DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

December 31, 1992

1037-2830-92

Dr. Alan Stoker
University of California
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, NM 87545

Dear Dr. Stoker:

Please find enclosed the final laboratory data report for tests on CDBM 2 and CDBM 3 samples, as requested under your Subcontract No. 9-XTI-027EE-1. An invoice for this work will be submitted under separate cover.

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.

We are pleased to provide this service to Los Alamos National Laboratory and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data report, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.

Mark D. Ankeny
Senior Scientist/Laboratory Manager

MDA/mjt
Enclosures

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INTRODUCTION

Daniel B. Stephens & Associates, Inc. (DBS&A) was requested by Dr. Alan Stoker of Los Alamos National Laboratory to perform laboratory analysis for properties of CDBM 2 and CDBM 3 samples, as outlined in your Subcontract No. 9-XTI-027EE-1. The scope of work included conducting tests for the following properties:

1. Initial moisture content, dry bulk density, and calculated porosity
2. Saturated hydraulic conductivity
3. Moisture characteristics
4. Unsaturated hydraulic properties (calculated)
5. Transient outflow

SUMMARY

The Hydrologic Testing Laboratory at DBS&A has completed laboratory tests on CDBM 2 and CDBM 3 samples as specified by Dr. Alan Stoker and summarized in Table 1. Tables 2 through 7 give the results of the specified analyses. Raw laboratory data and graphical plots of data (where appropriate) are contained in Appendices A through E. Appendix F lists the methods used in these analyses. A detailed description of each method is available upon request.

Initial moisture contents ranged from 2.67% in sample number CDBM-2 - 23.5-24 to 17.64% in CDBM-2 - 89-88.5. Calculated porosities showed a fairly small range of approximately 51% to 60%, with one sample, CDBM-3 - 38-37.5, showing a calculated porosity of 64.66%. These calculated values are based on the assumption of a specific gravity of 2.65 g/cm^3 ; however, the true specific gravity was probably closer to 2.50 g/cm^3 . Thus, there was typically a discrepancy between calculated porosities in Table 2 and measured porosities in Table 4, with calculated values being larger than the more realistic measured values. Measured values showed a lower and narrower range of 41% to 50%.

Calculation of unsaturated hydraulic conductivities requires measurement of saturated hydraulic conductivity and determination of α and N . All saturated hydraulic conductivity values, shown in Table 3, fell within a tight range bracketing 10^{-4} cm/sec . The calculated α and N values shown in Table 5 were remarkably consistent for this analysis.

Table 6 compares estimates of K_{unsat} for transient outflow measurements to calculated values of K_{unsat} . In general, values obtained from outflow measurements were lower than calculated values. A more extended discussion of possible reasons for the differences was presented in the August 1992 report delivered to Dr. Alan Stoker.

Overall, the results appear reasonable and internally consistent. However, DBS&A cannot guarantee that these results are representative of the undisturbed materials at the field site, nor can we assume any responsibility for interpretations or analyses based on these data. We recommend that careful evaluation of these laboratory results be made for your particular application.

TABLE 1. SUMMARY OF TESTS PERFORMED

LABORATORY SAMPLE NUMBER	INITIAL MOISTURE CONTENT	DRY BULK DENSITY	CALCULATED POROSITY	SATURATED HYDRAULIC CONDUCTIVITY	MOISTURE CHARACTERISTICS			UNSATURATED HYDRAULIC PROPERTIES (CALCULATED)	TRANSIENT OUTFLOW
					HANGING COLUMN	PRESSURE PLATE	THERMOCOUPLE PSYCHROMETER		
CDBM-2 - 23.5-24	X	X	X	X		X	X	X	
CDBM-2 - 34-33.5	X	X	X	X		X	X	X	
CDBM-2 - 44-43.5	X	X	X	X		X	X	X	
CDBM-2 - 54-53.5	X	X	X	X		X	X	X	
CDBM-2 - 64-63.5	X	X	X	X		X	X	X	
CDBM-2 - 89-88.5	X	X	X	X	X	X	X	X	X
CDBM-2 - 94-93.5	X	X	X	X		X	X	X	
CDBM-2 - 104-103.5	X	X	X	X	X	X	X	X	X
CDBM-2 - 114-113.5	X	X	X	X		X	X	X	
CDBM-2 - 124-123.5	X	X	X	X	X	X	X	X	X
CDBM-2 - 134-133.5	X	X	X	X	X	X	X	X	X
CDBM-2 - 144-143.5	X	X	X	X		X	X	X	

TABLE 1. SUMMARY OF TESTS PERFORMED (CONTINUED)

LABORATORY SAMPLE NUMBER	INITIAL MOISTURE CONTENT	DRY BULK DENSITY	CALCULATED POROSITY	SATURATED HYDRAULIC CONDUCTIVITY	MOISTURE CHARACTERISTICS			UNSATURATED HYDRAULIC PROPERTIES (CALCULATED)	TRANSIENT OUTFLOW
					HANGING COLUMN	PRESSURE PLATE	THERMOCOUPLE PSYCHROMETER		
CDBM-2 - 154-153.5	X	X	X	X		X	X	X	
CDBM-2 - 164-163.5	X	X	X	X	X	X	X	X	X
CDBM-2 - 174-173.5	X	X	X	X		X	X	X	
CDBM-2 - 184-183.5	X	X	X	X	X	X	X	X	X
CDBM-2 - 189-188.5	X	X	X	X	X	X	X	X	
CDBM-3 - 28-27.5	X	X	X	X		X	X	X	
CDBM-3 - 38-37.5	X	X	X	X		X	X	X	
CDBM-3 - 66.5-67	X	X	X	X		X	X	X	
CDBM-3 - 67.5-68	X	X	X	X		X	X	X

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**TABLE 2. SUMMARY OF INITIAL MOISTURE CONTENT,
DRY BULK DENSITY, AND CALCULATED POROSITY**

SAMPLE NUMBER	INITIAL MOISTURE CONTENT		DRY BULK DENSITY (g/cm ³)	CALCULATED POROSITY (%)
	GRAVIMETRIC (%, g/g)	VOLUMETRIC (%, cm ³ /cm ³)		
CDBM-2 - 23.5-24	2.27	2.67	1.17	55.70
CDBM-2 - 34-33.5	5.47	5.85	1.07	59.65
CDBM-2 - 44-43.5	7.38	9.27	1.26	52.63
CDBM-2 - 54-53.5	8.23	8.95	1.09	59.00
CDBM-2 - 64-63.5	9.15	11.25	1.23	53.59
CDBM-2 - 89-88.5	14.76	17.64	1.20	54.88
CDBM-2 - 94-93.5	10.00	10.45	1.05	60.55
CDBM-2 - 104-103.5	12.60	15.09	1.20	54.80
CDBM-2 - 114-113.5	12.13	15.59	1.29	51.50
CDBM-2 - 124-123.5	10.00	10.96	1.10	58.64
CDBM-2 - 134-133.5	9.47	11.73	1.24	53.25
CDBM-2 - 144-143.5	8.97	10.24	1.14	56.91
CDBM-2 - 154-153.5	8.57	11.10	1.29	51.15
CDBM-2 - 164-163.5	8.71	10.56	1.21	54.26
CDBM-2 - 174-173.5	8.56	10.07	1.18	55.60
CDBM-2 - 184-183.5	7.87	9.26	1.18	55.59
CDBM-2 - 189-188.5	7.92	9.42	1.19	55.14
CDBM-3 - 28-27.5	9.71	11.53	1.19	55.18
CDBM-3 - 38-37.5	8.90	8.34	0.94	64.66
CDBM-3 - 66.5-67	10.01	11.65	1.16	56.07
CDBM-3 - 67.5-68	10.03	12.26	1.22	53.89

TABLE 3. SUMMARY OF SATURATED HYDRAULIC CONDUCTIVITY TESTS

SAMPLE NUMBER	K_{sat} (cm/sec)	METHOD OF ANALYSIS	
		CONSTANT HEAD	FALLING HEAD
CDBM-2 - 23.5-24	6.2×10^{-5}	X	
CDBM-2 - 34-33.5	2.2×10^{-4}	X	
CDBM-2 - 44-43.5	7.0×10^{-5}	X	
CDBM-2 - 54-53.5	4.6×10^{-4}	X	
CDBM-2 - 64-63.5	1.2×10^{-4}	X	
CDBM-2 - 89-88.5	2.3×10^{-4}	X	
CDBM-2 - 94-93.5	1.5×10^{-3}	X	
CDBM-2 - 104-103.5	2.3×10^{-4}	X	
CDBM-2 - 114-113.5	1.6×10^{-4}	X	
CDBM-2 - 124-123.5	2.9×10^{-4}	X	
CDBM-2 - 134-133.5	1.6×10^{-4}	X	
CDBM-2 - 144-143.5	4.2×10^{-4}	X	
CDBM-2 - 154-153.5	1.0×10^{-4}	X	
CDBM-2 - 164-163.5	1.7×10^{-4}	X	
CDBM-2 - 174-173.5	2.1×10^{-4}	X	
CDBM-2 - 184-183.5	3.0×10^{-4}	X	
CDBM-2 - 189-188.5	1.8×10^{-4}	X	
CDBM-3 - 28-27.5	8.5×10^{-4}	X	
CDBM-3 - 38-37.5	4.5×10^{-4}	X	
CDBM-3 - 66.5-67	5.0×10^{-4}	X	
CDBM-3 - 67.5-68	2.7×10^{-4}	X

TABLE 4. SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 23.5-24	0	48.82
	34	47.59
	111	44.59
	308	35.54
	714	24.26
	2295	21.33
	5303	18.35
	15348	14.80
	2917	3.63
	6200	3.07
	19519	2.10
CDBM-2 - 34-33.5	0	46.18
	31	44.70
	107	40.50
	306	27.84
	714	20.68
	1632	18.80
	4875	16.96
	15909	15.93
	3885	4.99
	11208	3.30
	22517	2.56
CDBM-2 - 44-43.5	0	44.53
	31	43.68
	107	41.44
	306	30.77
	714	19.25
	1632	13.94
	4875	11.26
	15909	10.06
	5354	4.43
	14400	2.49

TABLE 4. SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 54-53.5	0	44.60
	34	42.43
	111	37.31
	308	25.24
	714	22.51
	2295	20.49
	5303	18.81
	15348	16.30
	4120	5.60
	18428	3.09
CDBM-2 - 64-63.5	0	45.13
	31	43.42
	107	39.53
	306	27.41
	714	17.30
	1632	14.26
	4875	11.69
	15909	10.79
	4304	4.25
	20212	2.64
CDBM-2 - 89-88.5	0	44.25
	68	35.91
	134	30.96
	207	26.56
	301	25.71
	707	22.26
	1448	19.74
	5252	17.12
	15042	13.09
	2774	7.79
	7791	6.04
	20835	4.89

TABLE 4. SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 94-93.5	0	50.25
	31	44.11
	107	32.60
	306	18.93
	714	16.59
	1632	15.59
	4875	13.15
	15909	12.21
	5792	4.94
	24118	3.06
CDBM-2 - 104-103.5	0	44.58
	69	41.39
	136	37.39
	208	31.40
	301	29.27
	707	21.31
	1448	18.53
	5252	17.21
	15042	15.47
	7506	6.07
	20743	4.43
CDBM-2 - 114-113.5	0	45.08
	31	43.61
	107	40.27
	306	30.52
	714	18.38
	1632	14.15
	4875	11.49
	15909	10.40
	4171	6.83
	15746	4.23

TABLE 4. SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 124-123.5	0	43.73
	69	39.33
	134	35.48
	207	28.64
	301	25.97
	707	22.46
	1448	17.97
	5252	16.85
	15042	13.92
	6037	6.46
	13359	4.68
CDBM-2 - 134-133.5	0	44.70
	68	41.07
	135	37.63
	207	32.31
	301	28.02
	707	18.44
	1448	15.32
	5252	13.98
	15042	12.39
	2499	6.38
	5242	5.91
CDBM-2 - 144-143.5	16857	3.66
	0	42.84
	31	41.18
	107	38.04
	306	20.57
	714	18.63
	1632	18.47
	4875	18.04
	15909	17.63
	4395	5.37
	19978	3.59

TABLE 4. SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 154-153.5	0	41.03
	31	39.52
	107	37.23
	306	28.71
	714	16.68
	1632	14.96
	4875	13.24
	15909	12.37
	4395	5.64
	16378	3.89
CDBM-2 - 164-163.5	0	43.56
	68	40.27
	136	37.02
	209	30.55
	301	27.74
	707	24.80
	1448	22.11
	5252	20.61
	15042	18.31
	5374	5.30
	25128	3.95
CDBM-2 - 174-173.5	0	41.22
	31	40.08
	107	36.60
	306	23.90
	714	18.77
	1632	16.64
	4875	14.28
	15909	13.41
	2978	6.47
	5711	4.70
	21895	3.41

TABLE 4. SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 184-183.5	0	43.23
	70	39.44
	137	34.35
	210	27.10
	301	24.35
	707	20.81
	1448	18.07
	5252	16.79
	15042	14.33
	2458	5.39
	4151	4.67
	21487	3.67
CDBM-2 - 189-188.5	0	43.00
	28	41.81
	97	38.40
	311	25.80
	714	17.66
	1530	16.06
	5150	13.61
	15297	12.26
	7547	4.17
	13247	3.31
CDBM-3 - 28-27.5	24526	2.86
	0	47.90
	34	41.13
	111	28.30
	308	22.76
	714	20.95
	2295	19.47
	5303	18.25
	15348	16.45
	6608	9.65
	19019	7.71

TABLE 4. SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-3 - 38-37.5	0	48.39
	34	45.63
	111	39.58
	308	24.94
	714	19.53
	2295	16.00
	5303	11.89
	15348	9.37
	2580	6.77
	4752	5.50
	16266	3.88
CDBM-3 - 66.5-67	0	44.56
	34	42.12
	111	36.69
	308	22.13
	714	17.69
	2295	14.22
	5303	13.11
	15348	11.74
	4956	5.82
	16847	3.91
CDBM-3 - 67.5-68	0	43.97
	34	42.43
	111	37.72
	308	23.02
	714	19.02
	2295	17.43
	5303	16.38
	15348	14.76
	4844	5.75
	18214	3.88

TABLE 5. SUMMARY OF UNSATURATED HYDRAULIC PROPERTIES (CALCULATED)

