DRAFT

Subsurface Conditions Data Report
North Safety Area
Third Runway Embankment
Sea-Tac International Airport

HARTCROWSER
Delivering smarter solutions

Prepared for
Port of Seattle and
HNTB

March 20, 2000
J-4978-18

CONTENTS

TABLES

FIGURES

CONTENTS (Continued)

FIGURES

CONTENTS (Continued)

Page

FIGURES (Continued)

APPENDIX B
LABORATORY TESTING PROGRAM

FIGURES

SUBSURFACE CONDITIONS DATA REPORT
NORTH SAFETY AREA
THIRD RUNWAY EMBANKMENT
SEA-TAC INTERNATIONAL AIRPORT

INTRODUCTION

This data report presents information on subsurface conditions, based on geotechnical and hydrogeologic field testing and laboratory testing to support the North Safety Area (NSA) construction for the Third Runway Embankment Project at the Sea-Tac International Airport.

The site is located at the Sea-Tac International Airport, in SeaTac, Washington (refer to Figure 1, Vicinity Map). The shaded area on Figure 1 is presented on Figure 2, Site and Exploration Plan, showing exploration locations both for this report and those performed previously by Hart Crowser and others. Cross sections showing inferred geologic conditions are provided on Figures 3 and 4. Figure 5 shows "wet season" or winter, groundwater elevation contours for the Shallow Regional Aquifer. Late summer or "dry season" groundwater elevation contours are shown in the Phase 3 Fill Subsurface Conditions Data Report (Hart Crowser, 1999c).

This report discusses the subsurface soil conditions in the North Safety Area followed by a discussion of the hydrogeologic conditions. Appendices A and B follow the main text and present results of our subsurface explorations and laboratory testing, respectively.

PURPOSE AND SCOPE

The purpose of this report is to provide information on subsurface soil and groundwater conditions affecting construction in the NSA. Proposed construction in this area includes the Third Runway embankment, retaining wall, and relocation of South 156th Street. Additional information in other reports is listed in the references at the end of this report. The information presented herein provides the basis for our geotechnical engineering analyses and recommendations.

Information presented herein was obtained in general accordance with Task 5.0—Explorations and Tests, presented in our proposal dated August 23, 1999, and subsequent modification.

GENERALIZED GEOLOGIC DESCRIPTION AND SUBSURFACE SOIL CONDITIONS

This section provides a description of the geologic and subsurface soil conditions within the North Safety Area (NSA), shown on Figure 2, based on Hart Crowser's explorations at the site and explorations by others.

Generalized Geologic Conditions

Generalized geologic conditions in the project area have been described in the Preliminary Engineering Report, Volume 2 (Applied Geotechnology Inc., 1994). The following is a summary of the geologic units identified at the Third Runway project site:

- Fill (loose to medium dense, locally dense, variably graded, silt, sand, and gravel);
- Alluvium (primarily soft to stiff peat, clay, and silt; and very loose to medium dense, fine to medium sand);
- Recessional Outwash (primarily loose to dense, silty sand and gravel, and/or medium stiff to hard, sandy silt and/or sandy clay);
- Glacial Till (dense to very dense, silty sand and gravel, and hard sandy silt);
- Advance Outwash (dense to very dense, non-silty to silty sand and gravel); and
- Lawton Clay (very stiff to hard silt and clay).

Subsurface Conditions

Subsurface soil conditions interpreted from materials encountered in explorations at the site and soil properties inferred from laboratory tests formed the basis for the information contained in this report. Variations between explorations occur due to the variability in gradation, moisture content, and density/consistency of soils at the site. The nature and extent of these variations may not become evident until construction. If variations become evident, it will be necessary to re-evaluate our interpretation of the soil conditions at the site, as well as any recommendations based on those interpretations.

Generalized subsurface conditions in the area are shown on Cross Sections 105+20 and 110+47, Figures 3 and 4, respectively. The following soil materials were observed in this area.

Soft Organic Clay and Loose, Silty Sand with Organics (PEAT). Two borings (HC99-B42 and HC99-B48) encountered peat in the upper 2-1/2 to 3 feet of the explorations. These two borings are located on or within 35 feet of Miller Creek. Other explorations nearby and to the northwest have also encountered peat, sometimes up to 10 feet or more in thickness. Figure 2 indicates the general region where peat is inferred to be present.

Soft to Stiff, Slightly Gravelly, Slightly Sandy to Sandy CLAY, and Slightly Sandy, Slightly Silty to Very Silty CLAY. Clay was encountered at depths ranging from about 4 to 10 feet from the ground surface. These soil units range from about 4 to 8 feet in thickness, and are mainly located in the northern region of the area, adjacent to Miller Creek.

Medium Stiff to Hard, Gravelly, Slightly Sandy to Sandy, Clayey SILT, Sandy SILT, and Slightly Gravelly, Sandy to Very Sandy SILT. These materials were encountered in the majority of the explorations in the area. Shallow deposit depths ranged from about 1 to 6 feet, and deeper layers were encountered at depths of about 10 to 30 feet.

Medium Dense to Very Dense, Slightly Gravelly to Gravelly, Slightly Silty to Very Silty SAND. These soils have been inferred to be the primary unit underlying the soils described above. The top of these soils extend from depths of less than 10 feet to more than 40 feet in the majority of the borings performed for this study.

Summary of Results from Laboratory Tests

Tables 1 through 4 summarize the parameters determined from tests performed on specimens taken from Shelby tube samples obtained during drilling. The samples within the Shelby tubes were extruded and prepared for assigned laboratory tests in general accordance with the applicable ASTM standards as discussed in Appendix B.

Hydrogeologic Conditions

Groundwater Occurrence

Groundwater was typically encountered in the borings that were advanced during this phase of work. The water levels observed in the open borings at the time of drilling (ATD) and subsequent to monitoring well installation and development are shown on the boring logs (Appendix A). Heaving conditions

were encountered at depth in the sands during drilling in HC99-B42 and HC99-B48.

Groundwater Monitoring

With the addition of 14 new wells, groundwater elevation data are now being collected monthly from 34 wells in the NSA. These data indicate seasonal changes in groundwater elevation and flow pattern in the NSA. Available data are compiled and presented in Table 5. Since regular monitoring began in March 1999, seasonal groundwater elevation fluctuations of 2 to 3 feet have typically been observed, with the seasonal low level typically observed in September or October, and high water level observed in March and early April.

Groundwater Flow Mapping

Shallow groundwater elevations observed in December 1999 are contoured on Figure 5. These groundwater levels represent early wet season conditions, with elevations that are typically about 0.5 to 1.5 feet above the dry season lows observed around October 1999.

Groundwater flow patterns appear to be generally unchanged by seasonal water level variations, with flow generally toward Miller Creek from the higher ground of the airport. This is consistent with conceptual models of local hydrogeology (Applied Geotechnology Inc., 1996), where recharge occurs on the higher ground of the airport, and water moves down into the Shallow Regional Aquifer before discharging to the creek. Artesian conditions observed in some wells (e.g., HC99-B43A) indicate an upward hydraulic gradient, consistent with the regional discharge of groundwater to the creek drainage basin, and the effects of local interbedding of more and less permeable soil units.

The pattern of groundwater flow is broadly consistent with the implied occurrence of significant recharge beneath the existing airport. Not all water levels are necessarily reflective of conditions in the Shallow Regional Aquifer, since perched zones occur above the main water table.

Hydraulic Conductivity Testing

Hydraulic conductivity testing was performed in seven monitoring wells in the NSA. The slug test method was used to test wells HC99-B44, HC99-B48, HC99-B50 through HC99-B52, HC99-B54, and HC99-B57. The locations of these wells are shown on Figures 2 and 5. Hydraulic conductivity test results are summarized in Table 6, and plots of the slug test results are presented in Appendix B. Test results in Table 6 are tabulated based on the general material

type observed within the screened interval of the wells. Three of the wells tested (HC99-B48, HC99-B52, and HC99-B57) are screened in medium dense to dense, shallow sands, and the geometric mean hydraulic conductivity for the tests on these materials was 2×10^{-3} cm/sec. Three of the wells (HC99-B44, HC99-B50, and HC99-B51) were screened in till-like soils, which have a geometric mean hydraulic conductivity of 2×10^{-4} cm/sec. The results for these three samples are very similar to previous test results (Hart Crowser, 1999b) which had a geometric mean hydraulic conductivity of 1.8×10^{-4} cm/sec for wells completed in similar materials. Monitoring well HC99-B54 was screened in a sandy silt, which had an estimated hydraulic conductivity of 3×10^{-5} cm/sec.

USE OF THIS REPORT

This report has been prepared for the exclusive use of HNTB and the Port of Seattle, for the site and project described herein. We completed this work according to generally accepted geotechnical engineering practices in the same or similar localities, related to the nature of the work accomplished, at the time the services were accomplished. We make no other warranty, express or implied.

Hart Crowser appreciates the opportunity to provide this information. Please call if you have any questions.

Sincerely,

HART CROWSER, INC.

JOSEPHA D. CELES, E.I.T.
Staff Geotechnical Engineer

JAMES R. BEAVER, E.I.T.
Project Geotechnical Engineer

MICHAEL J. BAILEY, P.E.
Project Manager

F:\docs\jobs\497818\NorthSafety(rpt).doc

REFERENCES

Applied Geotechnology, Inc., 1994. First Draft: Seattle-Tacoma International Airport Third Dependent Runway Preliminary Engineering Report, Volume 2, March 31, 1994.

Applied Geotechnology, Inc., 1996. Appendix Q-A: Baseline Groundwater Study, Final Environmental Impact Statement, Proposed Master Plan Update, Sea-Tac International Airport, SeaTac, Washington, January 3, 1996.

CivilTech Corporation, 1997. Geotechnical Report: South 154th St./156th Way Relocation, SeaTac International Airport, SeaTac, Washington, October 27, 1997.

Hart Crowser, 1999a. Draft Memorandum: Additional Explorations, Watermain Relocation Project, Sea-Tac International Airport, SeaTac, Washington, June 23, 1999.

Hart Crowser, 1999b. Subsurface Conditions Data Report, 404 Permit Support, Third Runway Embankment, Sea-Tac International Airport, SeaTac, Washington, July 9, 1999.

Hart Crowser, 1999c. Subsurface Conditions Data Report, Phase 3 Fill, Third Runway Embankment, Sea-Tac Airport Third Runway, November 12, 1999.

HWA GeoSciences Inc., 1998. Geotechnical and Dewatering Evaluation - Miller Creek Relocation, prepared for Parametrix, Inc.

F:\docs\jobs\497818\NorthSafety(rpt).doc

Key to Tables 1 through 4

Symbol	Description
w_n	Natural Moisture Content in Percent
γ_T	Total Unit Weight in pcf
σ_{vo}'	Initial Effective Vertical Stress in ksf
σ_p'	Past Effective Vertical Stress in ksf
σ_c'	Confining Stress in ksf
$\sigma_1 - \sigma_3$	Principal Stress Difference (or axial stress) in ksf
c'	Cohesion Intercept (based on effective stresses) in psf
ϕ'	Effective Friction Angle in Degrees
ϕ_{ave}'	Average Effective Friction Angle in Degrees
OCR	Overconsolidation Ratio
C_c	Compression Index
C_r	Recompression Index
e_0	Initial Void Ratio
c_v	Coefficient of Consolidation in ft^2/day
E_{50}	Modulus of Elasticity (determined at 50% of Peak Strength) in ksf
LL	Liquid Limit in Percent
PI	Plasticity Index in Percent
s_u	Undrained Shear Strength in psf

Table 1 - Summary of Consolidation Test Results

Boring Number	Sample Number	Depth in Feet	Soil Description	w_n %	γ_T pcf	σ_{v0}' ksf	σ_p' ksf	OCR	C_c	C_r	e_0	c_v at σ_p' ft²/day
HC99-B44	S-3	7 to 8.8	Soft, clayey, very silty SAND	15	139.0	0.9	1.9	2.1	9.57E-02	5.74E-03	0.367	2.6
HC99-B54A	S-1A	6.5 to 8.5	Soft CLAY	39	112	0.8	3.4	4.0	3.47E-01	9.59E-04	1.04	2.1
HC00-B167	S-3	10.5 to 11.5	Soft SILT	14	137	1.3	1.2	1.0	8.27E-02	7.58E-03	0.378	2.5
HC00-B165A	S-2A	9.5 to 11.5	Medium stiff CLAY	33	121	1.2	6	4.9	1.82E-01	2.58E-02	0.817	2.7
HC00-B163	S-6	15.5 to 16.3	Stiff CLAY	21	131	1.9	2.4	1.2	1.06E-01	1.44E-02	0.517	0.85
HC00-B164	S-4	7.5 to 10	Stiff CLAY	22	128	0.9	7	7.5	2.05E-01	2.24E-02	0.575	2.4
HC00-B169	S-5	15.5 to 16.8	Hard SILT	21	130	1.4	3.8	2.8	9.19E-02	7.20E-03	0.531	2.2

Table 2 - Summary of Isotropically Consolidated Undrained (CU) Triaxial Compression Test Results

Boring Number	Sample Number	Depth in Feet	Soil Description	w_n %	γ_T pcf	σ_c' ksf	$\sigma_1 - \sigma_3$ ksf	ϕ' deg	ϕ_{ave}' deg	E_{50} ksf	$\sigma_1 - \sigma_3/\sigma_c'$	E_{50}/σ_c'
HC99-B50	S-4	9.5 to 12	Soft CLAY	26.1	133.9	4.0	3.0	33.2		101.4	0.760	25.3
				30.2	122.0	8.0	3.9	33.2	34.3	653.1	0.490	81.6
				32.6	124.3	12.0	4.6	36.4		766.3	0.383	63.9
HC99-B52	S-4	9.5 to 12	Medium stiff CLAY	16.8	138.7	4.0	4.4	35.0		211.0	1.108	52.7
				16.8	138.7	7.0	5.6	34.4	34.6	928.3	0.796	132.6
				16.8	138.7	10.0	6.6	34.3		1104.2	0.663	110.4
HC99-B58	S-3	7 to 9	Medium stiff, sandy, very silty CLAY	23.7	131.4	4.0	3.4	35.5		340.7	0.852	85.2
				23.1	130.8	7.0	3.8	35.8	34.7	627.0	0.537	89.6
				23.1	130.8	10.0	4.1	32.9		682.7	0.410	68.3
HC00-B161	S-3	10.5 to 12.5	Medium stiff, sandy CLAY	21.8	129.4	4.0	3.2	36.5		1052.0	0.789	263.0
				18.4	133.2	7.0	3.8	34.6	35.3	635.7	0.545	90.8
				19.0	133.8	10.0	5.1	34.8		1699.9	0.510	170.0
HC00-B163	S-2/3	6 to 7.7 (S-2)	Stiff, sandy CLAY	29.7	121.6	4.0	4.0	35.8		398.1	0.995	99.5
		8 to 10 (S-3)		22.2	129.8	7.0	5.1	35.6	35.2	1272.3	0.727	181.8
				22.6	122.6	10.0	5.5	34.3		2186.1	0.547	218.6
HC00-B164	S-3	5 to 7.5	Stiff CLAY	23.6	123.6	4.0	4.7	32.9		517.9	1.165	129.5
				23.9	123.9	7.0	6.3	34.1	33.9	963.0	0.894	137.6
				21.4	129.0	10.0	7.4	34.8		1236.6	0.742	123.7
HC00-B175	S-3	10.5 to 12.5	Stiff CLAY	20.3	135.3	6.0	7.4	33.7		351.8	1.231	58.6
				17.9	140.0	9.0	6.4	33.7	33.7	1065.9	0.711	118.4
				19.4	134.3	12.0	6.4	33.7		2117.9	0.529	176.5

Table 3 - Summary of Unconsolidated Undrained (UU) Triaxial Compression Test Results

Boring Number	Sample Number	Depth in Feet	Soil Description	w_n %	γ_T pcf	LL %	PI %	s_u psf
HC00-B165A	S-2A	9.5 to 11.5	Medium stiff CLAY	31.9	148.3	31	11	1166
HC00-B172	S-3	10.5 to 12.5	Stiff CLAY	14.9	129.2	21	8	1038
HC00-B160	S-4	10 to 12.5	Hard CLAY	16.9	131.5	26	9	3072
HC00-B169	S-5	15.5 to 16.8	Hard SILT	20.7	135.8	28	5	3710
HC00-B170	S-5	20.5 to 21.5	Hard CLAY	22.6	137.9	35	13	5361
HC00-B169	S-3	10.5 to 12.5	Dense, slightly clayey, slightly gravelly, silty SAND	11.9	125.9	n/a	n/a	1511

Table 4 - Summary of Direct Shear Test Results

Boring Number	Sample Number	Depth in Feet	Soil Description	w_n %	γ_T pcf	c' psf	ϕ' deg	ϕ_{ave}' deg
HC99-B54A	S-1A	6.5 to 8.5	soft CLAY	32.9	118.8	0.0	30.8	
				32.7	116.2	0.0	29.3	29.8
				31.4	116.7	0.0	29.2	
HC99-B64	S-5	11.5 to 13	medium stiff, silty CLAY	15.3	134.4	0.0	31.1	
				13.9	137.6	0.0	29.3	29.1
				14.4	136.0	0.0	26.9	

Table 5 - Water Level Data

	AT96-B1		AT96A-B8		AT96A-B10		AT97-B41		AT97-B42		AT97-B57		AT97-B69	
	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Measuring Point	0.00	*407.7*	0.00	*412.7*	0.00	*319.7*	0.00	*312.2*	0.00	*325.2*	0.00	*235.7*	0.00	*337.2*
Ground Level*	*-0.3*	*408*	*-0.3*	*413*	*-0.3*	*320*	3.2	*309*	3.2	*322*	*-0.3*	*236*	3.2	*334*
Top of Screen*	*77.7*	*330*	*49.7*	*363*	*23.7*	*296*	*81.2*	*231*	*22.7*	*303*	*13*	*395*	*27.7*	*310*
Bottom of Screen*	*87.7*	*320*	*60.7*	*352*	*33.7*	*286*	*83.2*	*229*	*27.7*	*298*	*23*	*385*	*29.7*	*308*
Date: 3/8/1999	-	-	-	-	-	-	Flowing	>312	21.21	303.94	-	-	-	-
3/10/1999	dry	dry	-	-	8.15	311.55	-	-	-	-			6.18	331.02
4/5/1999	dry	dry	-	-	8.11	311.59	Flowing	>312	21.59	303.56	-	-	6.59	330.61
5/4/1999	dry	dry	-	-	8.35	311.35	0.91	311.24	22.17	302.98	-	-	7.43	329.77
5/15/1999	-	-	-	-	-	-	-	-	22.22	302.93			-	-
6/14/1999	dry	dry	47.86	364.84	8.74	310.96	1.27	310.88	22.58	302.57	2.11	233.59	8.08	329.12
7/13/1999	dry	dry	48.87	363.83	8.81	310.89	1.41	310.74	Abandoned		-	-	8.41	328.79
8/13/1999	dry	dry	48.10	364.60	9.06	310.64	1.57	310.58	Abandoned		3.10	232.60	8.83	328.37
9/14/1999	dry	dry	48.26	364.44	9.44	310.26	1.73	310.42	Abandoned		3.61	232.09	9.16	328.04
10/13/1999	dry	dry	48.49	364.21	9.74	309.96	1.77	310.38	Abandoned		3.72	231.98	9.12	328.08
11/11/1999	87.88	319.82	48.75	363.95	10.00	309.70	1.52	310.63	Abandoned		-	-	8.13	329.07
12/9/1999	dry	dry	48.88	363.82	9.50	310.20	0.72	311.43	Abandoned		-	-	6.80	330.40

Italics = Estimated
Depth* All depths are below measuring point (NOT below the ground surface)
- Indicates data not available.

Table 5 - Water Level Data

	HC99-B31		HC99-B32		HC99-B33		HC99-B34		HC99-B35		HC99-B36		HC99-B41	
	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Measuring Point	0.00	266.24	0.00	266.29	0.00	265.65	0.00	267.63	0.00	294.58	0.00	275.03	0.00	330.8
Ground Level*	2.5	263.7	3.1	263.2	2.9	262.8	2.4	265.2	2.0	292.6	2.4	272.6	3	328
Top of Screen*	17.5	248.7	13.1	253.2	11.9	253.8	7.4	260.2	15.0	279.6	6.4	268.6	28	302.8
Bottom of Screen*	27.5	238.7	23.1	243.2	21.9	243.8	17.4	250.2	25.0	269.6	10.4	264.6	38	292.8
Date: 3/8/1999	2.38	263.86	3.55	262.74	2.71	262.94	4.72	262.91	4.69	289.89	4.73	270.30	31.87	308.86
3/10/1999													-	-
4/5/1999	2.41	263.83	3.51	262.78	2.64	263.01	4.68	262.95	5.13	289.45	5.01	270.02	32.57	308.16
5/4/1999	2.58	263.66	4.14	262.15	3.19	262.46	5.44	262.19	5.58	289.00	5.83	269.20	33.17	307.56
5/15/1999													33.24	307.49
6/14/1999	2.93	263.31	4.75	261.54	2.61	263.04	5.88	261.75	6.48	288.10	6.23	268.80	33.56	307.17
7/13/1999	2.98	263.26	4.83	261.46	3.72	261.93	5.86	261.77	6.79	287.79	6.42	268.61	33.77	306.96
8/13/1999	3.11	263.13	5.05	261.24	3.90	261.75	6.12	261.51	7.29	287.29	6.68	268.35	33.97	306.76
9/14/1999	3.30	262.94	5.21	261.08	4.09	261.56	6.16	261.47	7.76	286.82	7.85	267.18	24.18	306.52
10/13/1999	2.97	263.27	4.77	261.52	3.70	261.95	5.89	261.74	7.79	286.79	6.91	268.12	24.29	306.53
11/11/1999	2.23	264.01	3.02	263.27	2.90	262.75	4.32	263.31	6.40	288.18	5.60	269.43	24.00	306.82
12/9/1999	2.19	264.05	3.08	263.21	1.44	264.21	4.35	263.28	Destroyed		4.29	270.74	23.06	307.76

Table 5 - Water Level Data

	HC99-B43A		HC99-B44		HC99-B45		HC99-B46		HC99-B47		HC99-B48		HC99-B50	
	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Measuring Point	0.00	295.58	0.00	286.95	0.00	285.29	0.00	332.93	0.00	281.22	0.00	281.14	0.00	288.04
Ground Level*	*3*	*293*	2.6	284.3	3.1	282.2	2.1	330.8	2.4	278.8	2.4	278.7	2.7	285.4
Top of Screen*	27.0	268.6	42.7	244.3	8.1	277.2	30.1	302.8	7.4	273.8	9.9	271.2	15.7	272.4
Bottom of Screen*	37.0	258.6	52.7	234.3	13.1	272.2	40.1	292.8	12.4	268.8	14.9	266.2	20.7	267.4
Date: 3/8/1999	–	–	–	–	6.70	278.59	22.01	310.81	–	–	–	–	–	–
3/10/1999	–	–			–	–	–	–	–	–				
4/5/1999	Under Pressure		–	–	7.50	277.79	22.48	310.34	–	–	–	–	–	–
5/4/1999	-10.1	306	–	–	7.93	277.36	23.09	309.73	6.26	274.96	–	–	–	–
5/15/1999	–	–			–	–	–	–	–	–				
6/14/1999	-9.2	304.81	–	–	8.99	276.30	23.75	309.07	7.44	273.78	–	–	–	–
7/13/1999	-9.5	305.04	–	–	9.00	276.29	24.17	308.65	6.99	274.23	–	–	–	–
8/13/1999	-10.4	305.96	–	–	9.43	275.86	24.53	308.29	7.56	273.66	–	–	–	–
9/14/1999	-9.2	304.81	–	–	11.09	274.20	24.84	307.98	9.03	272.19	–	–	–	–
10/13/1999	-9.5	305.04	–	–	9.81	275.48	25.21	307.72	8.59	272.63	–	–	–	–
11/11/1999	-9.7	305.27	–	–	8.38	276.91	25.33	307.60	5.12	276.10	–	–	–	–
12/9/1999	-10.1	305.73	4.85	282.10	6.52	278.77	24.42	308.51	3.48	277.74	4.22	276.92	6.42	281.62

Table 5 - Water Level Data

	HC99-B51		HC99-B52		HC99-B54		HC99-B55		HC99-B56		HC99-B57		HC99-B58	
	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Measuring Point	0.00	278.56	0.00	287.34	0.00	289.07	0.00	300.93	0.00	295.25	0.00	296.08	0.00	293.5
Ground Level*	2.6	275.9	2.8	284.6	2.2	286.9	2.3	298.6	2.5	292.7	1.8	294.3	2.3	291.2
Top of Screen*	15.6	262.9	7.8	279.6	40.2	248.9	12.3	288.6	6.0	289.2	6.8	289.3	6.3	287.2
Bottom of Screen*	20.6	257.9	12.8	274.6	50.2	238.9	17.3	283.6	11.0	284.2	11.8	284.3	8.3	285.2
Date: 3/8/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3/10/1999														
4/5/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5/4/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5/15/1999														
6/14/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7/13/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8/13/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9/14/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10/13/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11/11/1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–
12/9/1999	1.48	277.08	4.92	282.42	5.03	284.04	10.25	290.68	3.66	291.59	2.56	293.52	dry	dry

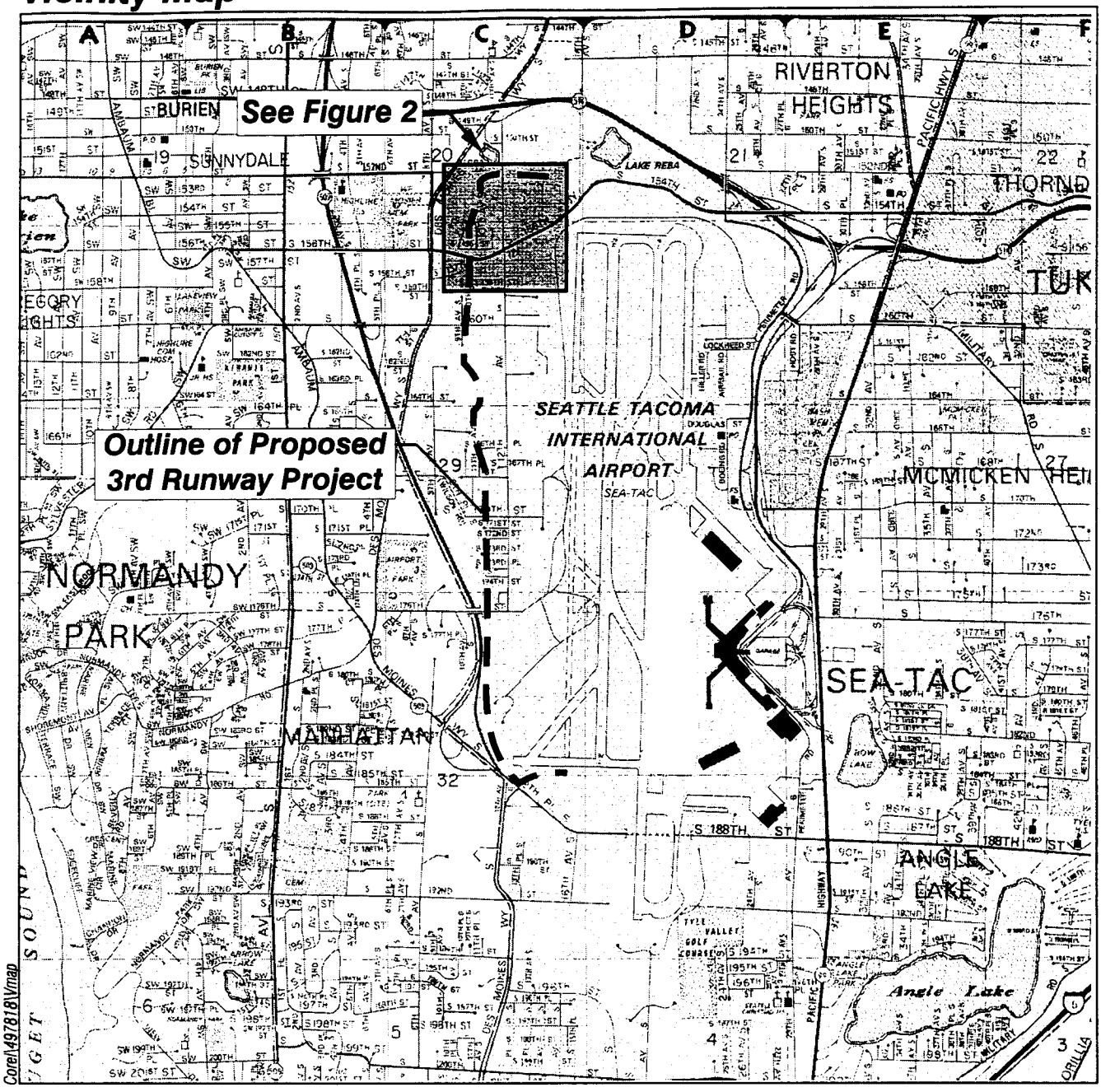
Table 5 - Water Level Data

	HC99-B61		HC99-B64		HC99-B65		HC99-B71		HC99-B72		HC99-B73	
	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet	Depth* in Feet	Elevation in Feet
Measuring Point	0.00	303.94	0.00	294.2	0.00	348.12	0.00	304.46	0.00	383.81	0.00	293.80
Ground Level*	2.1	301.8	2.2	292.0	2.5	345.6	2.5	302.0	2.3	381.6	2.1	291.7
Top of Screen*	9.1	294.8	12.2	282.0	34.5	313.6	9.5	295.0	12.3	371.6	14.1	279.7
Bottom of Screen*	14.1	289.8	17.2	277.0	44.5	303.6	19.5	285.0	17.3	366.6	24.1	269.7
Date: 3/8/1999	–	–	–	–	–	–	–	–	–	–	–	–
3/10/1999					–	–						
4/5/1999	–	–	–	–	–	–	–	–	–	–	–	–
5/4/1999	–	–	–	–	–	–	–	–	–	–	–	–
5/15/1999					–	–						
6/14/1999	–	–	–	–	–	–	–	–	–	–	–	–
7/13/1999	–	–	–	–	–	–	–	–	–	–	–	–
8/13/1999	–	–	–	–	–	–	–	–	–	–	–	–
9/14/1999	–	–	–	–	–	–	–	–	–	–	–	–
10/13/1999	13.30	290.64	–	–	40.23	307.89	14.53	289.93	–	–	10.38	283.42
11/11/1999	13.58	290.36	–	–	40.44	307.68	14.60	289.86	–	–	10.10	283.70
12/9/1999	9.40	294.54	6.87	287.33	39.64	308.48	7.20	297.26	5.35	378.46	5.25	288.55

Table 6 - Summary of Hydraulic Conductivity Estimates

Location	Screen Interval Depth in Feet	Soil Types in Screen Interval	Hydraulic Conductivity in cm/sec
		Shallow Sand	
HC99-B48	7.5 to 12.5	Dense to very dense, gravelly SAND	5×10^{-3}
HC99-B52	5 to 10	Loose to medium dense, slightly gravelly, silty SAND with organics (PEAT)	1×10^{-3}
HC99-B57	5 to 10	Medium dense, slightly gravelly, slightly silty SAND	8×10^{-4}
		Geometric Mean:	2×10^{-3}
		Till-Like Soils	
HC99-B44	40 to 50	Very dense, slightly gravelly, slightly silty SAND	5×10^{-4}
HC99-B50	13 to 18	Medium dense, slightly gravelly, silty SAND	1×10^{-4}
HC99-B51	13 to 18	Very stiff to hard, slightly gravelly, sandy SILT	1×10^{-4}
		Geometric Mean:	2×10^{-4}
		Silt	
HC99-B54	38 to 48	Very stiff to hard, very sandy SILT	3×10^{-5}

Vicinity Map



0 2000 4000

Scale in Feet

N

HARTCROWSER

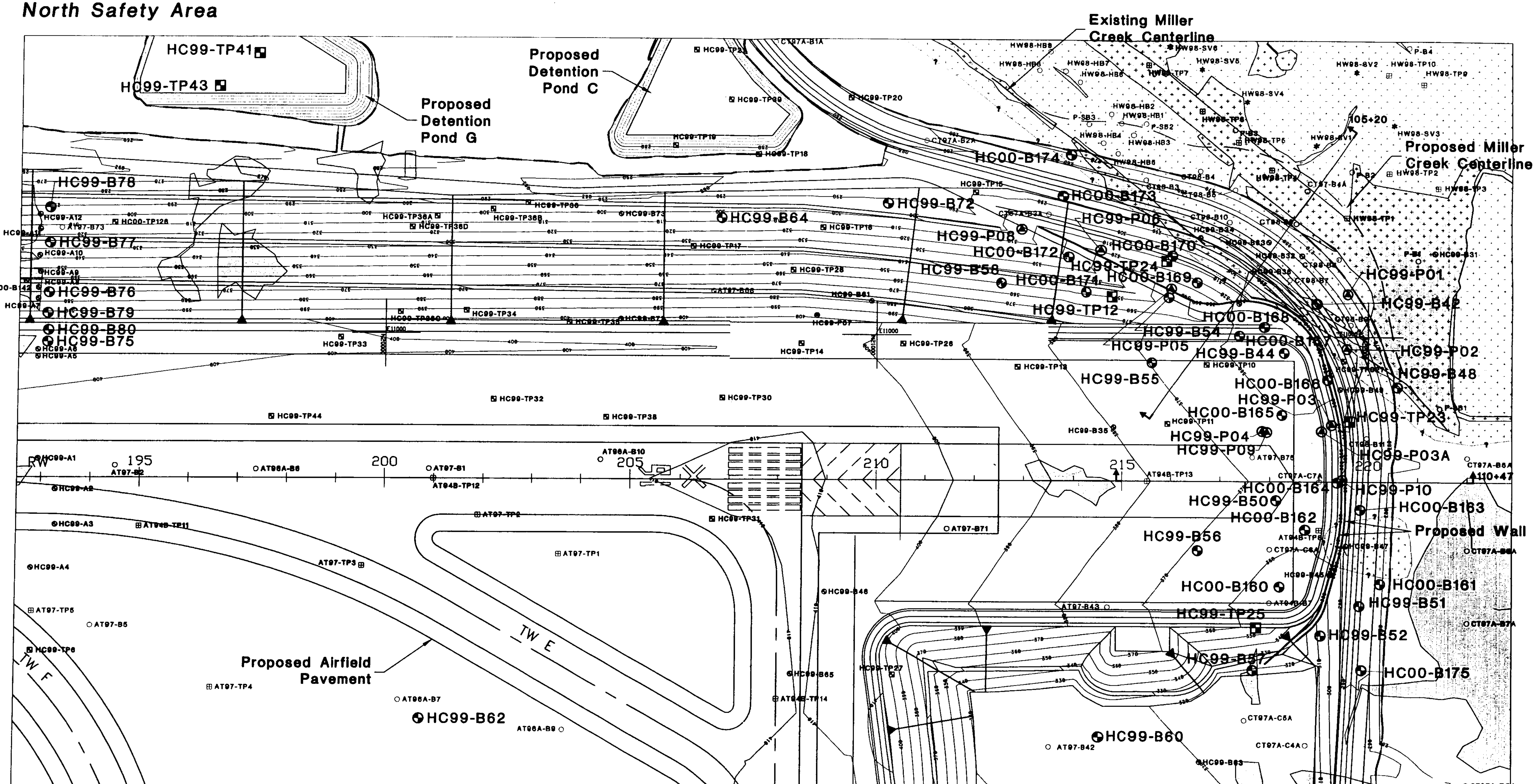
J-4978-18 12/99

Figure 1

AR 044246

Site and Exploration Plan

North Safety Area



Note: Only proposed topography shown. Base map prepared from drawing provided by HNTB entitled, "P_afltopo.dwg", dated February 22, 2000. Wetland delineation prepared from drawing provided by Parametrix entitled, "W_020800.dwg", dated February 8, 2000.

Exploration Location and Number:

HC99-TP24 ◪ Test Pit (Current Study by Hart Crowser)

HC99-B64 ⊕ Monitoring Well (Current Study by Hart Crowser)

HC99-P04 ⊛ Piezocone (Current Study by Hart Crowser)

See references for previous explorations.

105+20 Cross Section Location and Designation

Area of Peat

Wetland Location

— — — Fill Construction Limit

——400—— Proposed Elevation Contour in Feet

Z

0 200 400

Scale in Feet

HARTCROWSER

J-4978-18 3/00

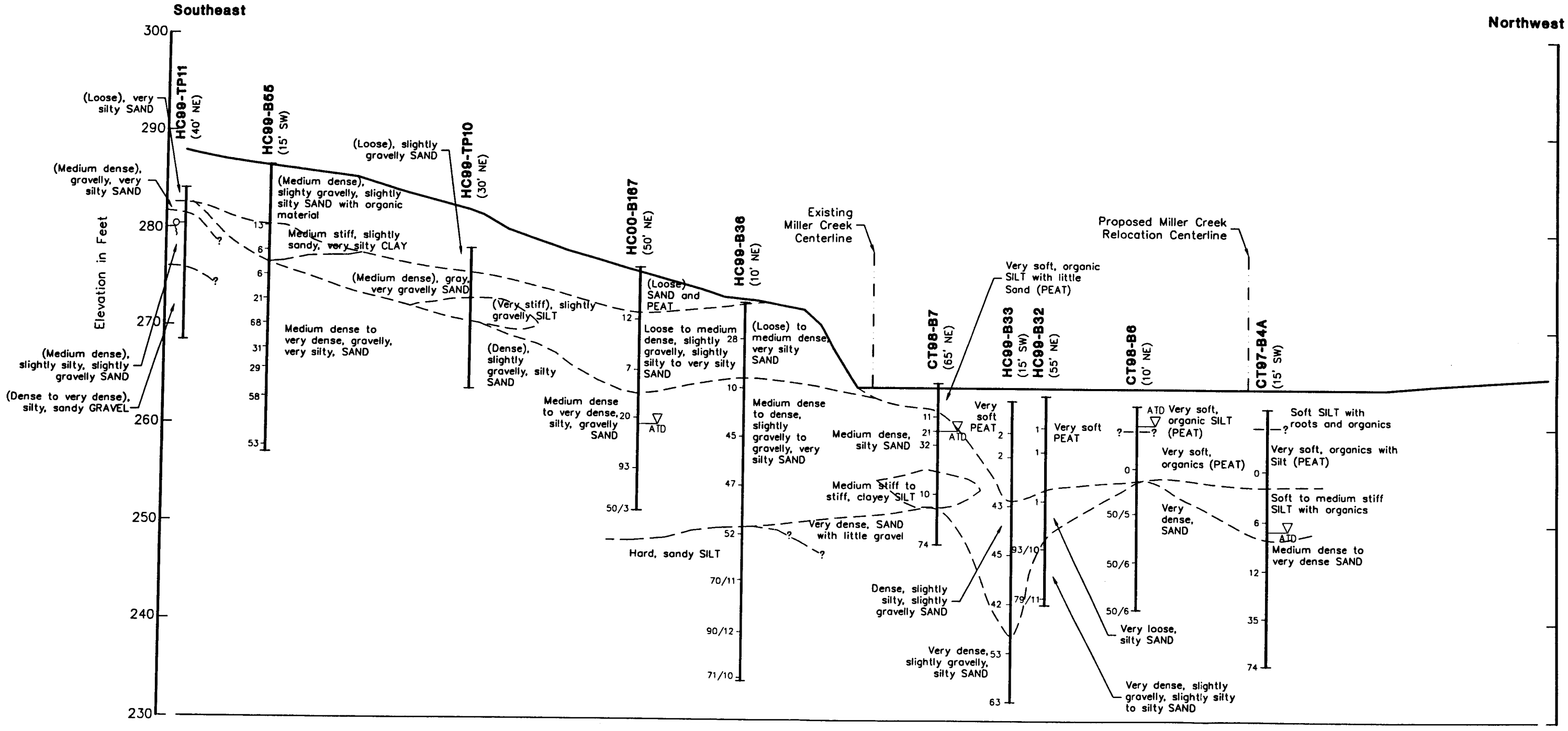
Figure 2

AR 044247

RC 3/20/00 1=200 (xref)see drawing file/woodstck.pc2

4978181 8.dwg

Cross Section 105+20
154th Realignment Stationing



HC99-B55 Exploration Number
(15' SW) (Offset Distance and Direction)

Exploration Location

53 N Value

ATD Water Level

Seep Location

– – – – Inferred Geologic Contact

Horizontal Scale in Feet
0 50 100
0 10 20
Vertical Scale in Feet
Vertical Exaggeration x 5

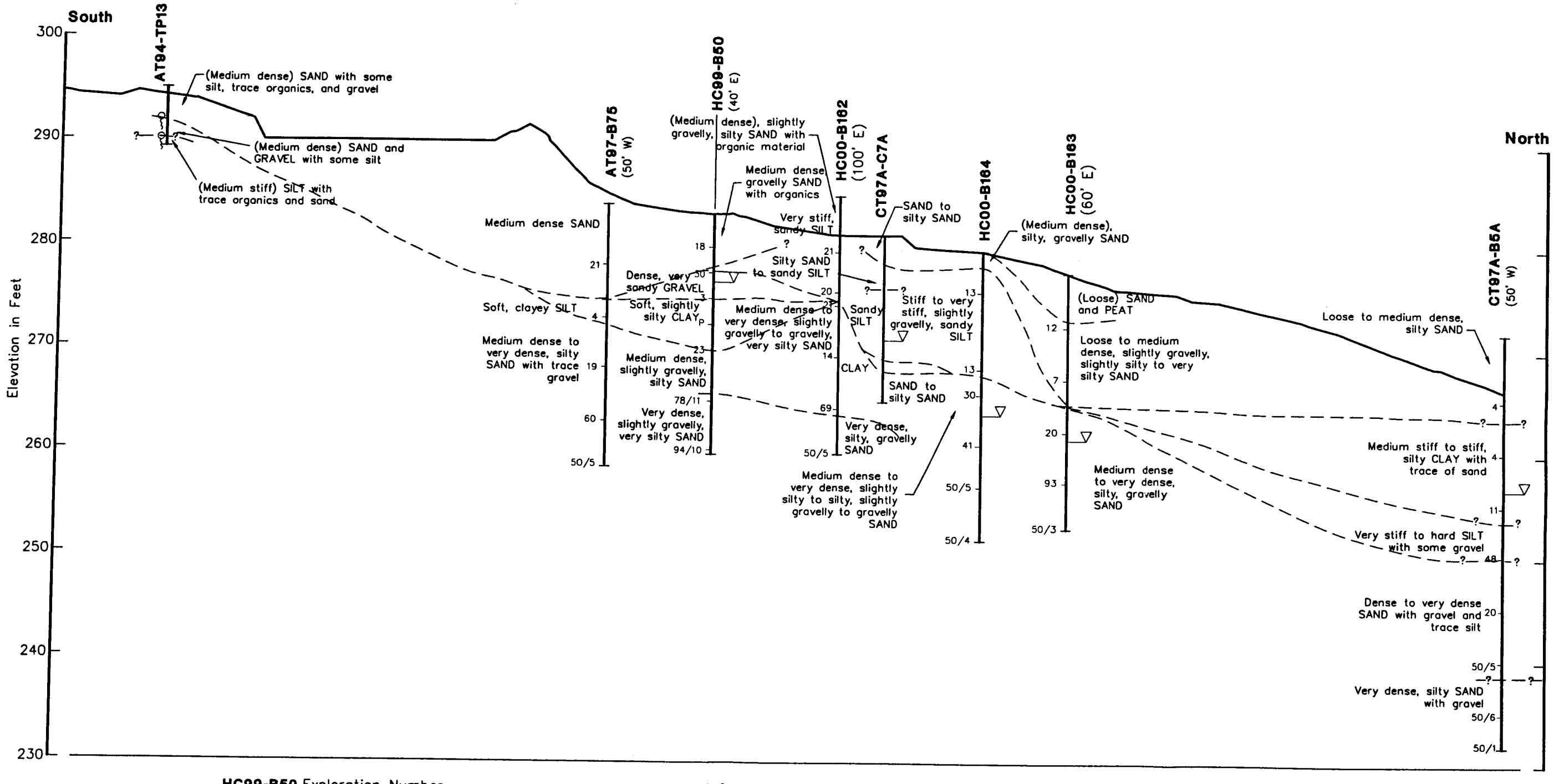
Note: Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

RC 3/20/00 1=50 woodstck.pc2
4978181S

HARTCROWSER
J-4978-18 3/00
Figure 3

AR 044248

Cross Section 110+47
154th Realignment Stationing



HC99-B50 Exploration Number
(40' E) (Offset Distance and Direction)

Exploration Location

19 N Value

ATD Water Level

Seep Location

– – – – Inferred Geologic Contact

Horizontal Scale in Feet
0 50 100
0 10 20
Vertical Scale in Feet
Vertical Exaggeration x 5

Note: Contacts between soil units are based upon interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

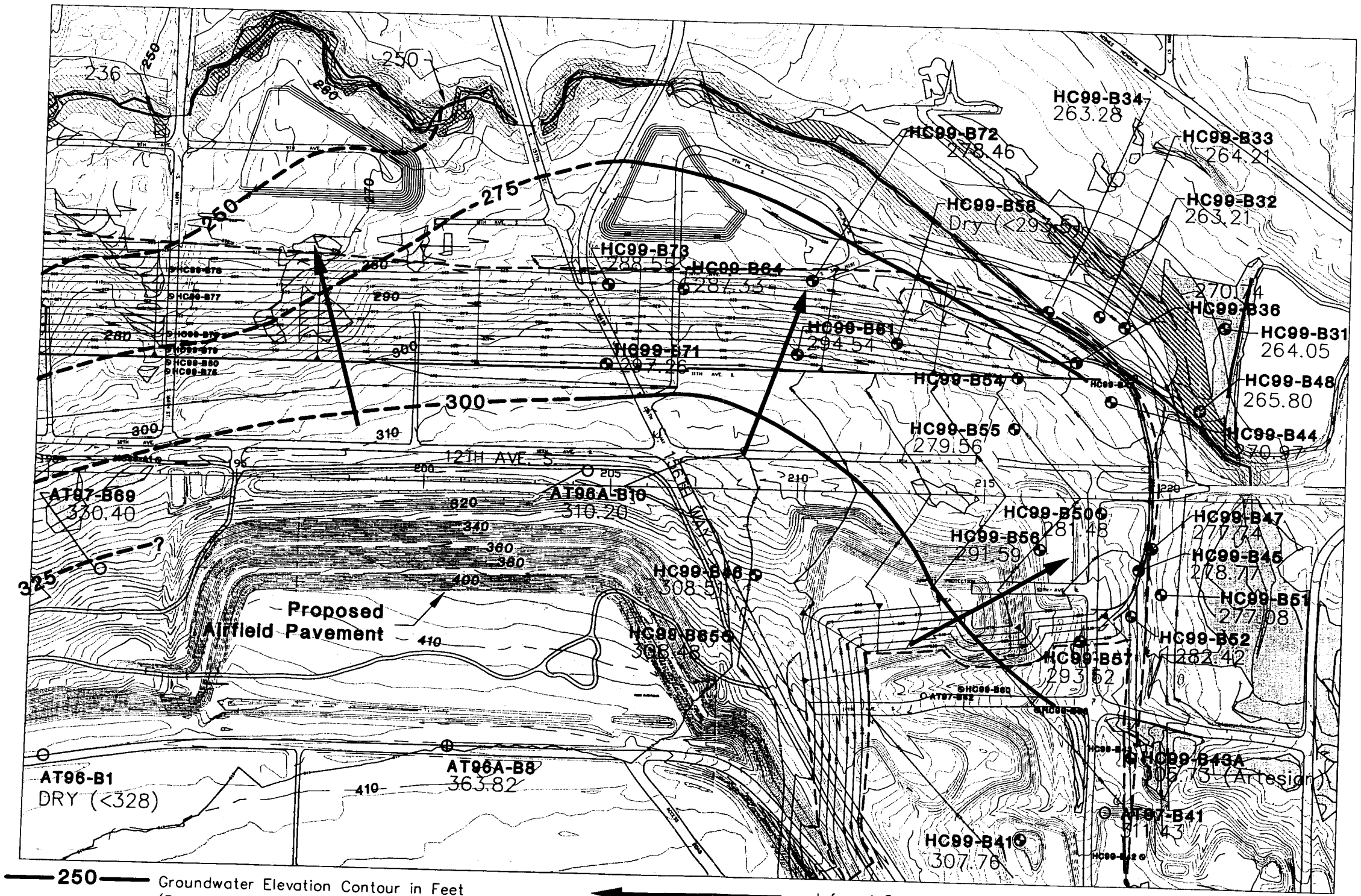
AR 044249

HARTCROWSER
J-4978-18 1/00
Figure 4

RC 3/20/00 1=50 woodstck.pc2
49781815

Groundwater Elevation Contour Map

Wet Season (December 9, 1999)



250 — Groundwater Elevation Contour in Feet (Dashed Where Inferred)

HC99-B35 — Monitoring Well Location and Number

286.79 (Artesian) — Groundwater Elevation in Feet (December 9, 1999); Water Level above Ground Surface

Inferred Groundwater Flow Direction

175 — Runway Stationing

Wetland

Note: Base map prepared from drawing provided by HNTB entitled, "Topo_Full.dwg", dated October 8, 1999. Wetland locations based on drawing provided by Parametrix entitled, "W_020800.dwg," dated February 8, 2000.

AR 044250

HARTCROWSER

J-4978-18 3/00

Figure 5

APPENDIX A
FIELD EXPLORATIONS METHODS AND ANALYSIS

APPENDIX A
FIELD EXPLORATIONS METHODS AND ANALYSIS

This appendix documents the processes Hart Crowser used in determining the nature of the soils underlying the project site addressed by this report. The discussion includes information on the following subjects:

- Explorations and Their Location;
- The Use of Auger Borings;
- Standard Penetration Test (SPT) Procedures;
- Use of Shelby Tubes
- Pocket Penetrometer (PP) and Torvane (TV);
- Excavation of Test Pits;
- Piezocone Penetrometer Probes
- Cone Penetration Test Procedures;
- Monitoring Well Installation;
- Monitoring Well Development;
- Water Level Measurement;
- Hydraulic Conductivity Testing (Slug Testing);
- Double-Ring Infiltrometer Test; and
- References for Appendix A.

Explorations and Their Location

Subsurface explorations for this project include the following:

- **Borings**
  HC99-B42, HC99-B44, HC99-B48, HC99-B50 through HC99-B52, HC99-B54 through HC99-B58, HC99-B60, HC99-B62, HC99-B64, HC99-B72, HC99-B75 through HC99-B80, and HC00-B160 through HC00-B175.

- **Test Pits**
  HC99-TP23 through HC99-TP25, HC99-TP41, and HC99-TP43.

- **Piezocones**
  HC99-P01 through HC99-P03, HC99-P03A, and HC99-P04 through HC99-P10.

The exploration logs within this appendix show our interpretation of the material encountered based on drilling (or excavation), sampling, and testing data. They indicate the depth where the soils change. Note that the change may be gradual. In the field, we classified the samples taken from the explorations according to

the methods presented on Figure A-1A - Key to Exploration Logs. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

Location of Explorations. Figure A-2 shows the location of explorations. Borings and test pits were located using a global positioning system (GPS) survey by Hart Crowser. Port of Seattle surveyors performed an x, y, z survey for the top of casing elevations of all wells and ground elevations for piezocones, test pits, and some borings completed without wells. Where available, the Port's survey supersedes the GPS locations. Where Port survey data is not available, ground surface elevations were interpreted from the aerial survey topography shown on Figure 2. The method used determines the accuracy of the location and elevation of the explorations.

The Use of Auger Borings

With depths ranging from 23.4 to 51.5 feet below the ground surface, nineteen hollow-stem auger borings, designated HC99-B42, HC99-B44, HC99-B48, HC99-B50 through HC99-B52, HC99-B54 through HC99-B58, HC99-B60, HC99-B62, HC99-B64, and HC99-B72 were drilled from November 8 through 19, 1999. In addition, with depths ranging from 15.0 to 40.0 feet, sixteen hollow-stem auger borings, designated HC00-B160 through HC00-B175, were drilled between January 20 and 26, 2000. Samples were obtained by use of the Standard Penetration Test (SPT) samples or a hydraulically pushed thin wall sampler referred to as a "Shelby tube." In some cases, borings were re-drilled to pre-determined depths immediately adjacent to existing borings, to obtain additional Shelby tube samples. These re-drilled borings are identified by appending a letter to the original boring number, i.e., HC99-B44A, but the re-drilled boring logs are typically not included in this report; the recovered Shelby tube samples are shown on the log of the original boring. The borings used a 3-3/8-inch inside diameter hollow-stem auger and were advanced with a truck-mounted drill rig subcontracted by Hart Crowser. The drilling was continuously observed by an engineering geologist from Hart Crowser. Detailed field logs were prepared of each boring. Using the Standard Penetration Test (SPT), we obtained samples at 2-1/2- to 5-foot-depth intervals for these borings.

This report also presents six shallow borings, designated HC99-B75 through HC99-B80, drilled on June 4, 1999. These borings were drilled to evaluate the subgrade conditions for the Seattle Public Utilities waterline located along South 160th Street. This waterline is located in an area that will be filled as part of the Third Runway Embankment.

Groundwater levels in the borings were noted at the time of drilling (ATD) and following installation and development of observation wells where noted on the boring logs and shown in Table 5.

The borings logs are presented on Figures A-2 through A-38 at the end of this appendix.

Standard Penetration Test (SPT) Procedures

This test is an approximate measure of soil density and consistency. To be useful, the results must be used with engineering judgment in conjunction with other tests. The SPT (as described in ASTM D 1587) was used to obtain disturbed samples. This test employs a standard 2-inch outside diameter split-spoon sampler. Using a 140-pound hammer, free falling 30 inches; the sampler is driven into the soil for 18 inches. The number of blows (N value) required to drive the sampler the last 12 inches only is the Standard Penetration Resistance. This resistance, or blow count, measures the relative density of granular soils and the consistency of cohesive soils. The blow counts are plotted on the boring logs at their respective sample depths.

Soil samples are recovered from the split-barrel sampler, field classified, and placed into water tight jars. They are then taken to Hart Crowser's laboratory for further testing.

Some instances of "heave" are noted on boring logs. Heave is a phenomenon that occurs typically within a sand soil where there is excess seepage pressure at the bottom of the auger (i.e., water within the augers is at a lower elevation than the groundwater level surrounding the boring). A sufficient difference in water levels will cause the sandy soils to be displace upward into the auger, thereby disturbing the soil formation. Therefore, the corresponding SPT N values do not accurately indicate density. Heave is typically controlled by sustaining the water level within the auger at or near the surrounding groundwater level; no drilling mud was used in the explorations described in this report.

In the Event of Hard Driving

Occasionally very dense materials or the presence of gravel and/or cobbles prevented driving the total 18-inch sample. When this happens, the penetration resistance is entered on logs as follows:

Penetration less than six inches. The log indicates the total number of blows over the number of inches of penetration.

Penetration greater than six inches. The blow count noted on the log is the sum of the total number of blows completed after the first 6 inches of penetration. This sum is expressed over the number of inches driven that exceed the first 6 inches. The number of blows needed to drive the first 6 inches is not reported. For example, a blow count series of 12 blows for 6 inches, 30 blows for 6 inches, and 50 (the maximum number of blows counted within a 6-inch increment for SPT) for 3 inches would be recorded as 80/9.

Use of Shelby Tubes

At some boring locations, as noted on the logs, a 3-inch-diameter thin-walled steel (Shelby) tube sampler was pushed hydraulically below the auger to obtain a relatively undisturbed sample for classification and testing of fine-grain soils. The tubes were sealed in the field and taken to our laboratory for extrusion and classification. The undisturbed samples were typically obtained for consolidation and shear strength testing.

Pocket Penetrometer (PP) and Torvane (TV)

The pocket penetrometer and torvane procedures provide quick approximate tests of the consistency (undrained shear strength) of a cohesive soil sample.

The pocket penetrometer device consists of a calibrated spring mechanism that measures penetration resistance of a 1/4-inch-diameter steel tip over a given distance. The penetration resistance is correlated to the unconfined compressive strength of the soil, which is typically twice the undrained shear strength of a saturated, cohesive soil.

The torvane device consists of a 1-inch-diameter plate with eight equally spaced and radially arranged 1/4-inch vanes. The vanes are pressed into the soil and the device is rotated. The vanes force a shear failure to take place over the area of plate face. The resistance at failure, as measured by a calibrated spring, correlates to the undrained shear strength of the sample tested. The exploration logs show the results of the pocket penetrometer and torvane tests.

Pocket penetrometer and torvane test results are generally considered valid only for predominantly fine-grained (non-sandy soils). Results may be artificially low for tests on disturbed samples (i.e., SPT) compared to relatively undisturbed samples from test pits or Shelby tubes.

Excavation of Test Pits

Five test pits, designated HC99-TP-23 through HC99-TP25, HC99-TP41, and HC99-TP43, were excavated across the site with a tractor-mounted backhoe provided by Port Construction Services. The test pits were excavated on November 9 through 10, 1999. The sides of these excavated pits offer direct observation of the subgrade soils. The test pits were located by and excavated under the direction of an engineering geologist from Hart Crowser. The geologist observed the soil exposed in the test pits and reported the findings on a field log. Our geologist took representative samples of soil types for testing at Hart Crowser's laboratory. Groundwater levels or seepage during excavation was noted by the geologist on the log. The density/consistency of the soils (as presented parenthetically on the test pit logs to indicate their having been estimated) is based on visual observation only, as disturbed soils cannot be measured for in-place density.

The test pit logs are presented on Figures A-39 through A-41.

Piezocone Penetrometer Probes

We used a piezocone penetrometer as a means to supplement our visual classification of soils provided in SPT samples. The logs of these probes are provided on Figures A-42 through A-52. Piezocone locations are shown on Figure 2. The cone probes, designated HC99-P01 through HC99-P10 and HC99-P03A, were advanced to depths ranging from 9 to 18.5 feet below the ground surface by Northwest Cone Exploration on December 1, 1999. The piezocone was mounted to a small bulldozer for locations in wetlands or with difficult access for cone probes designated HC99-P01 through HC99-P04. The significantly heavier cone truck was used for the other piezocone locations. The cone probe configuration used in the investigation is similar to that shown on Figure A-1B. This figure also shows the classification method used to develop the *soil behavior index* represented on the individual logs for classification purposes. The piezocone is arranged to measure the following parameters, which are used for the soil classification:

- Tip resistance, q_T in tsf (corrected resistance to soil penetration developed at the cone tip);
- Friction resistance, f_s in tsf (resistance to soil penetration developed along the friction sleeve); and
- Pore water pressure behind the cone tip, U_{bt} in psi.

The logs of the piezocone probes proposed by Northwest Cone Exploration are presented on Figures A-42 through A-52.

Cone Penetration Test Procedures

The electric piezocone penetrometer test procedure involves hydraulically pushing a series of cylindrical rods into the soil at a constant rate of two centimeters per second and subsequently monitoring soil and pore fluid response near the conical tip. The cylindrical rod at the bottom of the drill string houses the pressure transducer and load cells which, during probing, measure the parameters indicated above. The results are often used with engineering judgment in conjunction with other tests, preferably the SPT procedure, which allows soil sample collection for direct comparison purposes. Tests were performed in general accordance with procedures outlined in ASTM D 3441, Standard Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil.

The cone system is mounted on a truck or bulldozer to provide the necessary reaction for the applied loads. The cone tip has a surface area of about 10 square centimeters (cm^2) and an angle of 30 degrees from the axis. The friction sleeve has a surface area of about 150 cm^2. Prior to testing, a plastic filter element, which has been saturated under vacuum in glycerin, is placed behind the cone tip. This filter element transmits pore pressures to the transducer. Load cells measure end resistance on the tip and frictional resistance on the friction sleeve. As the cone penetrates the soil, measurements are continuously recorded on a portable computer at depth increments of about 5 centimeters.

The classification method used to develop an interpreted soil profile is based on normalized parameters provided by the piezocone, as there are no soil samples collected with a penetrometer system of this type.

The relationship between the cone tip resistance and friction ratio, which has been normalized for soil overburden stresses, can be established to predict soil behavior (Jeffries and Davies, 1991 and 1993). This relationship has been applied to the soil classification chart developed by Robertson as reported in Lunne et al., 1997 (refer to Figure A-1B) according to the following equation:

$$I_C = \sqrt{\{3 - \log[Q \cdot (1 - B_q)]\}^2 + [1.5 + 1.3 \cdot \log(F)]^2}$$

Where,

Ic = Soil behavior index

Q = Normalized cone tip resistance

$$Q = \frac{q_T - \sigma_{vo}}{\sigma'_{vo}}$$

q_T = Corrected cone tip resistance

σ_{VO} = Total overburden stress

σ'_{VO} = Effective overburdens stress

B_q = Normalized pore pressure

$$B_q = \frac{\Delta u}{q_T - \sigma_{vo}}$$

F = Normalized friction ratio

$$R_f = \frac{f_s}{q_T - \sigma_{vo}} \cdot 100\%$$

f_s = Sleeve friction

Using the above equation and the classification chart presented on Figure A-1B, we were able to develop the interpreted soil profiles provided on Figures A-42 through A-52. The classification chart used for this study has been established based on observed soil behavior from numerous studies for various soil types.

Monitoring Well Installation

Monitoring wells were completed in selected wells as noted on the logs to allow long term groundwater elevation monitoring. The wells were drilled using standard hollow-stem auger equipment. Two-inch-diameter Schedule 40 PVC riser pipe and 2-inch-diameter 0.020-inch machine-slotted screen were used for the well casings and screens. The well screen and casing riser is lowered down through the hollow-stem auger. As the auger is withdrawn, No. 10/20 silica sand is placed in the annular space from the base of the boring to approximately 2 to 3 feet above the top of the well screen.

Well seals were constructed by placing bentonite chips in the annular space on top of the filter sand to within 3 feet of ground surface. The remaining annular space was backfilled with concrete to complete the surface seal. For security, the monitoring wells were completed with locking stick-up steel monuments set in concrete. The monitoring well construction details are illustrated on the boring logs.

The monitoring well installations were constructed in accordance with Washington State Department of Ecology regulations.

Monitoring Well Development

The monitoring wells were developed using a Whale electric submersible pump, surge block, and/or a stainless steel bailer. First, sediment was removed from the bottom of the wells using a stainless steel bailer. Then the wells were surged during development using either a surge block, a stainless steel bailer, or by moving the submersible pump up and down within the well screen depth interval.

A minimum of ten casing volumes was removed during development, in addition to the volume of water added during drilling, if any. Where possible, development continued until negligible turbidity was visible. Sediment thickness at the bottom of the well was measured and recorded before and after development. Observations were recorded on a Well Development data form. Visual changes in turbidity during development were recorded in the comments space on this form. All development water was discharged to the ground surface in accordance with the Third Runway project Storm Water Pollution Prevention Plan (Parametrix, 1999).

Water Level Measurement

Water levels were measured using a Solinst water level probe, graduated in 0.01-foot increments. Depth to water was measured below the top of casing and recorded to the nearest hundredth of a foot. Depth to water was converted to groundwater elevation using survey information for the top of casing in the wells. Depth to water data and groundwater elevations are summarized in Table 5.

Hydraulic Conductivity Testing (Slug Testing)

Hydraulic conductivity testing was performed using the slug test method. In this method the water level (hydraulic head) in the well is rapidly raised or lowered, and the rate at which it returns to its initial state is used to calculate hydraulic conductivity for the formation surrounding the well screen. Data were collected using an Aquistar data logger in conjunction with a Instrumentation Northwest PSI9000 pressure transducer. Tests were conducted as follows:

- A transducer was set in the well and allowed to equilibrate with ambient conditions, and background water level data were collected.

- One or two slug rods (solid PVC rods) were rapidly introduced into the well (causing a near-instantaneous rise in water level), to initiate a falling head

test. Water level data were collected in logarithmically increasing time increments using the data logger and transducer. For wells where depth to water was small, a falling head test was not attempted.

- Water level in the well was allowed to re-equilibrate.

- The slug rod or rods were rapidly pulled from the well (causing a near-instantaneous drop in water level) to initiate a rising head test. Water level data were collected in logarithmically increasing time increments using the data logger and transducer.

- Most of the wells responded reasonably quickly, and therefore multiple slug tests were performed for most wells.

Data were pre-processed as described in Butler (1998) and plotted on Figures A-53 through A-59. Hydraulic conductivity values were estimated using the methods of Bouwer and Rice (1976) for confined and unconfined aquifers. The estimated values are summarized in Table 6.

