor Compaction
		CH	FH	HC	PP	TH	WP	RH		DS	WS	H						
8802			X															
8805	X		X	X	X	X		X	X									
8806A	X		X	X	X	X		X	X									
8807	X		X	X	X	X		X	X									
8808			X															
8814	X		X	X	X			X	X									
CACV-99-0021		X																
CACV-98-0039	X		X	X	X	X		X	X									
CACV-98-0043	X	X		X	X	X		X	X									
CACV-98-0046	X	X		X	X	X		X	X									
CACV-98-0049	X	X		X	X	X		X	X									

[1] θ = Initial moisture content, ρ_d = Dry bulk density, ϕ = Calculated porosity
[2] CH = Constant head, FH = falling head
[3] HC = Hanging column, PP = Pressure plate, TH = Thermocouple psychrometer, RH = Relative humidity box
[4] DS = Dry sieve, WS = Wet sieve, H = Hydrometer

Daniel B. Stephens & Associates, Inc.

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

Sample Number	Initial Moisture Content Gravimetric (%, g/g)	Initial Moisture Content Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
8805	20.7	34.9	1.68	2.03	36.4
8806A	23.4	38.6	1.64	2.03	37.9
8807	41.5	52.3	1.26	1.78	52.5
8814	14.4	22.6	1.57	1.79	40.8
CACV-98-0039	2.7	5.9	2.16	2.22	18.4
CACV-98-0043	10.4	13.3	1.28	1.41	51.8
CACV-98-0046	24.5	27.0	1.10	1.37	58.4
CACV-98-0049	12.2	11.6	0.95	1.07	64.0

Daniel B. Stephens & Associates, Inc.

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

Job Name:	LANL
Job Number:	9958.01
Sample Number:	8805
Ring Number:	8805
Depth:	NA
Test Date:	14-Sep-99
Field weight of sample* (g):	253.15
Tare weight, ring (g):	127.14
Tare weight, cap/plate/epoxy (g):	0.00
Dry weight of sample (g):	104.36
Sample volume (cm^3):	61.97
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	34.9
Initial Gravimetric Moisture Content (% g/g):	20.7
Dry bulk density (g/cm^3):	1.68
Wet bulk density (g/cm^3):	2.03
Calculated Porosity (% vol):	36.4
Percent Saturation:	95.9

Comments:

* Weight including tares

Laboratory analysis by: M. Devine
Data entered by: R. Smith
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

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

Job Name:	LANL
Job Number:	9958.01
Sample Number:	8806A
Ring Number:	8806A
Depth:	NA
Test Date:	8-Sep-99
Field weight of sample* (g):	524.53
Tare weight, ring (g):	133.26
Tare weight, cap/plate/epoxy (g):	0.00
Dry weight of sample (g):	316.98
Sample volume (cm^3):	192.70
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	38.6
Initial Gravimetric Moisture Content (% g/g):	23.4
Dry bulk density (g/cm^3):	1.64
Wet bulk density (g/cm^3):	2.03
Calculated Porosity (% vol):	37.9
Percent Saturation:	101.6

Comments:

* Weight including tares

Laboratory analysis by:	C. Pigman
Data entered by:	R. Smith
Checked by:	R. Smith

Daniel B. Stephens & Associates, Inc.

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

Job Name:	LANL
Job Number:	9958.01
Sample Number:	8807
Ring Number:	8807
Depth:	NA
Test Date:	8-Sep-99
Field weight of sample* (g):	253.68
Tare weight, ring (g):	120.63
Tare weight, cap/plate/epoxy (g):	0.00
Dry weight of sample (g):	94.00
Sample volume (cm^3):	74.66
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	52.3
Initial Gravimetric Moisture Content (% g/g):	41.5
Dry bulk density (g/cm^3):	1.26
Wet bulk density (g/cm^3):	1.78
Calculated Porosity (% vol):	52.5
Percent Saturation:	99.6

Comments:

* Weight including tares

Laboratory analysis by:	C. Pigman
Data entered by:	R. Smith
Checked by:	R. Smith

Daniel B. Stephens & Associates, Inc.

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

Job Name:	LANL
Job Number:	9958.01
Sample Number:	8814
Ring Number:	8814
Depth:	642.3-642.8
Test Date:	13-Oct-99
Field weight of sample* (g):	249.06
Tare weight, ring (g):	122.88
Tare weight, cap/plate/epoxy (g):	0.00
Dry weight of sample (g):	110.29
Sample volume (cm^3):	70.31
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	22.6
Initial Gravimetric Moisture Content (% g/g):	14.4
Dry bulk density (g/cm^3):	1.57
Wet bulk density (g/cm^3):	1.79
Calculated Porosity (% vol):	40.8
Percent Saturation:	55.4

Comments:

* Weight including tares

Laboratory analysis by: E. Koenig
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

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

Job Name:	LANL
Job Number:	9958.01
Sample Number:	CACV-98-0039
Ring Number:	CACV-98-0039
Depth:	NA
Test Date:	14-Sep-99
Field weight of sample* (g):	407.95
Tare weight, ring (g):	107.52
Tare weight, cap/plate/epoxy (g):	0.00
Dry weight of sample (g):	292.43
Sample volume (cm^3):	135.27
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	5.9
Initial Gravimetric Moisture Content (% g/g):	2.7
Dry bulk density (g/cm^3):	2.16
Wet bulk density (g/cm^3):	2.22
Calculated Porosity (% vol):	18.4
Percent Saturation:	32.1

Comments:

* Weight including tares

Laboratory analysis by:	M. Devine
Data entered by:	R. Smith
Checked by:	R. Smith

Daniel B. Stephens & Associates, Inc.

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

Job Name:	LANL
Job Number:	9958.01
Sample Number:	CACV-98-0043
Ring Number:	CACV-98-0043
Depth:	NA
Test Date:	8-Sep-99
Field weight of sample* (g):	251.91
Tare weight, ring (g):	130.79
Tare weight, cap/plate/epoxy (g):	0.00
Dry weight of sample (g):	109.72
Sample volume (cm^3):	85.85
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	13.3
Initial Gravimetric Moisture Content (% g/g):	10.4
Dry bulk density (g/cm^3):	1.28
Wet bulk density (g/cm^3):	1.41
Calculated Porosity (% vol):	51.8
Percent Saturation:	25.6

Comments:

* Weight including tares

Laboratory analysis by:	M. Devine
Data entered by:	R. Smith
Checked by:	R. Smith

Daniel B. Stephens & Associates, Inc.

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

Job Name:	LANL
Job Number:	9958.01
Sample Number:	CACV-98-0046
Ring Number:	CACV-98-0046
Depth:	NA
Test Date:	16-Sep-99
Field weight of sample* (g):	255.78
Tare weight, ring (g):	189.36
Tare weight, cap/plate/epoxy (g):	0.00
Dry weight of sample (g):	53.35
Sample volume (cm^3):	48.35
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	27.0
Initial Gravimetric Moisture Content (% g/g):	24.5
Dry bulk density (g/cm^3):	1.10
Wet bulk density (g/cm^3):	1.37
Calculated Porosity (% vol):	58.4
Percent Saturation:	46.3

Comments:

* Weight including tares

Laboratory analysis by:	M. Devine
Data entered by:	R. Smith
Checked by:	R. Smith

Daniel B. Stephens & Associates, Inc.

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

Job Name:	LANL
Job Number:	9958.01
Sample Number:	CACV-98-0049
Ring Number:	CACV-98-0049
Depth:	NA
Test Date:	12-Oct-99
Field weight of sample* (g):	447.50
Tare weight, ring (g):	127.41
Tare weight, cap/plate/epoxy (g):	86.84
Dry weight of sample (g):	207.84
Sample volume (cm^3):	218.12
Assumed particle density:	2.65

Initial Volumetric Moisture Content (% vol):	11.6
Initial Gravimetric Moisture Content (% g/g):	12.2
Dry bulk density (g/cm^3):	0.95
Wet bulk density (g/cm^3):	1.07
Calculated Porosity (% vol):	64.0
Percent Saturation:	18.2

Comments:

* Weight including tares

Laboratory analysis by: E. Koenig
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Method of Analysis	
		Constant Head	Falling Head
8802	3.9E-10		X
8805	9.4E-07		X
8806A	2.8E-07		X
8807	1.5E-09		X
8808	1.1E-06		X
8814	5.8E-07		X
CACV-99-0021	2.7E-04	X	
CACV-98-0039	2.9E-08		X
CACV-98-0043	1.0E-03	X	
CACV-98-0046	1.1E-02	X	
CACV-98-0049	3.5E-04	X	

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Saturated Hydraulic Conductivity
Falling Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Backpressure* (psi):	15.0
Sample number:	8802	*Offset* (cm):	1.1
Ring number:	8802	*Sample length* (cm):	2.55
Depth:	NA	*Sample x-sectional area* (cm^2):	28.42
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
12-Oct-99	14:12:10	19.0	31.3	1084.9	66370	3.9E-10	4.0E-10
13-Oct-99	08:38:20	18.0	30.9	1084.4			
Test # 2:							
20-Oct-99	17:03:56	18.5	95.2	1148.7	56164	3.9E-10	4.0E-10
21-Oct-99	08:40:00	19.5	94.8	1148.3			
Test # 3:							
29-Oct-99	08:21:55	19.5	90.3	1143.9	29210	3.8E-10	3.8E-10
29-Oct-99	16:28:45	20.0	90.1	1143.7			

***Average Ksat* (cm/sec):** **3.9E-10**

Comments:

Laboratory analysis by: M. Devine
Data entered by: D. O'Dowd
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Backpressure (psi):*	0.0
Sample number:	8805	*Offset (cm):*	1.3
Ring number:	8805	*Sample length (cm):*	2.53
Depth:	NA	*Sample x-sectional area (cm^2):*	24.46
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
18-Sep-99	11:01:50	20.0	21.5	20.2	163380	9.5E-07	9.4E-07
20-Sep-99	08:24:50	20.0	3.7	2.4			
Test # 2:							
20-Sep-99	09:58:50	20.0	35.4	34.1	30622	9.4E-07	9.5E-07
20-Sep-99	18:29:12	19.0	24.2	22.9			
Test # 3:							
21-Sep-99	19:15:37	19.0	33.8	32.5	50373	9.2E-07	9.4E-07
22-Sep-99	09:15:10	18.5	18.5	17.2			

***Average Ksat* (cm/sec):** **9.4E-07**

Comments:

Laboratory analysis by: R. Smith
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Backpressure* (psi):	0.0
Sample number:	8806A	*Offset* (cm):	2.7
Ring number:	8806A	*Sample length* (cm):	3.38
Depth:	NA	*Sample x-sectional area* (cm^2):	57.01
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
09-Sep-99	19:44:26	19.0	77.7	75.0	50626	2.9E-07	2.9E-07
10-Sep-99	09:48:12	20.0	55.6	52.9			
Test # 2:							
10-Sep-99	09:48:12	20.0	55.6	52.9	29579	2.7E-07	2.7E-07
10-Sep-99	18:01:11	19.0	46.3	43.6			
Test # 3:							
13-Sep-99	16:14:31	19.5	54.4	51.7	66961	2.8E-07	2.9E-07
14-Sep-99	10:50:32	19.0	35.5	32.8			

***Average Ksat* (cm/sec):** **2.8E-07**

Comments:

Laboratory analysis by: E. Koenig
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Backpressure* (psi):	15.0
Sample number:	8807	*Offset* (cm):	1.2
Ring number:	8807	*Sample length* (cm):	2.58
Depth:	NA	*Sample x-sectional area* (cm^2):	28.94
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
08-Oct-99	08:19:59	18.0	63.0	1116.5	19871	1.4E-09	1.4E-09
08-Oct-99	13:51:10	19.0	62.5	1116.0			
Test # 2:							
11-Oct-99	12:11:27	18.0	71.3	1124.8	17103	1.6E-09	1.7E-09
11-Oct-99	16:56:30	19.0	70.8	1124.3			
Test # 3:							
11-Oct-99	16:56:30	19.0	70.8	1124.3	55390	1.5E-09	1.5E-09
12-Oct-99	08:19:40	17.5	69.4	1122.8			

***Average Ksat* (cm/sec):** **1.5E-09**

Comments:

Laboratory analysis by: R. Smith
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Backpressure* (psi):	5.0
Sample number:	8808	*Offset* (cm):	10.6
Ring number:	8808	*Sample length* (cm):	11.47
Depth:	NA	*Sample x-sectional area* (cm^2):	28.97
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
01-Oct-99	08:21:10	18.0	53.3	394.3	16440	1.2E-06	1.2E-06
01-Oct-99	12:55:10	18.0	27.1	368.1			
Test # 2:							
04-Oct-99	09:41:32	17.5	56.2	397.2	14425	1.1E-06	1.2E-06
04-Oct-99	13:41:57	18.5	33.4	374.4			
Test # 3:							
04-Oct-99	13:41:57	18.5	33.4	374.4	13893	1.0E-06	1.0E-06
04-Oct-99	17:33:30	19.0	15.0	356.0			

***Average Ksat* (cm/sec):** **1.1E-06**

Comments:

Laboratory analysis by: E. Koenig
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Backpressure* (psi):	0.0
Sample number:	8814	*Offset* (cm):	0.0
Ring number:	8814	*Sample length* (cm):	2.58
Depth:	642.3-642.8	*Sample x-sectional area* (cm^2):	27.29
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
20-Oct-99	09:04:42	17.0	18.9	18.9	16116	5.3E-07	5.5E-07
20-Oct-99	13:33:18	19.0	16.6	16.6			
Test # 2:							
20-Oct-99	13:33:18	19.0	16.6	16.6	12947	5.9E-07	6.0E-07
20-Oct-99	17:09:05	18.5	14.8	14.8			
Test # 3:							
20-Oct-99	17:09:05	18.5	14.8	14.8	56865	5.9E-07	6.0E-07
21-Oct-99	08:56:50	19.5	8.9	8.9			

***Average Ksat* (cm/sec):** **5.8E-07**

Comments:

Laboratory analysis by: D. O'Dowd
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Collection vessel tare (g):*	11.32
Sample number:	CACV-99-0021	*Sample length (cm):*	5.33
Ring number:	NA	*Sample diameter (cm):*	8.57
Depth:	NA	*Sample x-sectional area (cm^2):*	57.72

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:								
13-Jan-00	17:35:19	18.0	3.6	14.1	2.7	312	2.3E-04	2.3E-04
13-Jan-00	17:40:31							
Test # 2:								
14-Jan-00	08:08:12	18.5	3.6	21.8	10.4	1035	2.6E-04	2.7E-04
14-Jan-00	08:25:27							
Test # 3:								
17-Jan-00	09:25:16	18.0	3.6	19.8	8.4	734	2.9E-04	3.1E-04
17-Jan-00	09:37:30							

***Average Ksat* (cm/sec):** **2.7E-04**

Comments:

Laboratory analysis by: M. Devine
Data entered by: D. O'Dowd
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Backpressure* (psi):	0.0
Sample number:	CACV-98-0039	*Offset* (cm):	1.5
Ring number:	CACV-98-0039	*Sample length* (cm):	2.59
Depth:	NA	*Sample x-sectional area* (cm^2):	52.21
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
01-Oct-99	09:03:35	18.0	81.9	80.4	260665	2.8E-08	2.9E-08
04-Oct-99	09:28:00	17.5	66.7	65.2			
Test # 2:							
04-Oct-99	09:28:00	17.5	66.7	65.2	29320	2.4E-08	2.5E-08
04-Oct-99	17:36:40	19.0	65.4	63.9			
Test # 3:							
04-Oct-99	17:36:40	19.0	65.4	63.9	57780	3.2E-08	3.3E-08
05-Oct-99	09:39:40	18.0	62.1	60.6			

***Average Ksat* (cm/sec):** **2.9E-08**

Comments:

Laboratory analysis by: R. Smith
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Collection vessel tare (g):*	10.85
Sample number:	CACV-98-0043	*Sample length (cm):*	2.15
Ring number:	CACV-98-0043	*Sample diameter (cm):*	7.13
Depth:	NA	*Sample x-sectional area (cm^2):*	39.89

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:								
21-Sep-99	11:05:45	20.5	5.2	40.2	29.3	300	1.0E-03	1.0E-03
21-Sep-99	11:10:45							
Test # 2:								
21-Sep-99	19:05:00	21.0	5.2	28.9	18.0	180	1.0E-03	1.0E-03
21-Sep-99	19:08:00							
Test # 3:								
22-Sep-99	12:52:36	20.5	5.2	35.7	24.9	241	1.1E-03	1.1E-03
22-Sep-99	12:56:37							

***Average Ksat* (cm/sec):** **1.0E-03**

Comments:

Laboratory analysis by: E. Koenig
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Collection vessel tare (g):*	11.55
Sample number:	CACV-98-0046	*Sample length (cm):*	2.45
Ring number:	CACV-98-0046	*Sample diameter (cm):*	5.02
Depth:	NA	*Sample x-sectional area (cm^2):*	19.78

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:								
29-Sep-99	17:33:54	20.0	0.5	60.3	48.8	1157	1.0E-02	1.0E-02
29-Sep-99	17:53:11							
Test # 2:								
30-Sep-99	16:37:27	20.0	0.5	23.0	11.5	256	1.1E-02	1.1E-02
30-Sep-99	16:41:43							
Test # 3:								
01-Oct-99	08:29:23	20.0	0.5	39.3	27.7	672	1.0E-02	1.0E-02
01-Oct-99	08:40:35							

***Average Ksat* (cm/sec):** **1.1E-02**

Comments:

Laboratory analysis by: E. Koenig
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Constant Head Method

Job name:	LANL	*Type of water used:*	TAP
Job number:	9958.01	*Collection vessel tare (g):*	11.42
Sample number:	CACV-98-0049	*Sample length (cm):*	3.81
Ring number:	CACV-98-0049	*Sample diameter (cm):*	8.54
Depth:	NA	*Sample x-sectional area (cm^2):*	57.29

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:								
22-Oct-99	13:28:08	19.5	14.7	25.8	14.4	198	3.3E-04	3.3E-04
22-Oct-99	13:31:26							
Test # 2:								
22-Oct-99	16:28:37	19.0	14.7	54.3	42.8	538	3.6E-04	3.7E-04
22-Oct-99	16:37:35							
Test # 3:								
23-Oct-99	14:04:03	19.0	14.7	32.1	20.7	269	3.5E-04	3.5E-04
23-Oct-99	14:08:32							

***Average Ksat* (cm/sec):** **3.5E-04**

Comments:

Laboratory analysis by: R. Smith
Data entered by: M.Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
8805	0	86.5
	6	87.0
	31	85.8
	124	82.3
	510	75.4
	15399	40.8
	848426	28.1
8806A	0	42.7
	27	41.6
	128	39.8
	520	37.8
	8872	22.9
	17745	19.8
	836961	7.7
8807	0	62.3
	52	60.6
	131	59.6
	495	59.0
	9790	47.1
	21314	43.8
	848426	15.1
8814	0	72.8
	6	74.6
	30	73.7
	126	71.3
	500	67.1
	8158	65.2
	15297	60.0
	848426	23.7

Daniel B. Stephens & Associates, Inc.

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

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
CACV-98-0039	0	10.8
	53	10.1
	126	9.9
	510	9.7
	9790	5.7
	12849	3.9
	836961	0.5
CACV-98-0043	0	66.3
	10	60.6
	38	54.4
	80	45.9
	255	24.0
	1020	14.4
	8464	4.0
	17337	3.2
	836961	1.4
CACV-98-0046	0	91.8
	10	73.1
	38	62.1
	80	59.3
	255	54.4
	1020	50.6
	6935	6.7
	13767	5.3
	836961	1.3

Daniel B. Stephens & Associates, Inc.

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

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
CACV-98-0049	0	39.8
	22	36.3
	52	33.5
	153	27.4
	510	16.0
	7037	2.5
	16725	1.9
	848426	0.5

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	LANL	*Dry wt. of sample* (g):	104.36
Job Number:	9958.01	*Tare wt., screen & clamp* (g):	1.97
Sample Number:	8805	*Tare wt., ring* (g):	127.14
Ring Number:	8805	*Tare wt., epoxy* (g):	0.00
Depth:	NA	*Sample volume* (cm^3):	61.97

Saturated weight at 0 cm tension* (g): 287.04
Volume of water † in saturated sample (cm^3): 53.57
Saturated moisture content (% vol): 86.45
Sample bulk density (g/cm^3): 1.68

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	24-Sep-99 / 22:20	287.04	0.00	86.45
	27-Sep-99 / 10:00	287.40	6.00	87.03
	01-Oct-99 / 15:30	286.61	31.00	85.76
	04-Oct-99 / 09:30	284.49	123.70	82.34
Pressure plate:	06-Oct-99 / 15:40	280.21	509.90	75.43

Dry weight of thermocouple sample* (g): 264.40
Tare weight, jar (g): 172.50
Sample bulk density (g/cm^3): 1.68

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	24-Sep-99 / 18:41	286.64	15399.0	40.76

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: E. Koenig/T. Gere
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Relative Humidity Box
(Main Drainage Curve)

Job Name: LANL
Job Number: 9958.01
Sample Number: 8805
Ring Number: 8805
Depth: NA

Dry weight of relative humidity box sample* (g): 70.98
Tare weight (g): 33.89
Sample bulk density (g/cm^3): 1.68

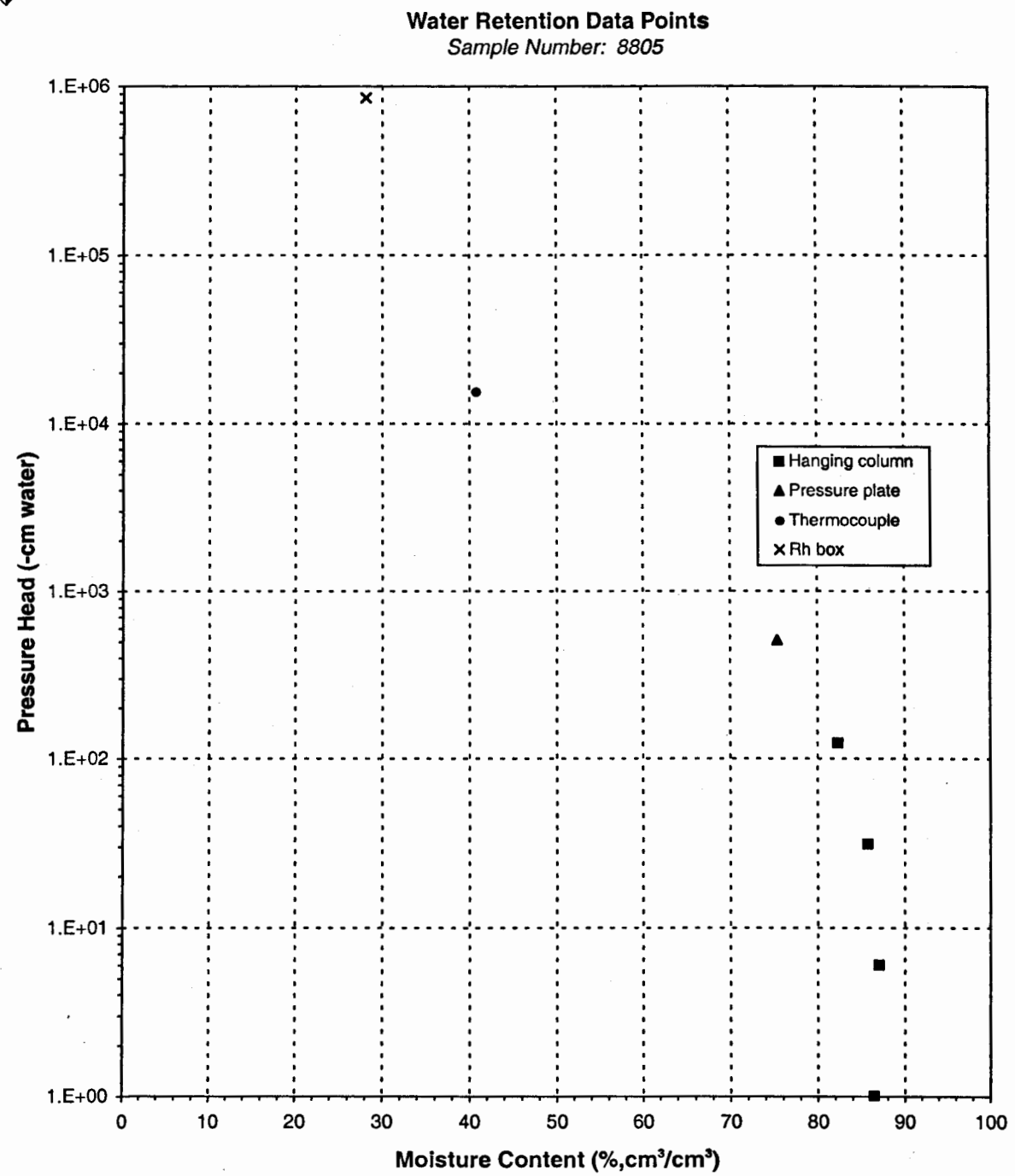
	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	15-Dec-99 / 09:02	77.17	848426	28.10

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: B. Baum
Data entered by: M. Devine
Checked by: R. Smith

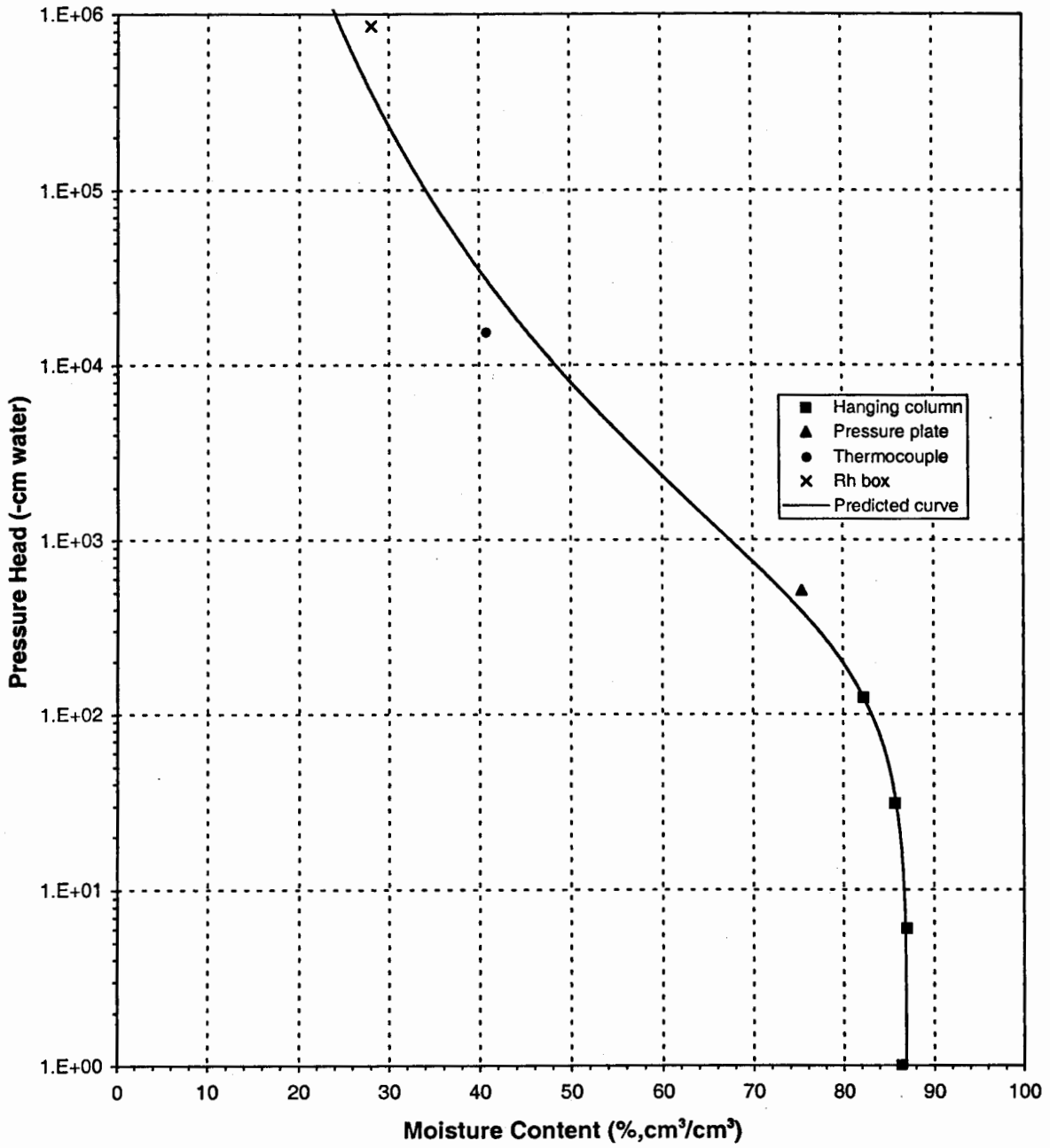
Daniel B. Stephens & Associates, Inc.