SAMPLE NUMBER	α (cm^{-1})			N (dimensionless)			θ_r (%, cm^3/cm^3)	θ_s (%, cm^3/cm^3)	K_{sat} (cm/sec)
	Calculated Value	95% Confidence Limits		Calculated Value	95% Confidence Limits				
		Lower	Upper		Lower	Upper			
CDBM-2 - 23.5-24	0.00468	-0.0013	0.0106	1.53590	1.1696	1.9022	2.10	48.82	6.2×10^{-5}
CDBM-2 - 34-33.5	0.00812	-0.0018	0.0180	1.45324	1.1907	1.7158	2.56	46.18	2.2×10^{-4}
CDBM-2 - 44-43.5	0.00470	0.0019	0.0075	1.64413	1.3912	1.8970	2.49	44.53	7.0×10^{-5}
CDBM-2 - 54-53.5	0.01288	-0.0087	0.0345	1.33785	1.1131	1.5626	3.09	44.60	4.6×10^{-4}
CDBM-2 - 64-63.5	0.00707	0.0020	0.0121	1.56858	1.3288	1.8084	2.64	45.13	1.2×10^{-4}
CDBM-2 - 89-88.5	0.01728	0.0003	0.0343	1.38533	1.2122	1.5585	4.89	44.25	2.3×10^{-4}
CDBM-2 - 94-93.5	0.02799	0.0023	0.0536	1.40403	1.2458	1.5623	3.06	50.25	1.5×10^{-3}
CDBM-2 - 104-103.5	0.00850	0.0016	0.0154	1.42544	1.2369	1.6140	4.43	44.58	2.3×10^{-4}
CDBM-2 - 114-113.5	0.00543	0.0027	0.0082	1.66179	1.4386	1.8850	4.23	45.06	1.6×10^{-4}
CDBM-2 - 124-123.5	0.01063	0.0017	0.0195	1.41696	1.2328	1.6012	4.68	43.73	2.9×10^{-4}
CDBM-2 - 134-133.5	0.00653	0.0028	0.0103	1.60281	1.3655	1.8401	3.66	44.70	1.6×10^{-4}

**TABLE 5. SUMMARY OF UNSATURATED HYDRAULIC PROPERTIES (CALCULATED)
(CONTINUED)**

SAMPLE NUMBER	α (cm ⁻¹)			N (dimensionless)			θ_r (%, cm ³ /cm ³)	θ_s (%, cm ³ /cm ³)	K _{sat} (cm/sec)
	Calculated Value	95% Confidence Limits		Calculated Value	95% Confidence Limits				
		Lower	Upper		Lower	Upper			
CDBM-2 - 144-143.5	0.01404	-0.0118	0.0399	1.36314	1.0871	1.6392	3.59	42.84	4.2 x 10 ⁻⁴
CDBM-2 - 154-153.5	0.00585	0.0007	0.0110	1.56712	1.2726	1.8616	3.89	41.03	1.0 x 10 ⁻⁴
CDBM-2 - 164-163.5	0.01001	-0.0035	0.0235	1.33832	1.1270	1.5496	3.95	43.56	1.7 x 10 ⁻⁴
CDBM-2 - 174-173.5	0.00795	-0.0005	0.0164	1.49743	1.2307	1.7641	3.41	41.22	2.1 x 10 ⁻⁴
CDBM-2 - 184-183.5	0.00999	-0.0001	0.0201	1.47142	1.2080	1.7349	3.67	43.23	3.0 x 10 ⁻⁴
CDBM-2 - 189-188.5	0.00765	0.0010	0.0143	1.50445	1.2783	1.7306	2.86	43.00	1.8 x 10 ⁻⁴
CDBM-3 - 28-27.5	0.04709	-0.0120	0.1062	1.32422	1.1801	1.4684	7.71	47.90	8.5 x 10 ⁻⁴
CDBM-3 - 38-37.5	0.00916	0.0032	0.0151	1.57662	1.3655	1.7877	3.88	48.39	4.5 x 10 ⁻⁴
CDBM-3 - 66.5-67	0.01147	0.0018	0.0211	1.48246	1.2764	1.6886	3.91	44.56	5.0 x 10 ⁻⁴
CDBM-3 - 67.5-68	0.01181	-0.0037	0.0273	1.40495	1.1680	1.6419	3.88	43.97	2.7 x 10 ⁻⁴

TABLE 6. SUMMARY OF TRANSIENT OUTFLOW RESULTS

SAMPLE NUMBER	FROM TRANSIENT OUTFLOW DATA				STEADY-STATE DATA	RELATIVE HYDRAULIC CONDUCTIVITY $K_{rel} = \frac{k_{transient}}{K_{sat}}$
	AVERAGE OUTFLOW PRESSURE P (-cm)	FRACTIONAL CHANGE IN MOISTURE CONTENT $\Delta \theta$	DIFFUSIVITY D (cm ² /sec)	UNSATURATED HYDRAULIC CONDUCTIVITY k (cm/sec)	SATURATED HYDRAULIC CONDUCTIVITY K_{sat} (cm/sec)	
CDBM-2 - 89-88.5	35.6	8.6×10^{-2}	7.4×10^{-3}	9.8×10^{-6}	2.4×10^{-4}	4.1×10^{-2}
	101.1	5.1×10^{-2}	4.1×10^{-4}	3.2×10^{-7}	2.3×10^{-4}	1.4×10^{-3}
CDBM-2 - 104-103.5	36.0	3.2×10^{-2}	4.7×10^{-1}	2.3×10^{-4}	2.4×10^{-4}	9.6×10^{-1}
	102.2	3.8×10^{-2}	1.5×10^{-2}	8.4×10^{-6}	2.3×10^{-4}	3.7×10^{-2}
CDBM-2 - 124-123.5	35.7	4.4×10^{-2}	5.0×10^{-2}	3.3×10^{-5}	2.9×10^{-4}	1.1×10^{-1}
	101.2	3.9×10^{-2}	8.6×10^{-3}	5.1×10^{-6}	2.9×10^{-4}	1.8×10^{-2}
CDBM-2 - 134-133.5	35.4	3.7×10^{-2}	7.1×10^{-1}	4.0×10^{-4}	1.6×10^{-4}	2.5×10^0
	101.3	3.7×10^{-2}	4.5×10^{-3}	2.4×10^{-6}	1.6×10^{-4}	1.5×10^{-2}
CDBM-2 - 164-163.5	35.6	3.2×10^{-2}	5.5×10^{-1}	2.7×10^{-4}	1.7×10^{-4}	1.5×10^0
	102.0	2.8×10^{-2}	3.7×10^{-3}	1.6×10^{-6}	1.7×10^{-4}	9.0×10^{-3}
CDBM-2 - 184-183.5	36.7	3.2×10^{-2}	1.1×10^{-2}	5.2×10^{-6}	3.1×10^{-4}	1.7×10^{-2}
	103.5	4.4×10^{-2}	3.5×10^{-3}	2.3×10^{-6}	3.1×10^{-4}	7.4×10^{-3}

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ENVIRONMENTAL SCIENTISTS AND ENGINEERS

TABLE 7. SUMMARY OF TRANSIENT OUTFLOW GRAPHICAL DATA

SAMPLE NUMBER	INITIAL PRESSURE P_1 (- cm)	FINAL PRESSURE P_2 (-cm)	PLATE IMPEDANCE/ SOIL IMPEDANCE a	α_1^2	REFERENCE POINT TIME T_{rp} (min)	TOTAL OUTFLOW FOR PRESSURE INCREMENT Q_p (cm ³)	LENGTH OF SAMPLE L (cm)	VOLUME OF SAMPLE V (cm ³)
CDBM-2 - 89-88.5	3.2	68.0	0.2	1.0	90.0	15.98	6.32	185.91
	68.0	134.1	$0.0 < a < 0.0667$	2.3	725.0	9.57	6.32	185.91
CDBM-2 - 104-103.5	3.4	68.7	1000	0.1	16.0	6.37	6.71	196.10
	68.7	135.7	1	0.8	65.0	7.48	6.71	196.10
CDBM-2 - 124-123.5	3.2	68.2	1	0.6	21.0	8.08	6.32	184.70
	68.2	134.2	0.2	1.8	44.0	7.22	6.32	184.70
CDBM-2 - 134-133.5	3.2	67.5	1000	0.1	9.9	6.97	6.48	189.38
	67.5	135.0	$0.0667 < a < 0.2$	2.0	78.0	6.97	6.48	189.38
CDBM-2 - 164-163.5	3.2	68.0	1000	0.1	12.5	5.85	6.41	184.88
	68.0	136.0	0.0667	2.1	87.0	5.25	6.41	184.88
CDBM-2 - 184-183.5	3.3	70.0	$0.0 < a < 0.0667$	2.3	30.0	6.12	6.62	192.83
	70.0	137.0	$0.0667 < a < 0.2$	1.9	110.0	8.39	6.62	192.83

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APPENDIX A

INITIAL MOISTURE CONTENT, DRY BULK DENSITY, AND CALCULATED POROSITY

**SUMMARY OF INITIAL MOISTURE CONTENT,
DRY BULK DENSITY, AND CALCULATED POROSITY**

SAMPLE NUMBER	INITIAL MOISTURE CONTENT		DRY BULK DENSITY (g/cm ³)	CALCULATED POROSITY (%)
	GRAVIMETRIC (%, g/g)	VOLUMETRIC (%, cm ³ /cm ³)		
CDBM-2 - 23.5-24	2.27	2.67	1.17	55.70
CDBM-2 - 34-33.5	5.47	5.85	1.07	59.65
CDBM-2 - 44-43.5	7.38	9.27	1.26	52.63
CDBM-2 - 54-53.5	8.23	8.95	1.09	59.00
CDBM-2 - 64-63.5	9.15	11.25	1.23	53.59
CDBM-2 - 89-88.5	14.76	17.64	1.20	54.88
CDBM-2 - 94-93.5	10.00	10.45	1.05	60.55
CDBM-2 - 104-103.5	12.60	15.09	1.20	54.80
CDBM-2 - 114-113.5	12.13	15.59	1.29	51.50
CDBM-2 - 124-123.5	10.00	10.96	1.10	58.64
CDBM-2 - 134-133.5	9.47	11.73	1.24	53.25
CDBM-2 - 144-143.5	8.97	10.24	1.14	56.91
CDBM-2 - 154-153.5	8.57	11.10	1.29	51.15
CDBM-2 - 164-163.5	8.71	10.56	1.21	54.26
CDBM-2 - 174-173.5	8.56	10.07	1.18	55.60
CDBM-2 - 184-183.5	7.87	9.26	1.18	55.59
CDBM-2 - 189-188.5	7.92	9.42	1.19	55.14
CDBM-3 - 28-27.5	9.71	11.53	1.19	55.18
CDBM-3 - 38-37.5	8.90	8.34	0.94	64.66
CDBM-3 - 66.5-67	10.01	11.65	1.16	56.07
CDBM-3 - 67.5-68	10.03	12.26	1.22	53.89

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DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAXL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (23.5-24.0)
RING NUMBER: 2-(23.5-24.0)
DEPTH: 23.5-24.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 397.96 (g)
TARE WEIGHT, RING: 107.01 (g)
TARE WEIGHT, CAP: 87.07 (g)
SAMPLE VOLUME: 169.80 (cc)
DATE AND TIME INTO OVEN: 8/28 @ 15:00
DATE AND TIME OUT OF OVEN: 8/31 @ 10:00

DRY WEIGHT OF SAMPLE: 199.35 (g)
DRY BULK DENSITY: 1.17 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 55.70 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 2.67 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 2.27 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (33.5-34.0)
RING NUMBER: 2-(33.5-34.0)
DEPTH: 33.5-34.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 423.30 (g)
TARE WEIGHT, RING: 108.72 (g)
TARE WEIGHT, CAP: 114.19 (g)
SAMPLE VOLUME: 177.69 (cc)
DATE AND TIME INTO OVEN: 9/03 @ 15:45
DATE AND TIME OUT OF OVEN: 9/07 @ 11:00

DRY WEIGHT OF SAMPLE: 190.00 (g)
DRY BULK DENSITY: 1.07 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 59.65 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 5.85 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 5.47 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (43.5-44.0)
RING NUMBER: 2-(43.5-44.0)
DEPTH: 43.5-44.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 467.29 (g)
TARE WEIGHT, RING: 111.26 (g)
TARE WEIGHT, CAP: 114.17 (g)
SAMPLE VOLUME: 179.44 (cc)
DATE AND TIME INTO OVEN: 9/03 @ 14:30
DATE AND TIME OUT OF OVEN: 9/07 @ 11:00

DRY WEIGHT OF SAMPLE: 225.23 (g)
DRY BULK DENSITY: 1.26 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 52.63 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 9.27 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 7.38 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (53.5-54.0)
RING NUMBER: 2-(53.5-54.0)
DEPTH: 53.5-54.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 479.65 (g)
TARE WEIGHT, RING: 125.06 (g)
TARE WEIGHT, CAP: 114.14 (g)
SAMPLE VOLUME: 204.45 (cc)
DATE AND TIME INTO OVEN: 8/28 @ 15:00
DATE AND TIME OUT OF OVEN: 8/31 @ 10:00

DRY WEIGHT OF SAMPLE: 222.16 (g)
DRY BULK DENSITY: 1.09 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 59.00 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 8.95 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 8.23 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (63.5-64.0)
RING NUMBER: 2-(63.5-64.0)
DEPTH: 63.5-64.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 478.85 (g)
TARE WEIGHT, RING: 113.92 (g)
TARE WEIGHT, CAP: 114.16 (g)
SAMPLE VOLUME: 186.80 (cc)
DATE AND TIME INTO OVEN: 9/03 @ 14:30
DATE AND TIME OUT OF OVEN: 9/07 @ 11:00

DRY WEIGHT OF SAMPLE: 229.75 (g)
DRY BULK DENSITY: 1.23 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 53.59 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 11.25 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 9.15 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDEM2 (88.5-89.0)
RING NUMBER: 2-(88.5-89.0)
DEPTH: 88.5-89.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 481.76 (g)
TARE WEIGHT, RING: 112.54 (g)
TARE WEIGHT, CAP: 114.13 (g)
SAMPLE VOLUME: 185.91 (cc)
DATE AND TIME INTO OVEN: 9/17 @ 15:00
DATE AND TIME OUT OF OVEN: 9/21 @ 11:00

DRY WEIGHT OF SAMPLE: 222.29 (g)
DRY BULK DENSITY: 1.20 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 54.88 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 17.64 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 14.76 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

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ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (93.5-94.0)
RING NUMBER: 2-(93.5-94.0)
DEPTH: 93.5-94.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 410.36 (g)
TARE WEIGHT, RING: 103.25 (g)
TARE WEIGHT, CAP: 114.15 (g)
SAMPLE VOLUME: 167.78 (cc)
DATE AND TIME INTO OVEN: 9/03 @ 15:45
DATE AND TIME OUT OF OVEN: 9/07 @ 11:00

DRY WEIGHT OF SAMPLE: 175.42 (g)
DRY BULK DENSITY: 1.05 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 60.55 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 10.45 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 10.00 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

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ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (103.5-104.0)
RING NUMBER: 2-(103.5-104.0)
DEPTH: 103.5-104.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 498.77 (g)
TARE WEIGHT, RING: 120.15 (g)
TARE WEIGHT, CAP: 114.15 (g)
SAMPLE VOLUME: 196.10 (cc)
DATE AND TIME INTO OVEN: 9/17 @ 15:00
DATE AND TIME OUT OF OVEN: 9/21 @ 11:00

DRY WEIGHT OF SAMPLE: 234.88 (g)
DRY BULK DENSITY: 1.20 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc).

