

**Appendix 2.5A—Geotechnical Investigation and Laboratory Testing Data Report – ESP**

(Excludes contents of report Appendix G)

Prepared by  
MACTEC Engineering and Consulting, Inc.

November 16, 2007

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engineering and constructing a better tomorrow

November 16, 2007

Mr. Thomas O. McCallum  
Southern Nuclear Operating Company, Inc.  
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Subject: **Data Report of Geotechnical Investigation and Laboratory Testing  
Southern Advanced Light Water Reactor, Early Site Permit  
Vogtle Electric Generating Plant  
Burke County, Georgia  
MACTEC Project Number 6141-05-0227**

Dear Mr. McCallum:

MACTEC Engineering and Consulting, Inc. (MACTEC) and our team of subconsultants are pleased to submit this data report relating to the Early Site Permit (ESP) for the Advanced Light Water Reactor (ALWR) proposed at SNOC's Plant Vogtle in Burke County, Georgia.

The scope of work was generally as described in Technical Specification 25144-000-3PS-CY00-00001, Rev. 0, with modifications based on discussions with BECHTEL and outlined in our Quality Assurance Project Document and subsequent correspondence. Broadly, the scope included soil borings, soil coring, rock coring, piezo-cone soundings, seismic cone soundings, well installation, field permeability testing using newly installed and pre-existing wells, borehole geophysical logging and laboratory soil testing.

This Data Report was originally submitted on February 22, 2006 and re-issued on August 9, 2006 in electronic file format. This revision of the Data Report, dated November 16, 2007 is submitted to include revisions to Appendix A – Boring Data and additional laboratory testing performed in October, 2007. Other Appendices (B, C, D, E, F, G) are unchanged and are not re-submitted with this revision, but are referenced in the Table of Contents.

The changes to the boring logs were made to clarify material descriptors of the various strata. The changes to the boring logs are based on re-examination of the soil samples by MACTEC and/or additional laboratory classification testing performed in October, 2007. In addition, revisions to the depth/elevation of the Utley Limestone in some of the borings were made based on the criteria used to identify the Utley Limestone for the COL Geotechnical Borings. Depictions of the changes are difficult to illustrate on the boring logs; therefore, a Log of Revisions to the geotechnical boring logs is provided in Appendix A.

Additional results of laboratory testing performed in October, 2007 are included in a new Appendix H – Carbonate Content Test Results as shown in the Table of Contents. Additional testing included carbonate content tests (ASTM D4373 and ASTM D3042), and index tests consisting of gradation (sieve), and Atterberg limits.

Should you have any questions, please do not hesitate to contact us at 404-873-4761.

Sincerely,

**MACTEC Engineering and Consulting, Inc.**

*Pieter J. DePree*

Pieter J. DePree, P.E.

Principal Engineer with Permission by: KMR



Wm. Allen Lancaster  
Project Manager

Distribution: Addressee (2)  
Mr. John Damm, BECHTEL (1)

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<u>Appendix</u>	<u>Submittal Date</u>	<u>Attachment Title</u>
A	November 16, 2007	Boring Data (Revised)
B	February 22, 2006	CPT Report
C	February 22, 2006	Geophysical Report
D	February 22, 2006	Field Permeability Testing
E	February 22, 2006	Laboratory Testing
F	February 22, 2006	Hammer Calibration
G	February 22, 2006	Core Photos
H	November 16, 2007	Carbonate Content Test Results (Not Previously Submitted)

## **1 BACKGROUND**

### **1.1 Purpose**

The purpose of the work is defined by Technical Specification 25144-000-3PS-CY00-00001, Rev. 0, prepared by Bechtel Power Corporation (Bechtel). In brief, the Southern Nuclear Operating Company, Inc. (SNOC) requires an Early Site Permit (ESP) for an Advanced Light Water Reactor (ALWR) at Plant Vogtle in Burke County, Georgia. Obtaining this permit requires significant geotechnical and geologic data.

### **1.2 Site Description**

The site is located west of the main Plant Vogtle area. Topography is generally defined by a gently rolling river terrace ranging from about elevation 210 to 280 feet, MSL. The area drains to the north and northwest toward the Savannah River. There has been some past grading including large fills in portions of the area. The area is generally wooded with small to medium pines and traversed by various roadways, mostly unpaved. Support buildings related to the existing plant are located along the southern side of the investigation area.

### **1.3 Project Description**

The project will consist of a new Advanced Light Water Reactor (ALWR) unit. Details of construction are not yet available, but we anticipate major components of the construction will include a reactor vessel, turbine building with turbine supports, and cooling towers. These major structures will likely require high capacity foundations which will likely bear at depth. Ancillary structures will include office and service buildings, buried pipelines and other utilities, and paved areas including parking, loading, and roadways. Grading with excavation and fill on the order of 30 to 40 feet is likely.

## **2 SCOPE OF WORK**

The scope of MACTEC's services was in general accordance with Technical Specification 2514-000-3PS-CY00-00001, Rev. 0, with modifications based on discussions with BECHTEL and outlined in our Quality Assurance Project Document (QAPD) and subsequent correspondence.

### **2.1 Preparation**

MACTEC obtained permits necessary for performing the work, prepared and submitted a QAPD for the work which was reviewed and approved by Bechtel. Exploratory locations were then located using surveying methods to the nearest 0.5 feet horizontally and the nearest 0.1 foot vertically using third order accuracy surveying techniques. At the completion of exploratory activities, locations were resurveyed to capture changes in locations necessitated by various

conditions and coordinated with BECHTEL. Completed locations are shown on Figure 1. Prior to exploration, the MACTEC team located existing underground utilities near the exploratory locations and submitted a report of the locations. In some cases, minor clearing and site preparation was required at the exploratory locations.

Prior to conducting standard penetration tests (SPT) our rig-mounted, automatic hammers were calibrated (see GRL Report in Appendix F). Hammer energy varied from 65 to 87 percent of theoretical. Although there was some correlation of hammer energy to depth, the correlation was not perfect and correction of SPT results to  $N_{60}$  values would entail some subjective judgment. Therefore, SPT results presented in the boring logs in Appendix A are uncorrected and results of hammer calibration are presented in Appendix F.

## **2.2 Subsurface Exploration**

### **2.2.1 Soil Boring and Sampling**

Twelve borings, designated B-1001 through B-1011 and B-1013, were drilled at the site. Boring locations are shown on Figure 1 and tabulated along with logs of borings in Appendix A. Boring B-1012 was eliminated from the scope by SNOC/BECHTEL.

Except for boring B-1003, all borings were advanced using mud-rotary drilling techniques and polymer and/or bentonite drilling fluid to depths of 100 to 304 feet below the ground surface. Standard Penetration Tests (SPT) were conducted continuously (at 1.5 foot intervals) in the upper 15 feet of each boring and at 5 to 10 foot intervals thereafter. Relatively undisturbed (Shelby Tube, Pitcher, or Piston) samples were collected at intervals selected by SNOC/BECHTEL. In cohesive soils, a pocket penetrometer and/or Torvane device were used to evaluate the undisturbed samples shortly after collection.

Borings were drilled at B-1002A and C-1005A to facilitate suspension logging. No sampling was conducted.

Soil samples from the SPT borings were placed into 8 oz. jars with threaded plastic lids. Adhesive paper labels were placed on the sides of the jars. The labels are pre-printed to accommodate pertinent sample information including project identification, date, boring number, sample number and depth, penetration resistance and a brief description of the enclosed sample. Jar samples were placed in cardboard boxes and stored in the on-site sample storage shed as directed by SNOC/BECHTEL. Jar and undisturbed samples selected for additional testing by SNOC/BECHTEL were returned to MACTEC's laboratory at the end of each week.

### **2.2.2 Continuous Soil Coring**

Boring B-1003 was advanced using continuous soil/rock coring procedures to a depth of 1338 feet using a Christensen 94 mm wire line system. A log of this boring is included in Appendix A. To core crystalline rock below a depth of about 1050 feet, grouted casing was installed to allow use of water rather than viscous mud for drilling fluid. Average core recovery was 77%

throughout the entire hole depth. Cores were logged continuously by MACTEC's field geologist prior to photographing and storage. Selected samples from the cores were sealed in glass jars and returned to the laboratory for further testing. Soil and rock cores were placed in wooden core boxes lined with plastic sheeting and stored on-site at the location specified by SNOC/Bechtel. Core boxes were stored in the on-site sample storage shed as directed by SNOC and Bechtel.

### **2.2.3 Seismic Suspension Logging**

Following completion of boreholes 1002, 1002A, 1003, and 1004 and C-1005A, these drill holes were filled with high-consistency drilling mud to maintain open holes. GeoVision then conducted geophysical suspension logging of the holes using various tools. The procedures and results are discussed in detail in Appendix C.

### **2.2.4 Cone Penetration Testing**

Static Cone Penetration Tests (CPT) were conducted at 12 locations (C-1001 through C-1010, plus C-1001A and C-1009A, added due to shallow refusal) to refusal, encountered at depths of 6 to 117 feet by Applied Research Associates, Inc. in general accordance with the specification. At 3 locations, seismic downhole tests were conducted in conjunction with the static CPT. Results are reported in Appendix B.