Daniel B. Stephens & Associates, Inc.

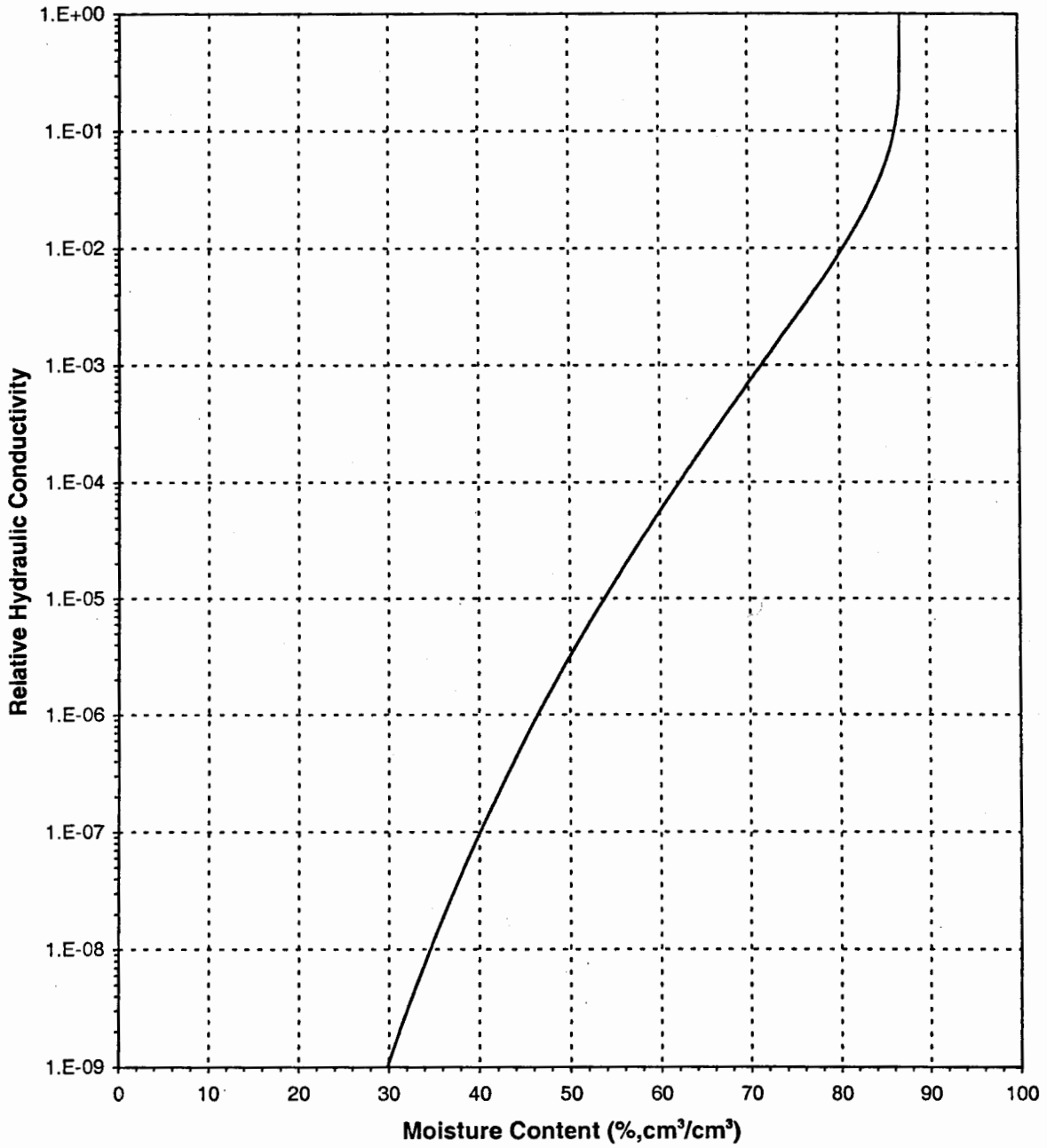
Predicted Water Retention Curve and Data Points

Sample Number: 8805



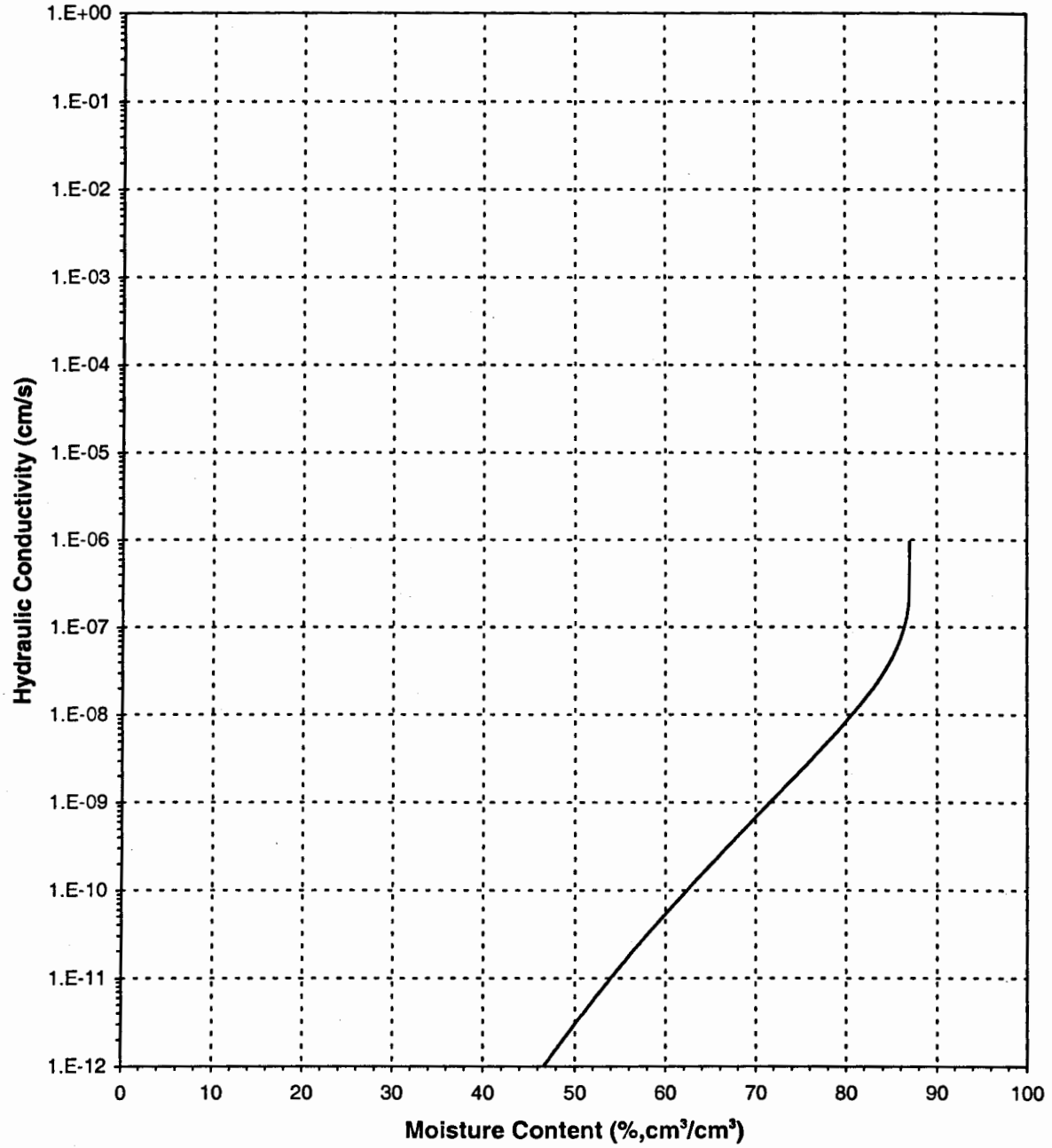
Daniel B. Stephens & Associates, Inc.

Plot of Relative Hydraulic Conductivity vs Moisture Content
Sample Number: 8805



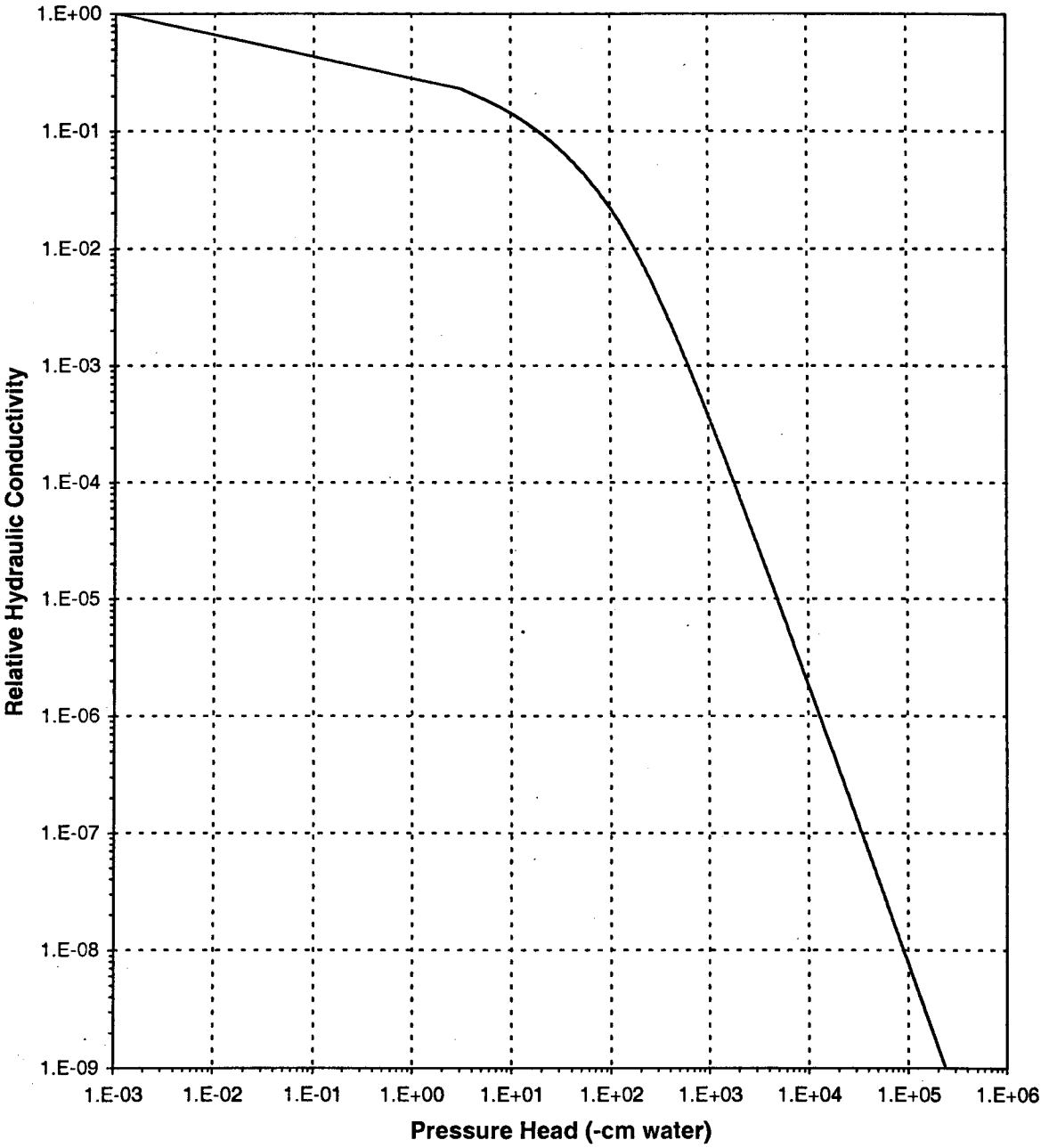
Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Moisture Content
Sample Number: 8805



Daniel B. Stephens & Associates, Inc.

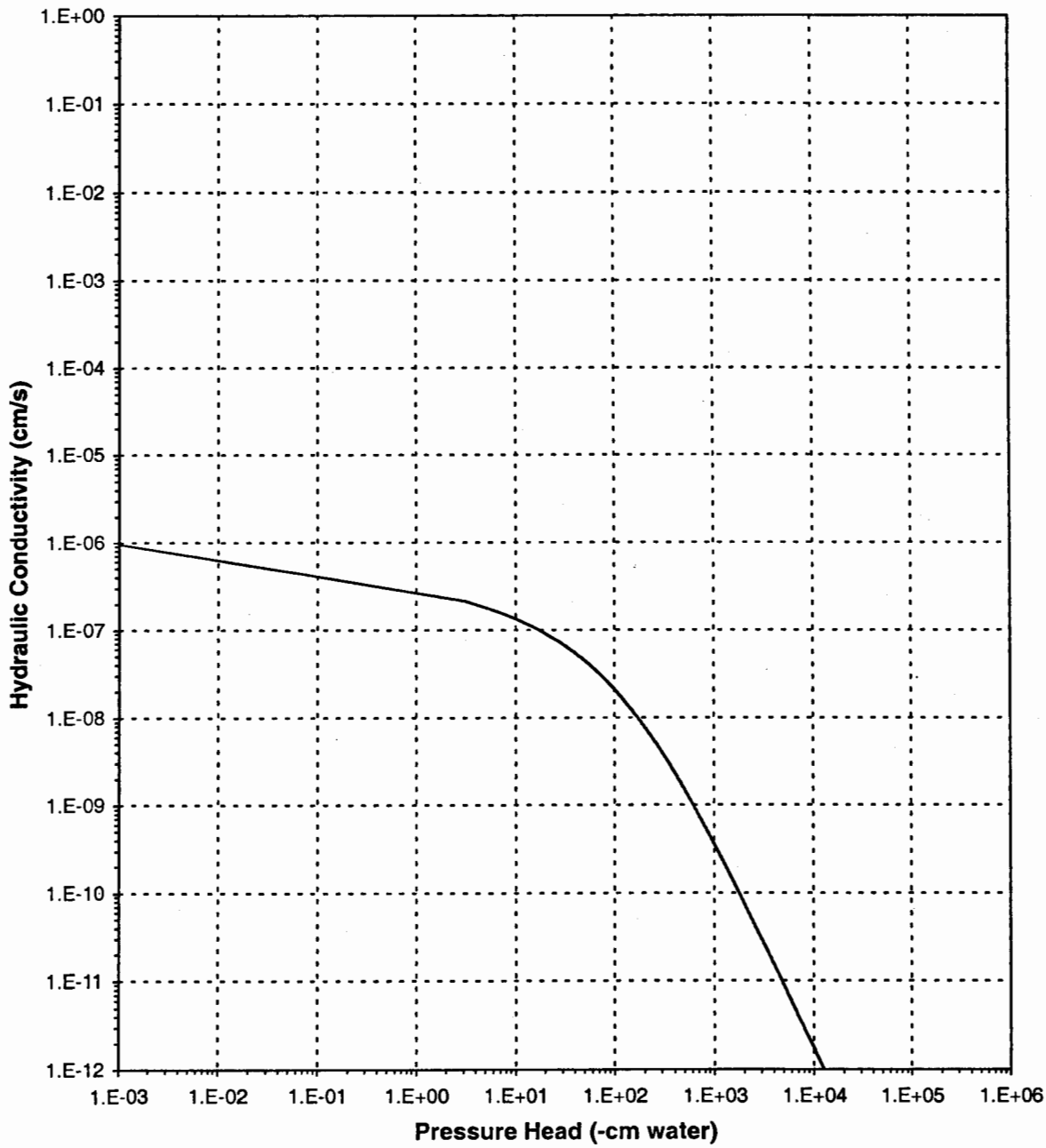
Plot of Relative Hydraulic Conductivity vs Pressure Head
Sample Number: 8805



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: 8805



Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	LANL	*Dry wt. of sample* (g):	316.98
Job Number:	9958.01	*Tare wt., screen & clamp* (g):	31.72
Sample Number:	8806A	*Tare wt., ring* (g):	133.26
Ring Number:	8806A	*Tare wt., epoxy* (g):	0.00
Depth:	NA	*Sample volume* (cm^3):	192.70

Saturated weight at 0 cm tension* (g): 564.29
Volume of water † in saturated sample (cm^3): 82.33
Saturated moisture content (% vol): 42.72
Sample bulk density (g/cm^3): 1.64

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	20-Sep-99 / 18:15	564.29	0.00	42.72
	23-Sep-99 / 13:23	562.03	26.70	41.55
	27-Sep-99 / 14:01	558.57	127.80	39.76
Pressure plate:	29-Sep-99 / 19:03	554.88	520.10	37.84

Dry weight of thermocouple sample* (g): 273.28
Tare weight, jar (g): 172.41
Sample bulk density (g/cm^3): 1.64

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	04-Oct-99 / 16:40	287.32	8872.3	22.90
	05-Oct-99 / 12:22	285.45	17744.5	19.85

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: E. Koenig/R. Smith
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Relative Humidity Box
(Main Drainage Curve)

Job Name: LANL
Job Number: 9958.01
Sample Number: 8806A
Ring Number: 8806A
Depth: NA

Dry weight of relative humidity box sample* (g): 93.17
Tare weight (g): 42.09
Sample bulk density (g/cm^3): 1.64

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	22-Sep-99 / 08:35	95.56	836961	7.69

Comments:

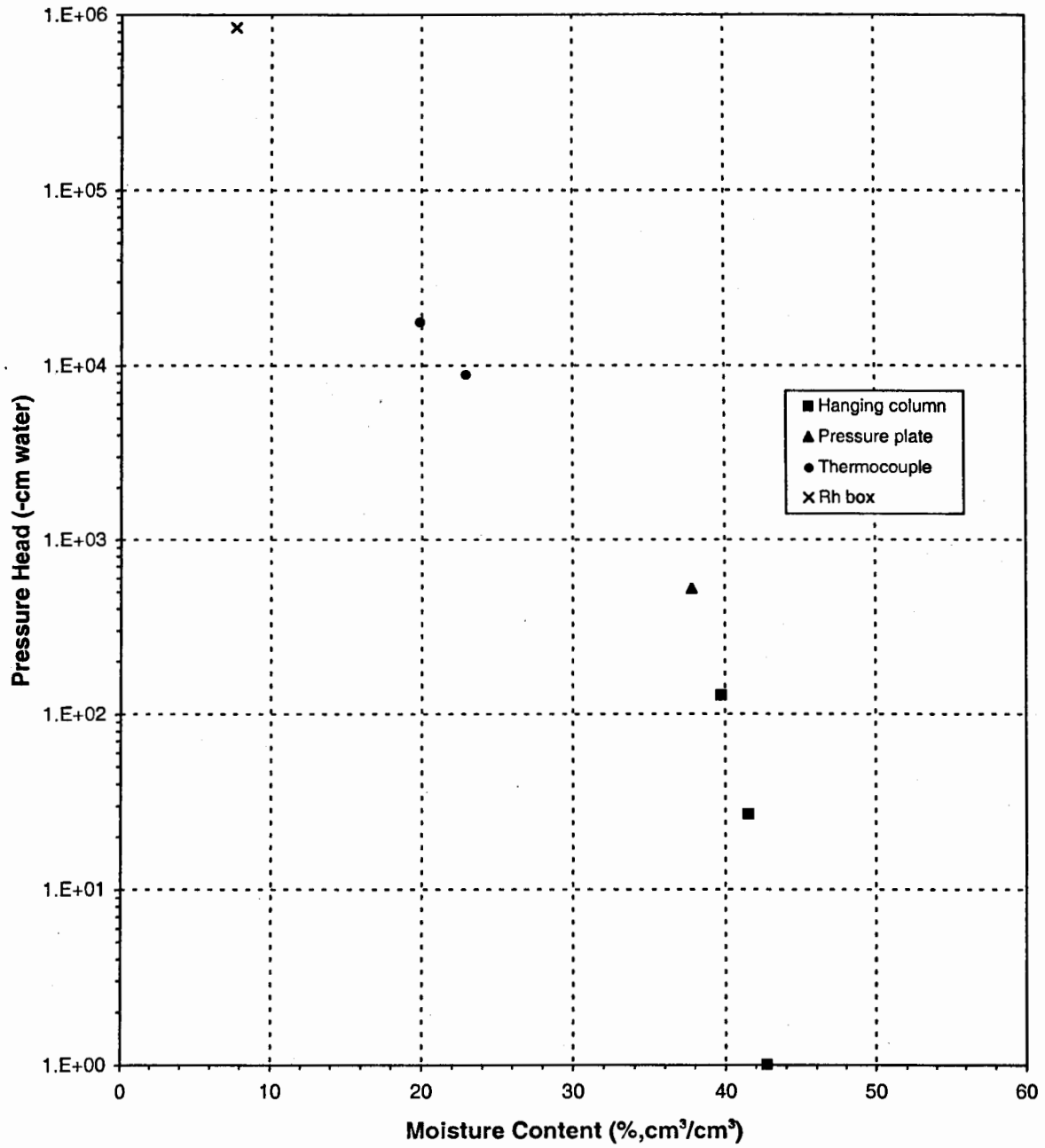
* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: M. Devine
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Water Retention Data Points

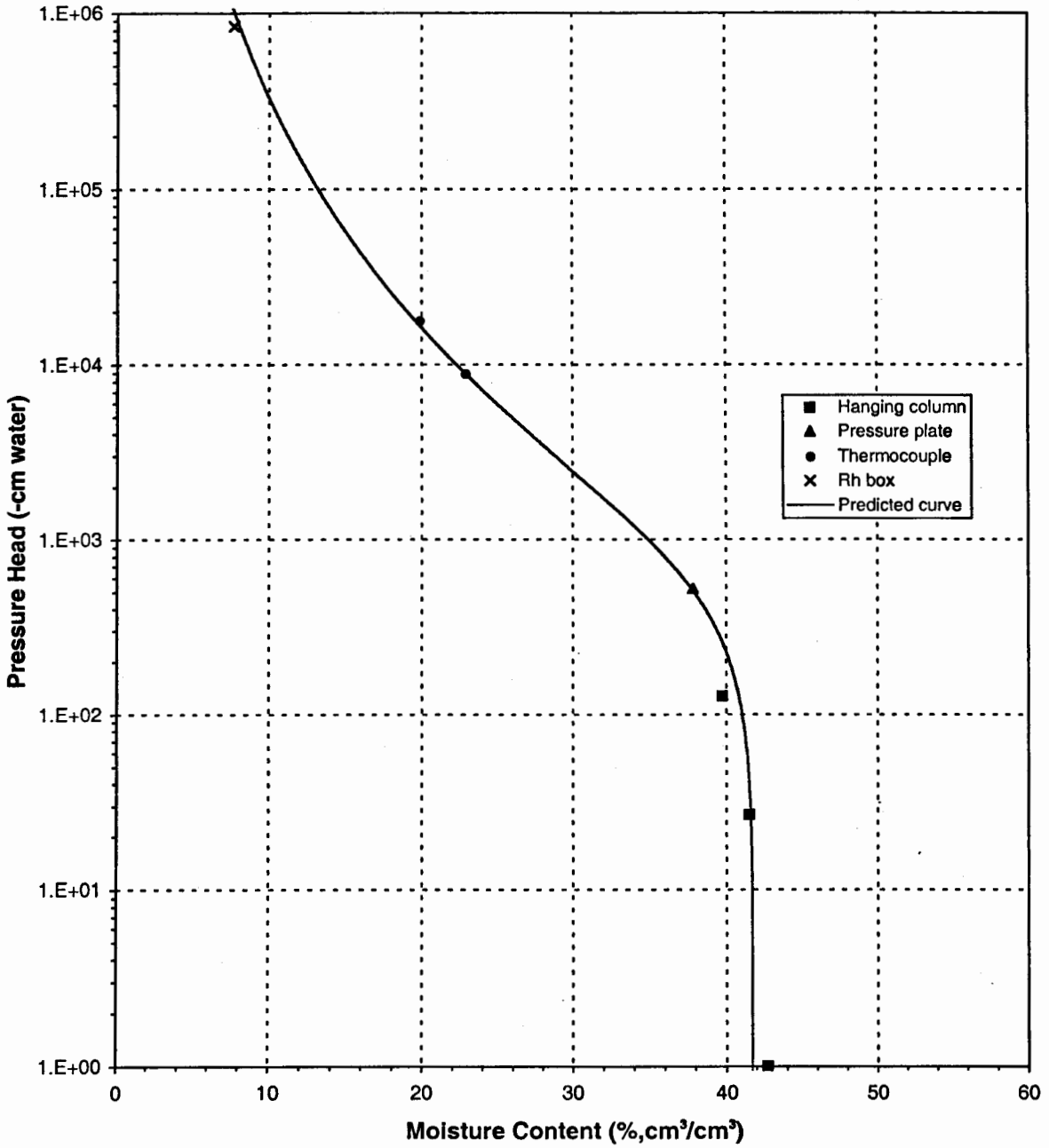
Sample Number: 8806A



Daniel B. Stephens & Associates, Inc.