CALCULATED POROSITY: 54.80 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 15.09 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 12.60 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (113.5-114.0)
RING NUMBER: 2-(113.5-114.0)
DEPTH: 113.5-114.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 486.02 (g)
TARE WEIGHT, RING: 114.16 (g)
TARE WEIGHT, CAP: 114.15 (g)
SAMPLE VOLUME: 178.82 (cc)
DATE AND TIME INTO OVEN: 9/03 @ 14:30
DATE AND TIME OUT OF OVEN: 9/07 @ 11:00

DRY WEIGHT OF SAMPLE: 229.83 (g)
DRY BULK DENSITY: 1.29 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 51.50 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 15.59 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 12.13 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (123.5-124.0)
RING NUMBER: 2-(123.5-124.0)
DEPTH: 123.5-124.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 454.14 (g)
TARE WEIGHT, RING: 117.34 (g)
TARE WEIGHT, CAP: 114.14 (g)
SAMPLE VOLUME: 184.70 (cc)
DATE AND TIME INTO OVEN: 9/17 @ 15:00
DATE AND TIME OUT OF OVEN: 9/21 @ 11:00

DRY WEIGHT OF SAMPLE: 202.42 (g)
DRY BULK DENSITY: 1.10 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 58.64 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 10.96 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 10.00 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pignan
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (133.5-134.0)
RING NUMBER: 2-(133.5-134.0)
DEPTH: 133.5-134.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 487.07 (g)
TARE WEIGHT, RING: 116.13 (g)
TARE WEIGHT, CAP: 114.13 (g)
SAMPLE VOLUME: 189.38 (cc)
DATE AND TIME INTO OVEN: 9/18 @ 11:00
DATE AND TIME OUT OF OVEN: 9/21 @ 11:00

DRY WEIGHT OF SAMPLE: 234.60 (g)
DRY BULK DENSITY: 1.24 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 53.25 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 11.73 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 9.47 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (143.5-144.0)
RING NUMBER: 2-(143.5-144.0)
DEPTH: 143.5-144.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 458.86 (g)
TARE WEIGHT, RING: 113.09 (g)
TARE WEIGHT, CAP: 114.12 (g)
SAMPLE VOLUME: 186.19 (cc)
DATE AND TIME INTO OVEN: 9/03 @ 14:30
DATE AND TIME OUT OF OVEN: 9/07 @ 11:00

DRY WEIGHT OF SAMPLE: 212.59 (g)
DRY BULK DENSITY: 1.14 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 56.91 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 10.24 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 8.97 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (153.5-154.0)
RING NUMBER: 2-(153.5-154.0)
DEPTH: 153.5-154.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 500.07 (g)
TARE WEIGHT, RING: 119.79 (g)
TARE WEIGHT, CAP: 114.14 (g)
SAMPLE VOLUME: 189.34 (cc)
DATE AND TIME INTO OVEN: 9/03 @ 14:30
DATE AND TIME OUT OF OVEN: 9/07 @ 11:00

DRY WEIGHT OF SAMPLE: 245.13 (g)
- DRY BULK DENSITY: 1.29 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 51.15 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 11.10 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 8.57 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (163.5-164.0)
RING NUMBER: 2-(163.5-164.0)
DEPTH: 163.5-164.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 476.45 (g)
TARE WEIGHT, RING: 118.70 (g)
TARE WEIGHT, CAP: 114.15 (g)
SAMPLE VOLUME: 184.88 (cc)
DATE AND TIME INTO OVEN: 9/17 @ 15:00
DATE AND TIME OUT OF OVEN: 9/21 @ 11:00

DRY WEIGHT OF SAMPLE: 224.08 (g)
DRY BULK DENSITY: 1.21 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 54.26 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 10.56 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 8.71 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (173.5-174.0)
RING NUMBER: 2-(173.5-174.0)
DEPTH: 173.5-174.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 466.34 (g)
TARE WEIGHT, RING: 113.66 (g)
TARE WEIGHT, CAP: 114.14 (g)
SAMPLE VOLUME: 186.77 (cc)
DATE AND TIME INTO OVEN: 9/03 @ 17:00
DATE AND TIME OUT OF OVEN: 9/07 @ 11:00

DRY WEIGHT OF SAMPLE: 219.74 (g)
DRY BULK DENSITY: 1.18 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 55.60 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 10.07 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 8.56 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (183.5-184.0)
RING NUMBER: 2-(183.5-184.0)
DEPTH: 183.5-184.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 477.04 (g)
TARE WEIGHT, RING: 118.08 (g)
TARE WEIGHT, CAP: 114.16 (g)
SAMPLE VOLUME: 192.83 (cc)
DATE AND TIME INTO OVEN: 9/18 @ 11:00
DATE AND TIME OUT OF OVEN: 9/21 @ 11:00

DRY WEIGHT OF SAMPLE: 226.95 (g)
DRY BULK DENSITY: 1.18 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 55.59 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 9.26 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 7.87 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (188.5-189.0)
RING NUMBER: 2-(188.5-189.0)
DEPTH: 188.5-189.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 492.74 (g)
TARE WEIGHT, RING: 125.19 (g)
TARE WEIGHT, CAP: 114.15 (g)
SAMPLE VOLUME: 197.49 (cc)
DATE AND TIME INTO OVEN: 9/18 @ 09:30
DATE AND TIME OUT OF OVEN: 9/21 @ 11:00

DRY WEIGHT OF SAMPLE: 234.80 (g)
DRY BULK DENSITY: 1.19 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 55.14 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 9.42 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 7.92 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankerly

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (27.5-28.0)
RING NUMBER: 3-(27.5-28.0)
DEPTH: 27.5-28.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 334.20 (g)
TARE WEIGHT, RING: 110.62 (g)
TARE WEIGHT, CAP: 0.00 (g)
SAMPLE VOLUME: 171.57 (cc)
DATE AND TIME INTO OVEN: 8/28 @ 15:00
DATE AND TIME OUT OF OVEN: 8/31 @ 10:00

DRY WEIGHT OF SAMPLE: 203.79 (g)
DRY BULK DENSITY: 1.19 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 55.18 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 11.53 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 9.71 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAXL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (37.5-38.0)
RING NUMBER: 3-(37.5-38.0)
DEPTH: 37.5-38.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 414.82 (g)
TARE WEIGHT, RING: 112.30 (g)
TARE WEIGHT, CAP: 114.15 (g)
SAMPLE VOLUME: 184.72 (cc)
DATE AND TIME INTO OVEN: 8/28 @ 15:00
DATE AND TIME OUT OF OVEN: 8/31 @ 10:00

DRY WEIGHT OF SAMPLE: 172.97 (g)
DRY BULK DENSITY: 0.94 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 64.66 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 8.34 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 8.90 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (66.5-67.0)
RING NUMBER: 3-(66.5-67.0)
DEPTH: 66.5-67.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 475.07 (g)
TARE WEIGHT, RING: 119.38 (g)
TARE WEIGHT, CAP: 114.20 (g)
SAMPLE VOLUME: 188.56 (cc)
DATE AND TIME INTO OVEN: 8/28 @ 15:00
DATE AND TIME OUT OF OVEN: 8/31 @ 10:00

DRY WEIGHT OF SAMPLE: 219.52 (g)
DRY BULK DENSITY: 1.16 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 56.07 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 11.65 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 10.01 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

DATA FOR INITIAL MOISTURE CONTENT,
BULK DENSITY, AND POROSITY

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (67.5-68.0)
RING NUMBER: 3-(67.5-68.0)
DEPTH: 67.5-68.0 FT.

FIELD WEIGHT OF SAMPLE (W/PAN AND RING): 465.27 (g)
TARE WEIGHT, RING: 112.99 (g)
TARE WEIGHT, CAP: 114.16 (g)
SAMPLE VOLUME: 177.10 (cc)
DATE AND TIME INTO OVEN: 8/28 @ 15:00
DATE AND TIME OUT OF OVEN: 8/31 @ 10:00

DRY WEIGHT OF SAMPLE: 216.41 (g)
DRY BULK DENSITY: 1.22 (g/cc)
PARTICLE DENSITY: 2.65 (g/cc)
(METHOD: ASSUME MEAN PARTICLE DENSITY
= 2.65 (g/cc))

CALCULATED POROSITY: 53.89 (% vol)

INITIAL MOISTURE CONTENT (VOLUMETRIC): 12.26 (% vol)

INITIAL MOISTURE CONTENT (GRAVIMETRIC): 10.03 (% g/g)

COMMENTS:

LABORATORY ANALYSIS PERFORMED BY: J. Kelsey
CALCULATIONS MADE BY: C. Pigman
CHECKED BY: M. Ankeny

APPENDIX B

SATURATED HYDRAULIC CONDUCTIVITY

SUMMARY OF SATURATED HYDRAULIC CONDUCTIVITY TESTS

SAMPLE NUMBER	K_{sat} (cm/sec)	METHOD OF ANALYSIS	
		CONSTANT HEAD	FALLING HEAD
CDBM-2 - 23.5-24	6.2×10^{-5}	X	
CDBM-2 - 34-33.5	2.2×10^{-4}	X	
CDBM-2 - 44-43.5	7.0×10^{-5}	X	
CDBM-2 - 54-53.5	4.6×10^{-4}	X	
CDBM-2 - 64-63.5	1.2×10^{-4}	X	
CDBM-2 - 89-88.5	2.3×10^{-4}	X	
CDBM-2 - 94-93.5	1.5×10^{-3}	X	
CDBM-2 - 104-103.5	2.3×10^{-4}	X	
CDBM-2 - 114-113.5	1.6×10^{-4}	X	
CDBM-2 - 124-123.5	2.9×10^{-4}	X	
CDBM-2 - 134-133.5	1.6×10^{-4}	X	
CDBM-2 - 144-143.5	4.2×10^{-4}	X	
CDBM-2 - 154-153.5	1.0×10^{-4}	X	
CDBM-2 - 164-163.5	1.7×10^{-4}	X	
CDBM-2 - 174-173.5	2.1×10^{-4}	X	
CDBM-2 - 184-183.5	3.0×10^{-4}	X	
CDBM-2 - 189-188.5	1.8×10^{-4}	X	
CDBM-3 - 28-27.5	8.5×10^{-4}	X	
CDBM-3 - 38-37.5	4.5×10^{-4}	X	
CDBM-3 - 66.5-67	5.0×10^{-4}	X	
CDBM-3 - 67.5-68	2.7×10^{-4}	X

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ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (23.5-24.0)
RING NUMBER: 2-(23.5-24.0)
DEPTH: 23.5-24.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 5.8 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.22 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD (CM)	FLOW VOL (CC)	ELAPSED TIME (SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
7/30	1226	21.0	5.3	1.6	960	6.1E-05	6.0E-05
7/30	1916	21.0	5.1	5.6	3270	6.7E-05	6.5E-05
7/31	1127	21.0	5.4	2.1	1200	6.4E-05	6.3E-05

AVERAGE K SAT: 6.2E-05 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (33.5-34.0)
RING NUMBER: 2-(33.5-34.0)
DEPTH: 33.5-34.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.1 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.22 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1335	21.0	6.3	6.2	960	2.1E-04	2.1E-04
8/03	1850	21.0	6.3	6.4	960	2.2E-04	2.2E-04
8/04	1157	21.0	6.3	6.6	960	2.3E-04	2.2E-04

AVERAGE K SAT: 2.2E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (43.5-44.0)
RING NUMBER: 2-(43.5-44.0)
DEPTH: 43.5-44.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.1 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.22 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD (CM)	FLOW VOL (CC)	ELAPSED TIME (SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1335	21.0	6.1	2.0	960	7.1E-05	6.9E-05
8/03	1850	21.0	6.1	2.0	960	7.1E-05	6.9E-05
8/04	1157	21.0	6.0	2.1	960	7.5E-05	7.3E-05

AVERAGE K SAT: 7.0E-05 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (53.5-54.0)
RING NUMBER: 2-(53.5-54.0)
DEPTH: 53.5-54.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 7.0 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.42 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
7/30	1226	21.0	4.1	7.7	960	4.6E-04	4.5E-04
7/30	1917	21.0	4.0	17.7	2190	4.8E-04	4.7E-04
7/31	1127	21.0	4.2	9.9	1200	4.7E-04	4.6E-04

AVERAGE K SAT: 4.6E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (63.5-64.0)
RING NUMBER: 2-(63.5-64.0)
DEPTH: 63.5-64.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.4 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.42 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1335	21.0	5.4	3.0	960	1.3E-04	1.2E-04
8/03	1850	21.0	5.3	3.0	960	1.3E-04	1.2E-04
8/04	1157	21.0	5.4	3.1	960	1.3E-04	1.3E-04

AVERAGE K SAT: 1.2E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAXL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (88.5-89.0)
RING NUMBER: 2-(88.5-89.0)
DEPTH: 88.5-89.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.3 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.42 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1335	21.0	5.1	5.3	960	2.3E-04	2.3E-04
8/03	1850	21.0	5.2	5.5	960	2.4E-04	2.3E-04
8/04	1157	21.0	5.1	5.5	960	2.4E-04	2.3E-04