### **2.2.5 Grouting Boreholes**

After completion of all drilling, sampling, and seismic logging activities in each borehole, holes were grouted full using tremie methods in general accordance with the specification. The grout mix specified in 25144-000-3PS-CY00-00001 was used. Displaced drilling fluid was sprayed over a wide area of the ground surface or allowed to flow into a mud pit excavated near selected boreholes. This procedure was discussed with Mr. Thomas of SNOC on June 14, 2005 at the Vogtle Site.

### **2.2.6 Field Permeability Testing**

In-situ hydraulic conductivity testing was conducted in accordance with Section 8 of ASTM D 4044 in the fifteen new observation wells recently installed at Plant Vogtle by others. The tests were performed utilizing both falling head ("slug-in") and rising head ("slug-out") tests to assess the water transmitting characteristics of the aquifer. The data acquired from the field permeability tests was analyzed to estimate the hydraulic conductivity of the aquifer using the Bower and Rice slug test methodology. A data report containing all of the information required by Section 9 of ASTM D 4044 was prepared presenting the results of the field permeability testing and analyses and is included in Appendix D.

### **2.2.7 Laboratory Testing**

Laboratory Testing was conducted based on laboratory assignments provided by Bechtel. The physical soil testing was performed within MACTEC's laboratory in Atlanta. Test results are included in Appendix E.

Additional testing was performed in October, 2007 which included carbonate content tests (ASTM D4373 and ASTM D3042), and index tests consisting of gradation (sieve), and Atterberg limits. These additional laboratory test results are contained in Appendix H – Carbonate Content Test Results.

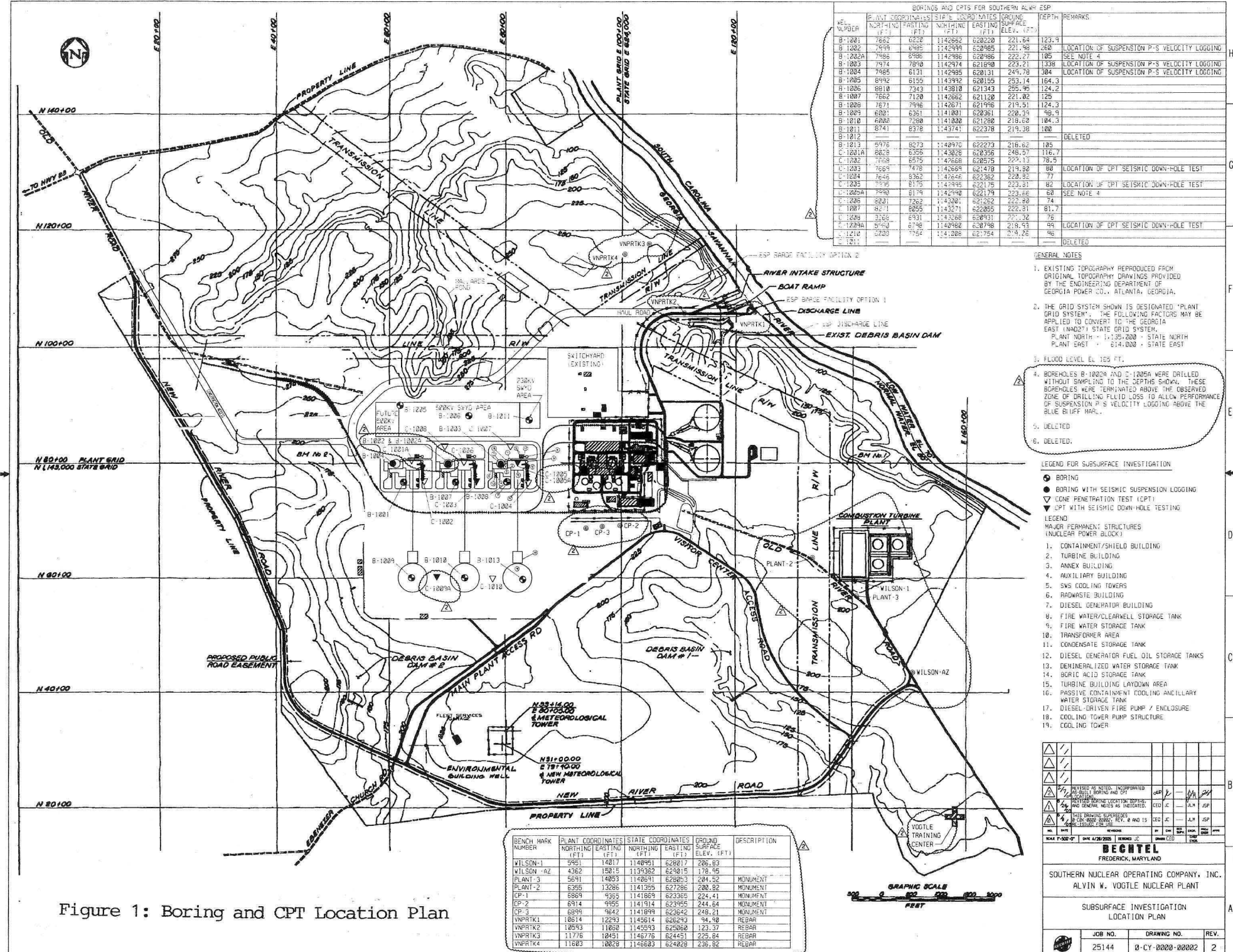


Figure 1: Boring and CPT Location Plan



Table 1: Equipment Summary



**PLANT VOGTLE - ALWR ESP - EQUIPMENT SUMMARY**

CME 55 Drilling Rig  
CME 75 Drilling Rig  
Speedstar Quickdrill 275 Drilling Rig  
Gardner Denver 15 W Drilling Rig  
Christiansen Wireline Coring System  
ARA Mack-1 Penetrometer Truck  
OYO Model 170 Suspension Logging Probe and Recorder  
Robertson Geologging Model 3ACS 3 Leg Caliper Probe  
Robertson Geologging HIRAT High Resolution Televiwer Probe  
InSitu miniTROLL Pressure Transducer  
Topcon 303 GTS Total Station

Table 2: Field Boring and CPT Summary



**PLANT VOGTLE - ALWR ESP - BORING/CPT LOCATIONS**

From Figure 1 - State Grid 1,143,000=plant grid 80+00 (North)

From Figure 1 - State Grid 624,000=plant grid 100+00 (East)

Description	Elevation (ft)	Plant Grid		State Grid		Termination Depth (ft)	Water Elevation (ft)
		Northing (ft)	Easting (ft)	Northing (ft)	Easting (ft)		
B 1001	221.64	7,661.92	6,220.42	1,142,661.92	620,220.42	123.9	NR
B 1002	221.98	7,998.52	6,985.47	1,142,998.52	620,985.47	260.0	166.0
B 1002A	222.27	7,985.62	6,986.07	1,142,985.62	620,986.07	105.0	176.0
B 1003	223.21	7,974.36	7,889.85	1,142,974.36	621,889.85	1,338.0	NR
B 1003 Top of Casing	224.85	7,974.99	7,889.45	1,142,974.99	621,889.45	1,338.0	NR
B 1004	249.78	7,985.41	6,131.44	1,142,985.41	620,131.44	304.0	117.0
B 1005	253.14	8,991.57	6,155.35	1,143,991.57	620,155.35	164.3	NR
B 1006	255.95	8,810.26	7,342.90	1,143,810.26	621,342.90	124.1	242.0
B 1007	221.02	7,662.29	7,120.13	1,142,662.29	621,120.13	125.0	161.0
B 1008	219.51	7,670.93	7,996.15	1,142,670.93	621,996.15	124.5	168.0
B 1009	220.39	6,000.54	6,361.26	1,141,000.54	620,361.26	98.9	NR
B 1010	218.60	6,000.12	7,279.68	1,141,000.12	621,279.68	104.5	203.0
B 1011	219.38	8,741.13	8,378.01	1,143,741.13	622,378.01	100.0	NR
B 1013	218.62	5,976.08	8,272.50	1,140,976.08	622,272.50	105.0	205.0
C 1001A	248.57	8,028.13	6,355.97	1,143,028.13	620,355.97	116.7	NR
C 1002	222.13	7,667.65	6,574.64	1,142,667.65	620,574.64	78.5	NR
C 1003	219.80	7,669.31	7,477.88	1,142,669.31	621,477.88	80.0	175.2
C 1004	220.82	7,646.13	8,361.85	1,142,646.13	622,361.85	77.0	NR
C 1005	223.81	7,995.27	8,174.61	1,142,995.27	622,174.61	82.0	189.8
C 1005A	223.66	7,989.75	8,179.26	1,142,989.75	622,179.26	90.0	NR
C 1006	222.80	8,001.46	7,261.58	1,143,001.46	621,261.58	74.0	NR
C 1007	222.81	8,270.62	8,055.05	1,143,270.62	622,055.05	81.7	NR
C 1008	221.30	8,268.48	6,930.90	1,143,268.48	620,930.90	76.0	NR
C 1009A	218.93	5,979.63	6,798.49	1,140,979.63	620,798.49	99.0	NR
C 1010	219.06	6,008.35	7,754.15	1,141,008.35	621,754.15	96.0	NR
OW 1001A Conc Pad/Grade	226.38	7,893.50	6,218.43	1,142,893.50	620,218.43	45.0	NR
OW 1001A Top of Casing	228.85	7,893.50	6,218.43	1,142,893.50	620,218.43	45.0	NR

NR = No Reading, unable to record water level due to drilling mud.