Double-Ring Infiltrometer Test

The double-ring infiltrometer test, based on ASTM D 3385, was used to measure infiltration in test pit HC99-TP41. Previous tests performed in the area were reported in the Phase 3 Fill Subsurface Conditions Data Report (Hart Crowser, 1999c).

The rings were driven into the ground about 6 inches. Bentonite was placed around the outside of the outer ring, to prevent water from coming out around the ring. The rings were filled with water, and the levels were maintained for a short duration before beginning the test, to obtain a saturated infiltration rate. Readings were recorded on field forms and indicated essentially no infiltration for 1.5 hours into the test. The test was terminated after steady rain caused caving within the side of the test pit and buried the ring.

References for Appendix A

Bouwer H., and R.C. Rice, 1976. A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, V.12 No. 3, 423-428, Water Resources Research.

Butler, James J., 1998. The Design, Performance, and Analysis of Slug Tests. CRC Press, Boca Raton, Florida.

Hvorslev, M.J., 1951. Time lag and soil permeability in ground-water observations, *U.S. Army Corps of Engineers, Waterways Exper. Sta. Bull No. 36.*

Jeffries, Michael G., and Michael P. Davies, 1991. Soil classification by the cone penetrometer test: Discussion, Can. Geotech. J. 28, 173-176.

Jeffries, Michael G., and Michael P. Davies, 1993. Use of CPTu to Estimate Equivalent SPT N_{60}. Geotechnical Testing Journal. GTJODJ, Vol. 16, No. 4, 458-468.

Lunne, T. P.K. Robertson, and J.J.M. Powell, 1997. Cone Penetration Testing in Geotechnical Practice, Blackie Academic and Professional, London.

Parametrix 1999. Seattle-Tacoma International Airport Third Runway Project Geotechnical Explorations Stormwater Pollution Prevention Plan, Prepared for Port of Seattle, January 29, 1999.

Van Rooy, D., 1988. A note on the computerized interpretation of slug test data, *Inst. Hydrodyn. Hydraulic Eng. Prog. Rep. 66*, Tech. Univ., Denmark, 47.

F:\docs\jobs\497818\NorthSafety(rpt).doc

Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance.
Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 – 4	Very soft	0 – 2	<0.125
Loose	4 – 10	Soft	2 – 4	0.125 – 0.25
Medium dense	10 – 30	Medium stiff	4 – 8	0.25 – 0.5
Dense	30 – 50	Stiff	8 – 15	0.5 – 1.0
Very dense	>50	Very stiff	15 – 30	1.0 – 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

	Estimated Percentage
Not identified in description	0 – 5
Slightly (clayey, silty, etc.)	5 – 12
Clayey, silty, sandy, gravelly	12 – 30
Very (clayey, silty, etc.)	30 – 50

Legends

Sampling Test Symbols

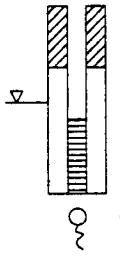
BORING SAMPLES

- Split Spoon
- Shelby Tube
- Cuttings
- Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

- Grab (Jar)
- Bag
- Shelby Tube

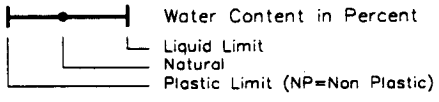
Groundwater Observations



- Surface Seal
- Groundwater Level on Date (ATD) At Time of Drilling
- Observation Well Tip or Slotted Section
- Groundwater Seepage (Test Pits)

Test Symbols

GS	Grain Size Classification
CN	Consolidation
UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits



PID	Photoionization Detector Reading
CA	Chemical Analysis
DT	*In Situ* Density Test

HARTCROWSER

J-4978-18 3/00

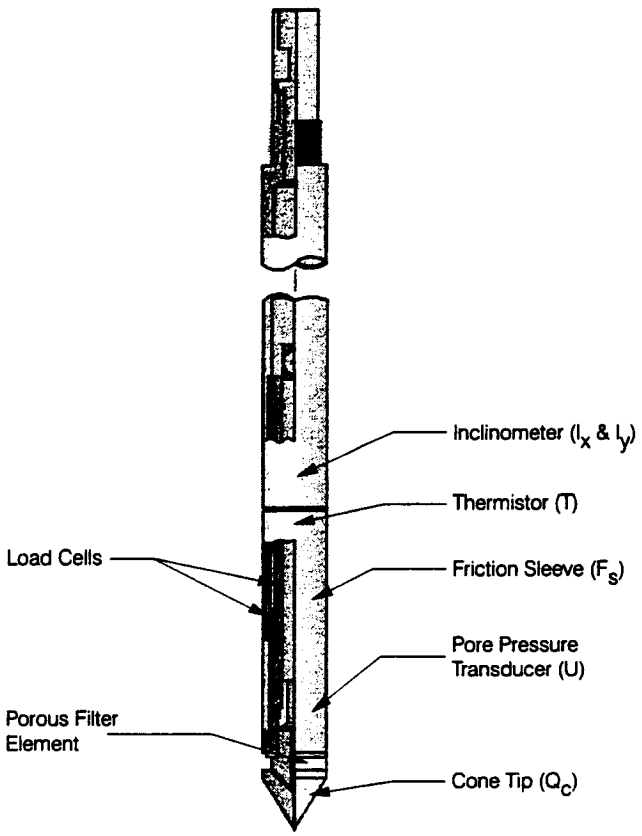
Figure A-1A

1=1 4978IB BORING1.DWG

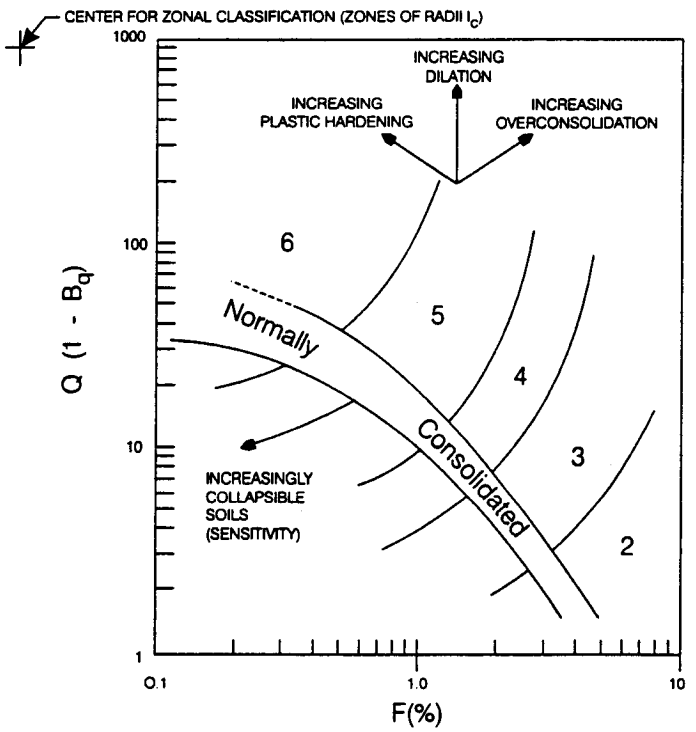
AR 044262

Electric (Piezocone) Cone Penetrometer

Schematic of Electric Piezocone (Typical)



Simplified Classification Chart (Jefferies and Davies, 1993 after Lunne et al., 1990)



Zone	Soil Behavior Type
1	sensitive fine grained
2	organic soils - peats
3	clays - clay to silty clay
4	silt mixtures - clayey silt to silty clay
5	sand mixtures - silty sand to sandy silt
6	sands - clean sand to silty sand

$$Q = \frac{q_T - F_{VO}}{F'_{VO}}$$

$$B_q = \frac{u - u_o}{q_T - F_{VO}}$$

$$F = \frac{f_s'}{q_T - F_{VO}} \times 100\%$$

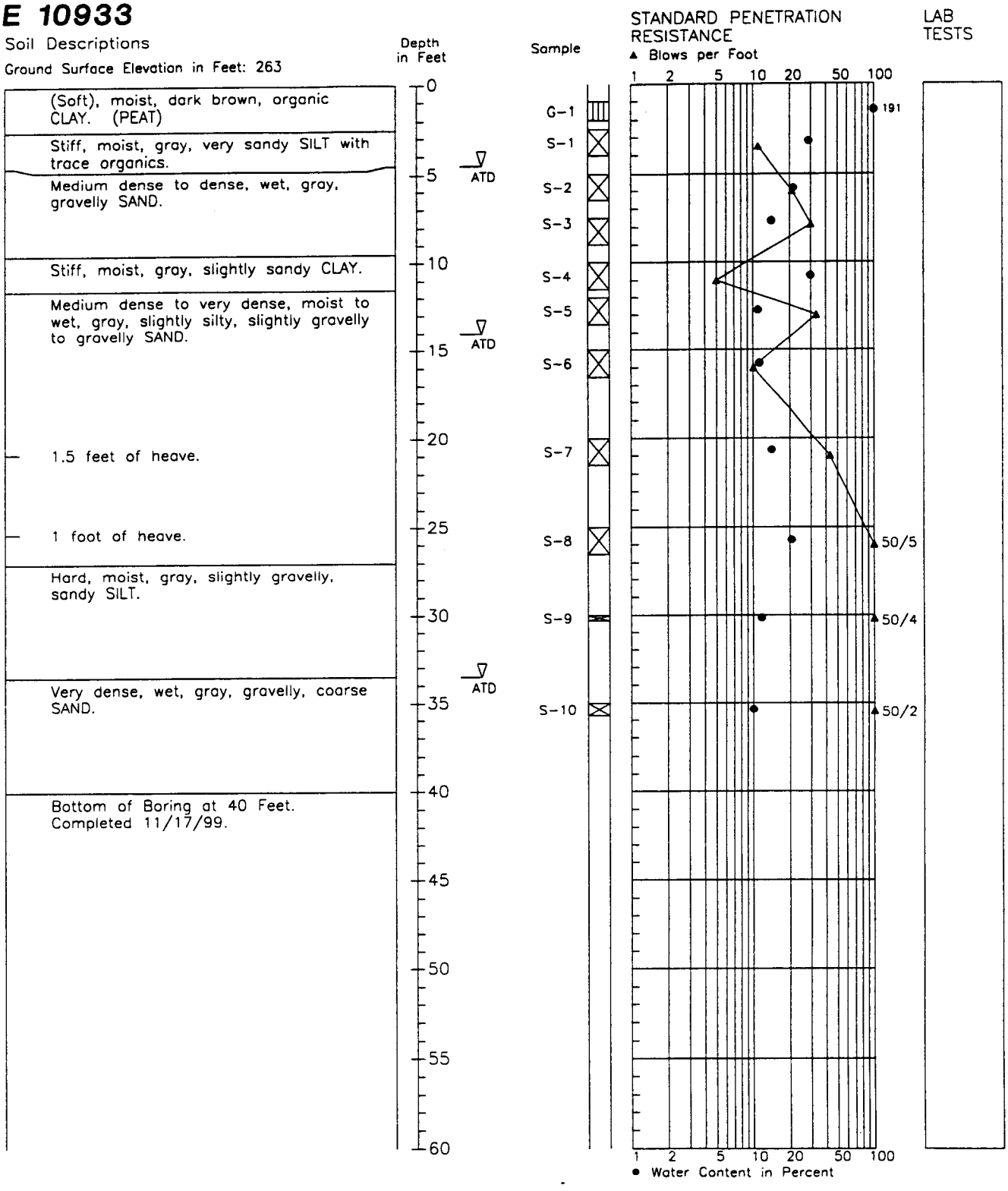
AR 044263

HARTCROWSER
J-4978-18 2/00
Figure A-1B

CorelM497818\piezocone

Boring Log HC99-B42

N 21896
E 10933



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/99 1=1 WDSTK.PC2
497818\LOGS

HARTCROWSER

J-4978-18 11/99

Figure A-2

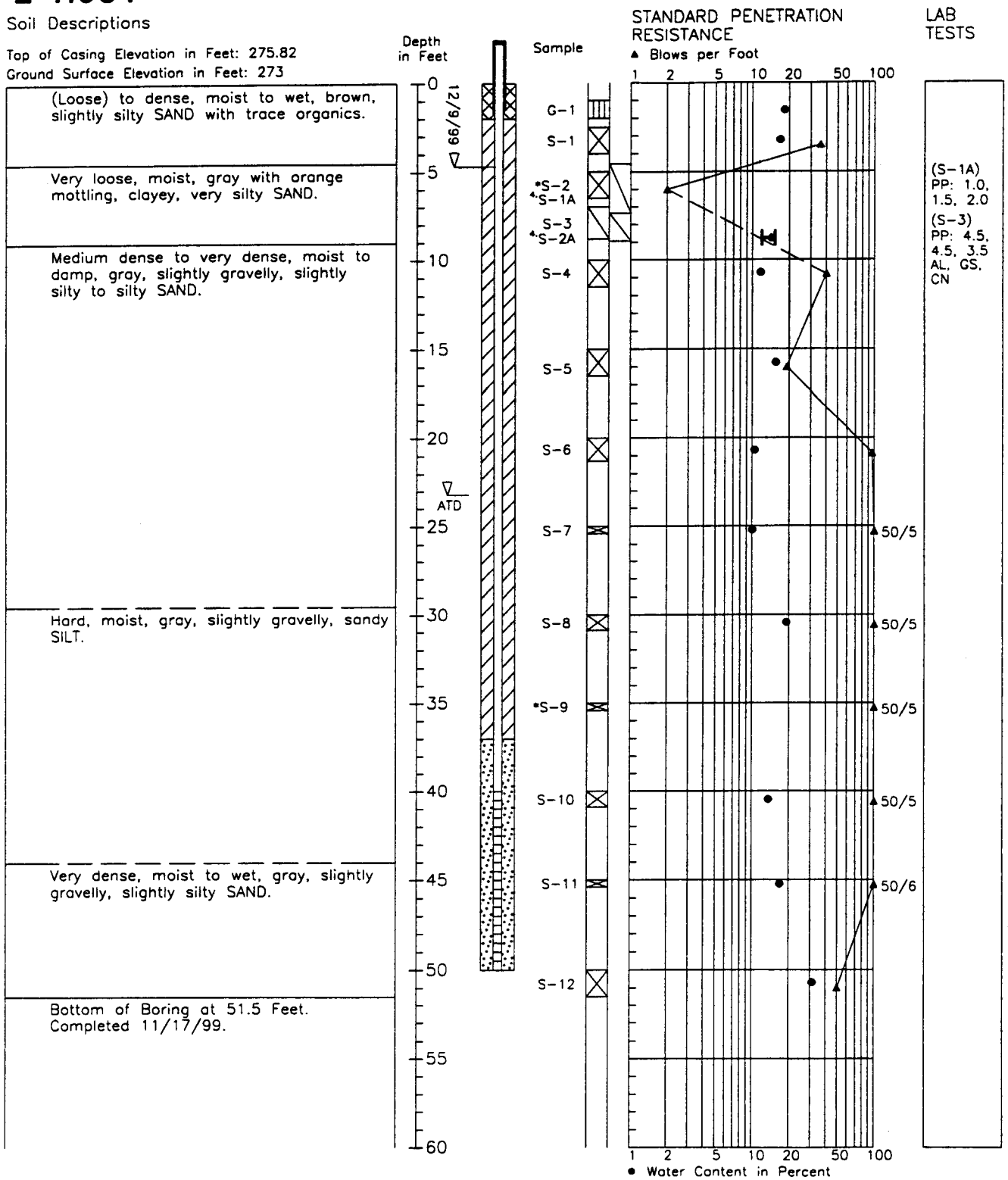
AR 044264

Boring Log HC99-B44

N 21830
E 11034

Soil Descriptions

Top of Casing Elevation in Feet: 275.82
Ground Surface Elevation in Feet: 273



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Shelby tube samples pushed in adjacent boring HC99-B44A located 5 feet south of HC99-B44.

HARTCROWSER
J-4978-18 11/99
Figure A-3

AR 044265

HEM 1/10/00 1=1 WDSKT-8.PC2
497818\LOGS

Boring Log HC99-B48

N 22058

E 11104

Soil Descriptions

Top of Casing Elevation in Feet: 270.02

Ground Surface Elevation in Feet: 268

(Loose), moist to wet, brown, silty SAND with organics. (PEAT)

Medium dense, moist to wet, gray, silty SAND.

Dense to very dense, wet, gray, gravelly SAND.

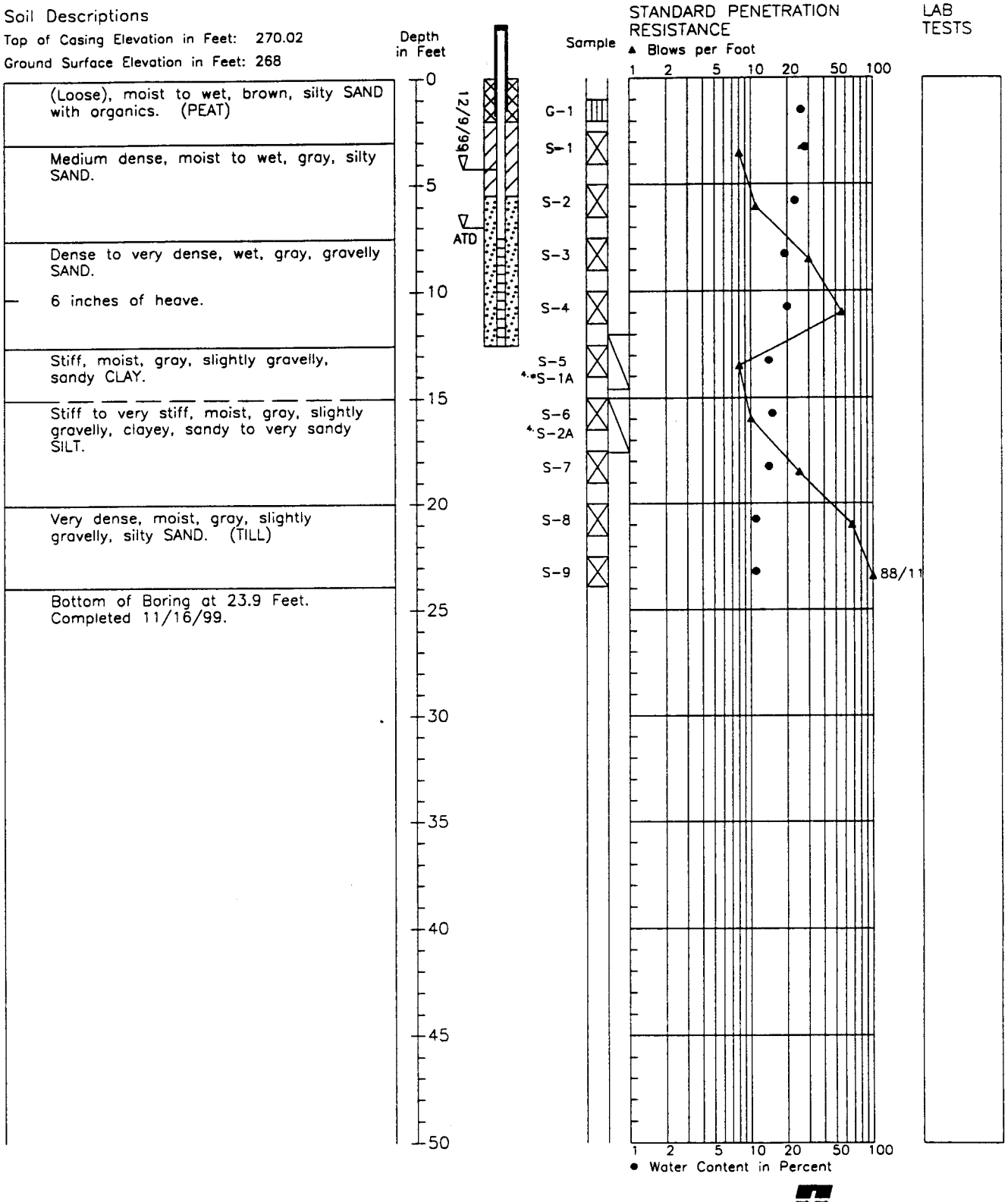
6 inches of heave.

Stiff, moist, gray, slightly gravelly, sandy CLAY.

Stiff to very stiff, moist, gray, slightly gravelly, clayey, sandy to very sandy SILT.

Very dense, moist, gray, slightly gravelly, silty SAND. (TILL)

Bottom of Boring at 23.9 Feet. Completed 11/16/99.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Shelby tube samples pushed in adjacent boring HC99-B48A located 5 feet northeast of HC99-B48.

HARTCROWSER

J-4978-18 11/99

Figure A-4

AR 044266

HEM 1/10/99 1=1 wdstk-B.pc2
497818\LOGS

Boring Log HC99-B50

N 21813

E 11340

Soil Descriptions

Top of Casing Elevation in Feet: 287.90

Ground Surface Elevation in Feet: 285

Medium dense, moist, gravelly SAND with organics.

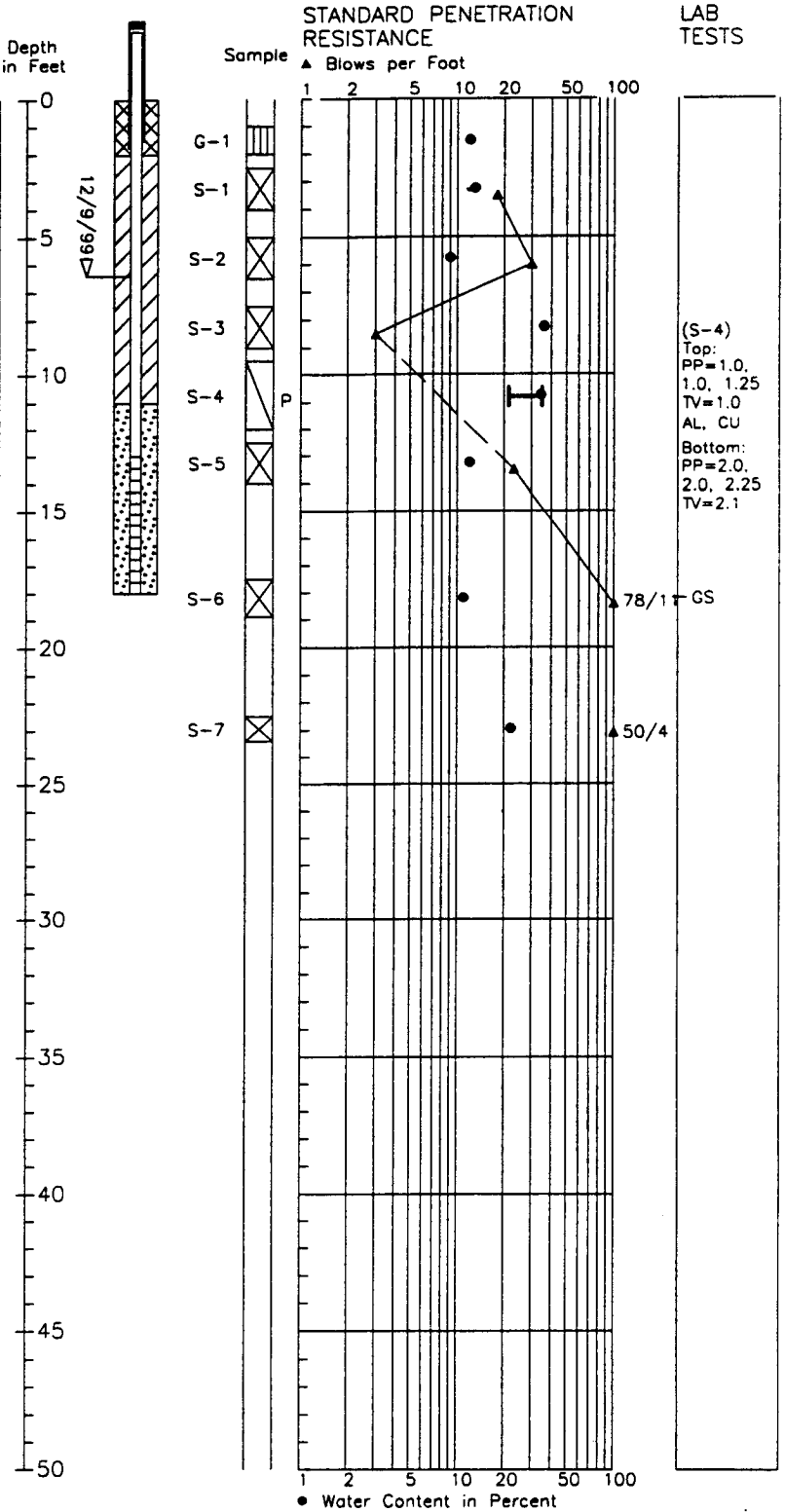
Dense, moist to wet, very sandy GRAVEL.

Soft, moist, gray, slightly sandy CLAY.

Medium dense, moist, gray, slightly gravelly, silty SAND.

Very dense, moist, gray, slightly gravelly, very silty SAND.

Bottom of Boring at 23.4 Feet.
Completed 11/16/99.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 11/99

Figure A-5

AR 044267

HEM 1/10/99 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC99-B51

N 21983

E 11557

Soil Descriptions

Top of Casing Elevation in Feet: 278.56

Ground Surface Elevation in Feet: 276

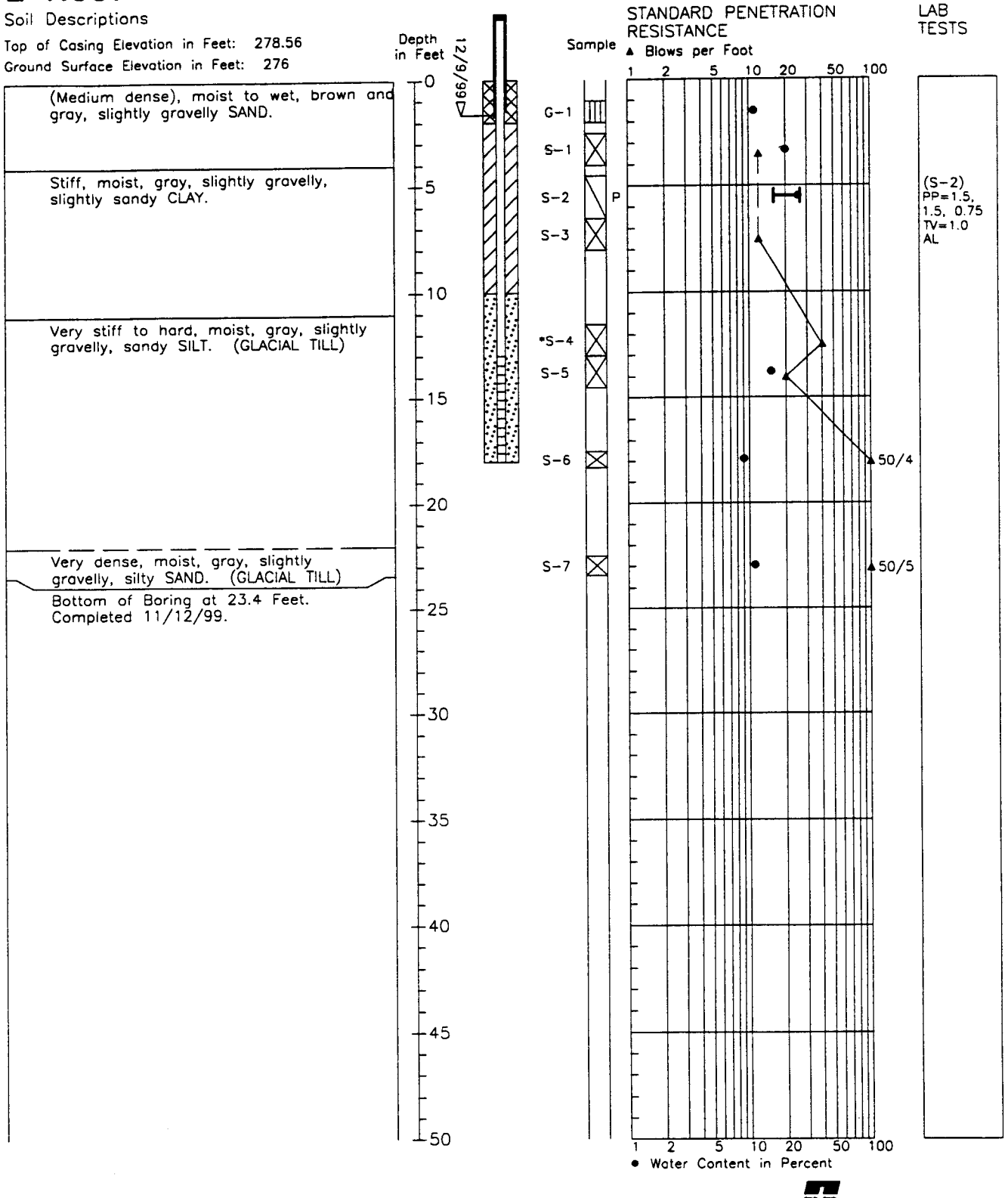
(Medium dense), moist to wet, brown and gray, slightly gravelly SAND.

Stiff, moist, gray, slightly gravelly, slightly sandy CLAY.

Very stiff to hard, moist, gray, slightly gravelly, sandy SILT. (GLACIAL TILL)

Very dense, moist, gray, slightly gravelly, silty SAND. (GLACIAL TILL)

Bottom of Boring at 23.4 Feet.
Completed 11/12/99.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER

J-4978-18 11/99

Figure A-6

AR 044268

Boring Log HC99-B52

N 21904
E 11617

Soil Descriptions

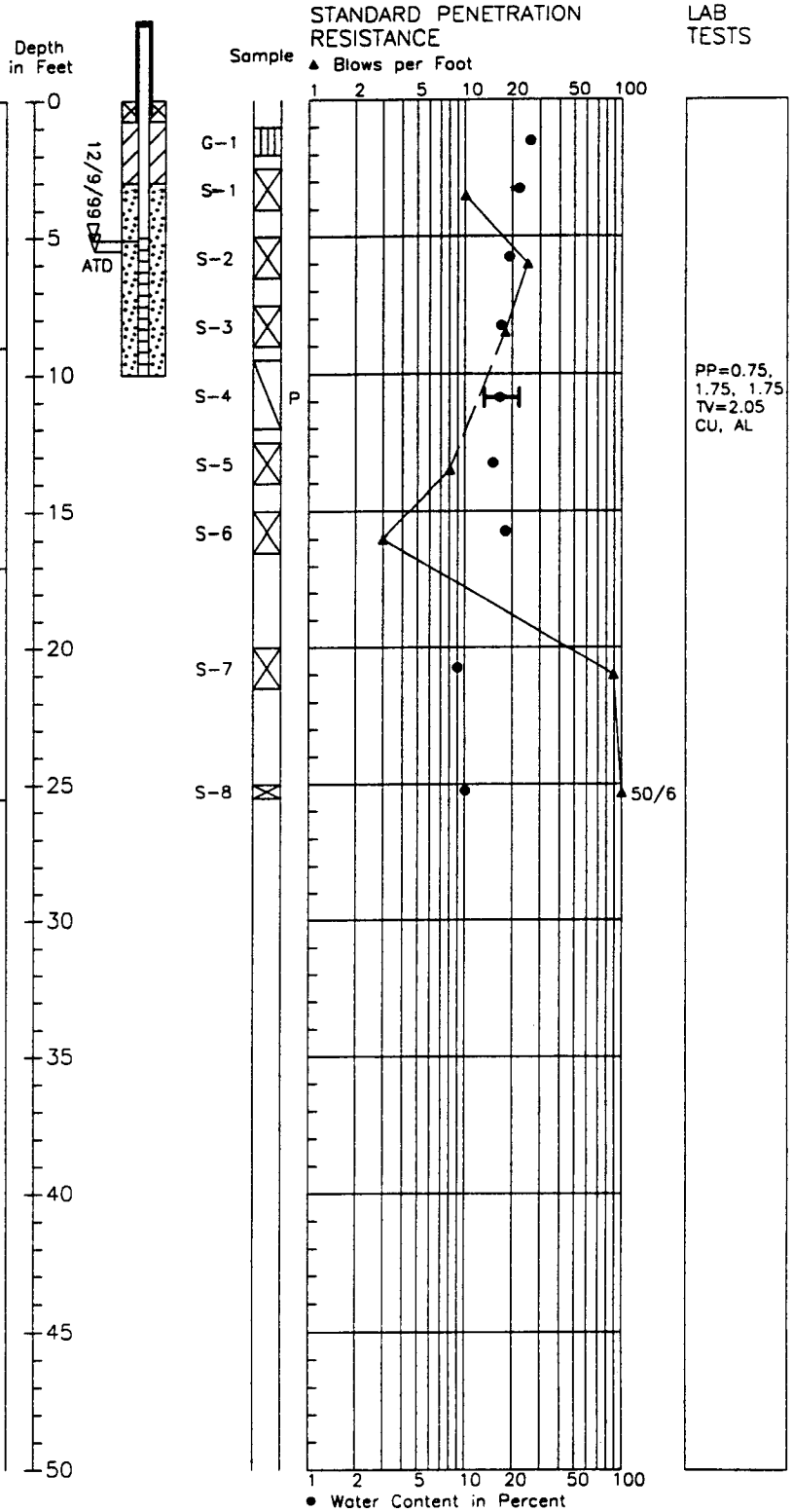
Top of Casing Elevation in Feet: 287.34
Ground Surface Elevation in Feet: 285

Loose to medium dense, moist to wet, brown to dark brown, slightly gravelly, silty SAND with organics.

Soft to stiff, moist, gray, slightly gravelly, slightly sandy CLAY.

Very dense, moist, gray, slightly gravelly, very silty SAND. (TILL)

Bottom of Boring at 25.5 Feet.
Completed 11/15/99.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER
J-4978-18 11/99
Figure A-7

AR 044269

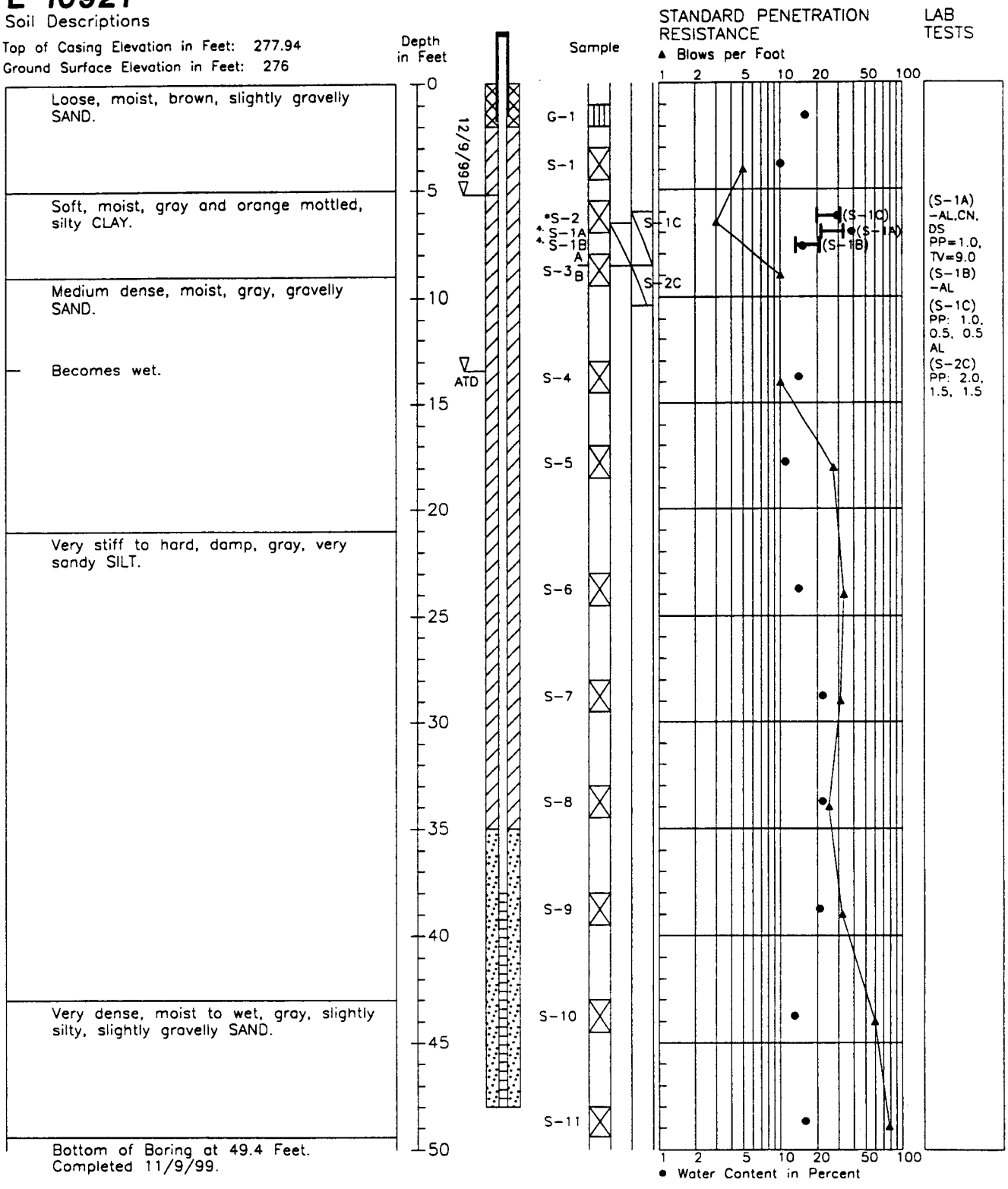
Boring Log HC99-B54

N 21596

E 10921

Soil Descriptions

Top of Casing Elevation in Feet: 277.94
Ground Surface Elevation in Feet: 276



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Shelby tube samples S-1A, S-1B, and S-1C and S-2C pushed in adjacent borings HC99-B54A, HC99-B54B, and HC99-B54C respectively.

HARTCROWSER

J-4978-18 11/99

Figure A-8

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

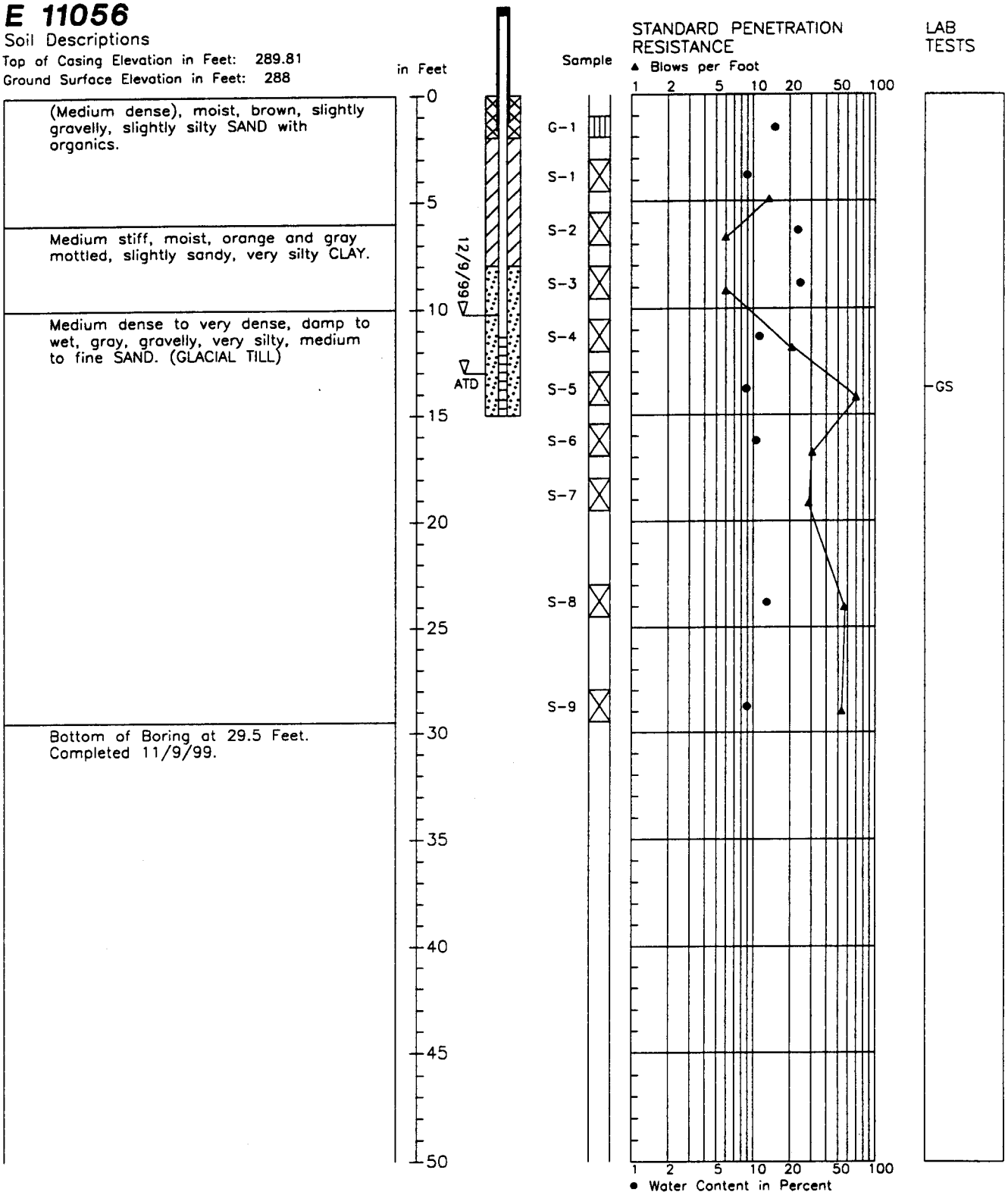
AR 044270

Boring Log HC99-B55

N 21560
E 11056

Soil Descriptions

Top of Casing Elevation in Feet: 289.81
Ground Surface Elevation in Feet: 288



(Medium dense), moist, brown, slightly gravelly, slightly silty SAND with organics.

Medium stiff, moist, orange and gray mottled, slightly sandy, very silty CLAY.

Medium dense to very dense, damp to wet, gray, gravelly, very silty, medium to fine SAND. (GLACIAL TILL)

Bottom of Boring at 29.5 Feet.
Completed 11/9/99.

1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

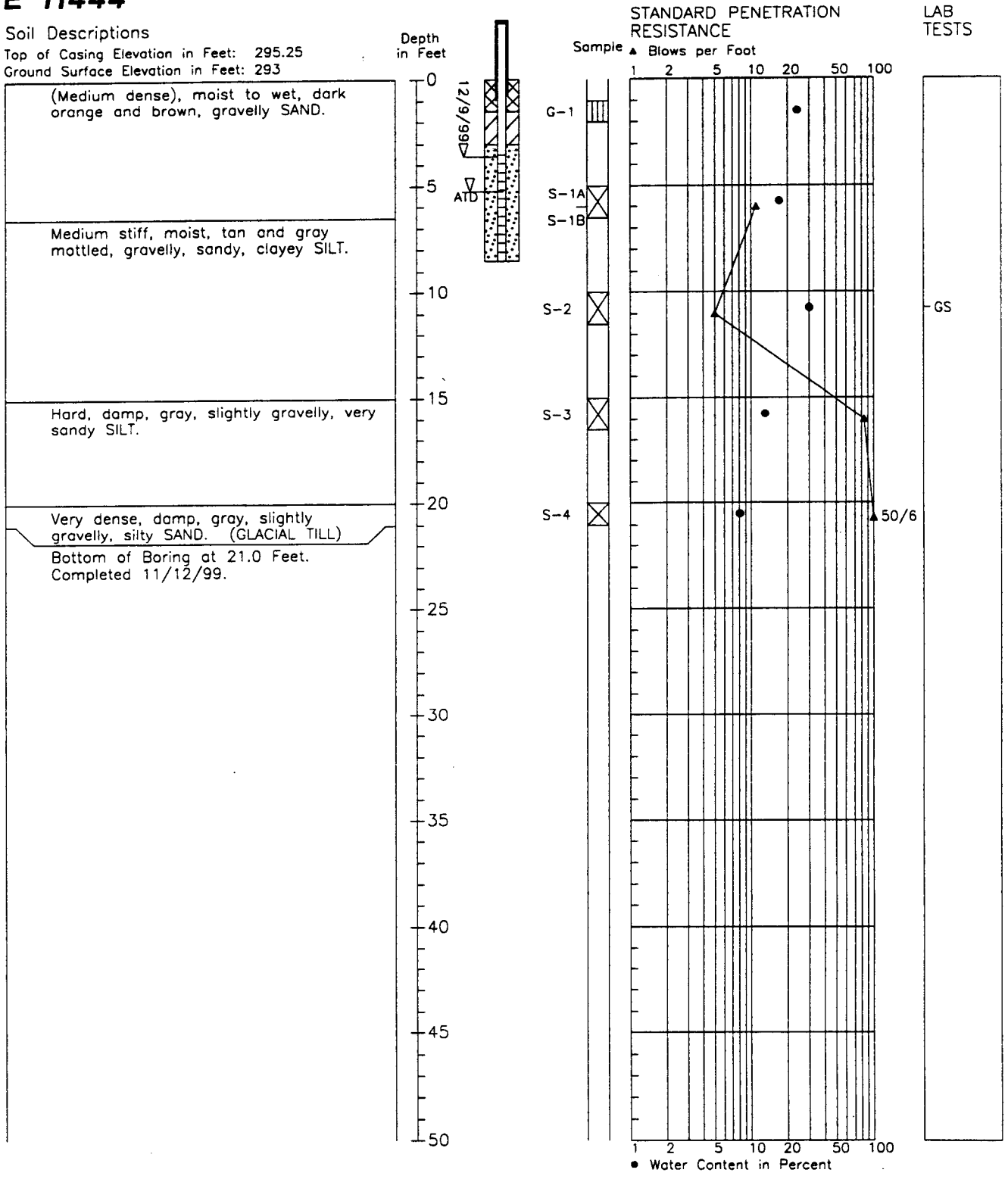
HARTCROWSER
J-4978-18 11/99
Figure A-9

AR 044271

Boring Log HC99-B56

N 21656

E 11444



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER

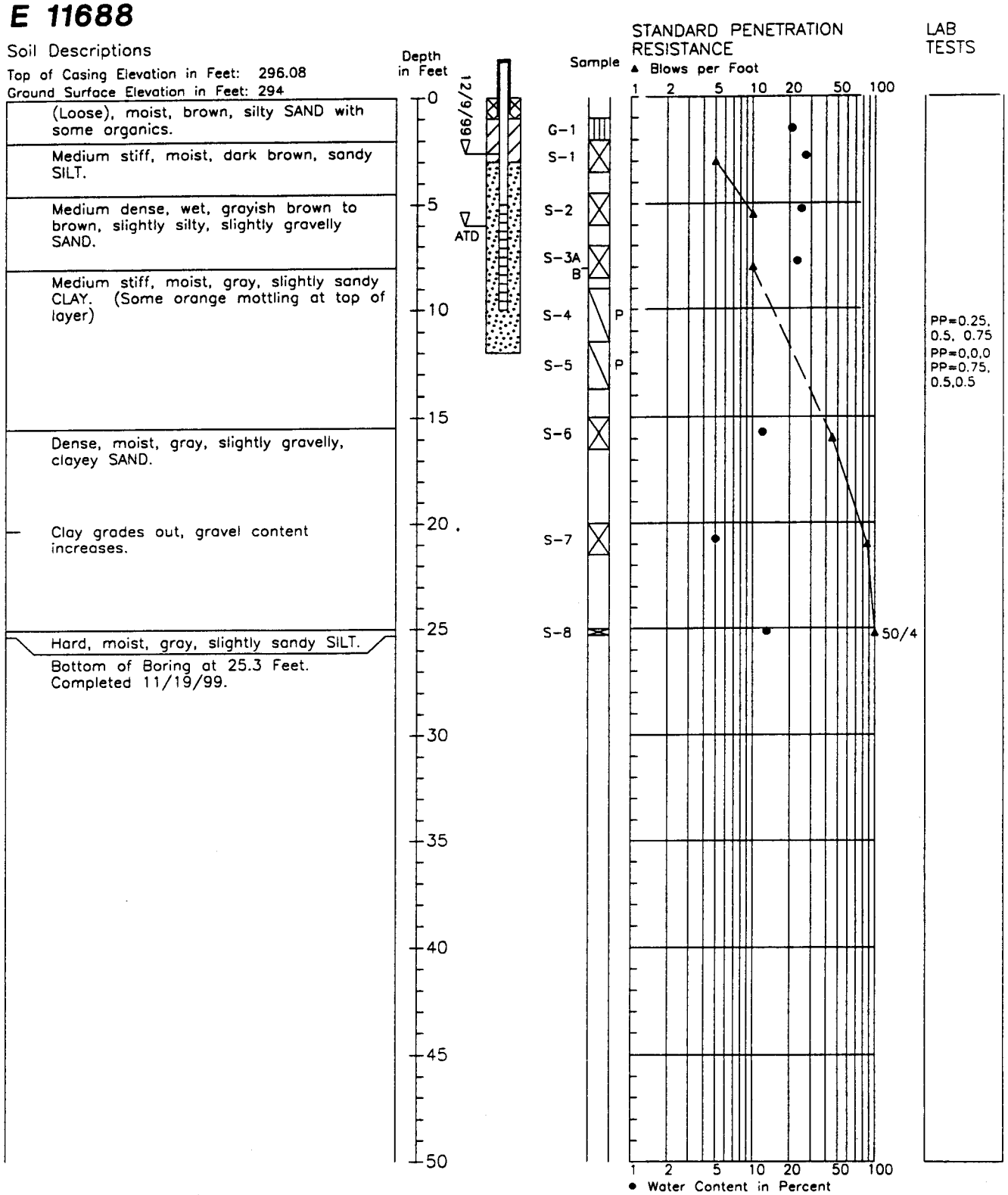
J-4978-18 11/99

Figure A-10

AR 044272

Boring Log HC99-B57

N 21768
E 11688



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 11/99

Figure A-11

AR 044273

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC99-B58

N 21254
E 10892

Soil Descriptions

Top of Casing Elevation in Feet: 293.50
Ground Surface Elevation in Feet: 291

(Loose), moist, brown, slightly gravelly SAND with trace organics.

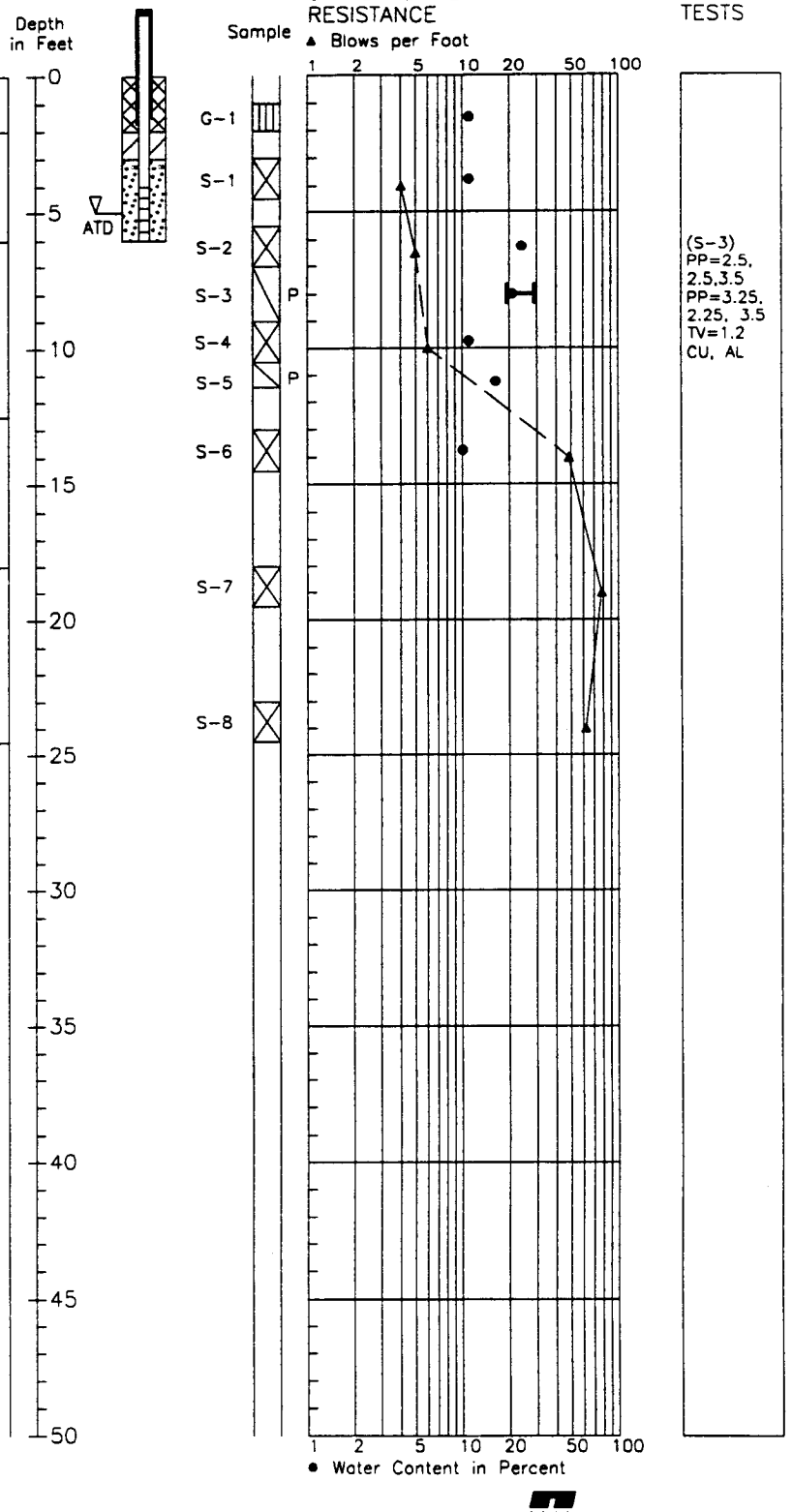
Loose, moist, tan to brown, slightly gravelly SAND.

Medium stiff, moist, brown and tan mottled, sandy, very silty CLAY.

Dense, gray, moist to wet, slightly clayey, gravelly SAND.

Hard, damp, gray, slightly gravelly, sandy SILT.

Bottom of Boring at 24.5 Feet.
Completed 11/9/99.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

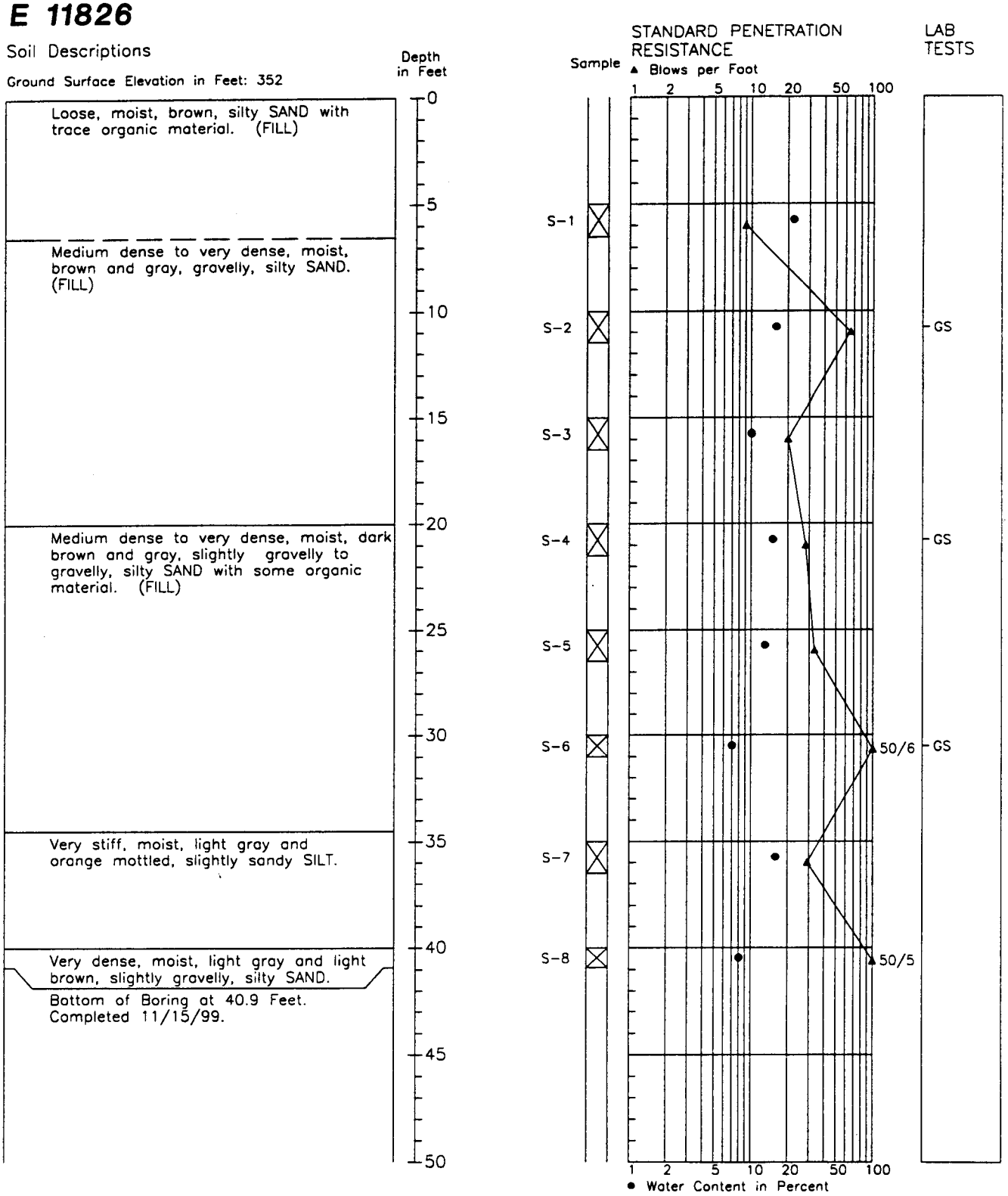
D:\#1 12/30/99 1=1 wdstk-B.pc2
497818\LOGS

HARTCROWSER
J-4978-18 11/99
Figure A-12

AR 044274

Boring Log HC99-B60

N 21454
E 11826



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 11/99

Figure A-13

AR 044275

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC99-B62

Approximate N 19580
Approximate E 10894

Soil Descriptions

Approximate Ground Surface Elevation in Feet: 278

Depth in Feet

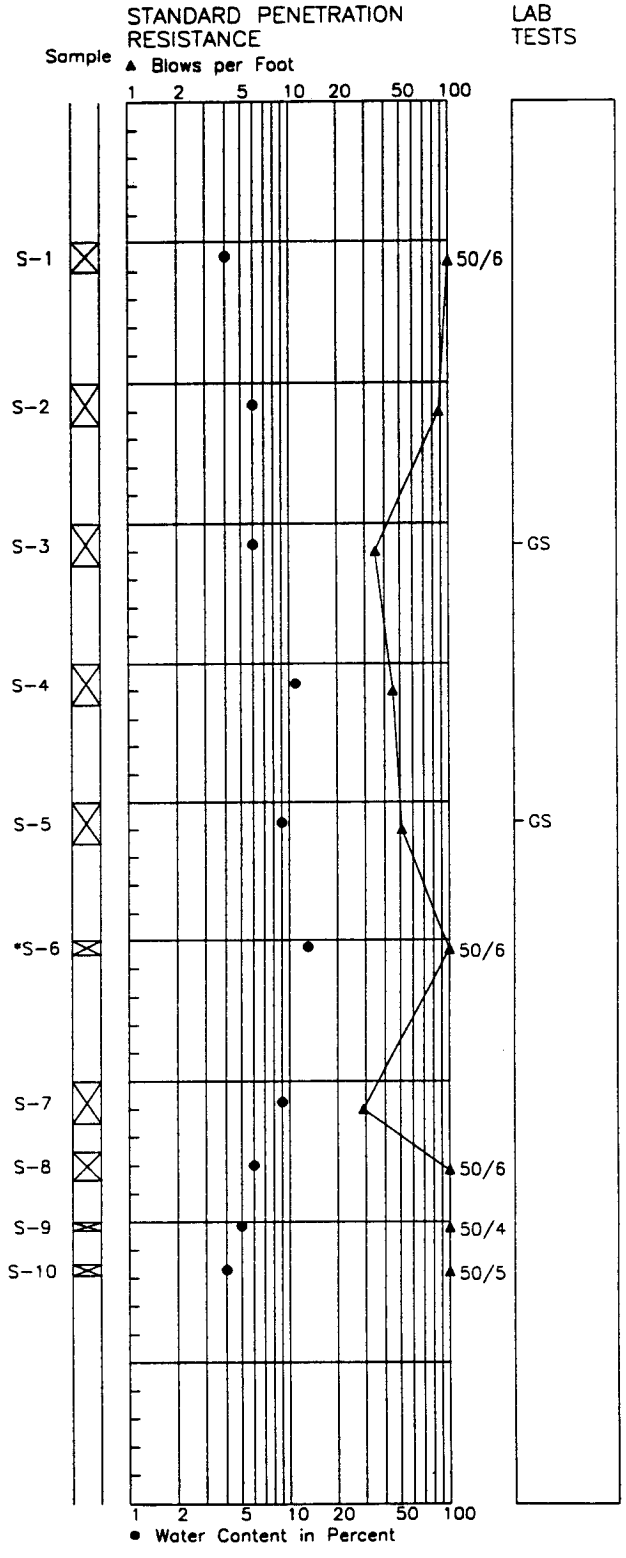
Very dense, moist, brown, slightly silty to silty, gravelly SAND. (FILL)

Dense, moist, brown, silty, very sandy GRAVEL. (FILL)

Medium dense to very dense, moist, brown, very silty, very sandy GRAVEL. (FILL)

Very dense, moist, brown, slightly clayey to clayey, very gravelly SAND. (FILL)

Bottom of Boring at 41.9 Feet.
Completed 11/18/99.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER

J-4978-18 11/99

Figure A-14

AR 044276

Boring Log HC99-B64

N 20681
E 10761

Soil Descriptions

Top of Casing Elevation in Feet: 294.20
Ground Surface Elevation in Feet: 292

Loose, wet, dark brown, silty, medium to fine SAND with some organic material.

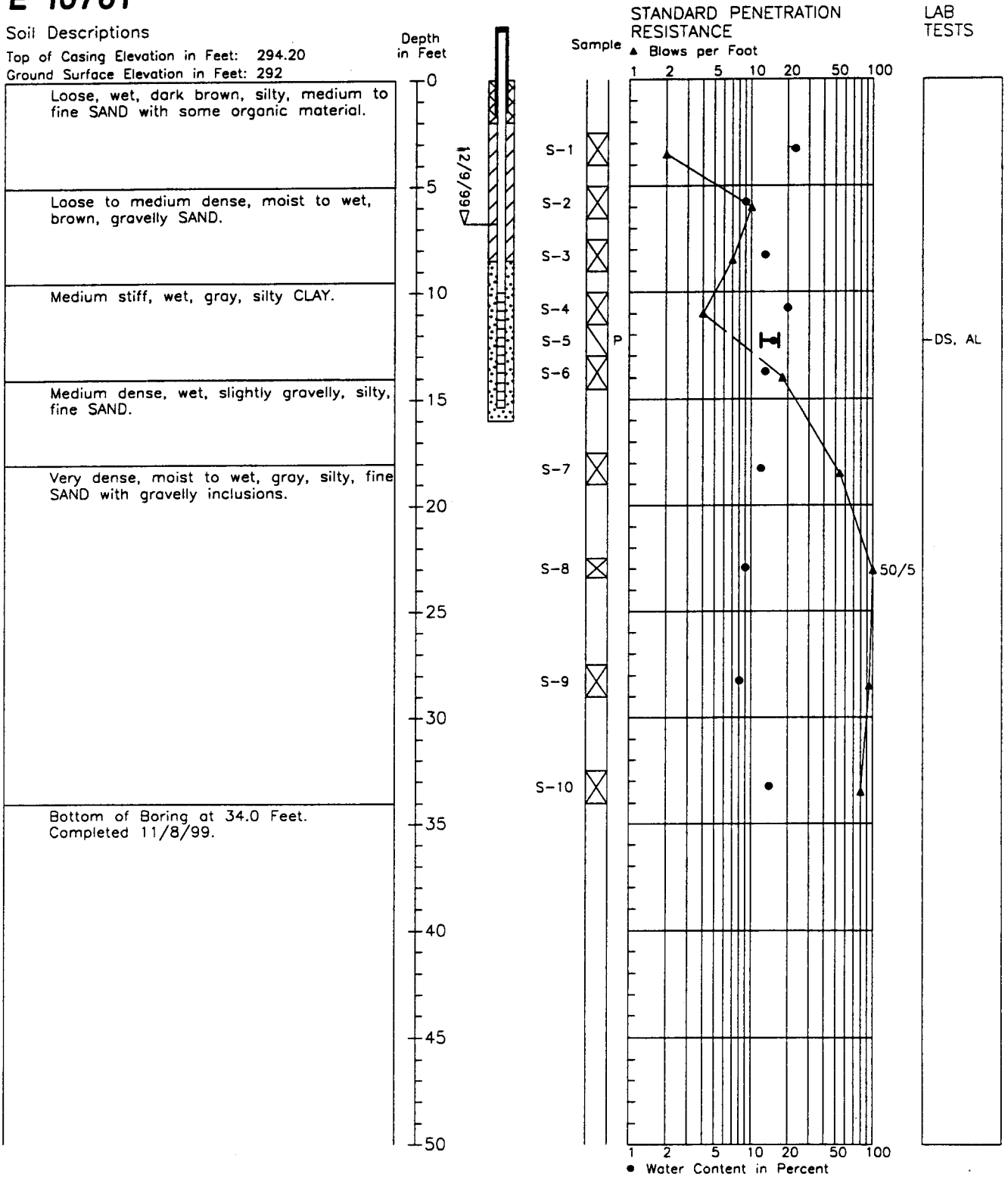
Loose to medium dense, moist to wet, brown, gravelly SAND.