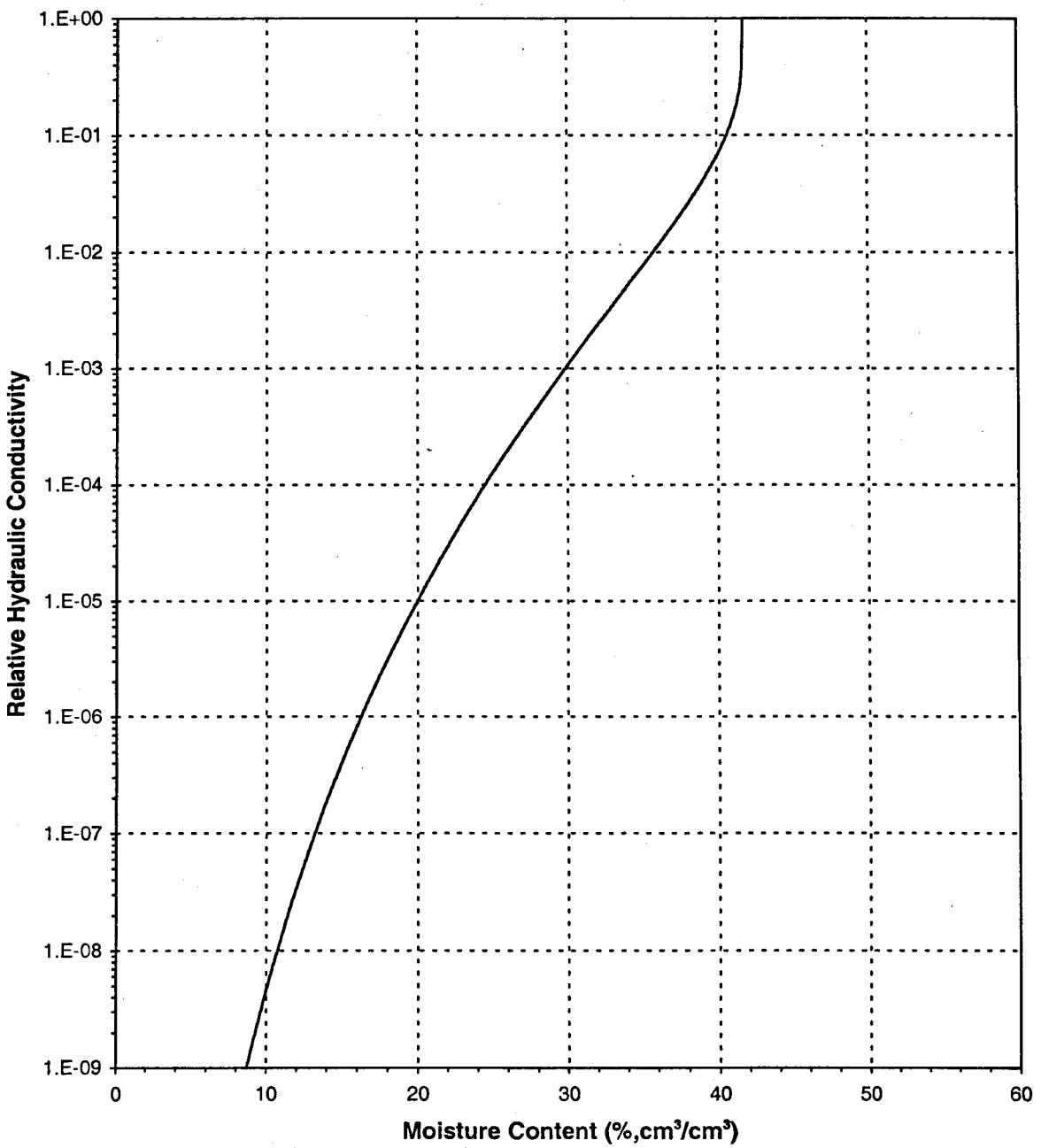
Predicted Water Retention Curve and Data Points

Sample Number: 8806A



Daniel B. Stephens & Associates, Inc.

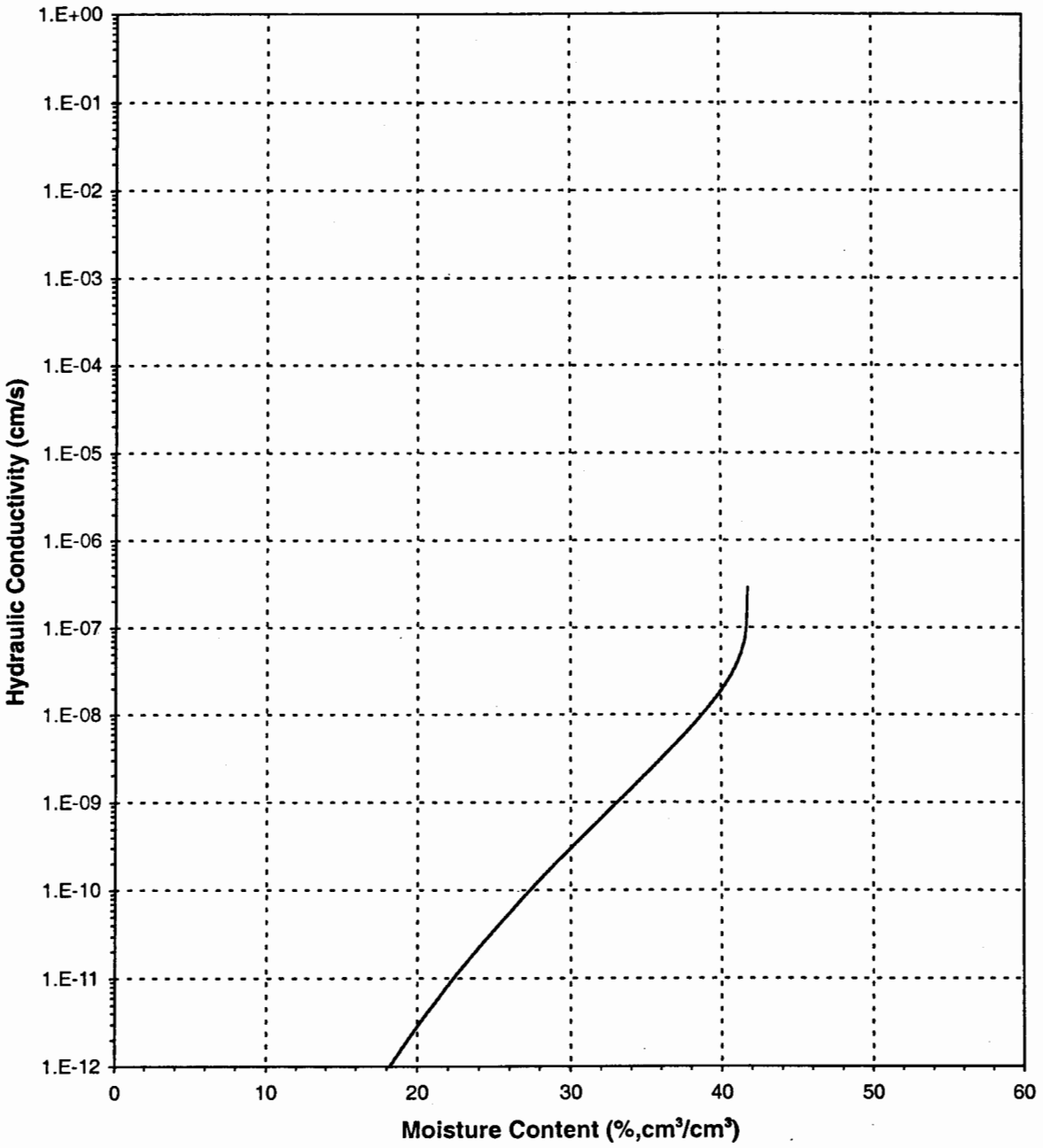
Plot of Relative Hydraulic Conductivity vs Moisture Content
Sample Number: 8806A



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Moisture Content

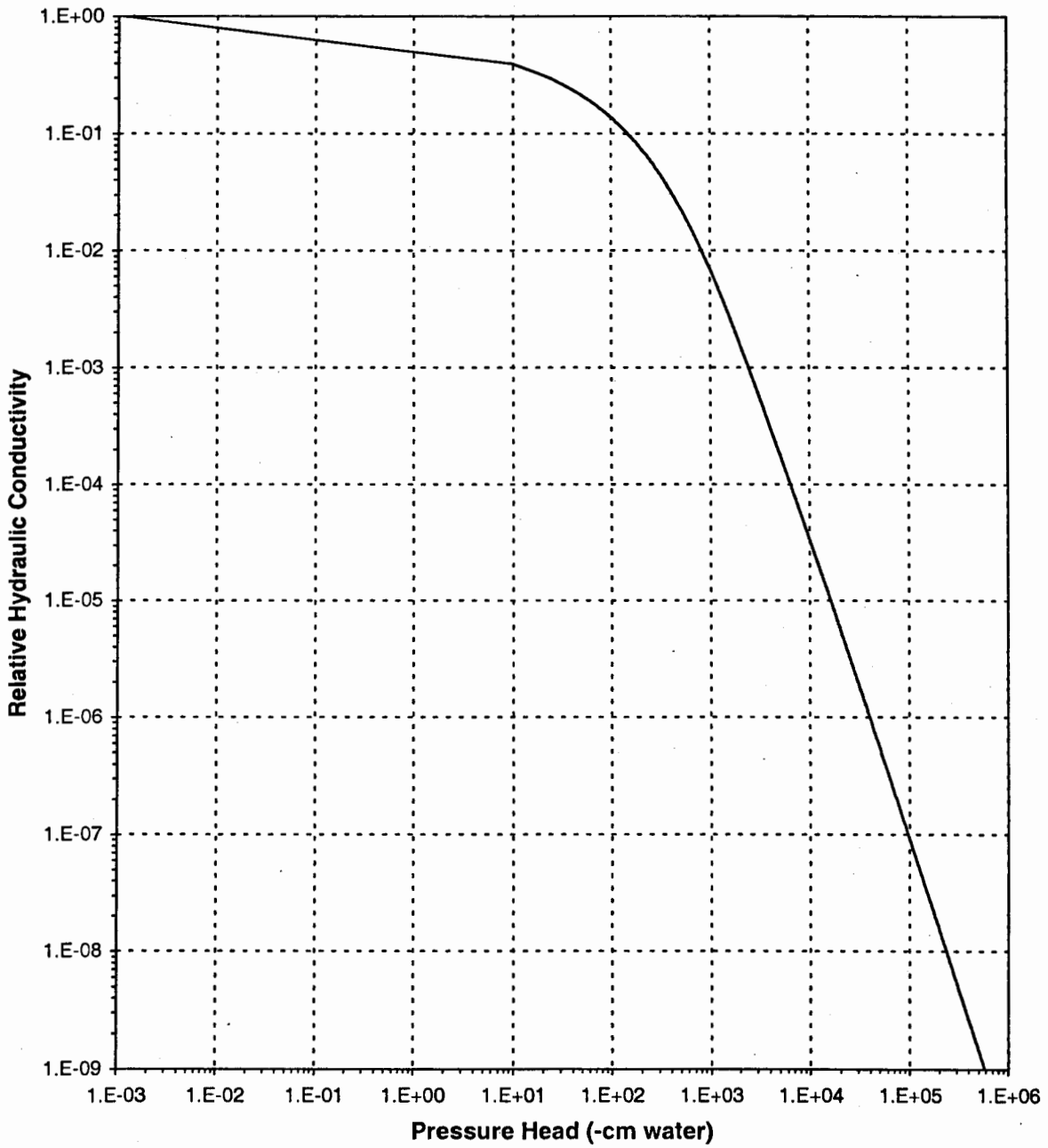
Sample Number: 8806A



Daniel B. Stephens & Associates, Inc.

Plot of Relative Hydraulic Conductivity vs Pressure Head

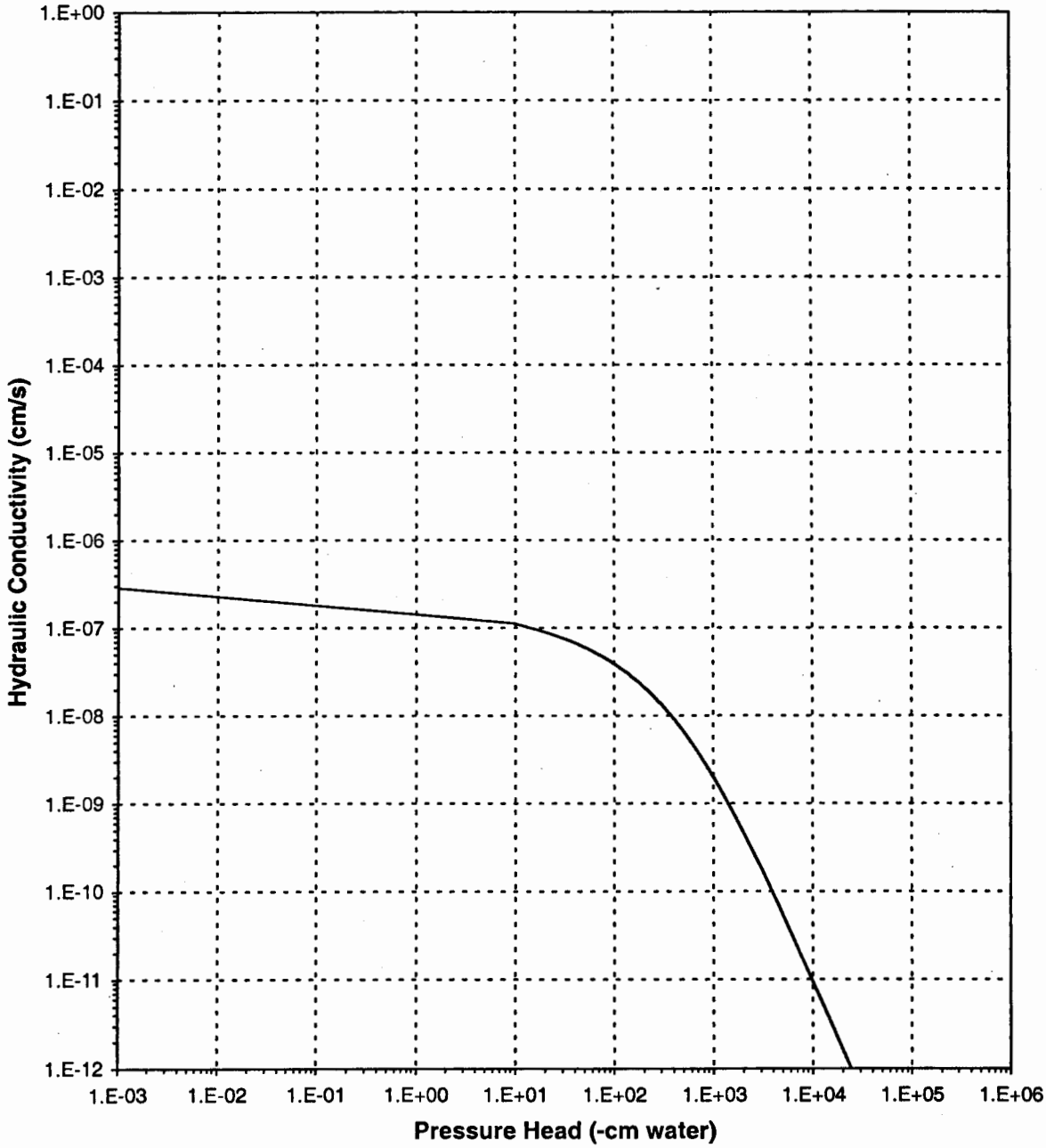
Sample Number: 8806A



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: 8806A



Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	LANL	*Dry wt. of sample* (g):	94.00
Job Number:	9958.01	*Tare wt., screen & clamp* (g):	0.63
Sample Number:	8807	*Tare wt., ring* (g):	120.63
Ring Number:	8807	*Tare wt., epoxy* (g):	0.00
Depth:	NA	*Sample volume* (cm^3):	74.66

Saturated weight at 0 cm tension* (g): 261.74
Volume of water † in saturated sample (cm^3): 46.48
Saturated moisture content (% vol): 62.26
Sample bulk density (g/cm^3): 1.26

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	11-Nov-99 / 14:10	261.74	0.00	62.26
	15-Nov-99 / 10:20	260.52	51.70	60.62
	17-Nov-99 / 19:30	259.79	130.60	59.64
Pressure plate:	20-Nov-99 / 19:30	259.30	494.60	58.99

Dry weight of thermocouple sample* (g): 245.79
Tare weight, jar (g): 166.69
Sample bulk density (g/cm^3): 1.26

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	29-Sep-99 / 15:13	275.40	9790.1	47.13
	30-Sep-99 / 17:29	273.32	21313.8	43.82

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: E. Koenig/R. Smith
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Relative Humidity Box
(Main Drainage Curve)

Job Name: LANL
Job Number: 9958.01
Sample Number: 8807
Ring Number: 8807
Depth: NA

Dry weight of relative humidity box sample* (g): 77.82
Tare weight (g): 44.85
Sample bulk density (g/cm^3): 1.26

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	17-Dec-99 / 08:30	81.78	848426	15.11

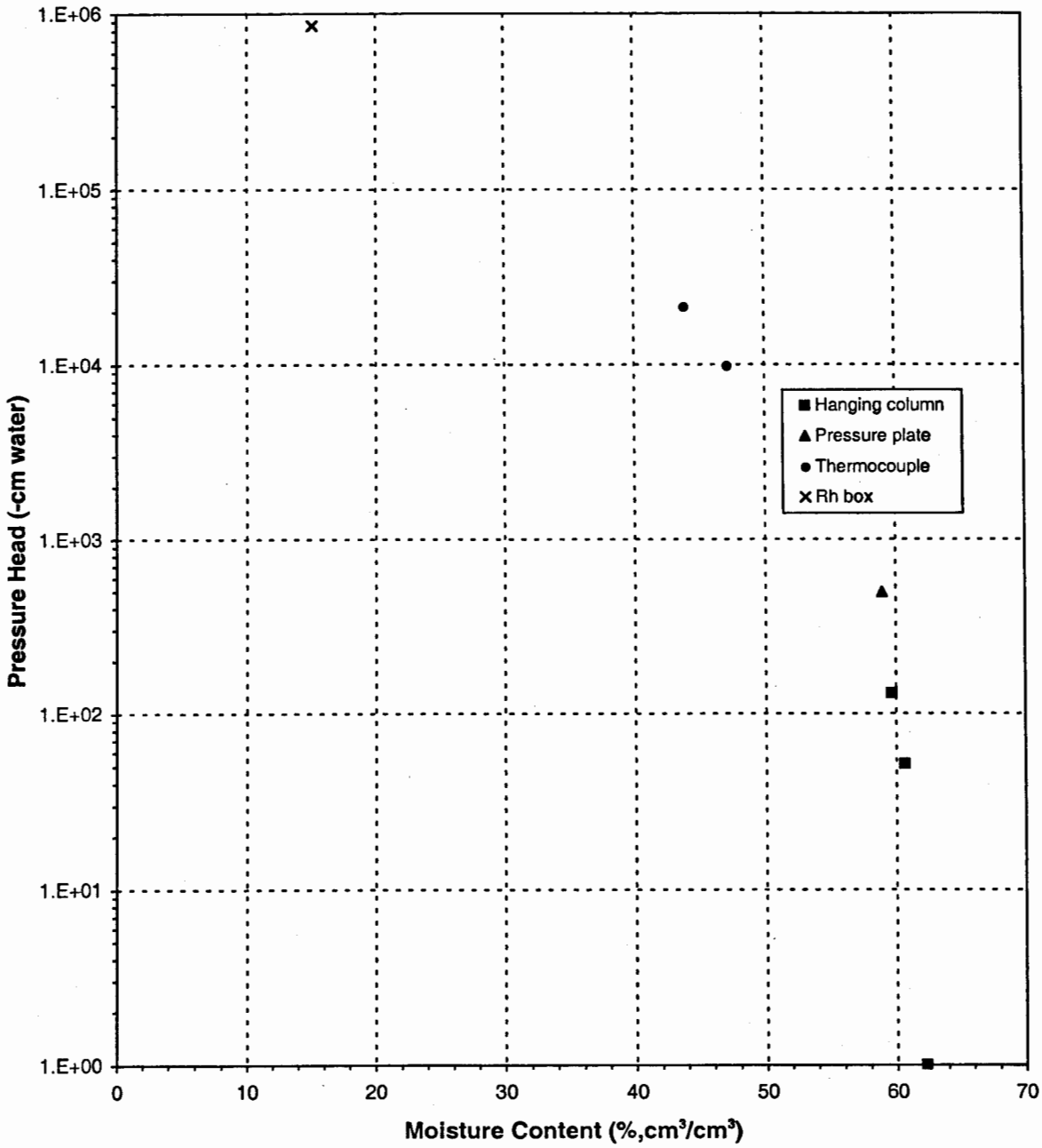
Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: B. Baum
Data entered by: M. Devine
Checked by: R. Smith

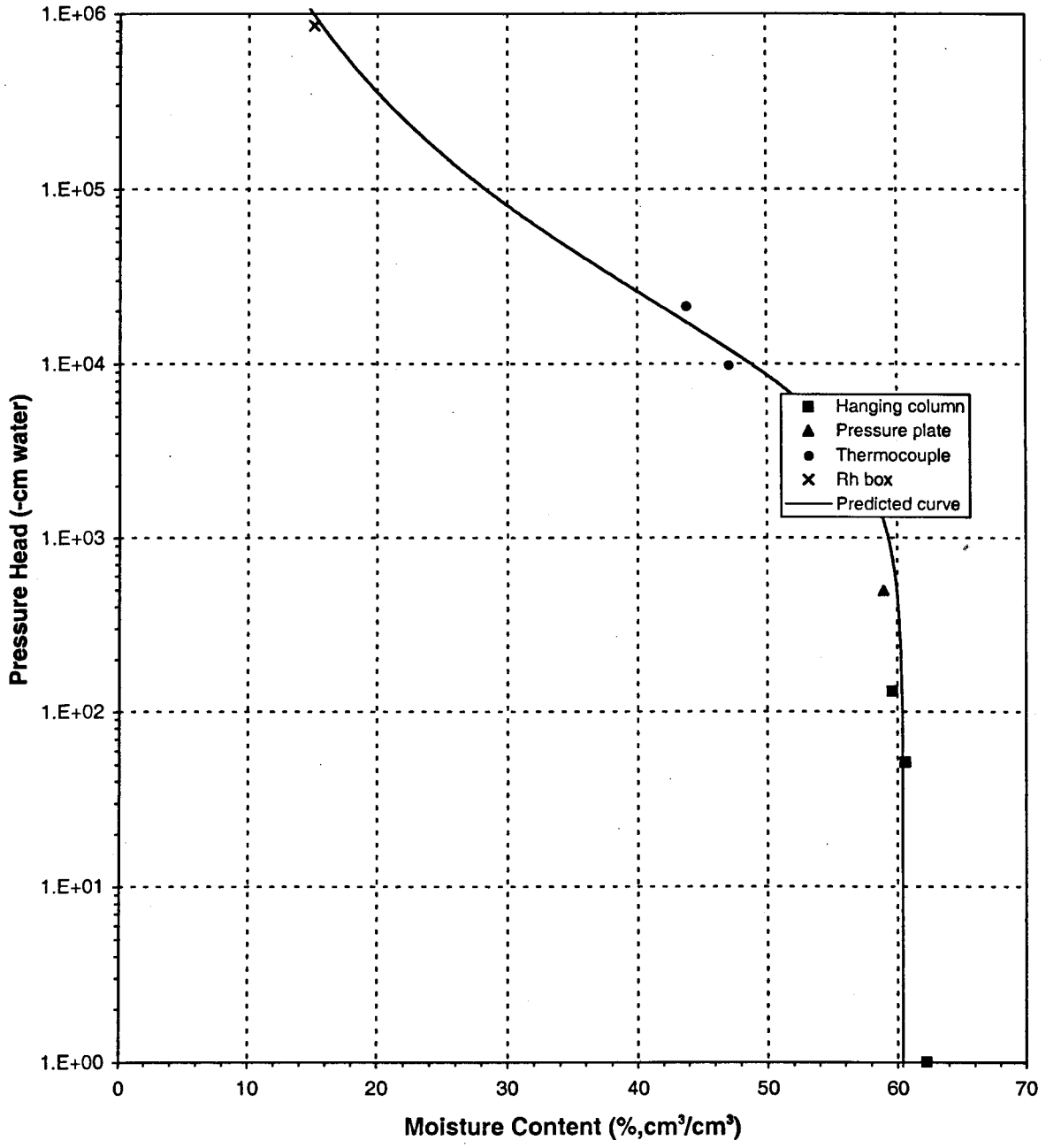
Daniel B. Stephens & Associates, Inc.

Water Retention Data Points
Sample Number: 8807



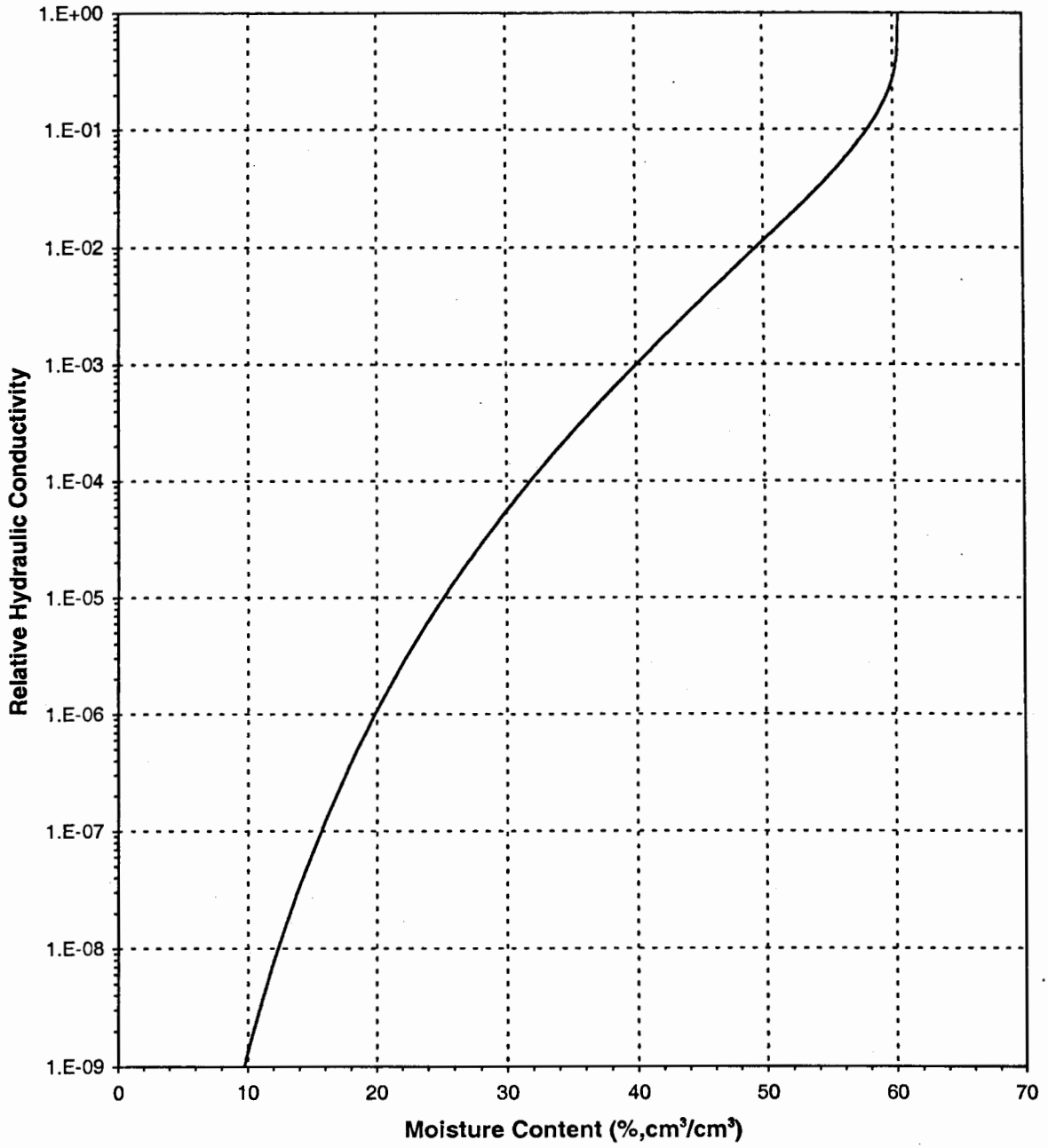
Daniel B. Stephens & Associates, Inc.