Table 3: Laboratory Test Summary



BORING NO.	SAMPLE NO.	DEPTH/ELEV.	USCS	MATERIAL DESCRIPTION	LL	PL	PI
B-1002	6	7.5'/214.28'		Silty sand			
	11	18.5'/203.48'		Silty sand			
	13	28.5'/193.48'		Silty sand			
	14	33.5'/188.48'		Sandy silt			
	15	38.5'/183.48'		Silty clay	48	27	21
	18	53.5'/168.48'		Silty sand			
	20	63.5'/158.48'		Silty sand			
	22	73.5'/148.48'		Silty sand			
	24	83.5'/138.48'		Silty sand			
	UD-1 Upper	92.0'/129.98'	GM	Silty gravel with sand	72	37	35
	UD-1 Middle	92.0'/129.98'		Silty gravel with sand			
	UD-2	103.5'/118.48'	CL	Sandy silt	34	22	12
	UD-3	113.5'/108.48'	SC	Clayey sand	29	19	10
	UD-4	123.5'/98.48'	GC-GM	Silty clayey gravel with sand	22	17	5
	UD-5	133.5'/88.48'	SM	Silty sand with gravel	32	25	7
	33	153.5'/68.48'	CL	Sandy silt with gravel	34	21	13
	38	188.5'/33.48'	SM	Silty sand	NP	NP	NP
	43	238.5'/-16.52'		Silty sand			
B-1003	3	15.0'/208.21'		Silty sand			
	7	35.0'/185.21'		Silty sand			
	11	55.0'/168.21'		Silty gravel with sand			
	14	75.0'/148.21'		Poorly graded sand with silt			
	17	88.0'/135.21'	SM	Silty sand with gravel	93	42	51
	UD-1	93.0'/130.21'	SM	Silty sand	54	32	22
	22	104.7'/118.51'	SM	Silty sand	83	51	32
	27	121.7'/101.51'	SM	Silty sand	NP	NP	NP
	31	141.7'/81.51'	SM	Silty sand	46	28	18
	36	165.7'/57.51'	SP-SM	Poorly graded sand with silt	NP	NP	NP
	40	185.7'/37.51'		Silty sand			
	44	205.7'/17.51'		Silty sand			
	51	240.7'/-17.49'		Poorly graded sand with silt			
	59	280.7'/-57.49'		Silty sand			
	66	315.7'/-92.49'	GW	Well-graded gravel with sand	53	38	15
	73	350.7'/-127.49'	CL	Silt with sand	41	22	19
	83	400.7'/-177.49'		Silty sand			
	93	450.7'/-227.49'		Silty sand			
	103	496.7'/-273.49'		Silty sand			

BORING NO.	SAMPLE NO.	DEPTH/ELEV.	USCS	MATERIAL DESCRIPTION	LL	PL	PI
B-1004	7	9.0'/240.78'		Silty sand			
	9	12.0'/237.78'		Silty sand			
	12	23.5'/226.28'		Silty sand			
	16	43.5'/206.28'	CH	Silt with sand	58	24	34
	18	53.5'/196.28'		Sandy silt			
	21	68.5'/181.28'		Silty sand			
	24	83.5'/166.28'		Silty sand			
	32	123.5'/126.28'	GM	Silty gravel with sand	43	19	24
	UD-1 Upper	144.0'/105.78'	SM	Silty sand	59	38	21
	UD-1 Middle	144.0'/105.78'		Silty sand			
	UD-2	153.5'/96.28'	SM	Silty sand	43	27	16
	UD-3 Upper	163.5'/86.28'	GC	Clayey gravel with sand	31	22	9
	UD-3 Middle	163.5'/86.28'		Clayey gravel with sand			
	UD-4 Upper	177.0'/72.78'	SM	Silty sand with gravel	31	22	9
	UD-4 Middle	177.0'/72.78'		Silty sand with gravel			
	UD-5	188.5'/61.28'	SM	Silty sand with gravel	34	27	7
	UD-6	198.5'/51.28'	SC	Silty sand	31	21	10
B-1006	6	7.5'/248.45'		Poorly graded sand with silt			
	14	33.5'/222.45'		Silty sand			
	19	58.5'/197.45'	CH	Silt with sand	97	30	67
	21	68.5'/187.45'		Silty sand			
	25	88.5'/167.45'		Silty sand			
	29	108.5'/147.45'		Silty sand with gravel			
	32	123.5'/132.45'	MH	Silt with sand	99	43	56
B-1010	6	7.5'/211.1'		Silty sand			
	14	33.5'/185.1'		Silty sand			
	19	58.5'/160.1'		Silty sand			
	22	73.5'/145.1'		Silty sand			
	27	98.5'/120.1'	CH	Sandy silt	94	36	58



## **APPENDIX A (Revised November 16, 2007)**

Table of As Built Surveyed Boring, Well, and Probe Locations

Key to Symbols

Log of Revisions to ESP Geotechnical Boring Logs

Boring Logs (14)

Table 2: Field Boring and CPT Summary





























**PLANT VOGTLE - ALWR ESP - BORING/CPT LOCATIONS**

From Figure 1 - State Grid 1,143,000=plant grid 80+00 (North)

From Figure 1 - State Grid 624,000=plant grid 100+00 (East)

Description	Elevation (ft)	Plant Grid		State Grid		Termination Depth (ft)	Water Elevation (ft)
		Northing (ft)	Easting (ft)	Northing (ft)	Easting (ft)		
B 1001	221.64	7,661.92	6,220.42	1,142,661.92	620,220.42	123.9	NR
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B 1002A	222.27	7,985.62	6,986.07	1,142,985.62	620,986.07	105.0	176.0
B 1003	223.21	7,974.36	7,889.85	1,142,974.36	621,889.85	1,338.0	NR
B 1003 Top of Casing	224.85	7,974.99	7,889.45	1,142,974.99	621,889.45	1,338.0	NR
B 1004	249.78	7,985.41	6,131.44	1,142,985.41	620,131.44	304.0	117.0
B 1005	253.14	8,991.57	6,155.35	1,143,991.57	620,155.35	164.3	NR
B 1006	255.95	8,810.26	7,342.90	1,143,810.26	621,342.90	124.1	242.0
B 1007	221.02	7,662.29	7,120.13	1,142,662.29	621,120.13	125.0	161.0
B 1008	219.51	7,670.93	7,996.15	1,142,670.93	621,996.15	124.5	168.0
B 1009	220.39	6,000.54	6,361.26	1,141,000.54	620,361.26	98.9	NR
B 1010	218.60	6,000.12	7,279.68	1,141,000.12	621,279.68	104.5	203.0
B 1011	219.38	8,741.13	8,378.01	1,143,741.13	622,378.01	100.0	NR
B 1013	218.62	5,976.08	8,272.50	1,140,976.08	622,272.50	105.0	205.0
C 1001A	248.57	8,028.13	6,355.97	1,143,028.13	620,355.97	116.7	NR
C 1002	222.13	7,667.65	6,574.64	1,142,667.65	620,574.64	78.5	NR
C 1003	219.80	7,669.31	7,477.88	1,142,669.31	621,477.88	80.0	175.2
C 1004	220.82	7,646.13	8,361.85	1,142,646.13	622,361.85	77.0	NR
C 1005	223.81	7,995.27	8,174.61	1,142,995.27	622,174.61	82.0	189.8
C 1005A	223.66	7,989.75	8,179.26	1,142,989.75	622,179.26	90.0	NR
C 1006	222.80	8,001.46	7,261.58	1,143,001.46	621,261.58	74.0	NR
C 1007	222.81	8,270.62	8,055.05	1,143,270.62	622,055.05	81.7	NR
C 1008	221.30	8,268.48	6,930.90	1,143,268.48	620,930.90	76.0	NR
C 1009A	218.93	5,979.63	6,798.49	1,140,979.63	620,798.49	99.0	NR
C 1010	219.06	6,008.35	7,754.15	1,141,008.35	621,754.15	96.0	NR
OW 1001A Conc Pad/Grade	226.38	7,893.50	6,218.43	1,142,893.50	620,218.43	45.0	NR
OW 1001A Top of Casing	228.85	7,893.50	6,218.43	1,142,893.50	620,218.43	45.0	NR

NR = No Reading, unable to record water level due to drilling mud.