Medium stiff, wet, gray, silty CLAY.

Medium dense, wet, slightly gravelly, silty, fine SAND.

Very dense, moist to wet, gray, silty, fine SAND with gravelly inclusions.

Bottom of Boring at 34.0 Feet.
Completed 11/8/99.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

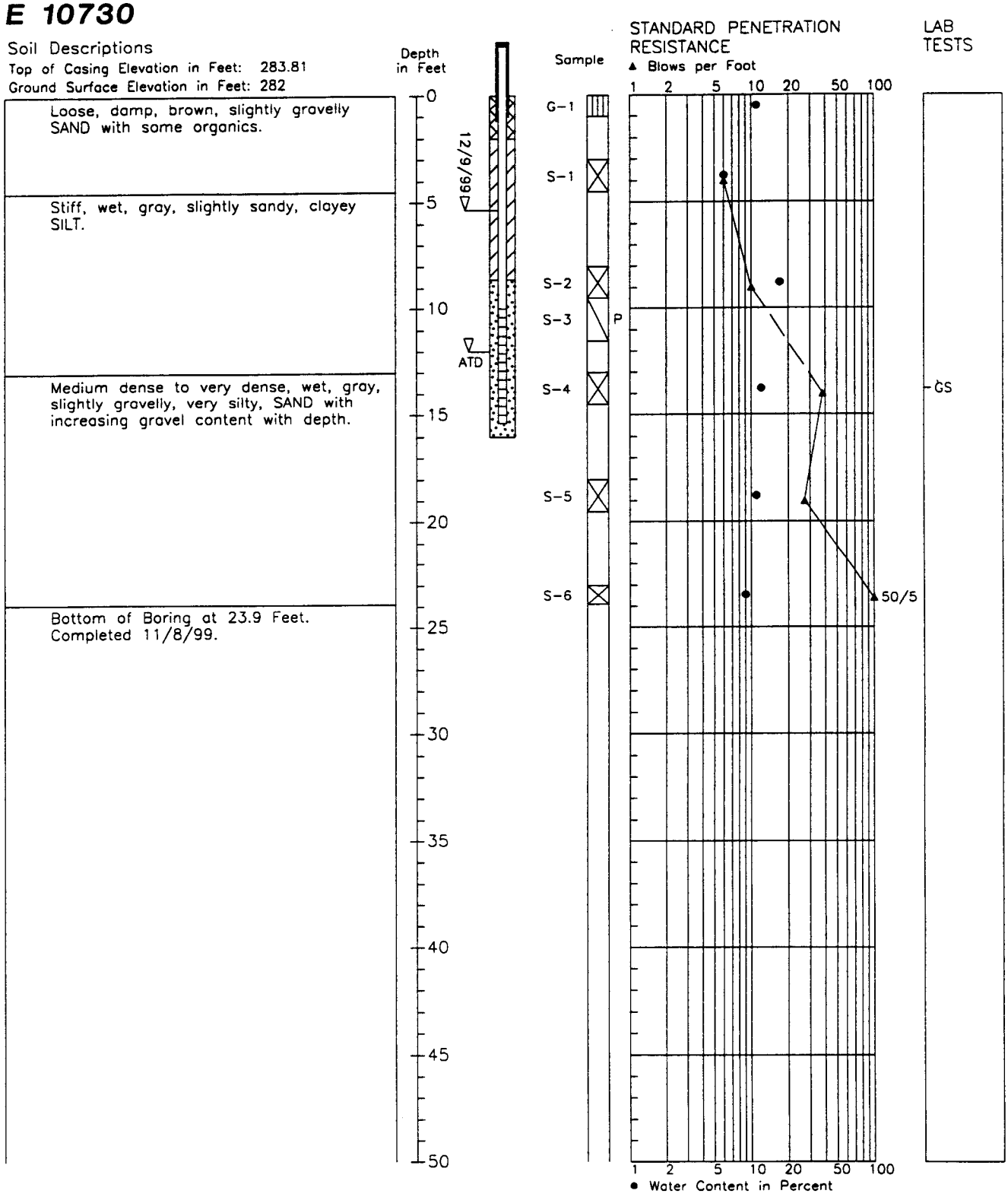
HARTCROWSER
J-4978-18 11/99
Figure A-15

AR 044277

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC99-B72

N 21023
E 10730



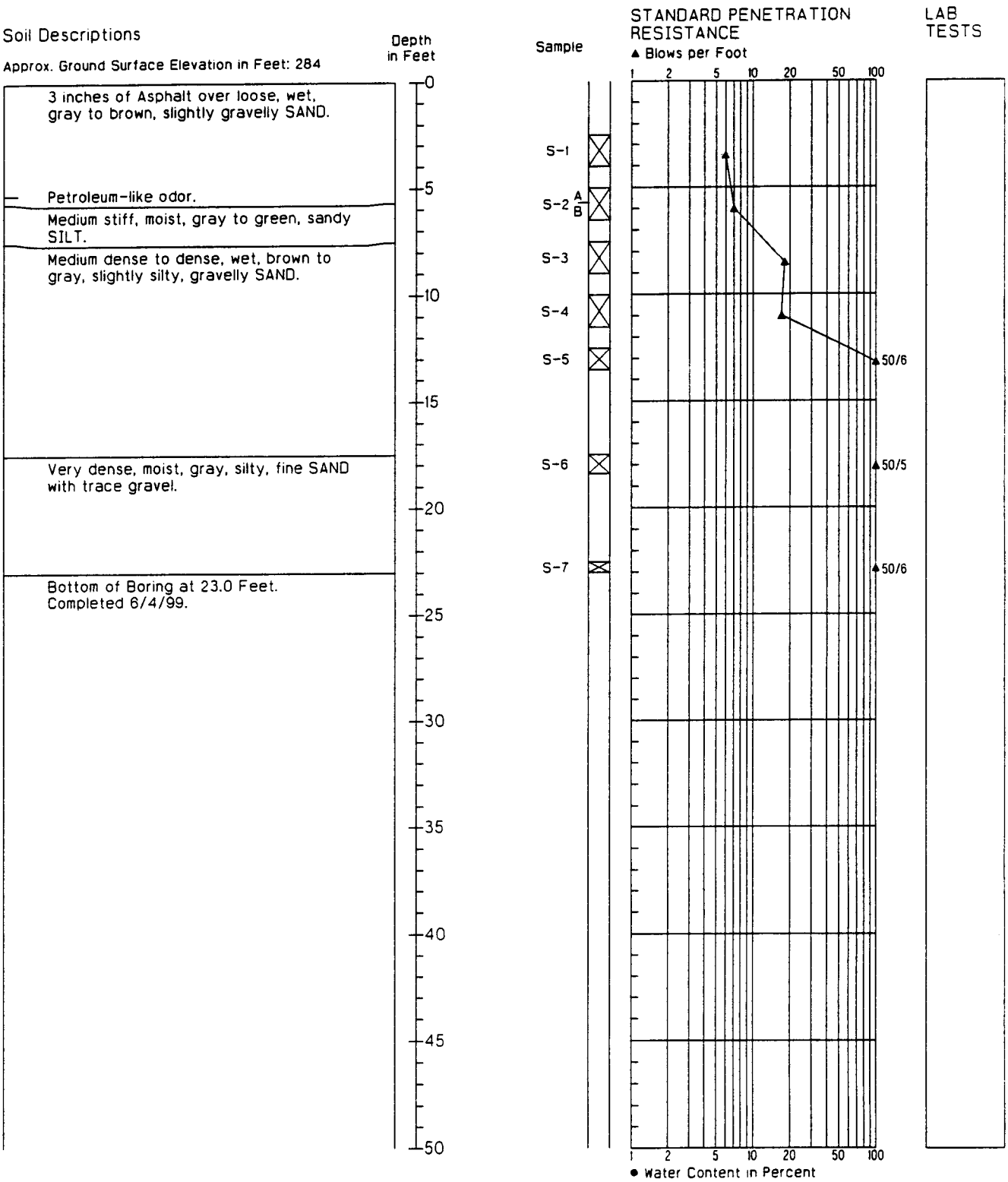
1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdslk-B.pc2
497818\LOGS

HARTCROWSER
J-4978-18 11/99
Figure A-16

AR 044278

Boring Log HC99-B75



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

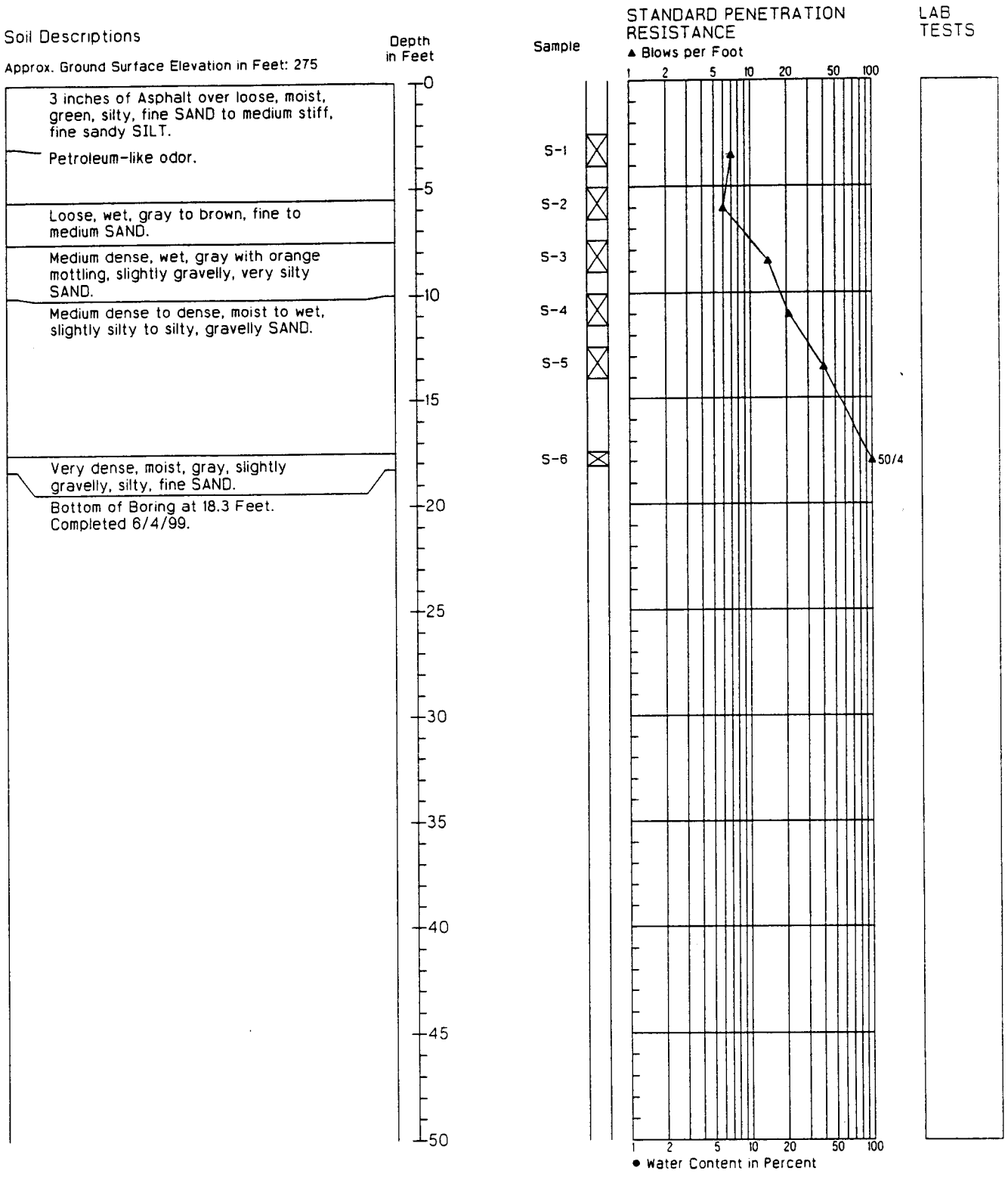
HARTCROWSER

J-4978-07 6/99

Figure A-17

AR 044279

Boring Log HC99-B76



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

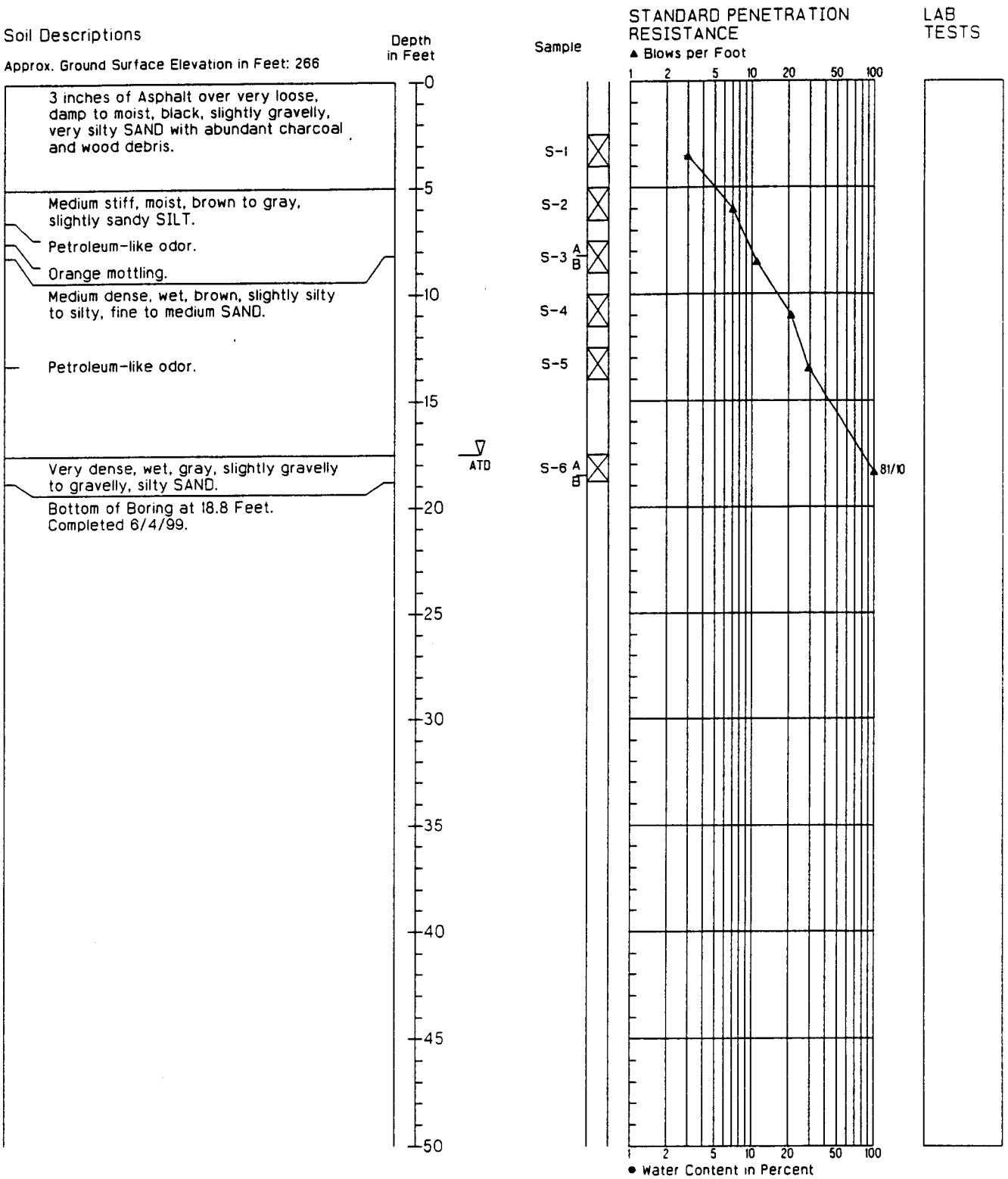
HARTCROWSER

J-4978-07 6/99

Figure A-18

AR 044280

Boring Log HC99-B77



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

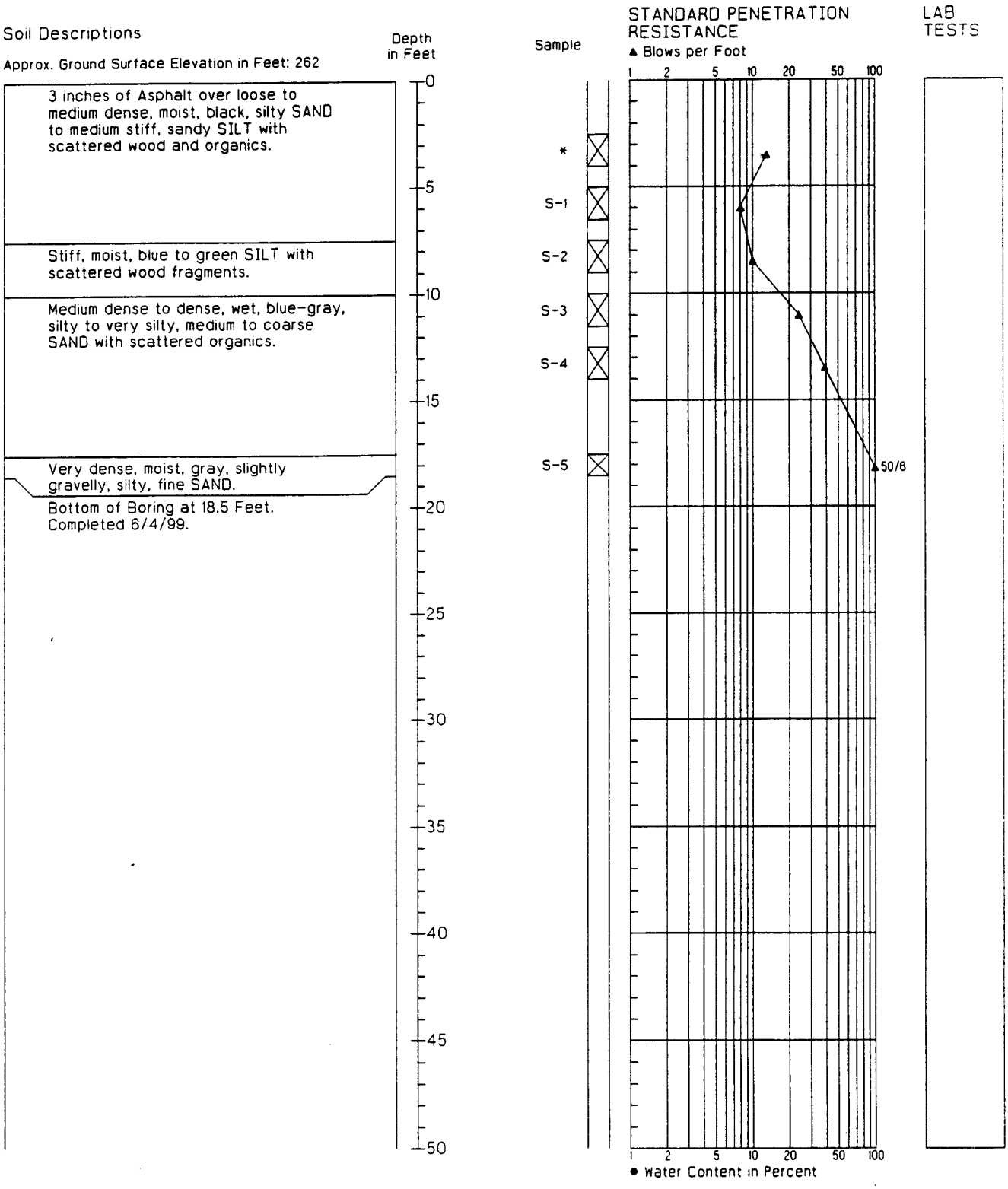
HARTCROWSER

J-4978-07 6/99

Figure A-19

AR 044281

Boring Log HC99-B78



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

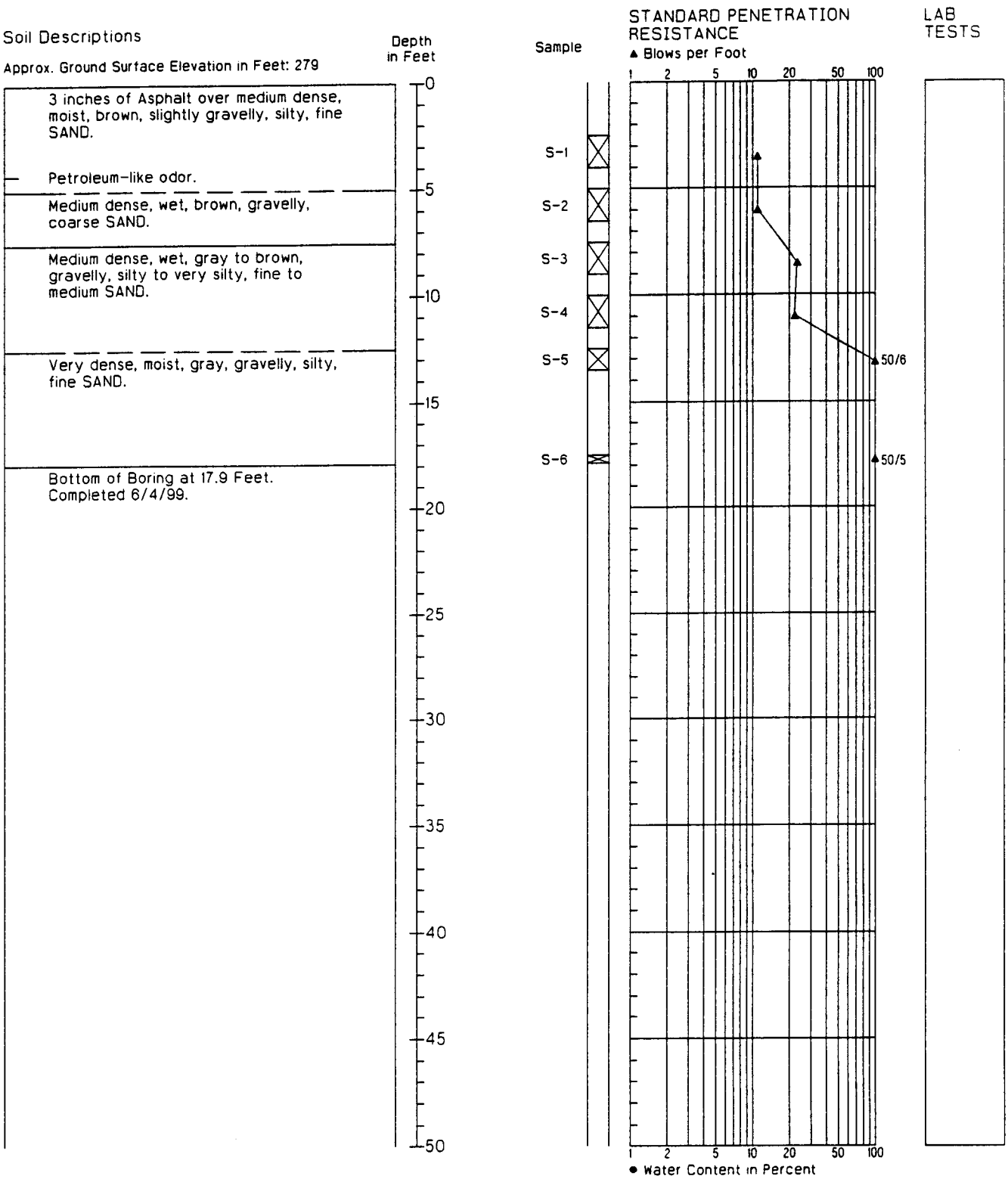
HARTCROWSER

J-4978-07 6/99

Figure A-20

AR 044282

Boring Log HC99-B79



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

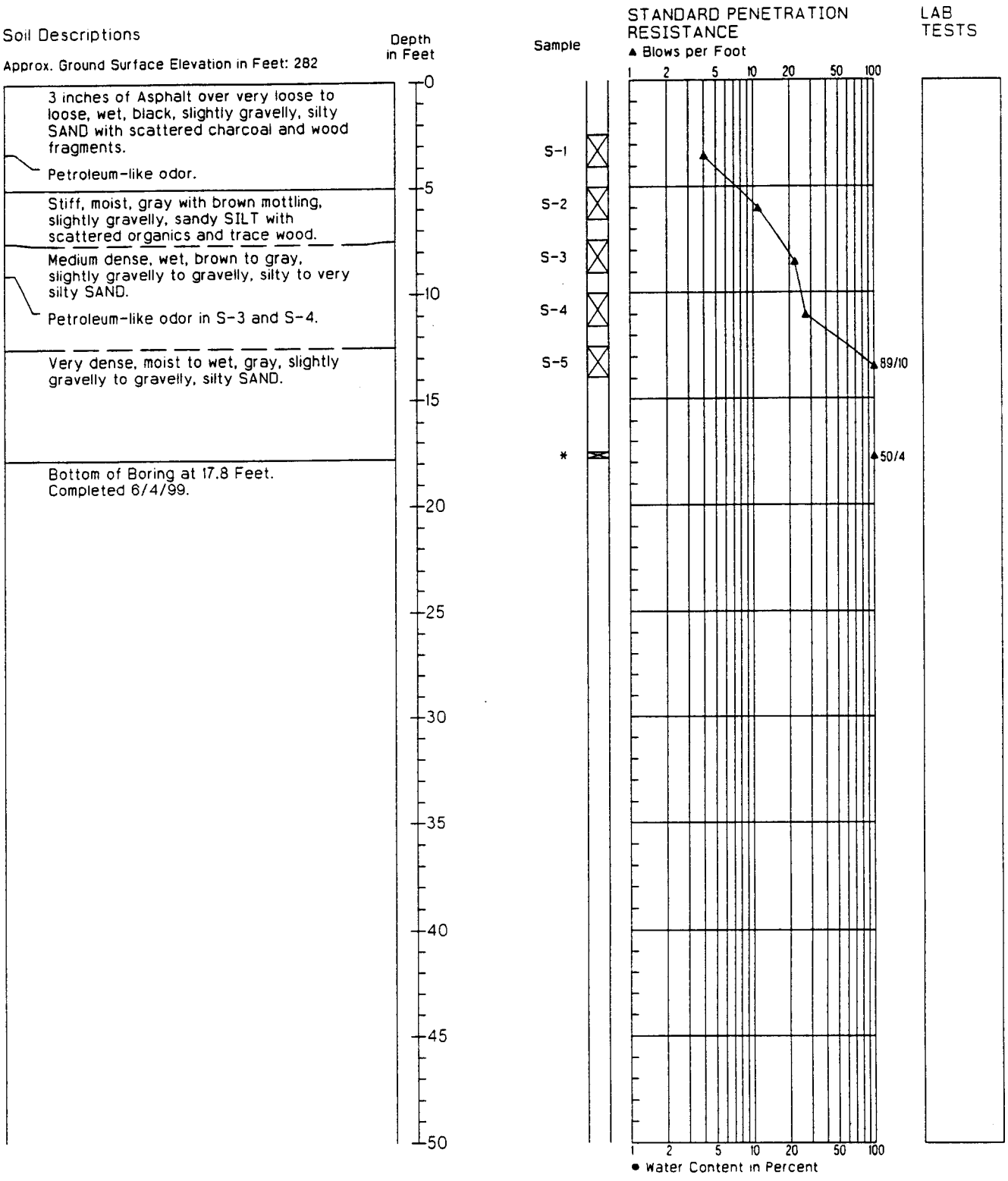
HARTCROWSER

J-4978-07 6/99

Figure A-21

AR 044283

Boring Log HC99-B80



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

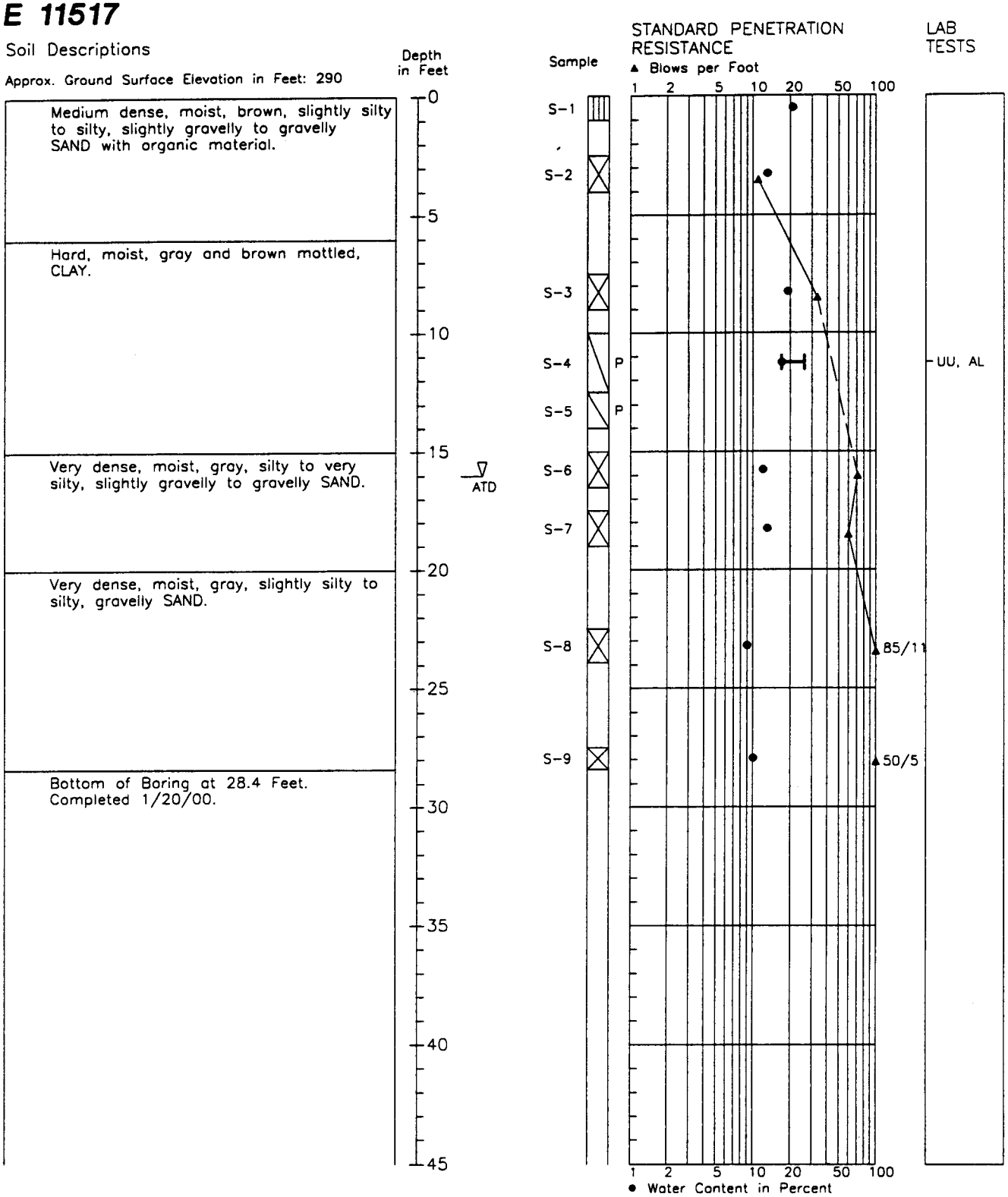
J-4978-07 6/99

Figure A-22

AR 044284

Boring Log HC00-B160

N 21820
E 11517



1. Refer to Figure A–1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 1/00

Figure A-23

AR 044285

HEM 2/27/00 1=1 wdslk-8.pc2
497818\LOGS

Boring Log HC00-B161

N 22024

E 11511

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 274

Depth in Feet

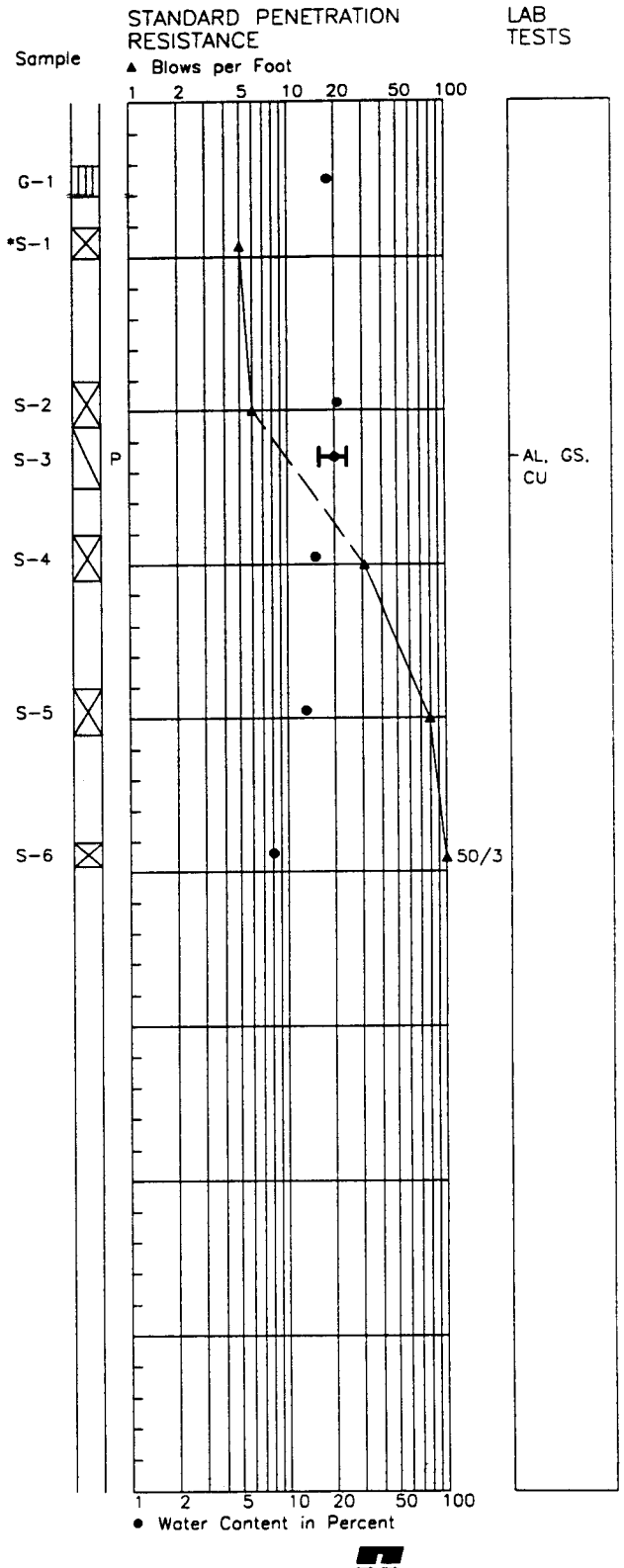
(Loose), wet, tan, slightly silty, gravelly SAND.

Medium stiff, moist, gray, sandy CLAY.

Hard, moist, gray, slightly gravelly, very sandy SILT.

Very dense, moist, gray, silty, gravelly SAND. (TILL)

Bottom of Boring at 24.8 Feet.
Completed 1/24/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 2/27/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER

J-4978-18 1/00

Figure A-24

AR 044286

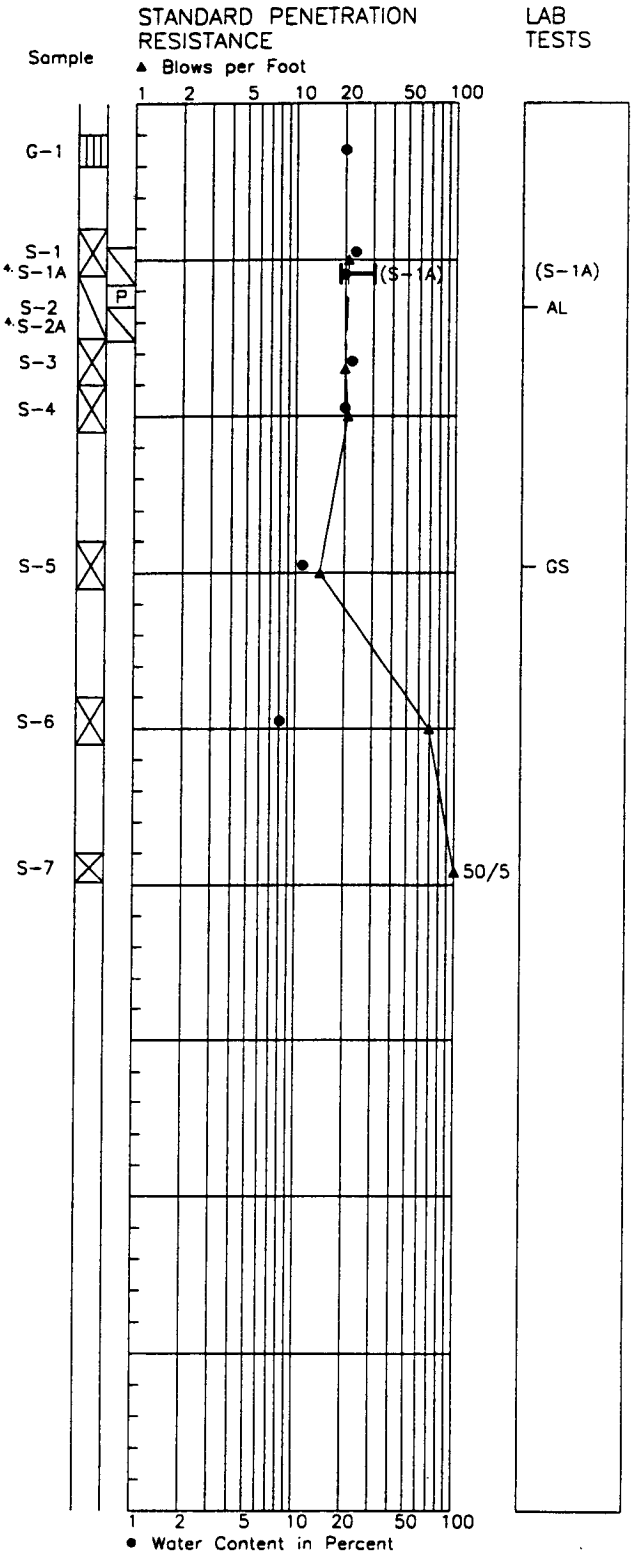
Boring Log HC00-B162

N 21872
E 11400

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 285

Depth in Feet	Soil Description
0	(Medium dense), moist, brown, slightly gravelly, silty SAND with organic material.
5	Very stiff, moist, brown and tan mottled CLAY.
10	Medium dense to very dense, moist, gray, gravelly, very silty SAND.
20	Very dense, moist, gray, silty, gravelly SAND. (TILL)
25	Bottom of Boring at 24.5 Feet. Completed 1/24/00.
30	
35	
40	
45	



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Shelby tube samples S-1A and S-2A pushed in adjacent boring HC00-B162A.

HARTCROWSER

J-4978-18 1/00

Figure A-25

AR 044287

HEM 2/27/00 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC00-B163

N 21984
E 11358

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 278

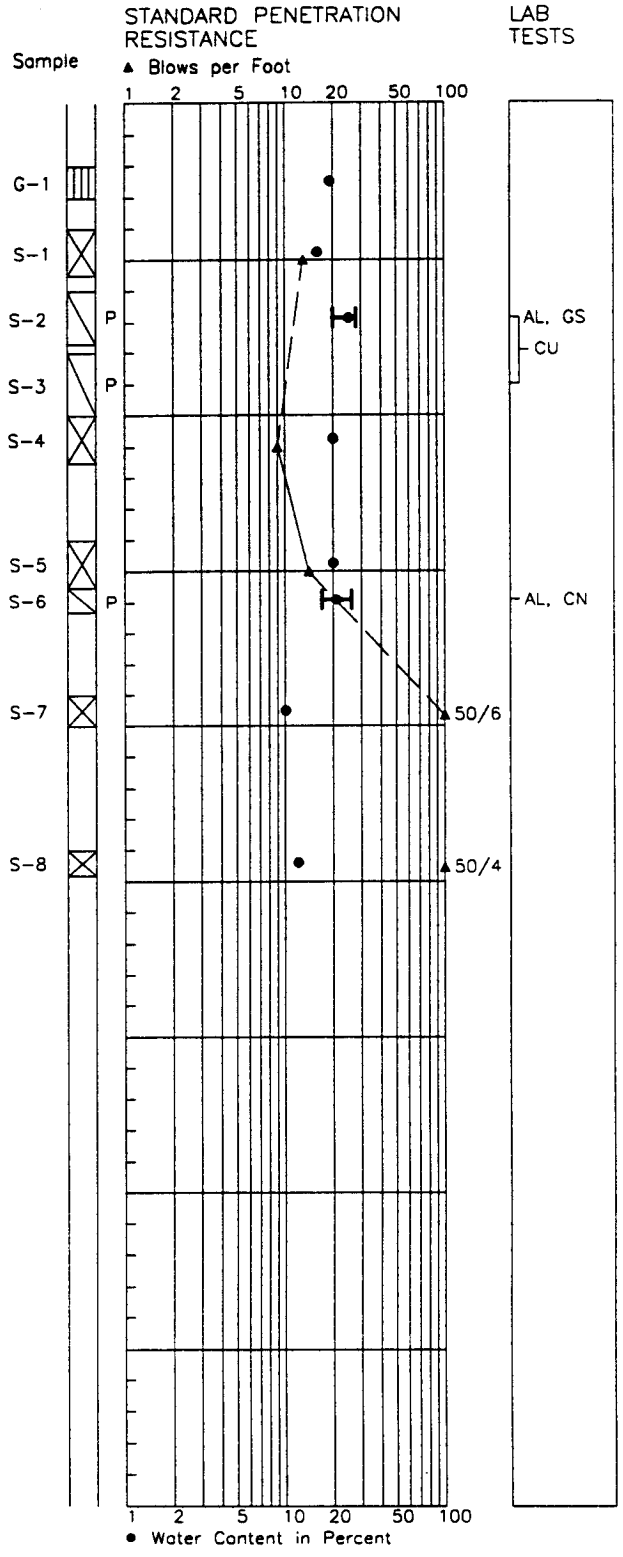
Depth in Feet

Medium dense, wet, tan, slightly gravelly, silty SAND.

Stiff to very stiff, moist, tan to gray, sandy CLAY.

Very dense, moist, gray, silty, gravelly SAND. (TILL)

Bottom of Boring at 24.8 Feet.
Completed 1/24/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

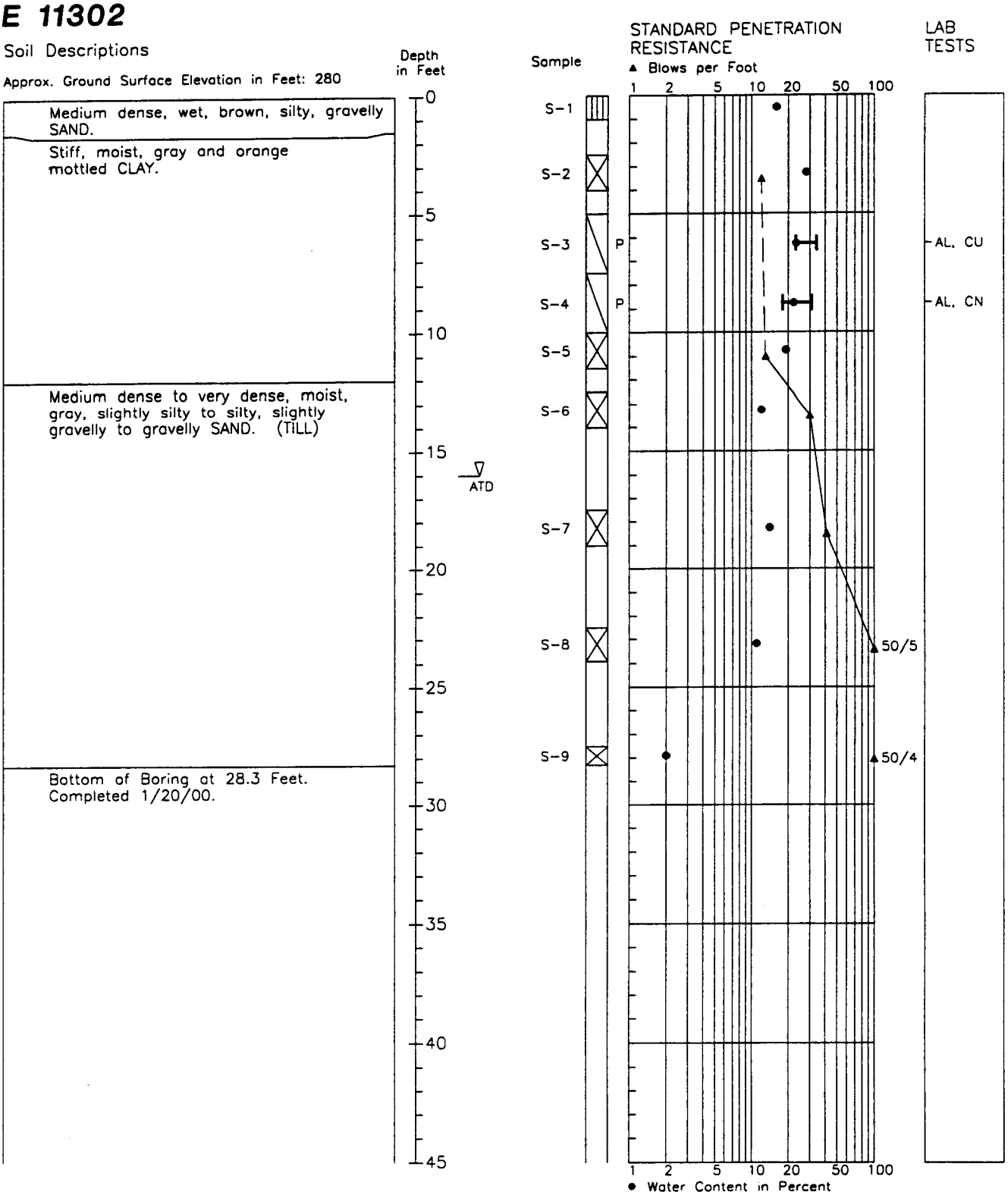
HEM 2/27/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER
J-4978-18 1/00
Figure A-26

AR 044288

Boring Log HC00-B164

N 21936
E 11302



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 2/27/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER

J-4978-18 1/00

Figure A-27

AR 044289

Boring Log HC00-B165

N 21825

E 11163

Soil Descriptions

Top of Casing Elevation in Feet: 278.48

Approx. Ground Surface Elevation in Feet: 277

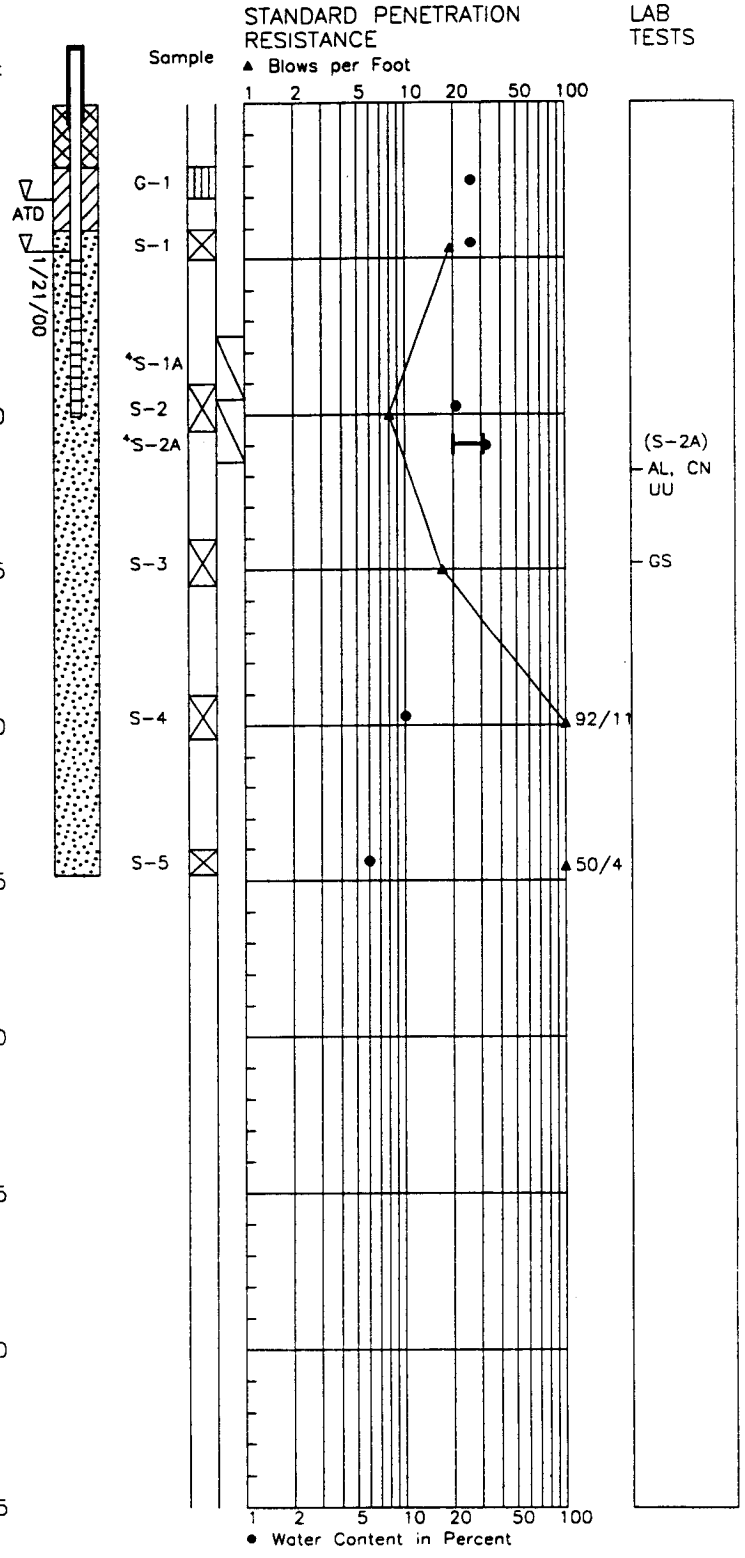
Medium dense, wet, brown, slightly silty to silty, gravelly SAND.

Medium stiff, moist, gray, CLAY.

Medium dense, gravelly, silty SAND.

Very dense, moist, gray, silty, gravelly SAND. (TILL)

Bottom of Boring at 24.8 Feet. Completed 1/21/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Shelby tube samples S-1A and S-2A pushed in adjacent boring HC00-B165A.

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER

J-4978-18 1/00

Figure A-28

AR 044290

Boring Log HC00-B166

N 21917
E 11089

Soil Descriptions

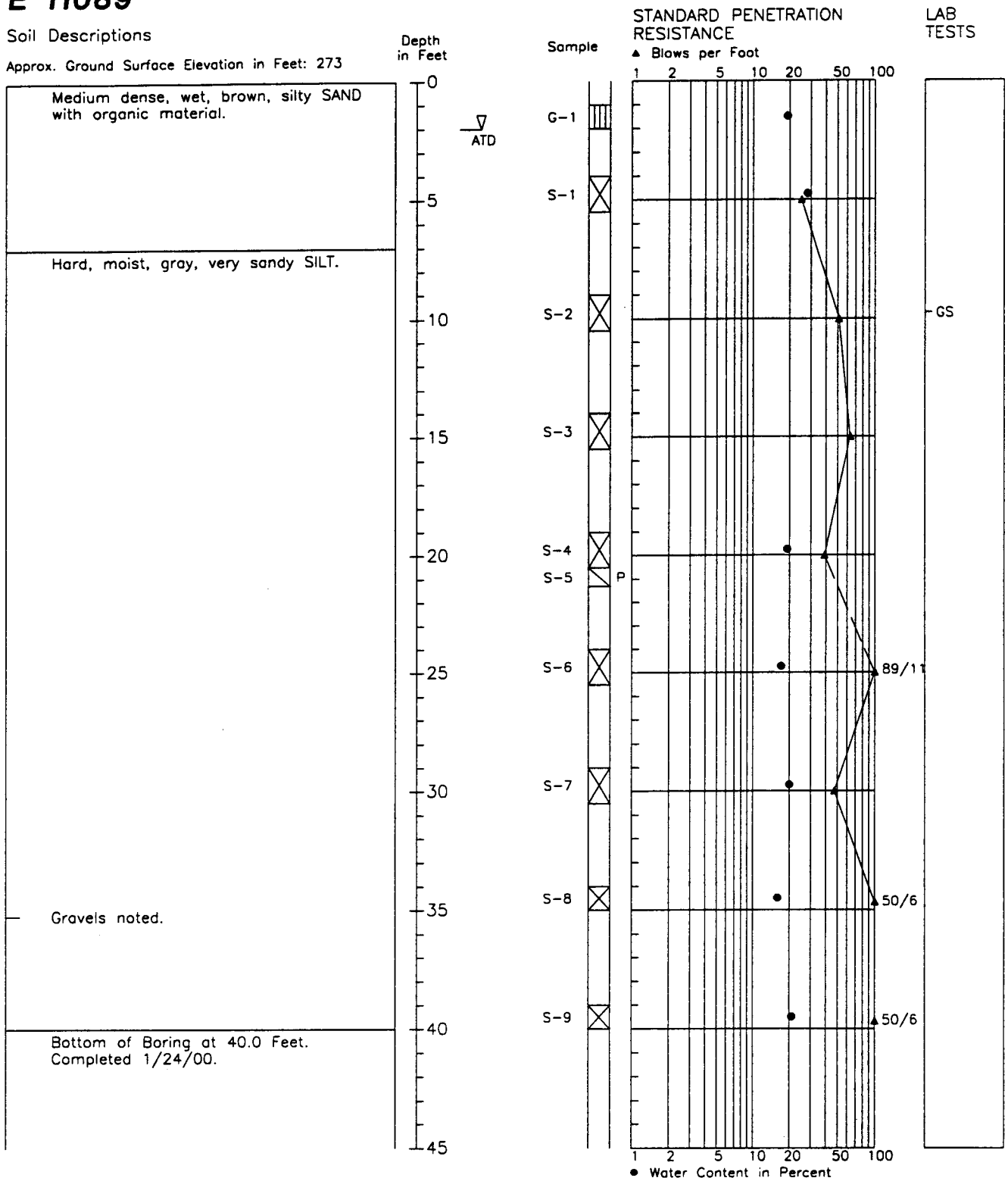
Approx. Ground Surface Elevation in Feet: 273

Medium dense, wet, brown, silty SAND with organic material.

Hard, moist, gray, very sandy SILT.

Gravels noted.

Bottom of Boring at 40.0 Feet.
Completed 1/24/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 1/00

Figure A-29

AR 044291

DJH 12/30/99 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC00-B167

N 21737
E 10999

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 276

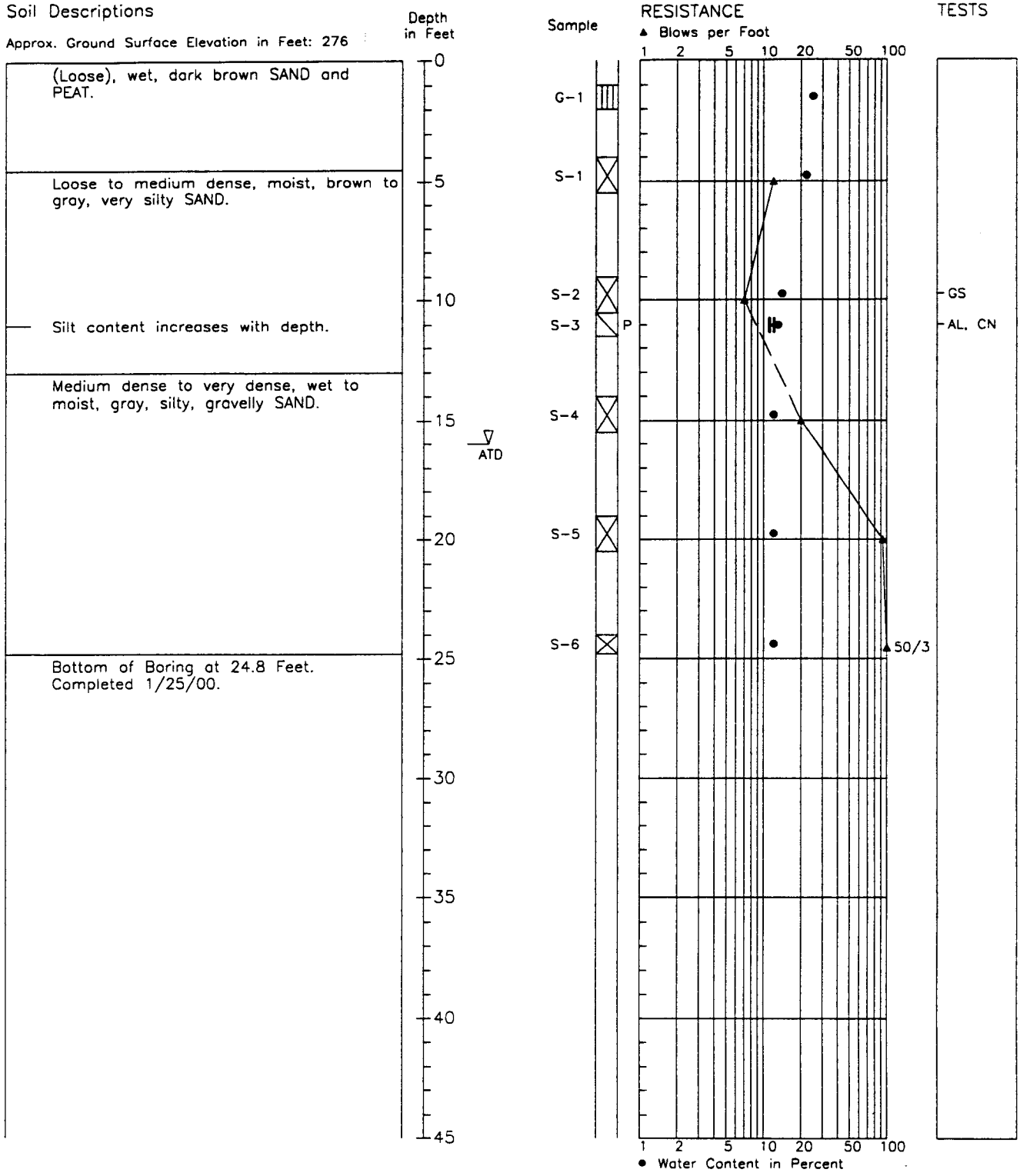
(Loose), wet, dark brown SAND and PEAT.

Loose to medium dense, moist, brown to gray, very silty SAND.

Silt content increases with depth.

Medium dense to very dense, wet to moist, gray, silty, gravelly SAND.

Bottom of Boring at 24.8 Feet.
Completed 1/25/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdslk-8.pc2
497818\LOGS

HARTCROWSER
J-4978-18 1/00
Figure A-30

AR 044292

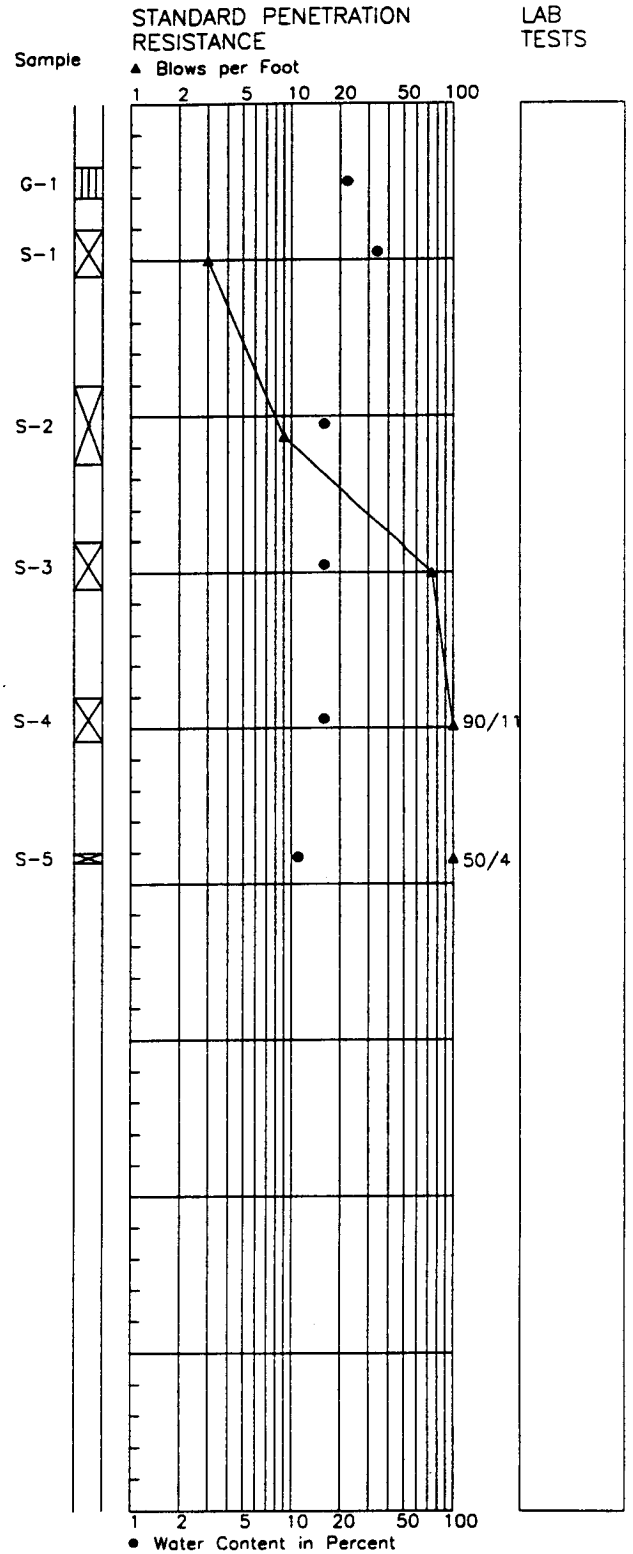
Boring Log HC00-B168

N 21789
E 10980

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 274

Soil Descriptions
(Medium dense), wet, brown, slightly silty SAND.
Soft, moist, gray, slightly sandy, clayey SILT.
Loose, wet, gray, slightly gravelly, silty SAND.
Hard, moist, gray, slightly gravelly, slightly sandy SILT.
Very dense, wet to moist, gray, silty, gravelly SAND. (TILL)
Bottom of Boring at 24.3 Feet. Completed 1/21/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 1/00

Figure A-31

AR 044293

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC00-B169

N 21653
E 10889

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 273

Depth in Feet

Medium dense, moist to wet, brown, slightly gravelly to gravelly, slightly silty SAND.