AVERAGE K SAT: 2.3E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAM 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (93.5-94.0)
RING NUMBER: 2-(93.5-94.0)
DEPTH: 93.5-94.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 5.8 (cm)
SAMPLE RADIUS: 3.0 (cm)
SAMPLE X-SECTIONAL AREA: 29.13 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1335	21.0	5.6	39.0	960	1.4E-03	1.4E-03
8/03	1850	21.0	5.6	40.1	960	1.5E-03	1.4E-03
8/04	1157	21.0	5.6	42.8	960	1.6E-03	1.5E-03

AVERAGE K SAT: 1.5E-03 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (103.5-104.0)
RING NUMBER: 2-(103.5-104.0)
DEPTH: 103.5-104.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.7 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.22 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1335	21.0	5.8	5.6	960	2.3E-04	2.3E-04
8/03	1850	21.0	5.8	5.7	960	2.4E-04	2.3E-04
8/04	1157	21.0	5.7	6.0	960	2.5E-04	2.5E-04

AVERAGE K SAT: 2.3E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (113.5-114.0)
RING NUMBER: 2-(113.5-114.0)
DEPTH: 113.5-114.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.2 (cm)
SAMPLE RADIUS: 3.0 (cm)
SAMPLE X-SECTIONAL AREA: 28.84 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	4.7	3.4	960	1.6E-04	1.6E-04
8/03	1851	21.0	4.8	3.5	960	1.6E-04	1.6E-04
8/04	1158	21.0	4.9	3.7	960	1.7E-04	1.7E-04

AVERAGE K SAT: 1.6E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (123.5-124.0)
RING NUMBER: 2-(123.5-124.0)
DEPTH: 123.5-124.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.3 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.22 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD (CM)	FLOW VOL (CC)	ELAPSED TIME (SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	5.0	6.4	960	2.9E-04	2.8E-04
8/03	1851	21.0	5.0	6.4	960	2.9E-04	2.8E-04
8/04	1158	21.0	5.0	7.1	960	3.2E-04	3.1E-04

AVERAGE K SAT: 2.9E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (133.5-134.0)
RING NUMBER: 2-(133.5-134.0)
DEPTH: 133.5-134.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.5 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.22 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD (CM)	FLOW VOL (CC)	ELAPSED TIME (SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	4.5	3.1	960	1.6E-04	1.5E-04
8/03	1851	21.0	4.6	3.2	960	1.6E-04	1.5E-04
8/04	1158	21.0	4.5	3.1	960	1.6E-04	1.6E-04

AVERAGE K SAT: 1.6E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (143.5-144.0)
RING NUMBER: 2-(143.5-144.0)
DEPTH: 143.5-144.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.4 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.32 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD (CM)	FLOW VOL (CC)	ELAPSED TIME (SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	5.1	9.3	960	4.1E-04	4.0E-04
8/03	1851	21.0	5.1	9.6	960	4.2E-04	4.1E-04
8/04	1158	21.0	5.2	10.2	960	4.4E-04	4.3E-04

AVERAGE K SAT: 4.2E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (153.5-154.0)
RING NUMBER: 2-(153.5-154.0)
DEPTH: 153.5-154.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.5 (cm)
SAMPLE RADIUS: 3.0 (cm)
SAMPLE X-SECTIONAL AREA: 29.13 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	4.9	2.2	960	1.0E-04	1.0E-04
8/03	1851	21.0	4.9	2.2	960	1.0E-04	1.0E-04
8/04	1158	21.0	5.0	2.3	960	1.0E-04	1.0E-04

AVERAGE K SAT: 1.0E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (163.5-164.0)
RING NUMBER: 2-(163.5-164.0)
DEPTH: 163.5-164.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.4 (cm)
SAMPLE RADIUS: 3.0 (cm)
SAMPLE X-SECTIONAL AREA: 28.84 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	4.5	3.2	960	1.7E-04	1.6E-04
8/03	1851	21.0	4.5	3.3	960	1.7E-04	1.7E-04
8/04	1158	21.0	4.5	3.5	960	1.8E-04	1.8E-04

AVERAGE K SAT: 1.7E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAXL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDEM2 (173.5-174.0)
RING NUMBER: 2-(173.5-174.0)
DEPTH: 173.5-174.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.4 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.32 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	4.7	4.3	960	2.1E-04	2.0E-04
8/03	1851	21.0	4.8	4.4	960	2.1E-04	2.0E-04
8/04	1158	21.0	4.8	4.6	960	2.1E-04	2.1E-04

AVERAGE K SAT: 2.1E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAXL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (183.5-184.0)
RING NUMBER: 2-(183.5-184.0)
DEPTH: 183.5-184.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.6 (cm)
SAMPLE RADIUS: 3.0 (cm)
SAMPLE X-SECTIONAL AREA: 29.13 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	4.7	5.9	960	3.0E-04	2.9E-04
8/03	1851	21.0	4.7	6.1	960	3.1E-04	3.0E-04
8/04	1158	21.0	4.7	6.2	960	3.1E-04	3.1E-04

AVERAGE K SAT: 3.0E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (188.5-189.0)
RING NUMBER: 2-(188.5-189.0)
DEPTH: 188.5-189.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.8 (cm)
SAMPLE RADIUS: 3.0 (cm)
SAMPLE X-SECTIONAL AREA: 29.13 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
8/03	1336	21.0	4.4	3.4	960	1.9E-04	1.8E-04
8/03	1851	21.0	4.4	3.5	960	1.9E-04	1.9E-04
8/04	1158	21.0	4.4	3.4	960	1.9E-04	1.8E-04

AVERAGE K SAT: 1.8E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (27.5-28.0)
RING NUMBER: 3-(27.5-28.0)
DEPTH: 27.5-28.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 5.9 (cm)
SAMPLE RADIUS: 3.0 (cm)
SAMPLE X-SECTIONAL AREA: 29.13 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
7/30	1226	21.0	5.1	20.9	960	8.6E-04	8.4E-04
7/30	1919	21.0	5.0	25.7	1200	8.7E-04	8.5E-04
7/31	1127	21.0	5.0	26.0	1200	8.8E-04	8.6E-04

AVERAGE K SAT: 8.5E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (37.5-38.0)
RING NUMBER: 3-(37.5-38.0)
DEPTH: 37.5-38.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.3 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.32 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD (CM)	FLOW VOL (CC)	ELAPSED TIME (SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
7/30	1226	21.0	4.6	8.9	960	4.3E-04	4.2E-04
7/30	1918	21.0	4.5	19.0	1980	4.6E-04	4.5E-04
7/31	1127	21.0	4.7	12.7	1200	4.9E-04	4.7E-04

AVERAGE K SAT: 4.5E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDM3 (66.5-67.0)
RING NUMBER: 3-(66.5-67.0)
DEPTH: 66.5-67.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.4 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.42 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
7/30	1226	21.0	4.6	9.5	960	4.7E-04	4.6E-04
7/30	1918	21.0	4.5	16.1	1500	5.2E-04	5.1E-04
7/31	1127	21.0	4.6	13.8	1200	5.4E-04	5.3E-04

AVERAGE K SAT: 5.0E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

CONSTANT HEAD PERMEAMETER DATA

JOB NAME: LAWL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (67.5-68.0)
RING NUMBER: 3-(67.5-68.0)
DEPTH: 67.5-68.0 FT.
TYPE OF WATER USED: TAP
SAMPLE LENGTH: 6.1 (cm)
SAMPLE RADIUS: 3.1 (cm)
SAMPLE X-SECTIONAL AREA: 29.22 (sq. cm)

DATE (1992)	TIME (DAY)	TEMP (C)	CHANGE HEAD(CM)	FLOW VOL(CC)	ELAPSED TIME(SEC)	K SAT (CM/SEC)	K SAT @ 20 (CM/SEC)
7/30	1226	21.0	5.1	6.5	960	2.7E-04	2.7E-04
7/30	1917	21.0	5.1	17.7	2520	2.8E-04	2.8E-04
7/31	1127	21.0	5.4	8.5	1200	2.7E-04	2.7E-04

AVERAGE K SAT: 2.7E-04 (CM/SEC)

COMMENTS:

LABORATORY ANALYSIS BY: J. Kirkman
CALCULATIONS MADE BY: M. Harder
CHECKED BY: M. Ankeny

APPENDIX C
MOISTURE CHARACTERISTICS

SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 23.5-24	0	48.82
	34	47.59
	111	44.59
	308	35.54
	714	24.26
	2295	21.33
	5303	18.35
	15348	14.80
	2917	3.63
	6200	3.07
CDBM-2 - 34-33.5	19519	2.10
	0	46.18
	31	44.70
	107	40.50
	306	27.84
	714	20.68
	1632	18.80
	4875	16.96
	15909	15.93
	3885	4.99
CDBM-2 - 44-43.5	11208	3.30
	22517	2.56
	0	44.53
	31	43.68
	107	41.44
	306	30.77
	714	19.25
	1632	13.94
	4875	11.26
	15909	10.06
	5354	4.43
	14400	2.49

SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 54-53.5	0	44.60
	34	42.43
	111	37.31
	308	25.24
	714	22.51
	2295	20.49
	5303	18.81
	15348	16.30
	4120	5.60
	18428	3.09
CDBM-2 - 64-63.5	0	45.13
	31	43.42
	107	39.53
	306	27.41
	714	17.30
	1632	14.26
	4875	11.69
	15909	10.79
	4304	4.25
	20212	2.64
CDBM-2 - 89-88.5	0	44.25
	68	35.91
	134	30.96
	207	26.56
	301	25.71
	707	22.26
	1448	19.74
	5252	17.12
	15042	13.09
	2774	7.79
	7791	6.04
	20835	4.89

SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 94-93.5	0	50.25
	31	44.11
	107	32.60
	306	18.93
	714	16.59
	1632	15.59
	4875	13.15
	15909	12.21
	5792	4.94
	24118	3.06
CDBM-2 - 104-103.5	0	44.58
	69	41.39
	136	37.39
	208	31.40
	301	29.27
	707	21.31
	1448	18.53
	5252	17.21
	15042	15.47
	7506	6.07
	20743	4.43
CDBM-2 - 114-113.5	0	45.08
	31	43.61
	107	40.27
	306	30.52
	714	18.38
	1632	14.15
	4875	11.49
	15909	10.40
	4171	6.83
	15746	4.23

SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 124-123.5	0	43.73
	69	39.33
	134	35.48
	207	28.64
	301	25.97
	707	22.46
	1448	17.97
	5252	16.85
	15042	13.92
	6037	6.46
	13359	4.68
CDBM-2 - 134-133.5	0	44.70
	68	41.07
	135	37.63
	207	32.31
	301	28.02
	707	18.44
	1448	15.32
	5252	13.98
	15042	12.39
	2499	6.38
	5242	5.91
	16857	3.66
CDBM-2 - 144-143.5	0	42.84
	31	41.18
	107	38.04
	306	20.57
	714	18.63
	1632	18.47
	4875	18.04
	15909	17.63
	4395	5.37
	19978	3.59

**SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)**

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 154-153.5	0	41.03
	31	39.52
	107	37.23
	306	28.71
	714	16.68
	1632	14.96
	4875	13.24
	15909	12.37
	4395	5.64
	16378	3.89
CDBM-2 - 164-163.5	0	43.56
	68	40.27
	136	37.02
	209	30.55
	301	27.74
	707	24.80
	1448	22.11
	5252	20.61
	15042	18.31
CDBM-2 - 174-173.5	0	41.22
	31	40.08
	107	36.60
	306	23.90
	714	18.77
	1632	16.64
	4875	14.28
	15909	13.41
	2978	6.47
	5711	4.70
	21895	3.41

**SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)**

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-2 - 184-183.5	0	43.23
	70	39.44
	137	34.35
	210	27.10
	301	24.35
	707	20.81
	1448	18.07
	5252	16.79
	15042	14.33
	2458	5.39
	4151	4.67
	21487	3.67
CDBM-2 - 189-188.5	0	43.00
	28	41.81
	97	38.40
	311	25.80
	714	17.66
	1530	16.06
	5150	13.61
	15297	12.26
	7547	4.17
	13247	3.31
	24526	2.86
CDBM-3 - 28-27.5	0	47.90
	34	41.13
	111	28.30
	308	22.76
	714	20.95
	2295	19.47
	5303	18.25
	15348	16.45
	6608	9.65
	19019	7.71

SUMMARY OF MOISTURE CHARACTERISTICS
OF THE INITIAL DRAINAGE CURVE (CONTINUED)

SAMPLE NUMBER	PRESSURE HEAD (-cm water)	MOISTURE CONTENT (%, cm ³ /cm ³)
CDBM-3 - 38-37.5	0	48.39
	34	45.63
	111	39.58
	308	24.94
	714	19.53
	2295	16.00
	5303	11.89
	15348	9.37
	2580	6.77
	4752	5.50
	16266	3.88
CDBM-3 - 66.5-67	0	44.56
	34	42.12
	111	36.69
	308	22.13
	714	17.69
	2295	14.22
	5303	13.11
	15348	11.74
	4956	5.82
	16847	3.91
CDBM-3 - 67.5-68	0	43.97
	34	42.43
	111	37.72
	308	23.02
	714	19.02
	2295	17.43
	5303	16.38
	15348	14.76
	4844	5.75
	18214	3.88

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (23.5-24.0)
RING NUMBER: 2-(23.5-24.0)
DEPTH: 23.5-24.0 FT.
SAMPLE VOLUME: 169.80 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 414.52 (g)
TARE RING: 107.01 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 25.27 (g)
DRY WEIGHT OF SAMPLE: 199.35 (g)
SATURATED MOISTURE CONTENT: 48.82 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 82.89 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
7/31	1300	--	0.00	--	414.52	--	--	48.82
8/04	0930	--	0.03	--	412.44	2.08	2.08	47.59
8/07	0930	--	0.11	--	407.34	5.10	7.18	44.59
8/11	1100	--	0.30	--	391.98	15.36	22.54	35.54
8/14	1720	--	0.70	--	372.83	19.15	41.69	24.26
8/18	1745	--	2.25	--	367.85	4.98	46.67	21.33
8/21	0830	--	5.20	--	362.79	5.06	51.73	18.35
8/26	1045	--	15.05	--	356.76	6.03	57.76	14.80
8/27	1545	--	--	2.86	337.79	18.97	76.73	3.63
8/27	1615	--	--	6.08	336.85	0.94	77.67	3.07
8/28	0830	--	--	19.14	335.20	1.65	79.32	2.10