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES		Undisturbed Sample		Auger Cuttings																																			
COARSE GRAINED SOILS (More than 50% of material is LARGER than No. 200 sieve size)	GRAVELS (More than 50% of coarse fraction is LARGER than the No. 4 sieve size)	CLEAN GRAVELS (Little or no fines)		GW	Well graded gravels, gravel - sand mixtures, little or no fines.		Split Spoon Sample			Bulk Sample																																	
		GRAVELS WITH FINES (Appreciable amount of fines)		GP	Poorly graded gravels or grave - sand mixtures, little or no fines.		Rock Core			Crandall Sampler																																	
				GM	Silty gravels, gravel - sand - silt mixtures.		Dilatometer			Pressure Meter																																	
				GC	Clayey gravels, gravel - sand - clay mixtures.		Packer			No Recovery																																	
	SANDS (More than 50% of coarse fraction is SMALLER than the No. 4 Sieve Size)	CLEAN SANDS (Little or no fines)		SW	Well graded sands, gravelly sands, little or no fines.		Water Table at time of boring			Water Table after 24 hours																																	
		SANDS WITH FINES (Appreciable amount of fines)		SP	Poorly graded sands or gravelly sands, little or no fines.																																						
				SM	Silty sands, sand - silt mixtures																																						
				SC	Clayey sands, sand - clay mixtures.																																						
FINE GRAINED SOILS (More than 50% of material is SMALLER than No. 200 sieve size)	SILTS AND CLAYS (Liquid limit LESS than 50)			ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts and with slight plasticity.	Correlation of Standard Penetration Resistance with Relative Density and Consistency																																					
				CL	Inorganic lays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.																																						
				OL	Organic silts and organic silty clays of low plasticity.	<table><tr><th colspan="2">SAND &amp; GRAVEL</th><th colspan="2">SILT &amp; CLAY</th></tr><tr><th>No. of Blows</th><th>Relative Density</th><th>No. of Blows</th><th>Consistency</th></tr><tr><td>0 - 4</td><td>Very Loose</td><td>0 - 2</td><td>Very Soft</td></tr><tr><td>5 - 10</td><td>Loose</td><td>3 - 4</td><td>Soft</td></tr><tr><td>11 - 30</td><td>Medium Dense</td><td>5 - 8</td><td>Firm</td></tr><tr><td>31 - 50</td><td>Dense</td><td>9 - 15</td><td>Stiff</td></tr><tr><td>Over 50</td><td>Very Dense</td><td>16 - 30</td><td>Very Stiff</td></tr><tr><td></td><td></td><td>31 - 50</td><td>Hard</td></tr><tr><td></td><td></td><td>Over 50</td><td>Very Hard</td></tr></table>				SAND & GRAVEL		SILT & CLAY		No. of Blows	Relative Density	No. of Blows	Consistency	0 - 4	Very Loose	0 - 2	Very Soft	5 - 10	Loose	3 - 4	Soft	11 - 30	Medium Dense	5 - 8	Firm	31 - 50	Dense	9 - 15	Stiff	Over 50	Very Dense	16 - 30	Very Stiff			31 - 50	Hard		
	SAND & GRAVEL		SILT & CLAY																																								
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Over 50	Very Dense	16 - 30	Very Stiff																																								
		31 - 50	Hard																																								
		Over 50	Very Hard																																								
SILTS AND CLAYS (Liquid limit GREATER than 50)			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.																																							
			CH	Inorganic clays of high plasticity, fat clays																																							
			OH	Organic clays of medium to high plasticity, organic silts.																																							
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils.																																							
BOUNDARY CLASSIFICATIONS: Soils possessing characteristics of two groups are designated by combinations of group symbols.																																											
<table><tr><td rowspan="2">SILT OR CLAY</td><td colspan="3">SAND</td><td colspan="2">GRAVEL</td><td rowspan="2">Cobbles</td><td rowspan="2">Boulders</td></tr><tr><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Coarse</td></tr><tr><td></td><td>No.200</td><td>No.40</td><td>No.10</td><td>No.4</td><td>3/4"</td><td>3"</td><td>12"</td></tr></table> U.S. STANDARD SIEVE SIZE									SILT OR CLAY	SAND			GRAVEL		Cobbles	Boulders	Fine	Medium	Coarse	Fine	Coarse		No.200	No.40	No.10	No.4	3/4"	3"	12"														
SILT OR CLAY	SAND			GRAVEL		Cobbles	Boulders																																				
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					KEY TO SYMBOLS AND DESCRIPTIONS																																						
																																											
Reference: The Unified Soil Classification System, Corps of Engineers, U.S. Army Technical Memorandum No. 3-357, Vol. 1, March, 1953 (Revised April, 1960)																																											



**Subject: Revisions to ESP Geotechnical Boring Logs  
Vogtle Electric Generating Plant  
Burke County, Georgia  
MACTEC Project Number 6141-05-0227**

**Note: The following revisions have been made to the Geotechnical Boring Logs prepared for the Plant Vogtle ESP Project. These revisions listed below have been made based on re-examination of samples by MACTEC and/or the results of additional laboratory testing.**

**REVISIONS TO SOIL CLASSIFICATION:**

<b>Boring Number</b>	<b>Depth Interval (feet)</b>	<b>Change</b>	<b>Basis for Change</b>
ALL LOGS	NA	Added boring ELEVATION and ELEVATION DATUM = NAVD 88 for each boring log.	Not Applicable
B-1001	88.5 – 93.0	Changed CLAYEY SAND (SC) to SHELL HASH	This change was based on visual/manual re-examination of the samples by MACTEC
B-1002	92.0 – 100.0	Revised classification from SILTY GRAVEL WITH SAND (GM) to SANDY ELASTIC SILT (MH); dark greenish gray, hard, fine, 30% fines, some small white shell fragments, contains cemented layers and nodules.	This change was based on re-interpretation of previous laboratory data along with additional confirmatory classification testing on sample UD-1. The coarse fraction previously identified in the lab results was attributed to shell and cemented fragments.
B-1002	113.5 – 123.5	Added contains cemented layers and nodules, 30% fines, fine quartz sand with some heavy black minerals observed under 20X hand lens.	This addition was based upon visual/manual re-examination of the samples by MACTEC.
B-1002	123.5 – 133.5	Revised classification from CLAYEY/SILTY GRAVEL WITH SAND (GC-GM) to FOSSILIFEROUS LIMESTONE; dark greenish gray, hard, dry, moderately cemented, some sandy SILT (ML), some shells.	This change was based upon visual/manual re-examination of the samples by MACTEC.



Boring Number	Depth Interval (feet)	Change	Basis for Change
B-1002	133.5 – 140.0	Revised classification from SILTY SAND WITH GRAVEL (SM) to FOSSILIFEROUS LIMESTONE; dark greenish gray, hard, dry, moderately cemented, some sandy SILT (ML), some shells.	This change was based upon re-examination of the samples by MACTEC and additional laboratory classification and carbonate content testing for sample UD-5. The gravel-sized fraction previously identified in the lab results was attributed to cemented pieces of limestone and some shells that were broken during the sampling process.
B-1002	140.0 – 153.5	Revised classification from SILTY SAND WITH GRAVEL (SM) to SILTY SAND (SM); dark green and gray, dry, hard, cemented layers and nodules, +HCL.	This change was based upon visual/manual re-examination of the samples by MACTEC.
B-1002	153.5 – 157.0	Revised classification from SANDY CLAY WITH GRAVEL (CL-ML) to SANDY CLAY (CL); gray, very stiff, cemented layers/nodules, trace shell hash, +HCL.	This change was based upon visual/manual re-examination of the samples by MACTEC.
B-1003	80.5 – 84.0	Revised classification from CLAYEY SAND WITH GRAVEL (SC); white-light tan, subangular sand and gravel, coarse sand and medium gravel, calcareous sand, moist to wet, +HCL to CLAYEY SAND (SC); white-light tan, subangular sand, coarse, gravel-sized fragments of cemented shell hash, calcareous sand, moist to wet, +HCL.	This change was based on visual/manual re-examination of the samples by MACTEC.
B-1003	86.0 – 96	Revised classification from SILTY SAND WITH GRAVEL (SM) to SILTY SAND (SM).	This change was based upon visual/manual re-examination of the samples by MACTEC.
B-1003	96.0 – 98.7	Revised classification from SILTY SAND (SM) to SANDY SILT (ML).	This change is based upon laboratory test results from sample DCS-18.
B-1003	145.7 – 149.0	Revised classification from SILTY SAND (SM) to SANDY LEAN CLAY (CL).	This change is based upon laboratory classification testing from sample DCS-31.
B-1003	315.7 – 325.7	Revised classification from GRAVEL WITH SAND (GM) to CLAY WITH SAND (CL).	This change was based on visual/manual re-examination of the sample by MACTEC and confirmatory laboratory classification testing on sample DCS-66. The gravel-sized fraction previously identified on the lab results was attributed to fragments of weakly cemented/partially indurated clay that were not sufficiently processed during initial sample preparation.