Predicted Water Retention Curve and Data Points
Sample Number: 8807



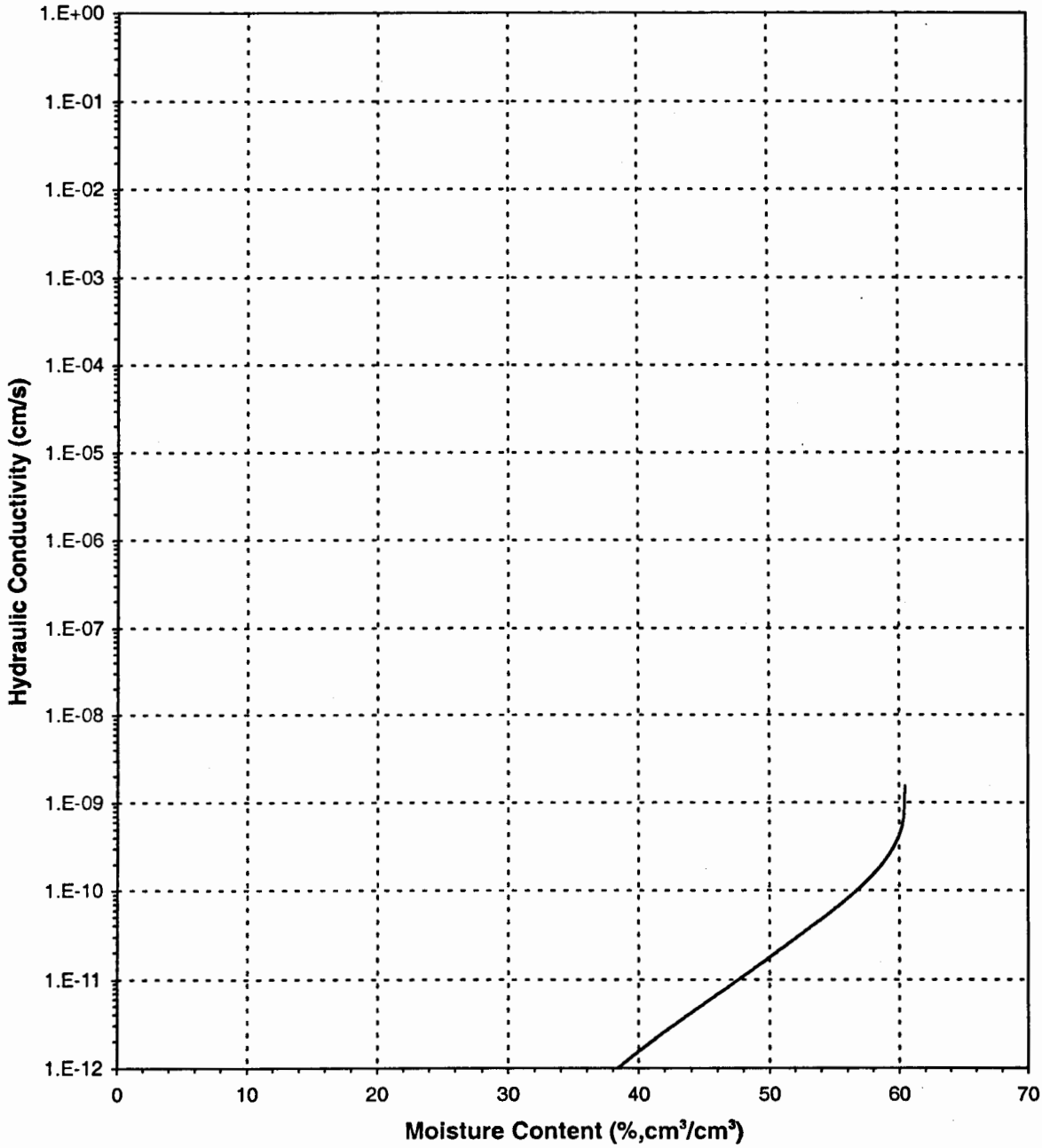
Daniel B. Stephens & Associates, Inc.

Plot of Relative Hydraulic Conductivity vs Moisture Content
Sample Number: 8807



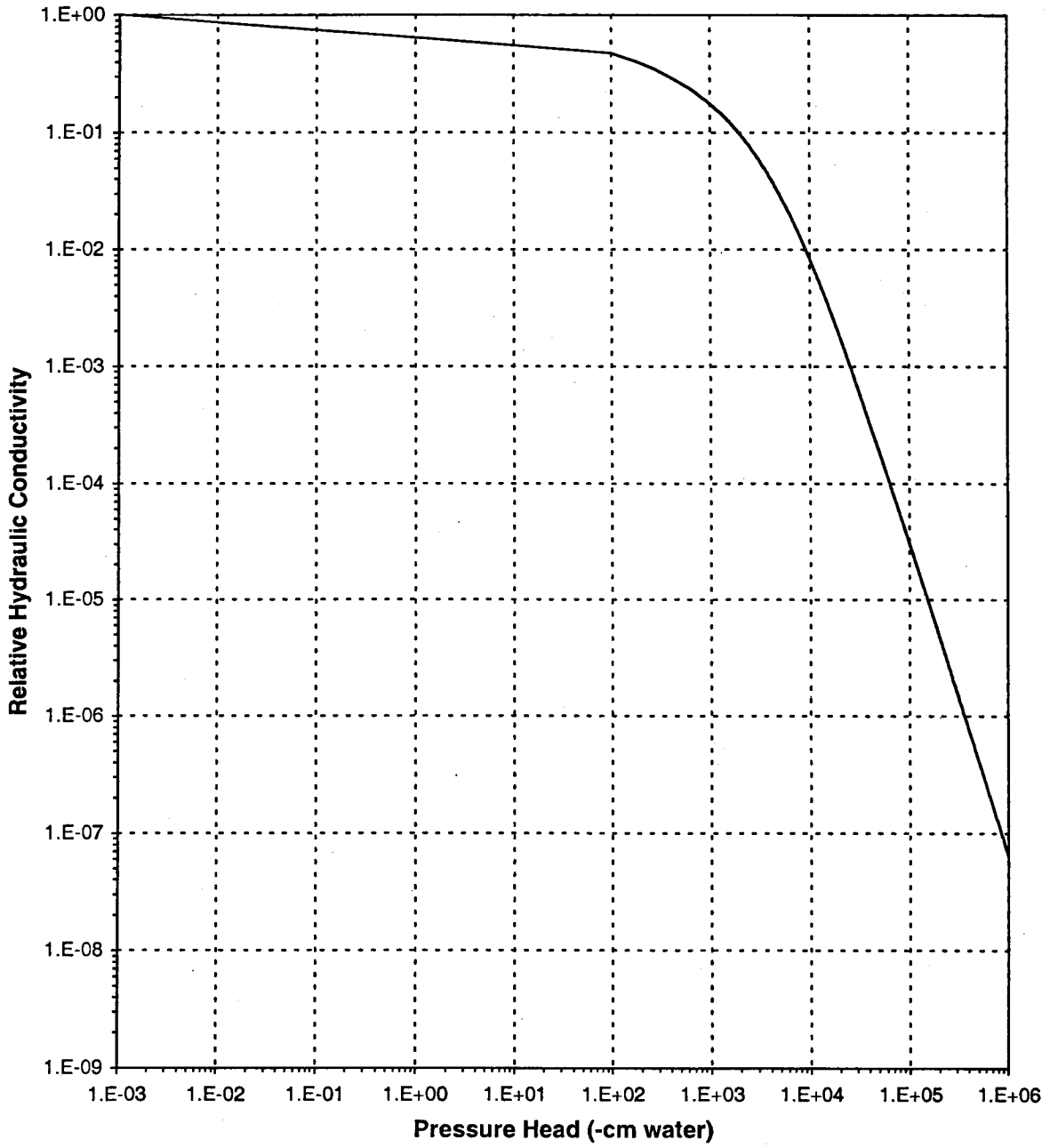
Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Moisture Content
Sample Number: 8807



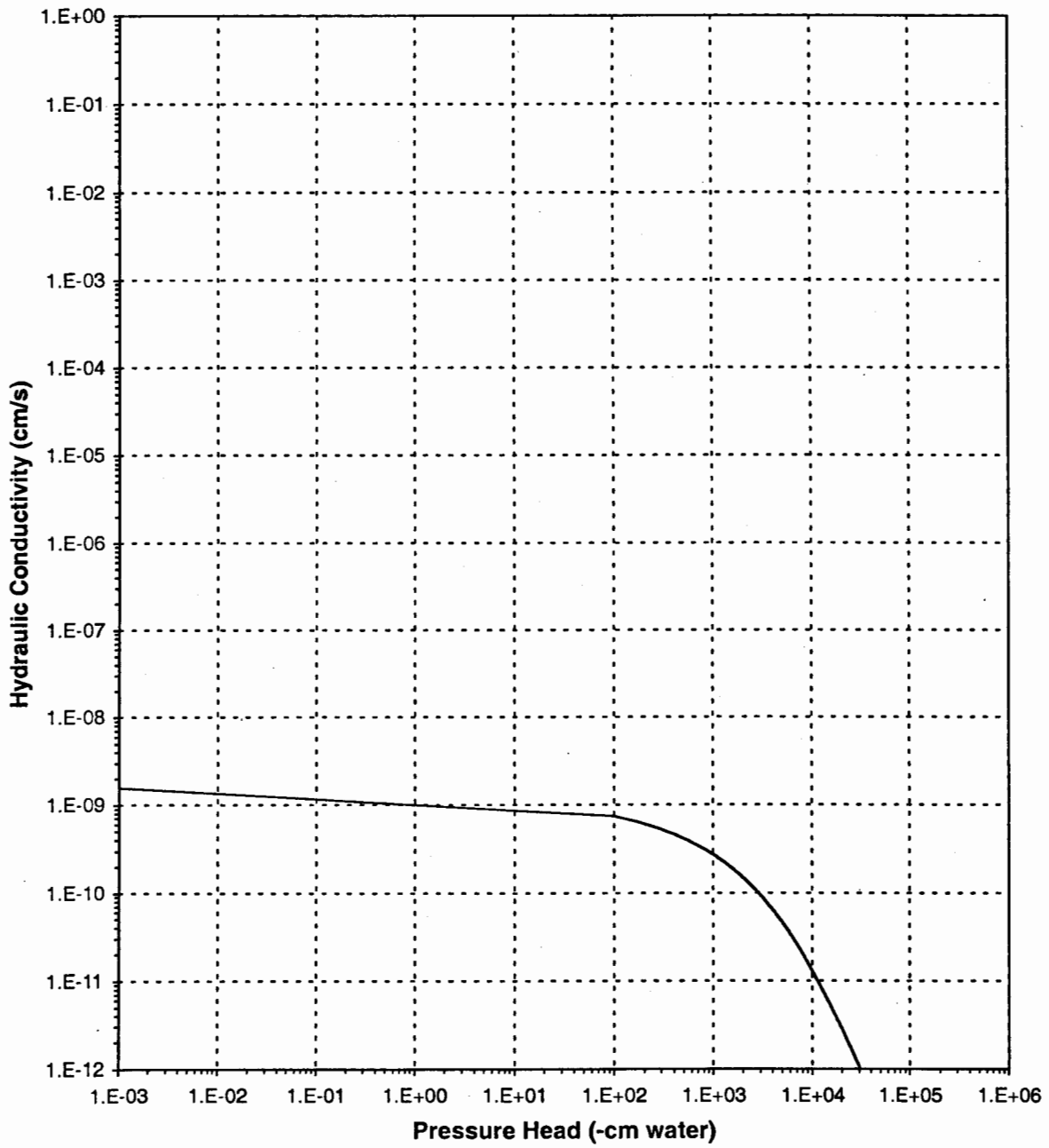
Daniel B. Stephens & Associates, Inc.

Plot of Relative Hydraulic Conductivity vs Pressure Head
Sample Number: 8807



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Pressure Head
Sample Number: 8807



Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	LANL	*Dry wt. of sample* (g):	110.29
Job Number:	9958.01	*Tare wt., screen & clamp* (g):	2.10
Sample Number:	8814	*Tare wt., ring* (g):	122.88
Ring Number:	8814	*Tare wt., epoxy* (g):	0.00
Depth:	642.3-642.8	*Sample volume* (cm^3):	70.31

Saturated weight at 0 cm tension* (g): 286.44
Volume of water † in saturated sample (cm^3): 51.17
Saturated moisture content (% vol): 72.78
Sample bulk density (g/cm^3): 1.57

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	20-Oct-99 / 10:00	286.44	0.00	72.78	
	23-Oct-99 / 14:55	287.70	6.00	74.57	
	26-Oct-99 / 09:45	287.12	29.70	73.75	
	28-Oct-99 / 13:30	285.43	125.60	71.34	
Pressure plate:	01-Nov-99 / 09:35	282.42	499.70	67.06	
	28-Nov-99 / 20:00	135.98	8158.40	65.24	SS1
	22-Nov-99 / 17:45	126.21	15297.00	60.01	SS2

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

SS1 = Analysis using subsample #1: Dry wt* = 129.43 g, Tare wt = 113.68 g.
SS2 = Analysis using subsample #2: Dry wt* = 123.36 g, Tare wt = 115.91 g.

Laboratory analysis by: E. Koenig
Data entered by: R. Smith
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Relative Humidity Box
(Main Drainage Curve)

Job Name: LANL
Job Number: 9958.01
Sample Number: 8814
Ring Number: 8814
Depth: 642.3-642.8

Dry weight of relative humidity box sample* (g): 77.33
Tare weight (g): 40.97
Sample bulk density (g/cm^3): 1.57

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	17-Dec-99 / 08:30	82.82	848426	23.70

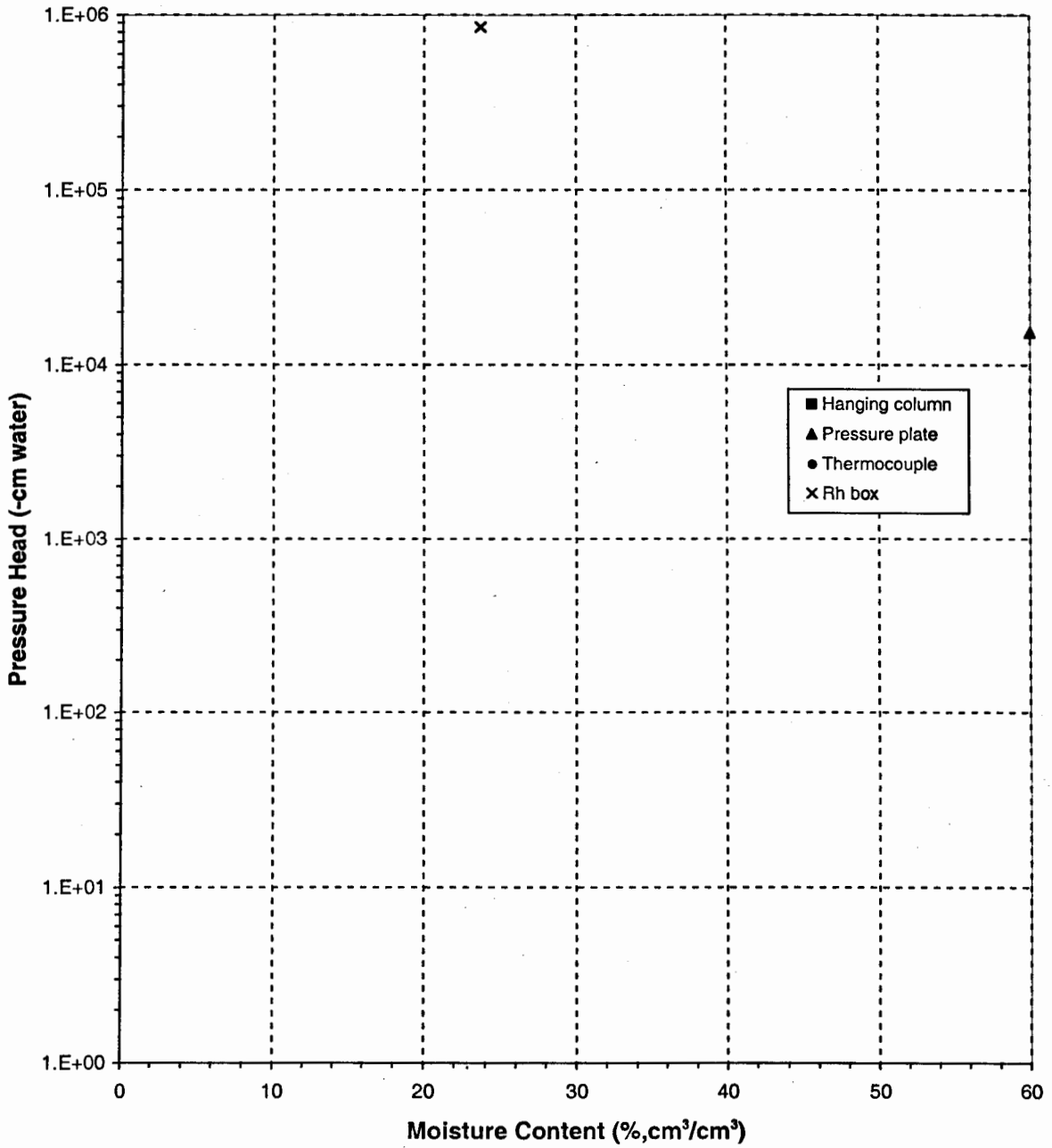
Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

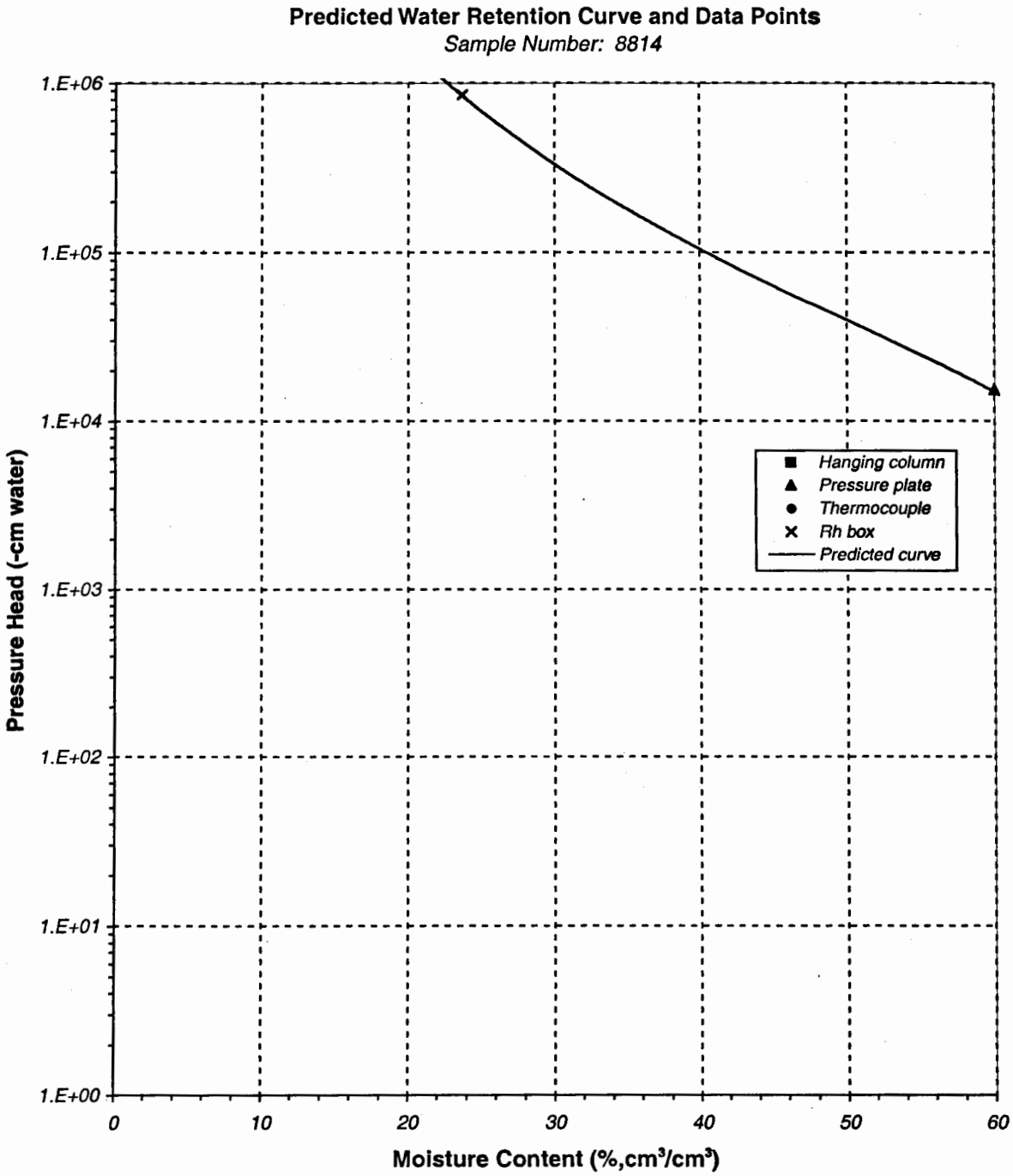
Laboratory analysis by: B. Baum
Data entered by: R. Smith
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Water Retention Data Points
Sample Number: 8814



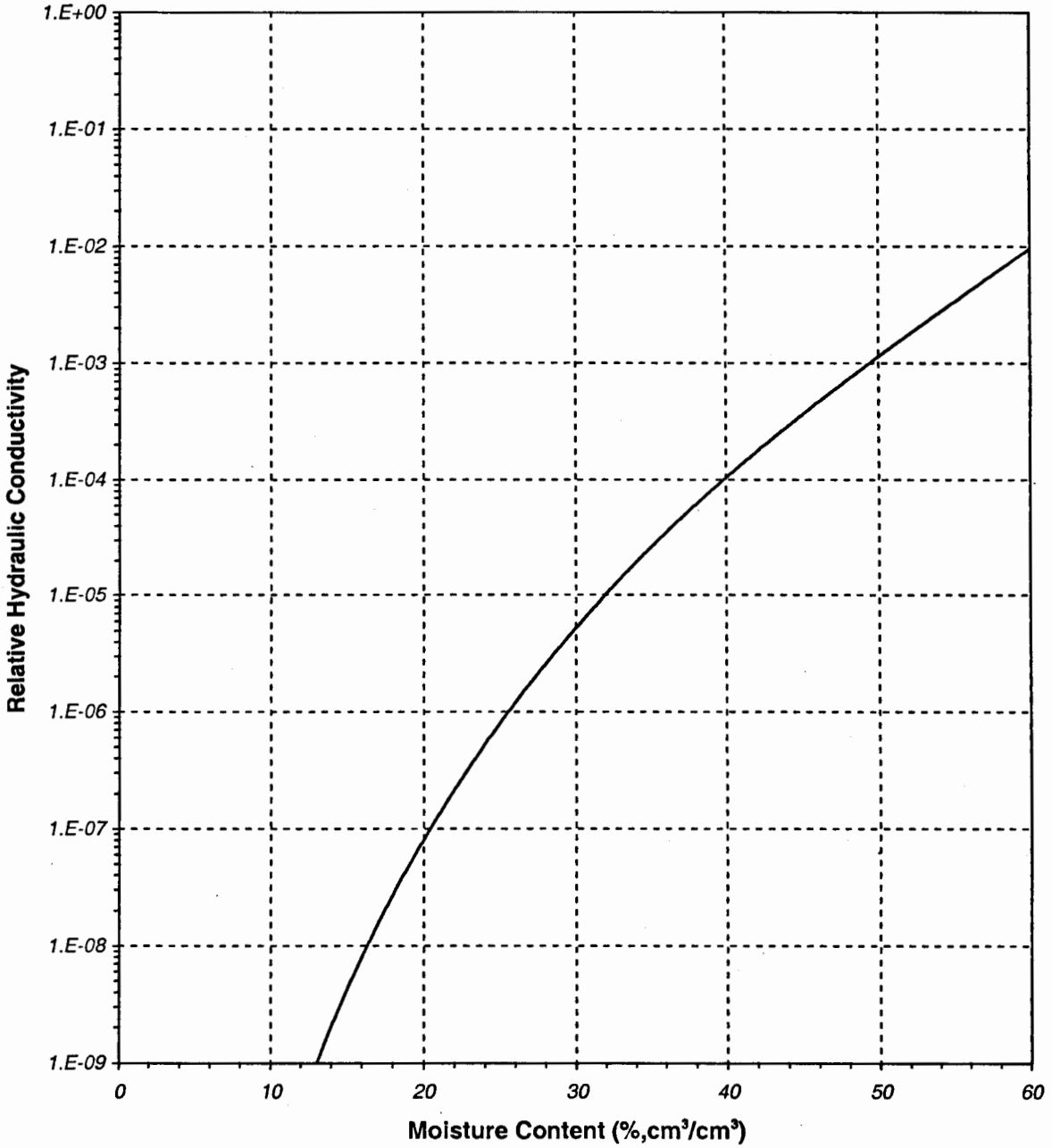
Daniel B. Stephens & Associates, Inc.



Daniel B. Stephens & Associates, Inc.