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (23.5-24.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (33.5-34.0)
RING NUMBER: 2-(33.5-34.0)
DEPTH: 33.5-34.0 FT.
SAMPLE VOLUME: 177.69 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 407.08 (g)
TARE RING: 108.72 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.31 (g)
DRY WEIGHT OF SAMPLE: 190.00 (g)
SATURATED MOISTURE CONTENT: 46.18 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 82.05 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/04	1630	--	0.00	--	407.08	--	--	46.18
8/07	1300	--	0.03	--	404.46	2.62	2.62	44.70
8/11	1100	--	0.11	--	396.99	7.47	10.09	40.50
8/14	1150	--	0.30	--	374.50	22.49	32.58	27.84
8/18	1330	--	0.70	--	361.78	12.72	45.30	20.68
8/21	0930	--	1.60	--	358.44	3.34	48.64	18.80
8/25	0945	--	4.78	--	355.17	3.27	51.91	16.96
8/28	1100	--	15.60	--	353.34	1.83	53.74	15.93
9/03	1045	--	--	3.81	333.90	19.44	73.18	4.99
9/03	1345	--	--	10.99	330.90	3.00	76.18	3.30
9/03	1515	--	--	22.08	329.57	1.33	77.51	2.56

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (33.5-34.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBH2 (43.5-44.0)
RING NUMBER: 2-(43.5-44.0)
DEPTH: 43.5-44.0 FT.
SAMPLE VOLUME: 179.44 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 442.57 (g)
TARE RING: 111.26 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.17 (g)
DRY WEIGHT OF SAMPLE: 225.23 (g)
SATURATED MOISTURE CONTENT: 44.53 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 79.91 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/04	1630	--	0.00	--	442.57	--	--	44.53
8/07	1300	--	0.03	--	441.04	1.53	1.53	43.68
8/11	1100	--	0.11	--	437.02	4.02	5.55	41.44
8/14	1150	--	0.30	--	417.87	19.15	24.70	30.77
8/18	1320	--	0.70	--	397.20	20.67	45.37	19.25
8/21	0930	--	1.60	--	387.67	9.53	54.90	13.94
8/25	0945	--	4.78	--	382.86	4.81	59.71	11.26
8/28	1100	--	15.60	--	380.71	2.15	61.86	10.06
9/01	1515	--	--	5.25	370.61	10.10	71.96	4.43
9/13	1345	--	--	14.12	367.13	3.48	75.44	2.49

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (43.5-44.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: COBM2 (53.5-54.0)
RING NUMBER: 2-(53.5-54.0)
DEPTH: 53.5-54.0 FT.
SAMPLE VOLUME: 204.45 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 464.37 (g)
TARE RING: 125.06 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 25.96 (g)
DRY WEIGHT OF SAMPLE: 222.16 (g)
SATURATED MOISTURE CONTENT: 44.60 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 91.19 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
7/31	1300	--	0.00	--	464.37	--	--	44.60
8/04	0930	--	0.03	--	459.93	4.44	4.44	42.43
8/07	0930	--	0.11	--	449.47	10.46	14.90	37.31
8/11	1115	--	0.30	--	424.79	24.68	39.58	25.24
8/14	1720	--	0.70	--	419.20	5.59	45.17	22.51
8/18	1745	--	2.25	--	415.08	4.12	49.29	20.49
8/21	0830	--	5.20	--	411.64	3.44	52.73	18.81
8/26	1045	--	15.05	--	406.51	5.13	57.86	16.30
8/27	1545	--	--	4.04	384.63	21.88	79.74	5.60
8/28	0930	--	--	18.07	379.49	5.14	84.88	3.09

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (53.5-54.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBH2 (63.5-64.0)
RING NUMBER: 2-(63.5-64.0)
DEPTH: 63.5-64.0 FT.
SAMPLE VOLUME: 186.80 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 454.09 (g)
TARE RING: 113.92 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.11 (g)
DRY WEIGHT OF SAMPLE: 229.75 (g)
SATURATED MOISTURE CONTENT: 45.13 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 84.31 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/04	1630	--	0.00	--	454.09	--	--	45.13
8/07	1300	--	0.03	--	450.88	3.21	3.21	43.42
8/11	1100	--	0.11	--	443.63	7.25	10.46	39.53
8/14	1150	--	0.30	--	420.98	22.65	33.11	27.41
8/18	1320	--	0.70	--	402.10	18.88	51.99	17.30
8/21	0930	--	1.60	--	396.42	5.68	57.67	14.26
8/25	0945	--	4.78	--	391.62	4.80	62.47	11.69
8/28	1100	--	15.60	--	389.93	1.69	64.16	10.79
9/03	1045	--	--	4.22	377.71	12.22	76.38	4.25
9/03	1345	--	--	19.82	374.72	2.99	79.37	2.64

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

Pressure Head vs. Moisture Content, Sample No. CDBM2 (63.5-64.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: C08M2 (88.5-89.0)
RING NUMBER: 2-(88.5-89.0)
DEPTH: 88.5-89.0 FT.
SAMPLE VOLUME: 185.91 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 443.21 (g)
TARE RING: 112.54 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.11 (g)
DRY WEIGHT OF SAMPLE: 222.29 (g)
SATURATED MOISTURE CONTENT: 44.25 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 82.27 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/07	1630	0.0	--	--	443.21	--	--	44.25
8/10	0915	68.0	--	--	427.70	15.51	15.51	35.91
8/14	1530	134.1	--	--	418.50	9.20	24.71	30.96
8/24	1100	206.6	--	--	410.32	8.18	32.89	26.56
8/28	1500	--	0.30	--	408.73	1.59	34.48	25.71
9/01	1045	--	0.69	--	402.32	6.41	40.89	22.26
9/04	0830	--	1.42	--	397.63	4.69	45.58	19.74
9/08	1500	--	5.15	--	392.77	4.86	50.44	17.12
9/15	1130	--	14.75	--	385.28	7.49	57.93	13.09
9/17	1000	--	--	2.7	375.42	9.86	67.79	7.79
9/17	1130	--	--	7.64	372.16	3.26	71.05	6.04
9/17	1415	--	--	20.43	370.03	2.13	73.18	4.89

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: C. Pigman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (88.5-89.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (93.5-94.0)
RING NUMBER: 2-(93.5-94.0)
DEPTH: 93.5-94.0 FT.
SAMPLE VOLUME: 167.78 (cc)
SATURATED WEIGHT AT 0 CM TENSION
 (WITH CAP AND RING): 389.25 (g)
 TARE RING: 103.25 (g)
 TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.27 (g)
DRY WEIGHT OF SAMPLE: 175.42 (g)
SATURATED MOISTURE CONTENT: 50.25 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 84.31 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)
8/04	1630	--	0.00	--	389.25	--	--
8/07	1300	--	0.03	--	378.94	10.31	10.31
8/11	1100	--	0.11	--	359.63	19.31	29.62
8/14	1150	--	0.30	--	336.70	22.93	52.55
8/18	1320	--	0.70	--	332.77	3.93	56.48
8/21	0930	--	1.60	--	331.09	1.68	58.16
8/25	0945	--	4.78	--	327.01	4.08	62.24
8/28	1100	--	15.60	--	325.42	1.59	63.83
9/03	1345	--	--	5.68	313.22	12.20	76.03
9/03	1515	--	--	23.65	310.08	3.14	79.17

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (93.5-94.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (103.5-104.0)
RING NUMBER: 2-(103.5-104.0)
DEPTH: 103.5-104.0 FT.
SAMPLE VOLUME: 196.10 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 468.54 (g)
TARE RING: 120.15 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.09 (g)
DRY WEIGHT OF SAMPLE: 234.88 (g)
SATURATED MOISTURE CONTENT: 44.58 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 87.42 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)
8/07	1430	0.0	--	--	468.54	--	--
8/10	0915	68.7	--	--	462.28	6.26	6.26
8/14	1530	135.7	--	--	454.45	7.83	14.09
8/24	1100	207.5	--	--	442.70	11.75	25.84
8/28	1500	--	0.30	--	438.52	4.18	30.02
9/01	1045	--	0.69	--	422.91	15.61	45.63
9/04	0830	--	1.42	--	417.45	5.46	51.09
9/08	1500	--	5.15	--	414.86	2.59	53.68
9/15	1130	--	14.75	--	411.45	3.41	57.09
9/17	1000	--	--	7.36	393.03	18.42	75.51
9/17	1415	--	--	20.34	389.81	3.22	78.73

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: C. Pigman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (103.5-104.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (113.5-114.0)
RING NUMBER: 2-(113.5-114.0)
DEPTH: 113.5-114.0 FT.
SAMPLE VOLUME: 178.82 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 450.89 (g)
TARE RING: 114.16 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.32 (g)
DRY WEIGHT OF SAMPLE: 229.83 (g)
SATURATED MOISTURE CONTENT: 45.06 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 80.58 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/04	1630	--	0.00	--	450.89	--	--	45.06
8/07	1300	--	0.03	--	448.29	2.60	2.60	43.61
8/11	1100	--	0.11	--	442.32	5.97	8.57	40.27
8/14	1150	--	0.30	--	424.89	17.43	26.00	30.52
8/18	1320	--	0.70	--	403.18	21.71	47.71	18.38
8/21	0930	--	1.60	--	395.61	7.57	55.28	14.15
8/25	0945	--	4.78	--	390.86	4.75	60.03	11.49
8/28	1100	--	15.60	--	388.91	1.95	61.98	10.40
9/01	1130	--	--	4.09	382.52	6.39	68.37	6.83
9/03	1045	--	--	15.44	377.87	4.65	73.02	4.23

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (113.5-114.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (123.5-124.0)
RING NUMBER: 2-(123.5-124.0)
DEPTH: 123.5-124.0 FT.
SAMPLE VOLUME: 184.70 (cc)
SATURATED WEIGHT AT 0 CM TENSION
 (WITH CAP AND RING): 427.15 (g)
 TARE RING: 117.34 (g)
 TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.62 (g)
DRY WEIGHT OF SAMPLE: 202.42 (g)
SATURATED MOISTURE CONTENT: 43.73 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 80.77 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/07	1430	0.0	--	--	427.15	--	--	43.73
8/11	1530	69.0	--	--	419.03	8.12	8.12	39.33
8/14	1530	134.2	--	--	411.91	7.12	15.24	35.48
8/24	1100	207.2	--	--	399.28	12.63	27.87	28.64
8/28	1500	--	0.30	--	394.35	4.93	32.80	25.97
9/01	1045	--	0.69	--	387.86	6.49	39.29	22.46
9/04	0830	--	1.42	--	379.57	8.29	47.58	17.97
9/08	1500	--	5.15	--	377.51	2.06	49.64	16.85
9/15	1130	--	14.75	--	372.09	5.42	55.06	13.92
9/17	1000	--	--	5.92	358.32	13.77	68.83	6.46
9/17	1130	--	--	13.10	355.03	3.29	72.12	4.68

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: C. Pigman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (123.5-124.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (133.5-134.0)
RING NUMBER: 2-(133.5-134.0)
DEPTH: 133.5-134.0 FT.
SAMPLE VOLUME: 189.38 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 465.02 (g)
TARE RING: 116.13 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 29.63 (g)
DRY WEIGHT OF SAMPLE: 234.60 (g)
SATURATED MOISTURE CONTENT: 44.70 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 84.66 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/07	1430	0.0	--	--	465.02	--	--	44.70
8/10	0915	67.5	--	--	458.14	6.88	6.88	41.07
8/14	1530	135.0	--	--	451.62	6.52	13.40	37.63
8/24	1100	206.8	--	--	441.54	10.08	23.48	32.31
8/28	1500	--	0.30	--	433.43	8.11	31.59	28.02
9/01	1045	--	0.69	--	415.29	18.14	49.73	18.44
9/04	0830	--	1.42	--	409.38	5.91	55.64	15.32
9/08	1500	--	5.15	--	406.84	2.54	58.18	13.98
9/15	1130	--	14.75	--	403.82	3.02	61.20	12.39
9/17	1130	--	--	2.45	392.45	11.37	72.57	6.38
9/17	1415	--	--	5.14	391.56	0.89	73.46	5.91
9/18	1045	--	--	16.53	387.30	4.26	77.72	3.66

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: C. Pigman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

Pressure Head vs. Moisture Content, Sample No. CDBM2 (133.5-134.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (143.5-144.0)
RING NUMBER: 2-(143.5-144.0)
DEPTH: 143.5-144.0 FT.
SAMPLE VOLUME: 186.19 (cc)
SATURATED WEIGHT AT 0 CM TENSION
 (WITH CAP AND RING): 430.93 (g)
 TARE RING: 113.09 (g)
 TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 25.48 (g)
DRY WEIGHT OF SAMPLE: 212.59 (g)
SATURATED MOISTURE CONTENT: 42.84 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 79.77 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/04	1630	--	0.00	--	430.93	--	--	42.84
8/07	1300	--	0.03	--	427.83	3.10	3.10	41.18
8/11	1100	--	0.11	--	421.98	5.85	8.95	38.04
8/14	1150	--	0.30	--	389.46	32.52	41.47	20.57
8/18	1320	--	0.70	--	385.85	3.61	45.08	18.63
8/21	0930	--	1.60	--	385.54	0.31	45.39	18.47
8/25	0945	--	4.78	--	384.75	0.79	46.18	18.04
8/28	1100	--	15.60	--	383.99	0.76	46.94	17.63
9/03	1045	--	--	4.31	361.15	22.84	69.78	5.37
9/03	1345	--	--	19.59	357.85	3.30	73.08	3.59

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

Pressure Head vs. Moisture Content, Sample No. CDBM2 (143.5-144.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (153.5-154.0)
RING NUMBER: 2-(153.5-154.0)
DEPTH: 153.5-154.0 FT.
SAMPLE VOLUME: 189.34 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 468.92 (g)
TARE RING: 119.79 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.32 (g)
DRY WEIGHT OF SAMPLE: 245.13 (g)
SATURATED MOISTURE CONTENT: 41.03 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 77.68 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)
8/04	1630	--	0.00	--	468.92	--	--
8/07	1300	--	0.03	--	466.06	2.86	2.86
8/11	1100	--	0.11	--	461.74	4.32	7.18
8/14	1150	--	0.30	--	445.60	16.14	23.32
8/18	1320	--	0.70	--	422.82	22.78	46.10
8/21	0930	--	1.60	--	419.57	3.25	49.35
8/25	0945	--	4.78	--	416.31	3.26	52.61
8/28	1100	--	15.60	--	414.66	1.65	54.26
9/03	1045	--	--	4.31	401.91	12.75	67.01
9/03	1345	--	--	16.06	398.60	3.31	70.32