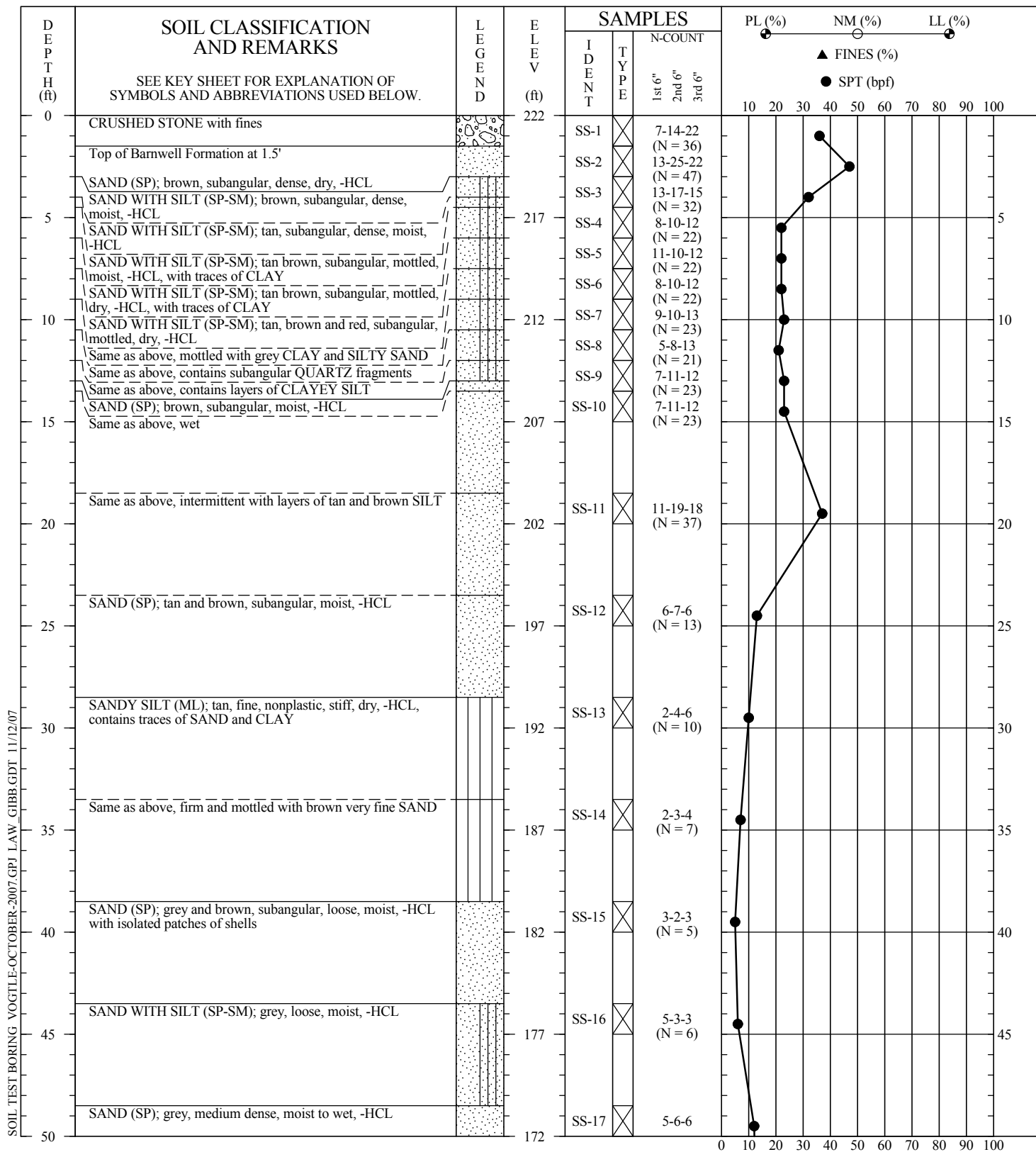
Boring Number	Depth Interval (feet)	Change	Basis for Change
B-1004	123.5 – 128.5	Revised classification from CLAYEY GRAVEL WITH SAND (GC) to CLAYEY SAND (SC); green to white, low to medium plasticity, loose, cemented shells and some shell fragments, 30% fines, +HCL.	This change was based upon visual/manual re-examination of the samples by MACTEC.
B-1004	134.0 – 145.5	Revised classification from CLAYEY GRAVEL WITH SAND (GC) to ELASTIC SILT WITH SAND (MH); green, nonplastic, hard, flaky, trace mica, some fine sand, cemented layers/nodules.	This change was based upon visual/manual re-examination of the samples by MACTEC and laboratory classification testing from samples SPT-34 and 35.
B-1004	145.5 – 163.5	Revised classification from SILTY SAND (SM), contains limestone fragments to FOSSILIFEROUS LIMESTONE; recovered mostly broken pieces of impure fossiliferous gray limestone (Marl), consisting of quartz sand, shell fragments, and some phosphatic material cemented in a carbonate matrix, some zones of SILTY SAND (SM).	This change was based upon visual/manual re-examination of the samples by MACTEC.
B-1004	163.5 – 173.5	Revised classification from CLAYEY GRAVEL WITH SAND (GC) to ELASTIC SILT (MH); green, low plasticity, hard, 15-20% fine quartz sand, cemented layers and shell hash, dry, +HCL.	This change was based upon visual/manual re-examination of the samples by MACTEC and laboratory classification testing from sample UD-3.
B-1004	177.0 – 183.5	Revised classification from SILTY SAND WITH GRAVEL (SM) to SILTY SAND (SM); green moist, cemented layers, +HCL.	This change was based upon visual/manual re-examination of the samples by MACTEC.
B-1004	183.5 – 198.5	Revised classification from SILTY SAND WITH GRAVEL (SM); green, very dense, homogeneous, trace CLAY, very fine sand, dry, +HCL to SILTY SAND (SM); green, very dense, homogeneous, very fine sand, some quartz, cemented layers, some sand-sized cemented carbonate observed with 20X hand lens. Added layer of LEAN CLAY WITH SAND (CL) from 188.5 to 189.5.	These changes were based upon re-examination of the samples by MACTEC and laboratory classification testing from sample UD-5.
B-1004	198.5 – 203.5	Added green, very dense, very fine sand, dry, +HCL.	This change was based upon visual/manual re-examination of the samples by MACTEC.

Boring Number	Depth Interval (feet)	Change	Basis for Change
B-1004	203.5 – 208.5	Revised classification from Same as above, gap graded, with black cemented fragments, +HCL to FOSSILIFEROUS LIMESTONE; recovered mostly limestone fragments consisting of sand and shells in a carbonate matrix.	This change was based upon visual/manual re-examination of the samples by MACTEC.
B-1004	213.5 – 223.5	Revised classification from SILTY SAND (SM) to CLAYEY SAND (SC).	This change is based upon laboratory classification testing from sample SPT-44.
B-1005	153.5 – 157.0	Revised classification from SILTY CLAYEY SAND (SC-SM) to SANDY SILT (ML); tan and white, dense, fine to medium grained, >20% shells, contains broken cemented shell hash/coquina, +HCL.	This change is based upon visual/manual re-examination of the samples by MACTEC.
B-1005	157.0 – 164.3	Revised classification from SILTY SAND (SP-SM) to SILTY SAND (SM)	This change is based upon re-examination by MACTEC of the original rig engineer's log for this boring.
B-1006	108.5 – 118.5	Revised classification from SILTY SAND WITH GRAVEL (SM) to SILTY SAND (SM); tan and white, dense, contains appreciable cemented shells, fine grained, wet, +HCL.	This change is based upon visual/manual re-examination of the samples by MACTEC.
B-1008	78.5 – 93.5	Changed CLAYEY SAND (SC); light brown and tan with gravel composed of cemented shells to CLAYEY SAND (SC); light brown and tan with cemented shells.	This change was based upon visual manual re-examination of the samples by MACTEC.
B-1008	93.5 – 124.5	Revised classification from SANDY CLAYEY SILT (SC-SM) to SANDY CLAYEY SILT (ML).	This change was based upon visual/manual re-examination of the samples by MACTEC.
B-1010	97 – 100	Revised classification from CLAYEY SAND (SC) to ELASTIC SILT (MH)	This change was based upon visual/manual re-examination of the samples and laboratory classification testing for sample SPT-27.
B-1011	12.0 – 13.5	Changed with gravel to with cemented shell hash.	This change was based upon visual/manual re-examination of the samples by MACTEC.

**REVISIONS TO LOCATION OF UTLEY LIMESTONE:**

<b>Boring Number</b>	<b>Original Depth of top of Utley Limestone (feet)</b>	<b>New Depth of top of Utley Limestone (feet)</b>
B-1001	58.5	88.5
B-1003	48.0	80.5
B-1004	63.5	123.5
B-1005	53.5	153.5
B-1006	Not Present	108.5
B-1007	70.0	Not Present
B-1008	63.5	77.0
B-1011	13.5	68.5

Note: Revisions to the depth/elevation of the Utley Limestone in the borings were made based on the criteria used to identify the Utley Limestone for the COL Geotechnical Borings, and based on re-examination of the samples by MACTEC.