Plot of Relative Hydraulic Conductivity vs Moisture Content

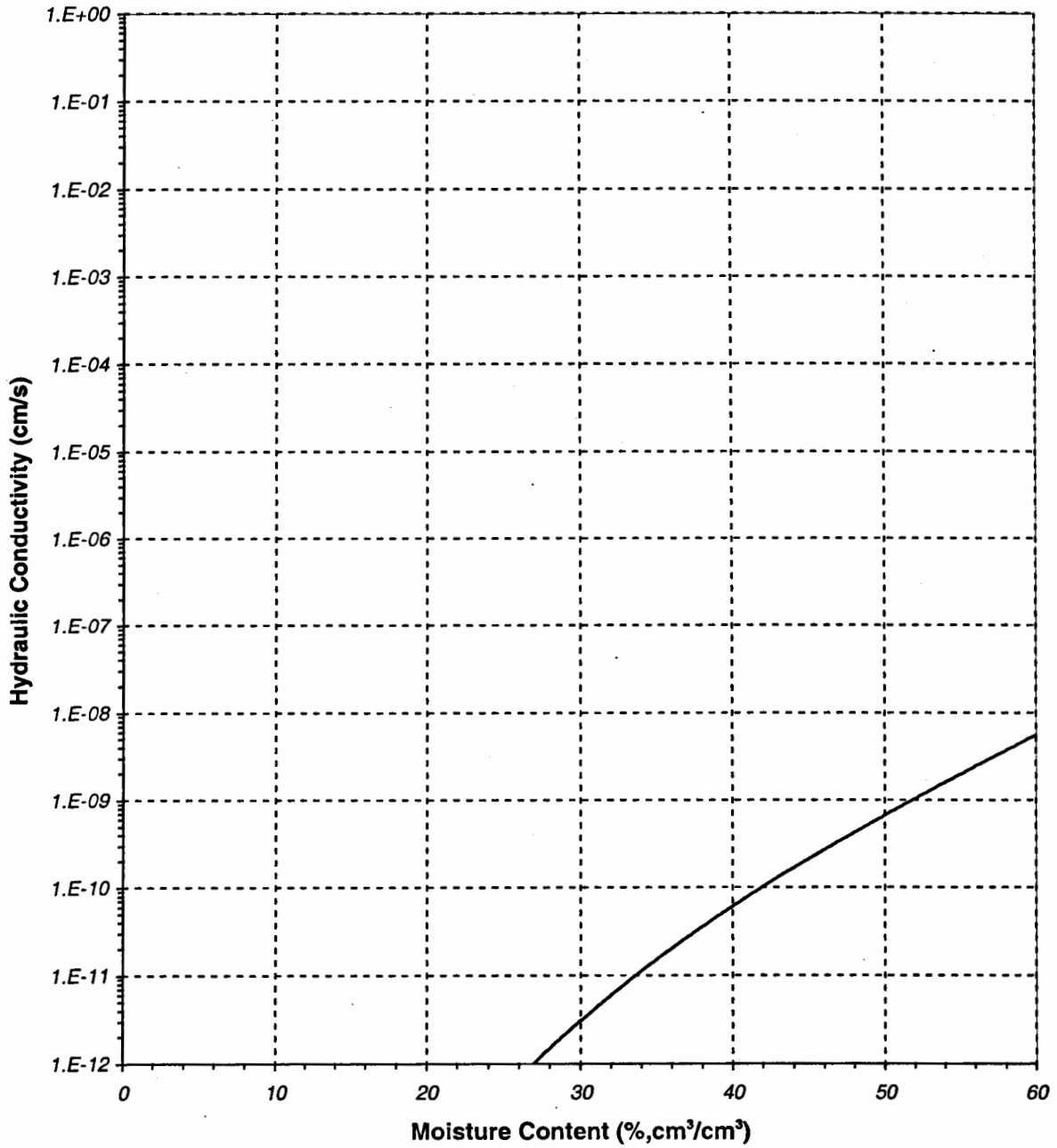
Sample Number: 8814



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Moisture Content

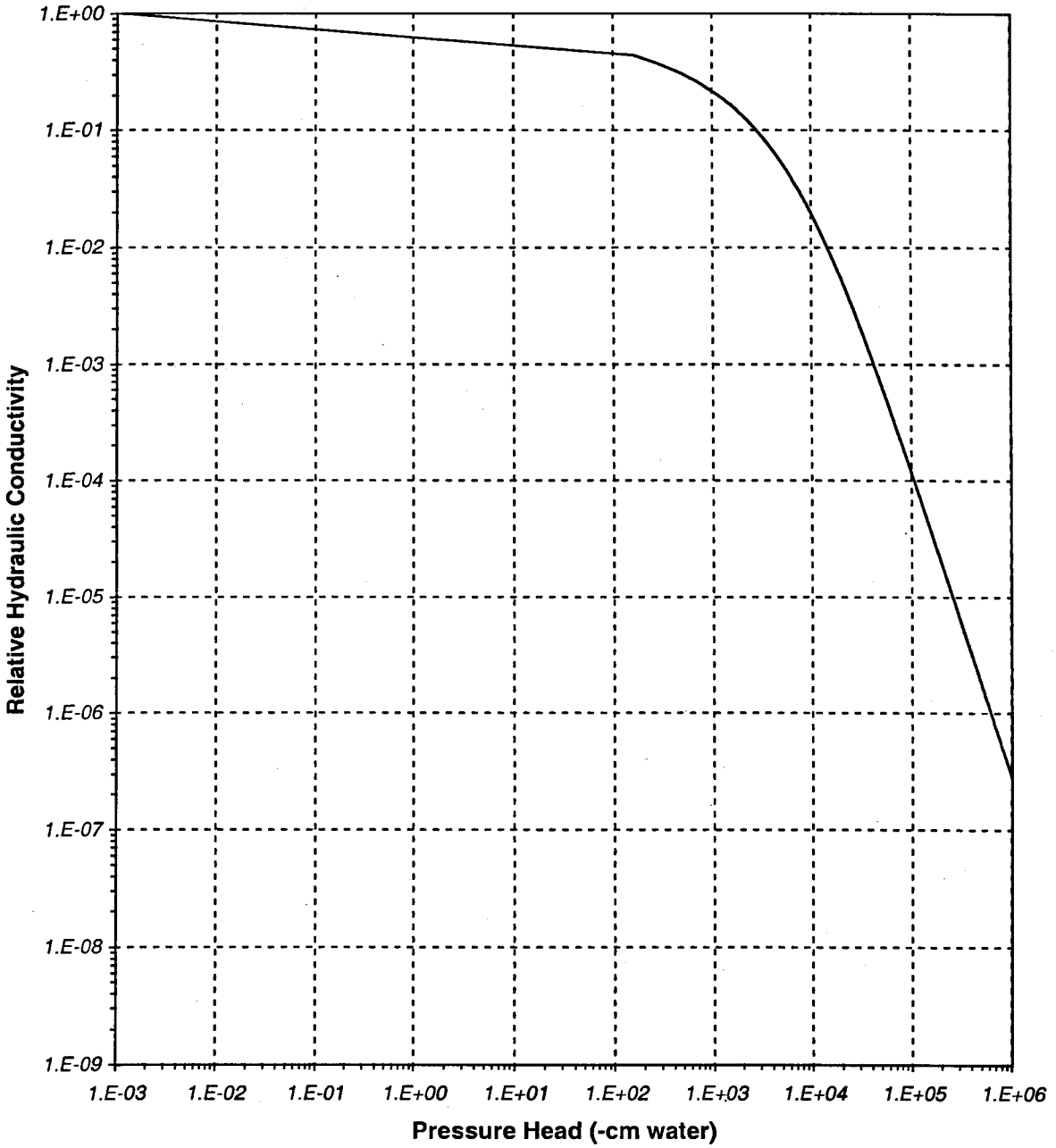
Sample Number: 8814



Daniel B. Stephens & Associates, Inc.

Plot of Relative Hydraulic Conductivity vs Pressure Head

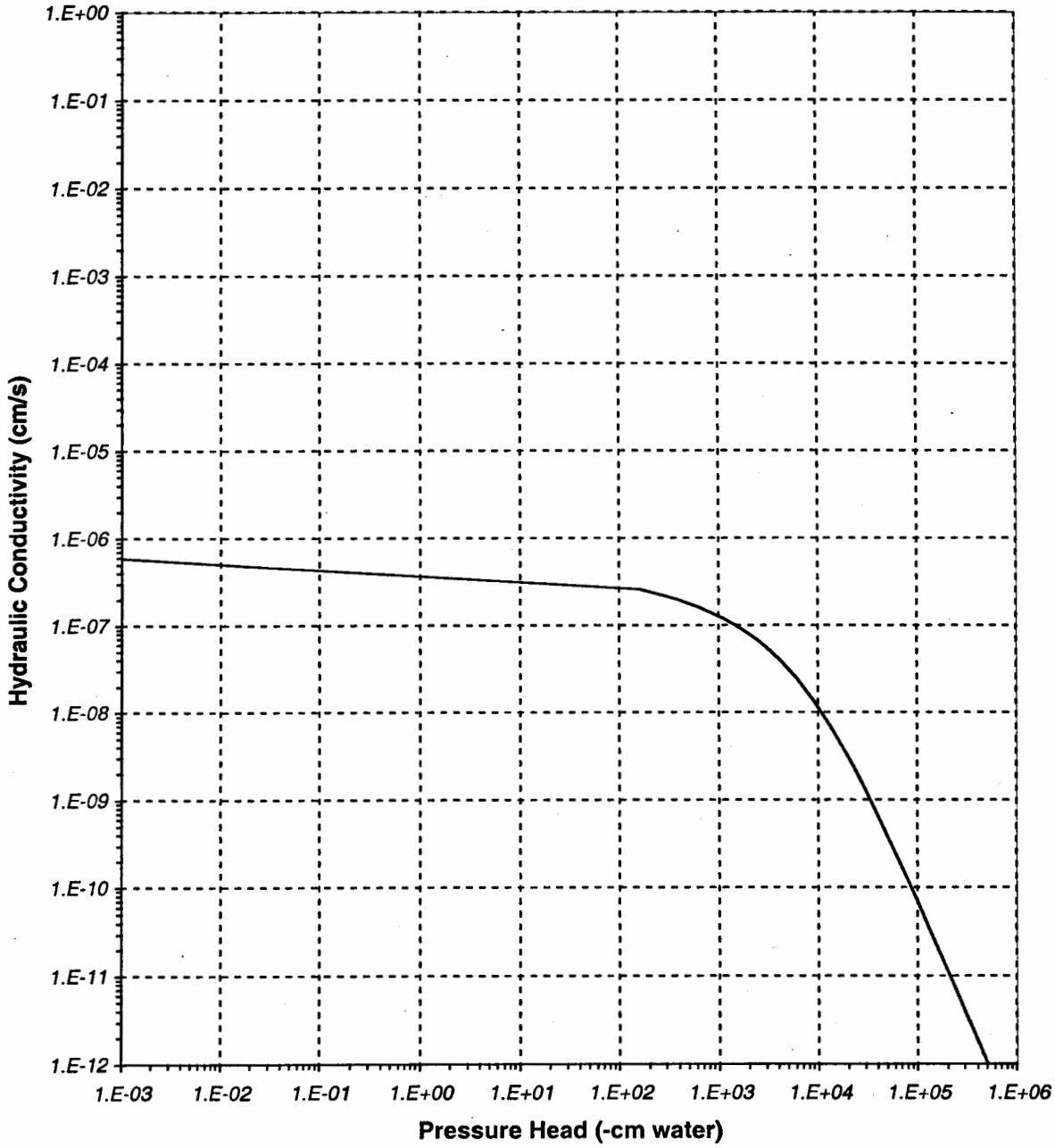
Sample Number: 8814



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: 8814



Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	LANL	*Dry wt. of sample* (g):	292.43
Job Number:	9958.01	*Tare wt., screen & clamp* (g):	31.06
Sample Number:	CACV-98-0039	*Tare wt., ring* (g):	107.52
Ring Number:	CACV-98-0039	*Tare wt., epoxy* (g):	0.00
Depth:	NA	*Sample volume* (cm^3):	135.27

Saturated weight at 0 cm tension* (g): 445.63
Volume of water † in saturated sample (cm^3): 14.62
Saturated moisture content (% vol): 10.81
Sample bulk density (g/cm^3): 2.16

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	18-Oct-99 / 15:45	445.63	0.00	10.81
	21-Oct-99 / 10:30	444.72	53.20	10.14
	23-Oct-99 / 15:00	444.45	126.40	9.94
Pressure plate:	26-Oct-99 / 09:50	444.16	509.90	9.72

Dry weight of thermocouple sample* (g): 342.31
Tare weight, jar (g): 205.68
Sample bulk density (g/cm^3): 2.16

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	22-Sep-99 / 10:32	345.89	9790.1	5.66
	24-Sep-99 / 18:24	344.78	12849.5	3.91

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: E. Koenig/T. Gere
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Water Activity Meter/Relative Humidity Box
(Main Drainage Curve)

Job Name: LANL
Job Number: 9958.01
Sample Number: CACV-98-0039
Ring Number: CACV-98-0039
Depth: NA

Dry weight of relative humidity box sample* (g): 86.71
Tare weight (g): 47.60
Sample bulk density (g/cm^3): 2.16

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	20-Sep-99 / 10:15	86.80	836961	0.51

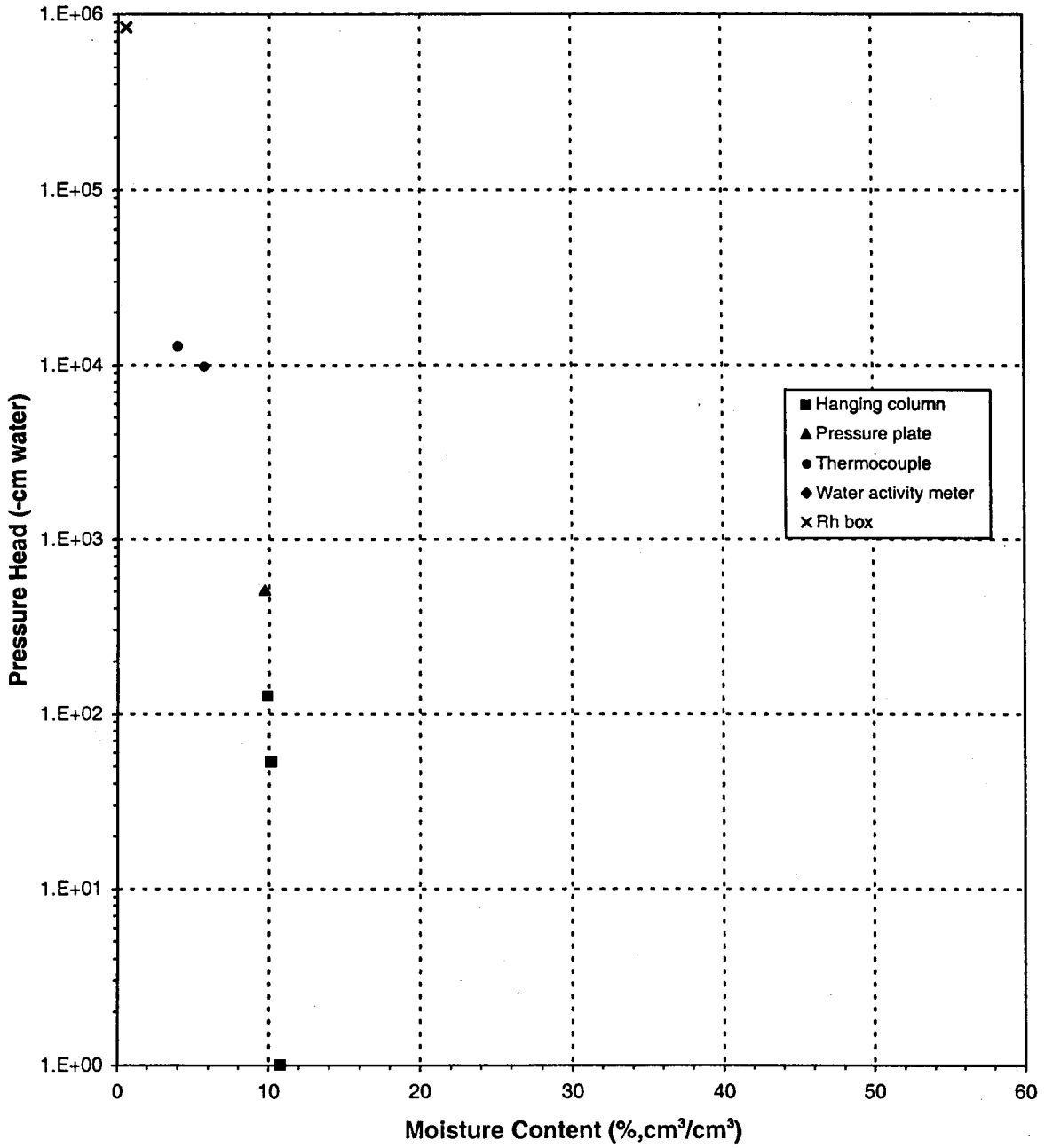
Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke/T. Gere
Data entered by: M. Devine
Checked by: R. Smith

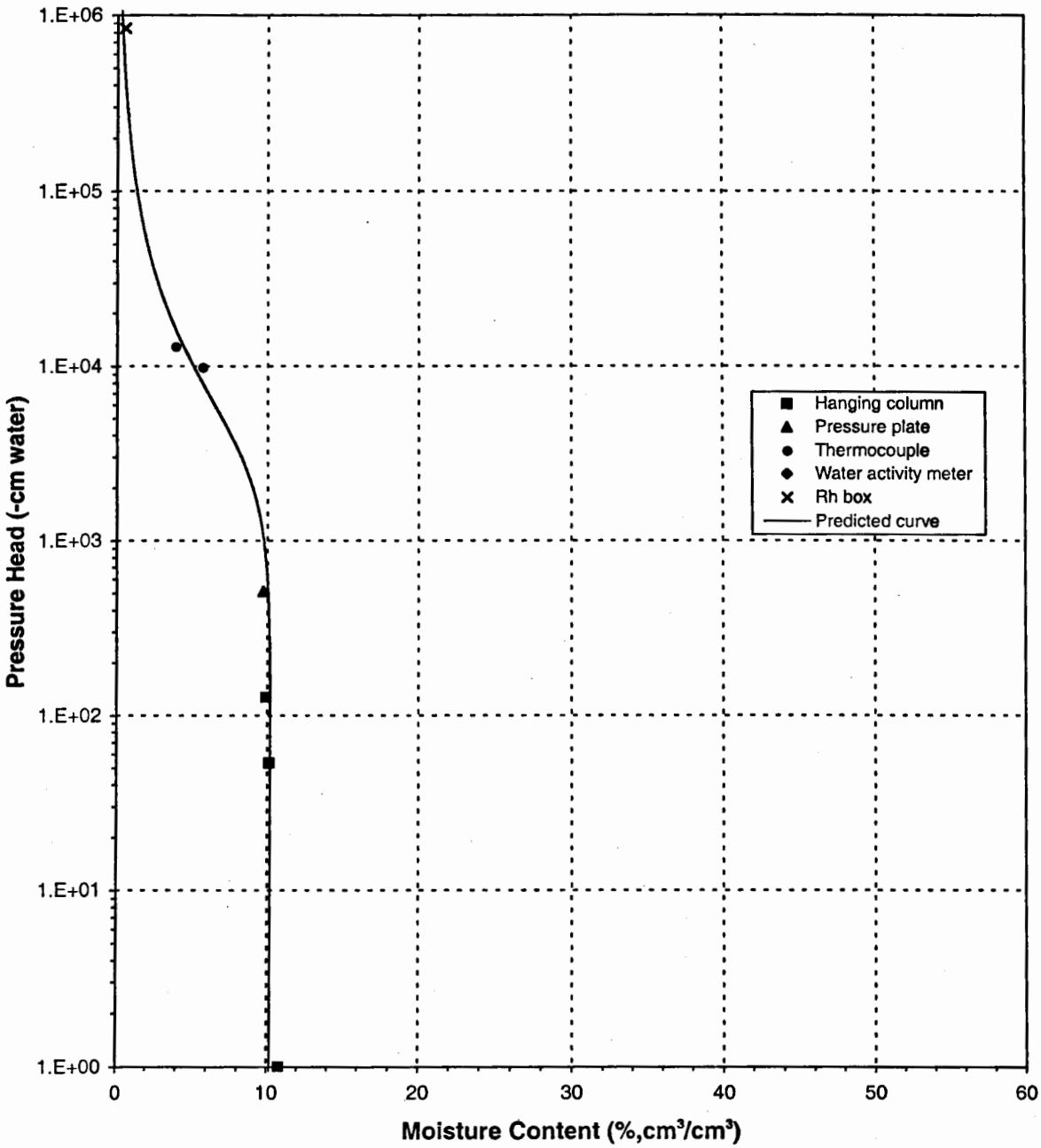
Daniel B. Stephens & Associates, Inc.

Water Retention Data Points
Sample Number: CACV-98-0039



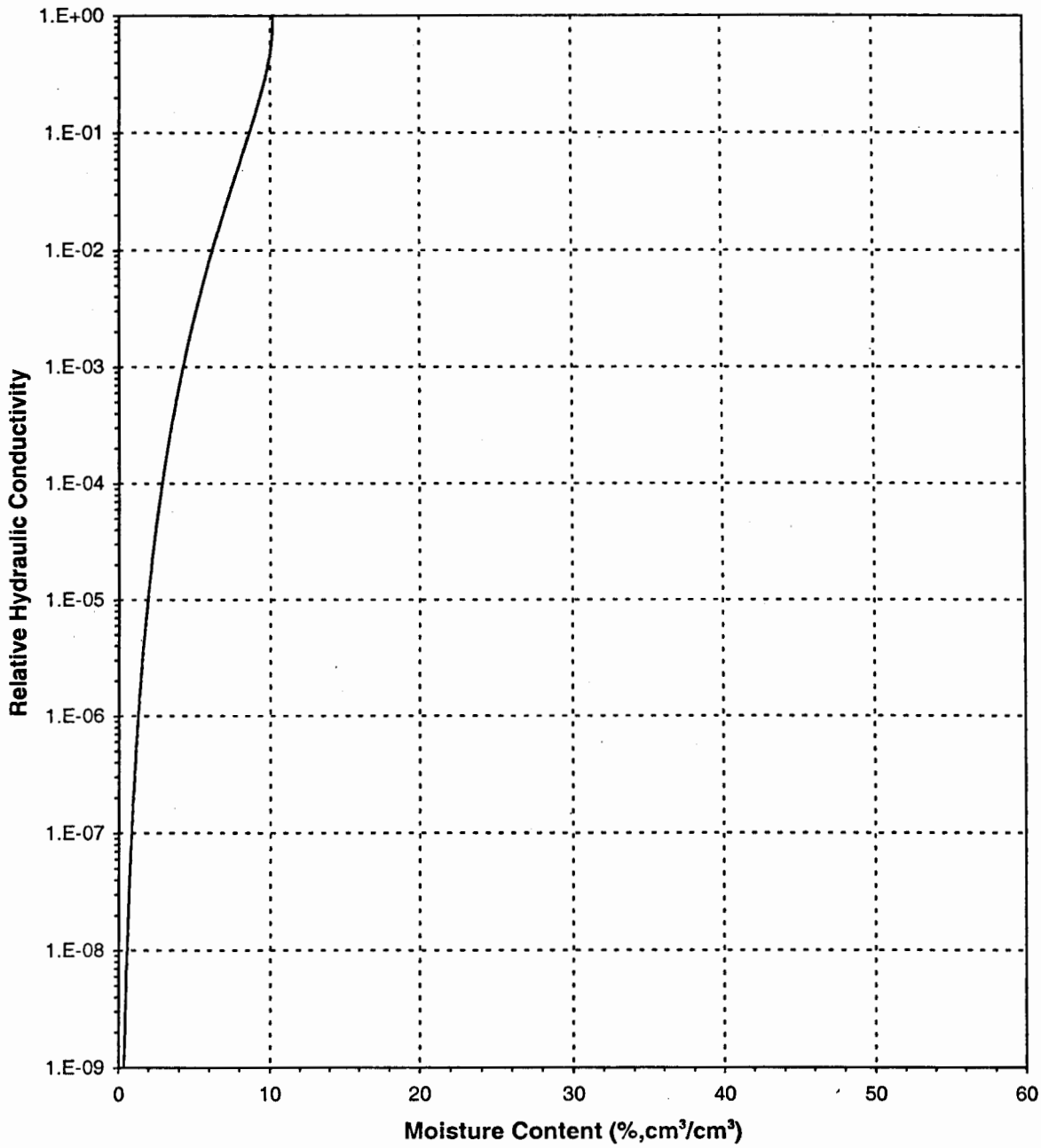
Daniel B. Stephens & Associates, Inc.

Predicted Water Retention Curve and Data Points
Sample Number: CACV-98-0039



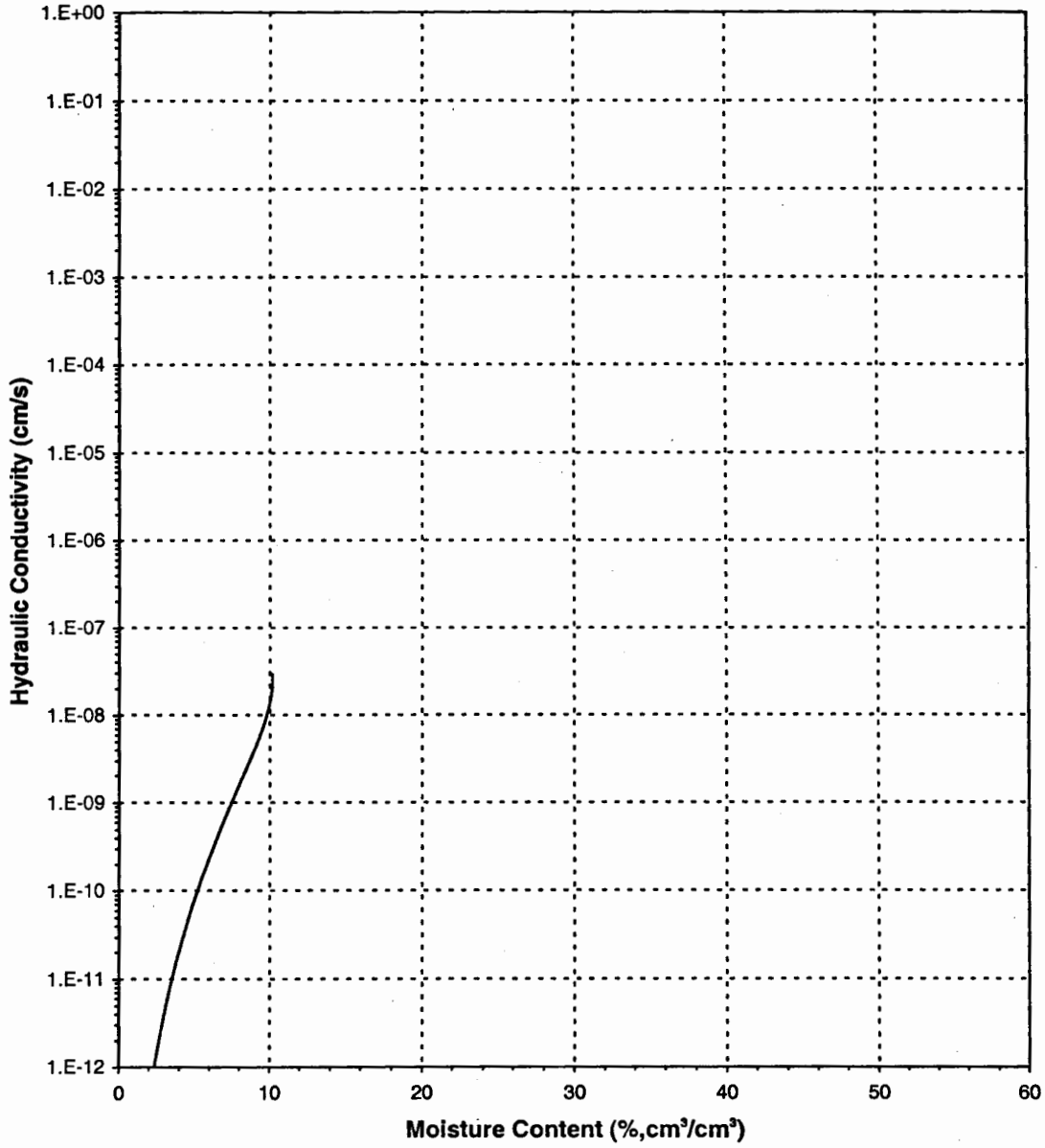
Daniel B. Stephens & Associates, Inc.

Plot of Relative Hydraulic Conductivity vs Moisture Content
Sample Number: CACV-98-0039



Daniel B. Stephens & Associates, Inc.