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (153.5-154.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBH2 (163.5-164.0)
RING NUMBER: 2-(163.5-164.0)
DEPTH: 163.5-164.0 FT.
SAMPLE VOLUME: 184.88 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 448.70 (g)
TARE RING: 118.70 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 25.38 (g)
DRY WEIGHT OF SAMPLE: 224.08 (g)
SATURATED MOISTURE CONTENT: 43.56 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 80.54 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/07	1630	0.0	--	--	448.70	--	--	43.56
8/10	0915	68.0	--	--	442.62	6.08	6.08	40.27
8/14	1530	136.0	--	--	436.60	6.02	12.10	37.02
8/24	1100	208.6	--	--	424.65	11.95	24.05	30.55
8/28	1500	--	0.30	--	419.45	5.20	29.25	27.74
9/01	1045	--	0.69	--	414.01	5.44	34.69	24.80
9/04	0830	--	1.42	--	409.04	4.97	39.66	22.11
9/08	1500	--	5.15	--	406.26	2.78	42.44	20.61
9/15	1130	--	14.75	--	402.01	4.25	46.69	18.31
9/17	1130	--	--	5.27	377.95	24.06	70.75	5.30
9/17	1415	--	--	24.64	375.47	2.48	73.23	3.95

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: C. Pigman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (163.5-164.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (173.5-174.0)
RING NUMBER: 2-(173.5-174.0)
DEPTH: 173.5-174.0 FT.
SAMPLE VOLUME: 186.77 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 436.54 (g)
TARE RING: 113.66 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.16 (g)
DRY WEIGHT OF SAMPLE: 219.74 (g)
SATURATED MOISTURE CONTENT: 41.22 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 76.98 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/04	1630	--	0.00	--	436.54	--	--	41.22
8/07	1300	--	0.03	--	434.42	2.12	2.12	40.08
8/11	1100	--	0.11	--	427.91	6.51	8.63	36.60
8/14	1150	--	0.30	--	404.19	23.72	32.35	23.90
8/18	1320	--	0.70	--	394.62	9.57	41.92	18.77
8/21	0930	--	1.60	--	390.64	3.98	45.90	16.64
8/25	0945	--	4.78	--	386.24	4.40	50.30	14.28
8/28	1100	--	15.60	--	384.60	1.64	51.94	13.41
9/01	0830	--	--	2.92	371.65	12.95	64.89	6.47
9/03	0830	--	--	5.60	368.33	3.32	68.21	4.70
9/03	1630	--	--	21.47	365.92	2.41	70.62	3.41

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (173.5-174.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LAHL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (183.5-184.0)
RING NUMBER: 2-(183.5-184.0)
DEPTH: 183.5-184.0 FT.
SAMPLE VOLUME: 192.83 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 454.66 (g)
TARE RING: 118.08 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.27 (g)
DRY WEIGHT OF SAMPLE: 226.95 (g)
SATURATED MOISTURE CONTENT: 43.23 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 83.36 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/07	1630	0.0	--	--	454.66	--	--	43.23
8/10	0915	70.0	--	--	447.36	7.30	7.30	39.44
8/14	1530	137.0	--	--	437.53	9.83	17.13	34.35
8/24	1100	209.9	--	--	423.56	13.97	31.10	27.10
8/28	1500	--	0.30	--	418.25	5.31	36.41	24.35
9/01	1045	--	0.69	--	411.42	6.83	43.24	20.81
9/04	0830	--	1.42	--	406.14	5.28	48.52	18.07
9/08	1500	--	5.15	--	403.68	2.46	50.98	16.79
9/15	1130	--	14.75	--	398.93	4.75	55.73	14.33
9/17	1615	--	--	2.41	381.70	17.23	72.96	5.39
9/18	1045	--	--	4.07	380.30	1.40	74.36	4.67
9/18	0945	--	--	21.07	378.38	1.92	76.28	3.67

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: C. Pigman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM2 (183.5-184.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM2 (188.5-189.0)
RING NUMBER: 2-(188.5-189.0)
DEPTH: 188.5-189.0 FT.
SAMPLE VOLUME: 197.49 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 469.81 (g)
TARE RING: 125.19 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 24.90 (g)
DRY WEIGHT OF SAMPLE: 234.80 (g)
SATURATED MOISTURE CONTENT: 43.00 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 84.92 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
8/07	1720	0.0	--	--	469.81	--	--	43.00
8/11	1430	28.4	--	--	467.46	2.35	2.35	41.81
8/14	1730	97.0	--	--	460.73	6.73	9.08	38.40
8/18	1815	--	0.31	--	435.84	24.89	33.97	25.80
8/25	1315	--	0.70	--	419.76	16.08	50.05	17.66
8/28	1430	--	1.50	--	416.60	3.16	53.21	16.06
9/01	0945	--	5.05	--	411.77	4.83	58.04	13.61
9/04	1600	--	15.00	--	409.10	2.67	60.71	12.26
9/14	1530	--	--	7.40	393.12	15.98	76.69	4.17
9/17	1415	--	--	12.99	391.42	1.70	78.39	3.31
9/18	0900	--	--	24.05	390.54	0.88	79.27	2.86

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

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Pressure Head vs. Moisture Content, Sample No. CDBM2 (188.5-189.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

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MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBH3 (27.5-28.0)
RING NUMBER: 3-(27.5-28.0)
DEPTH: 27.5-28.0 FT.
SAMPLE VOLUME: 171.57 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 422.60 (g)
TARE RING: 110.62 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 26.00 (g)
DRY WEIGHT OF SAMPLE: 203.79 (g)
SATURATED MOISTURE CONTENT: 47.90 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 82.19 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
7/31	1300	--	0.00	--	422.60	--	--	47.90
8/04	0930	--	0.03	--	410.98	11.62	11.62	41.13
8/07	0930	--	0.11	--	388.96	22.02	33.64	28.30
8/11	1115	--	0.30	--	379.46	9.50	43.14	22.76
8/14	1720	--	0.70	--	376.35	3.11	46.25	20.95
8/18	1745	--	2.25	--	373.82	2.53	48.78	19.47
8/21	0830	--	5.20	--	371.72	2.10	50.88	18.25
8/26	1045	--	15.05	--	368.64	3.08	53.96	16.45
8/27	1045	--	--	6.48	356.96	11.68	65.64	9.65
8/27	1345	--	--	18.65	353.64	3.32	68.96	7.71

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM3 (27.5-28.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (37.5-38.0)
RING NUMBER: 3-(37.5-38.0)
DEPTH: 37.5-38.0 FT.
SAMPLE VOLUME: 184.72 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 402.15 (g)
TARE RING: 112.30 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 27.50 (g)
DRY WEIGHT OF SAMPLE: 172.97 (g)
SATURATED MOISTURE CONTENT: 48.39 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 89.38 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
7/31	1300	--	0.00	--	402.15	--	--	48.39
8/04	0930	--	0.03	--	397.05	5.10	5.10	45.63
8/07	0930	--	0.11	--	385.89	11.16	16.26	39.58
8/11	1115	--	0.30	--	358.83	27.06	43.32	24.94
8/14	1720	--	0.70	--	348.84	9.99	53.31	19.53
8/18	1745	--	2.25	--	342.33	6.51	59.82	16.00
8/21	0830	--	5.20	--	334.73	7.60	67.42	11.89
8/26	1045	--	15.05	--	330.08	4.65	72.07	9.37
8/27	0845	--	--	2.53	325.27	4.81	76.88	6.77
8/27	1045	--	--	-4.66	322.93	2.34	79.22	5.50
8/27	1345	--	--	15.95	319.93	3.00	82.22	3.88

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: H. Ankeny

DANIEL B. STEPHENS & ASSOCIATES, INC.

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Pressure Head vs. Moisture Content, Sample No. CDBM3 (37.5-38.0)

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MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (66.5-67.0)
RING NUMBER: 3-(66.5-67.0)
DEPTH: 66.5-67.0 FT.
SAMPLE VOLUME: 188.56 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 448.11 (g)
TARE RING: 119.38 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 25.18 (g)
DRY WEIGHT OF SAMPLE: 219.52 (g)
SATURATED MOISTURE CONTENT: 44.56 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 84.03 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
7/31	1300	--	0.00	--	448.11	--	--	44.56
8/04	0930	--	0.03	--	443.50	4.61	4.61	42.12
8/07	0930	--	0.11	--	433.26	10.24	14.85	36.69
8/11	1115	--	0.30	--	405.80	27.46	42.31	22.13
8/14	1720	--	0.70	--	397.43	8.37	50.68	17.69
8/18	1745	--	2.25	--	390.90	6.53	57.21	14.22
8/21	0830	--	5.20	--	388.80	2.10	59.31	13.11
8/26	1045	--	15.05	--	386.22	2.58	61.89	11.74
8/27	1045	--	--	4.86	375.06	11.16	73.05	5.82
8/27	1345	--	--	16.52	371.45	3.61	76.66	3.91

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM3 (66.5-67.0)

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

MOISTURE RETENTION DATA - HANGING COLUMN/15 BAR PRESSURE PLATE (PORE SIZE DISTRIBUTION)

JOB NAME: LANL 5.1
JOB NUMBER: 2830.1
SAMPLE NUMBER: CDBM3 (67.5-68.0)
RING NUMBER: 3-(67.5-68.0)
DEPTH: 67.5-68.0 FT.
SAMPLE VOLUME: 177.10 (cc)
SATURATED WEIGHT AT 0 CM TENSION
(WITH CAP AND RING): 432.68 (g)
TARE RING: 112.99 (g)
TARE CAP: 0.00 (g)
TARE WEIGHT OF SCREEN AND CLAMP: 25.41 (g)
DRY WEIGHT OF SAMPLE: 216.41 (g)
SATURATED MOISTURE CONTENT: 43.97 (% vol)
INITIAL VOLUME OF WATER IN SAMPLE: 77.87 (cc)

DATE (1992)	TIME	HANGING COLUMN SUCTION (CM)	PRESSURE PLATE PRESSURE (BAR)	THERMO COUPLE POTENTIAL (BAR)	WEIGHT W/RING (G)	WEIGHT CHANGE (G)	TOTAL WEIGHT CHANGE (G)	MOISTURE CONTENT (% VOL)
7/31	1300	--	0.00	--	432.68	--	--	43.97
8/04	0930	--	0.03	--	429.95	2.73	2.73	42.43
8/07	0930	--	0.11	--	421.61	8.34	11.07	37.72
8/11	1115	--	0.30	--	395.57	26.04	37.11	23.02
8/14	1720	--	0.70	--	388.49	7.08	44.19	19.02
8/18	1745	--	2.25	--	385.67	2.82	47.01	17.43
8/21	0830	--	5.20	--	383.82	1.85	48.86	16.38
8/26	1045	--	15.05	--	380.95	2.87	51.73	14.76
8/27	1500	--	--	4.75	364.99	15.96	67.69	5.75
8/27	1615	--	--	17.86	361.68	3.31	71.00	3.88

COMMENTS: Assume density of water is 1.0 g/cc

LABORATORY ANALYSIS PERFORMED BY: J. Kirkman/J. Kelsey
CALCULATION MADE BY: C. Pigman
CHECKED BY: M. Ankeny

Pressure Head vs. Moisture Content, Sample No. CDBM3 (67.5-68.0)

APPENDIX D

UNSATURATED HYDRAULIC PROPERTIES (CALCULATED)

SUMMARY OF UNSATURATED HYDRAULIC PROPERTIES (CALCULATED)

SAMPLE NUMBER	α (cm ⁻¹)			N (dimensionless)			θ_r (%, cm ³ /cm ³)	θ_s (%, cm ³ /cm ³)	K _{sat} (cm/sec)
	Calculated Value	95% Confidence Limits		Calculated Value	95% Confidence Limits				
		Lower	Upper		Lower	Upper			
CDBM-2 - 23.5-24	0.00468	-0.0013	0.0106	1.53590	1.1696	1.9022	2.10	48.82	6.2 x 10 ⁻⁵
CDBM-2 - 34-33.5	0.00812	-0.0018	0.0180	1.45324	1.1907	1.7158	2.56	46.18	2.2 x 10 ⁻⁴
CDBM-2 - 44-43.5	0.00470	0.0019	0.0075	1.64413	1.3912	1.8970	2.49	44.53	7.0 x 10 ⁻⁵
CDBM-2 - 54-53.5	0.01288	-0.0087	0.0345	1.33785	1.1131	1.5626	3.09	44.60	4.6 x 10 ⁻⁴
CDBM-2 - 64-63.5	0.00707	0.0020	0.0121	1.56858	1.3288	1.8084	2.64	45.13	1.2 x 10 ⁻⁴
CDBM-2 - 89-88.5	0.01728	0.0003	0.0343	1.38533	1.2122	1.5585	4.89	44.25	2.3 x 10 ⁻⁴
CDBM-2 - 94-93.5	0.02799	0.0023	0.0536	1.40403	1.2458	1.5623	3.06	50.25	1.5 x 10 ⁻³
CDBM-2 - 104-103.5	0.00850	0.0016	0.0154	1.42544	1.2369	1.6140	4.43	44.58	2.3 x 10 ⁻⁴
CDBM-2 - 114-113.5	0.00543	0.0027	0.0082	1.66179	1.4386	1.8850	4.23	45.06	1.6 x 10 ⁻⁴
CDBM-2 - 124-123.5	0.01063	0.0017	0.0195	1.41696	1.2328	1.6012	4.68	43.73	2.9 x 10 ⁻⁴
CDBM-2 - 134-133.5	0.00653	0.0028	0.0103	1.60281	1.3655	1.8401	3.66	44.70	1.6 x 10 ⁻⁴

**SUMMARY OF UNSATURATED HYDRAULIC PROPERTIES (CALCULATED)
(CONTINUED)**

SAMPLE NUMBER	α (cm^{-1})			N (dimensionless)			θ_r (%, cm^3/cm^3)	θ_s (%, cm^3/cm^3)	K_{sat} (cm/sec)
	Calculated Value	95% Confidence Limits		Calculated Value	95% Confidence Limits				
		Lower	Upper		Lower	Upper			
CDBM-2 - 144-143.5	0.01404	-0.0118	0.0399	1.36314	1.0871	1.6392	3.59	42.84	4.2×10^{-4}
CDBM-2 - 154-153.5	0.00585	0.0007	0.0110	1.56712	1.2726	1.8616	3.89	41.03	1.0×10^{-4}
CDBM-2 - 164-163.5	0.01001	-0.0035	0.0235	1.33832	1.1270	1.5496	3.95	43.56	1.7×10^{-4}
CDBM-2 - 174-173.5	0.00795	-0.0005	0.0164	1.49743	1.2307	1.7641	3.41	41.22	2.1×10^{-4}
CDBM-2 - 184-183.5	0.00999	-0.0001	0.0201	1.47142	1.2080	1.7349	3.67	43.23	3.0×10^{-4}
CDBM-2 - 189-188.5	0.00765	0.0010	0.0143	1.50445	1.2783	1.7306	2.86	43.00	1.8×10^{-4}
CDBM-3 - 28-27.5	0.04709	-0.0120	0.1062	1.32422	1.1801	1.4684	7.71	47.90	8.5×10^{-4}
CDBM-3 - 38-37.5	0.00916	0.0032	0.0151	1.57662	1.3655	1.7877	3.88	48.39	4.5×10^{-4}
CDBM-3 - 66.5-67	0.01147	0.0018	0.0211	1.48246	1.2764	1.6886	3.91	44.56	5.0×10^{-4}
CDBM-3 - 67.5-68	0.01181	-0.0037	0.0273	1.40495	1.1680	1.6419	3.88	43.97	2.7×10^{-4}

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (23.5-24.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (23.5-24.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (33.5-34.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (33.5-34.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (43.5-44.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (43.5-44.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (53.5-54.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (53.5-54.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (63.5-64.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (63.5-64.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CBDM2 (88.5-89.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (88.5-89.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (93.5-94.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (93.5-94.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (103.5-104.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (103.5-104.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (113.5-114.0)

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Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (113.5-114.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (123.5-124.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (123.5-124.0).