DRILLER: Jimmy Oglesby (MACTEC)  
EQUIPMENT: CME-75 (Auto-Hammer)  
METHOD: Rotary Wash with Mud  
HOLE DIA.: 4 inches  
REMARKS: Plant Grid: N 7661.92, E 6220.42  
+HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 221.64  
ELEVATION DATUM = NAVD 88

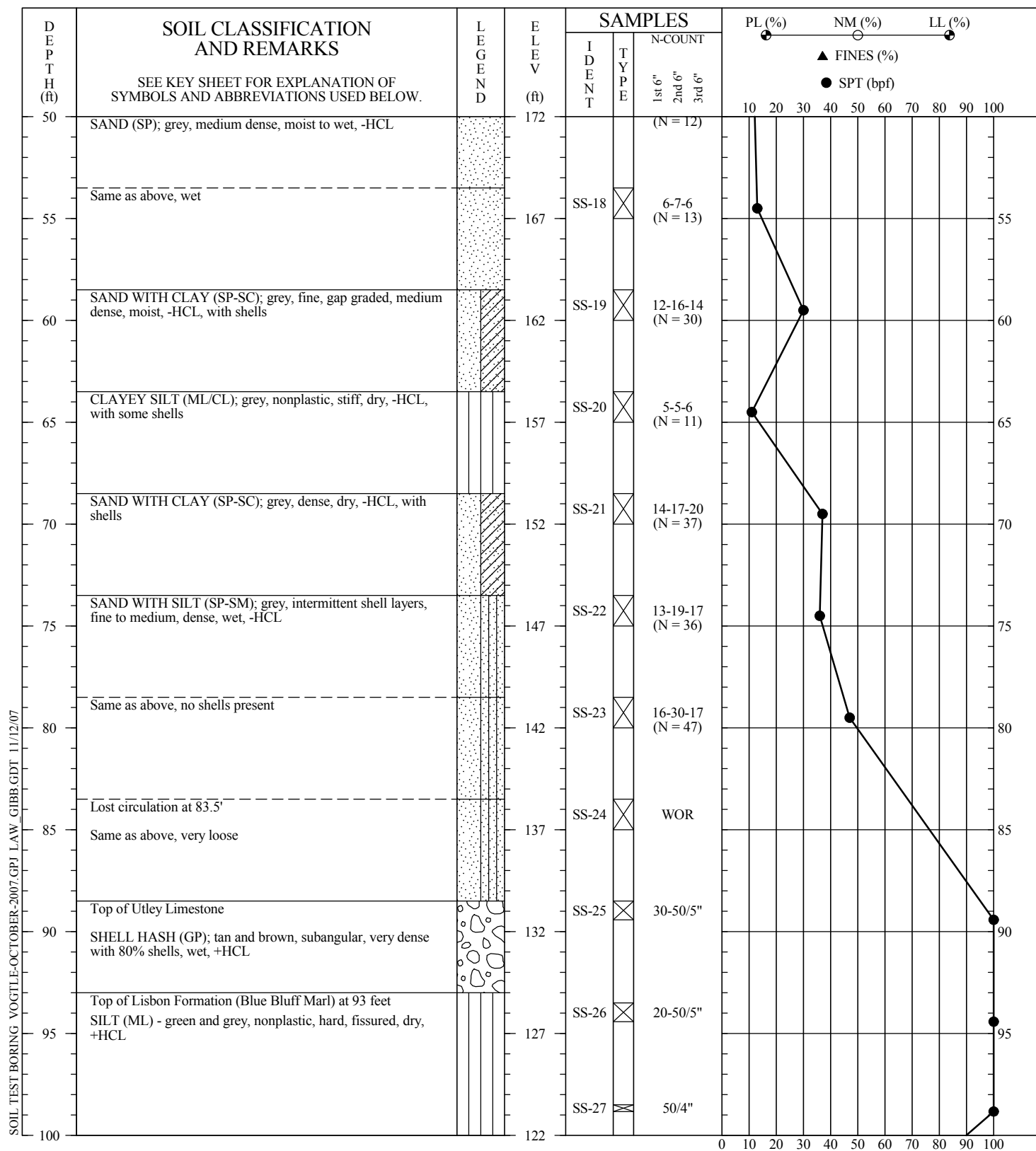
THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

## SOIL TEST BORING RECORD

**BORING NO.:** B-1001  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** August 30, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 1 OF 3





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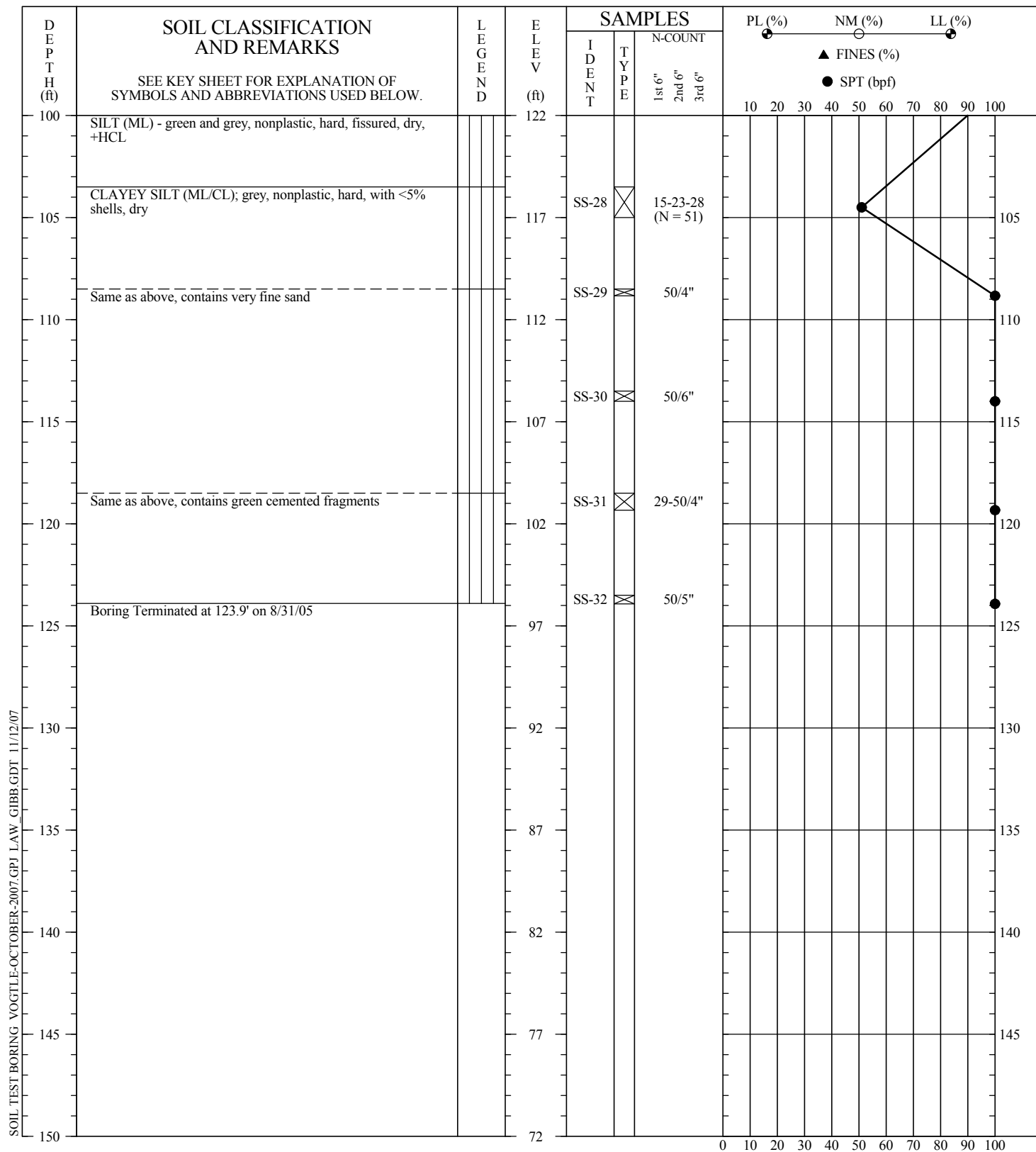
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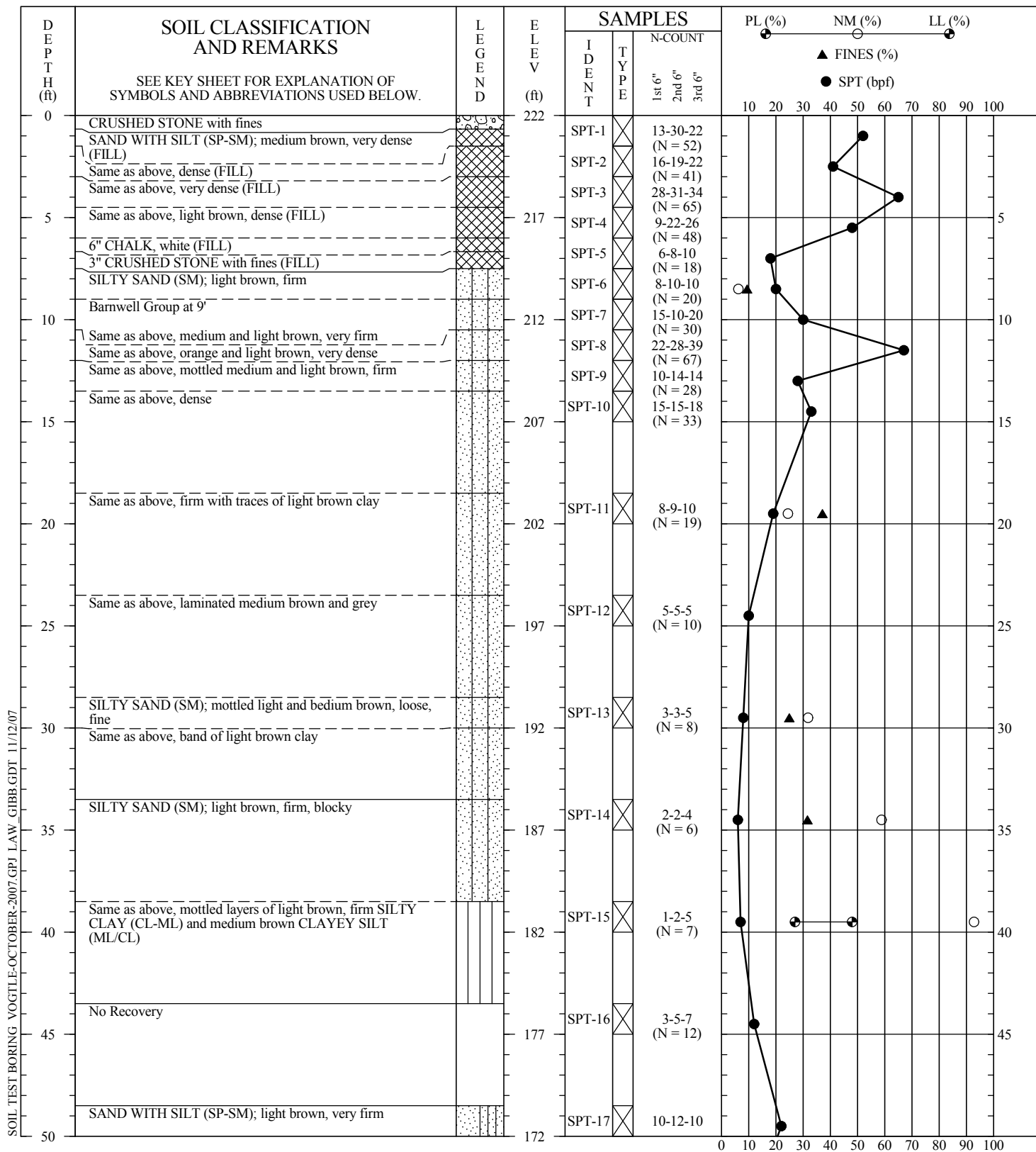
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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7998.52, E 6985.47 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/15/05  
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### SOIL TEST BORING RECORD