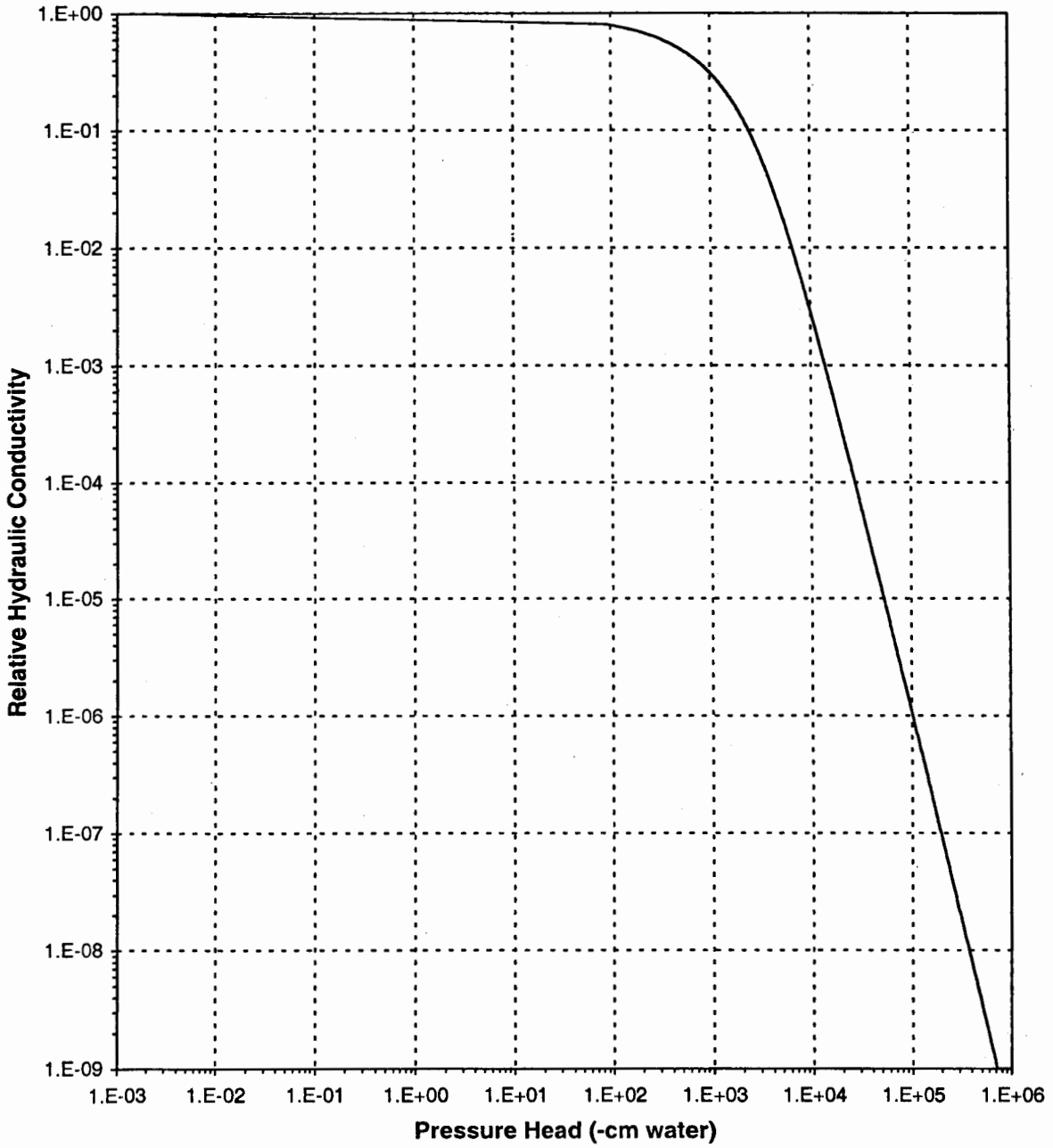
Plot of Hydraulic Conductivity vs Moisture Content
Sample Number: CACV-98-0039



Daniel B. Stephens & Associates, Inc.

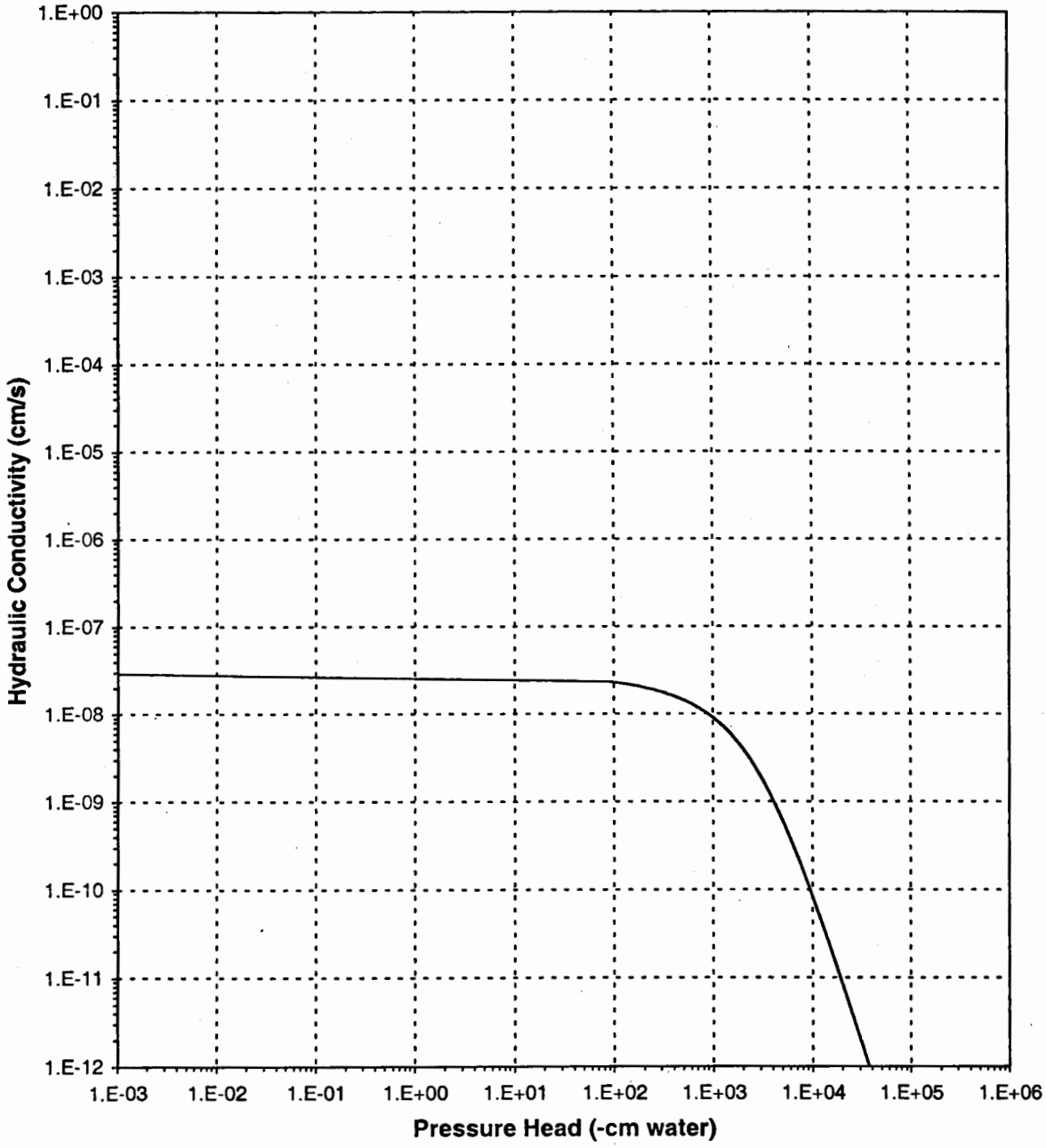
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: CACV-98-0039



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Pressure Head
Sample Number: CACV-98-0039



Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	LANL	*Dry wt. of sample* (g):	109.72
Job Number:	9958.01	*Tare wt., screen & clamp* (g):	29.02
Sample Number:	CACV-98-0043	*Tare wt., ring* (g):	130.79
Ring Number:	CACV-98-0043	*Tare wt., epoxy* (g):	0.00
Depth:	NA	*Sample volume* (cm^3):	85.85

Saturated weight at 0 cm tension* (g): 326.42
Volume of water † in saturated sample (cm^3): 56.89
Saturated moisture content (% vol): 66.27
Sample bulk density (g/cm^3): 1.28

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	01-Oct-99 / 12:00	326.42	0.00	66.27
	04-Oct-99 / 09:20	321.58	9.50	60.63
	06-Oct-99 / 15:40	316.20	38.10	54.36
	08-Oct-99 / 20:40	308.96	80.30	45.93
Pressure plate:	11-Oct-99 / 09:20	290.12	254.95	23.98
	13-Oct-99 / 14:25	281.90	1019.80	14.41

Dry weight of thermocouple sample* (g): 270.78
Tare weight, jar (g): 171.22
Sample bulk density (g/cm^3): 1.28

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	08-Oct-99 / 13:33	273.93	8464.3	4.04
	04-Oct-99 / 16:31	273.27	17336.6	3.20

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: E. Koenig/R. Smith
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Water Activity Meter/Relative Humidity Box
(Main Drainage Curve)

Job Name: LANL
Job Number: 9958.01
Sample Number: CACV-98-0043
Ring Number: CACV-98-0043
Depth: NA

Dry weight of relative humidity box sample* (g): 78.72
Tare weight (g): 39.92
Sample bulk density (g/cm^3): 1.28

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	22-Sep-99 / 08:32	79.15	836961	1.43

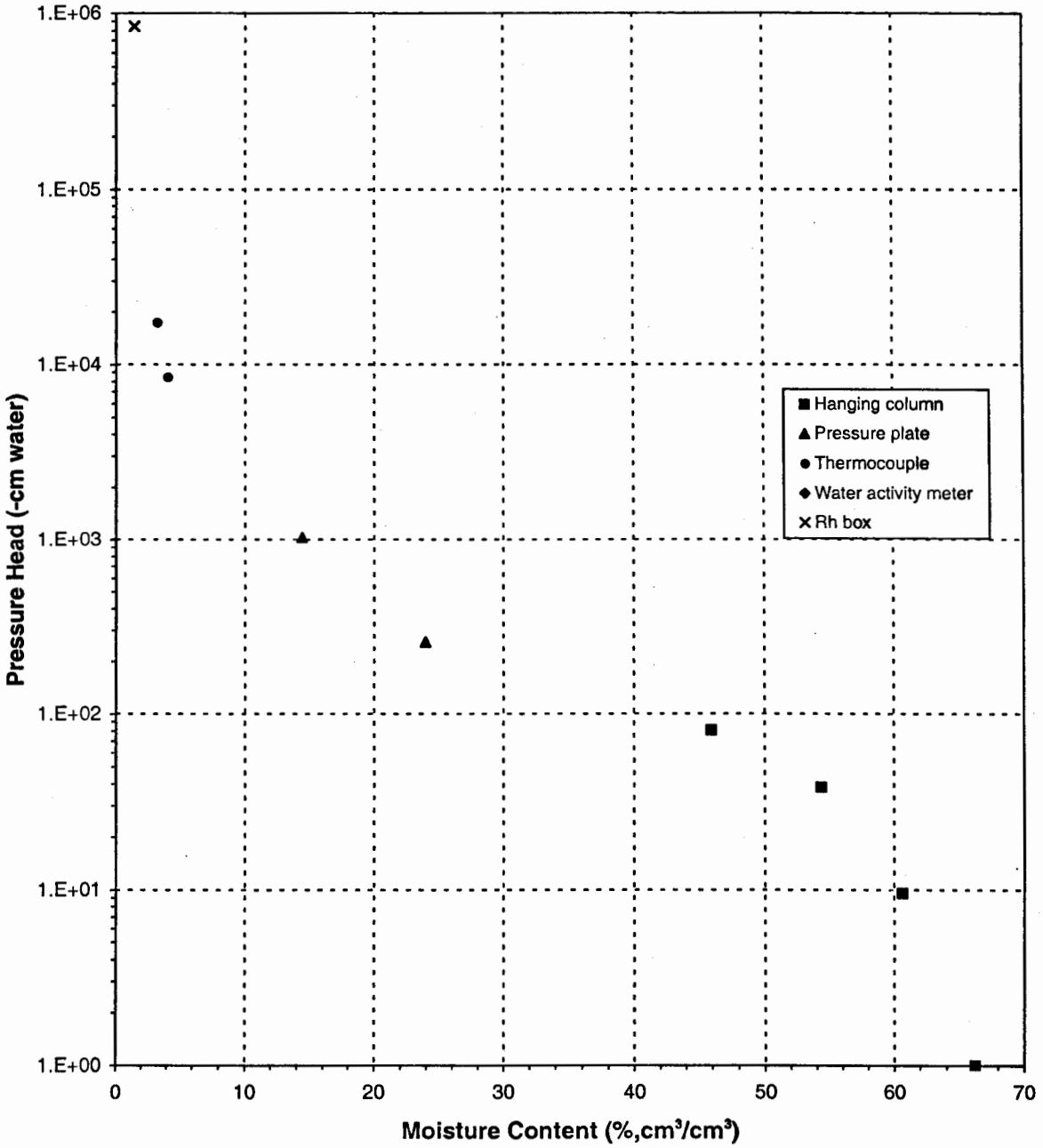
Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke/R. Smith
Data entered by: M. Devine
Checked by: R. Smith

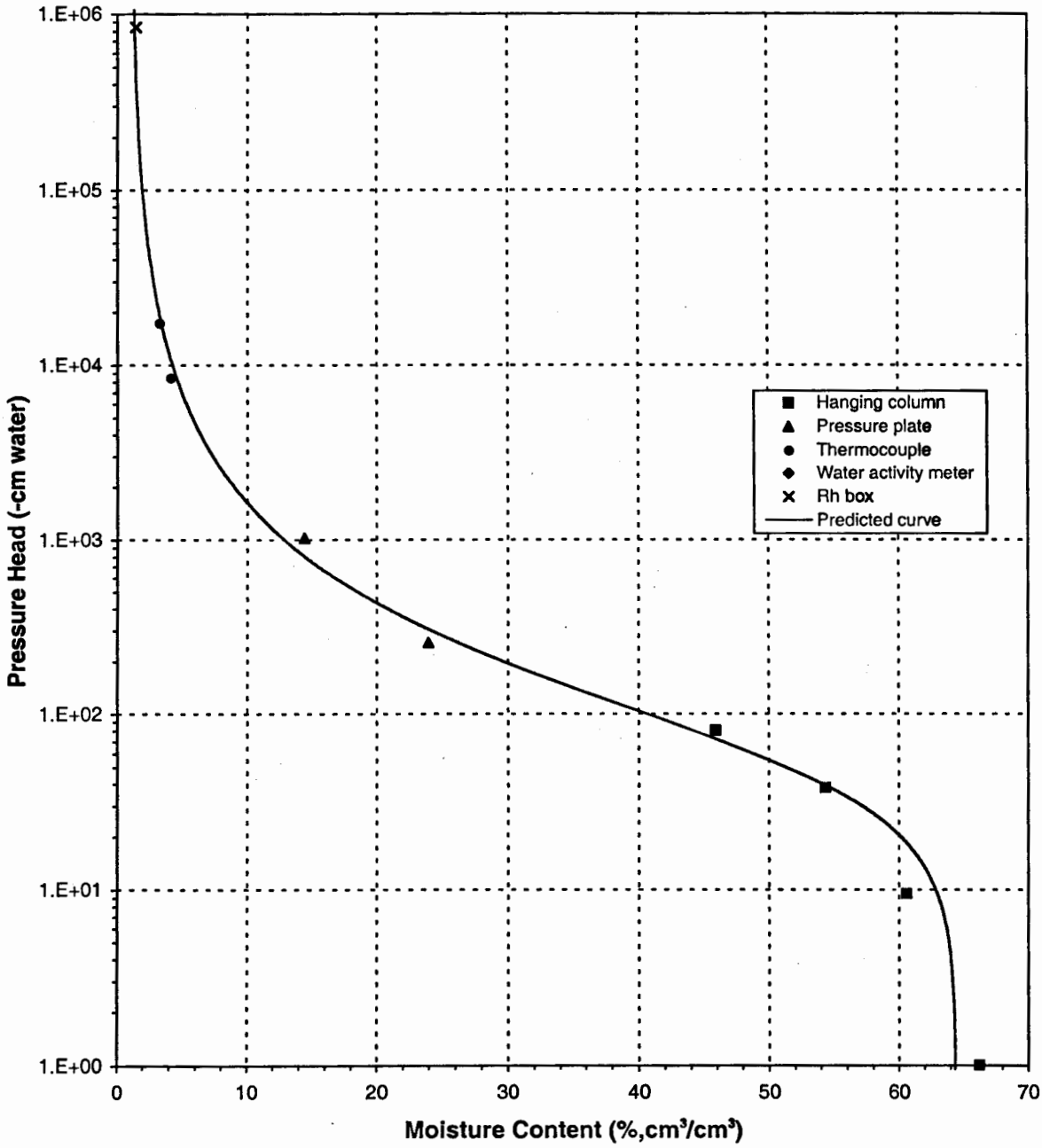
Daniel B. Stephens & Associates, Inc.

Water Retention Data Points
Sample Number: CACV-98-0043



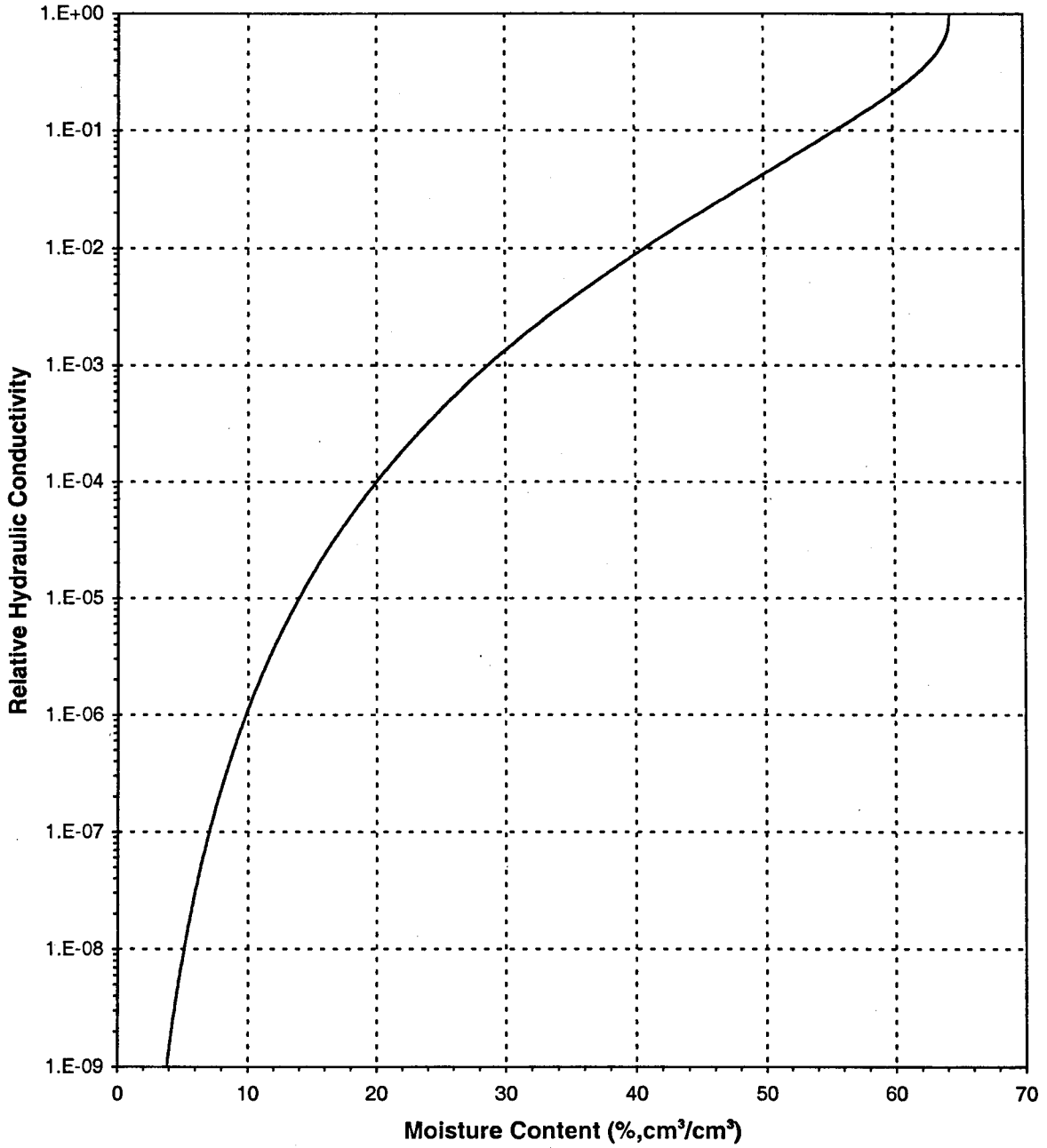
Daniel B. Stephens & Associates, Inc.

Predicted Water Retention Curve and Data Points
Sample Number: CACV-98-0043



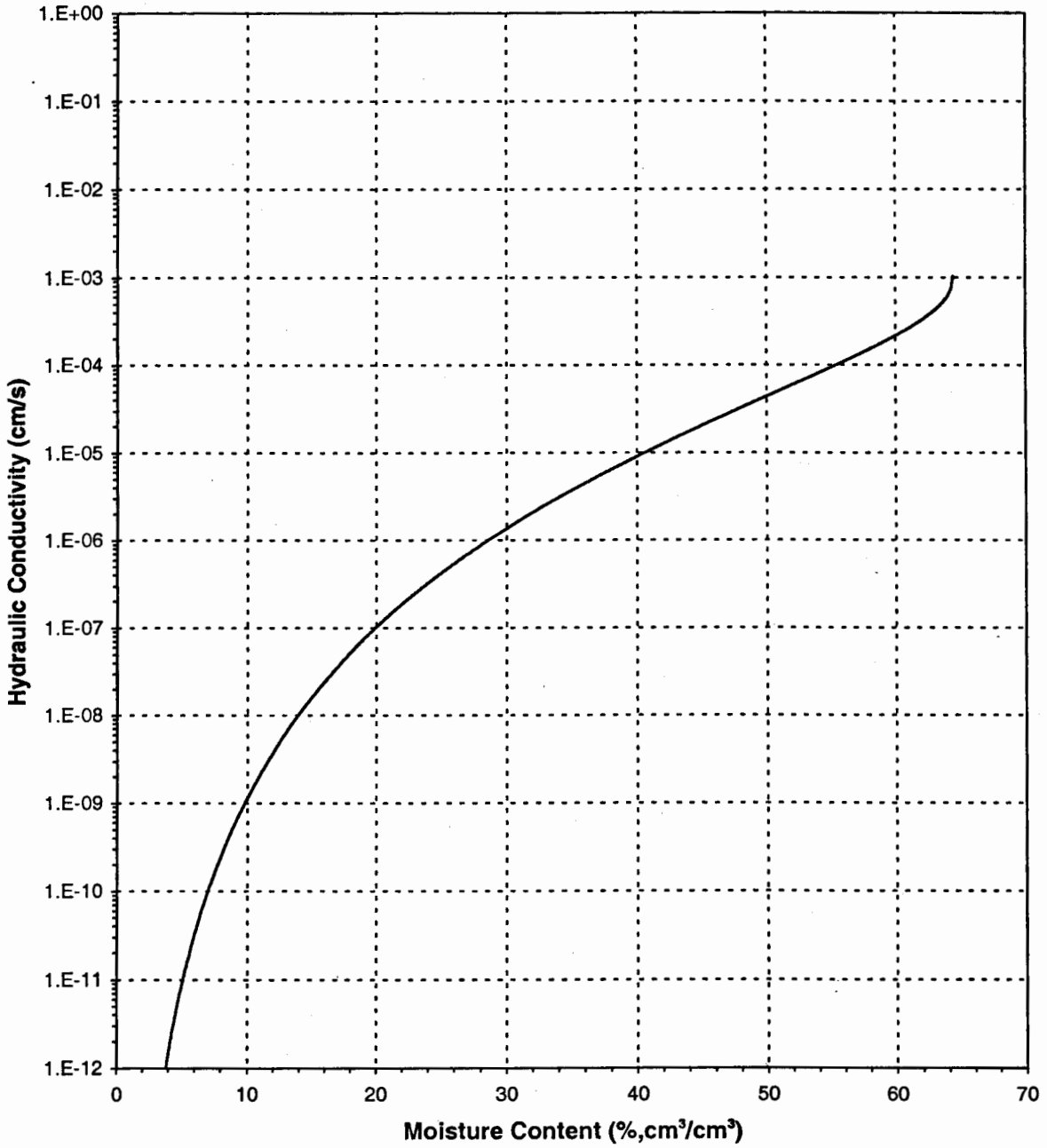
Daniel B. Stephens & Associates, Inc.

Plot of Relative Hydraulic Conductivity vs Moisture Content
Sample Number: CACV-98-0043



Daniel B. Stephens & Associates, Inc.

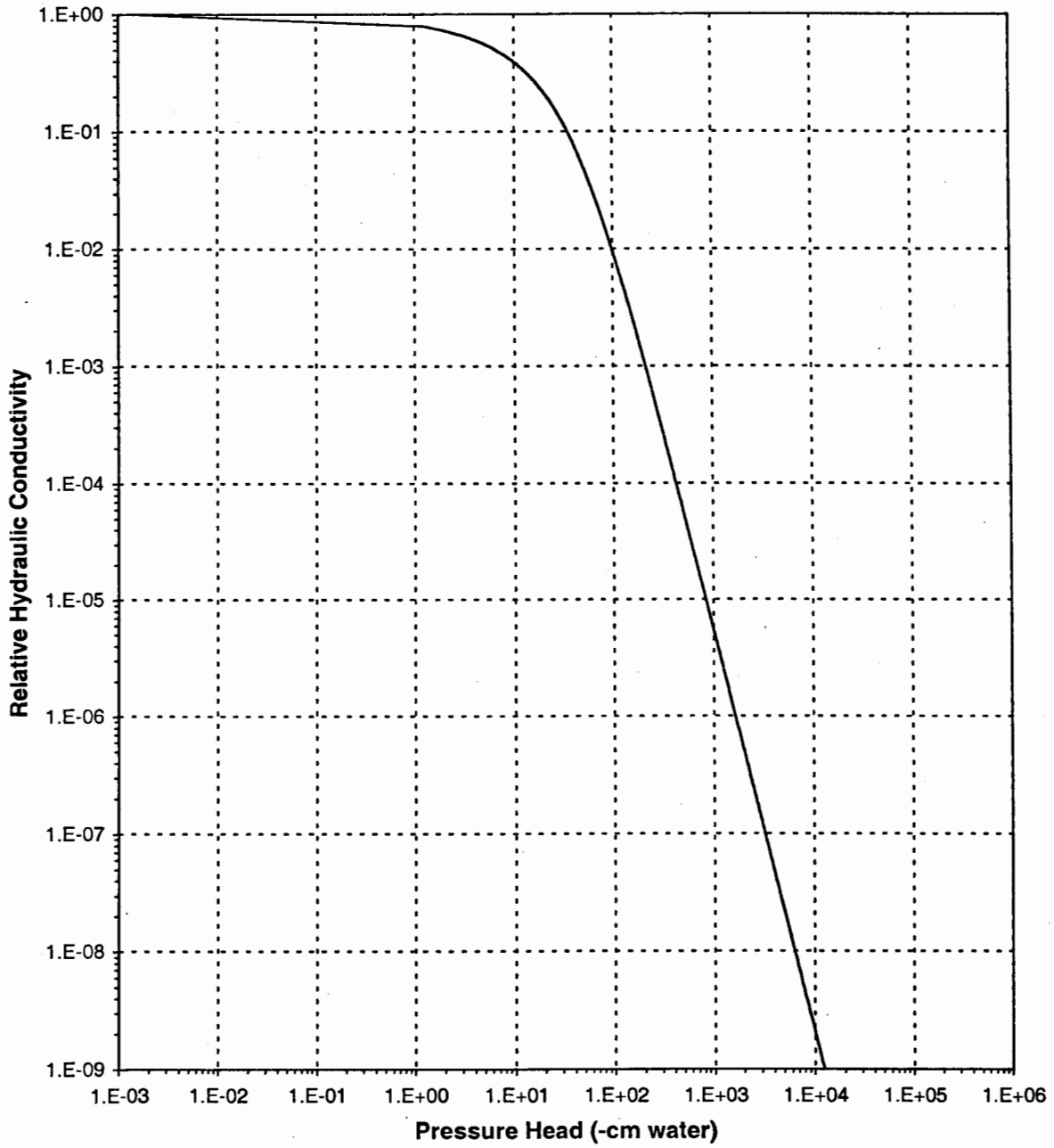
Plot of Hydraulic Conductivity vs Moisture Content
Sample Number: CACV-98-0043



Daniel B. Stephens & Associates, Inc.