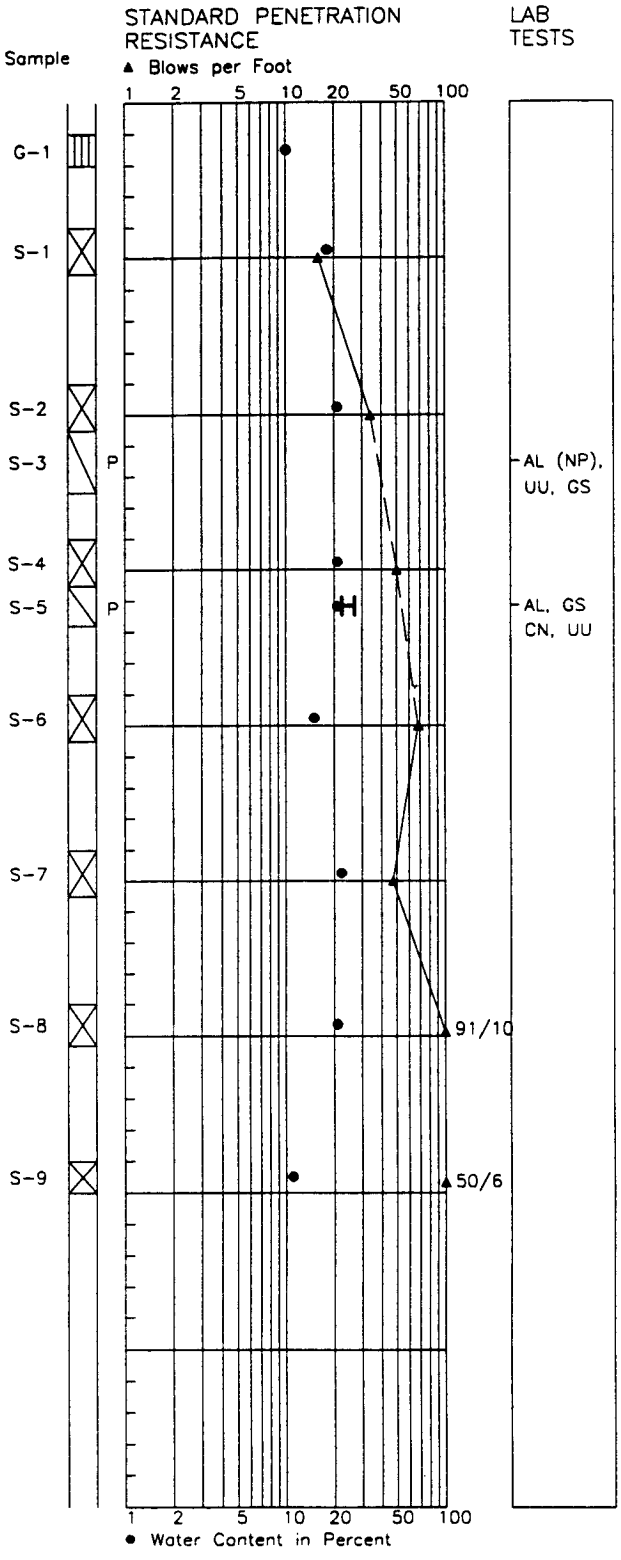
Dense, wet, gray, slightly clayey, slightly gravelly, silty SAND.

Hard, moist, gray, slightly sandy, clayey SILT.

Hard, moist, gray, slightly sandy to sandy SILT.

Very dense, wet, gray, slightly gravelly, very silty SAND.

Bottom of Boring at 35.0 Feet.
Completed 1/25/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdstk-B.pc2
497818\LOGS

HARTCROWSER
J-4978-18 1/00
Figure A-32

AR 044294

Boring Log HC00-B170

N 21602
E 10834

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 269

Depth in Feet

Medium dense, wet, dark brown to brown, silty to clean SAND.

Grades to gravelly.

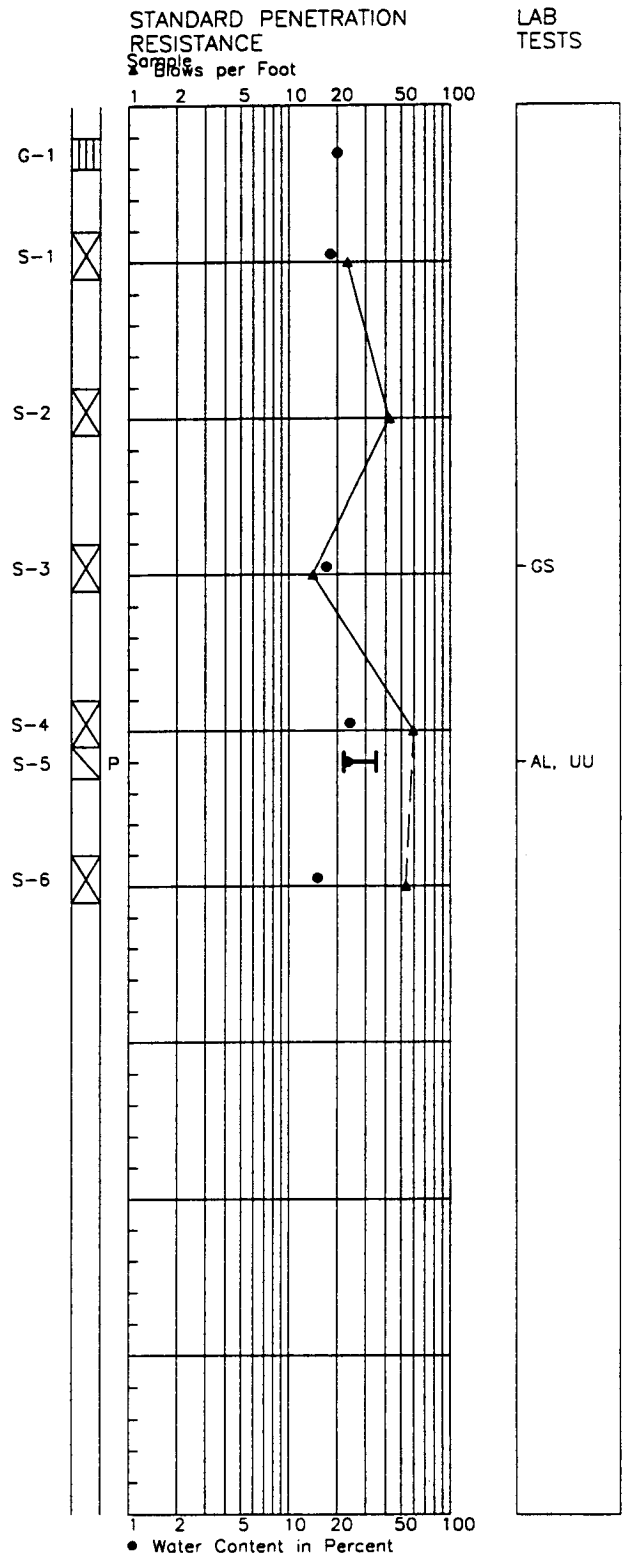
ATD

Medium dense to dense, wet, gray, slightly gravelly, silty to very silty SAND.

Hard, moist, gray, slightly sandy, silty CLAY.

Very dense, moist, gray, silty SAND.

Bottom of Boring at 25.5 Feet. Completed 1/21/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 1/00

Figure A-33

AR 044295

HEM 2/27/00 1=1 wdsite-8.pc2
497818\LOGS

Boring Log HC00-B171

N 21426
E 10910

Soil Descriptions

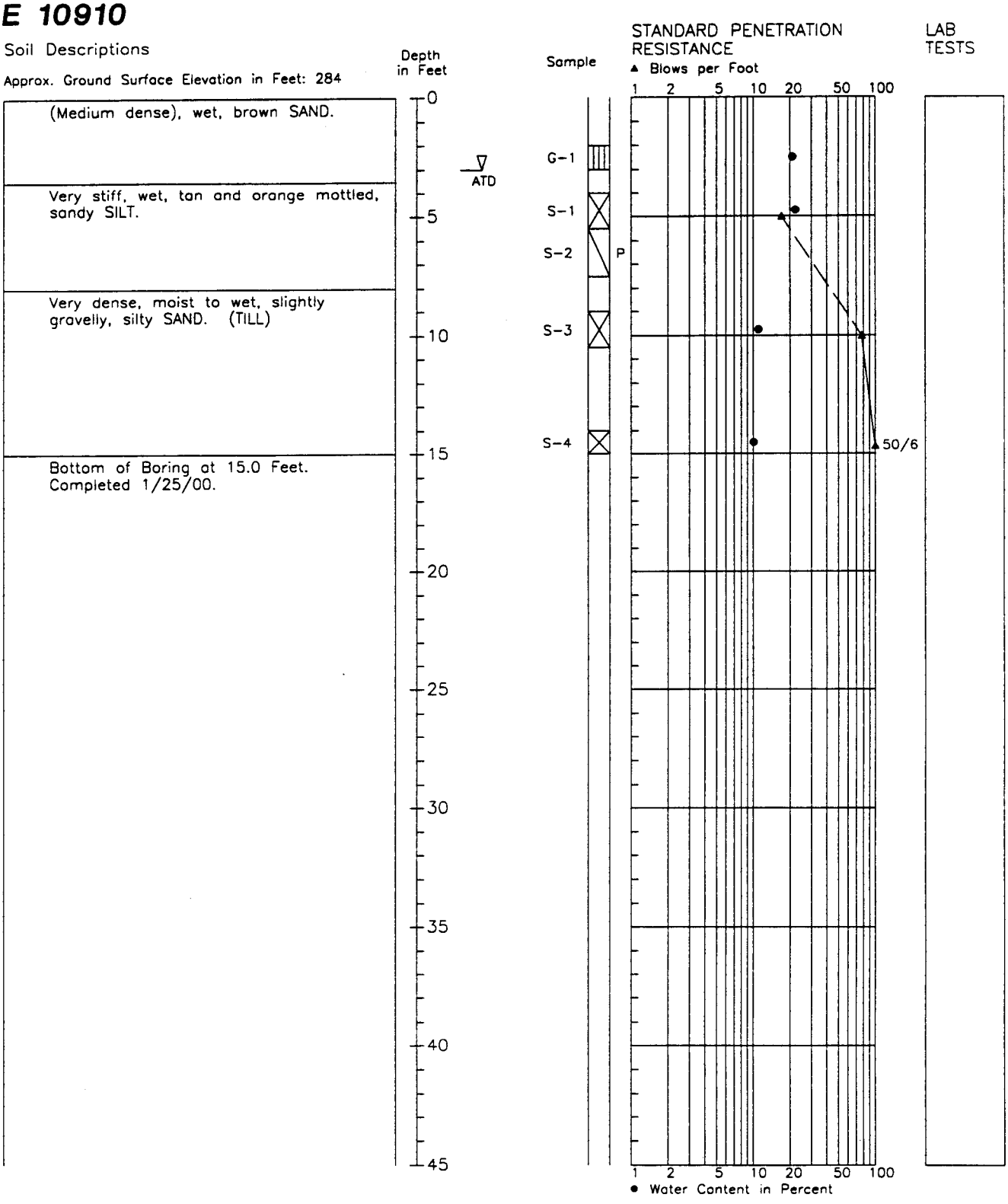
Approx. Ground Surface Elevation in Feet: 284

(Medium dense), wet, brown SAND.

Very stiff, wet, tan and orange mottled, sandy SILT.

Very dense, moist to wet, slightly gravelly, silty SAND. (TILL)

Bottom of Boring at 15.0 Feet.
Completed 1/25/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 1/00

Figure A-34

AR 044296

HEM 2/27/00 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC00-B172

N 21389
E 10838

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 280

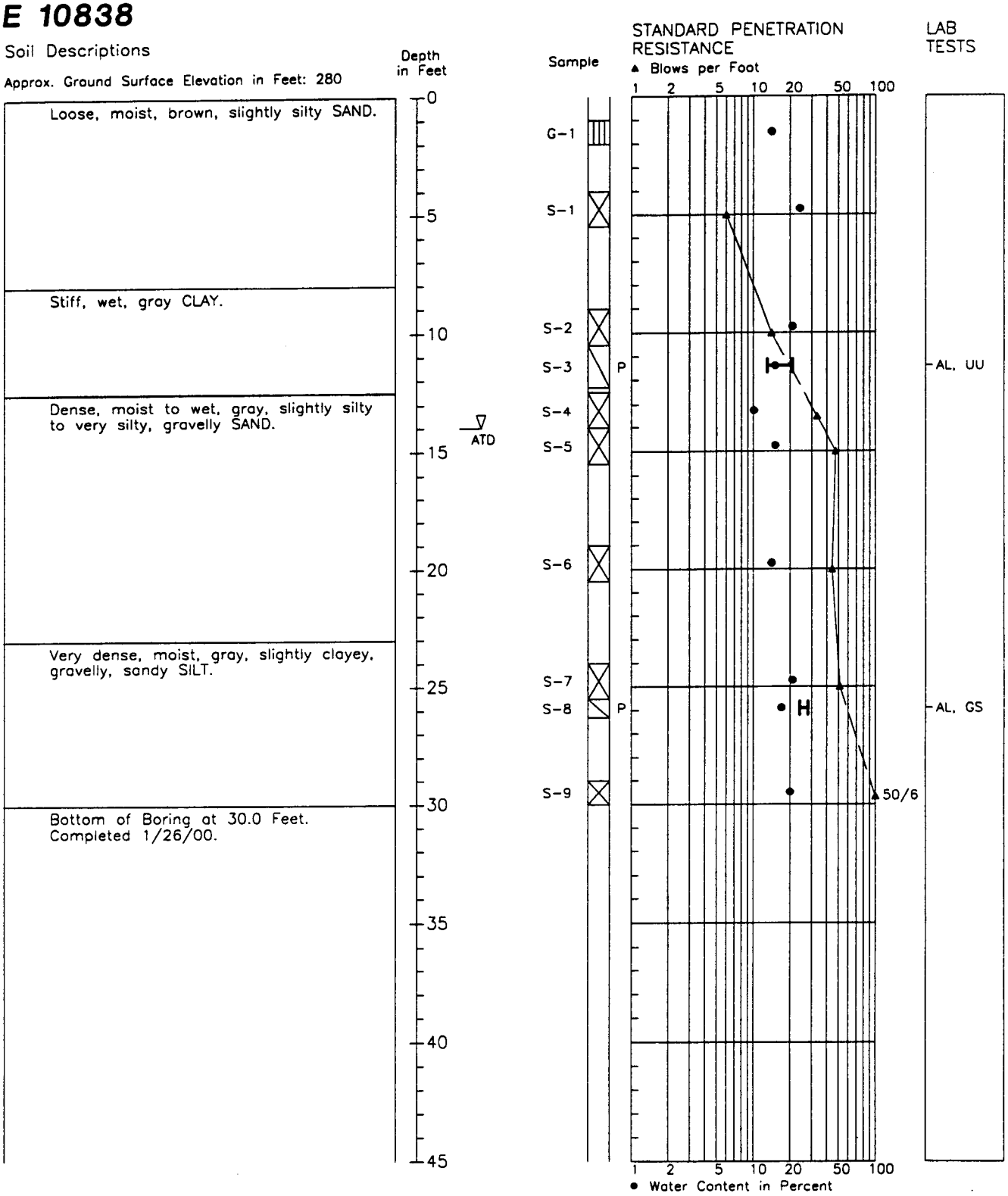
Loose, moist, brown, slightly silty SAND.

Stiff, wet, gray CLAY.

Dense, moist to wet, gray, slightly silty to very silty, gravelly SAND.

Very dense, moist, gray, slightly clayey, gravelly, sandy SILT.

Bottom of Boring at 30.0 Feet.
Completed 1/26/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 1/00

Figure A-35

AR 044297

HEM 2/27/00 1=1 wdslk-8.pc2
497818\LOGS

Boring Log HC00-B173

N 21378
E 10713

Soil Descriptions

Top of Casing Elevation in Feet: 276.13

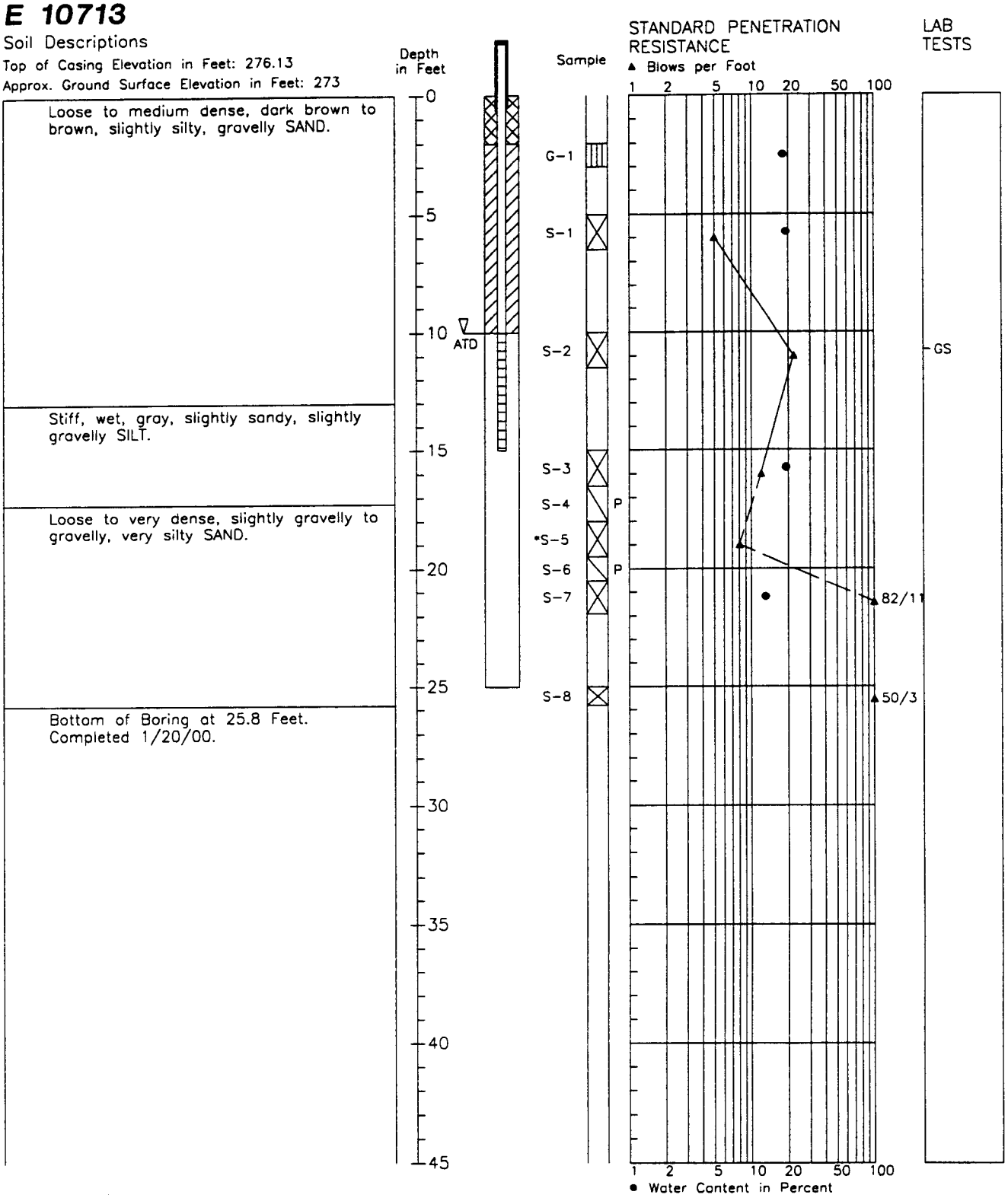
Approx. Ground Surface Elevation in Feet: 273

Loose to medium dense, dark brown to brown, slightly silty, gravelly SAND.

Stiff, wet, gray, slightly sandy, slightly gravelly SILT.

Loose to very dense, slightly gravelly to gravelly, very silty SAND.

Bottom of Boring at 25.8 Feet.
Completed 1/20/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 1/10/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER

J-4978-18 1/00

Figure A-36

AR 044298

Boring Log HC00-B174

N 21394

E 10628

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 267

(Loose), wet, brown, silty SAND.

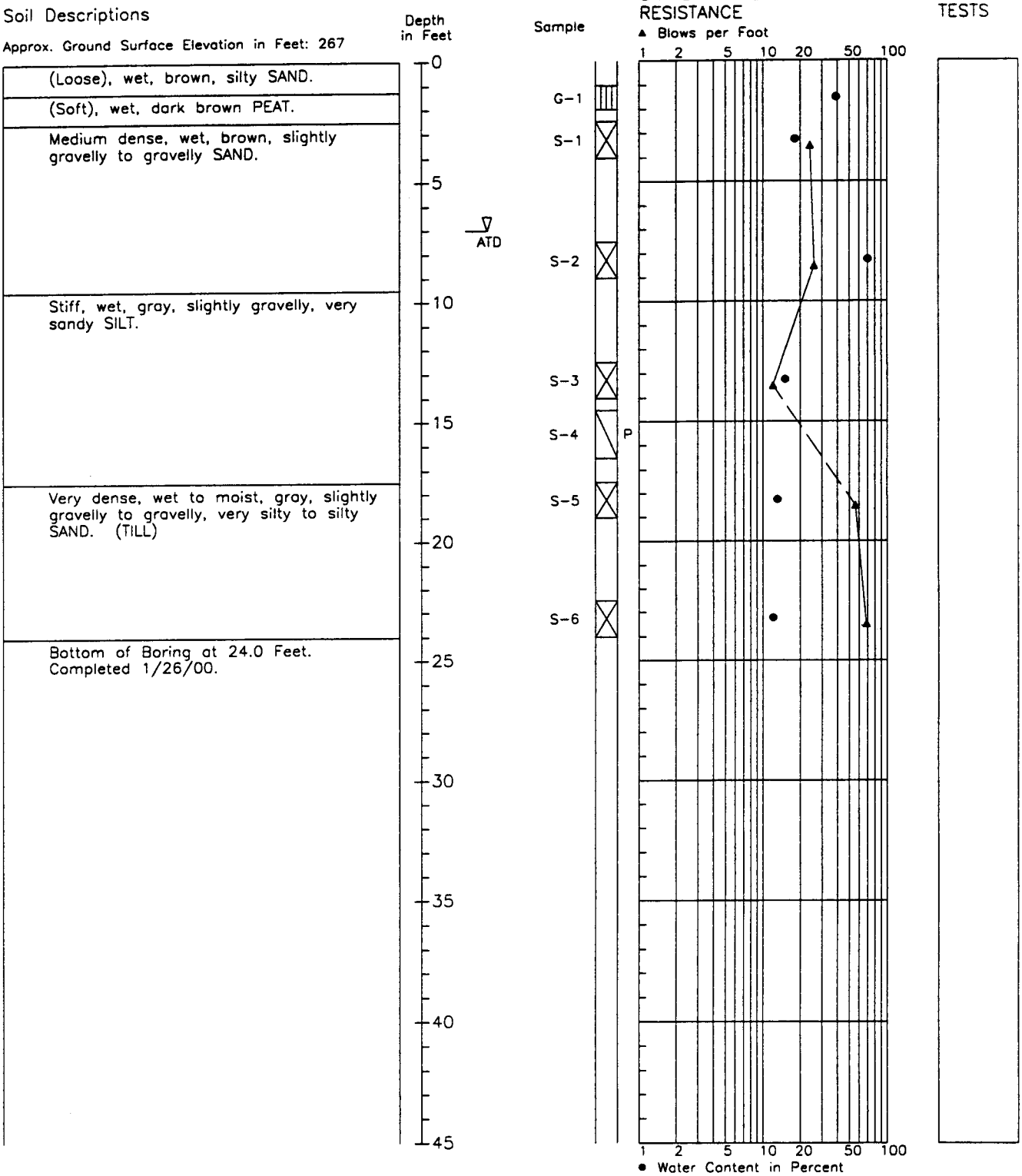
(Soft), wet, dark brown PEAT.

Medium dense, wet, brown, slightly gravelly to gravelly SAND.

Stiff, wet, gray, slightly gravelly, very sandy SILT.

Very dense, wet to moist, gray, slightly gravelly to gravelly, very silty to silty SAND. (TILL)

Bottom of Boring at 24.0 Feet.
Completed 1/26/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-18 1/00

Figure A-37

AR 044299

HEM 2/27/00 1=1 wdstk-8.pc2
497818\LOGS

Boring Log HC00-B175

N 21988

E 11687

Soil Descriptions

Approx. Ground Surface Elevation in Feet: 278

Medium dense, wet, brown, slightly silty to silty, gravelly SAND.

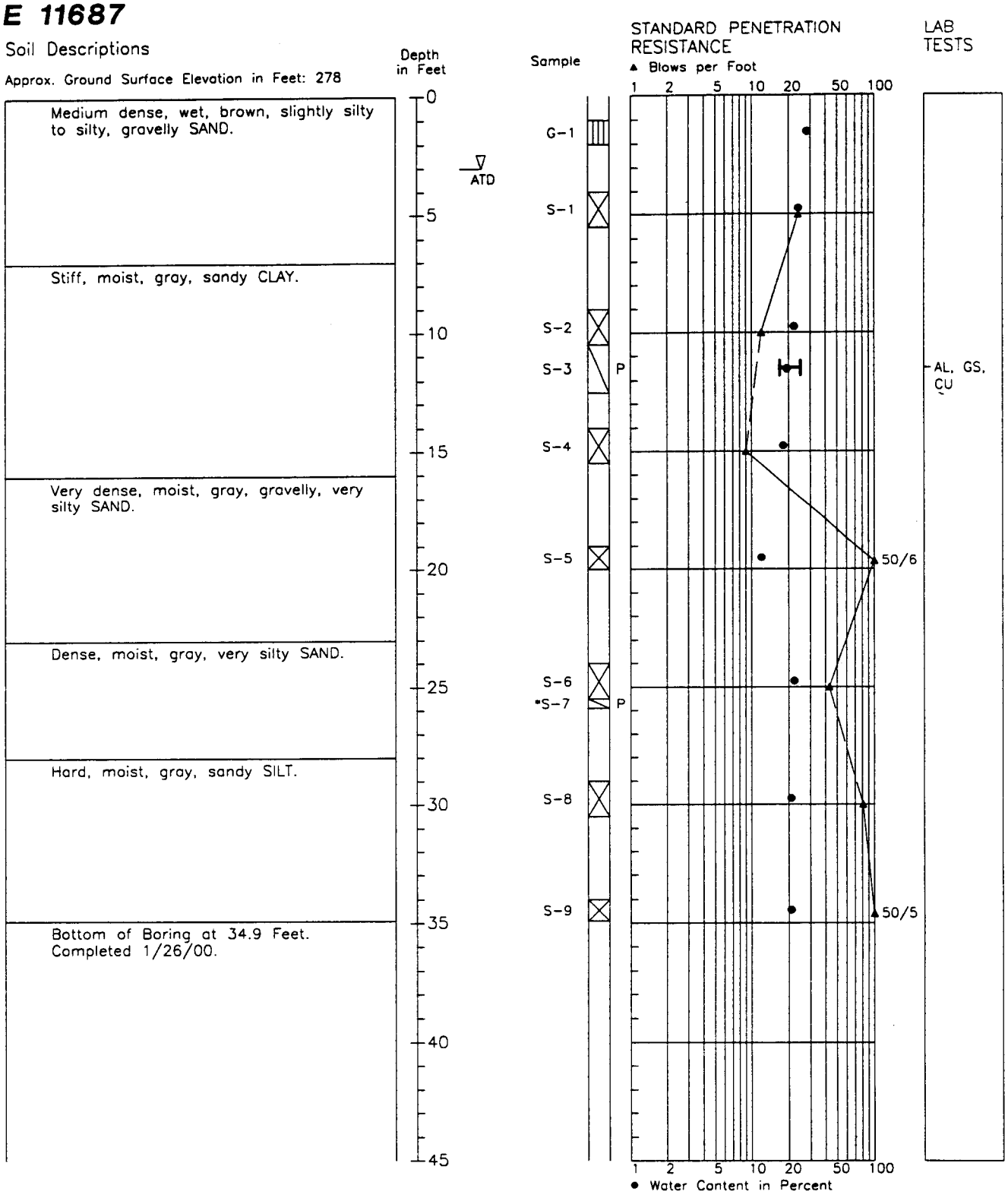
Stiff, moist, gray, sandy CLAY.

Very dense, moist, gray, gravelly, very silty SAND.

Dense, moist, gray, very silty SAND.

Hard, moist, gray, sandy SILT.

Bottom of Boring at 34.9 Feet.
Completed 1/26/00.



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HEM 2/27/00 1=1 wdstk-8.pc2
497818\LOGS

HARTCROWSER

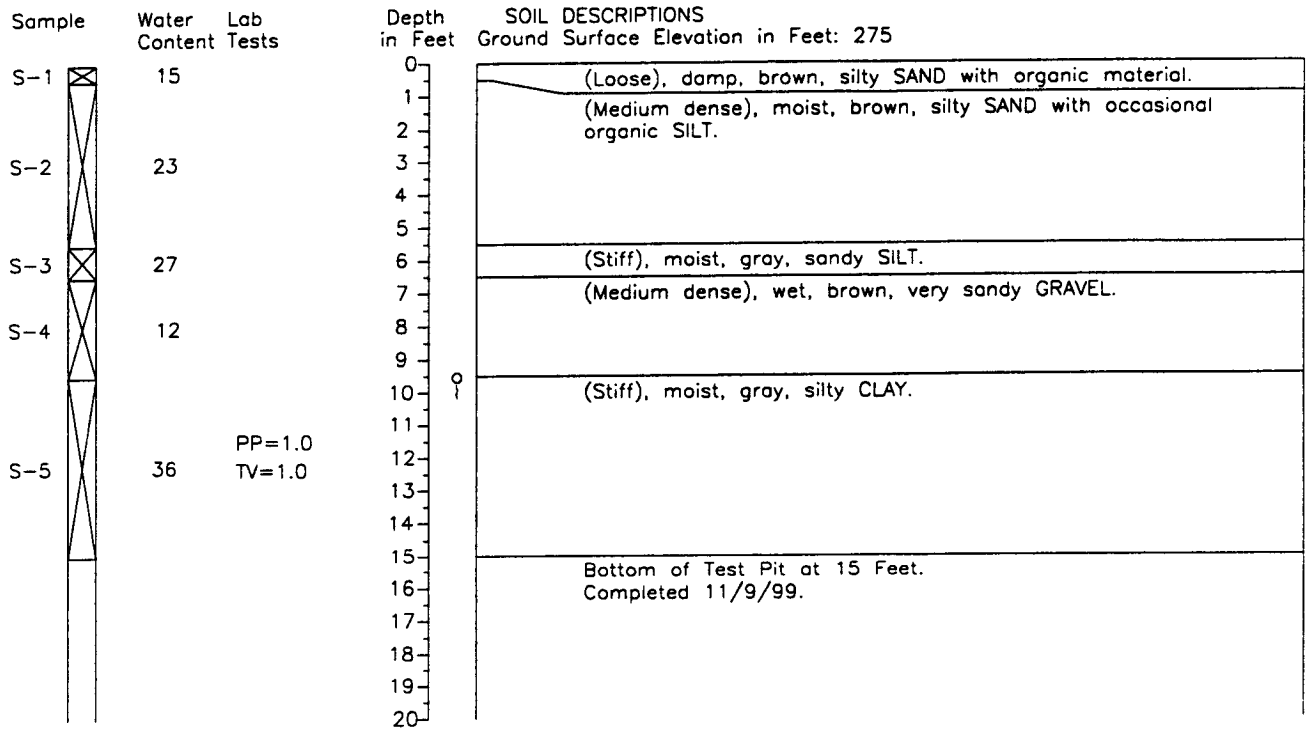
J-4978-18 1/00

Figure A-38

AR 044300

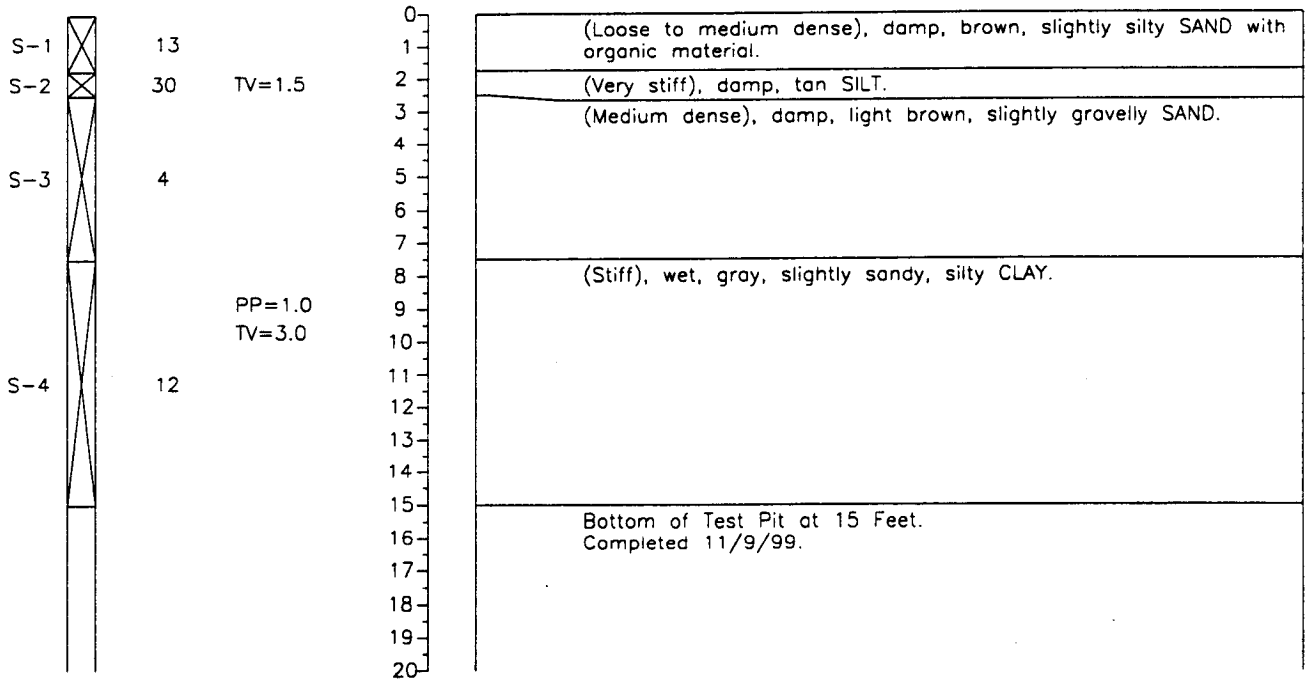
Test Pit Log HC99-TP23

N 21924
E 11198



Test Pit Log HC99-TP24

N 21590
E 10846



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

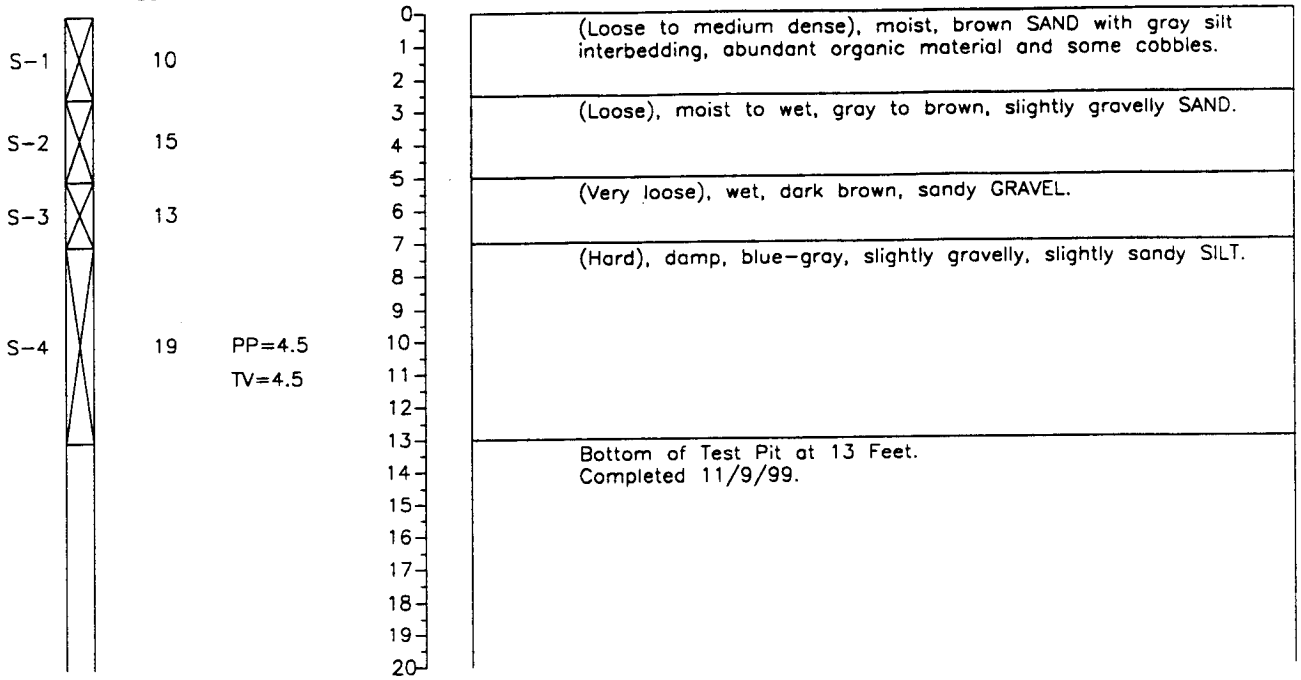
HARTCROWSER
J-4978-18 11/99
Figure A-39

AR 044301

hem 12/22/99 1=1 Test Pits
497818

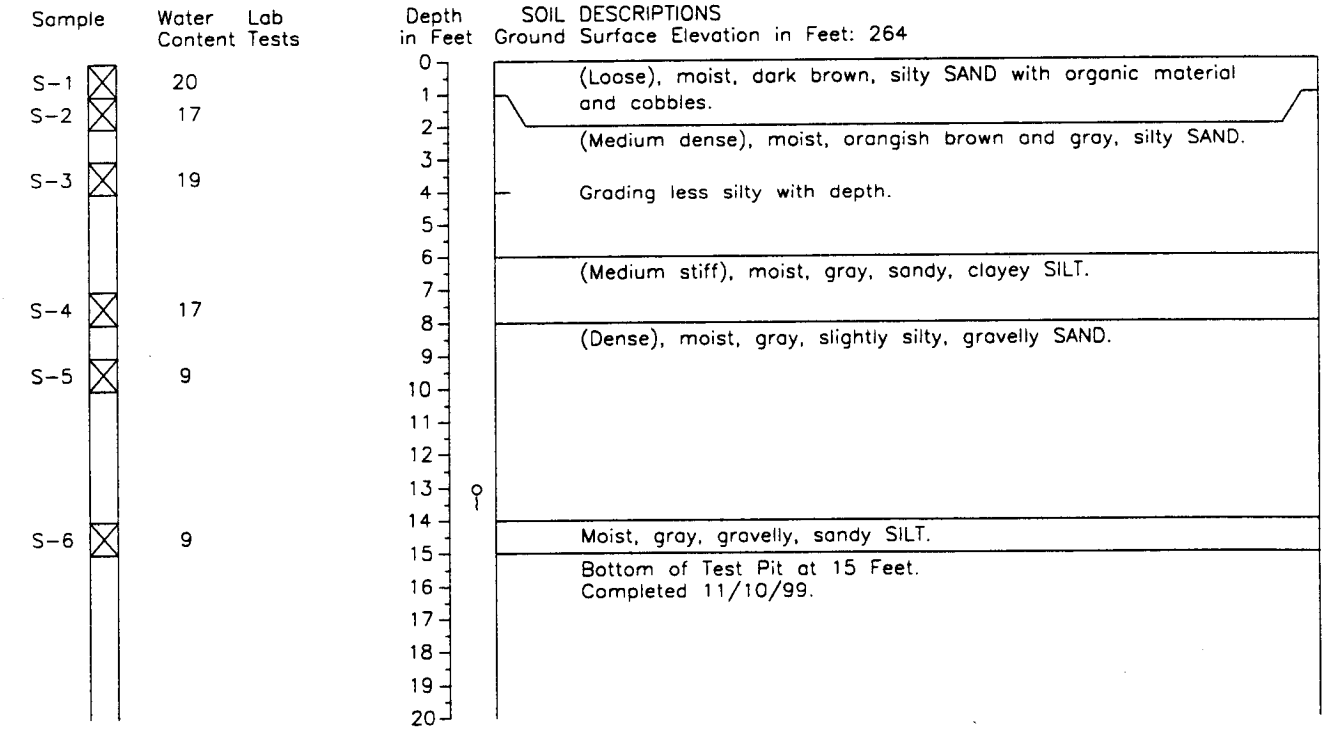
Test Pit Log HC99-TP25

N 21774
E 11602



Test Pit Log HC99-TP41

N 19736
E 10428



1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

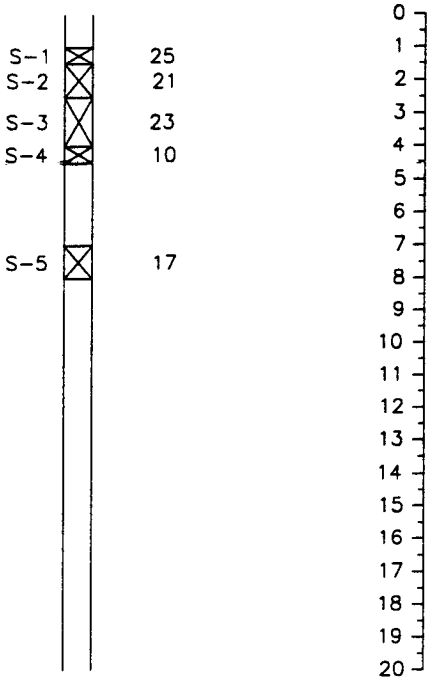
DJH 12/30/99 1-1 Test Pits
497818

HARTCROWSER
J-4978-18 11/99
Figure A-40

AR 044302

Test Pit Log HC99-TP43

N 19655
E 10494



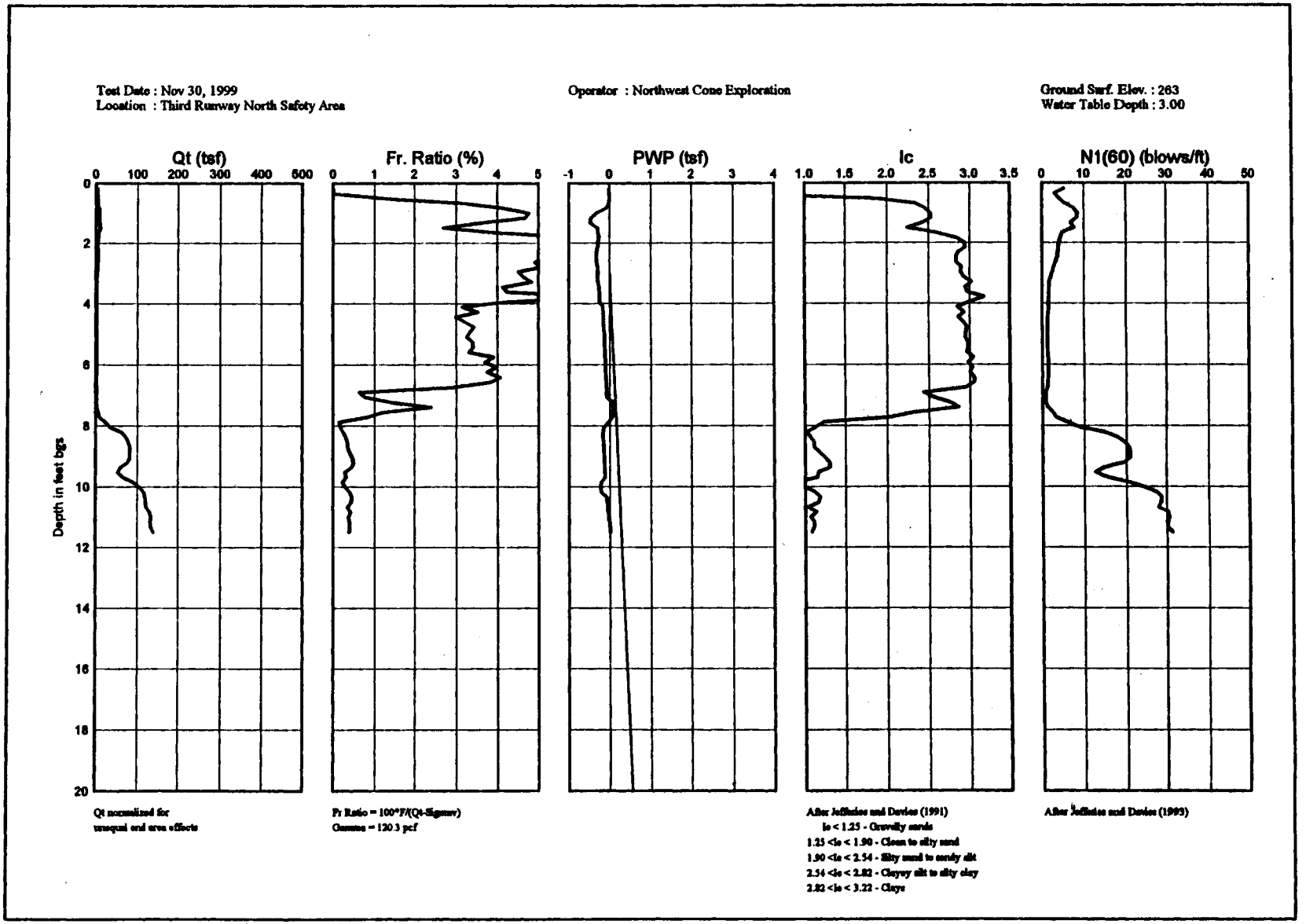
Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet: 262
0 – 4	(Medium dense), moist, brown, silty SAND with organic material.
2 – 3	(Hard), moist, gray and tan with orange mottling, sandy SILT.
3 – 4	(Medium dense), moist, brown and tan with orange mottling, slightly silty SAND.
4 – 7	(Loose), moist, grayish brown, gravelly, coarse SAND.
7 – 10	(Medium stiff), moist, gray and tan mottled, sandy CLAY.
10 – 15	(Very dense), moist, gray, slightly silty, gravelly SAND.
15	Bottom of Test Pit at 15 Feet. Completed 11/10/99.

1. Refer to Figure A-1A for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER
J-4978-18 11/99
Figure A-41

AR 044303

Cone Penetration Probe Log HC99-P01 N 21959 E 10912



PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

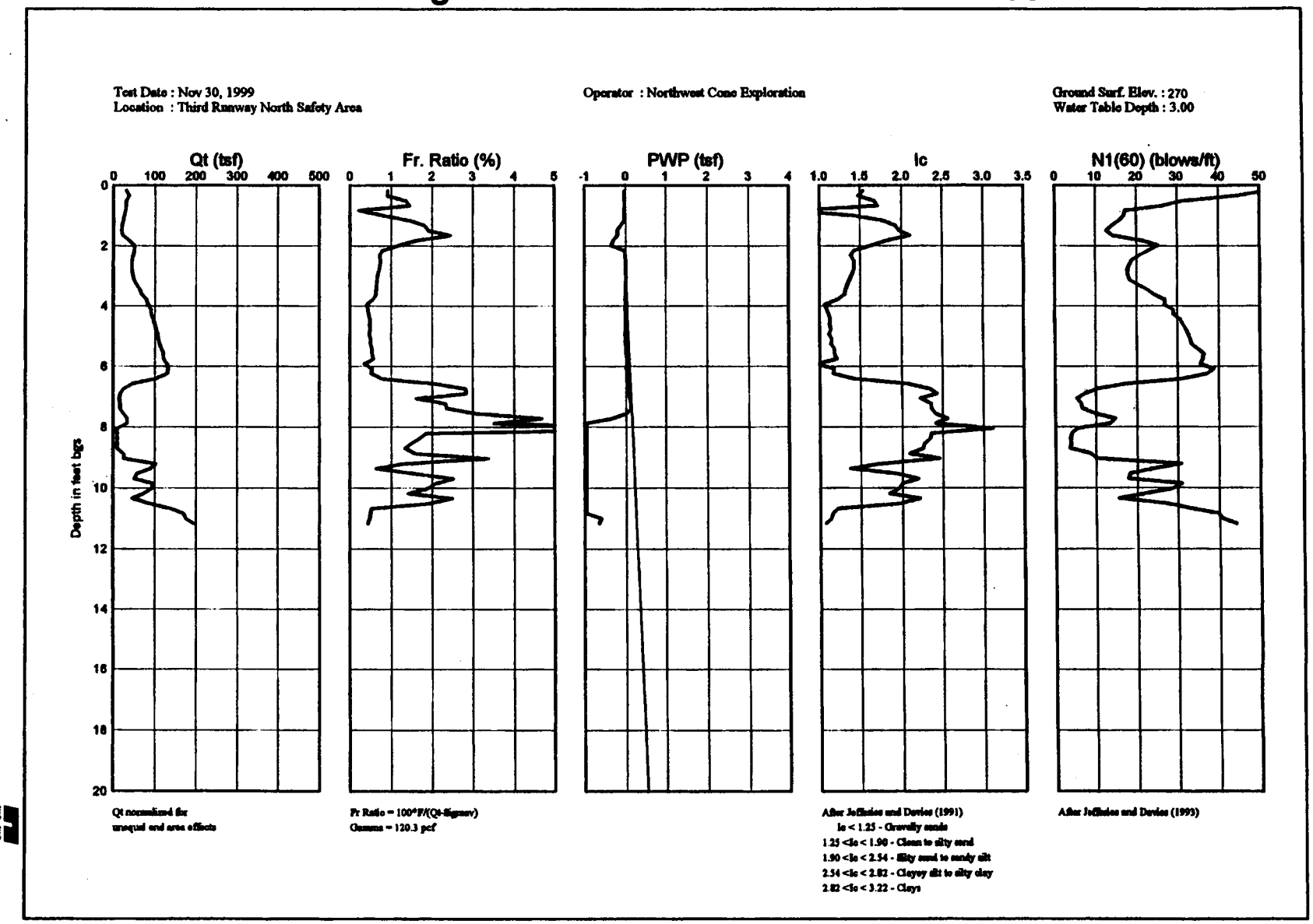
Hart Crowser

HARTCROWSER
J-4978-18 12/99
Figure A-42

AR 044304

corel/497818/cone01

Cone Penetration Probe Log HC99-P02 N 21951 E 11051



PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

Hart Crowser

HARTCROWSER

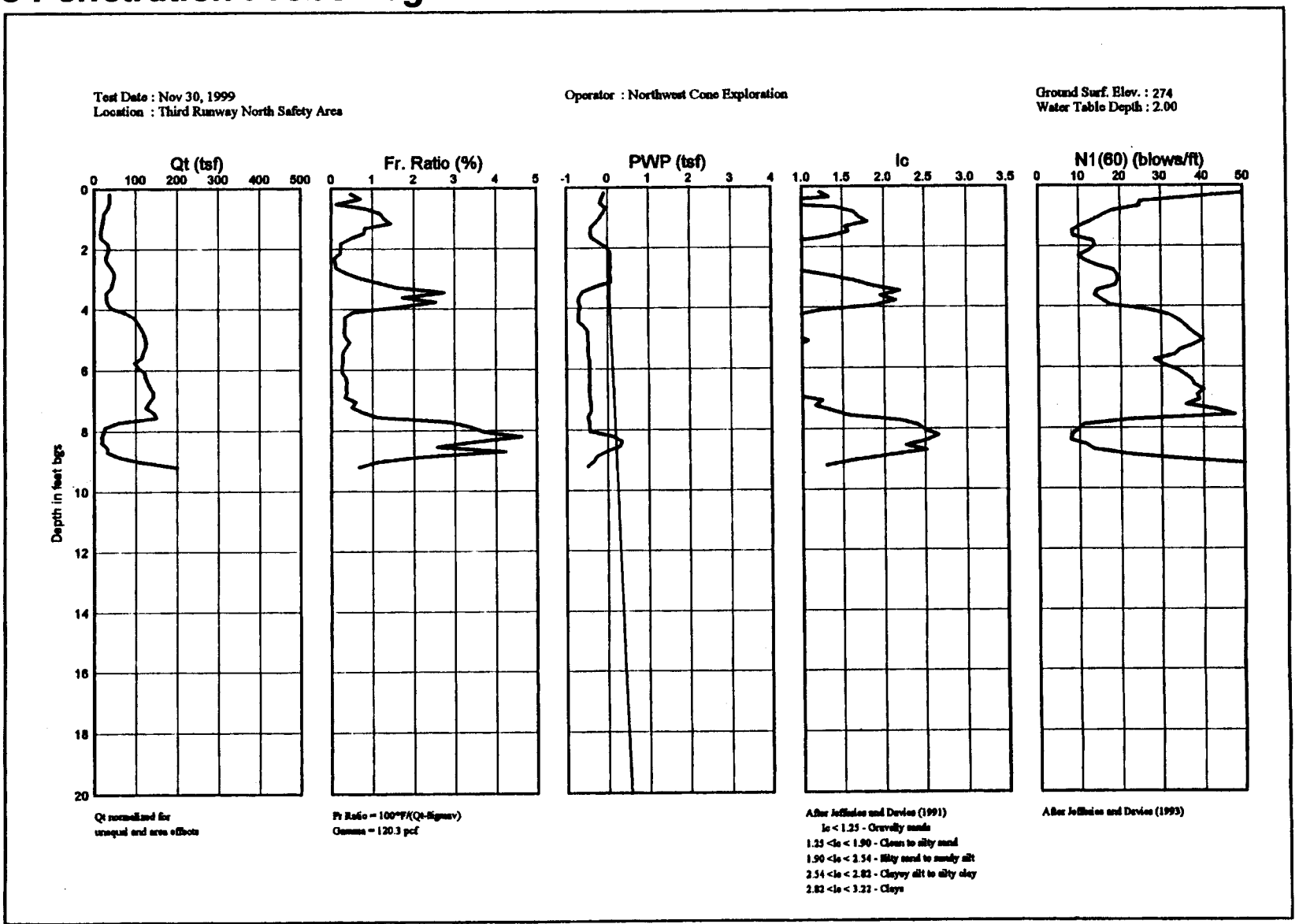
J-4978-18 12/99

Figure A-43

AR 044305

corel/497818/cone02

Cone Penetration Probe Log HC99-P03 N 21926 E 11183



PROJECT NO. 4978-18 DATE. December 7, 1999 DRAWN BY: Keith Brown

Hart Crowser

HARTCROWSER
J-4978-18 12/99
Figure A-44

AR 044306

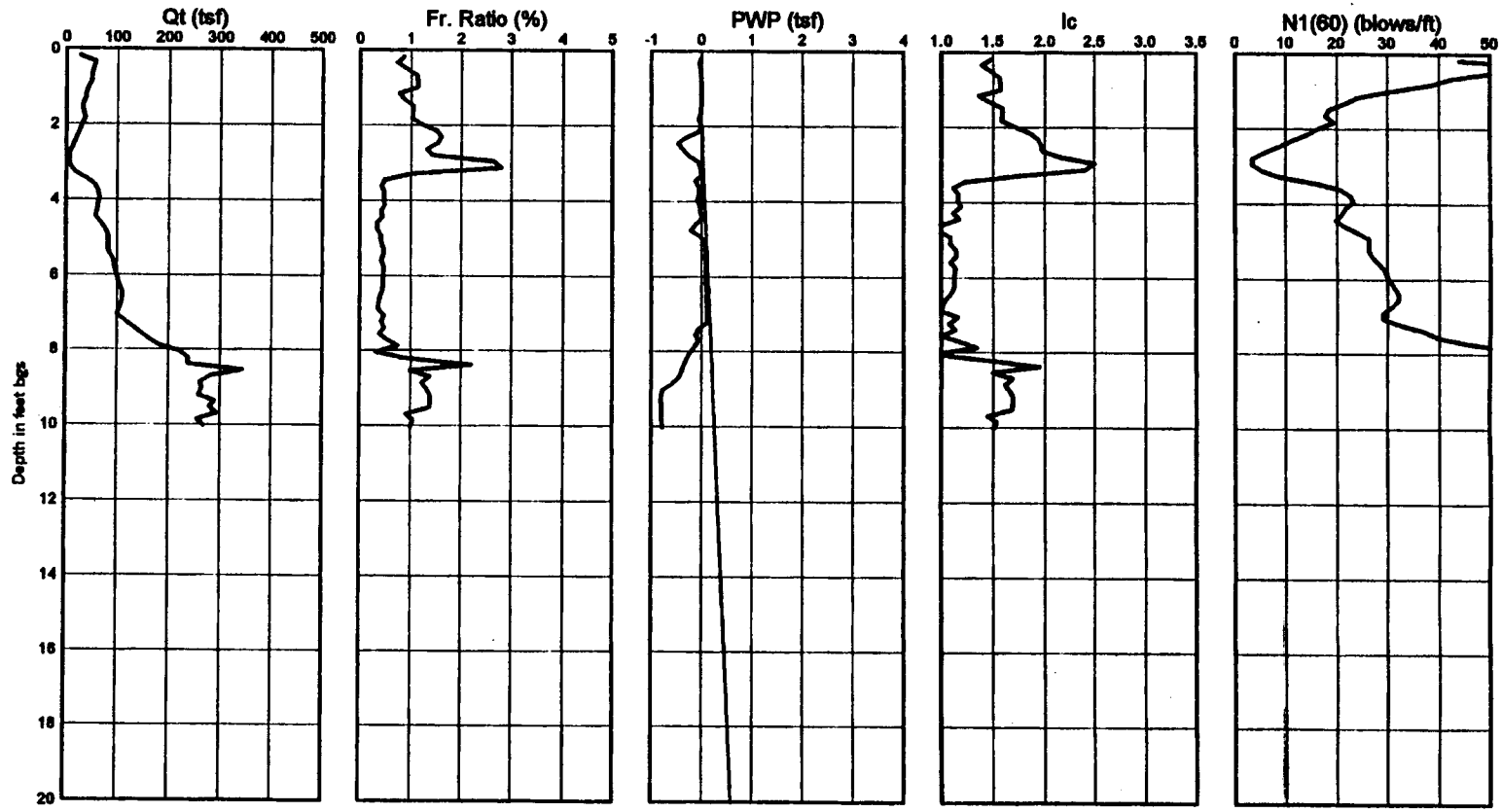
corel/497818/cone03

Cone Penetration Probe Log HC99-P03A N 21905 E 11197

Test Date : Dec 01, 1999
Location : Third Runway North Safety Area

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 276
Water Table Depth : 2.00



Qt normalized for unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

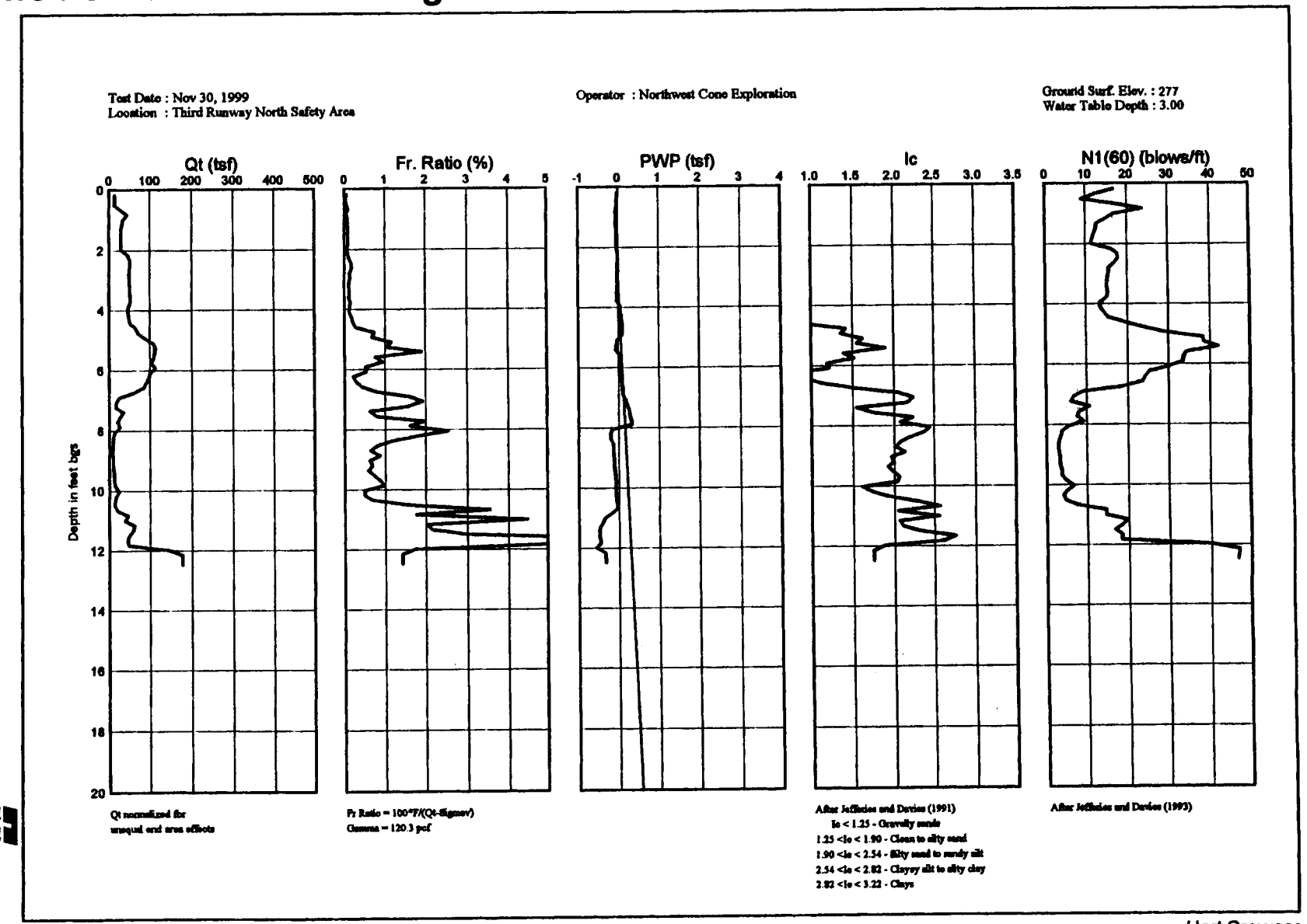
Hart Crowser

HARTCROWSER
J-4978-18 12/99
Figure A-45

AR 044307

corel/497818/cone03a

Cone Penetration Probe Log HC99-P04 N 21786 E 11096



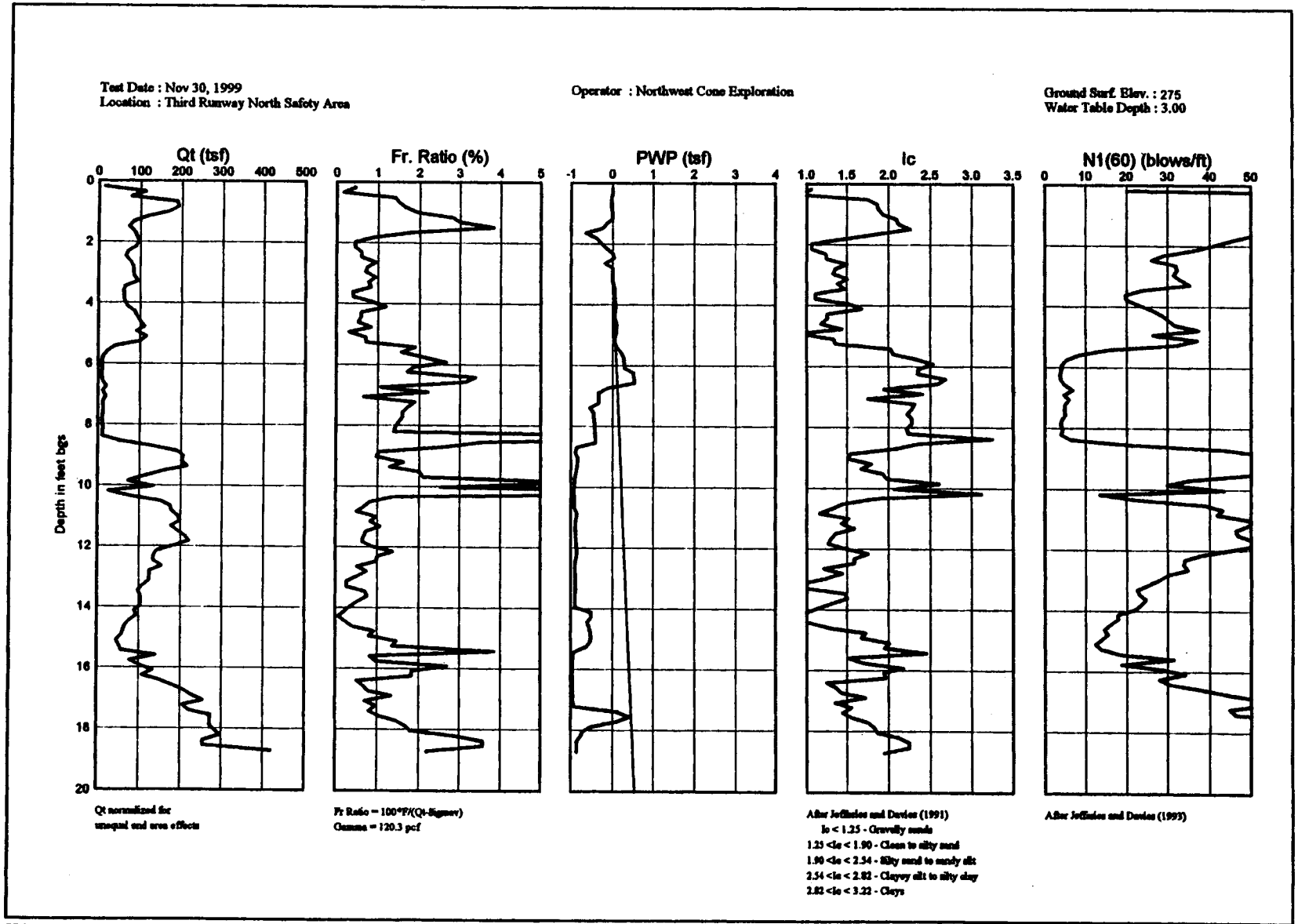
PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown Hart Crowser