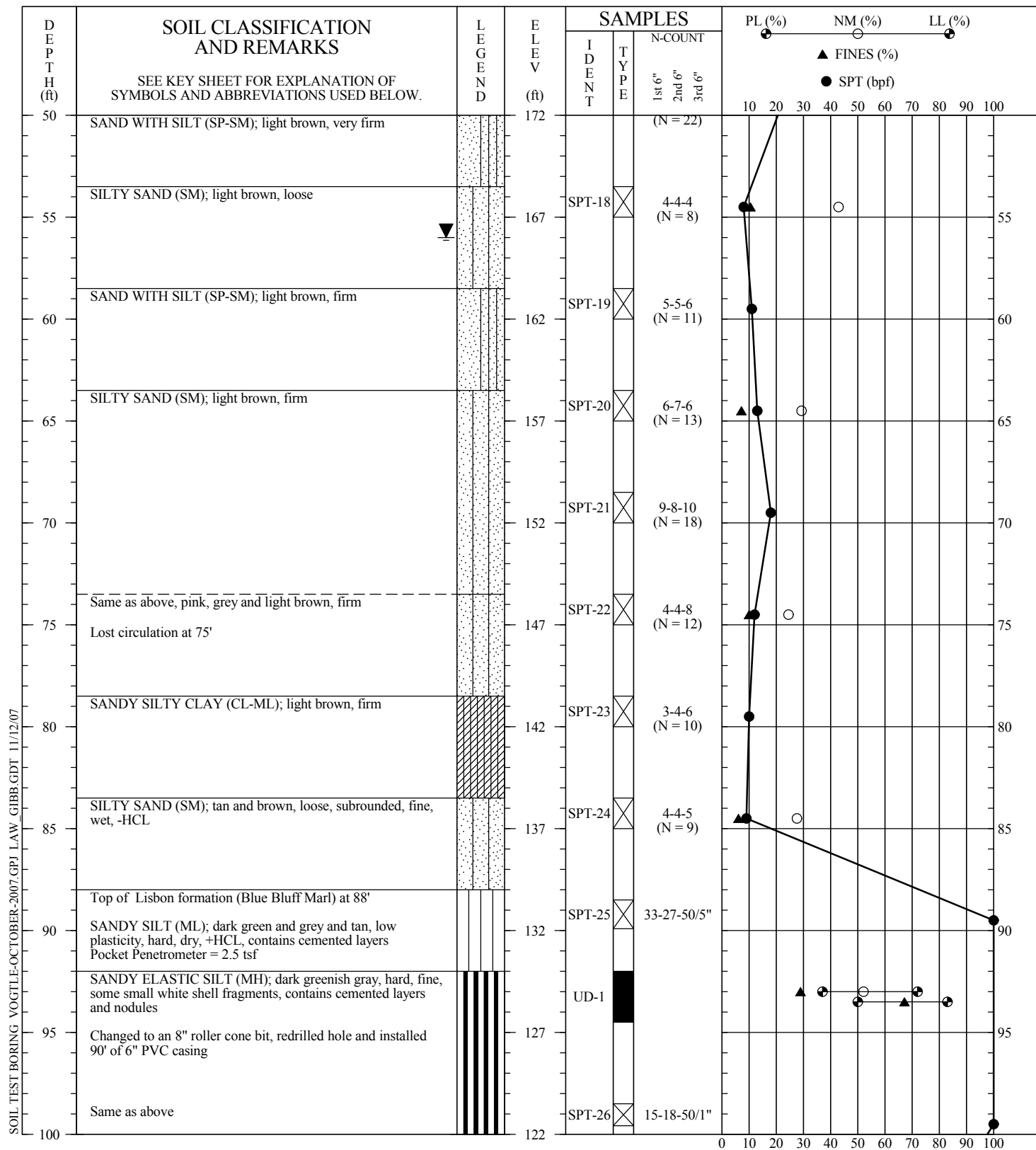
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**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
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PAGE 1 OF 6