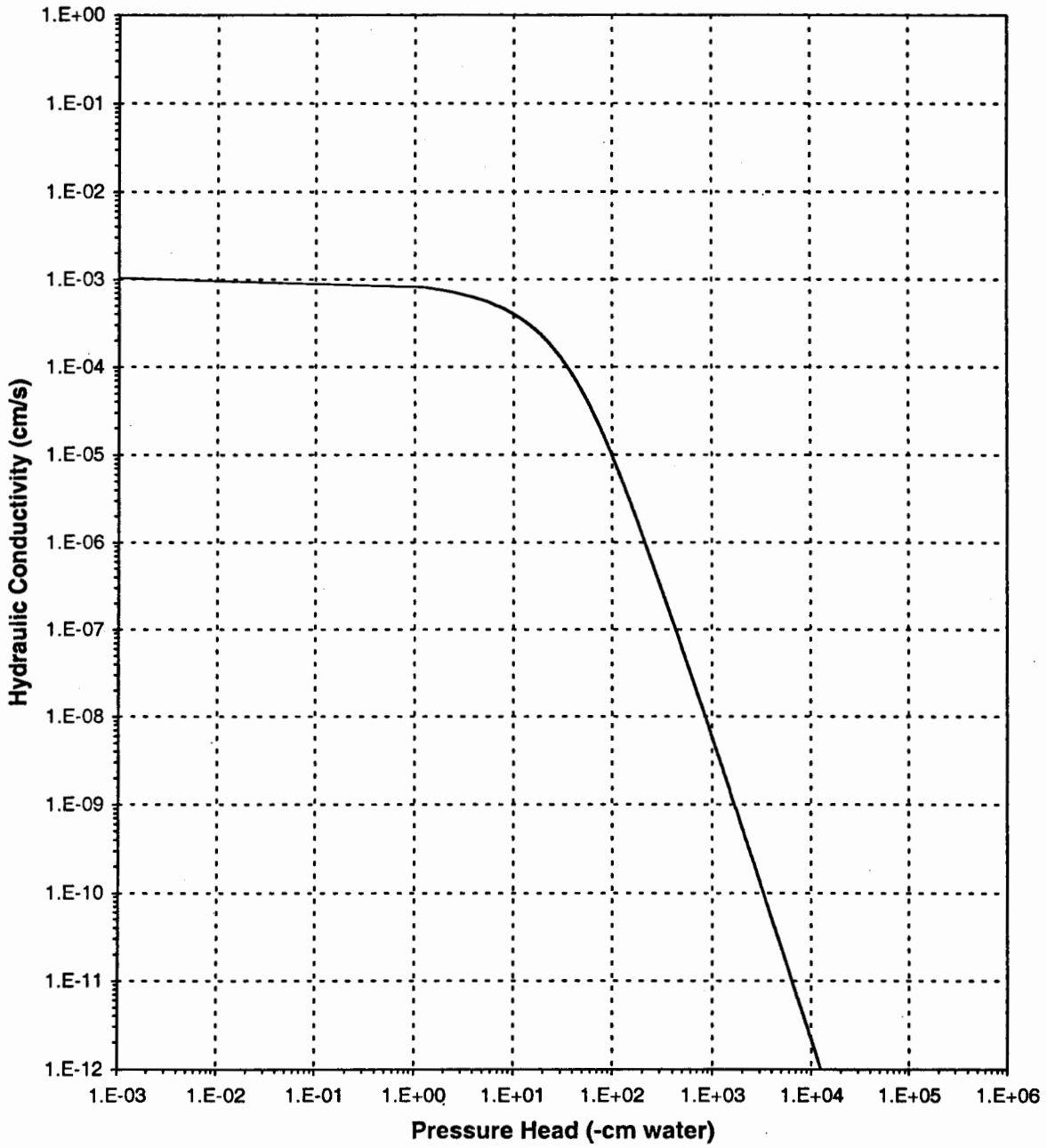
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: CACV-98-0043



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Pressure Head
Sample Number: CACV-98-0043



Daniel B. Stephens & Associates, Inc.

Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	LANL	*Dry wt. of sample* (g):	53.35
Job Number:	9958.01	*Tare wt., screen & clamp* (g):	40.07
Sample Number:	CACV-98-0046	*Tare wt., ring* (g):	189.36
Ring Number:	CACV-98-0046	*Tare wt., epoxy* (g):	0.00
Depth:	NA	*Sample volume* (cm^3):	48.35

Saturated weight at 0 cm tension* (g): 327.17
Volume of water † in saturated sample (cm^3): 44.39
Saturated moisture content (% vol): 91.80
Sample bulk density (g/cm^3): 1.10

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	01-Oct-99 / 11:40	327.17	0.00	91.80
	04-Oct-99 / 09:20	318.13	9.60	73.11
	06-Oct-99 / 15:40	312.80	38.20	62.08
	08-Oct-99 / 20:40	311.46	80.40	59.31
Pressure plate:	11-Oct-99 / 09:20	309.09	254.95	54.41
	13-Oct-99 / 14:23	307.26	1019.80	50.63

Dry weight of thermocouple sample* (g): 259.63
Tare weight, jar (g): 173.72
Sample bulk density (g/cm^3): 1.10

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	07-Oct-99 / 10:37	264.84	6934.6	6.69
	08-Oct-99 / 13:38	263.77	13767.3	5.32

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: E. Koenig/R. Smith
Data entered by: M. Devine
Checked by: R. Smith

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Water Activity Meter/Relative Humidity Box
(Main Drainage Curve)

Job Name: LANL
Job Number: 9958.01
Sample Number: CACV-98-0046
Ring Number: CACV-98-0046
Depth: NA

Dry weight of relative humidity box sample* (g): 75.66
Tare weight (g): 39.99
Sample bulk density (g/cm^3): 1.10

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	22-Sep-99 / 08:31	76.09	836961	1.35

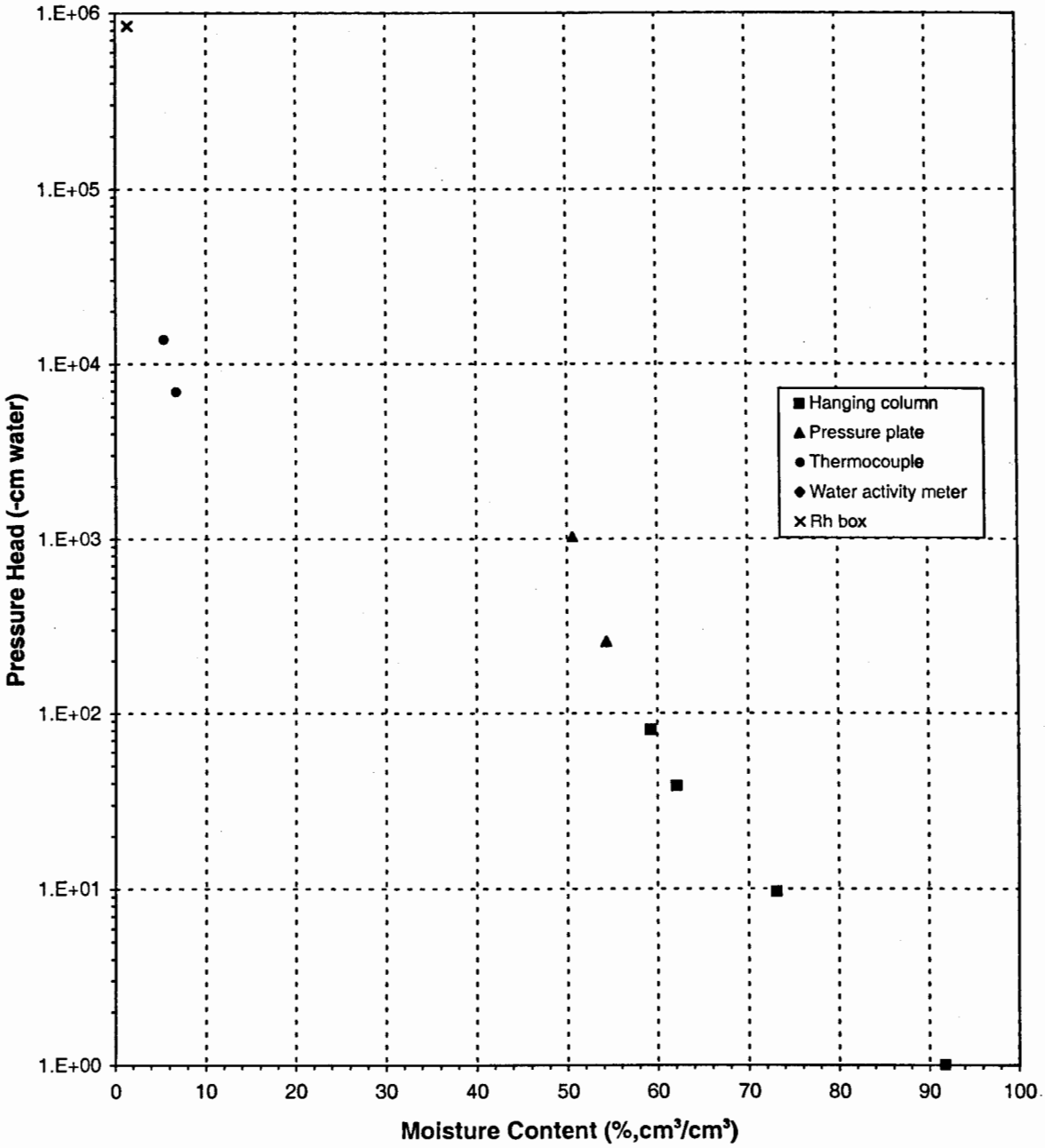
Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke/R. Smith
Data entered by: M. Devine
Checked by: R. Smith

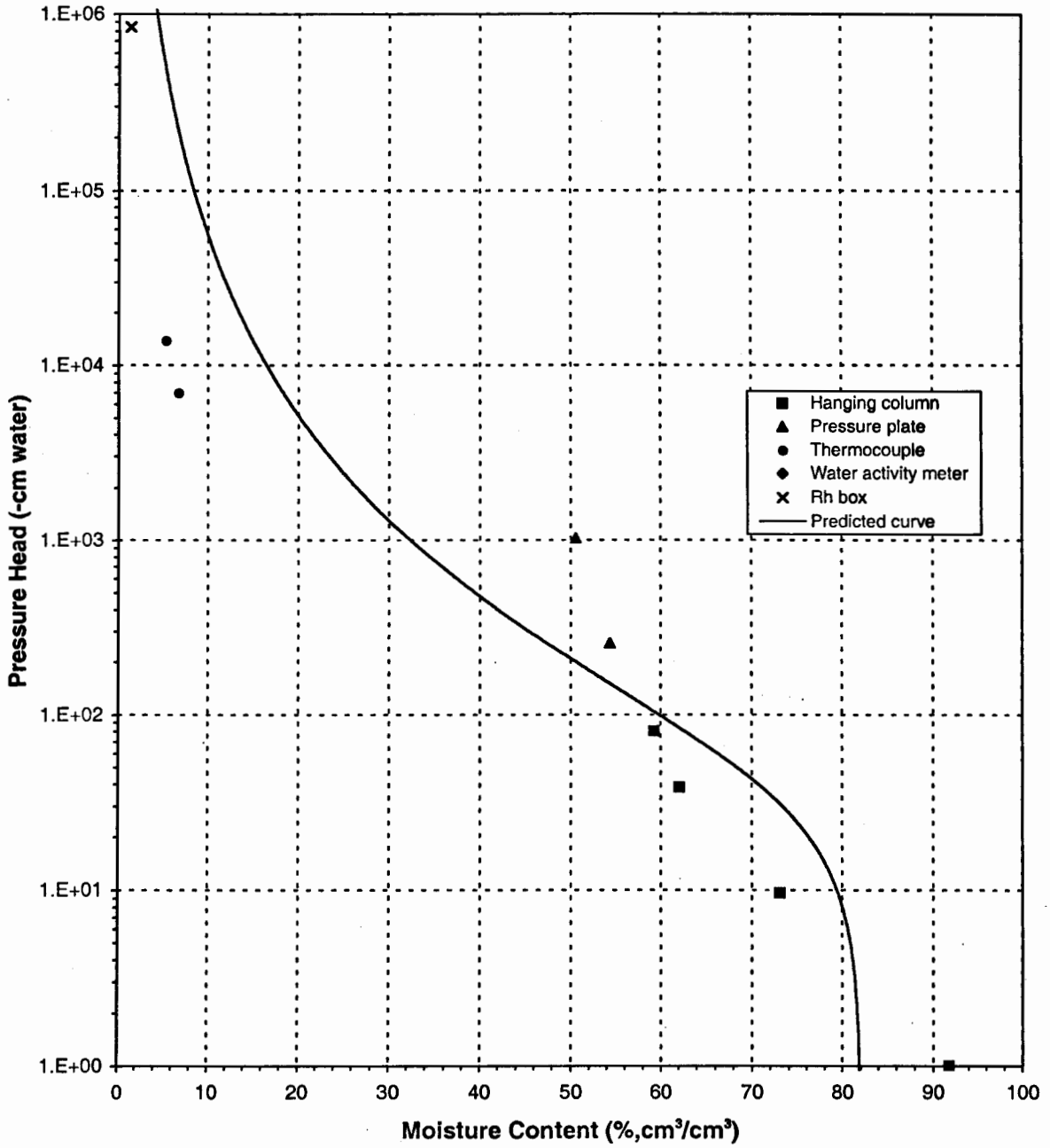
Daniel B. Stephens & Associates, Inc.

Water Retention Data Points
Sample Number: CACV-98-0046



Daniel B. Stephens & Associates, Inc.

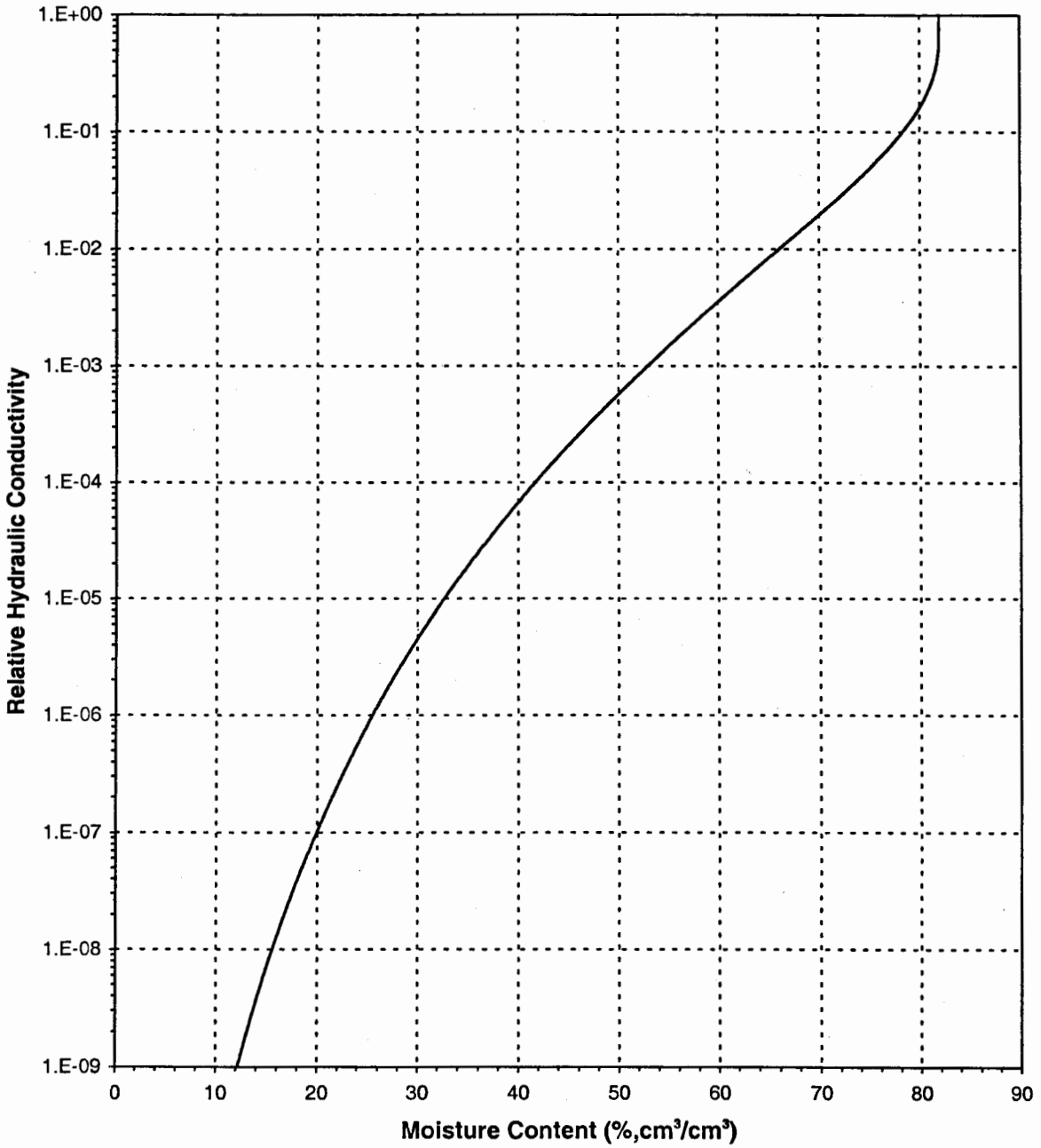
Predicted Water Retention Curve and Data Points
Sample Number: CACV-98-0046



Daniel B. Stephens & Associates, Inc.

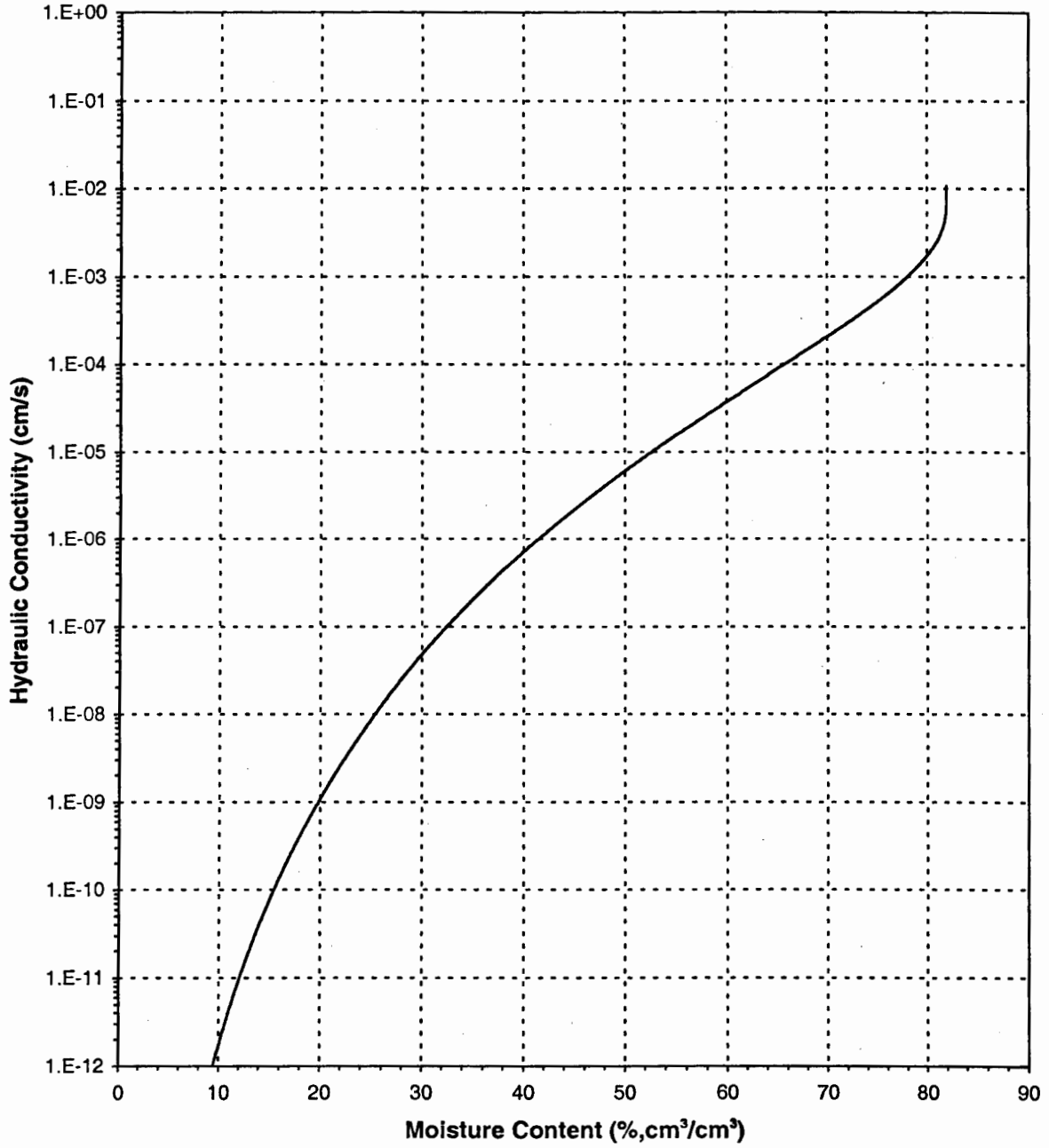
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: CACV-98-0046



Daniel B. Stephens & Associates, Inc.

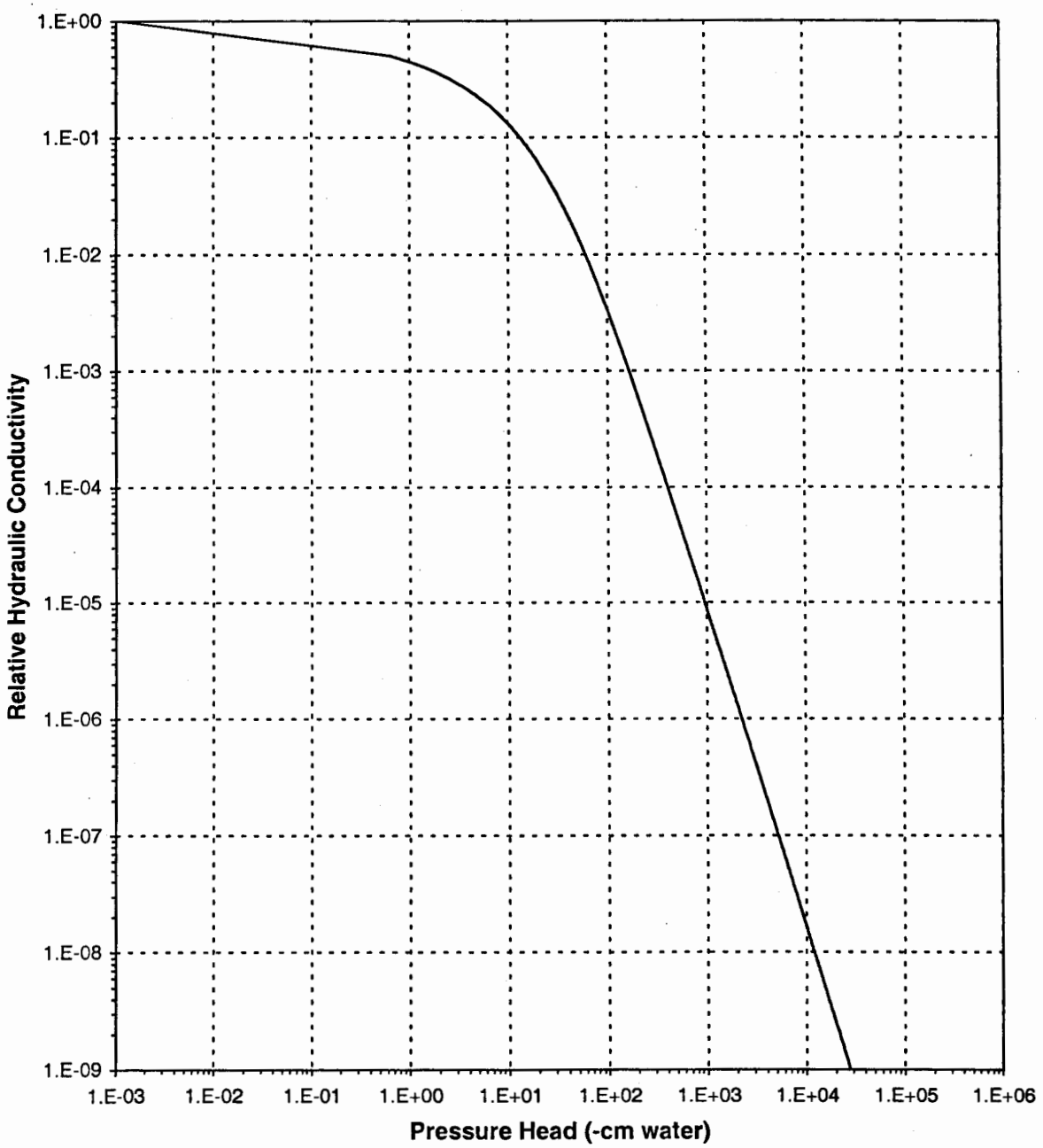
Plot of Hydraulic Conductivity vs Moisture Content
Sample Number: CACV-98-0046



Daniel B. Stephens & Associates, Inc.