HARTCROWSER
J-4978-18 12/99
Figure A-46

AR 044308

corel/497818/cone04

Cone Penetration Probe Log HC99-P05 N 21600 E 10903



PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

Hart Crowser

HARTCROWSER

J-4978-18 12/99

Figure A-47

AR 044309

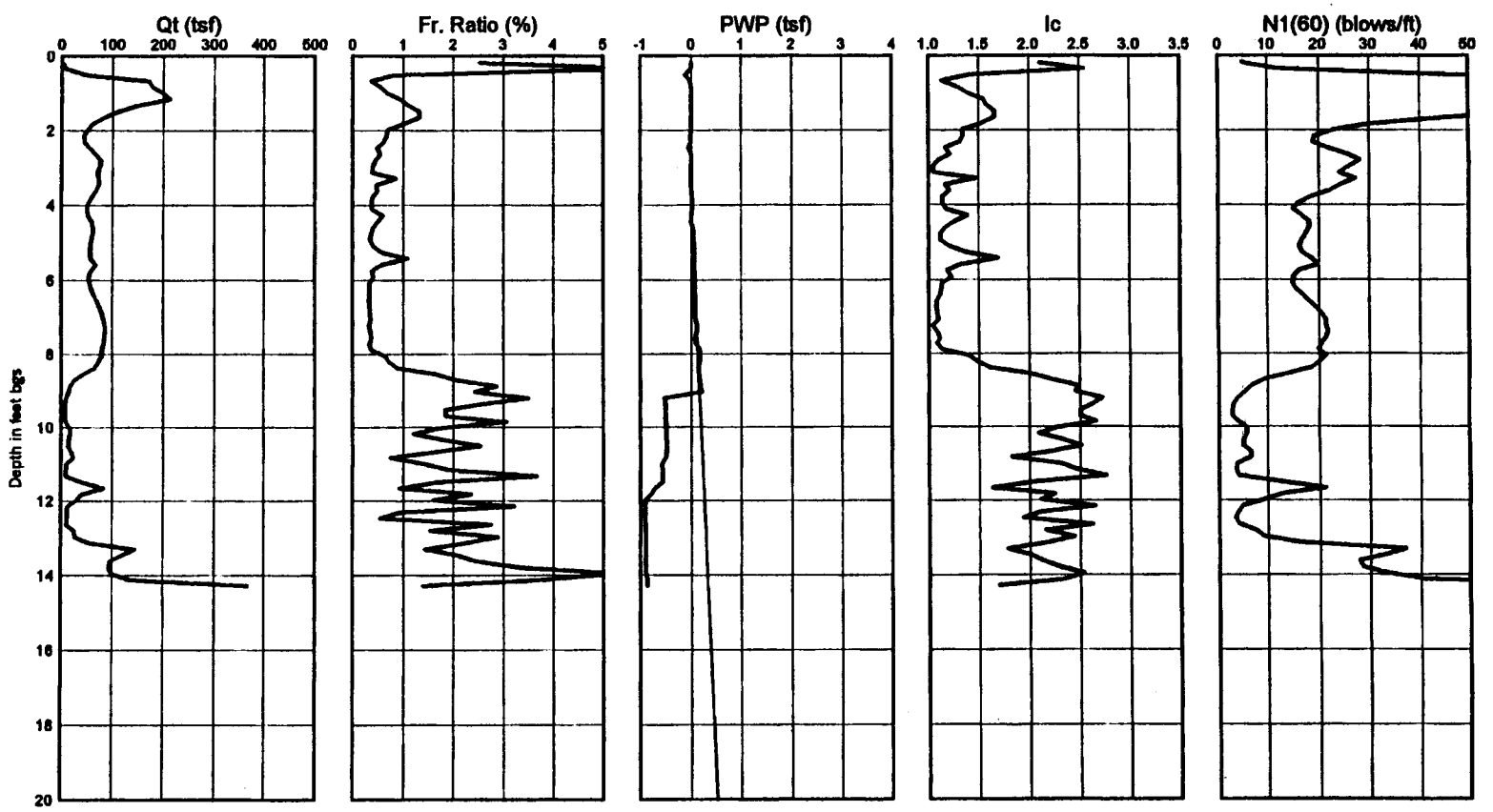
corel/497818/cone05

Cone Penetration Probe Log HC99-P06 N 21456 E 10824

Test Date : Dec 01, 1999
Location : Third Runway North Safety Area

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 274
Water Table Depth : 4.00



Qt normalized for unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

Hart Crowser

HARTCROWSER J-4978-18 12/99
Figure A-48

AR 044310

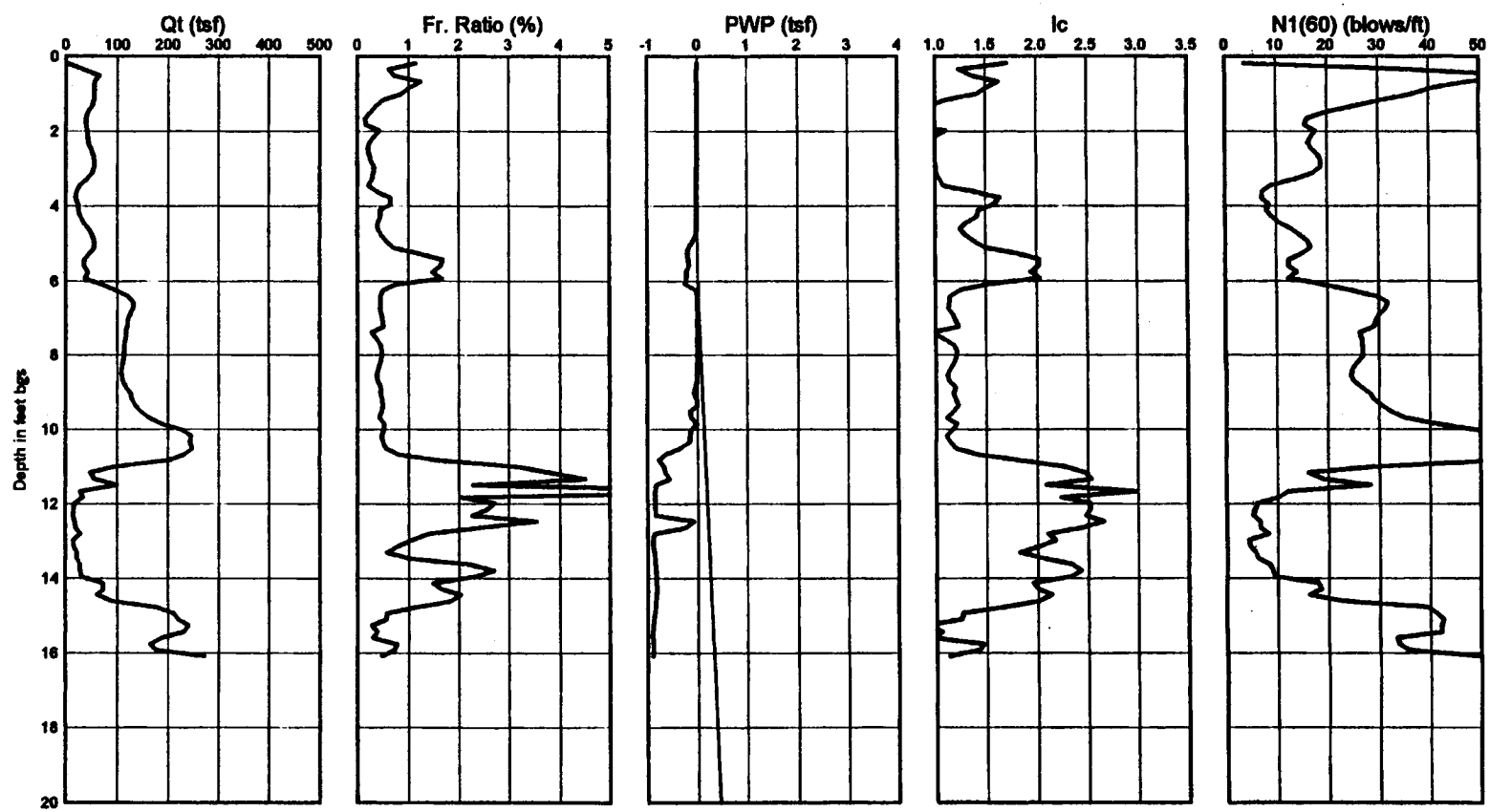
corel/497818/cone06

Cone Penetration Probe Log HC99-P07 N 20879 E 10960

Test Date : Dec 01, 1999
Location : Third Runway North Safety Area

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 303
Water Table Depth : 6.00



Qt normalized for unequal end area effects

Fr Ratio = 100*F/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 <Ic < 1.90 - Clean to silty sand
1.90 <Ic < 2.54 - Silty sand to sandy silt
2.54 <Ic < 2.82 - Clayey silt to silty clay
2.82 <Ic < 3.22 - Clays

After Jefferies and Davies (1993)

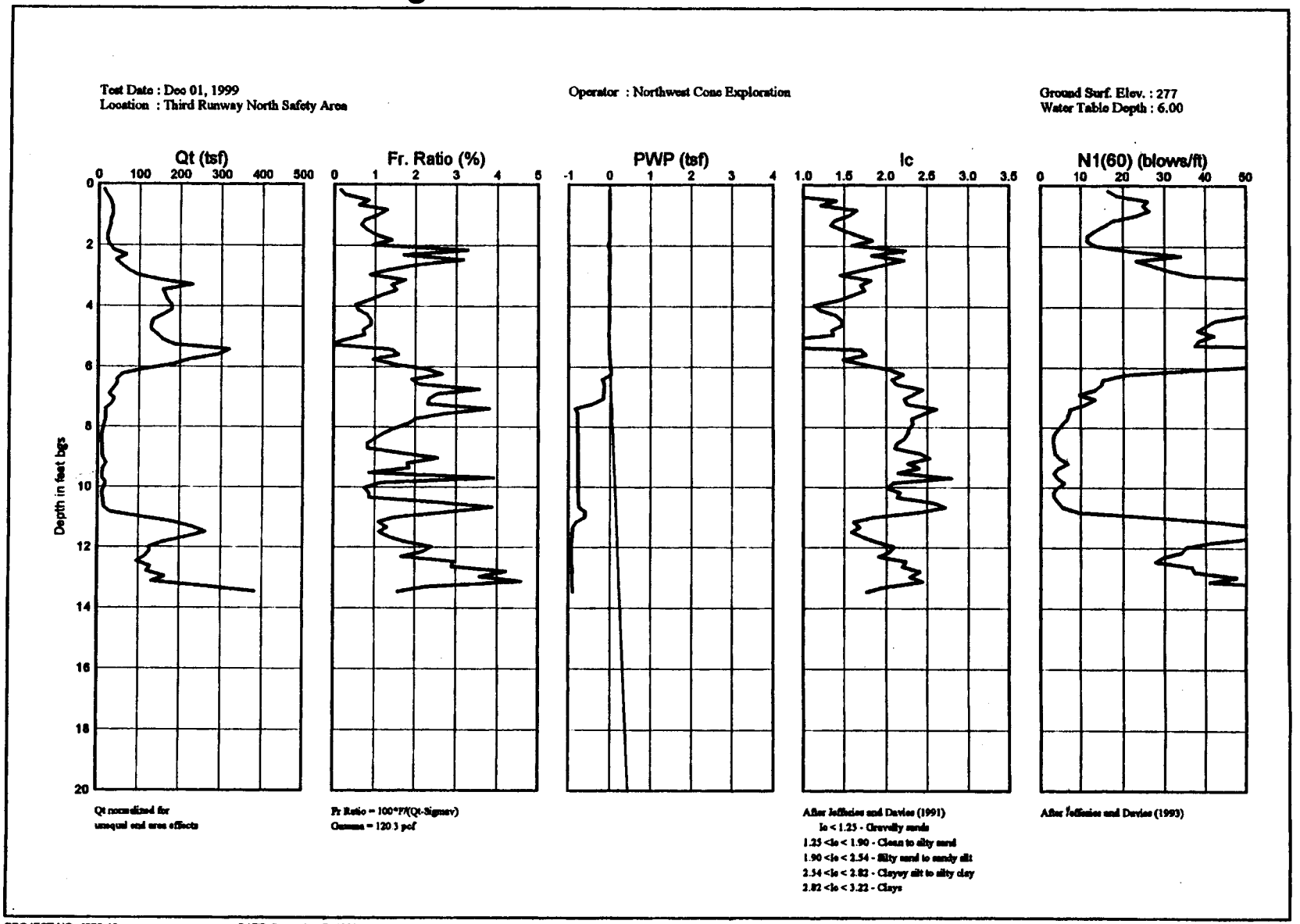
PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

Hart Crowser

HARTCROWSER
J-4978-18 12/99
Figure A-49
AR 044311

corel/497818/cone07

Cone Penetration Probe Log HC99-P08 N 21296 E 10781



PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

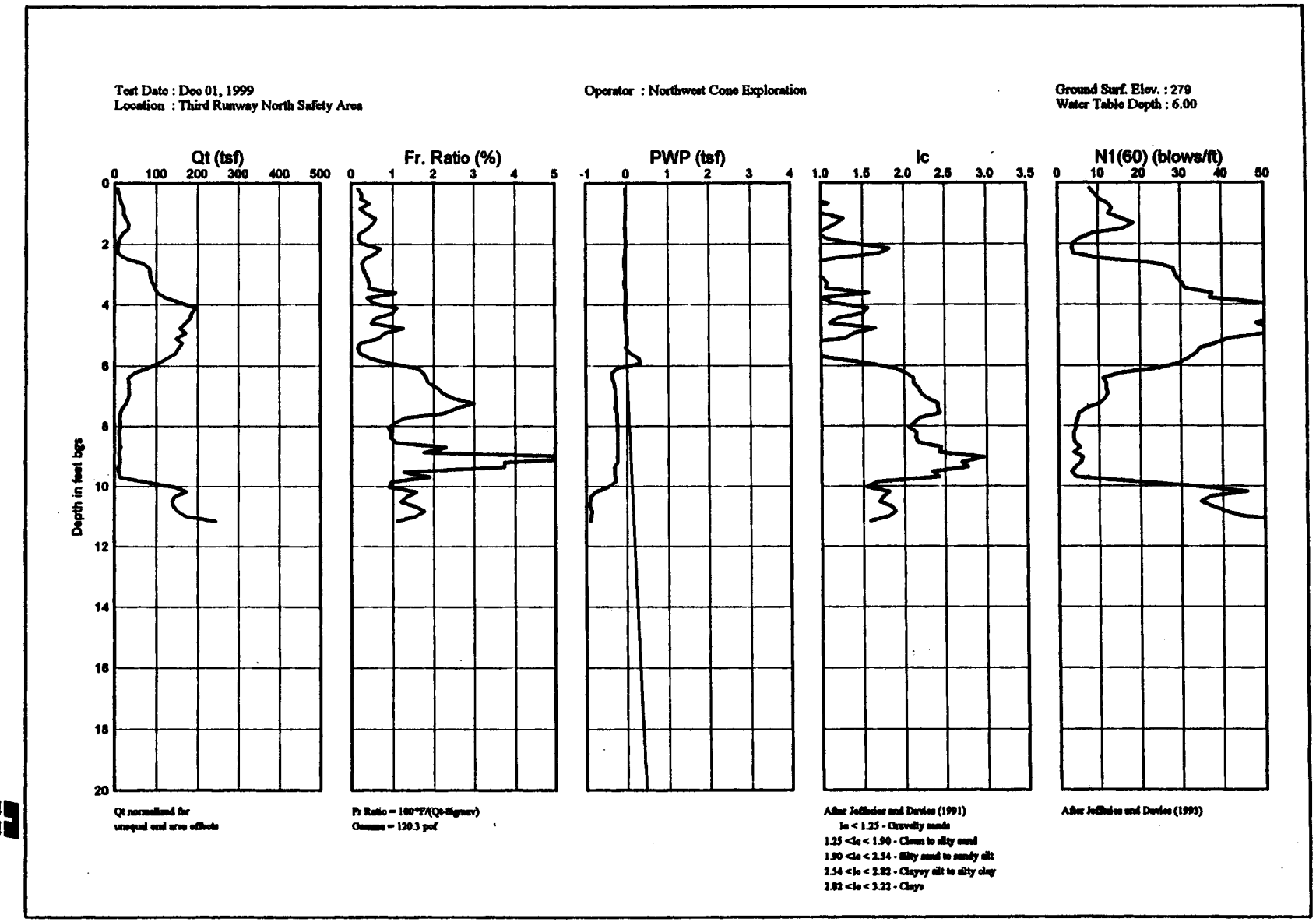
Hart Crowser

HARTCROWSER J-4978-18 12/99 Figure A-50

AR 044312

corel/497818/cone08

Cone Penetration Probe Log HC99-P09 N 21794 E 11199



PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

Hart Crowser

HARTCROWSER

J-4978-18 12/99

Figure A-51

AR 044313

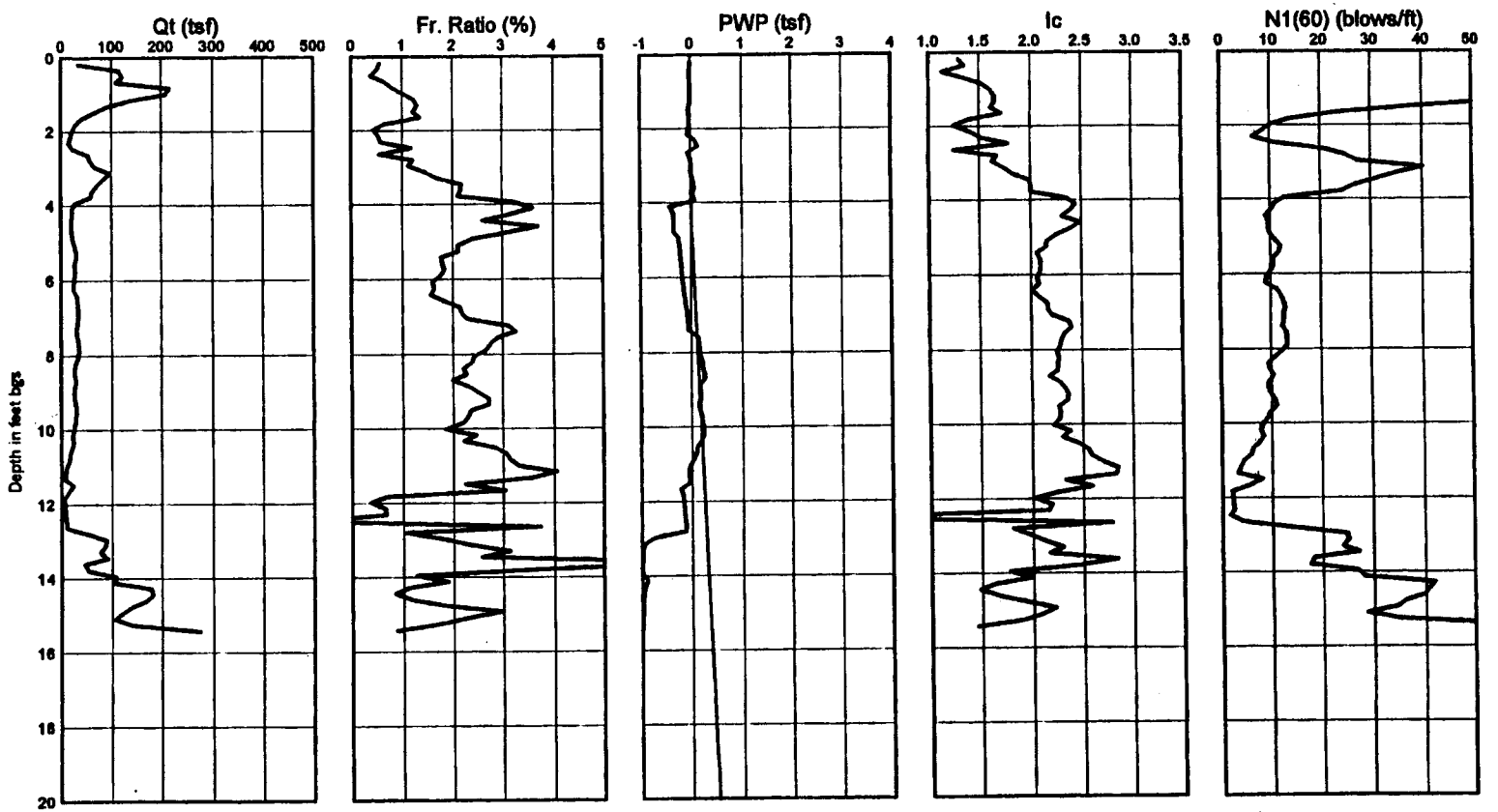
corel/497818/cone09

Cone Penetration Probe Log HC99-P10 N 21948 E 11297

Test Date : Dec 01, 1999
Location : Third Runway North Safety Area

Operator : Northwest Cone Exploration

Ground Surf. Elev. : 279
Water Table Depth : 4.00



Qt normalized for unequal end area effects

Fr Ratio = 100*FA/(Qt-Sigmav)
Gamma = 120.3 pcf

After Jefferies and Davies (1991)
Ic < 1.25 - Gravelly sands
1.25 < Ic < 1.90 - Clean to silty sand
1.90 < Ic < 2.54 - Silty sand to sandy silt
2.54 < Ic < 2.82 - Clayey silt to silty clay
2.82 < Ic < 3.22 - Clays

After Jefferies and Davies (1993)

PROJECT NO. 4978-18 DATE: December 7, 1999 DRAWN BY: Keith Brown

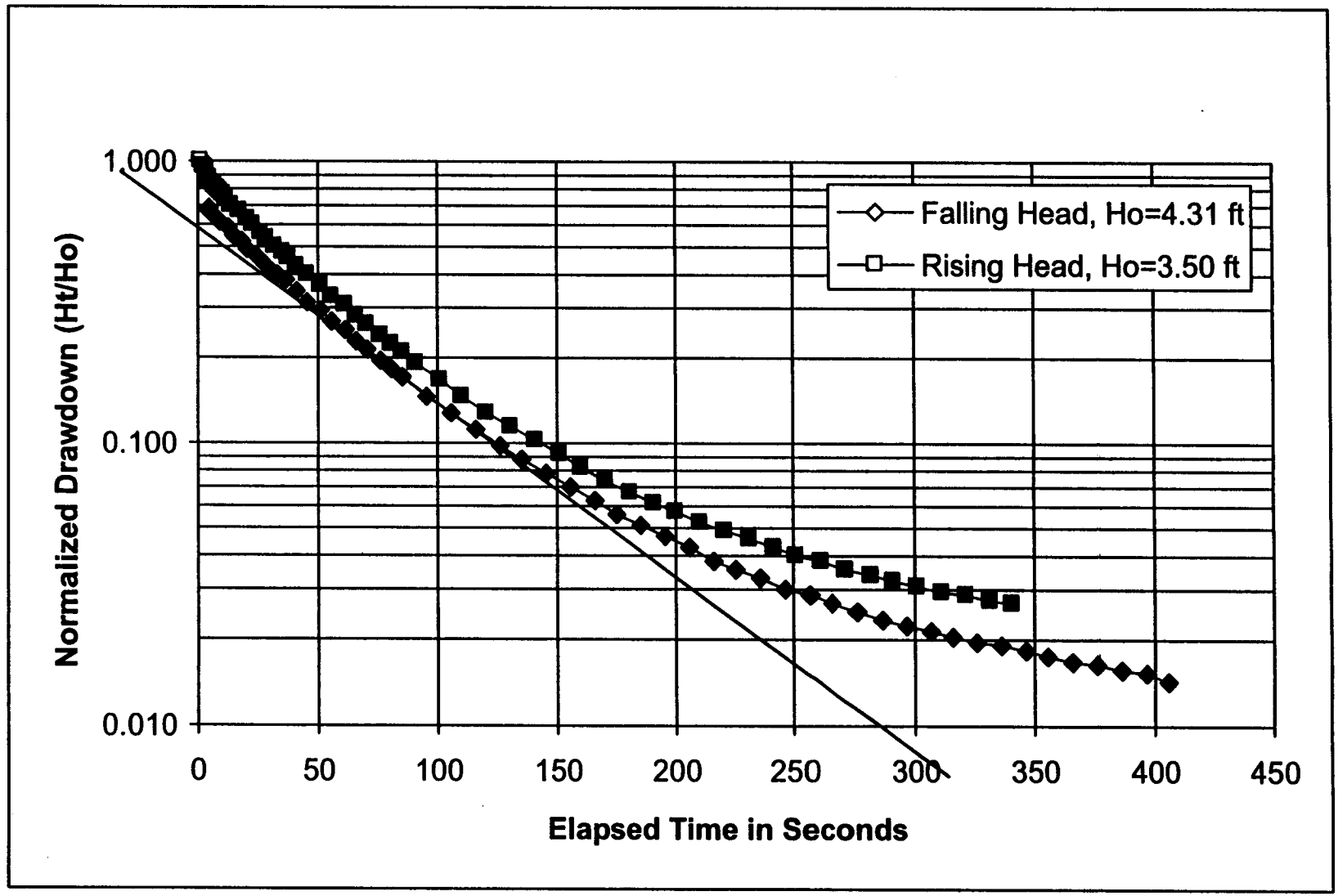
Hart Crowser

HARTCROWSER
J-4978-18 12/99
Figure A-52

AR 044314

corel/497818/cone10

Log of Normalized Drawdown vs. Time for HC99-B44

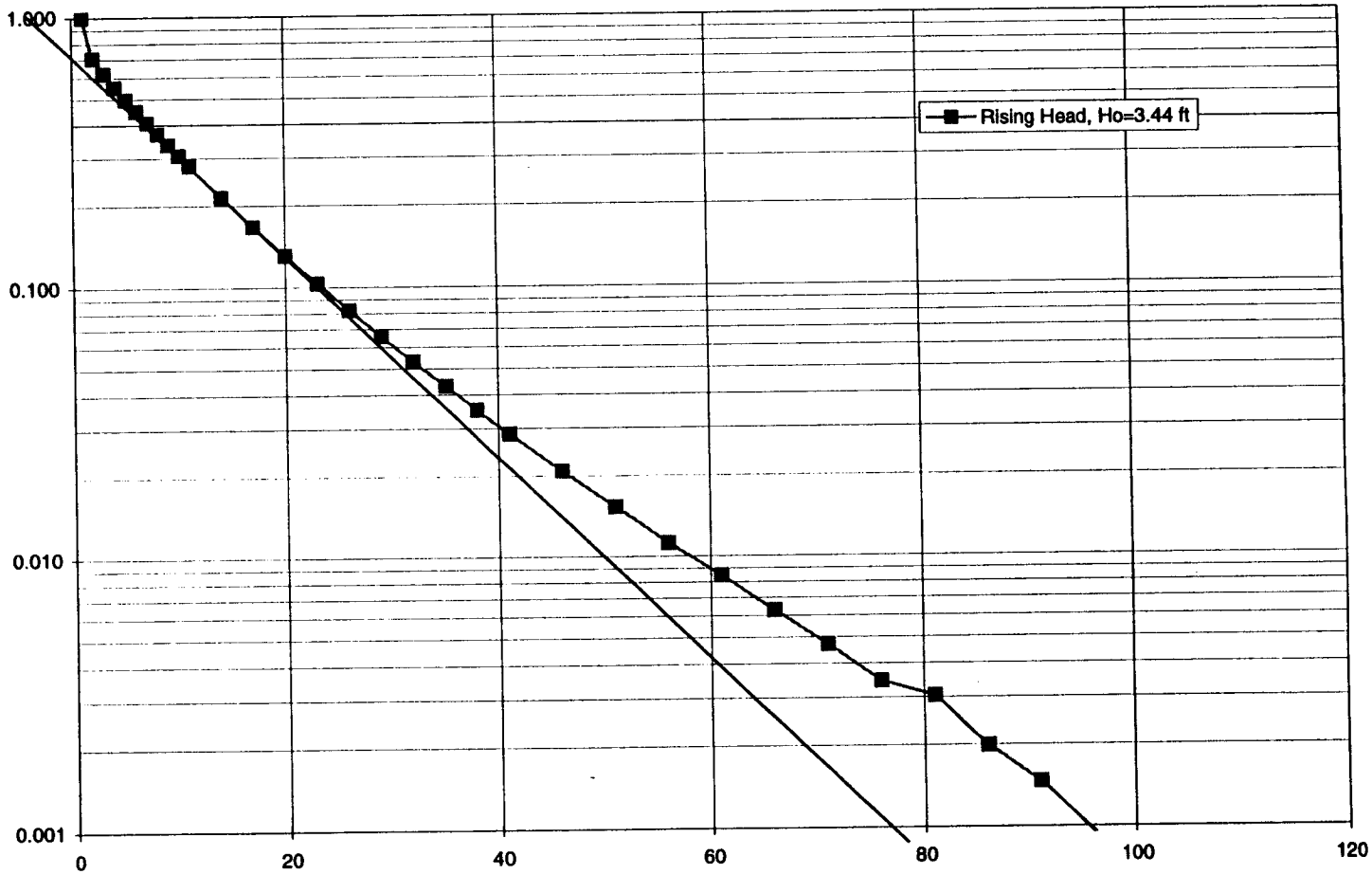


HARTCROWSER 1/00
J-4978-18
Figure A-53

AR 044315

corel/497818/Time01

Log of Normalized Drawdown vs. Time for HC99-B48



HARTCROWSER

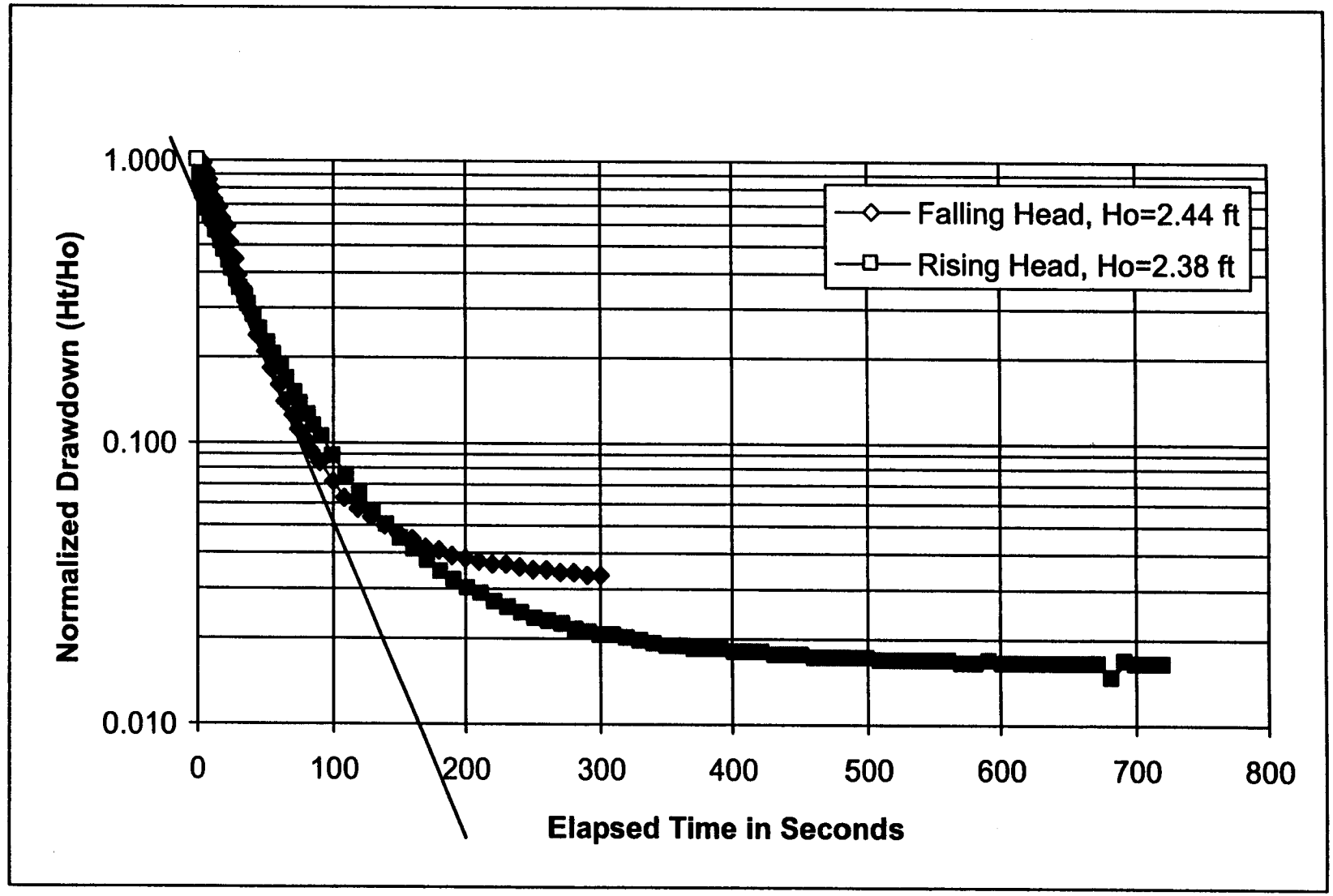
J-4978-18 1/00

Figure A-54

AR 044316

corel/497818/Time02

Log of Normalized Drawdown vs. Time for HC99-B52

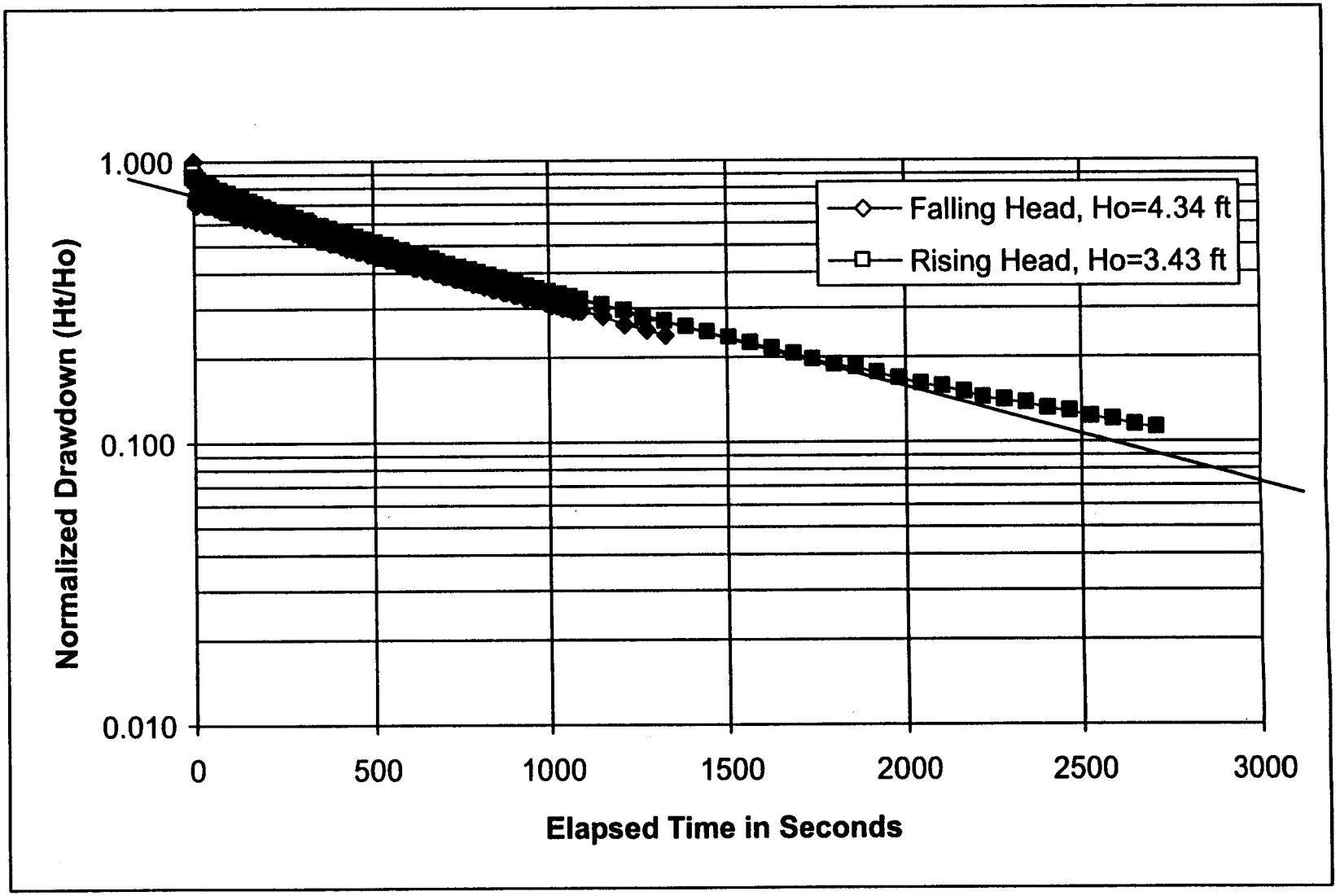


HARTCROWSER
J-4978-18 1/00
Figure A-57

AR 044317

corel/497818/Time05

Log of Normalized Drawdown vs. Time for HC99-B54

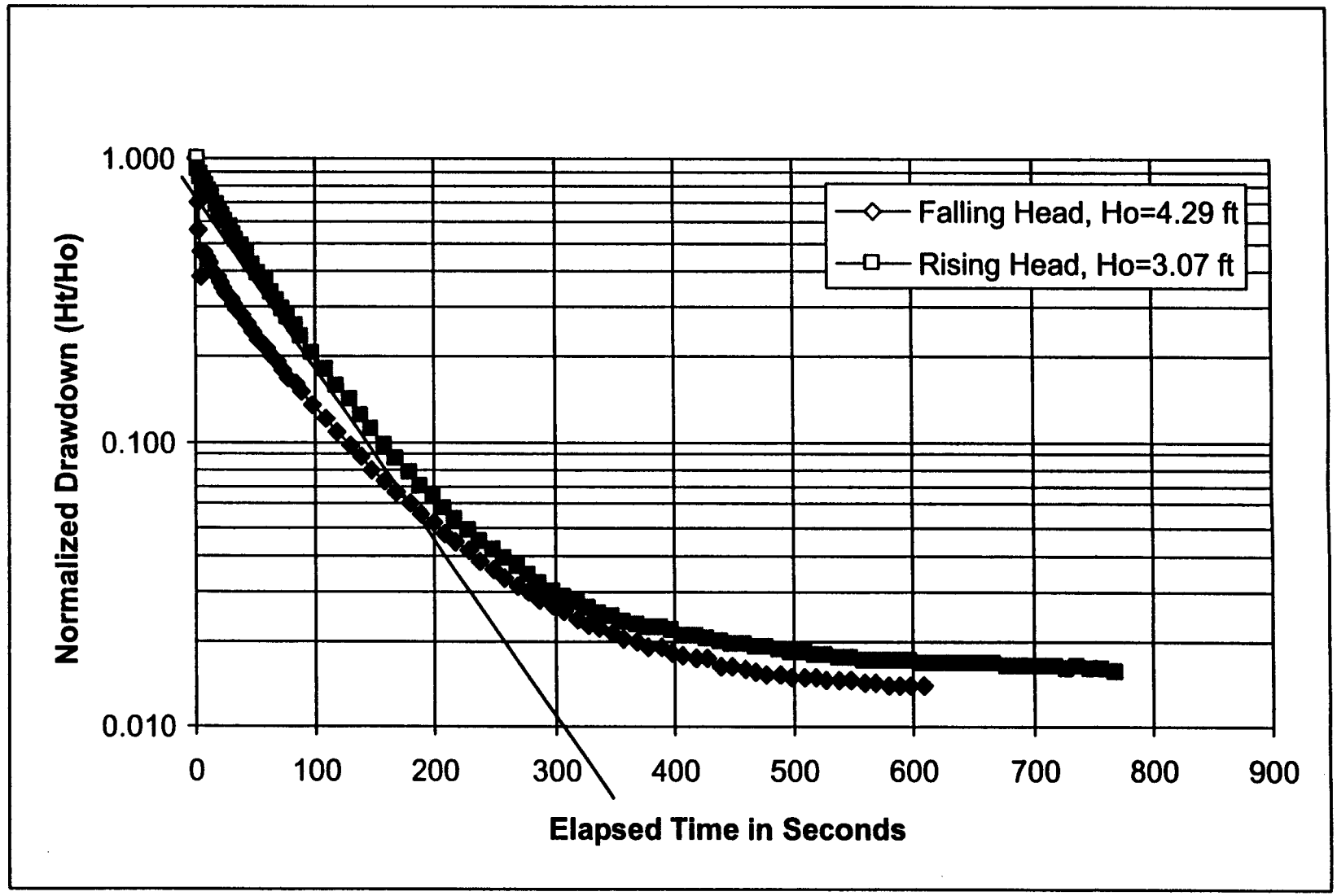


HARTCROWSER 1/00
J-4978-18
Figure A-58

AR 044318

corel/497818/Time06

Log of Normalized Drawdown vs. Time for HC99-B57

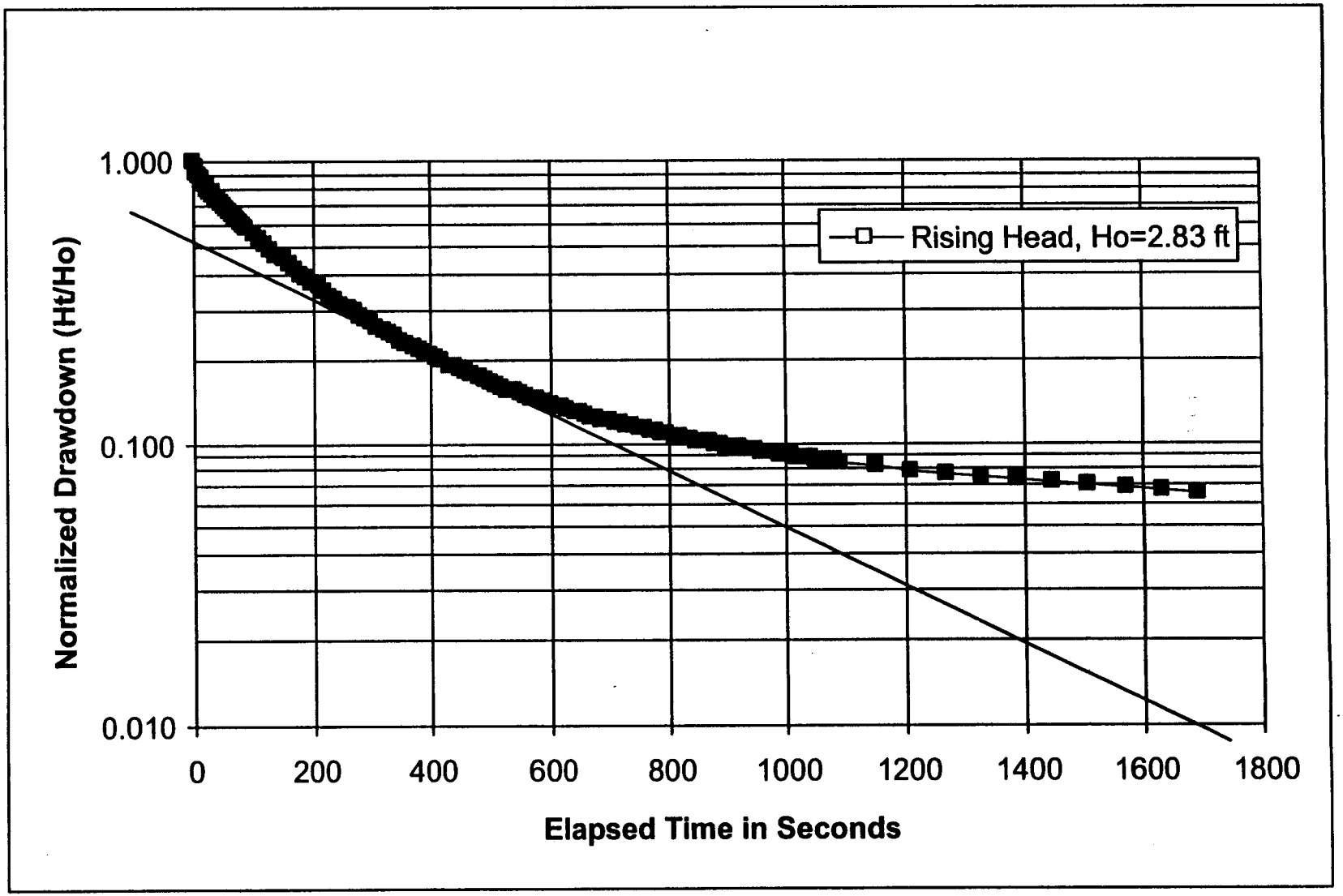


HARTCROWSER 1/00
J-4978-18
Figure A-59

AR 044319

corel/497818/Time07

Log of Normalized Drawdown vs. Time for HC99-B50



HARTCROWSER

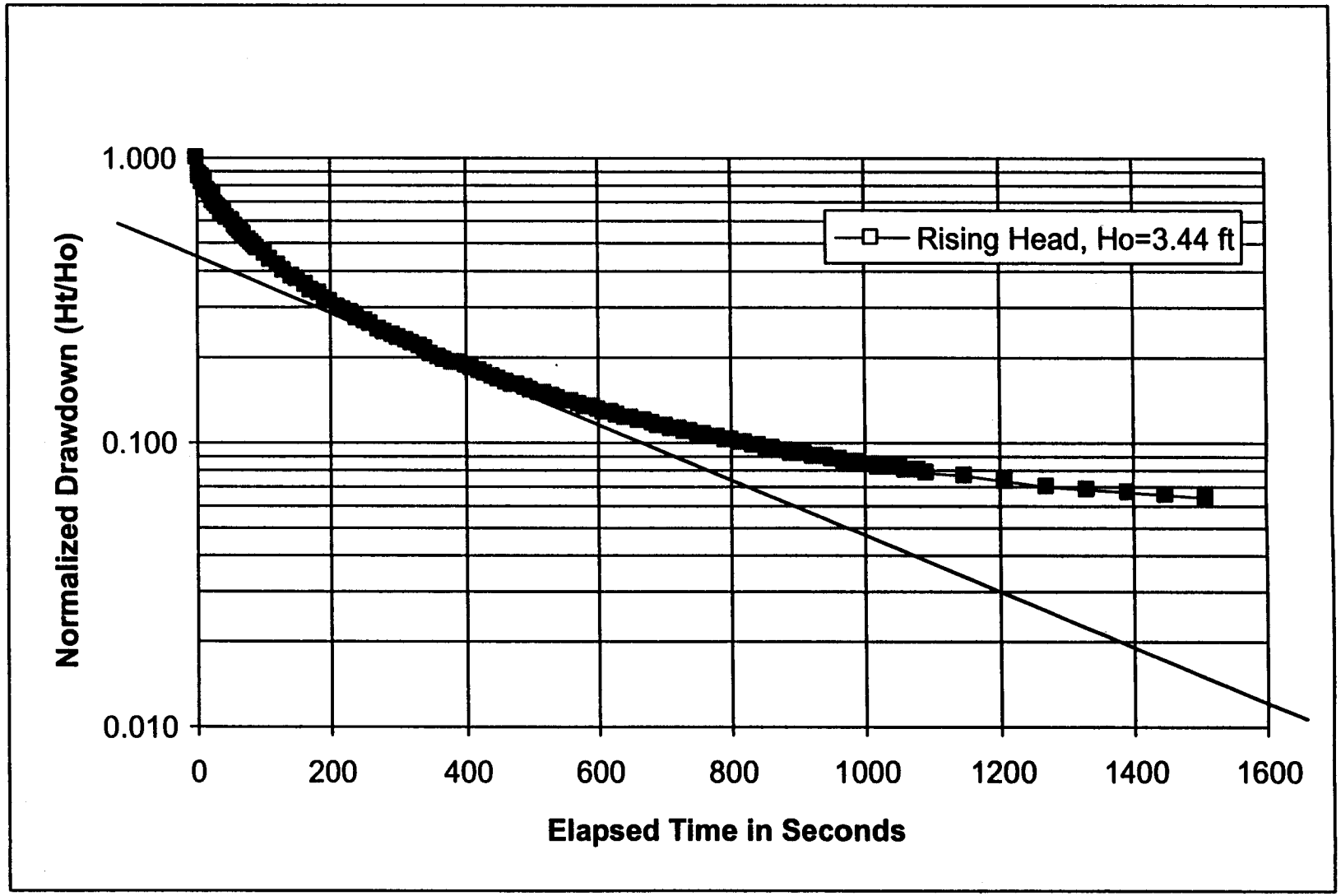
J-4978-18 1/00

Figure A-55

AR 044320

corel/497818/Time03

Log of Normalized Drawdown vs. Time for HC99-B51



HARTCROWSER 1/00

J-4978-18

Figure A-56

AR 044321

corel/497818/Time04

APPENDIX B
LABORATORY TESTING PROGRAM

APPENDIX B
LABORATORY TESTING PROGRAM

A laboratory testing program was performed for this study to evaluate the basic index and geotechnical engineering properties of the site soils. Disturbed and relatively undisturbed samples were tested. The tests performed and the procedures followed are outlined below.

Soil Classification

Field Observation and Laboratory Analysis. Soil samples from the explorations were visually classified in the field and then taken to our laboratory where the classifications were verified in a relatively controlled laboratory environment. Field and laboratory observations include density/consistency, moisture condition, and grain size and plasticity estimates.

The classifications of selected samples were checked by laboratory tests such as Atterberg limits determinations and grain size analyses. Classifications were made in general accordance with the Unified Soil Classification (USC) System, ASTM D 2487, as presented on Figure B-1.

Note that the term "trace" used on exploration logs generally indicate a material within the soil matrix that constitutes a relatively small fraction by weight of the total soil. The usage of this term in not associated with the ASTM simplified classification procedure.

Water Content Determinations

Water contents were determined for most samples recovered in the explorations in general accordance with ASTM D 2216, as soon as possible following their arrival in our laboratory. The results of these tests are plotted or recorded at the respective sample depth on the exploration logs. In addition, water contents are routinely determined for samples subjected to other testing. These are also presented on the exploration logs.

Grain Size Analysis (GS)

Grain size distribution was analyzed on representative samples in general accordance with ASTM D 422. Wet sieve analysis was used to determine the size distribution greater than the U.S. No. 200 mesh sieve. The size distribution for particles smaller than the No. 200 mesh sieve was determined by the hydrometer method for selected samples. The results of the tests are presented

as curves on Figures B-2 through B-10 plotting percent finer by weight versus sieve size.

Atterberg Limits (AL)

We determined Atterberg limits for selected fine-grained soil samples. The liquid limit and plastic limit were determined in general accordance with ASTM D 4318-84. The results of the Atterberg Limits analyses and the plasticity characteristics are summarized in the Liquid and Plastic Limits Test Report, Figures B-11 through B-15. This relates the plasticity index (liquid limit minus the plastic limit) to the liquid limit. The results of the Atterberg limits tests are also shown graphically on the boring logs.

Consolidation Test (CN)

The one-dimensional consolidation test provides data for estimating settlement and preconsolidation pressure. The test was performed in general accordance with ASTM D 2435. A relatively undisturbed, fine-grained sample was carefully trimmed and fit into a rigid ring with porous stones placed on the top and bottom of the sample to allow drainage. Vertical loads were then applied incrementally to the sample in such a way that the sample was allowed to consolidate under each load increment. Measurements were made of the compression of the sample (with time) under each load increment. Rebound was measured during the unloading phase. In general, each load was left in place until the completion of 100 percent primary consolidation, as computed using Taylor's square root of time method. The next load increment was applied soon after attaining 100 percent primary consolidation. For the 4 tsf load increment, the load was left in-place for about 16 hours to record secondary compression characteristics. The test results plotted in terms of axial strain and coefficient of consolidation versus applied load (stress) are presented on Figures B-16 through B-22.

Consolidated Undrained Triaxial Compression Test (CU)

The consolidated undrained triaxial compression test with pore pressure measurements estimates the effective strength of the soil at various stress levels. The test was performed in general accordance with ASTM D 4767.

A relatively undisturbed fine-grained sample was trimmed to a length of about 6 inches, encased in a rubber membrane, and placed in the triaxial cell. With the sample in the triaxial test cell, an all-around pressure was applied hydraulically. The sample was allowed to consolidate under the applied pressure with drainage occurring through porous stones and slotted filter paper placed around the

sample. When consolidation was completed, drainage lines from the sample were closed, a back pressure was applied to saturate the sample, and the sample was loaded to failure under undrained conditions by application of increasing axial load at a constant strain rate.

During loading, we recorded the magnitude of excess pore water pressure developed. From the data, an effective stress plot was developed to illustrate the variation in effective shear strength with varying consolidation (or overburden) pressures. The data are plotted using shear stress versus principal stress as Mohr's circles. The tangent to the Mohr's circles for a test series represents the effective angle of internal friction (ϕ'). The intercept along the vertical axis is the effective cohesion (c').

Test results for the samples tested are presented on Figures B-23 through B-36. For each sample the first figure presents shear stress and normal stress data in a Mohr's circle format along with stress-strain plots, while the second figure in the set presents the stress-stain data and a stress path plot. The effective friction angles (ϕ') provided in Tables 1 through 4 of the main text were determined by assuming that $c' = 0$ for drained conditions.

Unconsolidated Undrained Triaxial Compression Test (UU)

The unconsolidated undrained triaxial compression test estimates the total strength of the soil at various stress levels. The test was performed in general accordance with ASTM D 2850. A relatively undisturbed fine-grained sample was trimmed to a length of about 6 inches, encased in a rubber membrane, and placed in the triaxial cell. With the sample in the triaxial test cell, an all-around pressure was applied hydraulically, although the drainage valves remained closed. Thus the sample was not allowed to consolidate. The sample was loaded to failure under undrained conditions by application of increasing axial load at a constant strain rate.

The data are plotted (Figures B-37 through B-42) using shear stress versus principal stress as Mohr's circles. Because the test is a measure of the total stress strength of a soil, the tangent to the Mohr's circle for a test extends horizontally to the vertical axis in a straight line. The intercept along the vertical axis is the cohesion (c = undrained shear strength, τ, of the soil).

Direct Shear Test (DS)

The undrained direct shear test was performed by PSI, Inc., in general accordance with ASTM D 3080-90. The test sample was trimmed from a relatively undisturbed soil sample and placed in the direct shear box. The sample

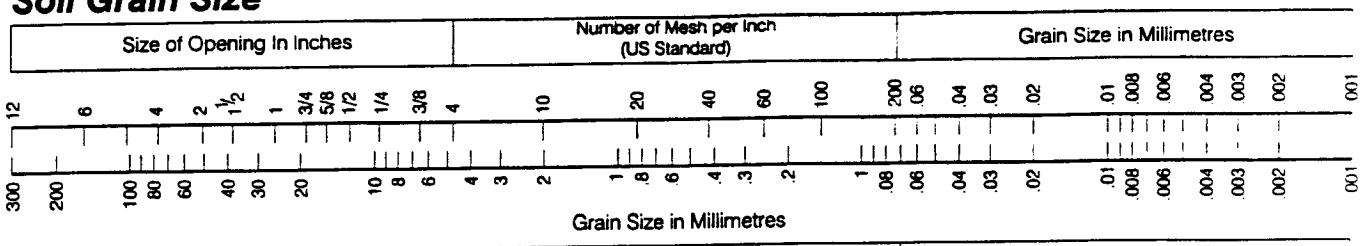
was not allowed to consolidate under an applied vertical load prior to shearing. A horizontal force was applied to the shear box containing the sample. In this way, the sample fails along a predetermined failure plane. The shearing took place at a constant strain rate, and was done quickly enough so that no drainage would occur.

The data are presented on a Mohr-Coulomb diagram plotting shear (failure) stress versus normal stress (Figures B-43 and B-44. The line through the points of failure represents the effective angle of internal friction (ϕ) and the intercept along the vertical axis is the cohesion intercept (c').