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (133.5-134.0)

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Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (133.5-134.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (143.5-144.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (143.5-144.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (153.5-154.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (153.5–154.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (163.5-164.0)

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Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (163.5-164.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (173.5-174.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (173.5-174.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (183.5-184.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (183.5-184.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM2 (188.5-189.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM2 (188.5-189.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM3 (27.5-28.0)

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Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM3 (27.5-28.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM3 (37.5-38.0)

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Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM3 (37.5-38.0)

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Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM3 (66.5-67.0)

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Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM3 (66.5-67.0)

Relative Hydraulic Conductivity vs. Pressure Head,
Sample No. CDBM3 (67.5-68.0)

Relative Hydraulic Conductivity vs. Moisture Content,
Sample No. CDBM3 (67.5-68.0)

APPENDIX E
TRANSIENT OUTFLOW

SUMMARY OF TRANSIENT OUTFLOW RESULTS

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SAMPLE NUMBER	FROM TRANSIENT OUTFLOW DATA				STEADY-STATE DATA	RELATIVE HYDRAULIC CONDUCTIVITY $K_{rel} = \frac{k_{transient}}{K_{sat}}$
	AVERAGE OUTFLOW PRESSURE P (-cm)	FRACTIONAL CHANGE IN MOISTURE CONTENT $\Delta \theta$	DIFFUSIVITY D (cm ² /sec)	UNSATURATED HYDRAULIC CONDUCTIVITY k (cm/sec)	SATURATED HYDRAULIC CONDUCTIVITY K_{sat} (cm/sec)	
CDBM-2 - 89-88.5	35.6	8.6×10^{-2}	7.4×10^{-3}	9.8×10^{-6}	2.4×10^{-4}	4.1×10^{-2}
	101.1	5.1×10^{-2}	4.1×10^{-4}	3.2×10^{-7}	2.3×10^{-4}	1.4×10^{-3}
CDBM-2 - 104-103.5	36.0	3.2×10^{-2}	4.7×10^{-1}	2.3×10^{-4}	2.4×10^{-4}	9.6×10^{-1}
	102.2	3.8×10^{-2}	1.5×10^{-2}	8.4×10^{-6}	2.3×10^{-4}	3.7×10^{-2}
CDBM-2 - 124-123.5	35.7	4.4×10^{-2}	5.0×10^{-2}	3.3×10^{-5}	2.9×10^{-4}	1.1×10^{-1}
	101.2	3.9×10^{-2}	8.6×10^{-3}	5.1×10^{-6}	2.9×10^{-4}	1.8×10^{-2}
CDBM-2 - 134-133.5	35.4	3.7×10^{-2}	7.1×10^{-1}	4.0×10^{-4}	1.6×10^{-4}	2.5×10^0
	101.3	3.7×10^{-2}	4.5×10^{-3}	2.4×10^{-6}	1.6×10^{-4}	1.5×10^{-2}
CDBM-2 - 164-163.5	35.6	3.2×10^{-2}	5.5×10^{-1}	2.7×10^{-4}	1.7×10^{-4}	1.5×10^0
	102.0	2.8×10^{-2}	3.7×10^{-3}	1.6×10^{-6}	1.7×10^{-4}	9.0×10^{-3}
CDBM-2 - 184-183.5	36.7	3.2×10^{-2}	1.1×10^{-2}	5.2×10^{-6}	3.1×10^{-4}	1.7×10^{-2}
	103.5	4.4×10^{-2}	3.5×10^{-3}	2.3×10^{-6}	3.1×10^{-4}	7.4×10^{-3}

SUMMARY OF TRANSIENT OUTFLOW GRAPHICAL DATA

SAMPLE NUMBER	INITIAL PRESSURE P_1 (- cm)	FINAL PRESSURE P_2 (-cm)	PLATE IMPEDANCE/ SOIL IMPEDANCE a	α_1^2	REFERENCE POINT TIME T_{rp} (min)	TOTAL OUTFLOW FOR PRESSURE INCREMENT Q_o (cm ³)	LENGTH OF SAMPLE L (cm)	VOLUME OF SAMPLE V (cm ³)
CDBM-2 - 89-88.5	3.2	68.0	0.2	1.0	90.0	15.98	6.32	185.91
	68.0	134.1	$0.0 < a < 0.0667$	2.3	725.0	9.57	6.32	185.91
CDBM-2 - 104-103.5	3.4	68.7	1000	0.1	16.0	6.37	6.71	196.10
	68.7	135.7	1	0.8	65.0	7.48	6.71	196.10
CDBM-2 - 124-123.5	3.2	68.2	1	0.6	21.0	8.08	6.32	184.70
	68.2	134.2	0.2	1.8	44.0	7.22	6.32	184.70
CDBM-2 - 134-133.5	3.2	67.5	1000	0.1	9.9	6.97	6.48	189.38
	67.5	135.0	$0.0667 < a < 0.2$	2.0	78.0	6.97	6.48	189.38
CDBM-2 - 164-163.5	3.2	68.0	1000	0.1	12.5	5.85	6.41	184.88
	68.0	136.0	0.0667	2.1	87.0	5.25	6.41	184.88
CDBM-2 - 184-183.5	3.3	70.0	$0.0 < a < 0.0667$	2.3	30.0	6.12	6.62	192.83
	70.0	137.0	$0.0667 < a < 0.2$	1.9	110.0	8.39	6.62	192.83

Experimental Outflow points for LANL CDBM2 (88.5-89.0) FT.
From Outflow Data

Experimental Outflow points for LANL CDBM2 (103.5-104.0) FT.
From Outflow Data

Experimental Outflow points for LANL CDBM2 (123.5-124.0) FT.
From Outflow Data

Experimental Outflow points for LANL CDBM2 (133.5-134.0) FT.
From Outflow Data

Experimental Outflow points for LANL CDBM2 (183.5-184.0) FT.
From Outflow Data

Experimental Outflow points for LANL CDBM2 (183.5-184.0) FT.
From Outflow Data

APPENDIX F
LABORATORY METHODS

SUMMARY OF LABORATORY METHODS

<u>Methods</u>	<u>Reference</u>
Moisture Content	ASTM D 2216-80
Bulk Density	MOSA*, 1986. Chp. 13, pp. 363-367
Porosity	MOSA*, 1986. Chp. 18, pp. 444-445
Saturated Hydraulic Conductivity	
Constant Head	ASTM D 2434-68
Falling Head	MOSA*, 1986. Chp. 28, pp. 700-703
Moisture Retention Characteristics	
Hanging Column	MOSA*, 1986. Chp. 26, pp. 637-639
Pressure Plate Extractor	ASTM D 2325-68
Thermocouple Psychrometer	MOSA*, 1986. Chp. 26, pp. 597-618 Operators Manual for the SC-10A Thermocouple Psychrometer Sample Chamber (manufactured by Decagon Devices Inc., Pullman, WA)
Unsaturated Hydraulic Conductivity (Calculated from Moisture Retention Data)	Van Genuchten, M. 1980. A Closed Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils. <i>Soil Sci. Soc. Am. J.</i> 44:892-898.
Unsaturated Hydraulic Conductivity (Transient Outflow)	Kunze, R. and D. Kirkham. 1962. Simplified Accounting for Membrane Impedance in Capillary Conductivity Determinations. <i>Soil Sci. Soc. Am. J.</i> 26:421-426.

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- Klute, A. (ed.) 1986. *Methods of Soil Analysis. Part 1.* 2nd ed. American Society of Agronomy. Madison, WI.

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December 31, 1992

1048-2830-92

Dr. Alan Stoker
University of California
Los Alamos National Laboratory
Subcontract No. 9-XTI-027EE-1
P.O. Box 1663
Los Alamos, NM 87545

Dear Dr. Stoker:

Please find enclosed the final laboratory data report for tests on tuff samples from the Los Alamos area, as requested under your Subcontract No. 9-XTI-027EE-1. An invoice for this work will be submitted under separate cover.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be 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.

We are pleased to provide this service to Los Alamos National Laboratory and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data report, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.

Mark D. Ankeny
Senior Scientist/Laboratory Manager

MDA/mjt
Enclosures

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SUMMARY

The Hydrologic Testing Laboratory has completed laboratory tests on tuff samples from the Los Alamos area as requested by Dr. Alan Stoker of Los Alamos National Laboratory. The results of the testing are presented in Tables 1 through 4. A discussion of the testing program is including in the following paragraphs. A detailed description of the methods used to perform the analyses reported herein is available upon request.

Materials

Four moderately welded, intact tuff samples were selected for permeability testing and analysis. Three samples were from the MCM 5.1 series (68.0-69.0, 73.0-74.0, and 83.0-84.0), and one sample was from the PC4 series (168.5-169.0). The three MCM series samples were encased in epoxy prior to testing using the same methodology used and summarized in earlier reports. The PC4 sample was tested as received, in a tight stainless steel ring. Initial physical inspection and subsequent data analysis of all the samples showed no evidence for annular flow.

Sample densities varied among the four samples from 1.14 to 1.41 g/cm³. Based upon a measured particle density of 2.55, these densities correspond to porosities of approximately 45 to 55%. These values are consistent with previous testing performed on similar materials.

Methods

To summarize the device, a peristaltic pump drives air flow. Two valves control direction of air flow through the sample. Two valves control wetting and drying. Two valves, in conjunction with the pump, are used to control system mean pressure. Two thermocouples are used to monitor temperature. An electronic scale is used to monitor the change in sample weight. A relative humidity sensor is used to monitor water potential.

The main components of the air permeability apparatus consist of a peristaltic pump for positive air volume displacement connected to an inlet and an outlet port on the soil sample. Solenoid

valves control air flow through the apparatus and are configured so that flow through the sample is reversed periodically (at user-specified intervals) through the use of a pair of these valves (Figure 1).

Reversing flow has several physical and experimental advantages:

1. There is no net pressure gradient across the sample due to unidirectional flow.
2. Drift in offsets of pressure transducers cancel out; i.e., an overestimate of pressure drop in one direction is canceled by an underestimate of the pressure drop in the other direction.
3. Compressive advection is increased.

Reversal of flow direction causes large local fluctuations in air pressure, which force air to be compressed in and out of dead-end pores. Given that equilibrium of water content at more negative water potentials is due more to vapor than to liquid flow, and that transport of water vapor from dead-end pores must, necessarily, be due more to vapor than to liquid flow, this compression reduces the time to equilibrium.

Also present on this basic device are a wetting and a drying circuit. By use of another pair of solenoid valves, air can be forced through a Drierite column or over a free water surface to wet or dry the air stream before a subsequent pass through the soil column. A humidity sensor has been added in line to measure relative humidity of water in equilibrium with the soil core. This sensor appears susceptible to pressure fluctuations caused by air permeability measurements run at different mean system pressures. The sensor readings themselves, however, are corrected for temperature and pressure fluctuations. Temperature is also used in calculation of air viscosity when determining apparent permeabilities.

Klinkenberg (slip-flow) measurements are taken at preprogrammed pressure steps. One valve is used when pumping down system pressure for below-ambient air pressure measurements. A

second solenoid valve is used when pressurizing the system for above-ambient pressure measurements.

Theory

Apparent permeability was related to intrinsic permeability by Klinkenberg¹ as

$$k_a = k_{\infty} \left[1 + \frac{b}{\bar{p}} \right] \quad (1)$$

where

k_{∞} = intrinsic permeability

b = the Klinkenberg constant

$\bar{p}$ = the mean pressure of the permeability measurement

He also derived an expression relating b to capillary pore radius as

$$b = \frac{4 K_1 \lambda \bar{p}}{r_c} \quad (2)$$

where

K_1 = a constant approximately equal to one

λ = the mean free path of a gas molecule

$\bar{p}$ = the mean pressure

r_c = is the capillary radius.

The measured value of air permeability relative to intrinsic permeability of the tuff as a porous medium is affected by several factors:

¹ Klinkenberg, L.J. 1941. The permeability of porous media to liquids and gases. *Am. Pet. Inst. Drilling Prod. Pract.*, pp. 200-213.

- Any water-filled pores will cause an underestimate of intrinsic permeability by occluding air flow.
- Water flow through clay layers of saturated clays is negligible, but drying of interlayer water can shrink clays and result in higher intrinsic permeabilities from air than from water measurements.
- Clays can plug pore throats. This phenomenon is also likely to result in air measurements of permeability being higher.
- Slip flow of air (the Klinkenberg effect) causes apparent permeability to be higher than intrinsic permeability, which would cause an overestimate of intrinsic permeability. This last issue (slip flow) led to development of equipment to quantify slip flow in volcanic tuff.