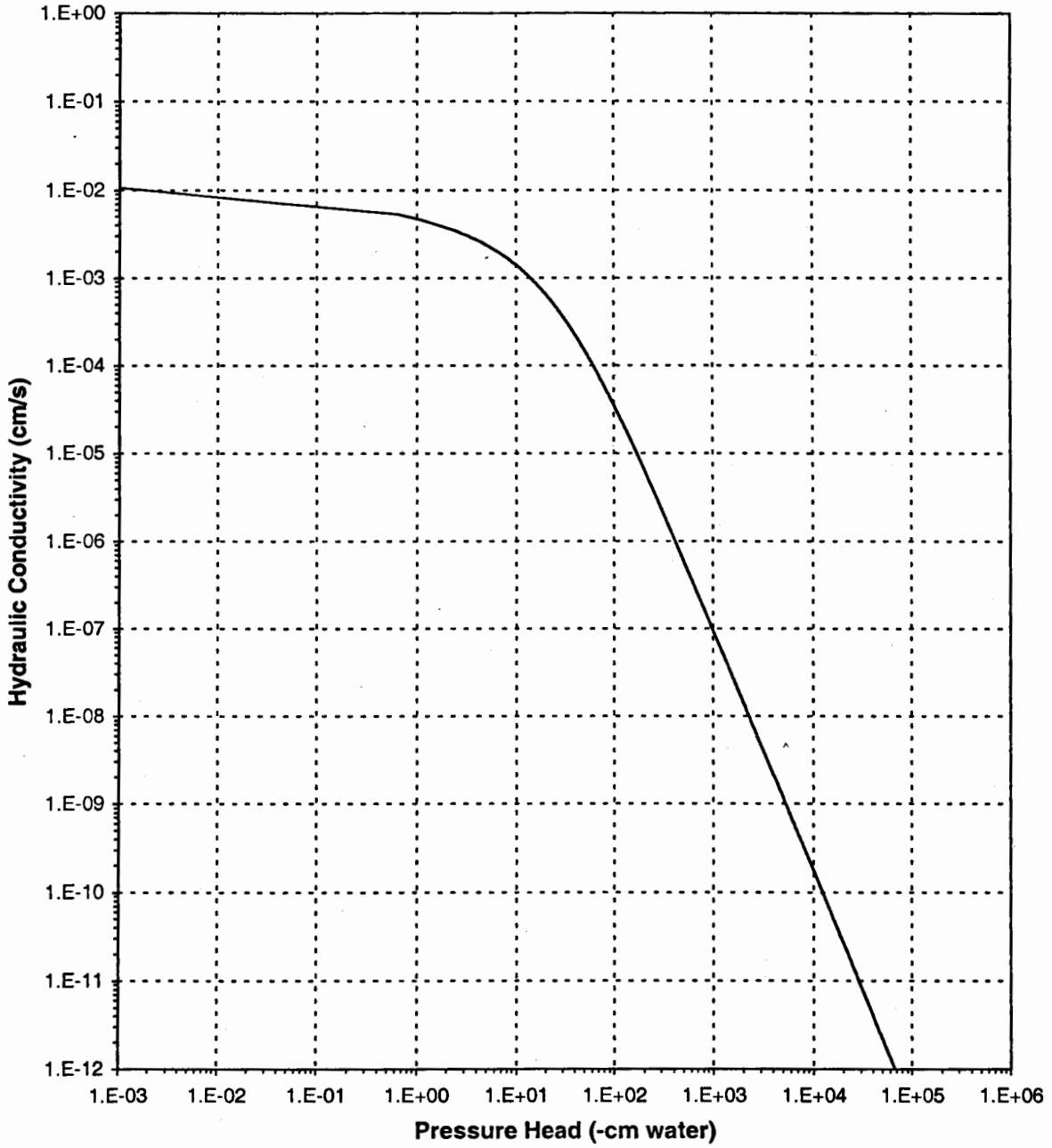
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: CACV-98-0046



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Pressure Head
Sample Number: CACV-98-0046



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Moisture Retention Data

Hanging Column/Pressure Plate/Thermocouple

(Main Drainage Curve)

Job Name:	LANL	*Dry wt. of sample* (g):	207.84
Job Number:	9958.01	*Tare wt., screen & clamp* (g):	29.03
Sample Number:	CACV-98-0049	*Tare wt., ring* (g):	127.41
Ring Number:	CACV-98-0049	*Tare wt., epoxy* (g):	0.00
Depth:	NA	*Sample volume* (cm^3):	218.12

Saturated weight at 0 cm tension* (g): 451.02
Volume of water † in saturated sample (cm^3): 86.74
Saturated moisture content (% vol): 39.77
Sample bulk density (g/cm^3): 0.95

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Hanging column:	28-Oct-99 / 11:05	451.02	0.00	39.77
	01-Nov-99 / 10:05	443.36	21.60	36.26
	03-Nov-99 / 12:15	437.36	51.60	33.50
	05-Nov-99 / 18:37	423.97	152.50	27.37
Pressure plate:	08-Nov-99 / 09:35	399.09	509.90	15.96

Dry weight of thermocouple sample* (g): 179.32
Tare weight, jar (g): 114.62
Sample bulk density (g/cm^3): 0.95

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Thermocouple:	07-Nov-99 / 18:11	180.99	7036.6	2.46
	01-Nov-99 / 12:10	180.61	16724.7	1.90

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: E. Koenig/R. Smith
Data entered by: D.O'Dowd
Checked by: R. Smith

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Moisture Retention Data

Water Activity Meter/Relative Humidity Box

(Main Drainage Curve)

Job Name: LANL
Job Number: 9958.01
Sample Number: CACV-98-0049
Ring Number: CACV-98-0049
Depth: NA

Dry weight of relative humidity box sample* (g): 67.36
Tare weight (g): 40.97
Sample bulk density (g/cm^3): 0.95

	Date/Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)
Relative humidity box:	28-Oct-99 / 09:48	67.49	848426	0.48

Comments:

* Weight including tares
† Assumed density of water is 1.0 g/cm^3

Laboratory analysis by: J. Locke/R. Smith
Data entered by: D.O'Dowd
Checked by: R. Smith

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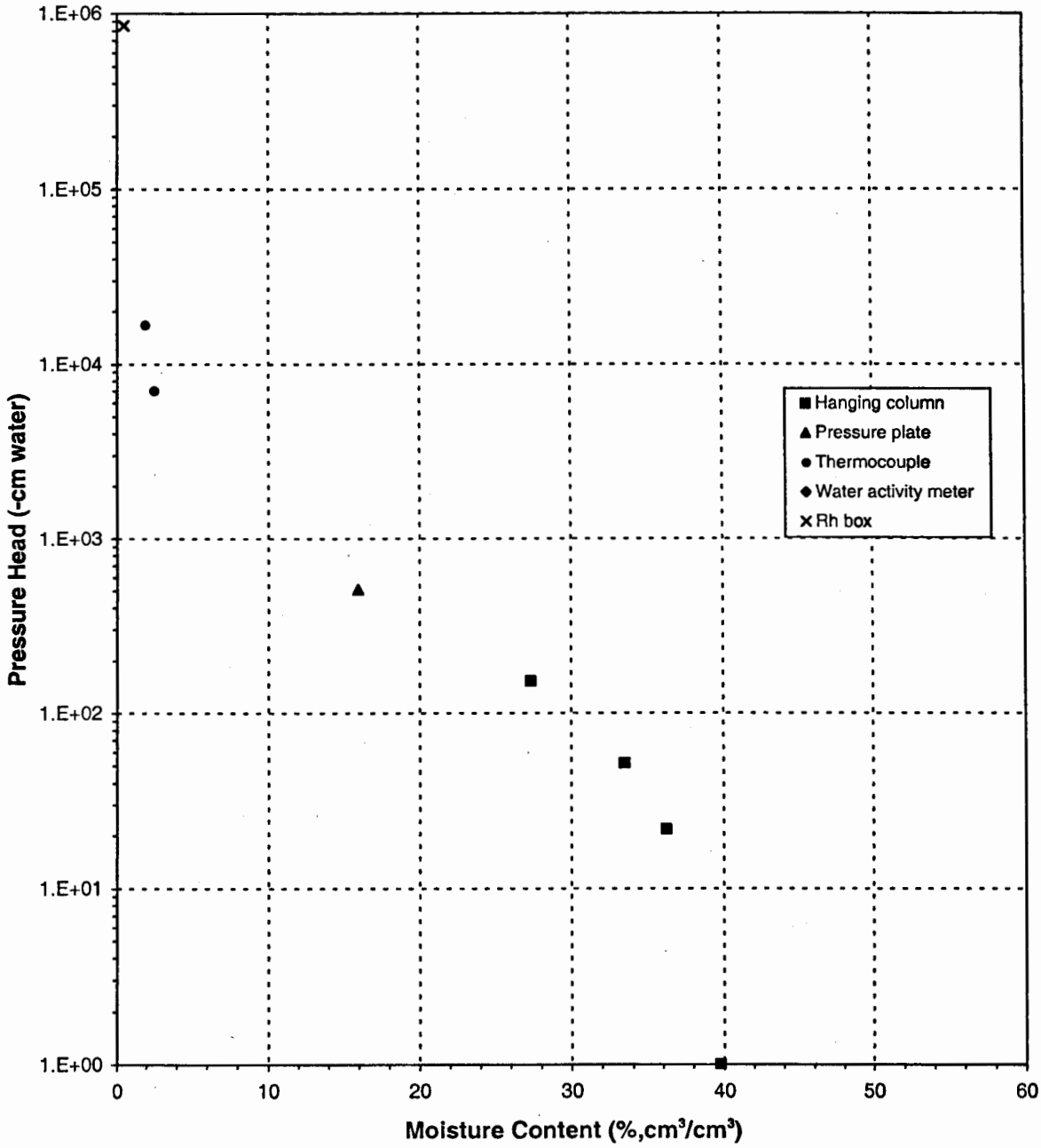
Water Retention Data Points
Sample Number: CACV-98-0049



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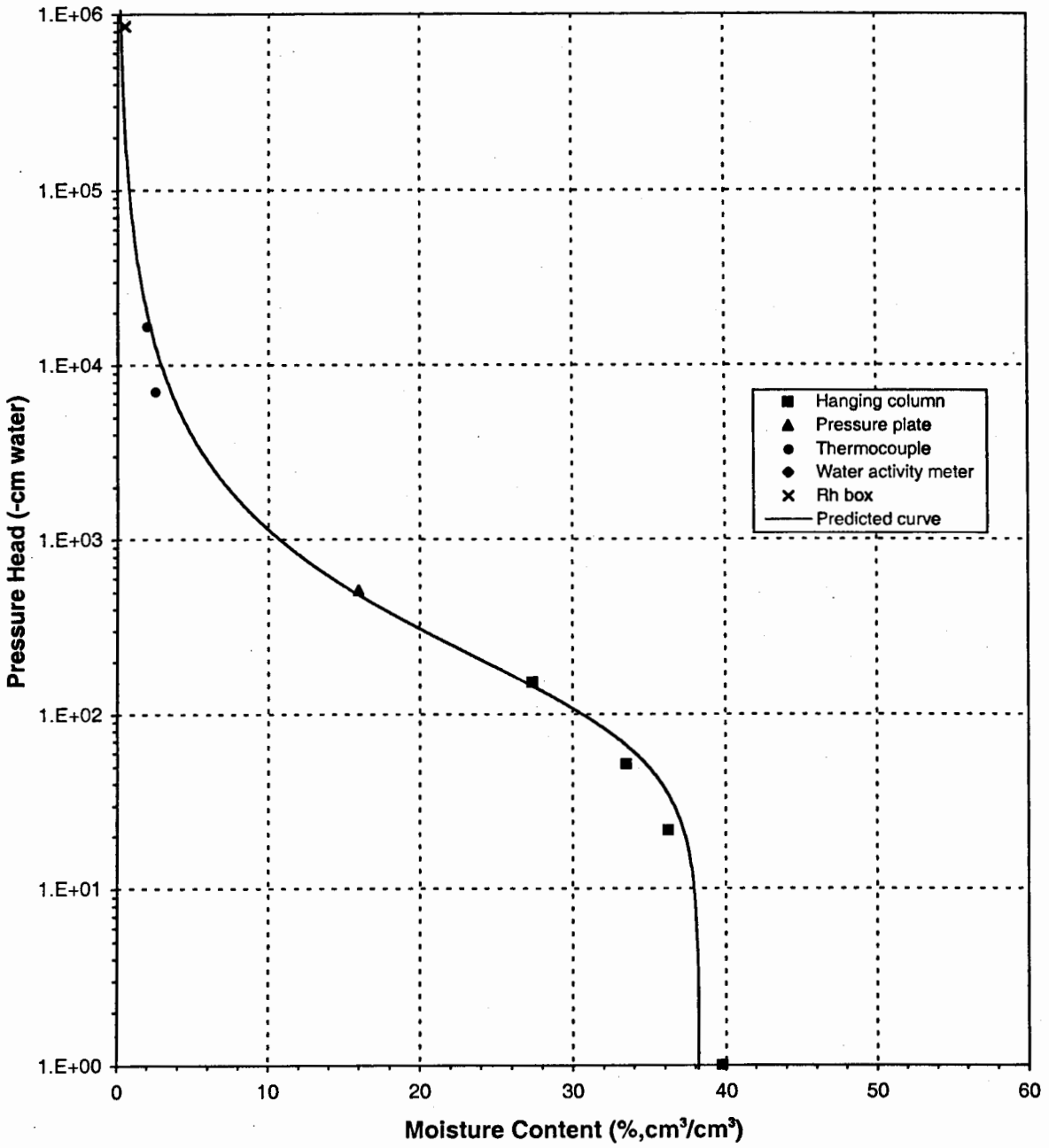
Predicted Water Retention Curve and Data Points
Sample Number: CACV-98-0049



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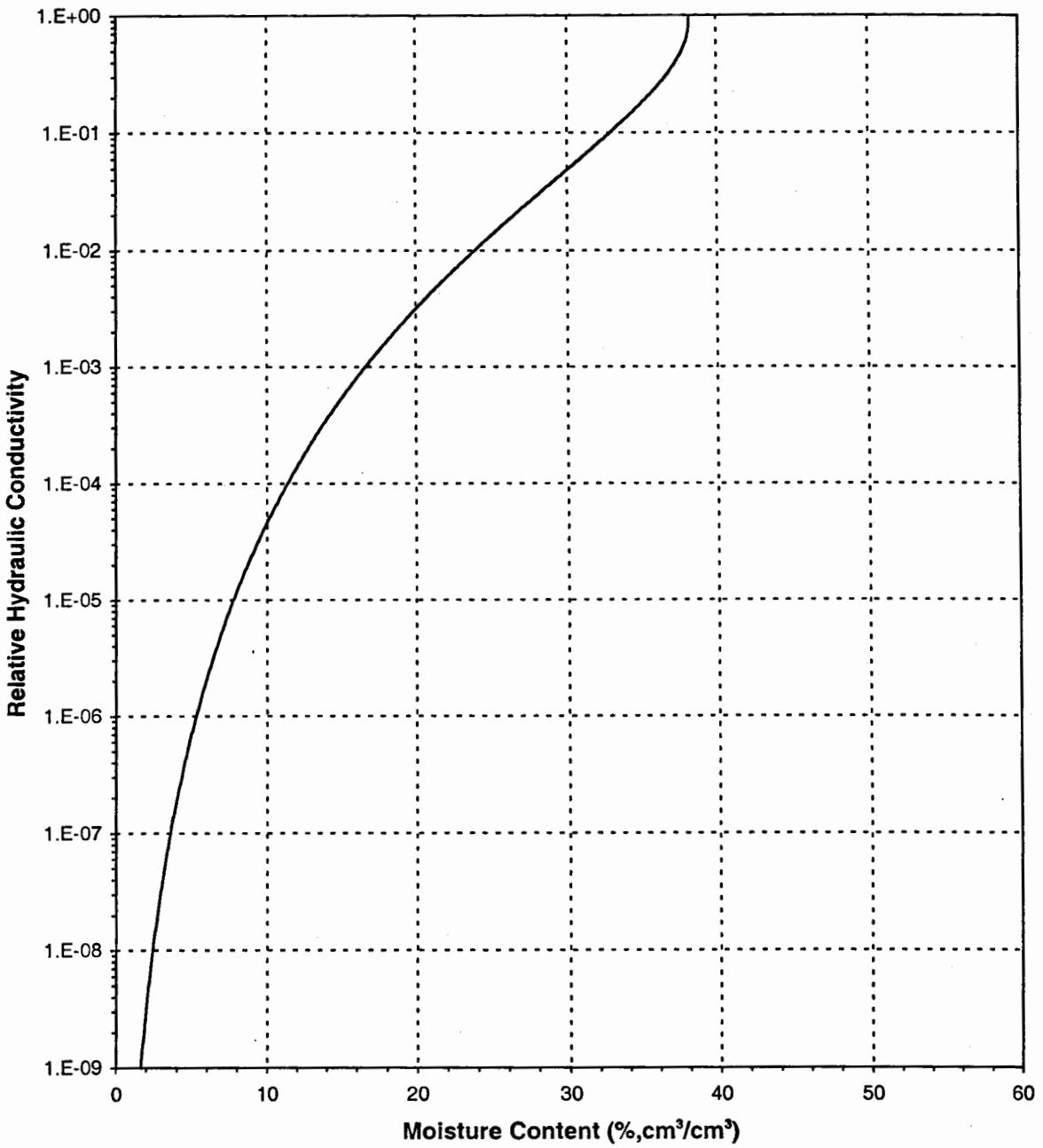
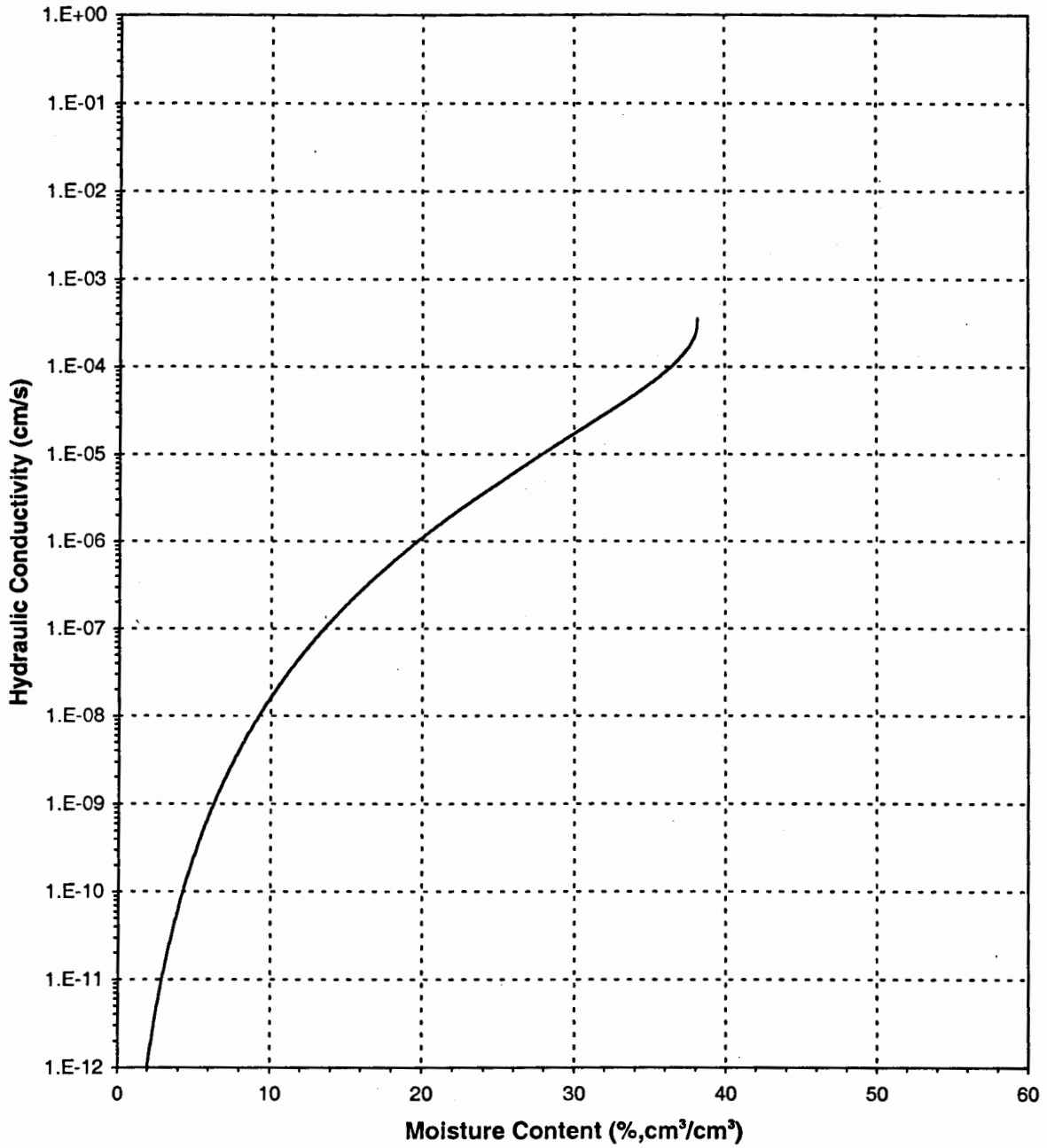
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: CACV-98-0049



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Moisture Content
Sample Number: CACV-98-0049



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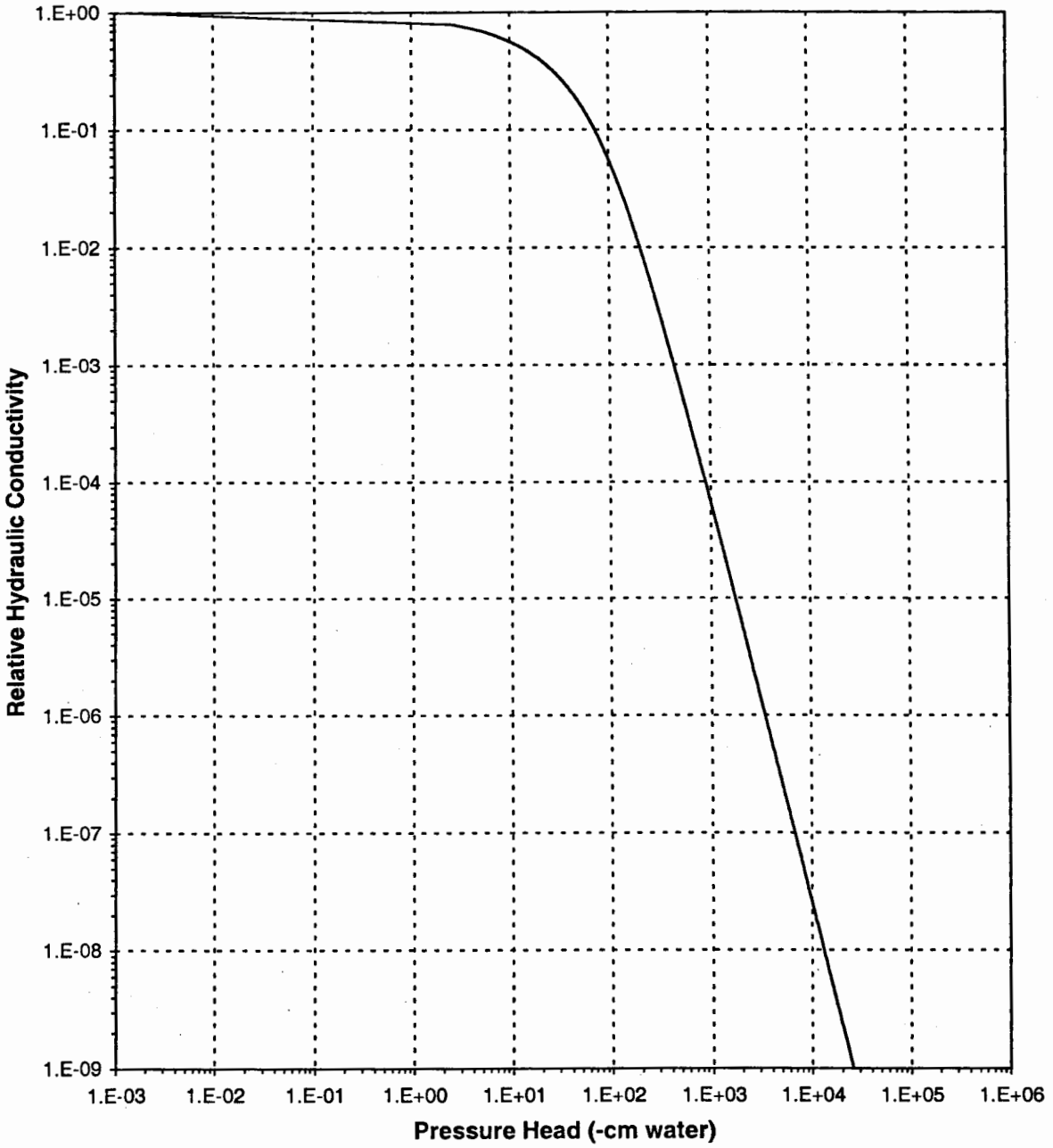
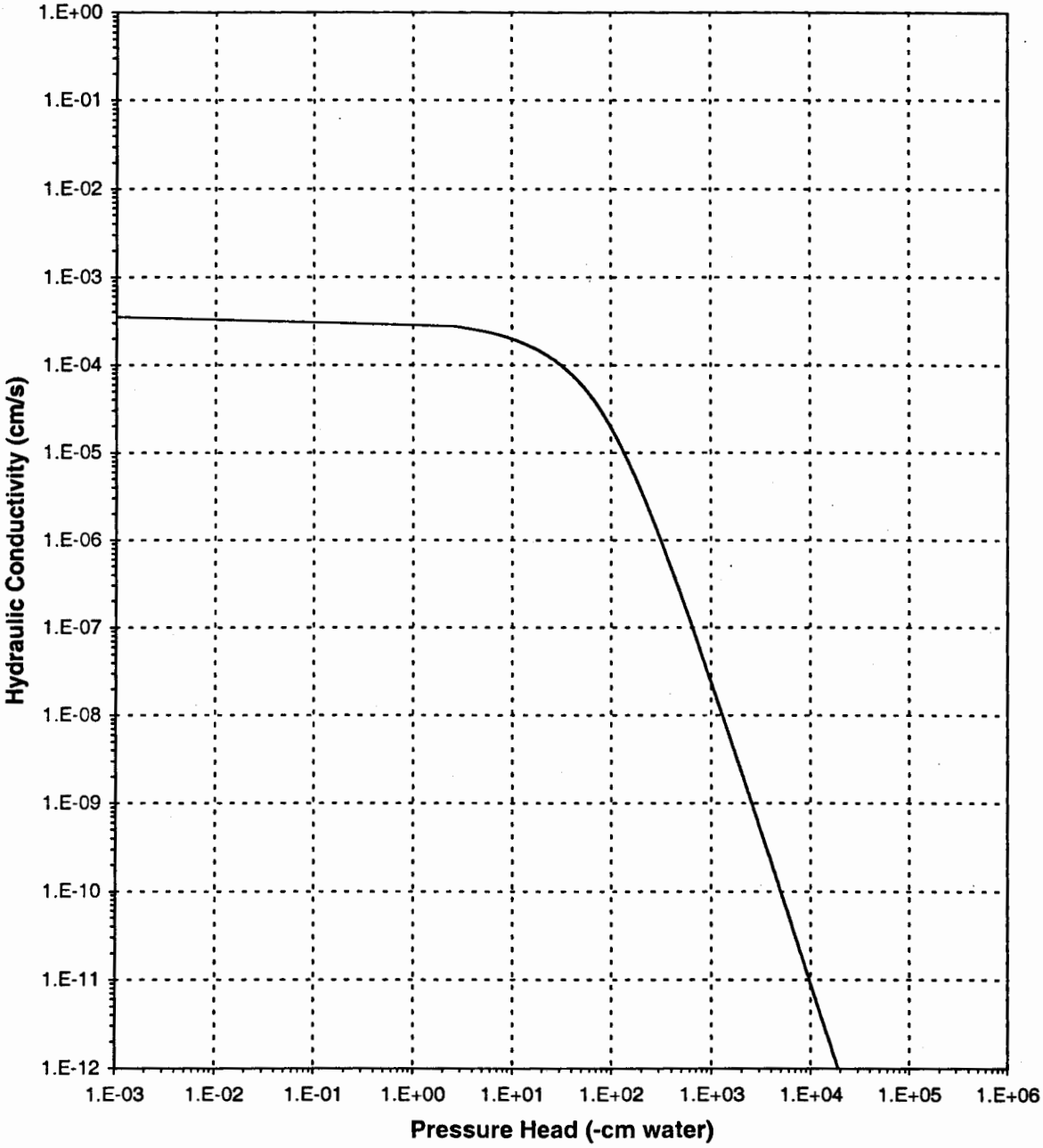
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: CACV-98-0049



Daniel B. Stephens & Associates, Inc.

Plot of Hydraulic Conductivity vs Pressure Head
Sample Number: CACV-98-0049



Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1}) Calculated Value	α 95% Confidence Limits Lower	α 95% Confidence Limits Upper	N (dimensionless) Calculated Value	N 95% Confidence Limits Lower	N 95% Confidence Limits Upper	θ_r	θ_s
8805	0.0046	0.0000	0.0113	1.1527	1.1019	1.2035	0.0000	0.8704
8806A	0.0015	0.0005	0.0025	1.2318	1.1863	1.2774	0.0000	0.4177
8807	0.0002	0.0000	0.0003	1.2781	1.1861	1.3702	0.0000	0.6046
8814	0.0001	0.0000	0.0002	1.2572	1.1636	1.3508	0.0000	0.7202
CACV-98-0039	0.0003	0.0000	0.0008	1.6160	0.7434	2.4886	0.0000	0.1021
CACV-98-0043	0.0186	0.0096	0.0277	1.5739	1.3564	1.7913	0.0106	0.6442
CACV-98-0046	0.0236	0.0000	0.0928	1.2936	1.0177	1.5695	0.0000	0.8201
CACV-98-0049	0.0090	0.0047	0.0133	1.5752	1.4051	1.7452	0.0000	0.3823