F:\docs\jobs\497818\NorthSafety(rpt).doc

Unified Soil Classification (USC) System

Soil Grain Size



COBBLES	GRAVEL	SAND	SILT and CLAY
Coarse-Grained Soils			Fine-Grained Soils

Coarse-Grained Soils

G W	G P	G M	G C	S W	S P	S M	S C
Clean GRAVEL <5% fines	*	GRAVEL with >12% fines		Clean SAND <5% fines	*	SAND with >12% fines	
GRAVEL >50% coarse fraction larger than No. 4				SAND >50% coarse fraction smaller than No. 4			
Coarse-Grained Soils >50% larger than No. 200 sieve							

G W and S W $\left(\frac{D_{60}}{D_{10}}\right)$ >4 for G W, >6 for S W & $1 \leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right) \leq 3$

G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A line with PI <4

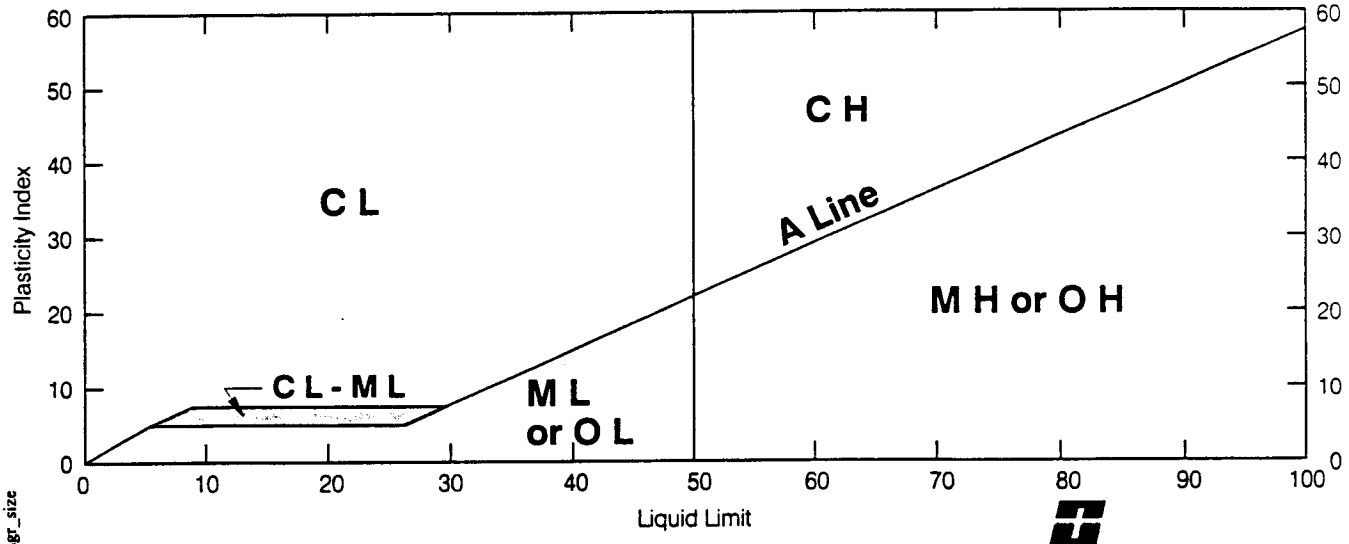
G C and S C Atterberg limits above A Line with PI >7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases required use of dual symbols

D_{10}, D_{30}, and D_{60} are the particles diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

Fine-Grained Soils

M L	C L	O L	M H	C H	O H	Pt
SILT	CLAY	Organic	SILT	CLAY	Organic	Highly Organic Soils
Soils with Liquid Limit <50%			Soils with Liquid Limit >50%			
Fine-Grained Soils >50% smaller than No. 200 sieve						



CorelVforms\gr_size

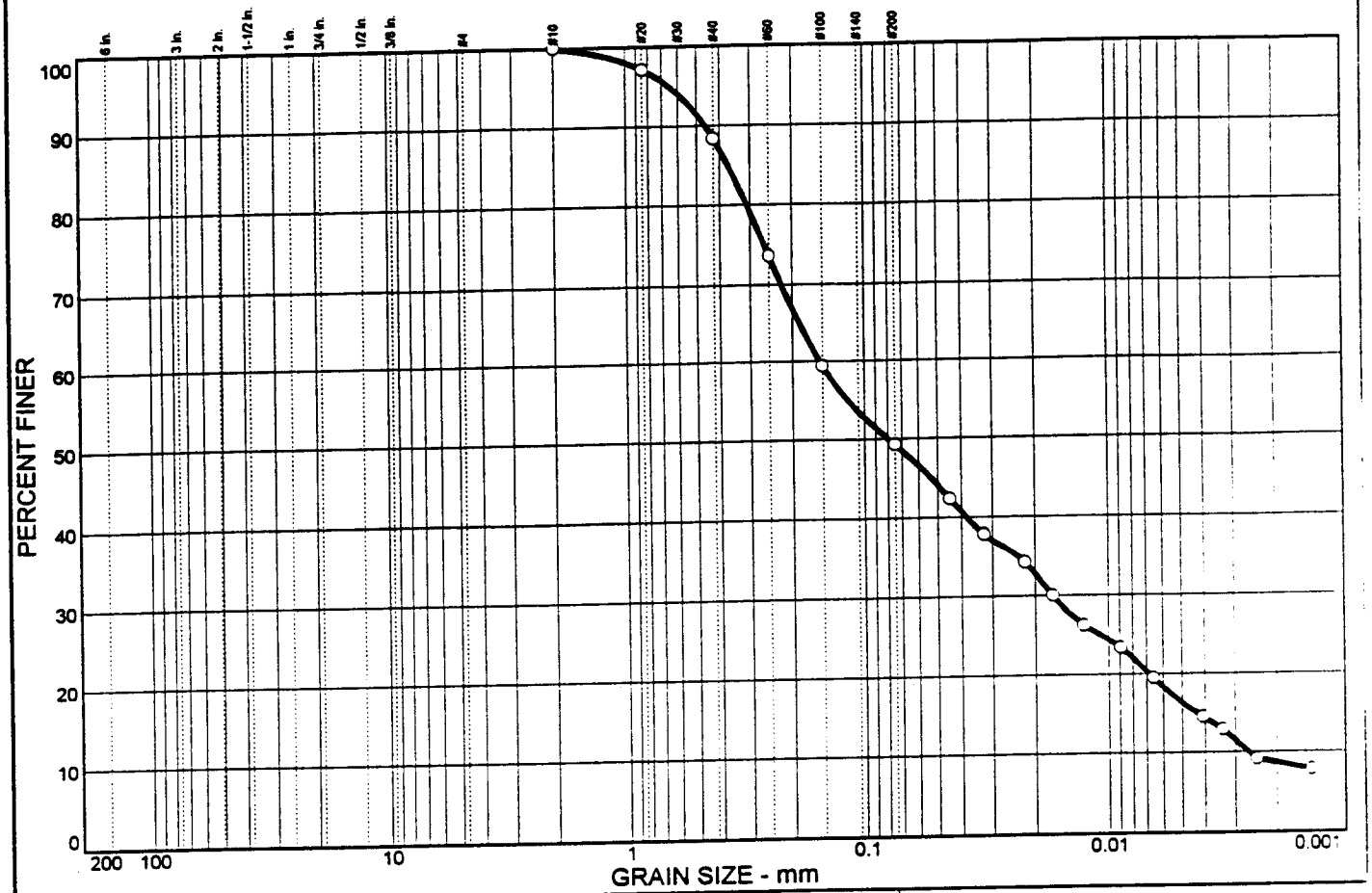
HARTCROWSER

J-4978-18 1/00

Figure B-1

AR 044327

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	11.6	39.1	33.0	16.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	16	4	0.369	0.154	0.0797	0.0170	0.0044	0.0026	0.71	58.48

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Clayey, very silty, medium to fine SAND	SC-SM	

Remarks:

○

Project: Third Runway North Safety Area

Client: Port of Seattle

○ **Source:** HC00-B44 **Sample No.:** S-3

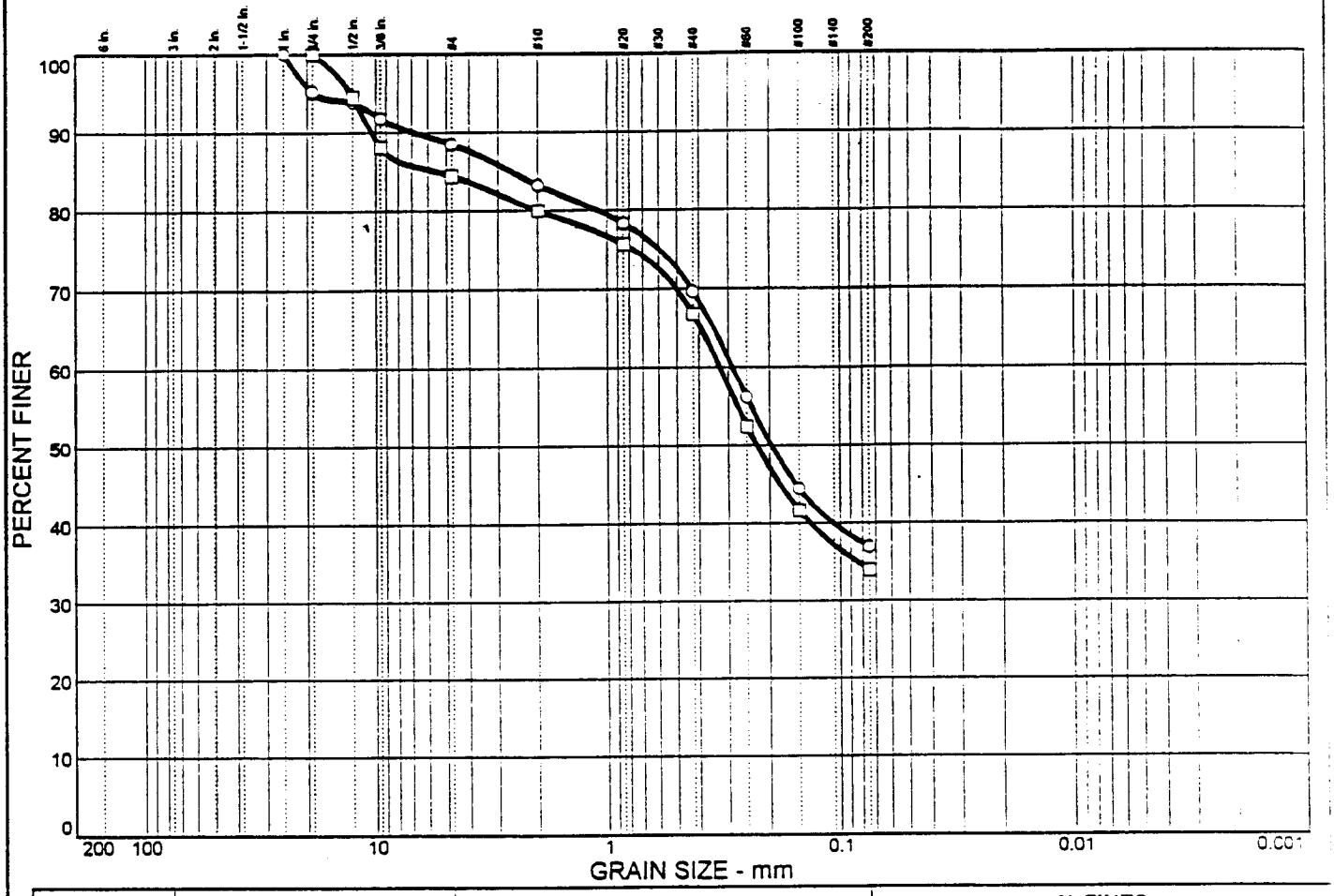
HARTCROWSER

J-4978-18 2/29/2000

Figure No. B-2

AR 044328

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	4.9	6.6	5.2	13.7	32.7	36.9	
□	0.0	0.0	15.5	4.5	13.3	32.7	34.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			2.62	0.289	0.197					
□			5.49	0.327	0.227					

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Slightly gravelly, very silty SAND	SM	12
□ Gravelly, very silty, medium to fine SAND	SM	9%

Remarks:

○

□

Project: Third Runway North Safety Area

Client: Port of Seattle

○ **Source:** HC99-B50 **Sample No.:** S-6

□ **Source:** HC99-B55 **Sample No.:** S-5

HARTCROWSER

J-4978-18 12/3/99

Figure No. B-3

AR 044329

PARTICLE SIZE DISTRIBUTION TEST REPORT

	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	13.9	2.2	5.2	13.6	38.5	26.6
□	0.0	0.0	6.1	2.7	12.3	37.1	41.8	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_U
○			3.21	0.0498	0.0256	0.0061	0.0019			
□			0.613	0.226	0.148					

	MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○	Gravelly, sandy, clayey SILT	ML	
□	Slightly gravelly, very silty, medium to fine SAND	SM	12%

Remarks:

○

□

Project: Third Runway North Safety Area

Client: Port of Seattle

○ **Source:** HC99-B56 **Sample No.:** S-2

□ **Source:** HC99-B72 **Sample No.:** S-4

HARTCROWSER

J-4978-18 12/3/99

Figure No. B-4

AR 044330

PARTICLE SIZE DISTRIBUTION TEST REPORT

	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	5.8	18.6	4.0	13.9	32.1	25.6	
□	0.0	8.7	5.5	3.2	11.1	37.3	34.2	
△	0.0	0.0	11.9	6.3	15.4	45.0	21.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			14.4	0.478	0.310	0.117				
□			3.87	0.272	0.189					
△			3.29	0.347	0.267	0.148				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Gravelly, silty, medium to fine SAND	SM	16%
□ Gravelly, very silty, medium to fine SAND	SM	16%
△ Slightly gravelly, silty SAND	SM	7%

Remarks:

○ NSA Stockpile Fill
□ NSA Stockpile Fill
△ NSA Stockpile Fill

Project: Third Runway North Safety Area

Client: Port of Seattle

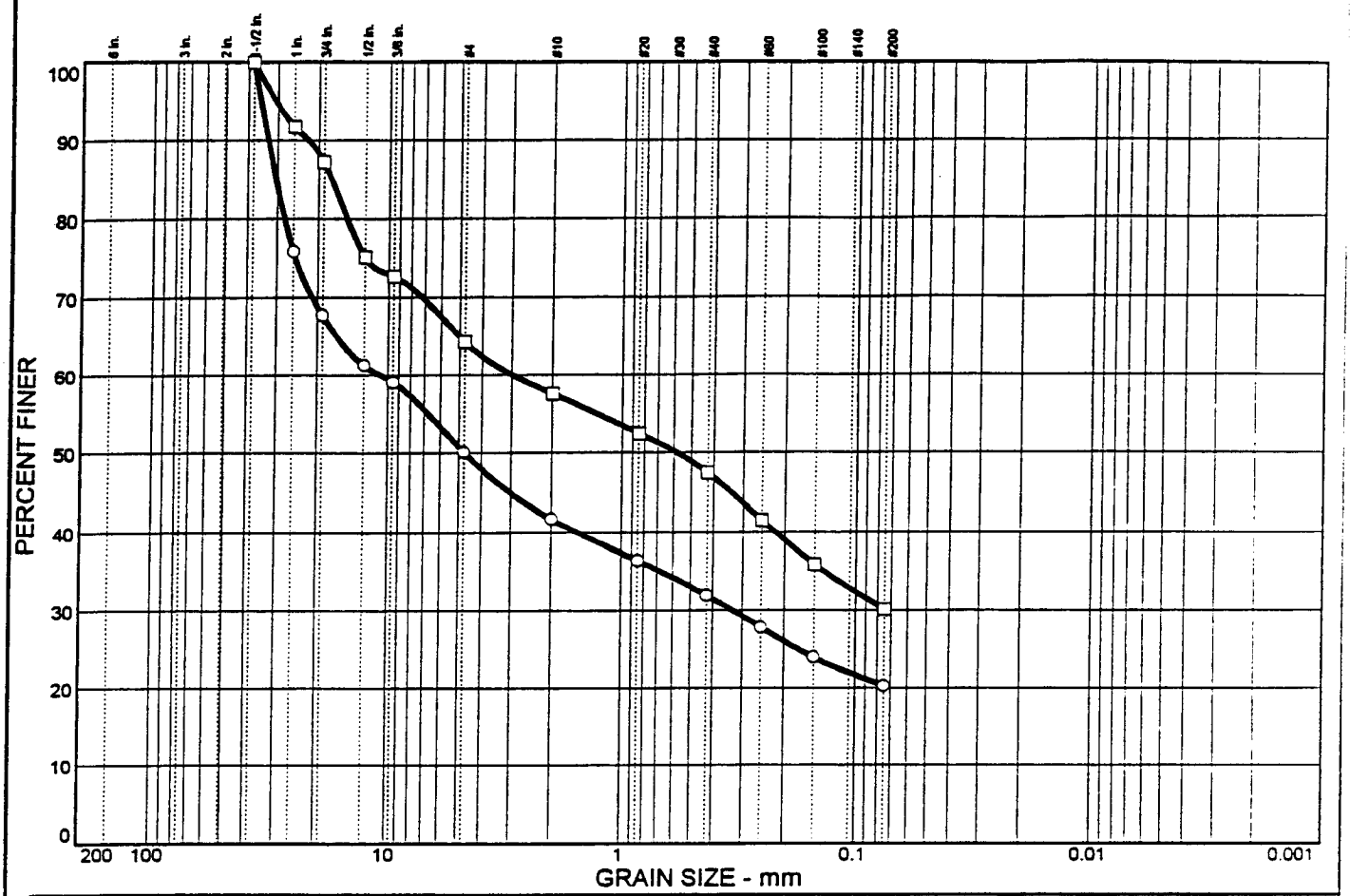
○ **Source:** HC99-B60 **Sample No.:** S-2
□ **Source:** HC99-B60 **Sample No.:** S-4
△ **Source:** HC99-B60 **Sample No.:** S-6

HARTCROWSER

J-4978-18 12/21/99
Figure No. B-5

AR 044331

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	32.3	17.6	8.4	9.8	11.6	20.3	
□	0.0	12.7	23.0	6.7	10.2	17.3	30.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_U
○			30.3	10.8	4.71	0.330				
□			17.5	2.98	0.581					

	MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○	Silty, very sandy GRAVEL	GM	6%
□	Very silty, very sandy GRAVEL	GM	9%

Remarks:

○ Phase 1 Embankment Fill

□ Phase 1 Embankment Fill

Project: Third Runway North Safety Area

Client: Port of Seattle

○ **Source:** HC99-B62 **Sample No.:** S-3

□ **Source:** HC99-B62 **Sample No.:** S-5

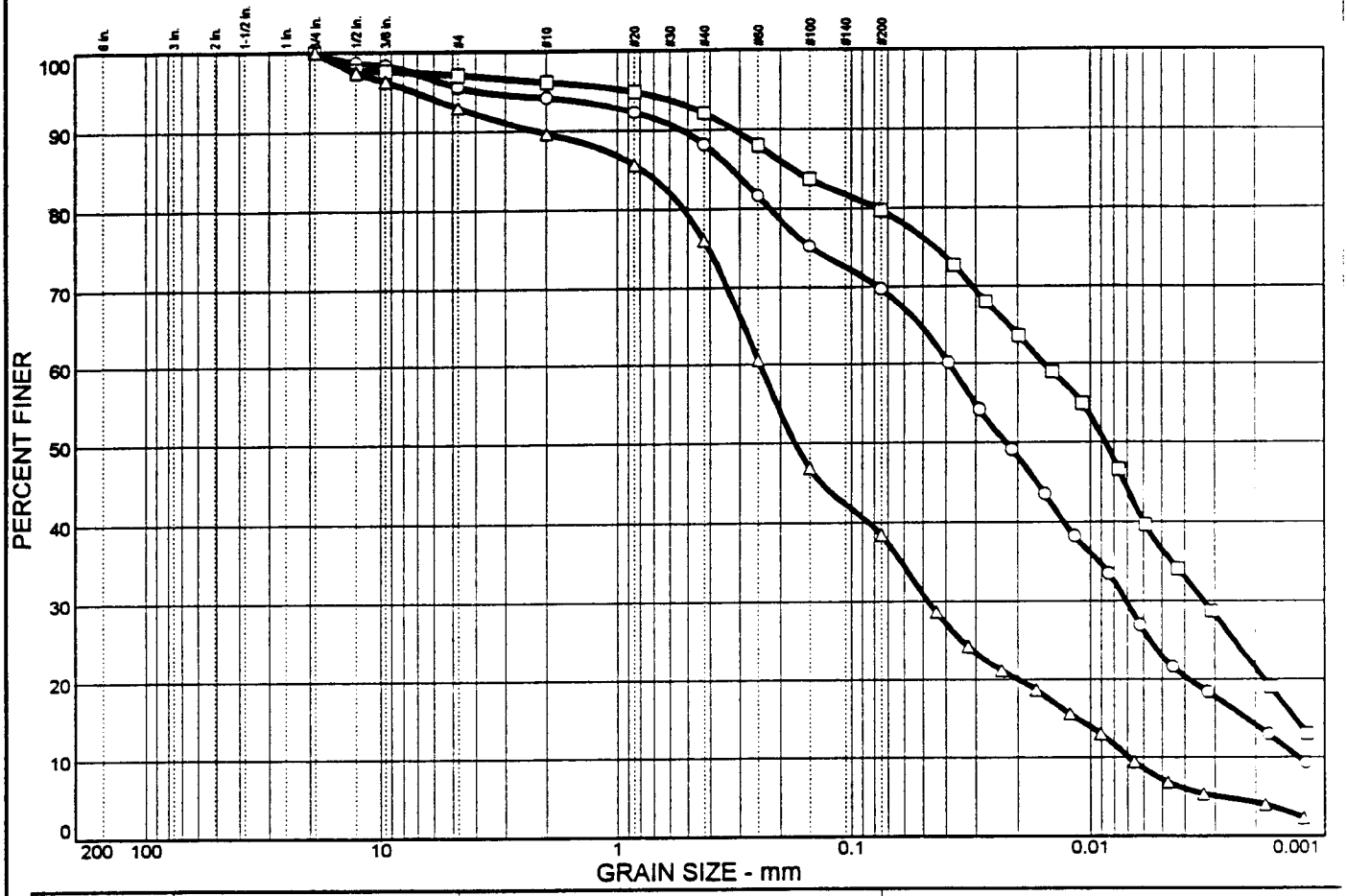
HARTCROWSER

J-4978-18 12/21/99

Figure No. B-6

AR 044332

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	4.3	1.4	6.1	18.5	46.6	23.1
□	0.0	0.0	2.9	0.9	4.0	12.4	43.3	36.5
△	0.0	0.0	6.9	3.4	13.7	37.6	31.2	7.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_U
○	24	8	0.320	0.0389	0.0224	0.0071	0.0022	0.0013	1.00	29.88
□	28	8	0.175	0.0156	0.0087	0.0033	0.0014			
△	NV	NP	0.771	0.245	0.173	0.0476	0.0114	0.0069	1.34	35.57

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Sandy, lean CLAY	CL	
□ Sandy, lean CLAY	CL	
△ Slightly clayey, slightly gravelly, silty, medium to fine SAND	SM	

Remarks:

○

□

△

Project: Third Runway North Safety Area

Client: Port of Seattle

○ **Source:** HC00-B161 **Sample No.:** S-3

□ **Source:** HC00-B163 **Sample No.:** S-2

△ **Source:** HC00-B169 **Sample No.:** S-3

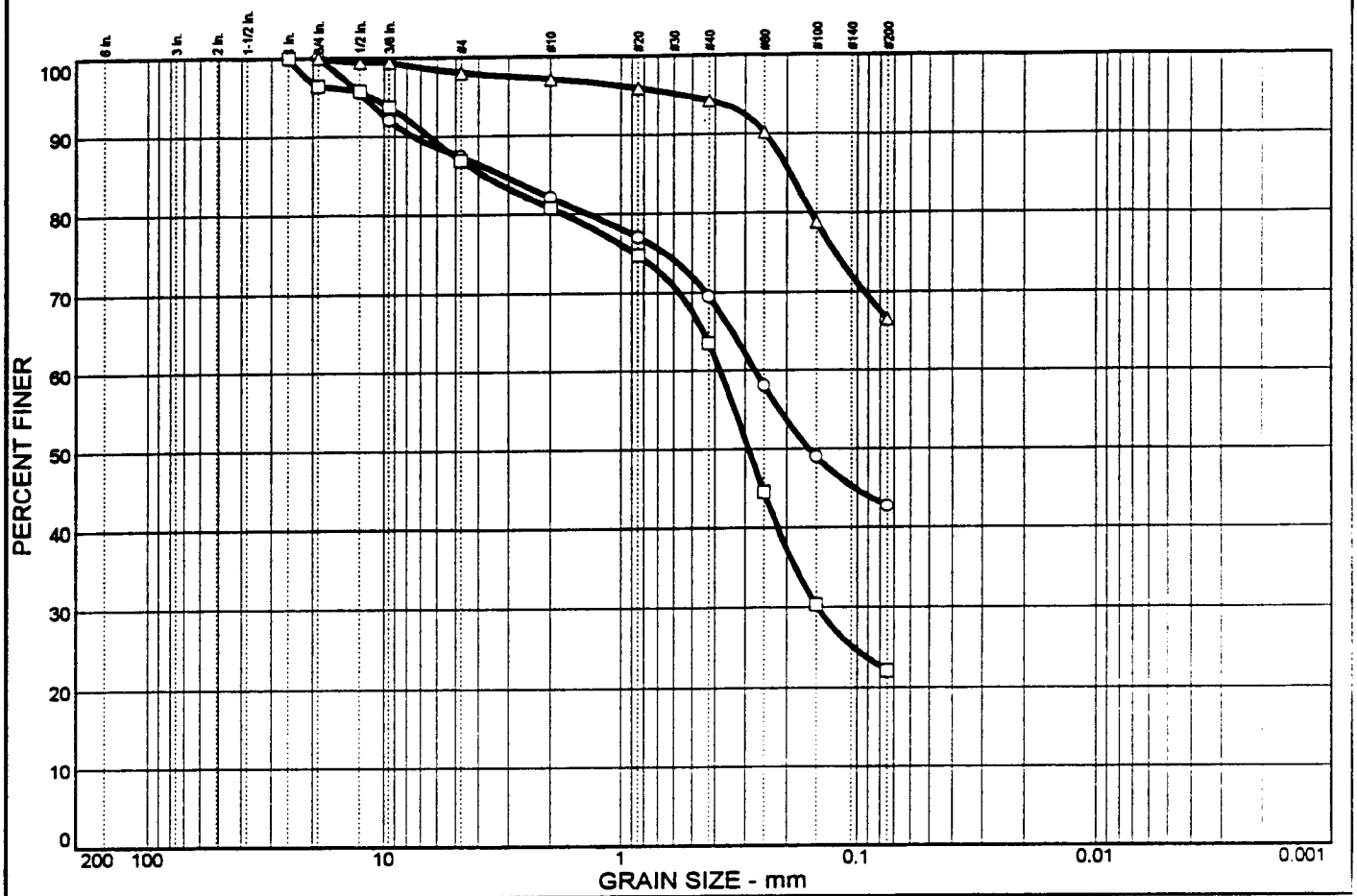
HARTCROWSER

J-4978-18 2/25/2000

Figure No. B-7

AR 044333

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	12.6	5.3	12.6	26.8	42.7	
□	0.0	3.5	9.6	6.1	17.3	41.4	22.1	
△	0.0	0.0	1.9	0.9	2.9	27.8	66.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			3.18	0.272	0.161					
□			3.80	0.380	0.289	0.148				
△			0.194							

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Gravelly, very silty SAND	SM	13%
□ Gravelly, silty SAND	SM	14%
△ Very sandy SILT	ML	17%

Remarks:

○

□

△

Project: Third Runway North Safety Area

Client: Port of Seattle

○ **Source:** HC00-B162 **Sample No.:** S-5

□ **Source:** HC00-B165 **Sample No.:** S-3

△ **Source:** HC00-B166 **Sample No.:** S-2

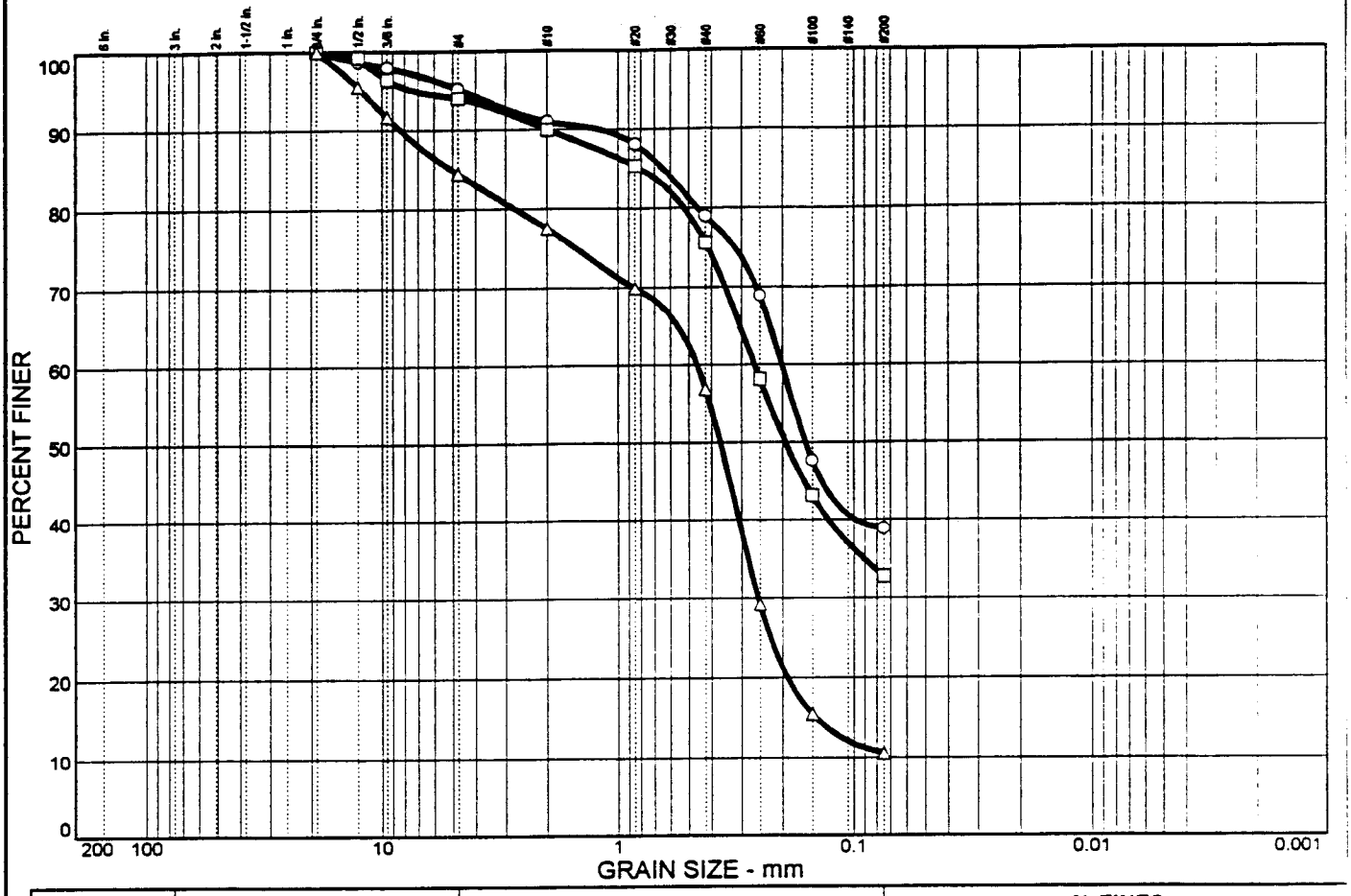
HARTCROWSER

J-4978-18 2/23/2000

Figure No. B-8

AR 044334

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	4.7	4.3	12.0	40.2	38.8	
□	0.0	0.0	5.9	4.1	14.4	42.8	32.8	
△	0.0	0.0	15.6	6.9	20.5	46.4	10.6	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	NV	NP	0.649	0.201	0.160					
□			0.815	0.263	0.194					
△	NV	NP	5.09	0.460	0.368	0.254	0.144			

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Very silty, medium to fine SAND	SM	14%
□ Slightly gravelly, very silty, medium to fine SAND	SM	15%
△ Slightly silty, gravelly SAND	SP-SM	21%

Remarks:

○

□

△

Project: Third Runway North Safety Area

Client: Port of Seattle

○ **Source:** HC00-B167 **Sample No.:** S-2

□ **Source:** HC00-B170 **Sample No.:** S-3

△ **Source:** HC00-B173 **Sample No.:** S-2

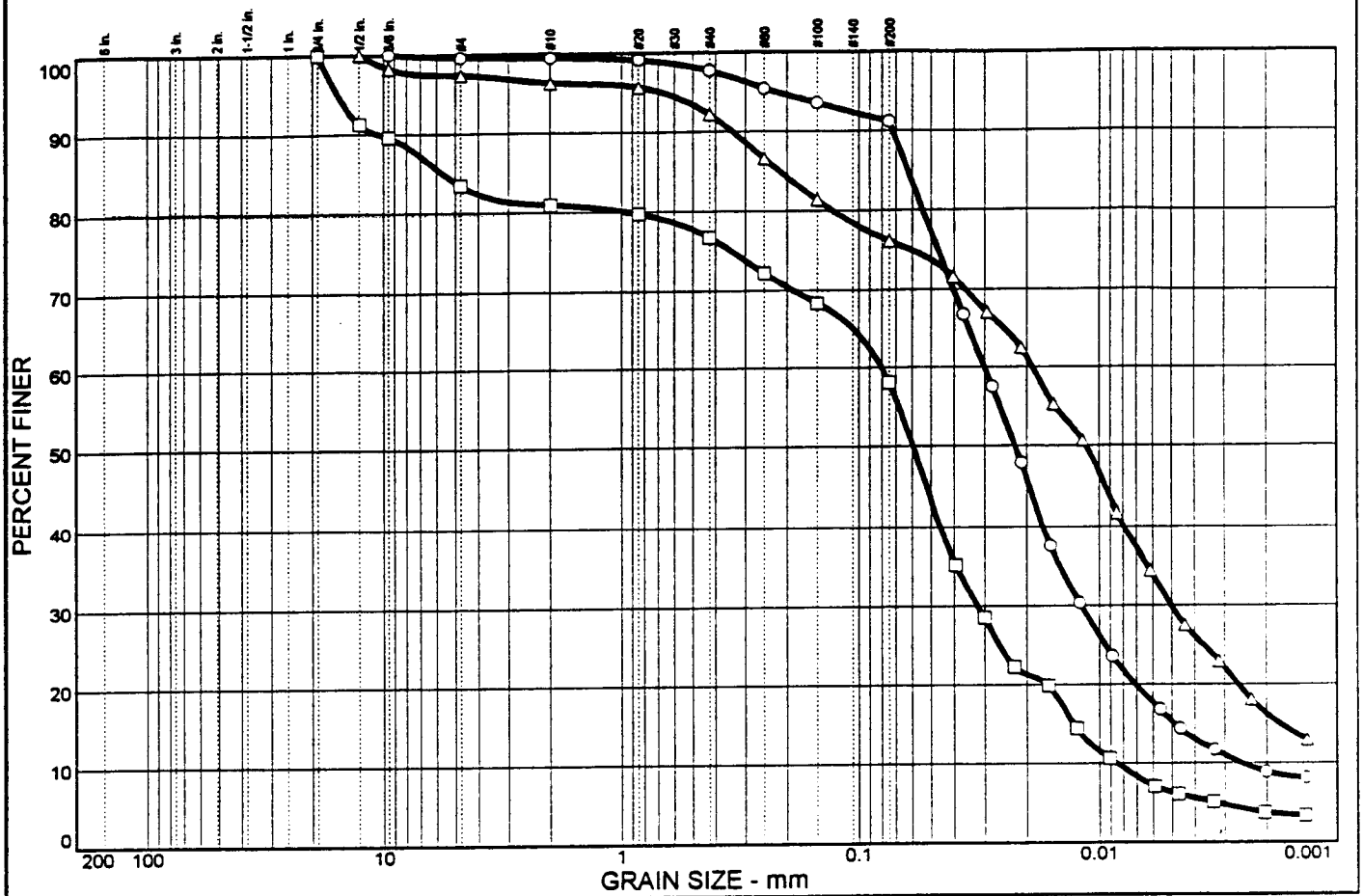
HARTCROWSER

J-4978-18 2/23/2000

Figure No. B-9

AR 044335

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.4	0.2	1.7	6.5	75.8	15.4
□	0.0	0.0	16.5	2.5	4.3	18.6	51.8	6.3
△	0.0	0.0	2.6	1.1	4.1	16.1	46.2	29.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	28	5	0.0626	0.0301	0.0224	0.0119	0.0049	0.0025	1.87	11.89
□	28	4	5.62	0.0804	0.0594	0.0320	0.0128	0.0084	1.52	9.55
△	25	8	0.216	0.0190	0.0114	0.0050	0.0018			

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Slightly sandy, clayey SILT	ML	21%
□ Slightly clayey, gravelly, sandy SILT	ML	18%
△ Sandy, lean CLAY	CL	17%

Remarks:

○

□

△

Project: Third Runway North Safety Area

Client: Port of Seattle

○ **Source:** HC00-B169 **Sample No.:** S-5

□ **Source:** HC00-B172 **Sample No.:** S-8

△ **Source:** HC00-B175 **Sample No.:** S-3

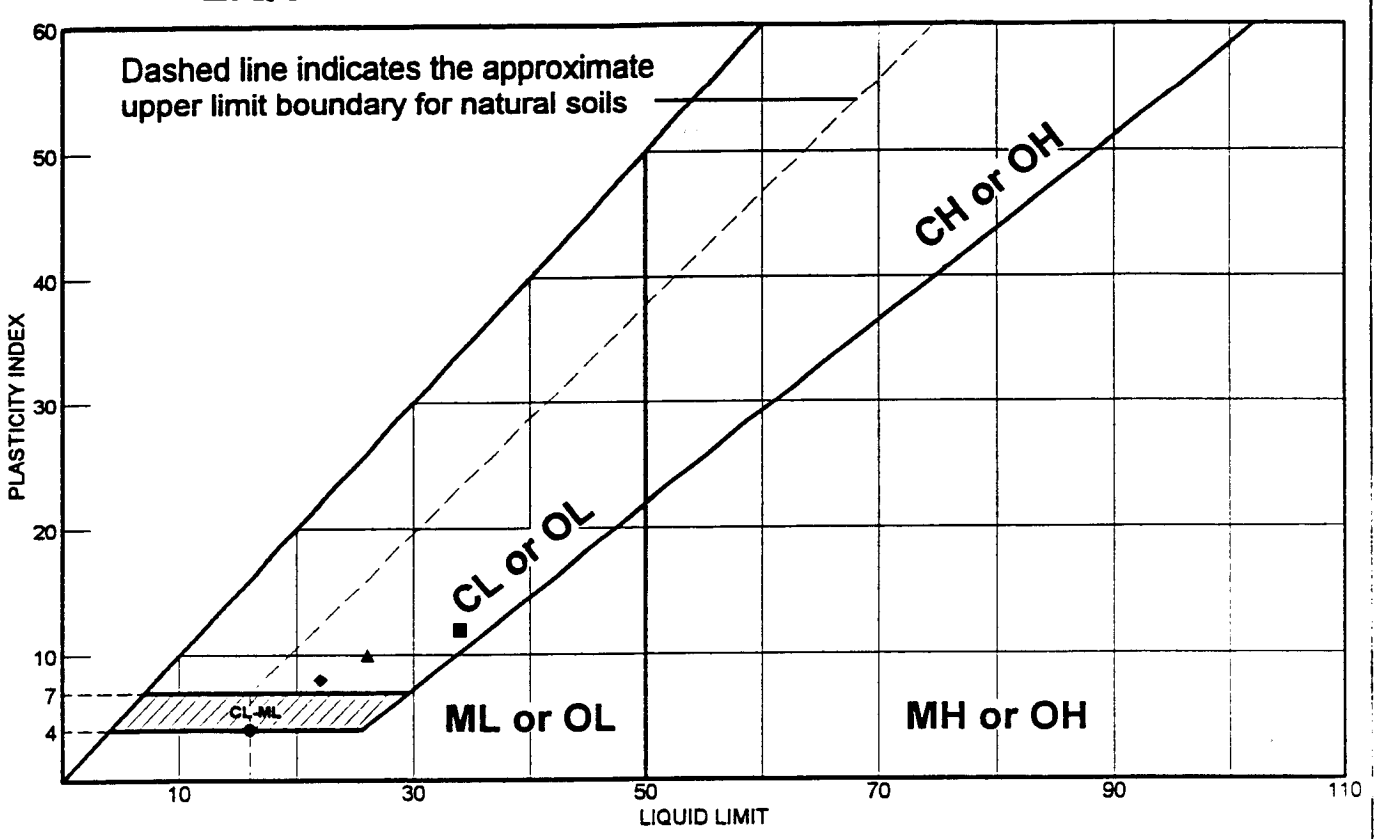
HARTCROWSER

J-4978-18 3/3/2000

Figure No. B-10

AR 044336

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description	LL	PL	PI	-200	USCS
● Source: HC99-B44 Sample No.: S-3 Clayey, very silty, medium to fine SAND	16	12	4	49.3	SC-SM
■ Source: HC99-B50 Sample No.: S-4 Lean CLAY	34	22	12		CL
▲ Source: HC99-B51 Sample No.: S-2 CLAY	26	16	10		CL
◆ Source: HC99-B52 Sample No.: S-4 lean CLAY	22	14	8		CL
▼ Source: HC99-B54a Sample No.: S-1A CLAY	34	22	12		CL

Remarks:

●

■

▲

◆

▼Consolidation Test

Project: Third Runway North Safety Area

Client: Port of Seattle

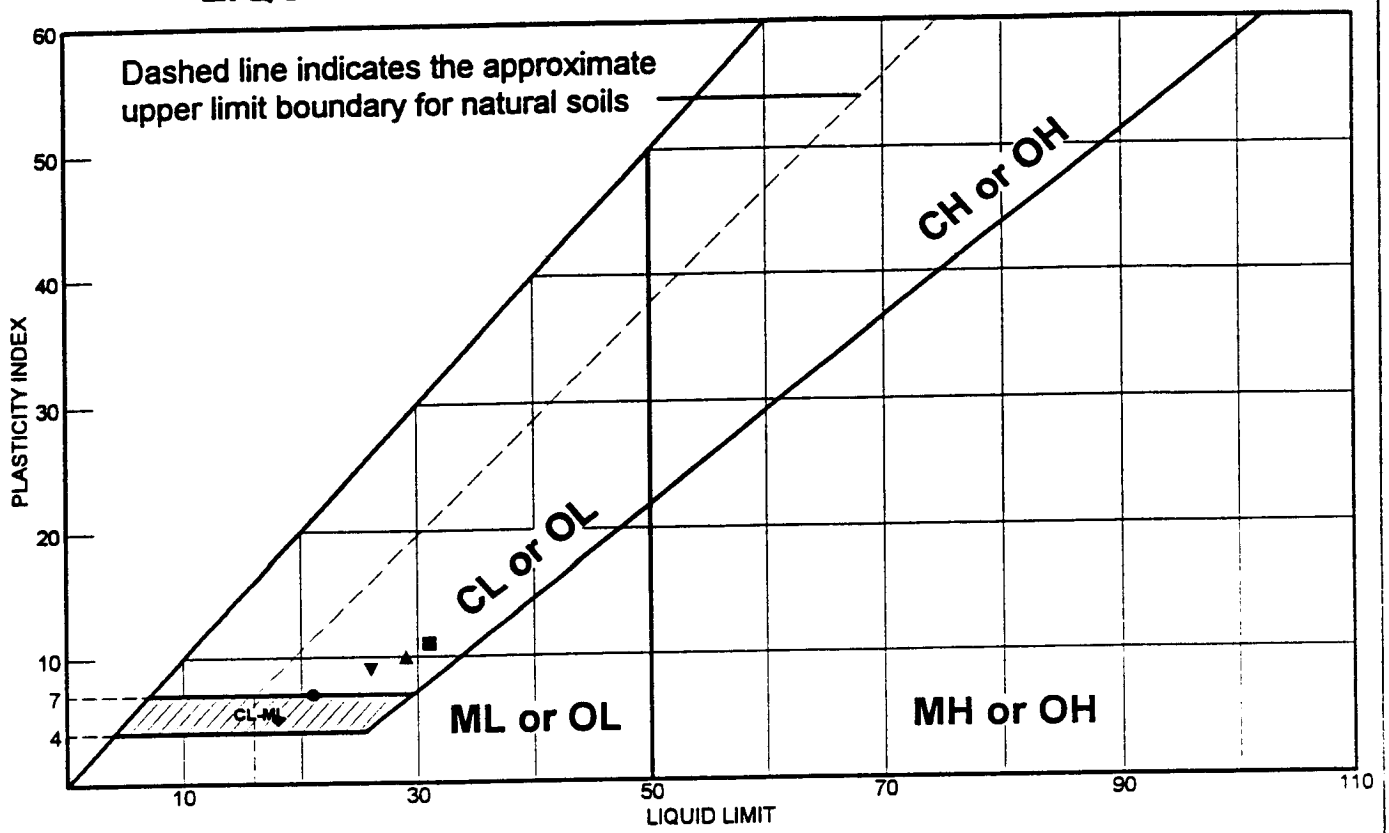
Location:

HARTCROWSER

J-4978-18 3/1/2000

Figure No. B-11

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description	LL	PL	PI	-200	USCS
● Source: HC99-B54b Sample No.: S-1B Lean CLAY	21	14	7		CL
■ Source: HC99-B54c Sample No.: S-1C Lean CLAY	31	20	11		CL
▲ Source: HC99-B58 Sample No.: S-3 Sandy, very silty, lean CLAY	29	19	10	70.1	CL
◆ Source: HC99-B64 Sample No.: S-5 Silty CLAY	18	13	5		CL-ML
▼ Source: HC00-B160 Sample No.: S-4 Lean CLAY	26	17	9		CL

Remarks:

●

■

▲

◆

▼

Project: Third Runway North Safety Area

Client: Port of Seattle

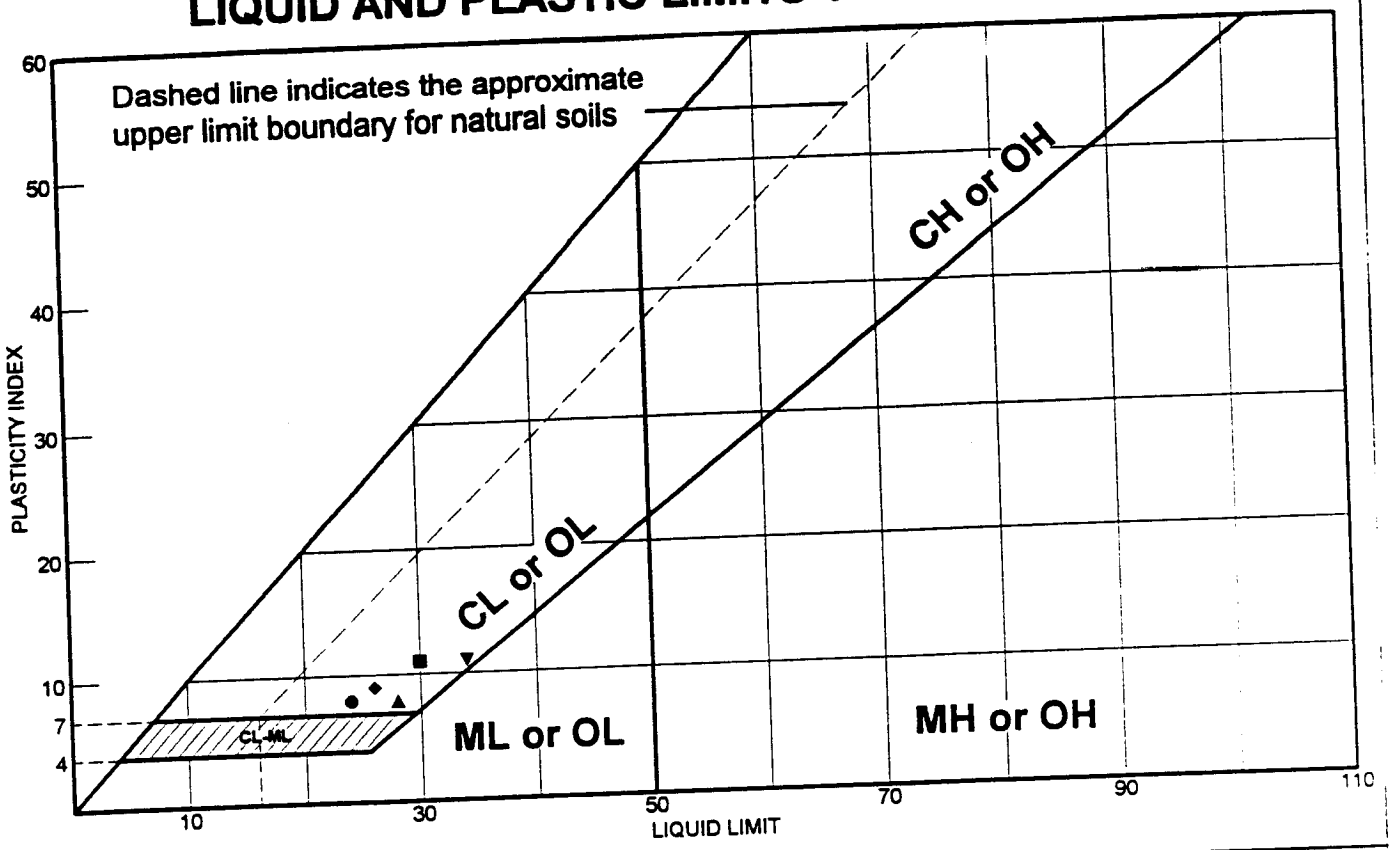
Location:

HARTCROWSER

J-4978-18 3/1/2000

Figure No. B-12

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description		LL	PL	PI	-200	USCS
● Source: HC00-B161 Sandy, lean CLAY	Sample No.: S-3	24	16	8	69.7	CL
■ Source: HC00-B162a Lean CLAY	Sample No.: S-1A	30	19	11		CL
▲ Source: HC00-B163 Sandy, lean CLAY	Sample No.: S-2	28	20	8	79.8	CL
◆ Source: HC00-B163 Lean CLAY	Sample No.: S-6	26	17	9		CL
▼ Source: HC00-B164 Lean CLAY	Sample No.: S-3	34	23	11		CL

Remarks:

●

■

▲

◆

▼

Project: Third Runway North Safety Area

Client: Port of Seattle

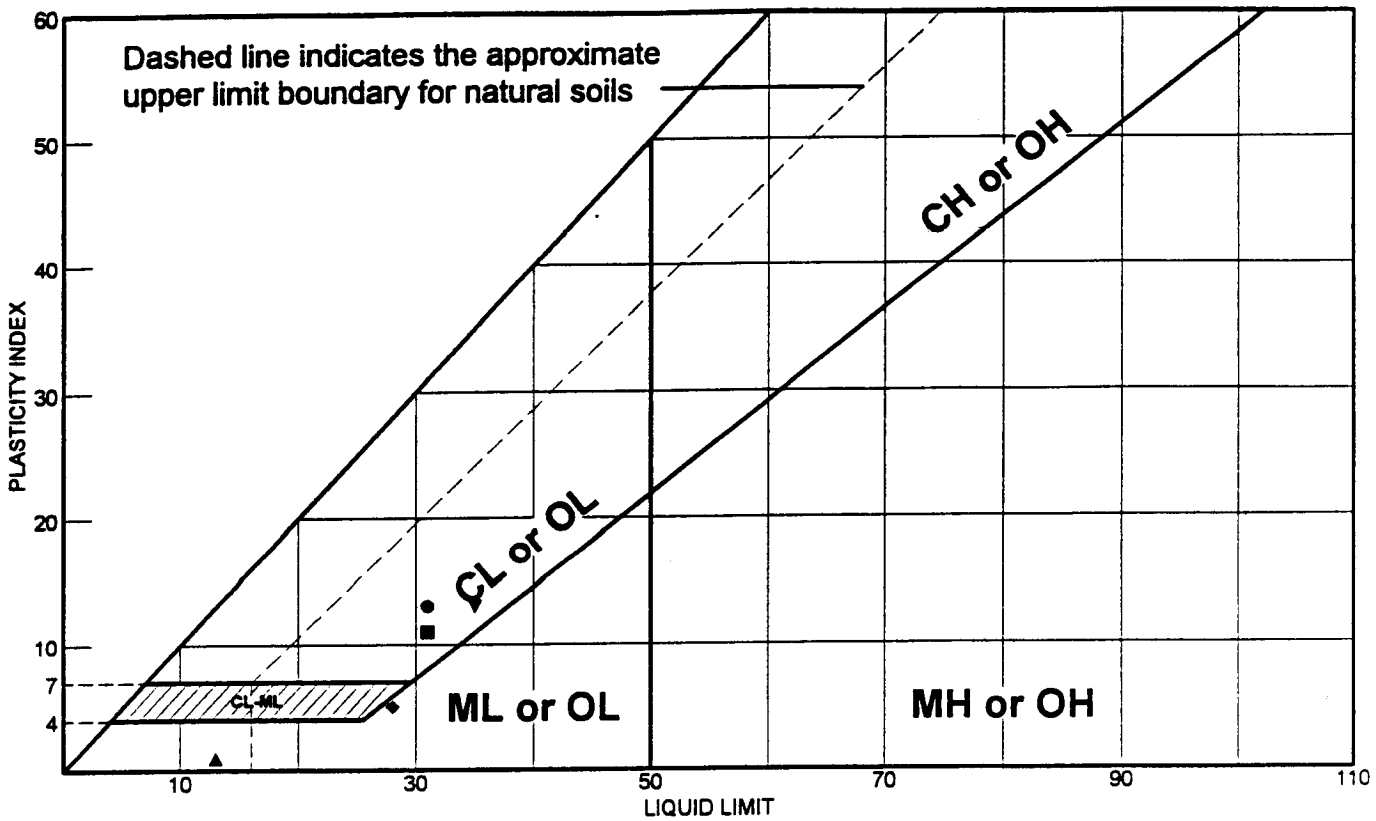
Location:

HARTCROWSER

J-4978-18 3/1/2000

Figure No. B-13

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description		LL	PL	PI	-200	USCS
● Source: HC00-B164 Lean CLAY	Sample No.: S-4	31	18	13		CL
■ Source: HC00-B165a Lean CLAY	Sample No.: S-2A	31	20	11		CL
▲ Source: HC00-B167 SILT	Sample No.: S-3	13	12	1		ML
◆ Source: HC00-B169 SILT	Sample No.: S-5	28	23	5		ML
▼ Source: HC00-B170 lean CLAY	Sample No.: S-5	35	22	13		CL

Remarks:

●

■

▲

◆

▼

Project: Third Runway North Safety Area

Client: Port of Seattle

Location:

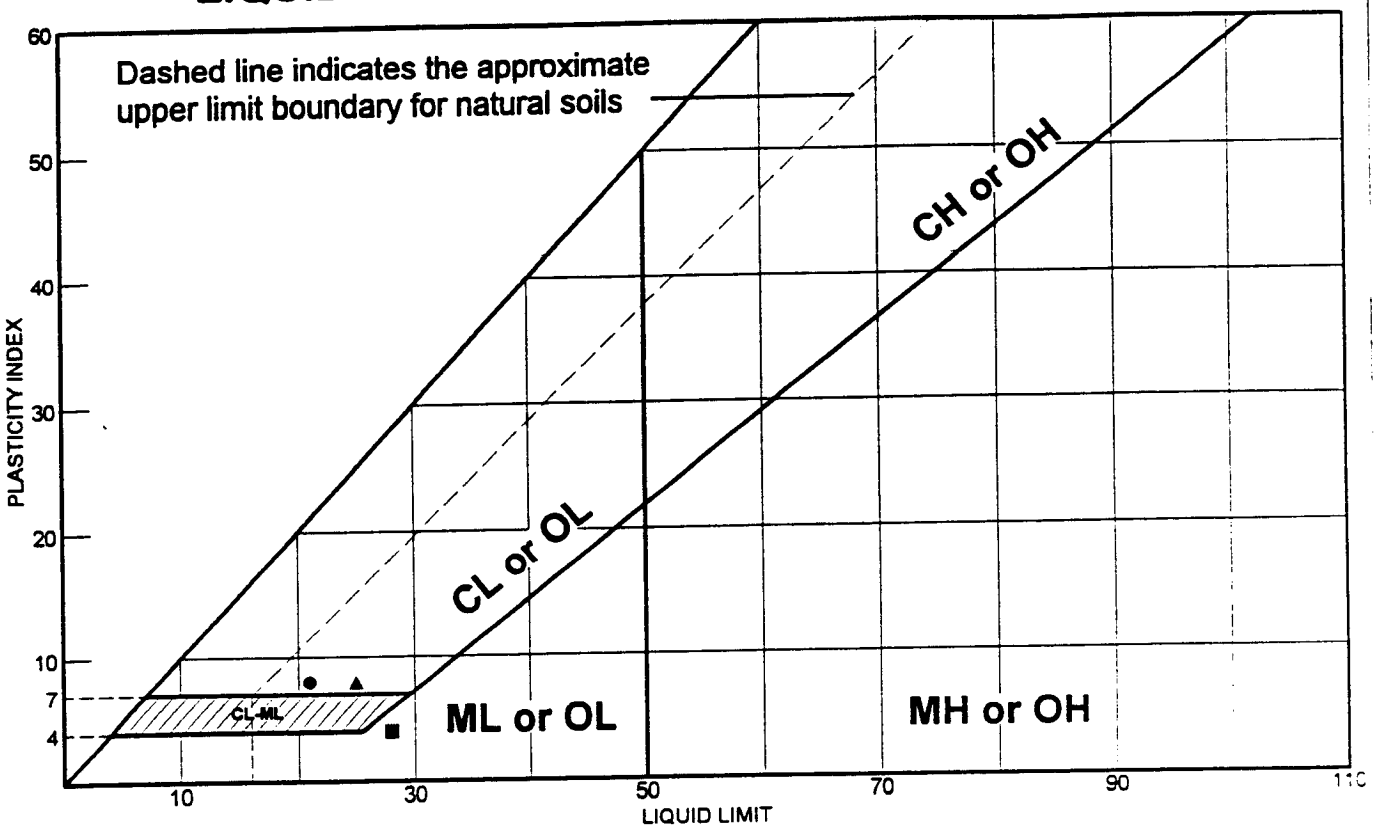
HARTCROWSER

J-4978-18 3/1/2000

Figure No. B-14

AR 044340

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description	LL	PL	PI	-200	USCS
● Source: HC00-B172 Sample No.: S-3 Lean CLAY	21	13	8		CL
■ Source: HC00-B172 Sample No.: S-8 SILT	28	24	4		ML
▲ Source: HC00-B175 Sample No.: S-3 Lean CLAY	25	17	8		CL

Remarks:

●

■

▲

Project: Third Runway North Safety Area

Client: Port of Seattle

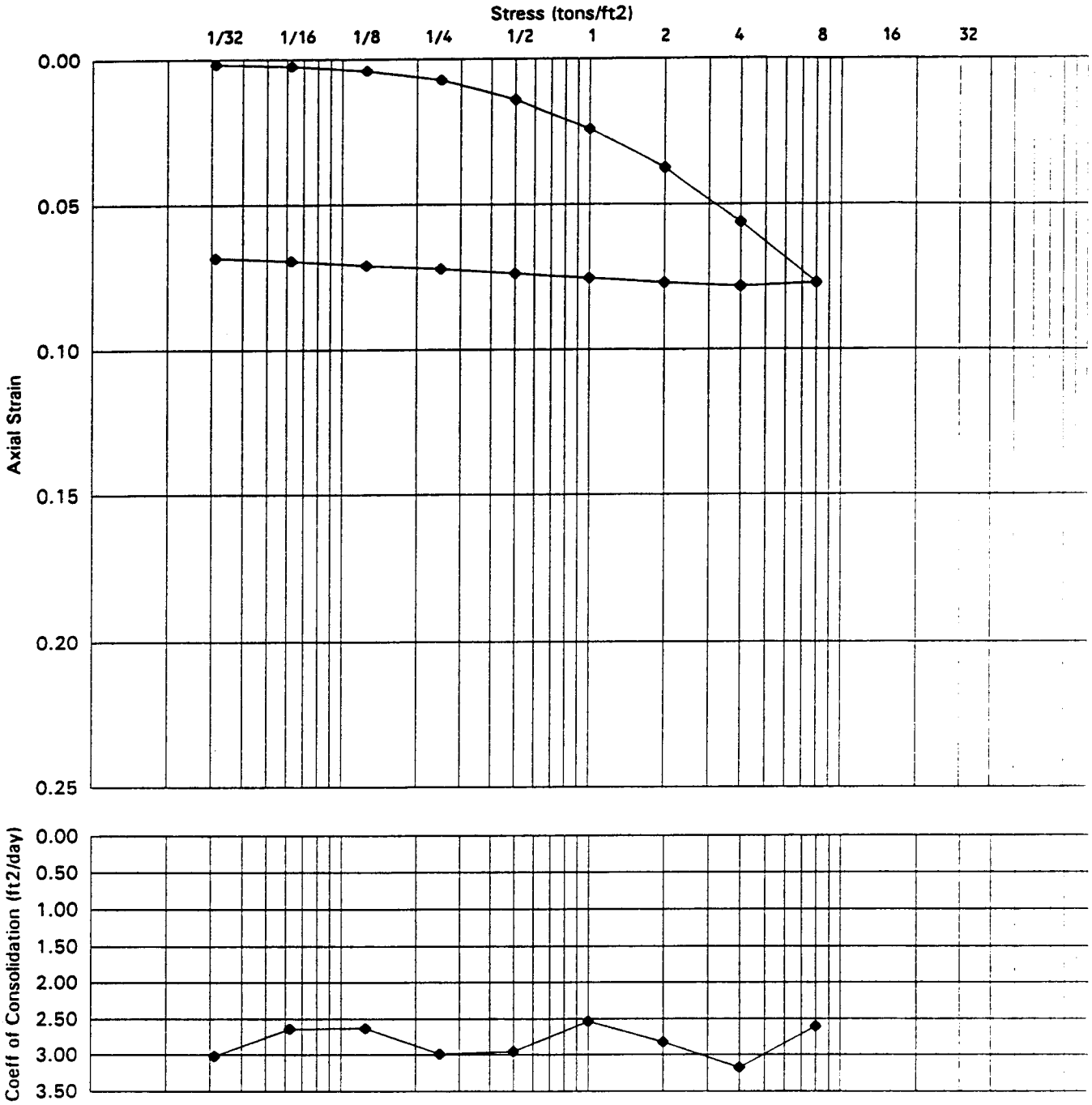
Location:

HARTCROWSER

J-4978-18 3/1/2000

Figure No. B-15

CONSOLIDATION TEST RESULTS



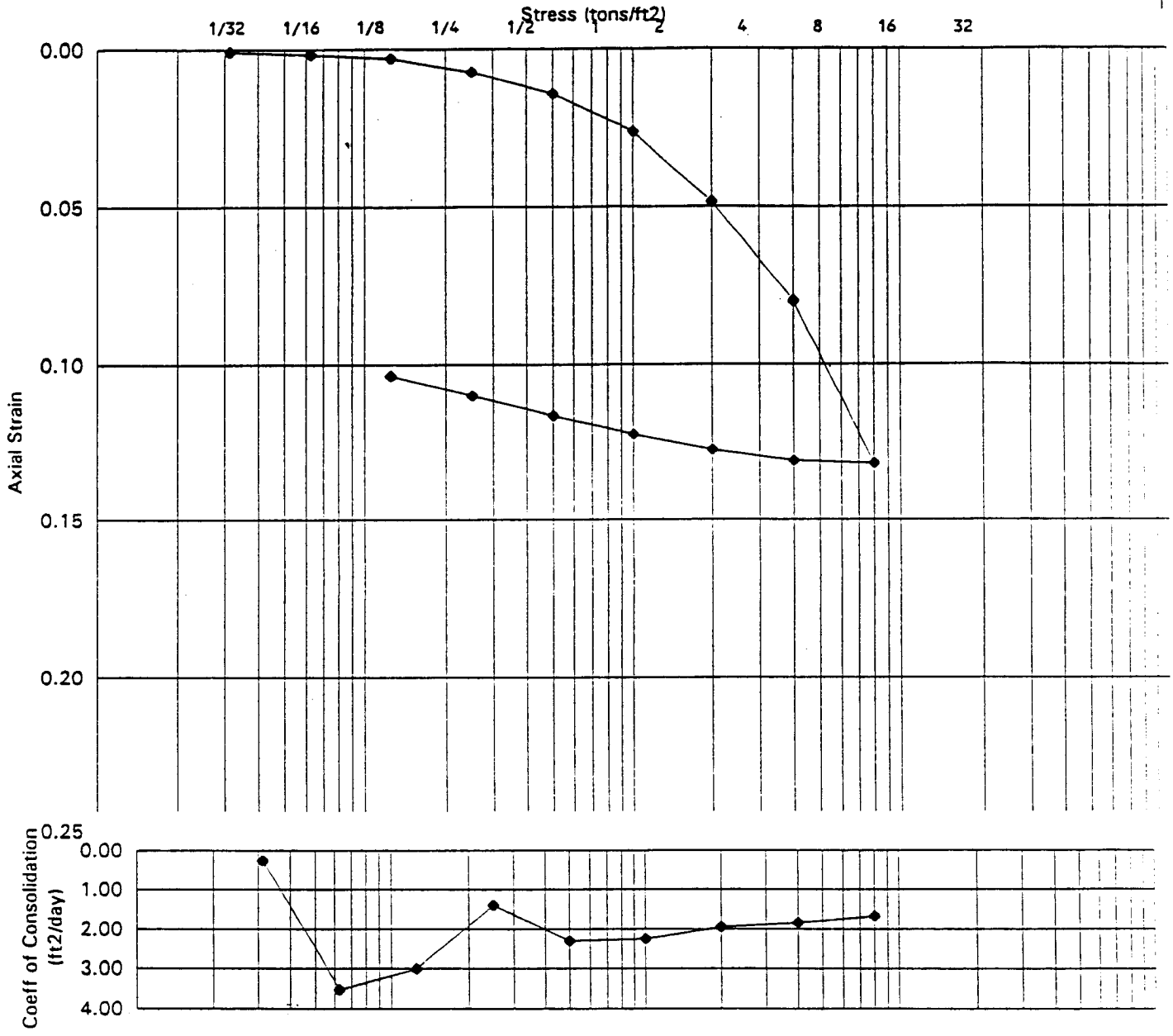
Expl. No.	Sample No.	Depth (ft)	W.C. % Before	W.C. % After	Atterberg Limit LL	Atterberg Limit PL	Atterberg Limit PI	Wet Wt (pcf)	USC	Description
B44	S-3	7 –8.8	15%	13%	16	12	4	139 pcf	SC-SM	Clayey, very silty SAND

Remarks:

HARTCROWSER J-4978-18 1/26/2000
Figure B–16

AR 044342

CONSOLIDATION TEST RESULTS



Expl. No.	Sample No.	Depth (ft)	W.C. % Before	W.C. % After	Atterberg Limit LL	Atterberg Limit PL	Atterberg Limit PI	Wet Wt (pcf)	USC	Description
B54A	S-1A	6.5 - 8.5	39%	34%	34	22	12	112 pcf	CL	CLAY

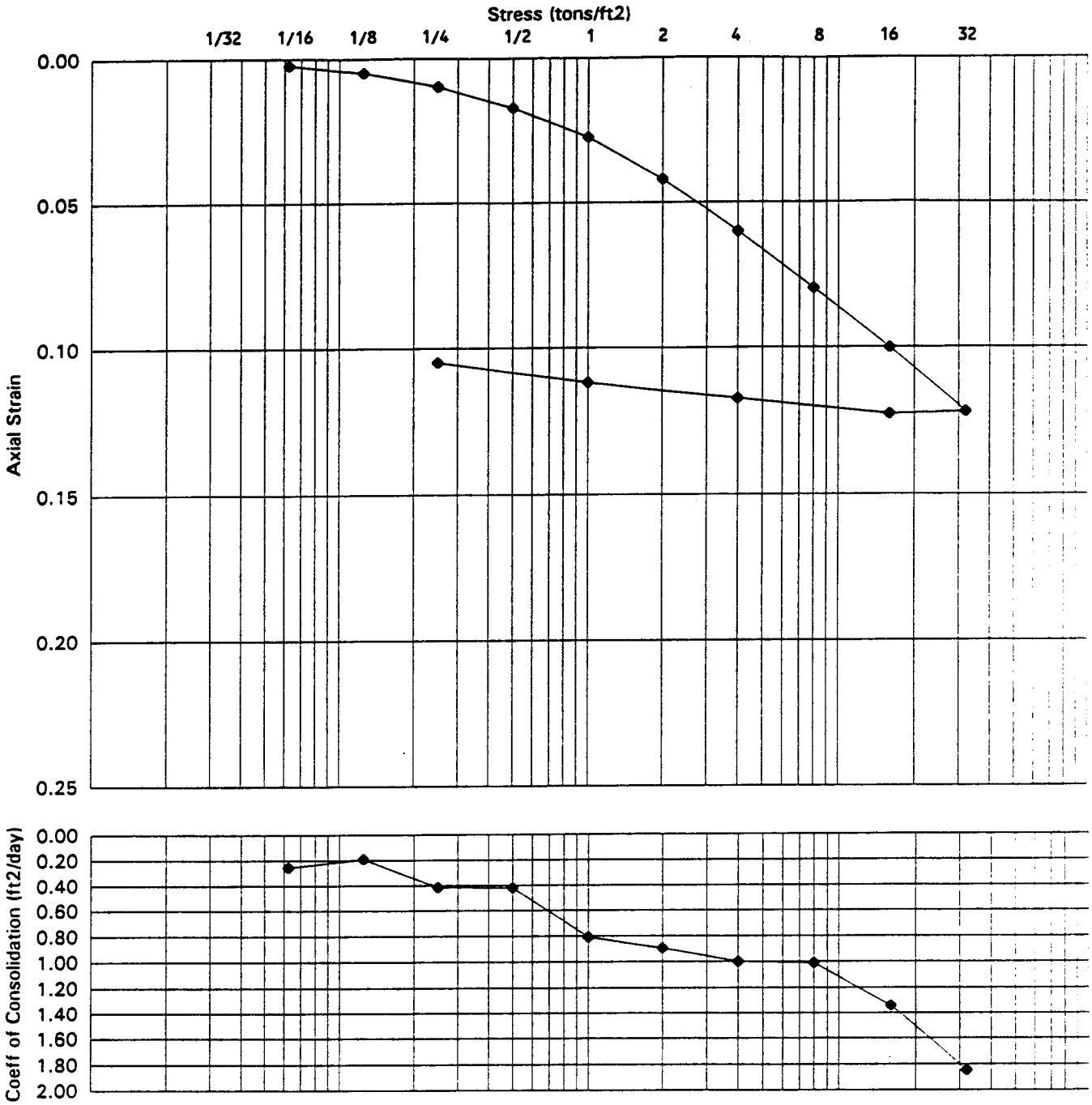
Remarks:

HARTCROWSER

J-4978-18 11/17/99

Figure B-17

CONSOLIDATION TEST RESULTS



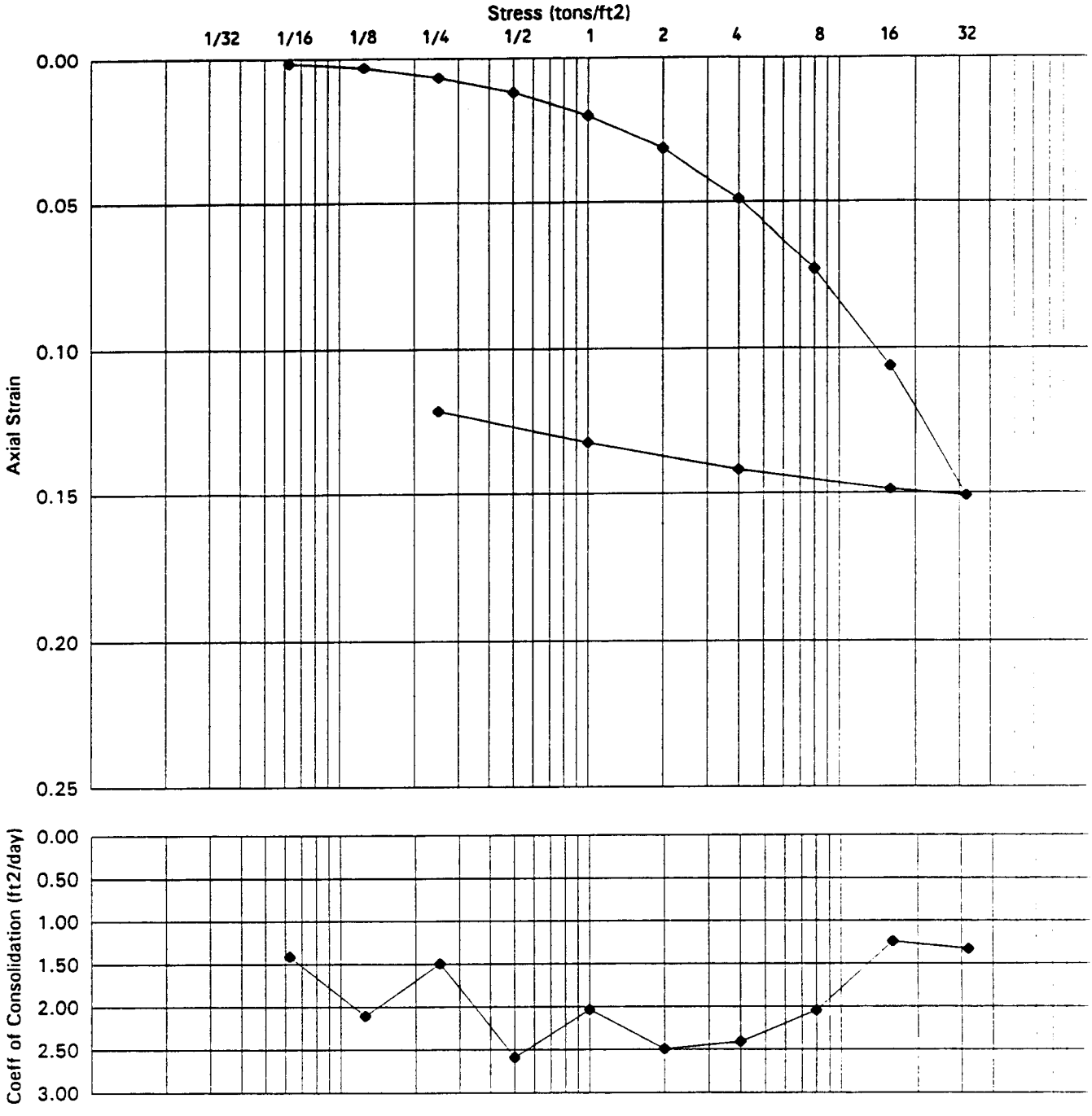
Expl. No.	Sample No.	Depth (ft)	W.C. %		Atterberg Limit			Wet Wt (pcf)	USC	Description
			Before	After	LL	PL	PI			
B163	S-6	15.5 -16.3	21%	16%	26	17	9	131 pcf	CL	Lean CLAY

Remarks:

HARTCROWSER J-4978-18 2/16/2000
Figure B-18

AR 044344

CONSOLIDATION TEST RESULTS

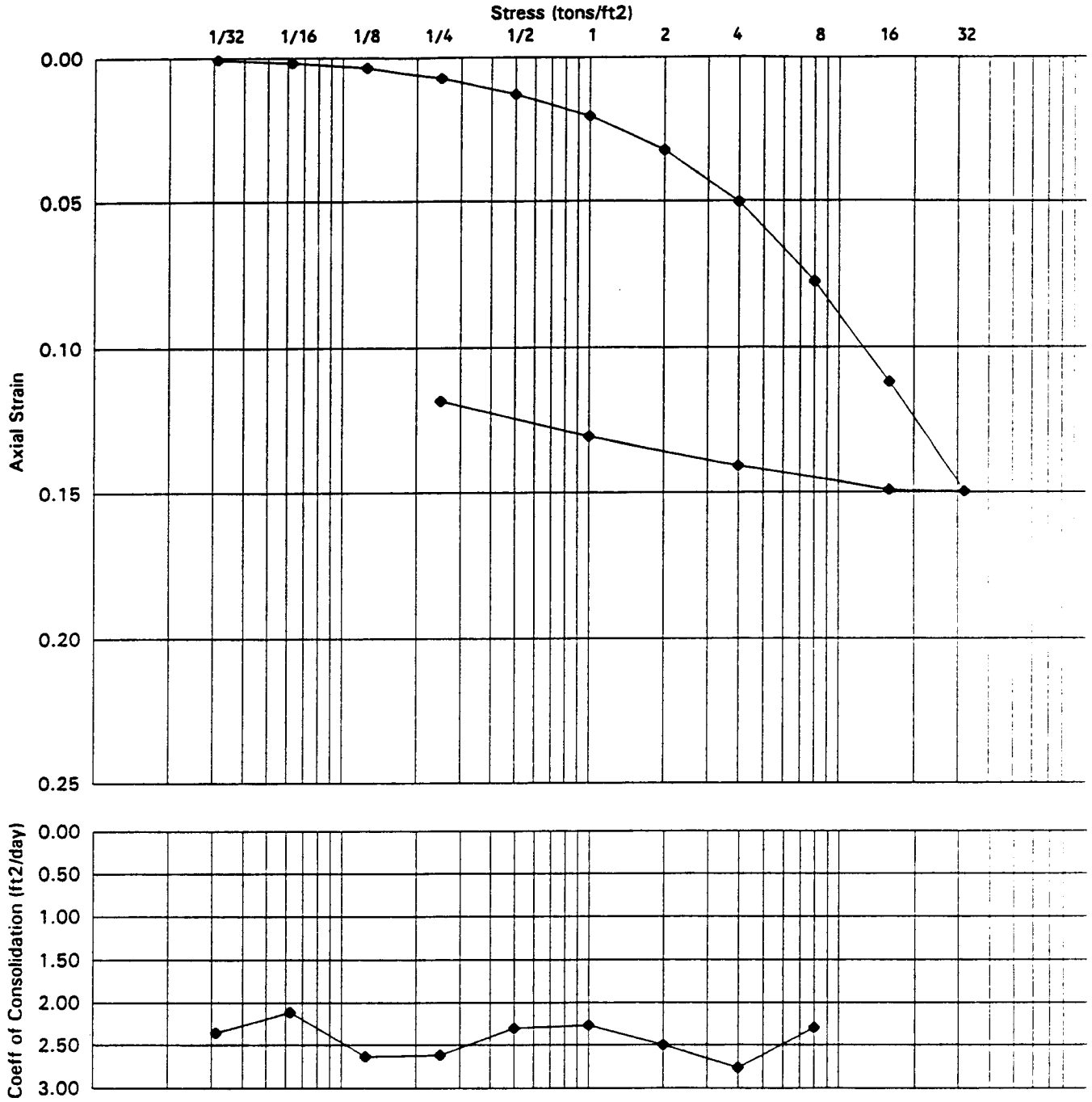


Expl. No.	Sample No.	Depth (ft)	W.C. %		Atterberg Limit			Wet Wt (pcf)	USC	Description
			Before	After	LL	PL	PI			
B164	S-4	7.5 -10.0	22%	19%	31	18	13	128 pcf	CL	Lean CLAY

Remarks:

HARTCROWSER J-4978-18 2/18/2000
Figure B-19

CONSOLIDATION TEST RESULTS



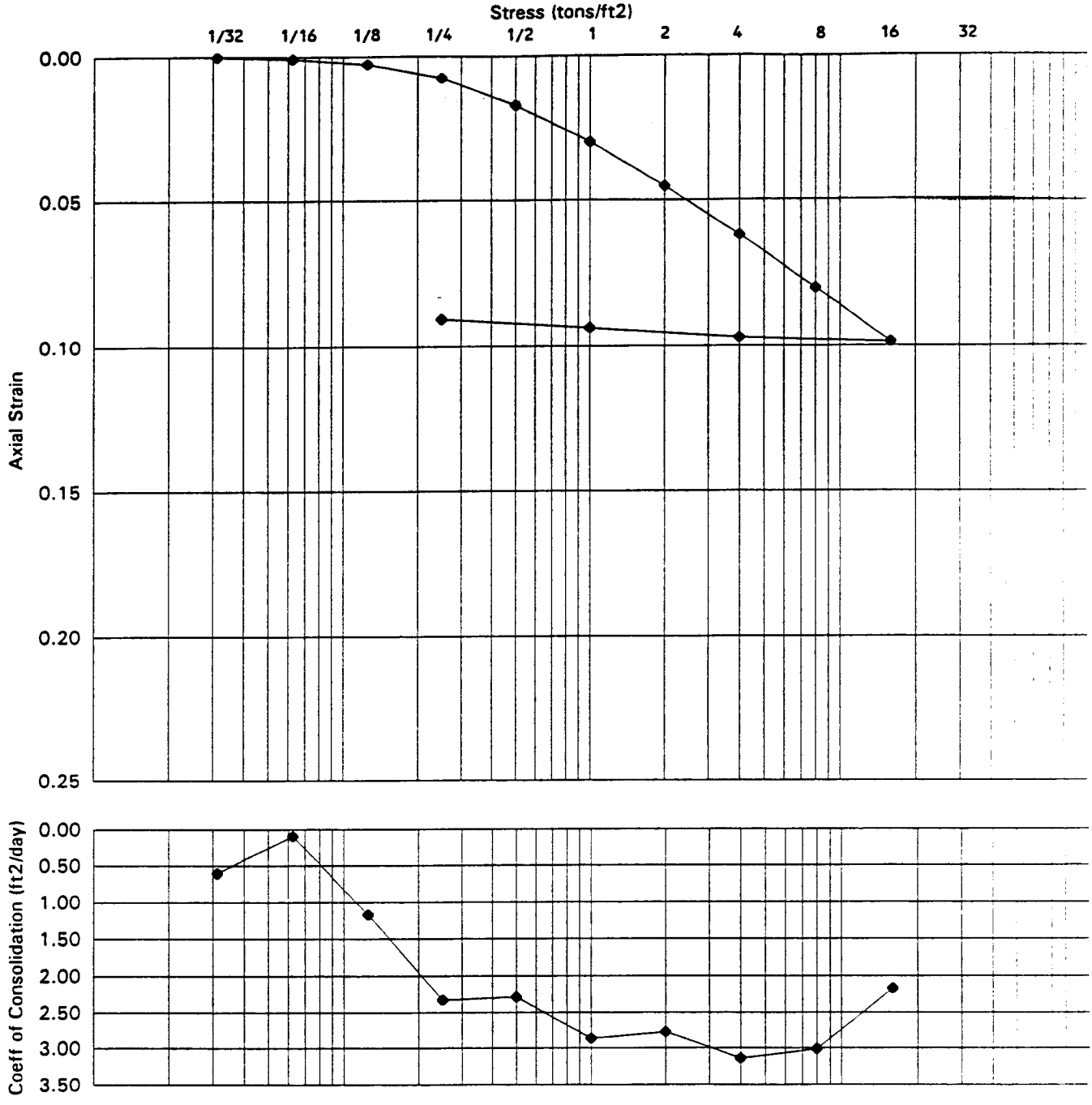
Expl. No.	Sample No.	Depth (ft)	W.C. %		Atterberg Limit			Wet Wt (pcf)	USC	Description
			Before	After	LL	PL	PI			
B165A	S-2A	9.5 -11.5	33%	27%	31	20	11	121 pcf	CL	Lean CLAY

Remarks:

HARTCROWSER J-4978-18 2/3/2000
Figure B-20

AR 044346

CONSOLIDATION TEST RESULTS



Expl. No.	Sample No.	Depth (ft)	W.C. % Before	W.C. % After	Atterberg Limit LL	Atterberg Limit PL	Atterberg Limit PI	Wet Wt (pcf)	USC	Description
B167	S-3	10.5-11.5	14%	11%	13	12	1	137 pcf	ML	SILT

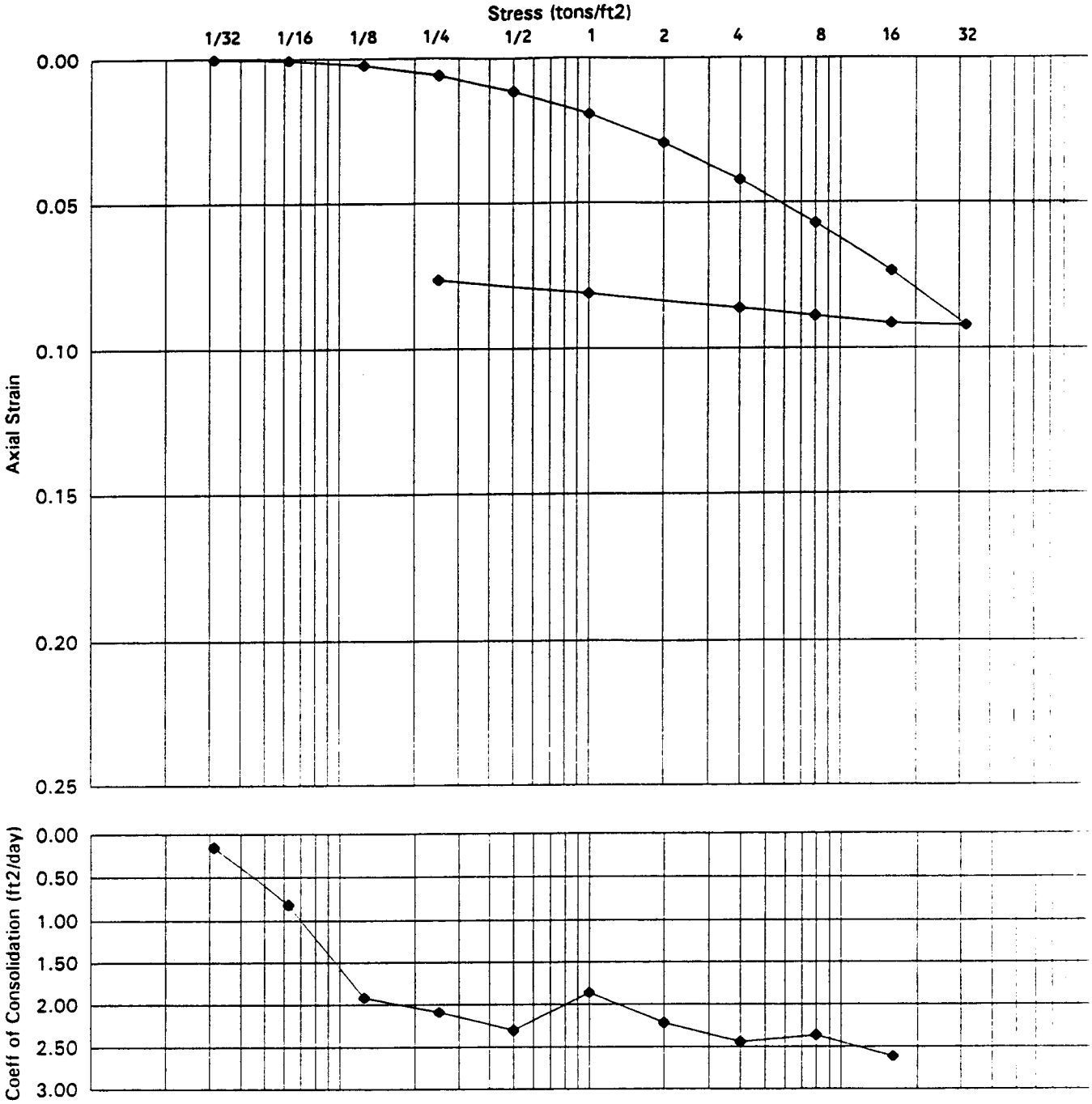
Remarks:

HARTCROWSER

J-4978-18 2/1/2000

Figure B-21

CONSOLIDATION TEST RESULTS

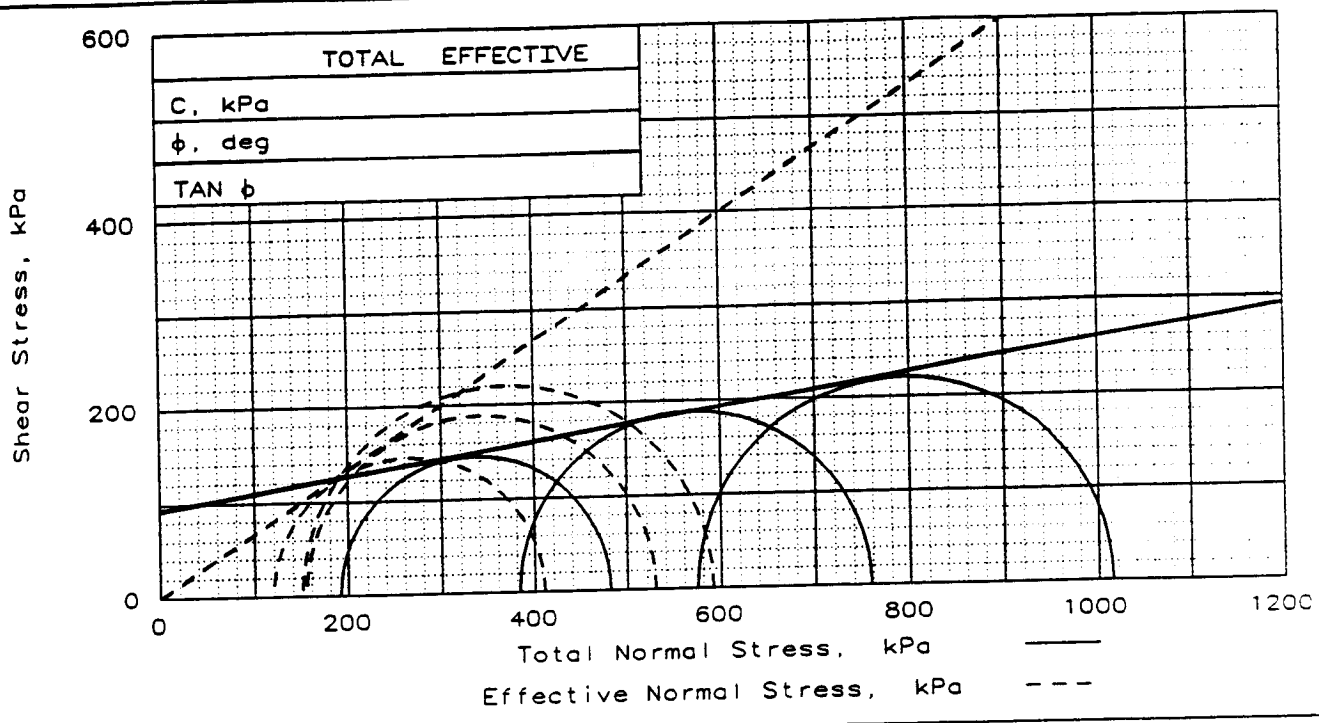


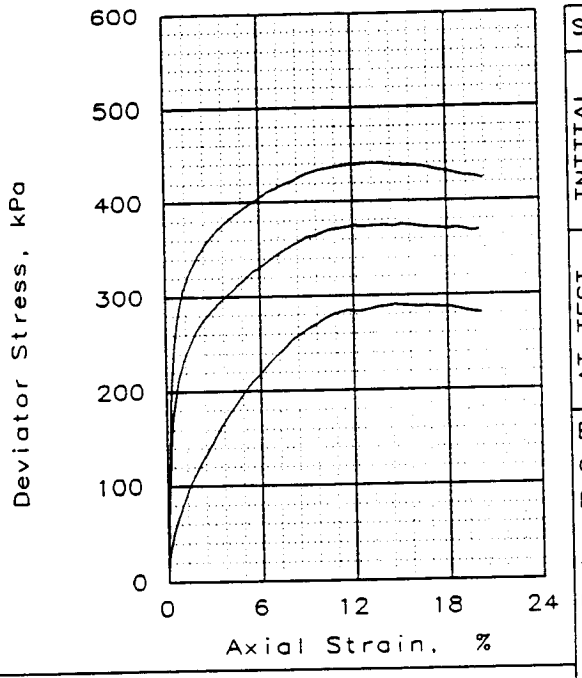
Expl. No.	Sample No.	Depth (ft)	W.C. %		Atterberg Limit			Wet Wt (pcf)	USC	Description
			Before	After	LL	PL	PI			
B169	S-5	15.5 -16.8	21%	19%	28	23	5	130 pcf	ML	SILT

Remarks:

HARTCROWSER J-4978-18 2/9/2000
Figure B-22

AR 044348





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	26.1	30.2	32.6
	DRY DENSITY, g/cc	1.7	1.5	1.5
	SATURATION, %	116.3	110.1	114.9
	VOID RATIO	0.594	0.727	0.751
	DIAMETER, cm	7.06	7.11	7.06
	HEIGHT, cm	15.18	15.35	15.26
AT TEST	WATER CONTENT, %	24.3	28.4	28.5
	DRY DENSITY, g/cc	1.7	1.6	1.6
	SATURATION, %	112.5	112.8	114.1
	VOID RATIO	0.572	0.668	0.661
	DIAMETER, cm	7.03	7.03	6.94
	HEIGHT, cm	15.12	15.17	15.00
BACK PRESSURE, kPa		69	69	69
CELL PRESSURE, kPa		261	452	643
FAILURE STRESS, kPa		290	375	440
PORE PRESSURE, kPa		141	298	493
STRAIN RATE, %/min.		0.040	0.040	0.040
ULTIMATE STRESS, kPa				
PORE PRESSURE, kPa				
$\bar{\sigma}_1$ FAILURE, kPa		411	530	591
$\bar{\sigma}_3$ FAILURE, kPa		120	155	151

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Lean CLAY

LL= 34 PL= 22 PI= 12.0
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

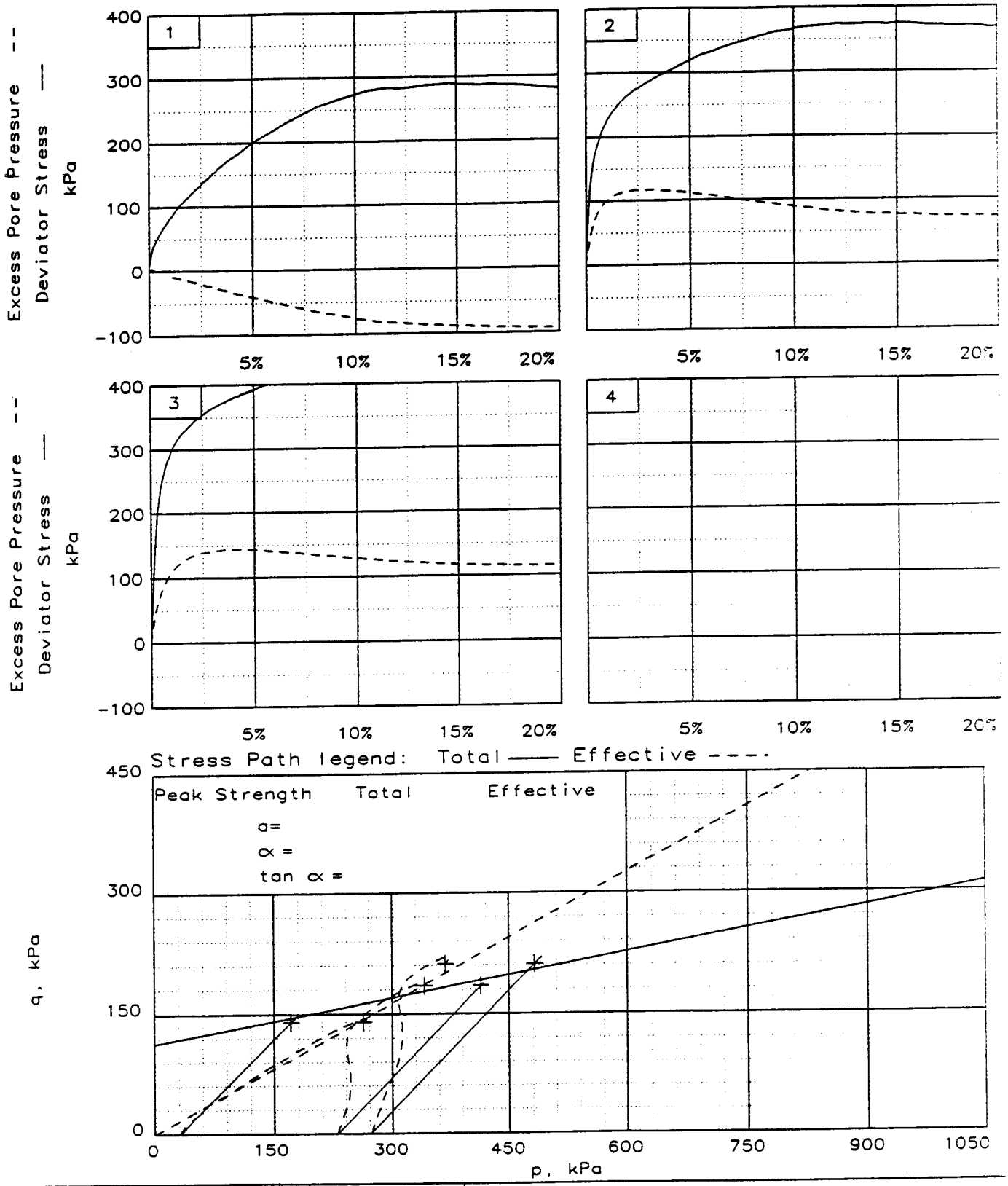
PROJECT: Third Runway NSA

SAMPLE LOCATION: HC99-B50/S-4

HARTCROWSER J4978-18 1/10/00
Figure B-23

AR 044349

STRESS-STRAIN AND STRESS PATHS REPORT



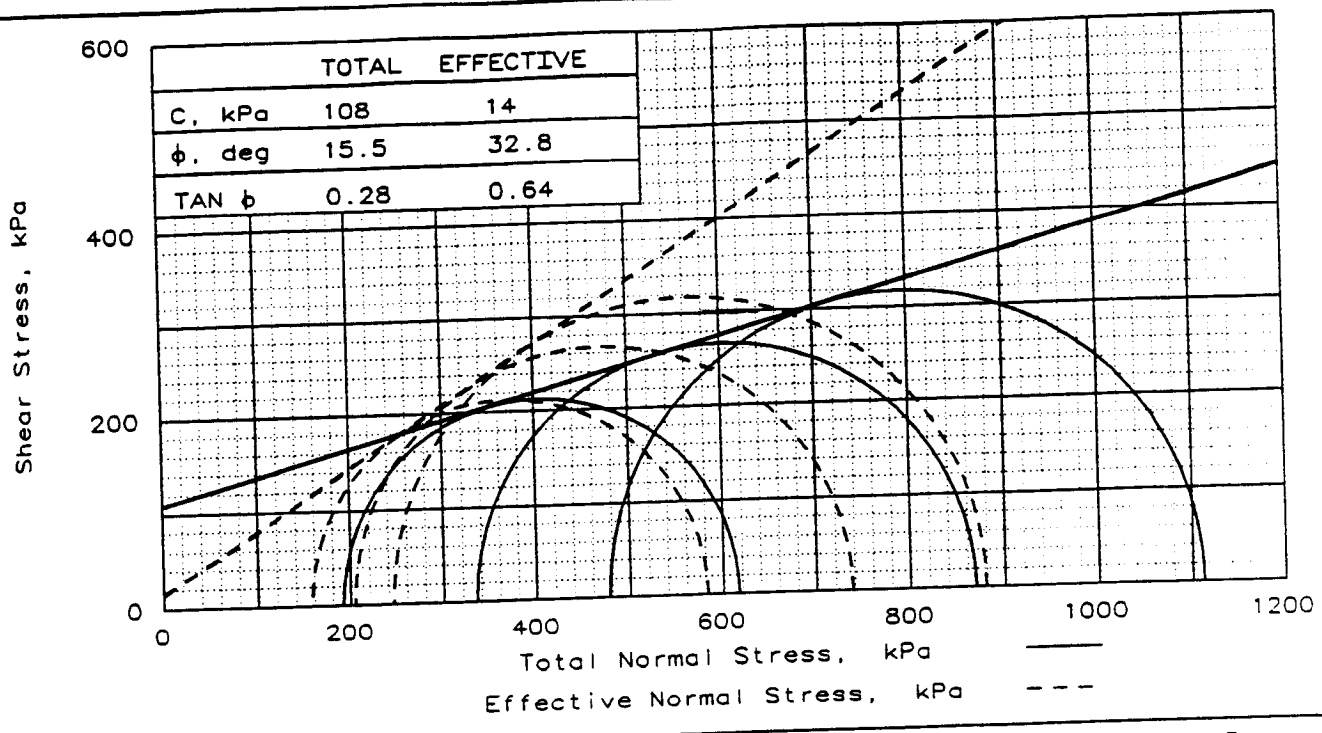
Client: HNTB
Project: Third Runway NSA
Location: HC99-B50/S-4
File: 3RW

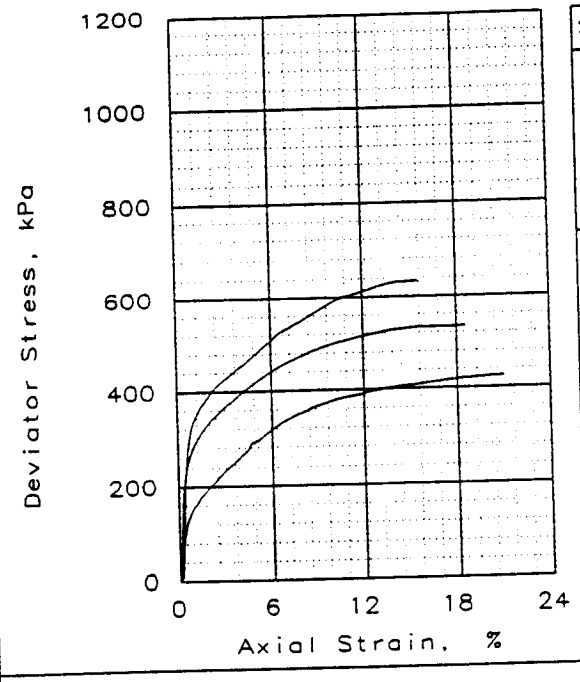
J4978-18 1/10/00

HARTCROWSER

Figure B-24

AR 044350





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	16.8	16.8	16.8
	DRY DENSITY, g/cc	1.9	1.9	1.9
	SATURATION, %	108.3	122.5	105.0
	VOID RATIO	0.411	0.363	0.424
	DIAMETER, cm	7.02	6.95	6.97
	HEIGHT, cm	13.75	13.46	13.03
AT TEST	WATER CONTENT, %	15.6	15.6	19.1
	DRY DENSITY, g/cc	2.0	2.0	2.0
	SATURATION, %	119.0	130.1	146.8
	VOID RATIO	0.347	0.318	0.345
	DIAMETER, cm	6.91	6.87	6.84
	HEIGHT, cm	13.54	13.31	12.79
BACK PRESSURE, kPa		69	69	69
CELL PRESSURE, kPa		261	404	547
FAILURE STRESS, kPa		425	533	634
PORE PRESSURE, kPa		103	200	301
STRAIN RATE, %/min.		0.040	0.040	0.040
ULTIMATE STRESS, kPa				
PORE PRESSURE, kPa				
$\bar{\sigma}_1$ FAILURE, kPa		582	738	880
$\bar{\sigma}_3$ FAILURE, kPa		158	205	246

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Shelby Tube
DESCRIPTION: CLAY

LL= 22 PL= 14 PI= 8.0
SPECIFIC GRAVITY= 2.65
REMARKS:

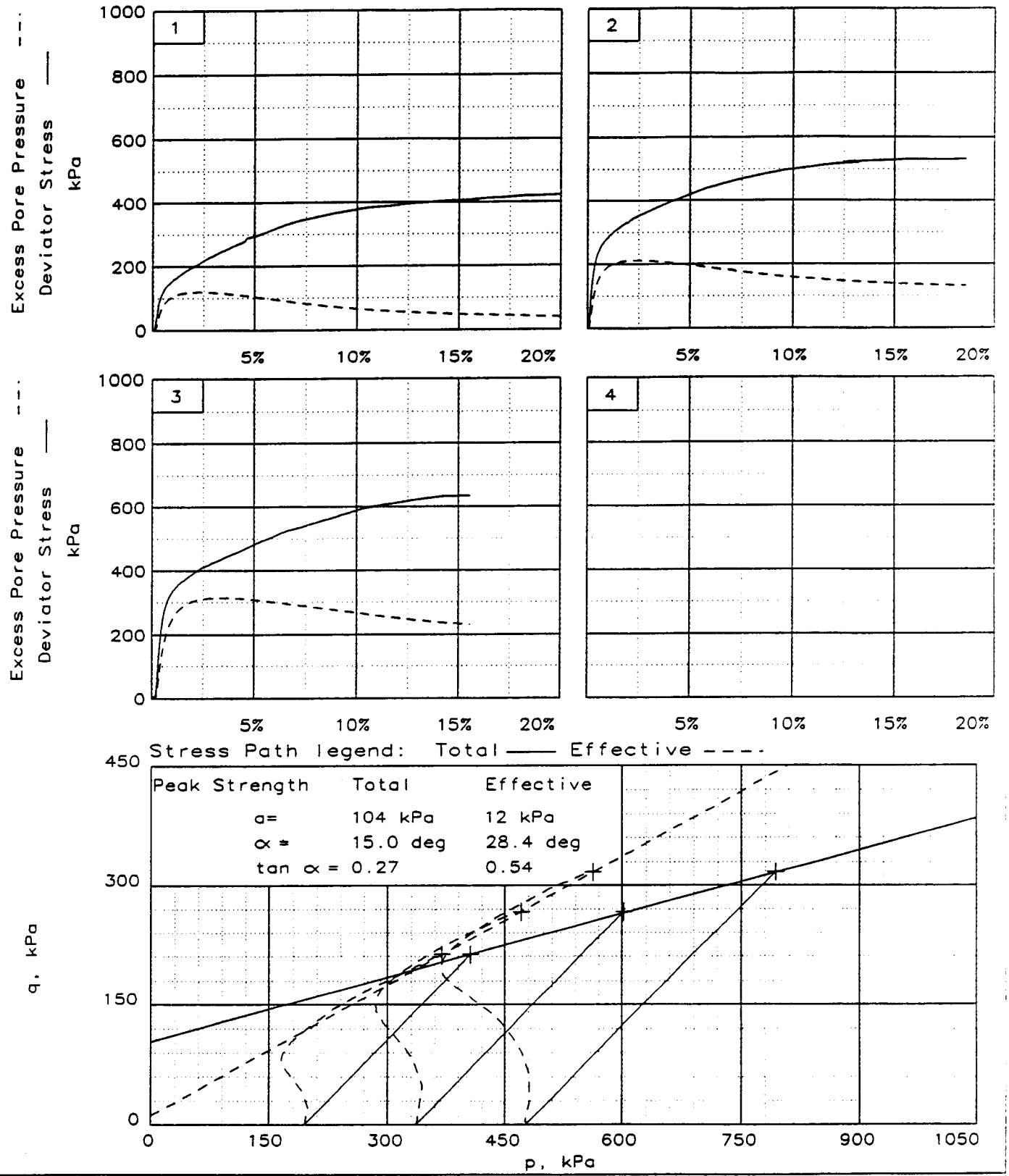
CLIENT: HNTB

PROJECT: SeaTac Third Runway
North Safety Area
SAMPLE LOCATION: HC99-B52/S-4

HARTCROWSER J4978-18 1/24/00
Figure B-25

AR 044351

STRESS-STRAIN AND STRESS PATHS REPORT



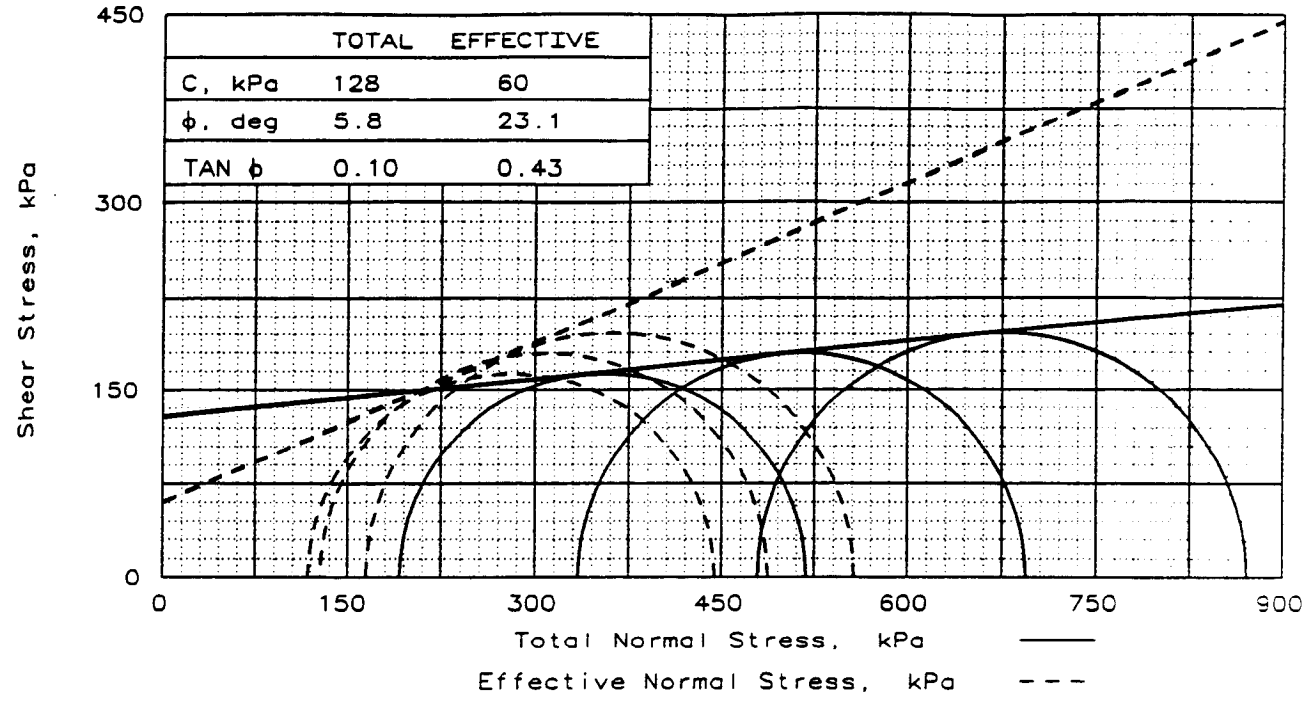
Client: HNTB
Project: SeaTac Third Runway Nort
Location: HC99-B52/S-4
File: 3RWA

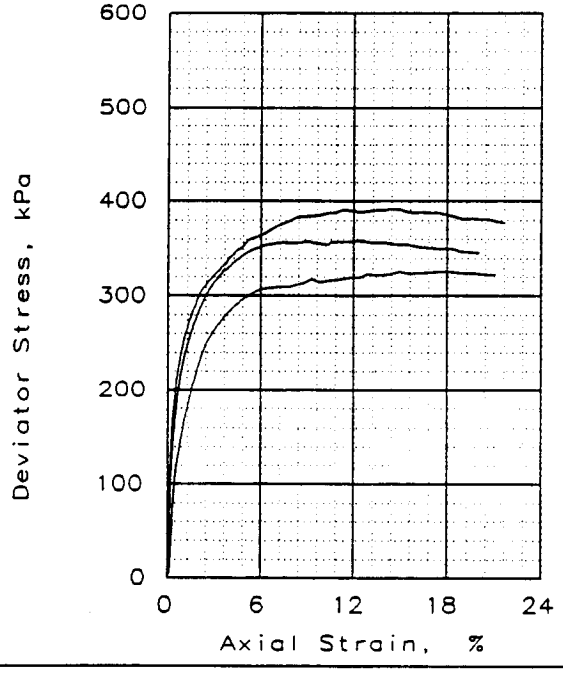
J4978-18 1/24/00

HARTCROWSER

Figure B-26

AR 044352





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	23.7	23.1	23.1
	DRY DENSITY, g/cc	1.7	1.7	1.7
	SATURATION, %	119.2	108.3	106.0
	VOID RATIO	0.527	0.565	0.579
	DIAMETER, cm	7.11	7.20	7.21
	HEIGHT, cm	16.27	16.36	15.61
AT TEST	WATER CONTENT, %	22.6	19.0	21.5
	DRY DENSITY, g/cc	1.8	1.8	1.8
	SATURATION, %	133.2	107.3	122.2
	VOID RATIO	0.450	0.470	0.487
	DIAMETER, cm	6.99	7.05	7.03
	HEIGHT, cm	15.99	16.03	15.24
BACK PRESSURE, kPa		207	138	207
CELL PRESSURE, kPa		399	616	542
FAILURE STRESS, kPa		326	392	359
PORE PRESSURE, kPa		281	452	414
STRAIN RATE, %/min.		0.040	0.040	0.040
ULTIMATE STRESS, kPa				
PORE PRESSURE, kPa				
$\bar{\sigma}_1$ FAILURE, kPa		444	557	488
$\bar{\sigma}_3$ FAILURE, kPa		118	165	128

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Sandy, very silty, lean CLAY
LL= 29 PL= 19 PI= 10.0
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

PROJECT: 3rd Runway North Safety Area

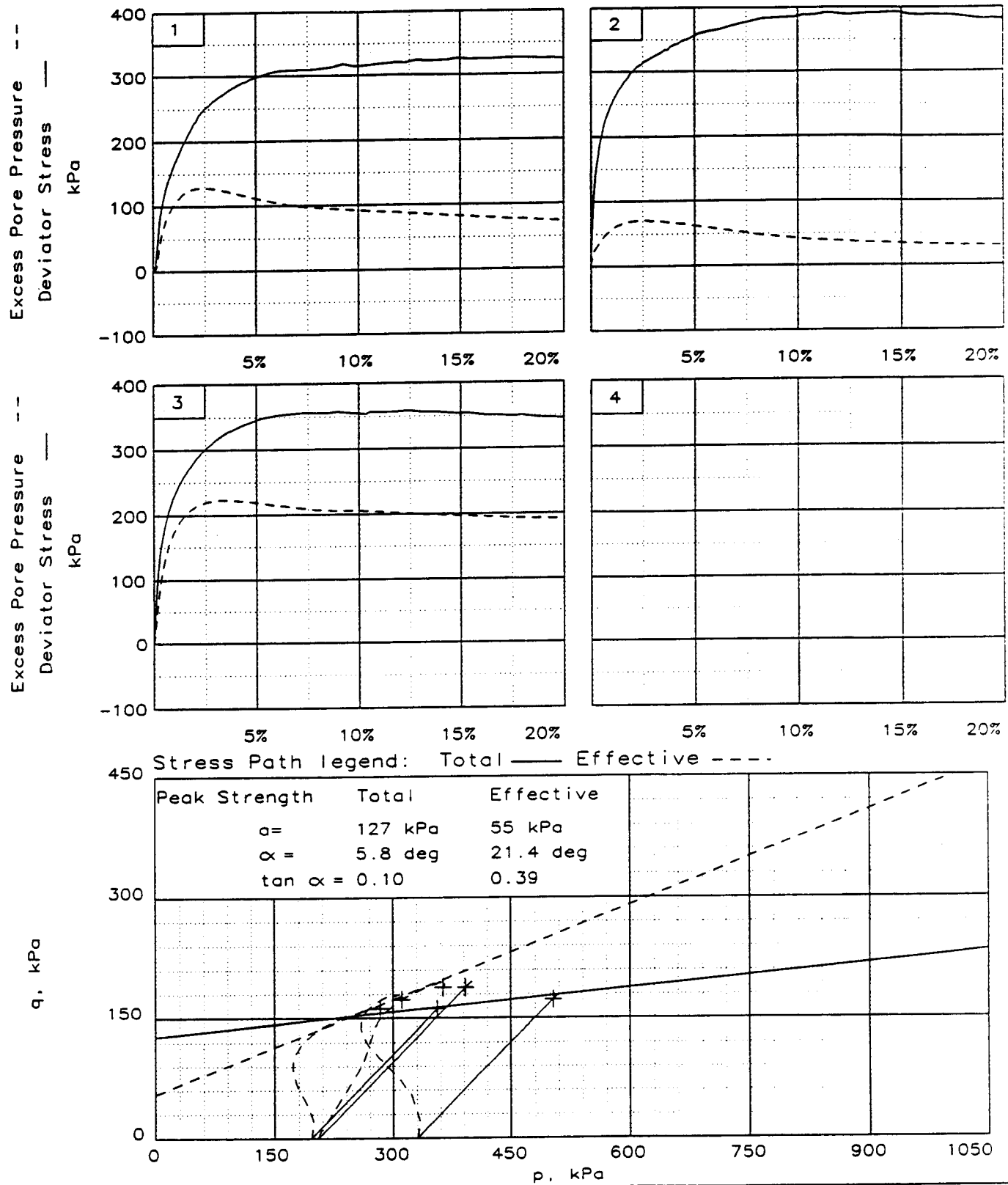
SAMPLE LOCATION: HC99-B58/S-3

HARTCROWSER J4978-18 1/30/00

Figure B-27

AR 044353

STRESS-STRAIN AND STRESS PATHS REPORT



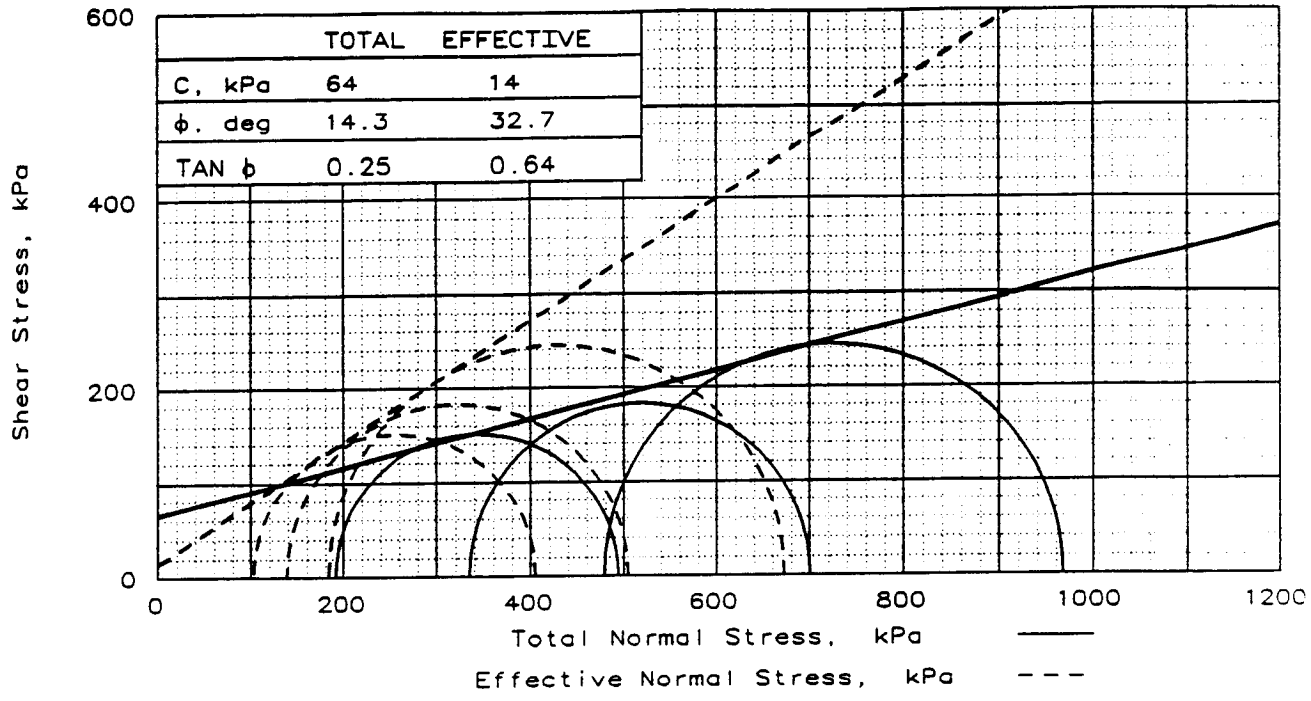
Client: HNTB
Project: 3rd Runway North Safety
Location: HC99-B58/S-3
File: 3RWB

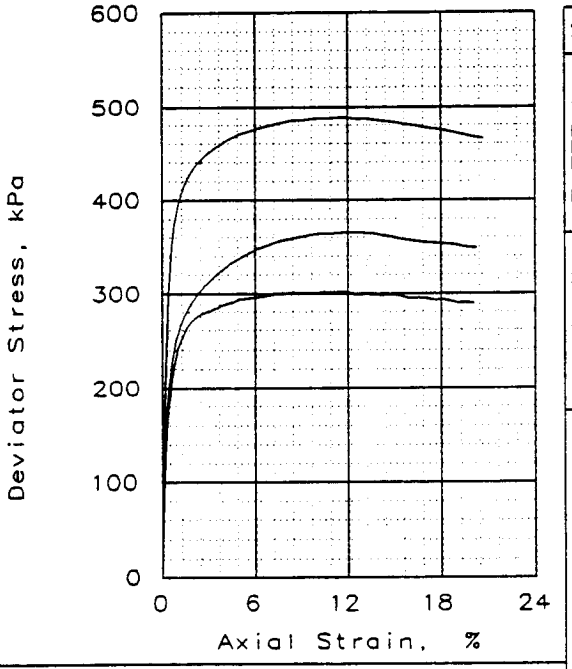
J4978-18 1/30/00

HARTCROWSER

Figure B-28

AR 044354





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	21.8	18.4	19.0
	DRY DENSITY, g/cc	1.7	1.8	1.8
	SATURATION, %	106.0	105.6	107.0
	VOID RATIO	0.545	0.463	0.471
	DIAMETER, cm	7.25	7.28	7.26
	HEIGHT, cm	15.46	14.83	15.52
AT TEST	WATER CONTENT, %	20.7	16.4	16.5
	DRY DENSITY, g/cc	1.7	1.9	1.9
	SATURATION, %	104.2	107.9	105.2
	VOID RATIO	0.526	0.403	0.417
	DIAMETER, cm	7.22	7.18	7.17
	HEIGHT, cm	15.39	14.63	15.32
BACK PRESSURE, kPa		138	138	138
CELL PRESSURE, kPa		330	473	616
FAILURE STRESS, kPa		302	365	489
PORE PRESSURE, kPa		227	334	433
STRAIN RATE, %/min.		0.040	0.040	0.040
ULTIMATE STRESS, kPa				
PORE PRESSURE, kPa				
$\bar{\sigma}_1$ FAILURE, kPa		405	504	672
$\bar{\sigma}_3$ FAILURE, kPa		103	139	184

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Sandy, lean CLAY

LL= 24 PL= 16 PI= 8.0
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

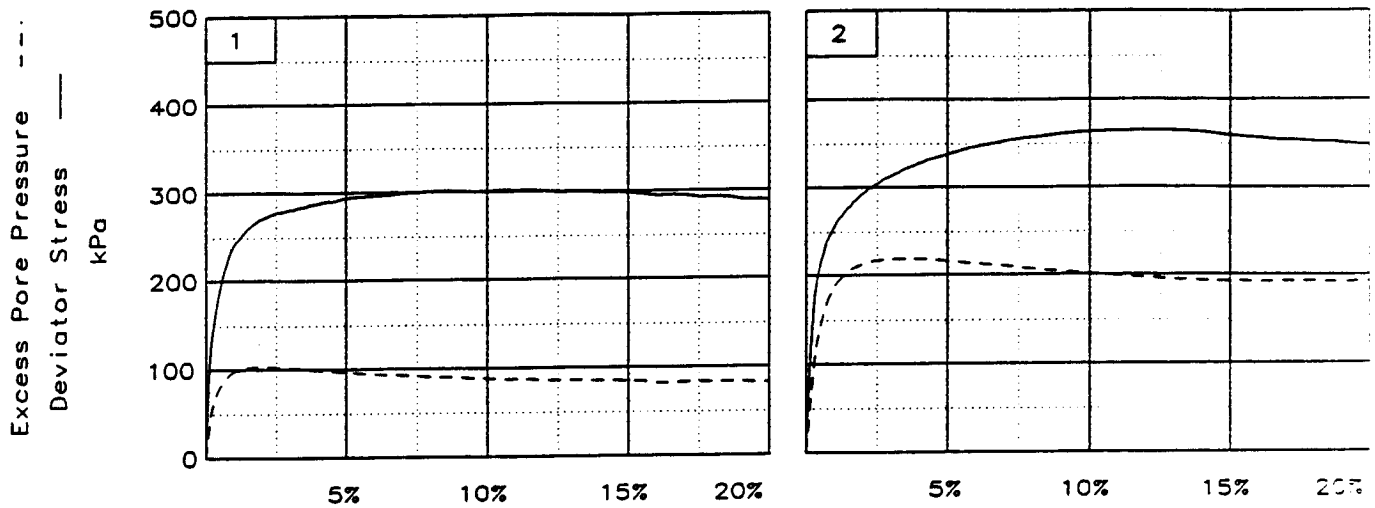
PROJECT: Third Runway NSA

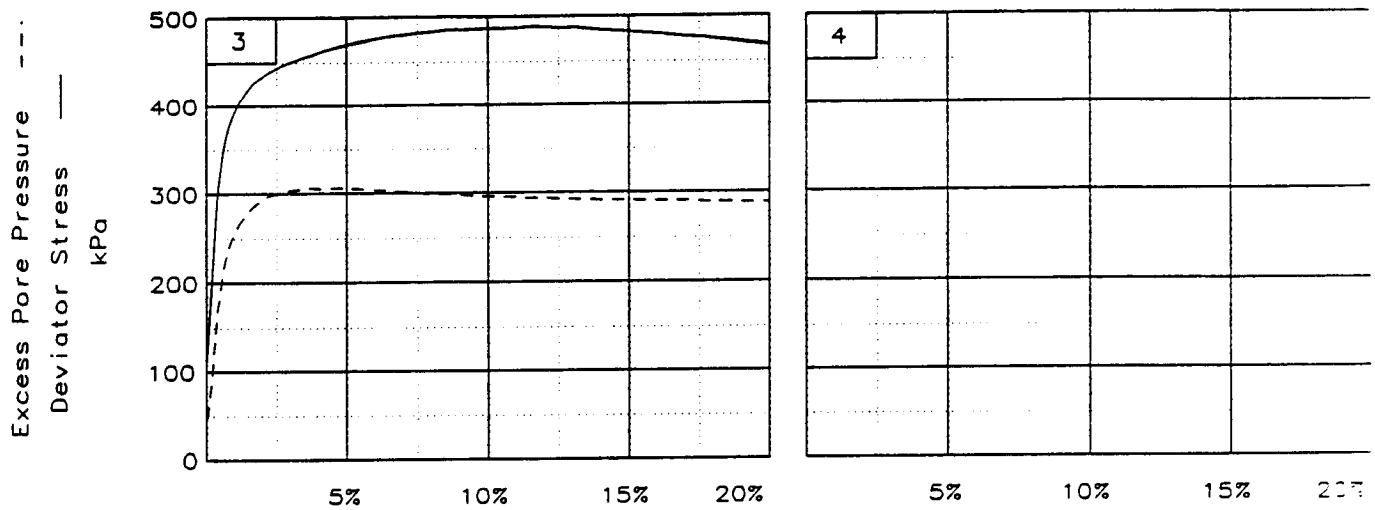
SAMPLE LOCATION: HCOO-B161/S-3

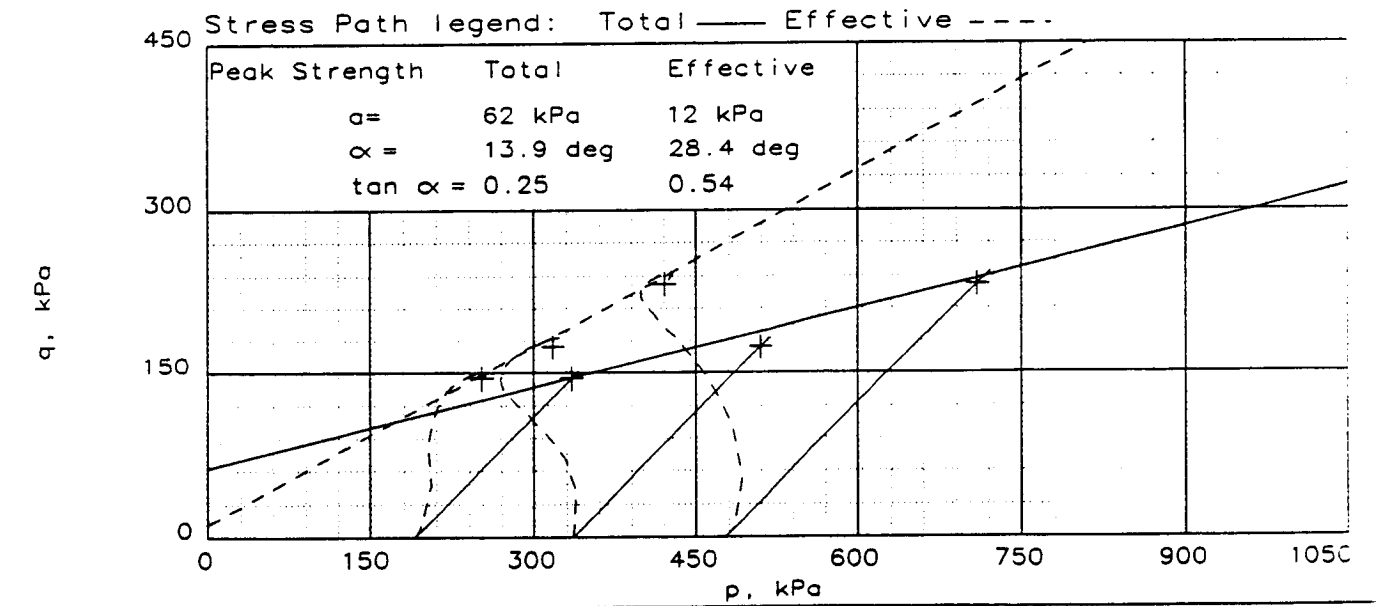
HARTCROWSER J4978-18 2/21/00
Figure B-29

AR 044355

STRESS-STRAIN AND STRESS PATHS REPORT







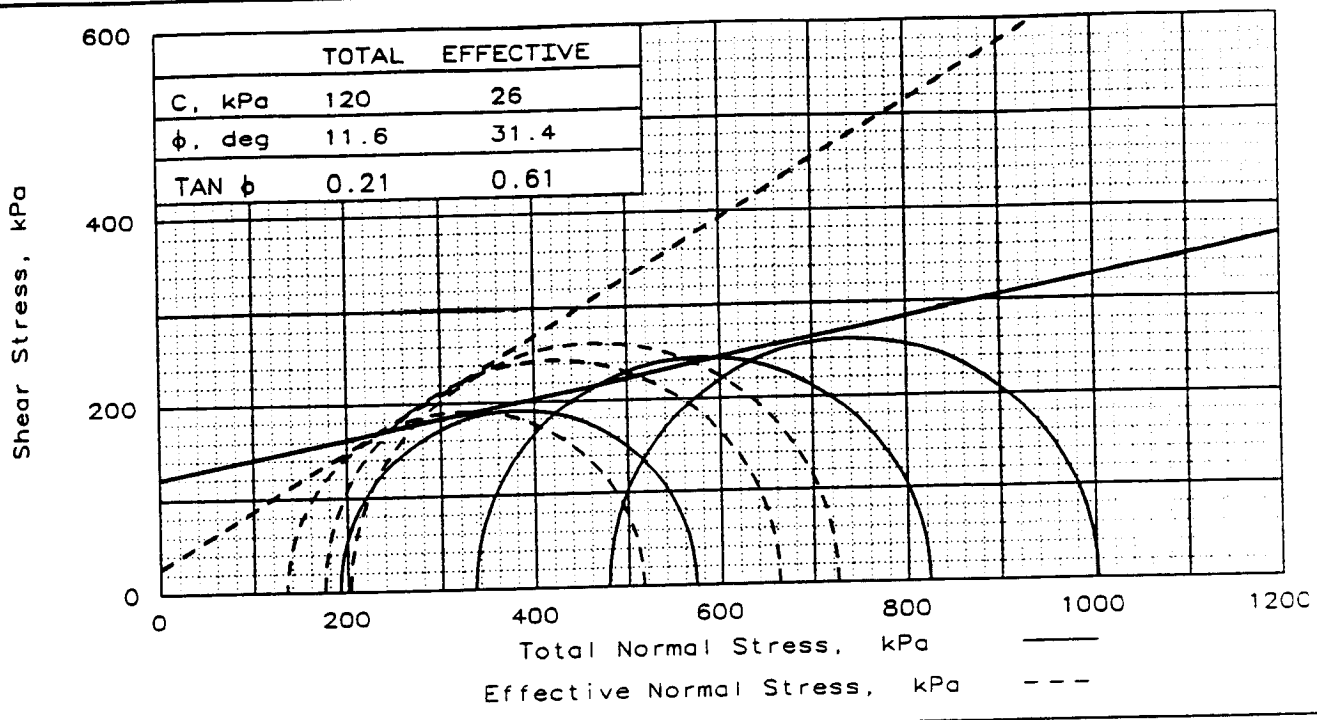
Client: HNTB
Project: Third Runway NSA
Location: HC00-B161/S-3
File: 3RWJ

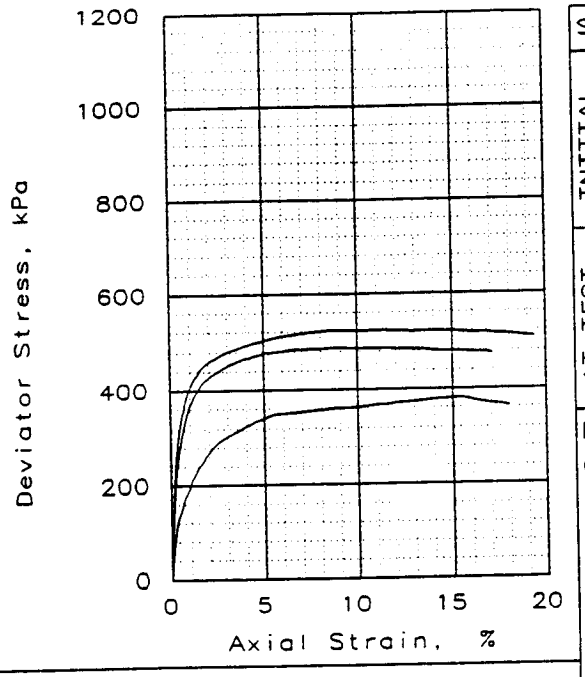
J4978-18 2/21/00

HARTCROWSER

Figure B-30

AR 044356





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	29.7	22.2	22.6
	DRY DENSITY, g/cc	1.5	1.7	1.6
	SATURATION, %	101.3	103.9	98.7
	VOID RATIO	0.778	0.566	0.607
	DIAMETER, cm	7.21	7.23	7.29
	HEIGHT, cm	15.29	15.22	15.79
AT TEST	WATER CONTENT, %	29.1	20.6	20.3
	DRY DENSITY, g/cc	1.5	1.8	1.7
	SATURATION, %	100.5	112.8	98.7
	VOID RATIO	0.768	0.484	0.544
	DIAMETER, cm	7.20	7.10	7.19
	HEIGHT, cm	15.27	14.96	15.59
BACK PRESSURE, kPa		138	138	138
CELL PRESSURE, kPa		330	473	617
FAILURE STRESS, kPa		381	488	523
PORE PRESSURE, kPa		195	298	414
STRAIN RATE, %/min.		0.040	0.040	0.040
ULTIMATE STRESS, kPa				
PORE PRESSURE, kPa				
$\bar{\sigma}_1$ FAILURE, kPa		516	662	726
$\bar{\sigma}_3$ FAILURE, kPa		135	175	203