The approach used to obtain the Klinkenberg or slip flow can also be used to quantify Knudsen diffusion, another manifestation of the pore-wall/gas molecule interaction phenomenon. Hadley² showed that the Knudsen diffusion coefficient (D_k) can be calculated at zero saturation from the Klinkenberg constant as

$$D_k = \left[\frac{b k_L}{\phi \mu_G} \right] \quad (3)$$

where

- b = the slope of the line of the graphs in Figures 3 through 6,
i.e., the Klinkenberg constant
- k_L = the permeability
- ϕ = the porosity
- μ_G = the gas viscosity

² Hadley, G.R. 1982. Theoretical treatment of evaporation front drying. *Int. J. Heat and Mass Transfer* 25:1511-1522.

Given the variable pore size distribution and variable water saturation of tuff *in situ*, the resolution possible with this new tool should prove particularly valuable on tuff. In Albuquerque (approximately 5000-ft elevation), ambient pressure is approximately 0.85 atmosphere. Los Alamos (7000-ft elevation) has an ambient pressure of approximately 0.75 atmosphere. Inspection of the data shows that apparent permeability of tuff can vary significantly from sea level to Los Alamos.

Results

Apparent permeability measurements were fairly consistent among the four samples. For example, at a volumetric water content of approximately 30% (v/v), apparent permeabilities varied from 3.5 to 7.4 darcies. Apparent permeability is a function of both water content (which can be re-expressed as air filled porosity) and mean air pressure (i.e., the average system air pressure). This is clearly shown in Figure 2: Apparent permeability decreases as mean system pressure increases. This effect is less pronounced at higher water contents where slip flow occurs only through larger pores and the slip phenomenon is of less significance.

Plots of measured permeabilities versus moisture contents are shown for each sample in Figures 3 through 6. In general, three trends are significant: (1) permeability increases with decreasing moisture content, (2) changes in permeability decrease with decreasing moisture content, and (3) the slope of the data for a given moisture content increases with decreasing moisture content (slip flow) but the additional permeability is not large.

A comparison of slopes for each of the three MCM samples shows more variability. At the lowest measured water content, MCM 5.1 68.0-69.0 showed the most slip flow (steepest slope). Interestingly, sample MCM 5.1 73.0-74.0 slope was approximately half of the MCM 5.1 68.0-69.0 slope, and the slope of MCM 5.1 83.0-84.0 was about half of the MCM 5.1 73.0-74.0 slope.

These 'halvings' correlate to the phenomenon we see in Figures 7 and 8, which show the water potential (expressed as relative humidity) and water content relationship for two of the MCM 5.1 samples. Comparing the change in volumetric water content for each sample as water potential

went from 70% to 20% RH shows the same 'halving'. This result is consistent with the large increase in slopes, inasmuch as an extremely large change in potential with a small change in water content implies that only small pores are being opened up for air movement. Figure 7 (sample MCM 5.1 68.0-69.0) records an unexpected change in the slope at water contents below 2.5% (v/v). This change is likely due to measurement errors encountered with our capacitance type humidity sensor at values less than 5% RH.

Information is unavailable for the other two samples due to controller programming problems encountered during testing. Given the existence of adequate theory (including tortuosity), improved experimental controls should lead to direct quantification of this relationship.

Figure 9, which depicts a typical Θ - Ψ curve for this type of material, is included here for reference. Moisture retention testing of material adjacent to the cores analyzed and reported here is available in previous reports dated January 1991 (MCM series) and August 1992 (PC4 series).

The combination of bidirectional air flow, valving, sensors, and software has resulted in an improved ability to measure slip flow. The regression equations (Tables 1 through 4), with the exception of PC4 - 168.5-169.0, typically exhibited r^2 values of 0.99.

While the slippage factor appears constant (i.e., high r^2 for the linear regression), Ertekin et al.³ pointed out that Klinkenberg's experimental data indicated that the slippage factor increased with increasing pressure. Currently, most workers regard the slippage factor as constant as a function of mean pressure. With more accurate measurement of air flow, this assumption can be tested.

As pointed out by A.T. Corey⁴, air permeability as a function of water content would be a useful tool in developing solutions to aeration, infiltration, and drainage problems. Corey also pointed

³ Ertekin, T., G.R. King, and F.C. Schwerer. 1986. Dynamic gas slippage: A unique dual-mechanism approach to the flow of gas in tight formations. *SPEFE* Feb:43-52.

⁴ Corey, A.T. 1986. Air permeability. Chapter 48. In *Methods of Soil Analysis, Part 1*, Agronomy Monograph #9 (2nd ed).

out that no tool has yet been developed for routine measurements of air permeability. Given the importance of vapor phase movement in environmental modeling and remediation efforts in Los Alamos and elsewhere, this methodology will contribute to our understanding of unsaturated zone processes.

Given the novel experimental design of the device and the preliminary nature of the research, we cannot yet guarantee that these results are fully representative of the undisturbed materials at the field site, nor can we assume any responsibility for interpretations or analyses based on this data. We recommend that careful evaluation of these laboratory results be made for your particular application.

**TABLE 1. INTRINSIC PERMEABILITY (SLOPE AND INTERCEPT) AND
ITS RELATIONSHIP TO VOLUMETRIC WATER CONTENT
SAMPLE MCM 5.1 68.0-69.0**

VOLUMETRIC WATER CONTENT θ (% v/v)	INTERCEPT	SLOPE	r^2
	INTRINSIC PERMEABILITY k (darcies)	KLINKENBERG CONSTANT b	
33.79	7.146	0.274	0.367
31.71	7.391	2.649	0.996
29.78	7.503	4.393	0.999
27.83	7.884	5.991	0.999
25.79	8.745	7.376	0.998
23.82	9.393	8.906	0.995
21.79	10.085	10.364	0.992
19.85	10.444	12.206	0.991
17.70	10.839	12.565	0.987
15.89	11.054	13.844	0.987
13.82	10.934	14.943	0.984
11.85	10.807	15.631	0.984
9.89	10.924	15.993	0.983
7.90	10.865	16.361	0.979
5.88	10.628	16.763	0.979
3.91	10.123	17.364	0.980
1.96	10.341	17.318	0.980

**TABLE 2. INTRINSIC PERMEABILITY (SLOPE AND INTERCEPT) AND
ITS RELATIONSHIP TO VOLUMETRIC WATER CONTENT
SAMPLE MCM 5.1 73.0-74.0**

VOLUMETRIC WATER CONTENT θ (% v/v)	INTERCEPT	SLOPE	r^2
	INTRINSIC PERMEABILITY k (darcies)	KLINKENBERG CONSTANT b	
43.47	3.710	-0.683	0.92
41.56	5.108	-0.780	0.77
39.47	5.127	0.109	--
37.43	5.327	1.059	0.92
35.37	5.612	1.946	0.97
33.30	5.880	2.933	0.99
31.24	6.101	3.935	0.99
29.27	6.404	4.808	0.99
27.21	6.896	5.496	0.99
25.19	7.221	6.173	0.99
23.03	7.618	6.741	0.99
21.06	7.940	7.184	0.99
18.95	8.066	7.557	0.99
16.91	8.080	7.928	0.99
14.84	8.101	8.188	0.99
12.82	8.312	8.248	0.99
10.76	8.156	8.447	0.99
8.72	8.327	8.436	0.99
6.66	8.392	8.521	0.99
4.57	8.439	8.574	0.99
2.60	8.292	8.835	0.99
0.58	8.425	9.287	0.99

-- Adjusted r^2 value $\leq$ 0.00

**TABLE 3. INTRINSIC PERMEABILITY (SLOPE AND INTERCEPT) AND
ITS RELATIONSHIP TO VOLUMETRIC WATER CONTENT
SAMPLE MCM 5.1 83.0-84.0**

VOLUMETRIC WATER CONTENT θ (% v/v)	INTERCEPT	SLOPE	r^2
	INTRINSIC PERMEABILITY k (darcies)	KLINKENBERG CONSTANT b	
41.67	1.20	2.37	0.999
40.75	1.20	2.63	0.999
39.85	1.18	2.81	0.999
38.98	1.23	2.91	0.999
38.06	1.17	3.11	0.999
37.12	1.15	3.29	0.997
36.25	1.20	3.41	0.997
35.33	1.26	3.52	0.997
34.47	1.30	3.63	0.996
33.54	1.30	3.77	0.996
32.68	1.34	3.87	0.995
31.76	1.32	4.04	0.996
30.84	1.33	4.18	0.994
29.98	1.33	4.27	0.994
29.06	1.41	4.36	0.992
28.14	1.45	4.44	0.992
27.27	1.42	4.58	0.993
26.35	1.42	4.67	0.992
25.49	1.44	4.75	0.992
24.56	1.46	4.87	0.992
23.65	1.39	4.95	0.991
22.80	1.46	4.96	0.990
21.90	1.41	5.05	0.989

**TABLE 3. INTRINSIC PERMEABILITY (SLOPE AND INTERCEPT) AND
ITS RELATIONSHIP TO VOLUMETRIC WATER CONTENT (CONTINUED)
SAMPLE MCM 5.1 83.0-84.0**

VOLUMETRIC WATER CONTENT θ (% v/v)	INTERCEPT	SLOPE	r^2
	INTRINSIC PERMEABILITY k (darcies)	KLINKENBERG CONSTANT b	
20.98	1.39	5.12	0.988
20.11	1.43	5.15	0.988
19.21	1.47	5.16	0.991
18.30	1.44	5.23	0.989
17.36	1.35	5.33	0.988
16.49	1.26	5.42	0.989
15.57	1.24	5.44	0.988
14.71	1.40	5.33	0.989
13.79	1.30	5.42	0.986
12.91	1.33	5.40	0.986
12.03	1.43	5.34	0.990
11.11	1.44	5.33	0.987
10.20	1.27	5.48	0.986
9.35	1.38	5.38	0.987
8.43	1.37	5.37	0.988
7.54	1.31	5.43	0.988
6.62	1.48	5.33	0.988
5.76	1.41	5.40	0.987
4.84	1.40	5.41	0.985
3.93	1.37	5.47	0.987
3.03	1.34	5.48	0.988
2.16	1.30	5.55	0.988
1.26	1.82	5.14	0.990

**TABLE 4. INTRINSIC PERMEABILITY (SLOPE AND INTERCEPT) AND
ITS RELATIONSHIP TO VOLUMETRIC WATER CONTENT
SAMPLE PC4 168.5-169.0**

VOLUMETRIC WATER CONTENT θ (% v/v)	INTERCEPT	SLOPE	r^2
	INTRINSIC PERMEABILITY k (darcies)	KLINKENBERG CONSTANT b	
32.29	1.57	-0.08	--
32.03	3.52	-0.49	0.449
31.77	4.01	-0.31	0.139
31.51	4.35	0.05	--
31.22	4.06	0.66	0.456
30.96	4.09	0.99	0.799
30.68	3.66	1.68	0.977
30.40	3.25	2.27	0.995
30.13	2.94	2.77	0.997
29.84	2.62	3.28	0.990
29.58	2.32	3.71	0.994
29.30	1.97	4.18	0.985
29.02	1.88	4.44	0.971
28.74	1.52	4.88	0.974
28.45	1.22	5.26	0.963
28.18	0.95	5.61	0.968
27.91	0.74	5.96	0.952
27.63	0.65	6.18	0.952
27.36	0.39	6.51	0.945
27.08	0.24	6.73	0.939
26.79	0.00	7.08	0.941
26.51	-0.32	7.40	0.935

-- Adjusted r^2 value ≤ 0.00

**TABLE 4. INTRINSIC PERMEABILITY (SLOPE AND INTERCEPT) AND
ITS RELATIONSHIP TO VOLUMETRIC WATER CONTENT (CONTINUED)
SAMPLE PC4 168.5-169.0**

VOLUMETRIC WATER CONTENT θ (% v/v)	INTERCEPT	SLOPE	r^2
	INTRINSIC PERMEABILITY k (darcies)	KLINKENBERG CONSTANT b	
26.24	0.06	7.25	0.934
25.95	-0.14	7.44	0.940
25.69	-0.65	7.94	0.930
25.41	-0.80	8.17	0.919
25.12	-0.95	8.46	0.906
24.85	-0.95	8.50	0.925
24.57	-1.07	8.73	0.928
24.28	-0.76	8.50	0.894
24.02	-1.32	9.03	0.912
23.74	-1.29	9.11	0.903
23.46	-1.10	9.15	0.896
23.18	-1.28	9.31	0.914
22.90	-1.38	9.48	0.901
22.63	-1.64	9.78	0.885
22.35	-1.76	9.90	0.879
22.07	-2.04	10.21	0.886
21.80	-2.48	10.69	0.879
21.52	-1.79	10.24	0.869
21.23	-2.50	10.83	0.868
20.96	-3.01	11.32	0.869
20.68	-2.67	11.07	0.854
20.40	-3.07	11.51	0.850
20.12	-2.87	11.46	0.866
19.85	0.78	8.43	0.895

Valve Configuration Notes

N.O. = Normally Open Valve Port
(Closes when valve is actuated)

N.C. = Normally Closed Valve Port
(Opens when valve is actuated)

IN. = Inlet Valve Port
(Always Open)

Vapor Equilibrium System (VES) Schematic

Figure 1

Sample No. MCM 5.1 68.0-69.0
Apparent And Intrinsic Permeability
vs. Water Content

Figure 2

Sample No. MCM 5.1 68.0-69.0
 Permeability vs. Mean Pressure
 $\Delta\Theta \approx 2.0\% \text{ (v/v)}$

Figure 3

Sample No. MCM 5.1 73.0-74.0
 Permeability vs. Mean Pressure
 $\Delta\theta \approx 2.0\%$ (v/v)

Figure 4

Sample No. PC4 83.0-84.0
 Permeability vs. Mean Pressure
 $\Delta\Theta \approx 1.00\%$ (v/v)

Figure 5

Sample No. PC4 168.5-169.0
 Permeability vs. Mean Pressure
 $\Delta\Theta \approx 0.3\% \text{ (v/v)}$

Figure 6

Sample No. MCM 5.1 68.0-69.0
Relative Humidity vs. Water Content

Figure 7

Sample No. MCM 5.1 73.0-74.0
Relative Humidity vs. Water Content

Figure 8

Sample No. MCM 5.1 67.0-67.5
Pressure Head vs. Moisture Content

Figure 9