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Sandy, lean CLAY

LL= 28 PL= 20 PI= 8.0
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

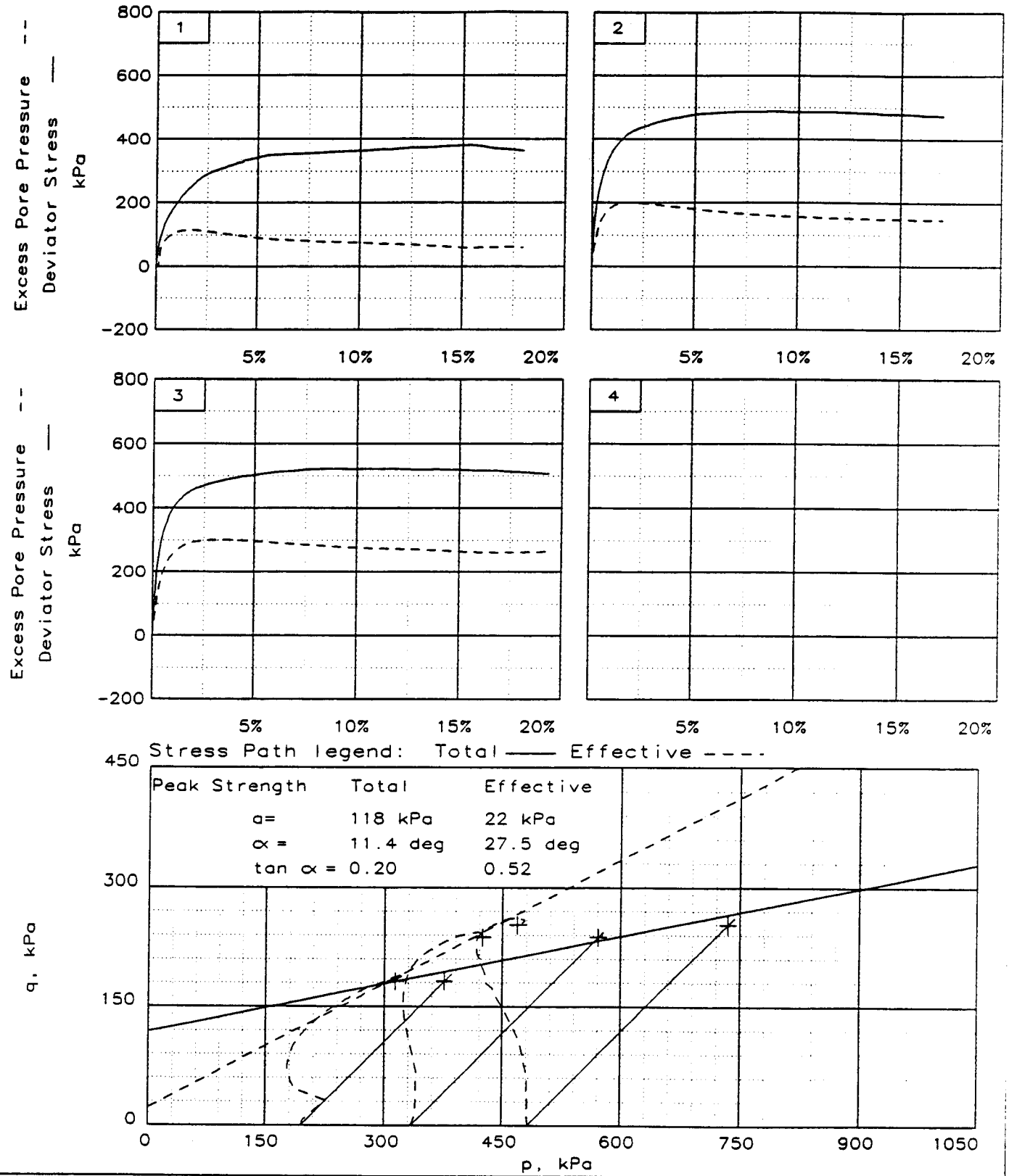
PROJECT: Third Runway NSA

SAMPLE LOCATION: HC00-B163 S-2/3

HARTCROWSER J4978-18 2/18/00
Figure B-31

AR 044357

STRESS-STRAIN AND STRESS PATHS REPORT



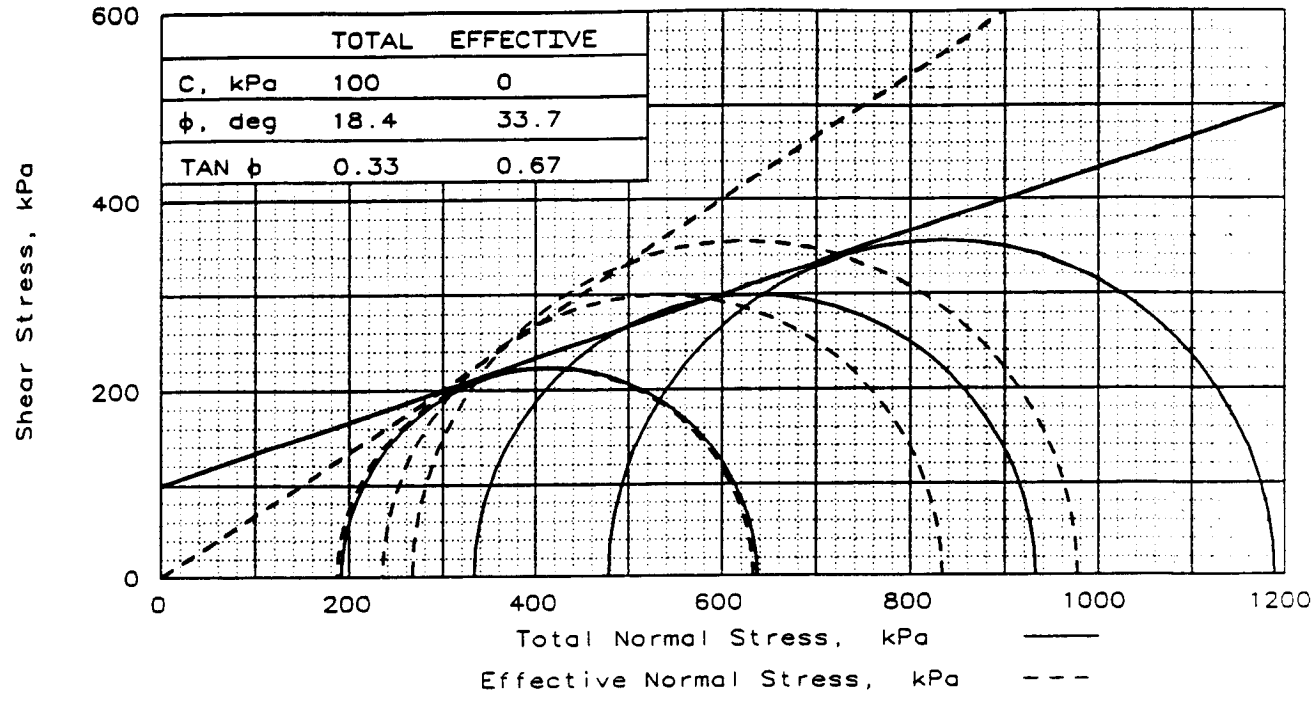
Client: HNTB
Project: Third Runway NSA
Location: HC00-B163 S-2/3
File: 3RWG

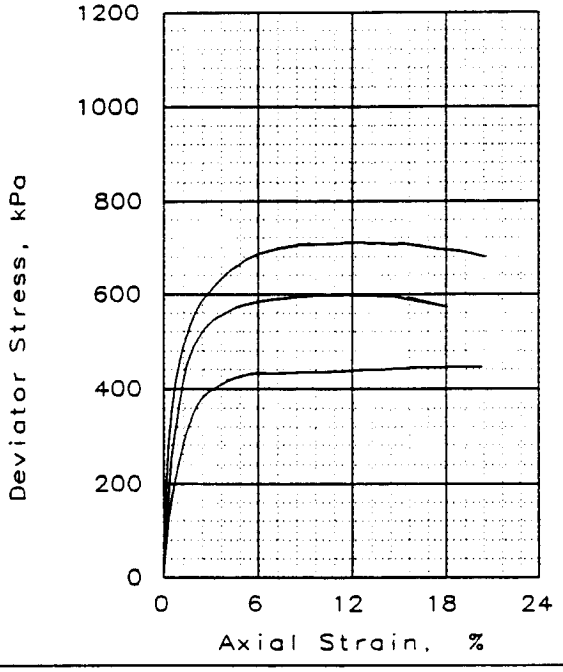
J4978-18 2/18/00

HARTCROWSER

Figure B-32

AR 044358





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	23.6	23.9	21.4
	DRY DENSITY, g/cc	1.6	1.6	1.7
	SATURATION, %	97.1	102.9	106.1
	VOID RATIO	0.645	0.616	0.536
	DIAMETER, cm	7.37	7.26	7.24
	HEIGHT, cm	15.17	14.64	15.16
AT TEST	WATER CONTENT, %	23.5	23.5	20.3
	DRY DENSITY, g/cc	1.7	1.7	1.8
	SATURATION, %	104.8	111.2	116.6
	VOID RATIO	0.595	0.560	0.461
	DIAMETER, cm	7.29	7.18	7.12
	HEIGHT, cm	15.01	14.47	14.91
BACK PRESSURE, kPa		138	138	138
CELL PRESSURE, kPa		330	472	616
FAILURE STRESS, kPa		446	599	710
PORE PRESSURE, kPa		142	237	349
STRAIN RATE, %/min.		0.040	0.040	0.040
ULTIMATE STRESS, kPa				
PORE PRESSURE, kPa				
$\bar{\sigma}_1$ FAILURE, kPa		633	834	977
$\bar{\sigma}_3$ FAILURE, kPa		187	235	267

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Lean CLAY

LL= 34 PL= 23 PI= 11.0
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

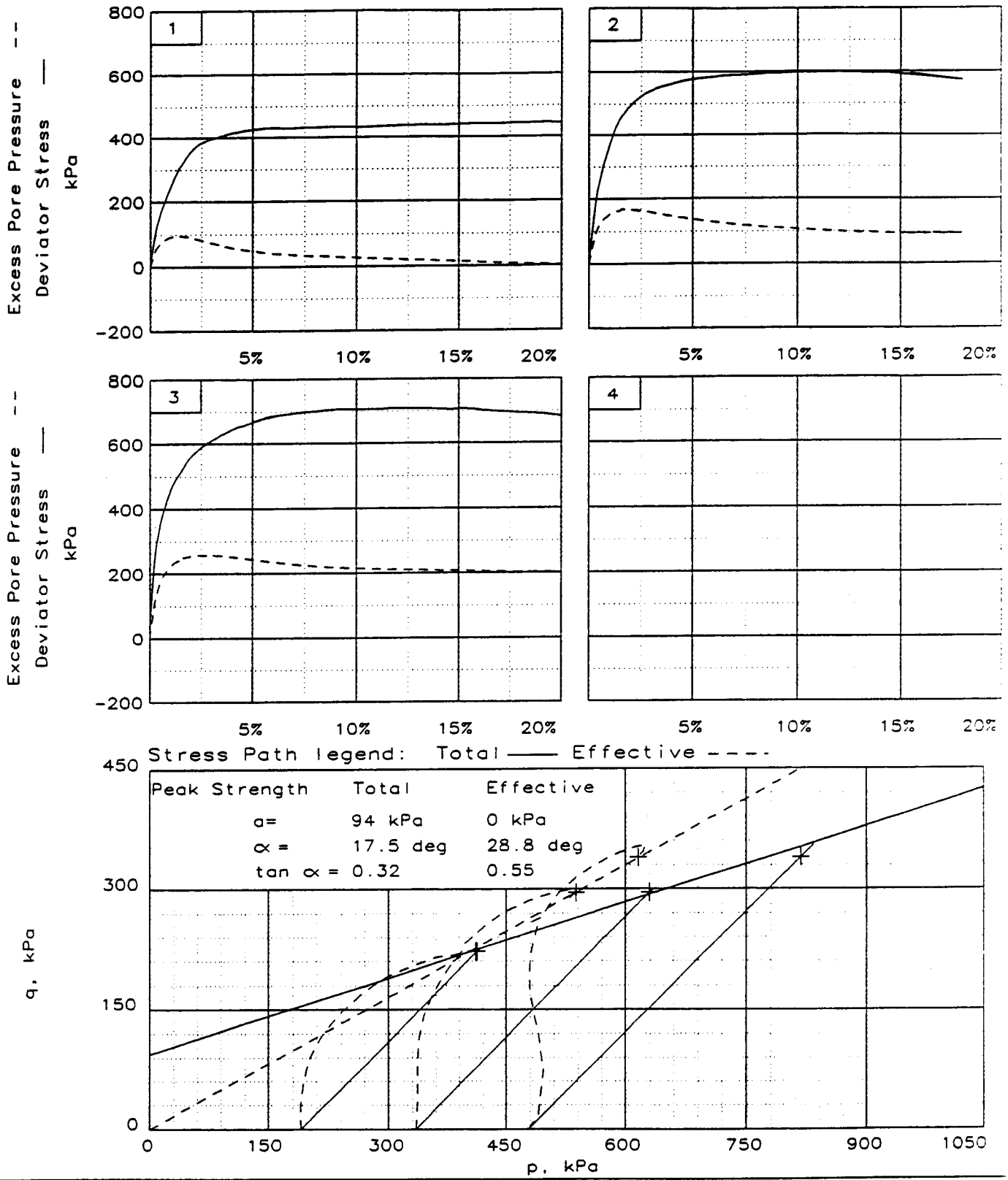
PROJECT: Third Runway NSA

SAMPLE LOCATION: HC00-B164/S-3

HARTCROWSER J4978-18 2/18/00
Figure B-33

AR 044359

STRESS-STRAIN AND STRESS PATHS REPORT



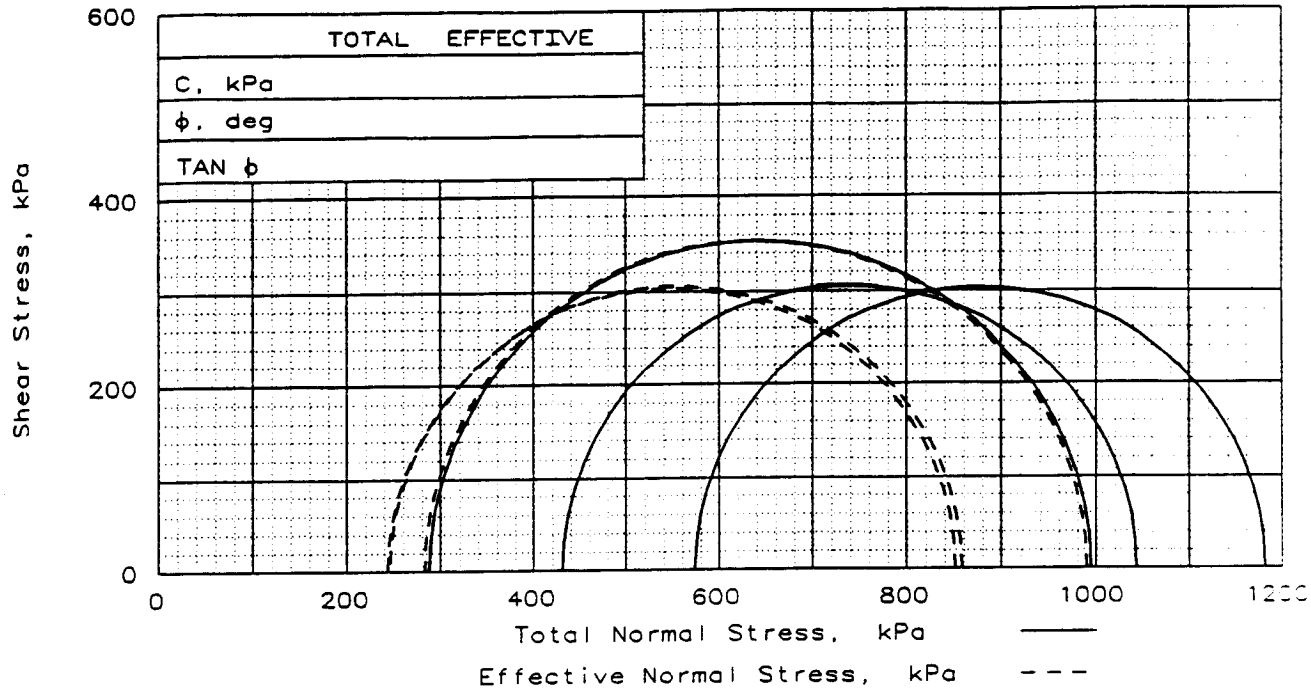
Client: HNTB
Project: Third Runway NSA
Location: HC00-B164/S-3
File: 3RWE

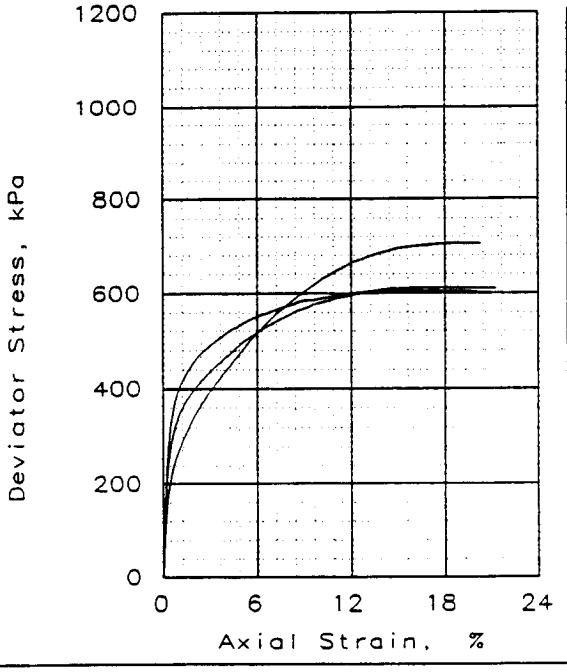
J4978-18 2/15/00

HARTCROWSER

Figure B-34

AR 044360





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	20.3	17.9	19.4
	DRY DENSITY, g/cc	1.8	1.9	1.8
	SATURATION, %	110.4	110.8	104.0
	VOID RATIO	0.488	0.428	0.495
	DIAMETER, cm	7.21	7.22	7.26
	HEIGHT, cm	14.99	15.03	15.30
AT TEST	WATER CONTENT, %	19.3	16.1	16.9
	DRY DENSITY, g/cc	1.8	1.9	1.9
	SATURATION, %	112.3	111.4	109.5
	VOID RATIO	0.455	0.383	0.410
	DIAMETER, cm	7.16	7.14	7.12
	HEIGHT, cm	14.88	14.87	15.00
BACK PRESSURE, kPa		138	138	138
CELL PRESSURE, kPa		425	569	712
FAILURE STRESS, kPa		707	612	607
PORE PRESSURE, kPa		143	323	468
STRAIN RATE, %/min.		0.040	0.040	0.040
ULTIMATE STRESS, kPa				
PORE PRESSURE, kPa				
$\bar{\sigma}_1$ FAILURE, kPa		990	858	852
$\bar{\sigma}_3$ FAILURE, kPa		283	246	244

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Sandy, lean CLAY

LL= 25 PL= 17 PI= 8.0
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

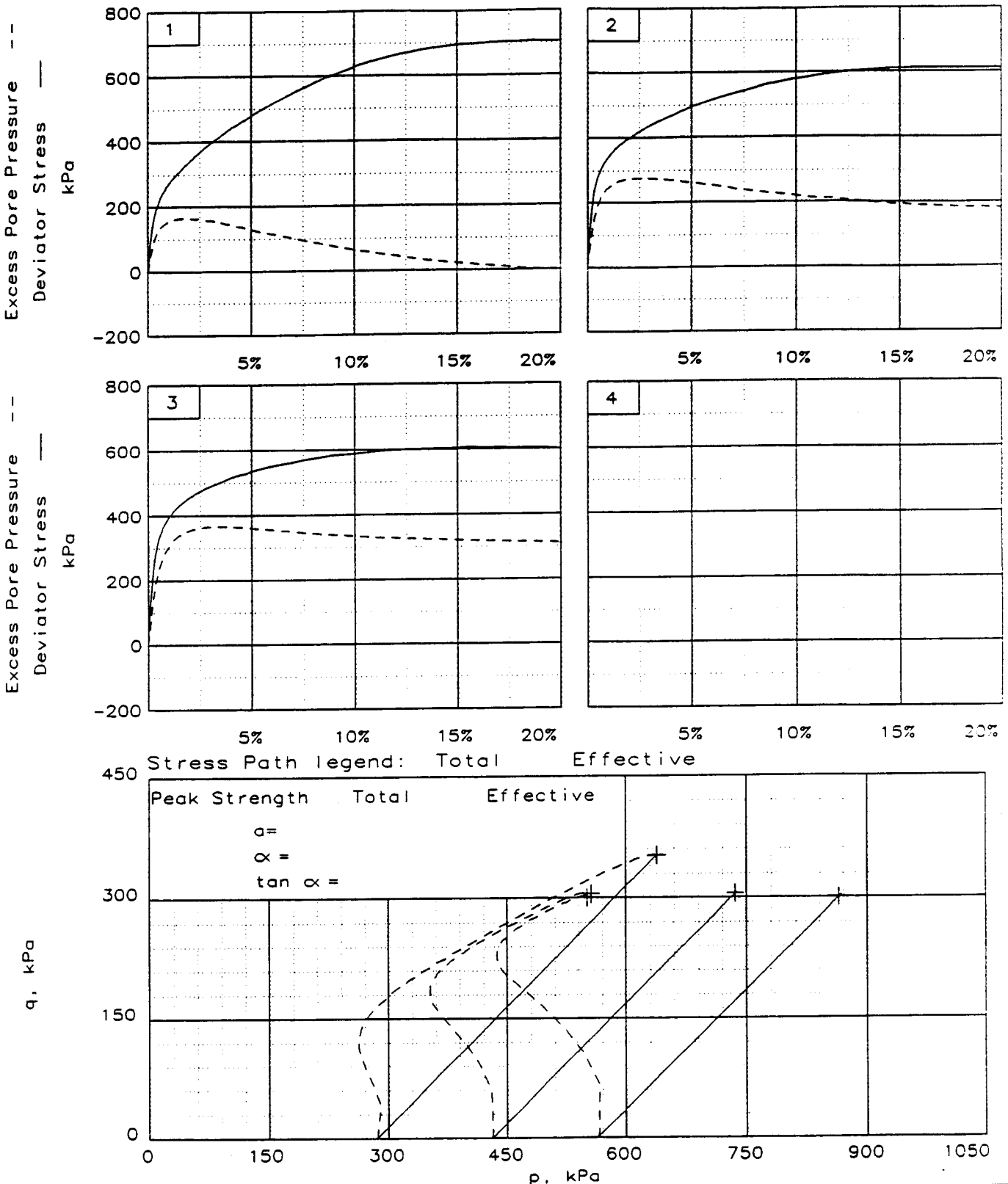
PROJECT: Third Runway NSA

SAMPLE LOCATION: HC00-B175/S-3

HARTCROWSER J4978-18 2/29/00
Figure B-35

AR 044361

STRESS-STRAIN AND STRESS PATHS REPORT



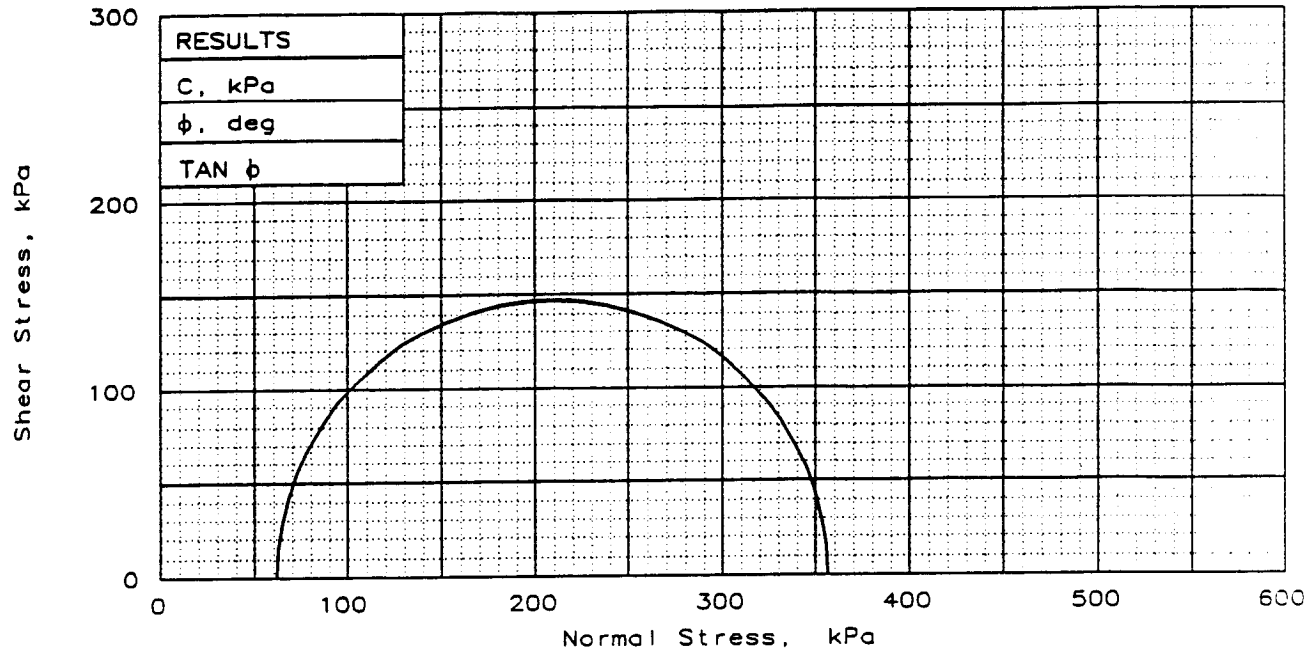
Client: HNTB
Project: Third Runway NSA
Location: HC00-B175/S-3
File: 3RWQ

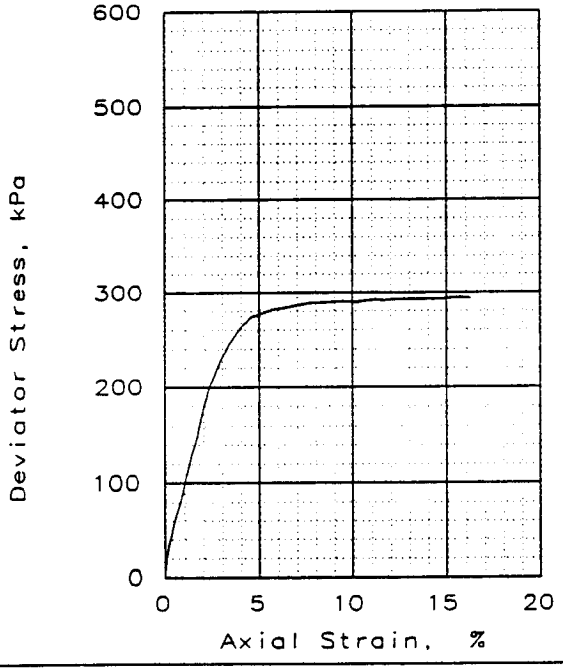
J4978-18 2/29/00

HARTCROWSER

Figure 8-36

AR 044362





SAMPLE NO.		1
INITIAL	WATER CONTENT, %	16.9
	DRY DENSITY, g/cc	1.8
	SATURATION, %	96.9
	VOID RATIO	0.463
	DIAMETER, cm	7.28
	HEIGHT, cm	14.89
AT TEST	WATER CONTENT, %	16.9
	DRY DENSITY, g/cc	1.8
	SATURATION, %	96.8
	VOID RATIO	0.463
	DIAMETER, cm	7.28
	HEIGHT, cm	14.89
BACK PRESSURE, kPa		0
CELL PRESSURE, kPa		62
FAILURE STRESS, kPa		294
PORE PRESSURE, kPa		
STRAIN RATE, %/min.		0.300
ULTIMATE STRESS, kPa		
PORE PRESSURE, kPa		
σ_1 FAILURE, kPa		356
σ_3 FAILURE, kPa		62

TYPE OF TEST:
Unconsolidated undrained
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Lean CLAY

LL= 26 PL= 17 PI= 9.0
SPECIFIC GRAVITY= 2.65
REMARKS:

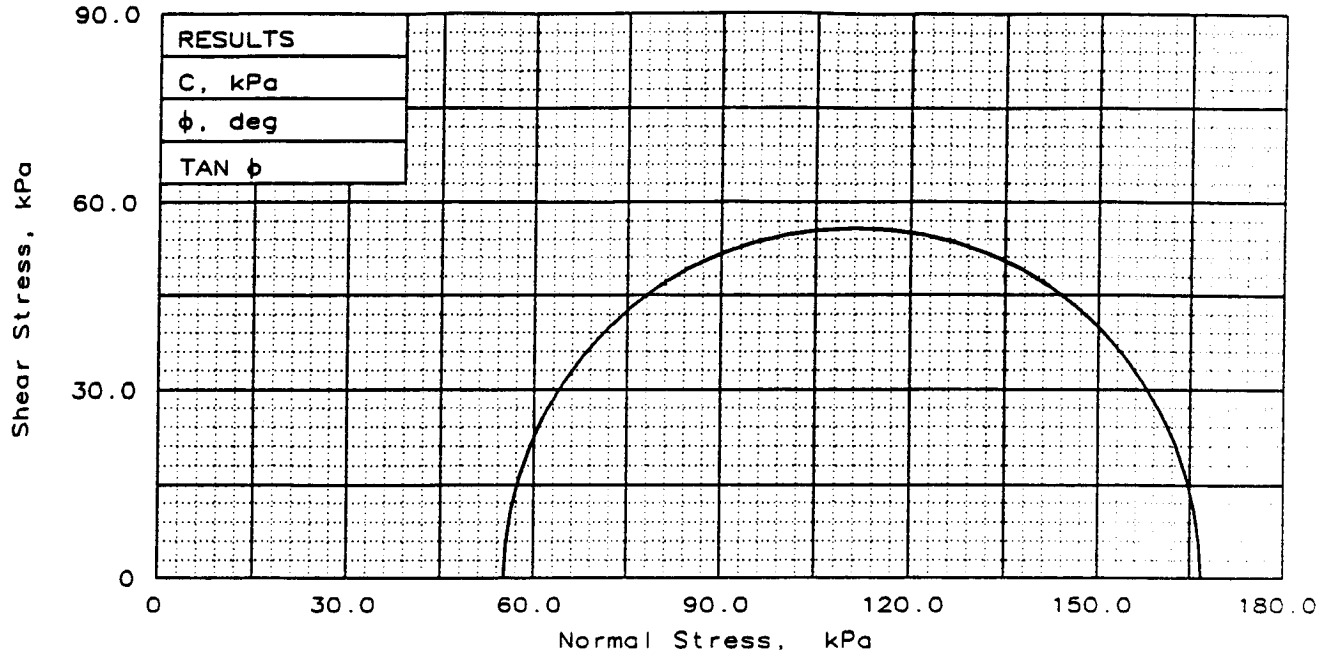
CLIENT: HNTB

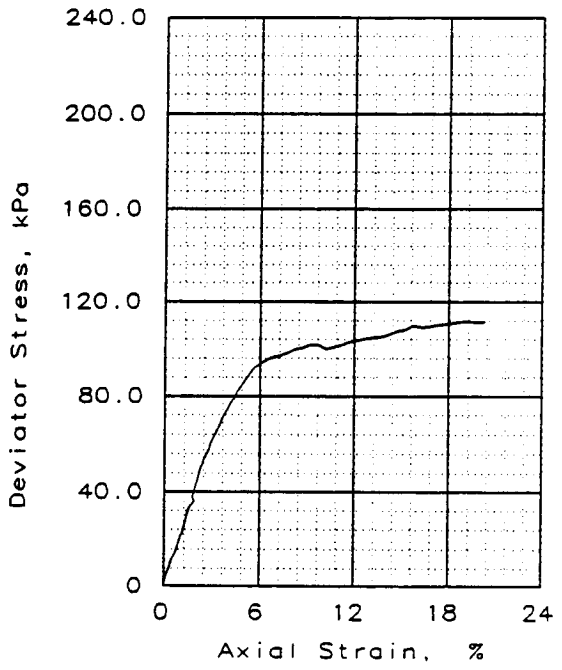
PROJECT: Third Runway NSA

SAMPLE LOCATION: B-160/S-4

HARTCROWSER J4978-18 2/19/00
Figure B-37

AR 044363





SAMPLE NO.		1
INITIAL	WATER CONTENT, %	31.9
	DRY DENSITY, g/cc	1.5
	SATURATION, %	104.7
	VOID RATIO	0.808
	DIAMETER, cm	7.23
	HEIGHT, cm	15.12
AT TEST	WATER CONTENT, %	31.8
	DRY DENSITY, g/cc	1.5
	SATURATION, %	104.2
	VOID RATIO	0.808
	DIAMETER, cm	7.23
	HEIGHT, cm	15.12
BACK PRESSURE, kPa		0.0
CELL PRESSURE, kPa		55.2
FAILURE STRESS, kPa		111.6
PORE PRESSURE, kPa		
STRAIN RATE, %/min.		0.300
ULTIMATE STRESS, kPa		
PORE PRESSURE, kPa		
σ_1 FAILURE, kPa		166.7
σ_3 FAILURE, kPa		55.2

TYPE OF TEST:
Unconsolidated undrained
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Lean CLAY

LL= 31 PL= 20 PI= 11.0
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

PROJECT: Third Runway NSA

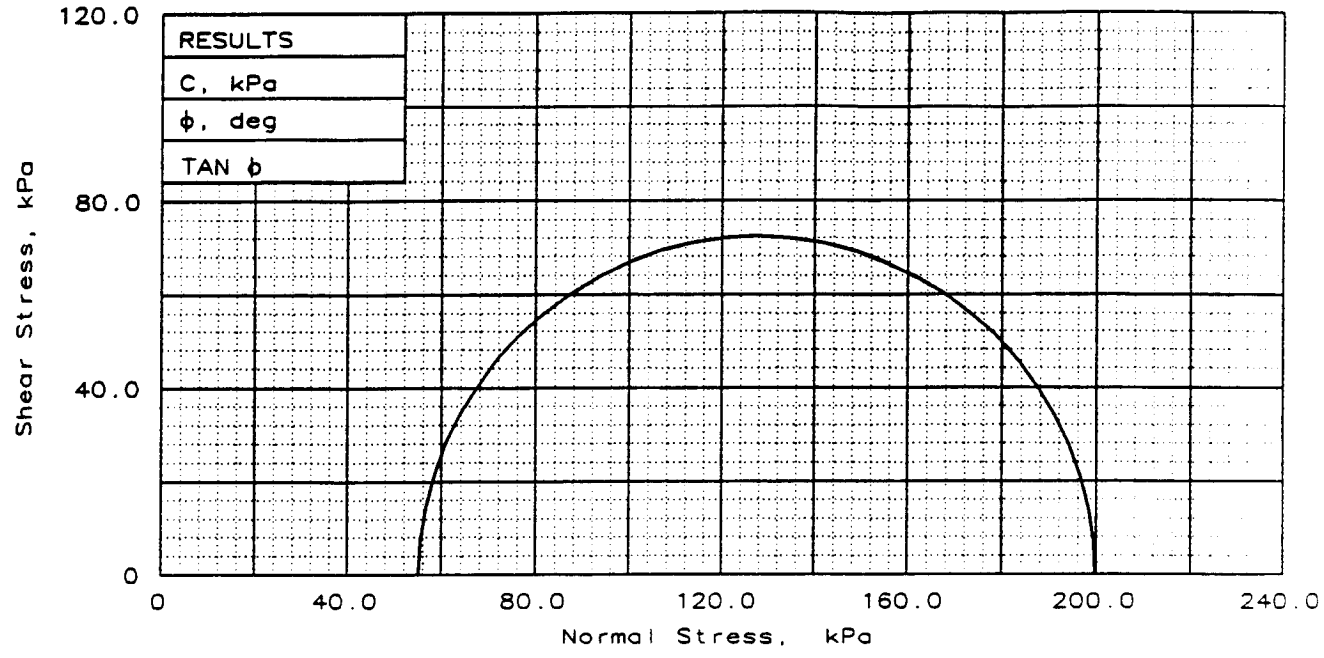
SAMPLE LOCATION: HC00-B165a/S-2a

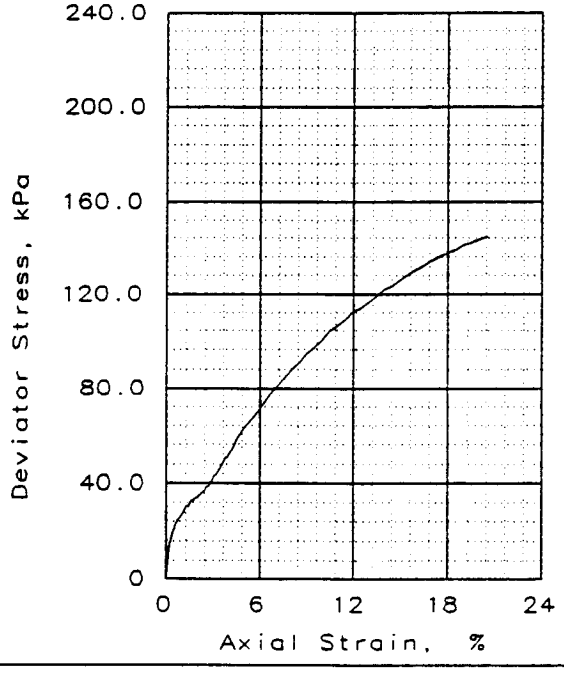
HARTCROWSER

J4978-18 2/23/00

Figure B-38

AR 044364





SAMPLE NO.		1
INITIAL	WATER CONTENT, %	11.9
	DRY DENSITY, g/cc	1.9
	SATURATION, %	87.5
	VOID RATIO	0.361
	DIAMETER, cm	7.41
	HEIGHT, cm	15.60
AT TEST	WATER CONTENT, %	11.1
	DRY DENSITY, g/cc	1.9
	SATURATION, %	81.5
	VOID RATIO	0.361
	DIAMETER, cm	7.41
	HEIGHT, cm	15.60
BACK PRESSURE, kPa		0.0
CELL PRESSURE, kPa		55.2
FAILURE STRESS, kPa		144.6
PORE PRESSURE, kPa		
STRAIN RATE, %/min.		0.300
ULTIMATE STRESS, kPa		
PORE PRESSURE, kPa		
σ_1 FAILURE, kPa		199.7
σ_3 FAILURE, kPa		55.2

TYPE OF TEST:
Unconsolidated undrained
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Sl. clayey, sl. gravelly, silty, m-f SAND
LL= NV PL= NP PI=
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

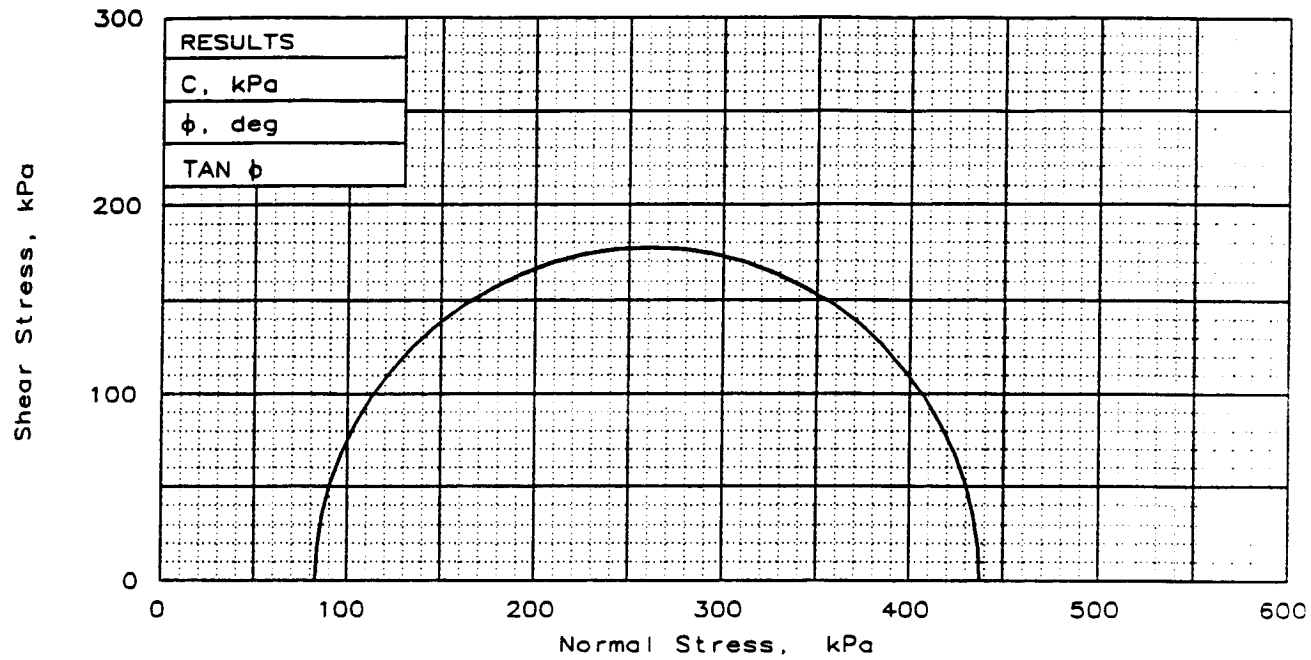
PROJECT: Third Runway NSA

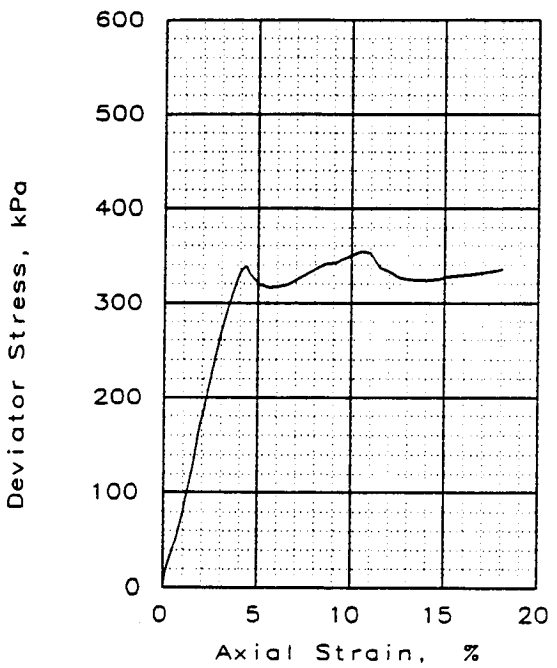
SAMPLE LOCATION: HC00-B169/S-3

HARTCROWSER J4978-18 2/18/00

Figure B-39

AR 044365





SAMPLE NO.		1
INITIAL	WATER CONTENT, %	20.7
	DRY DENSITY, g/cc	1.7
	SATURATION, %	106.5
	VOID RATIO	0.515
	DIAMETER, cm	7.20
	HEIGHT, cm	15.31
AT TEST	WATER CONTENT, %	20.6
	DRY DENSITY, g/cc	1.7
	SATURATION, %	105.9
	VOID RATIO	0.515
	DIAMETER, cm	7.20
	HEIGHT, cm	15.31
BACK PRESSURE, kPa		0
CELL PRESSURE, kPa		83
FAILURE STRESS, kPa		355
PORE PRESSURE, kPa		
STRAIN RATE, %/min.		0.300
ULTIMATE STRESS, kPa		
PORE PRESSURE, kPa		
σ_1 FAILURE, kPa		437
σ_3 FAILURE, kPa		83

TYPE OF TEST:
Unconsolidated undrained
SAMPLE TYPE: Shelby Tube
DESCRIPTION: SILT

LL= 28 PL= 23 PI= 5.0
SPECIFIC GRAVITY= 2.65
REMARKS:

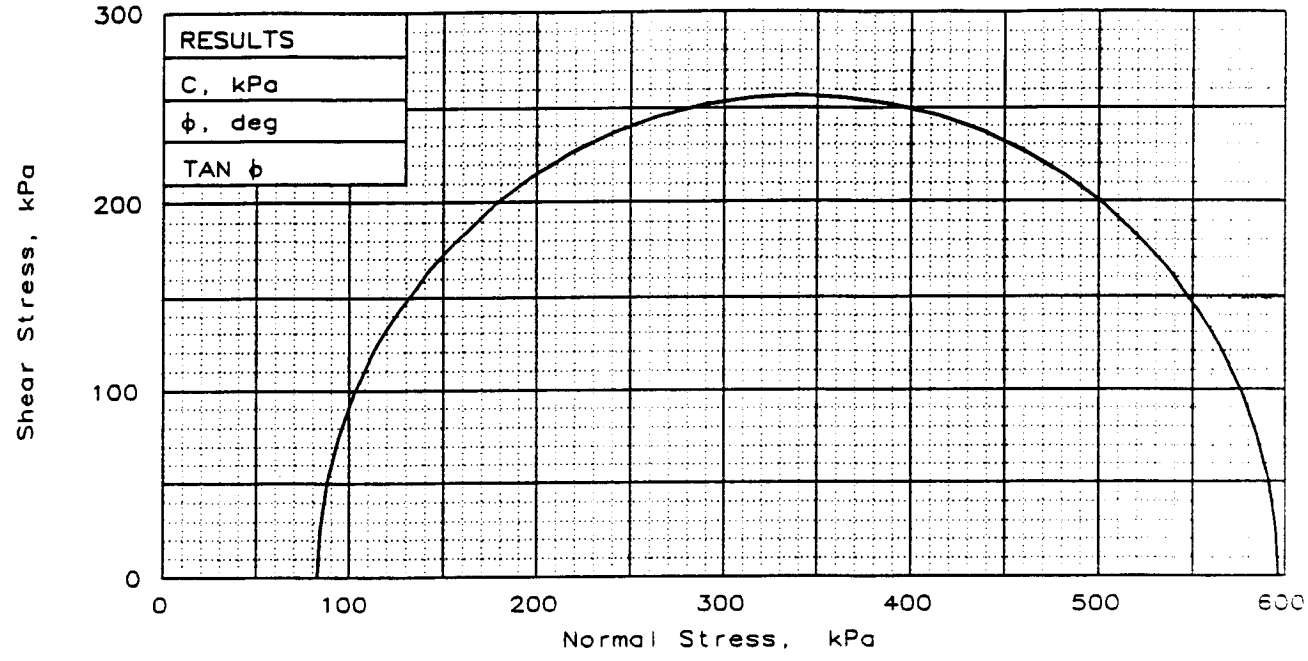
CLIENT: HNTB

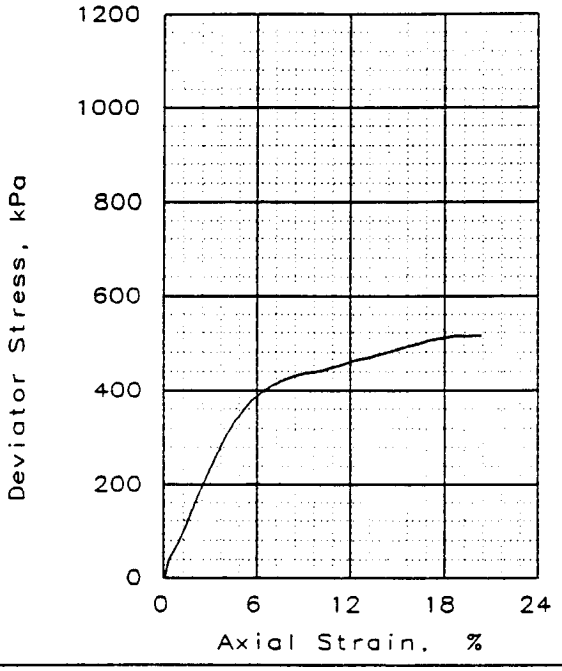
PROJECT: Third Runway NSA

SAMPLE LOCATION: HC00-B169/S-5

HARTCROWSER J4978-18 2/18/00
Figure B-40

AR 044366





SAMPLE NO.		1
INITIAL	WATER CONTENT, %	22.6
	DRY DENSITY, g/cc	1.7
	SATURATION, %	98.0
	VOID RATIO	0.622
	DIAMETER, cm	7.28
	HEIGHT, cm	15.15
AT TEST	WATER CONTENT, %	22.8
	DRY DENSITY, g/cc	1.7
	SATURATION, %	98.7
	VOID RATIO	0.622
	DIAMETER, cm	7.28
	HEIGHT, cm	15.15
BACK PRESSURE, kPa		0
CELL PRESSURE, kPa		83
FAILURE STRESS, kPa		513
PORE PRESSURE, kPa		
STRAIN RATE, %/min.		
ULTIMATE STRESS, kPa		
PORE PRESSURE, kPa		
σ_1 FAILURE, kPa		596
σ_3 FAILURE, kPa		83

TYPE OF TEST:
Unconsolidated undrained
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Lean CLAY

LL= 35 PL= 22 PI= 13.0
SPECIFIC GRAVITY= 2.70
REMARKS:

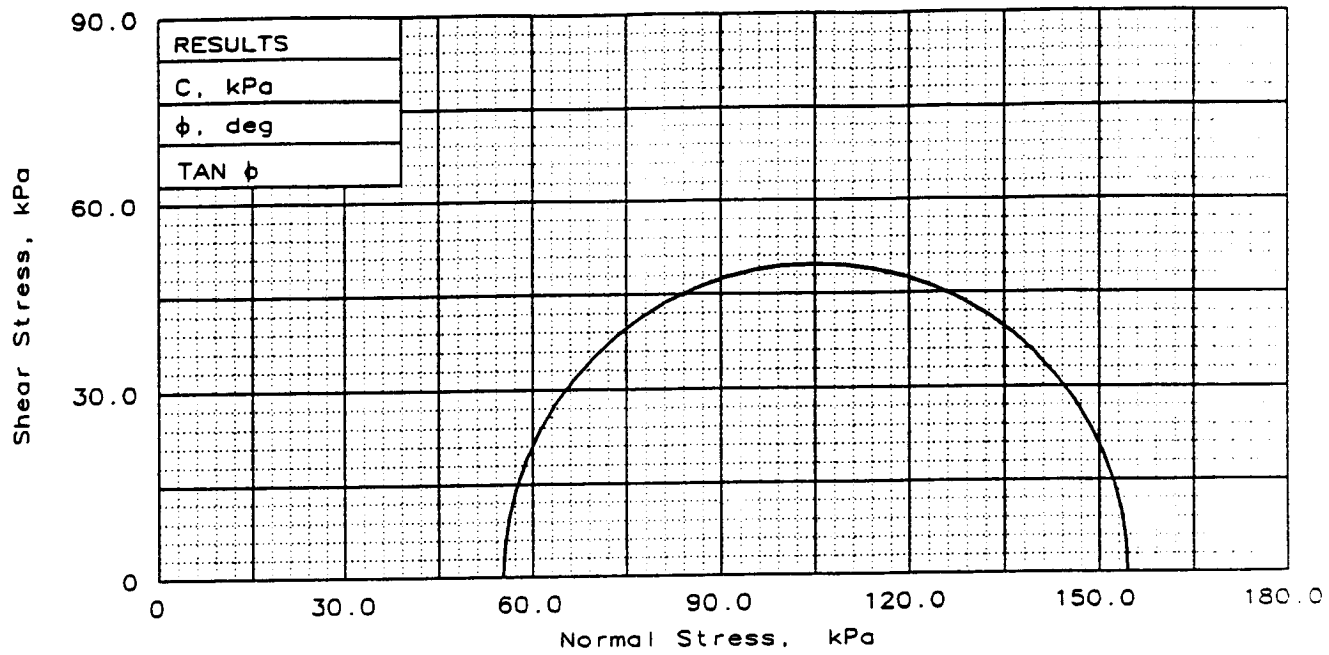
CLIENT: HNTB

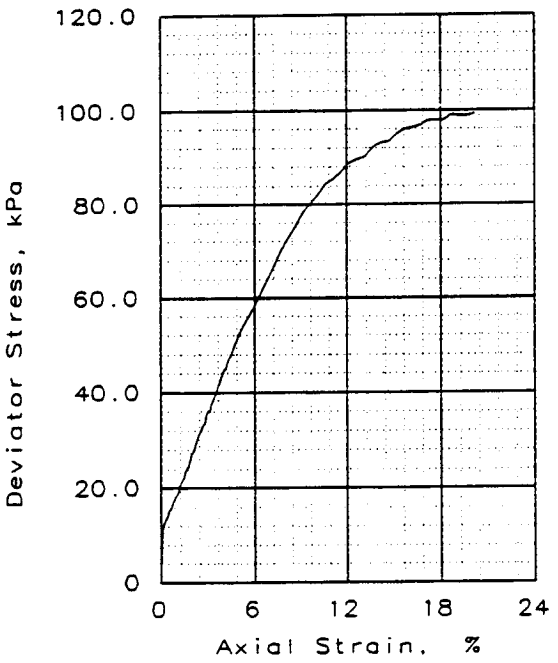
PROJECT: 3rd Runway North Safety Area

SAMPLE LOCATION: HC00-B170/S-5

HARTCROWSER J4978-18 2/2/00
Figure B-41

AR 044367





SAMPLE NO.		1
INITIAL	WATER CONTENT, %	14.9
	DRY DENSITY, g/cc	2.0
	SATURATION, %	113.3
	VOID RATIO	0.348
	DIAMETER, cm	7.21
	HEIGHT, cm	14.98
AT TEST	WATER CONTENT, %	14.9
	DRY DENSITY, g/cc	2.0
	SATURATION, %	113.3
	VOID RATIO	0.348
	DIAMETER, cm	7.21
	HEIGHT, cm	14.98
BACK PRESSURE, kPa		0.0
CELL PRESSURE, kPa		55.2
FAILURE STRESS, kPa		99.3
PORE PRESSURE, kPa		
STRAIN RATE, %/min.		0.300
ULTIMATE STRESS, kPa		
PORE PRESSURE, kPa		
σ_1 FAILURE, kPa		154.5
σ_3 FAILURE, kPa		55.2

TYPE OF TEST:
Unconsolidated undrained
SAMPLE TYPE: Shelby Tube
DESCRIPTION: Lean CLAY

LL= 21 PL= 13 PI= 8.0
SPECIFIC GRAVITY= 2.65
REMARKS:

CLIENT: HNTB

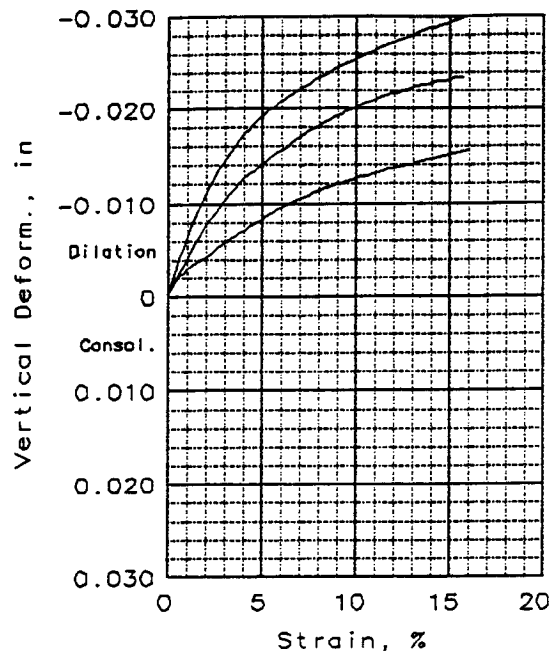
PROJECT: Third Runway NSA

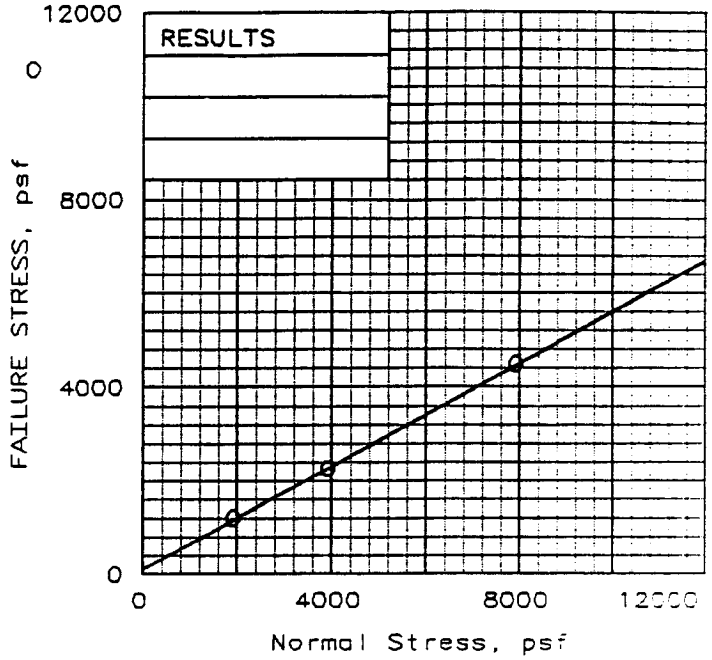
SAMPLE LOCATION: HC00-B172/S-3

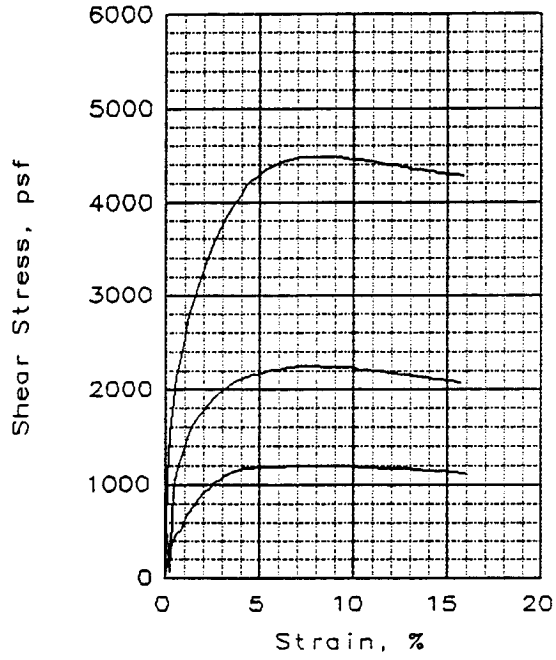
HARTCROWSER J4978-18 2/21/00
Figure B-42

AR 044368

Due to a clerical error this number has been omitted.







SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	32.9	32.7	31.4
	DRY DENSITY, pcf	89.4	87.6	88.8
	SATURATION, %	98.4	93.7	92.3
	VOID RATIO	0.921	0.959	0.934
	DIAMETER, in	2.42	2.42	2.42
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	31.3	31.5	27.5
	DRY DENSITY, pcf	92.1	92.1	98.2
	SATURATION, %	99.7	100.3	101.2
	VOID RATIO	0.863	0.865	0.748
	DIAMETER, in	2.42	2.42	2.42
	HEIGHT, in	0.97	0.95	0.90
NORMAL STRESS, psf		2000	4000	8000
FAILURE STRESS, psf		1192	2249	4478
STRAIN, %		6.5	7.1	7.2
ULTIMATE STRESS, psf				
STRAIN, %				
Strain rate, in/min		0.1311	0.1311	0.1311

SAMPLE TYPE: SHELBY
DESCRIPTION: GRAY CLAY

SPECIFIC GRAVITY= 2.75
REMARKS: IN-SITU

CLIENT: HART CROWSER

PROJECT: THIRD RUNWAY 4978-18

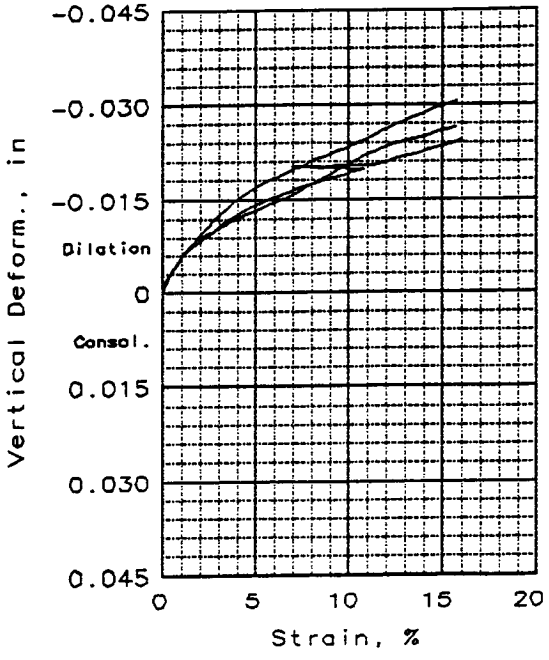
SAMPLE LOCATION: HC99-B54A / S-1A

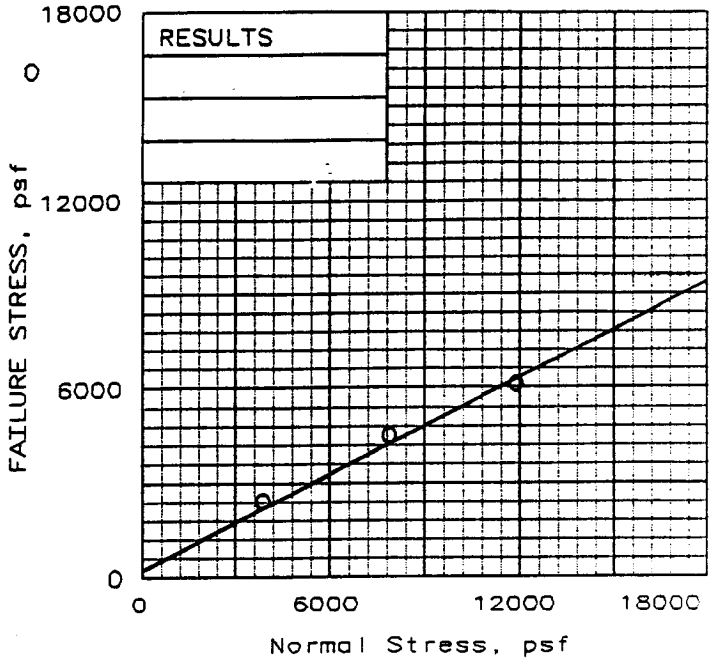
PROJ. NO.: 745-95082 DATE: 11/24/99

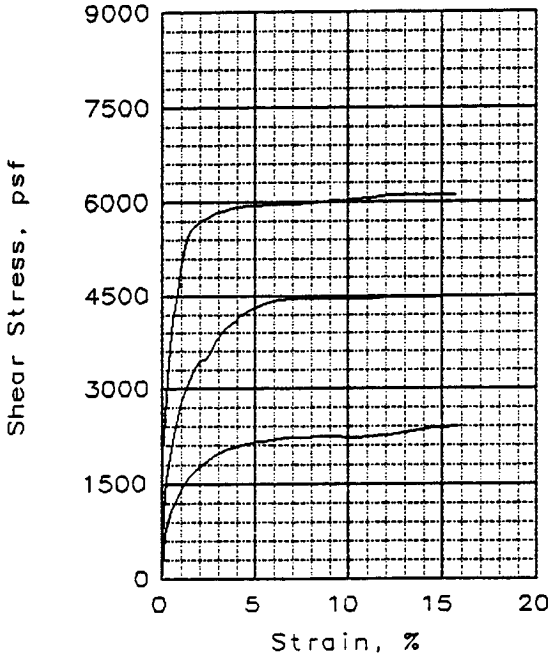
DIRECT SHEAR TEST REPORT

PROFESSIONAL SERVICE INDUSTRIES

Figure B-43







SAMPLE NO.:		1	2	3
INITIAL	WATER CONTENT, %	15.3	13.9	14.4
	DRY DENSITY, pcf	116.6	120.8	118.9
	SATURATION, %	88.8	91.0	88.9
	VOID RATIO	0.473	0.421	0.444
	DIAMETER, in	2.42	2.42	2.42
	HEIGHT, in	1.00	1.00	1.00
AT TEST	WATER CONTENT, %	14.7	11.8	12.7
	DRY DENSITY, pcf	122.6	130.0	127.5
	SATURATION, %	100.8	100.9	100.5
	VOID RATIO	0.400	0.321	0.347
	DIAMETER, in	2.42	2.42	2.42
	HEIGHT, in	0.95	0.93	0.93
NORMAL STRESS, psf		4000	8000	12000
FAILURE STRESS, psf		2415	4488	6095
STRAIN, %		15.8	15.2	12.2
ULTIMATE STRESS, psf				
STRAIN, %				
Strain rate, in/min		0.1311	0.1311	0.1311

SAMPLE TYPE: Shelby Tube
DESCRIPTION: Gray silty CLAY

SPECIFIC GRAVITY= 2.75
REMARKS: In-situ, some coarse sand

CLIENT: Hart Crowser

PROJECT: Third Runway - 4978-18

SAMPLE LOCATION: B-64, S-5

PROJ. NO.: 745-95082 DATE: 12/10/99

DIRECT SHEAR TEST REPORT

PROFESSIONAL SERVICE INDUSTRIES

Figure B-44