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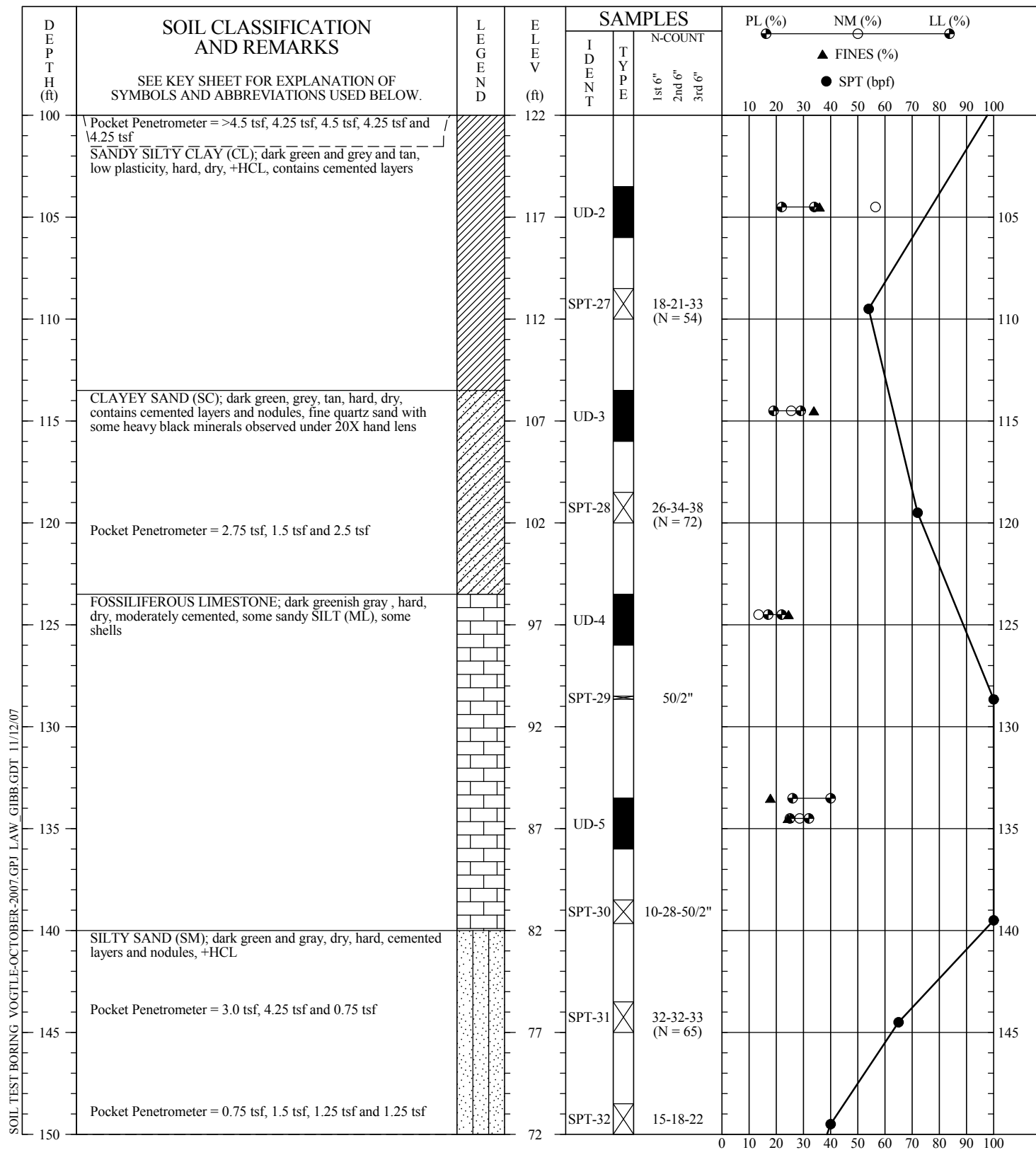
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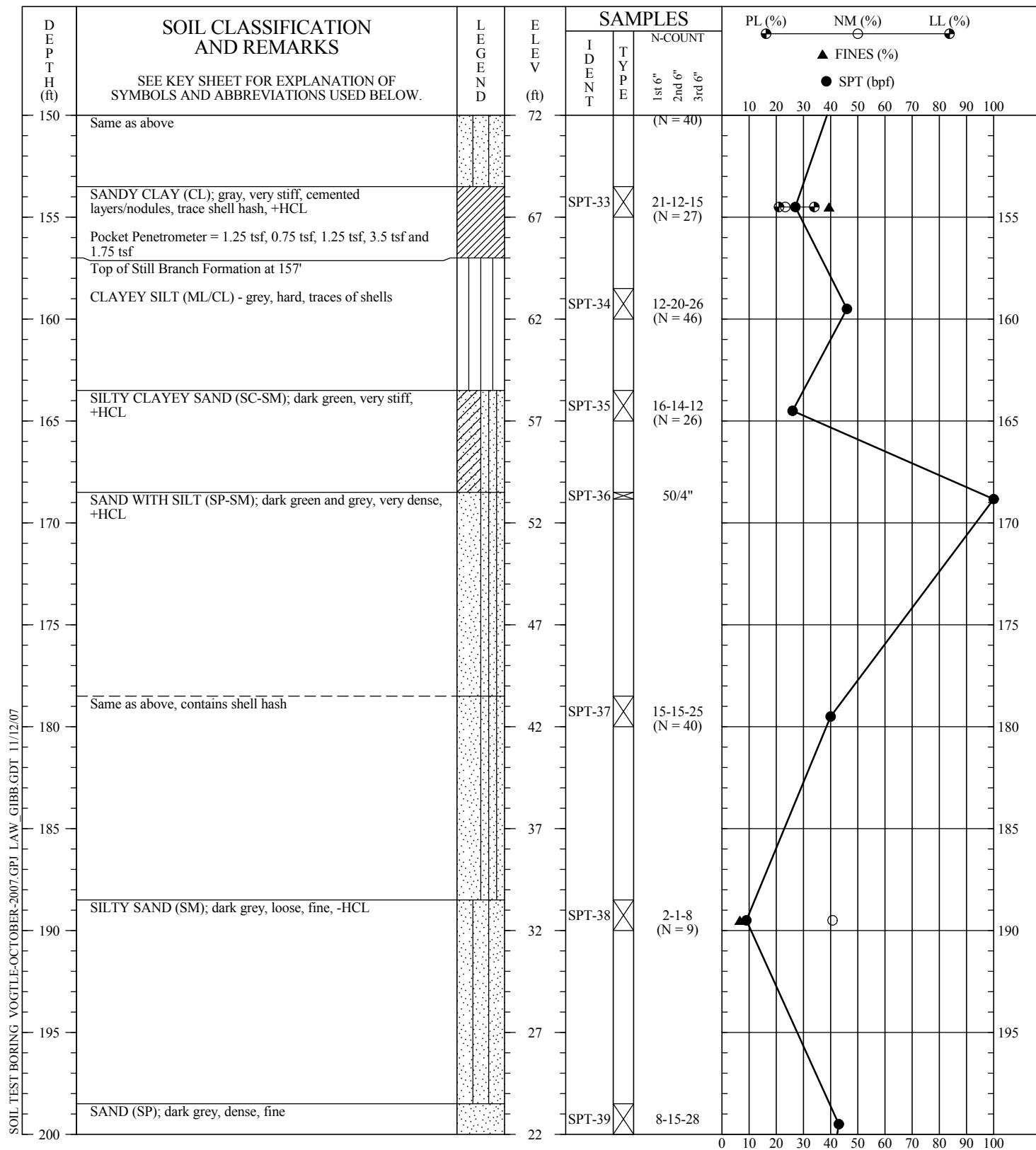
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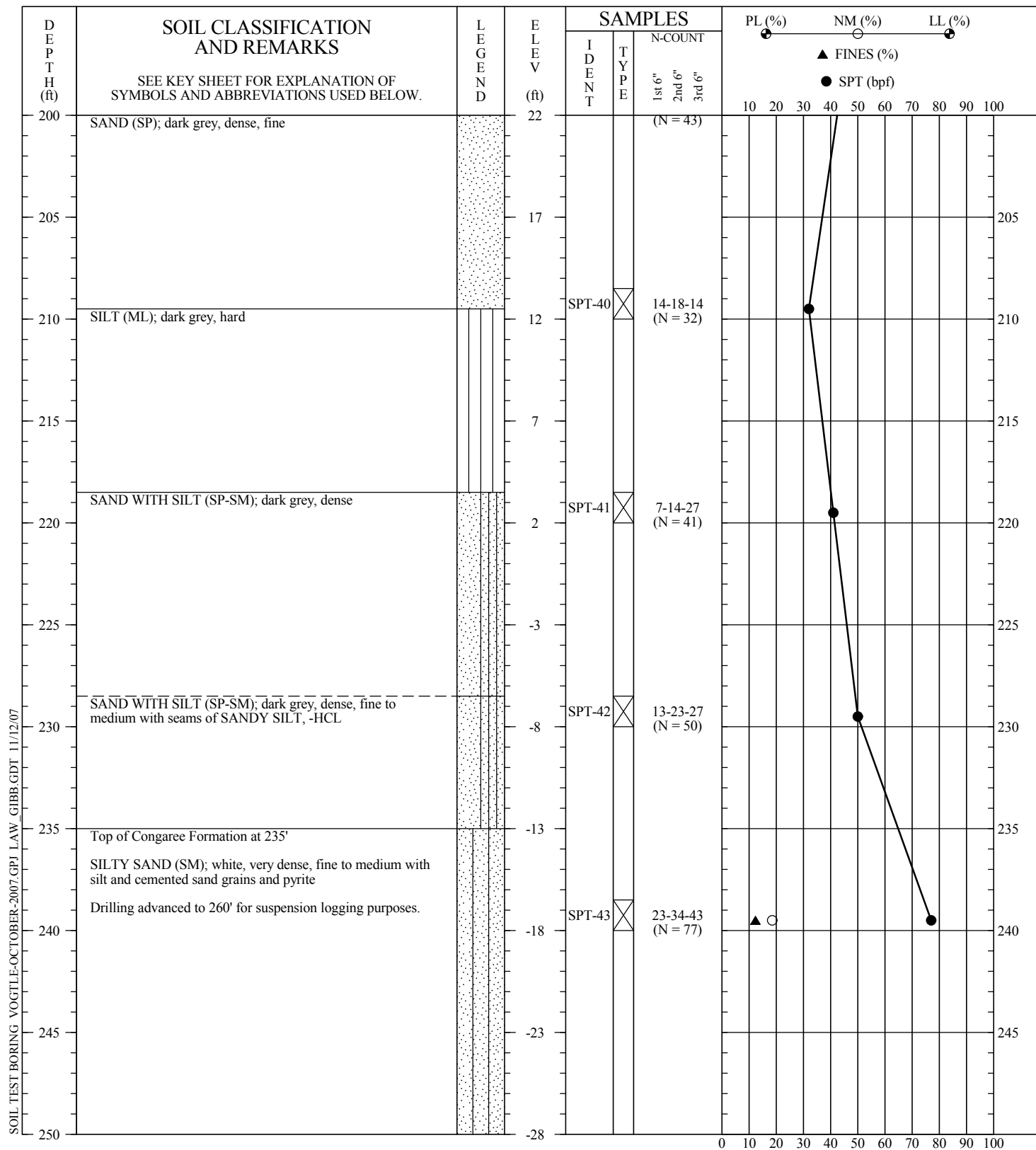
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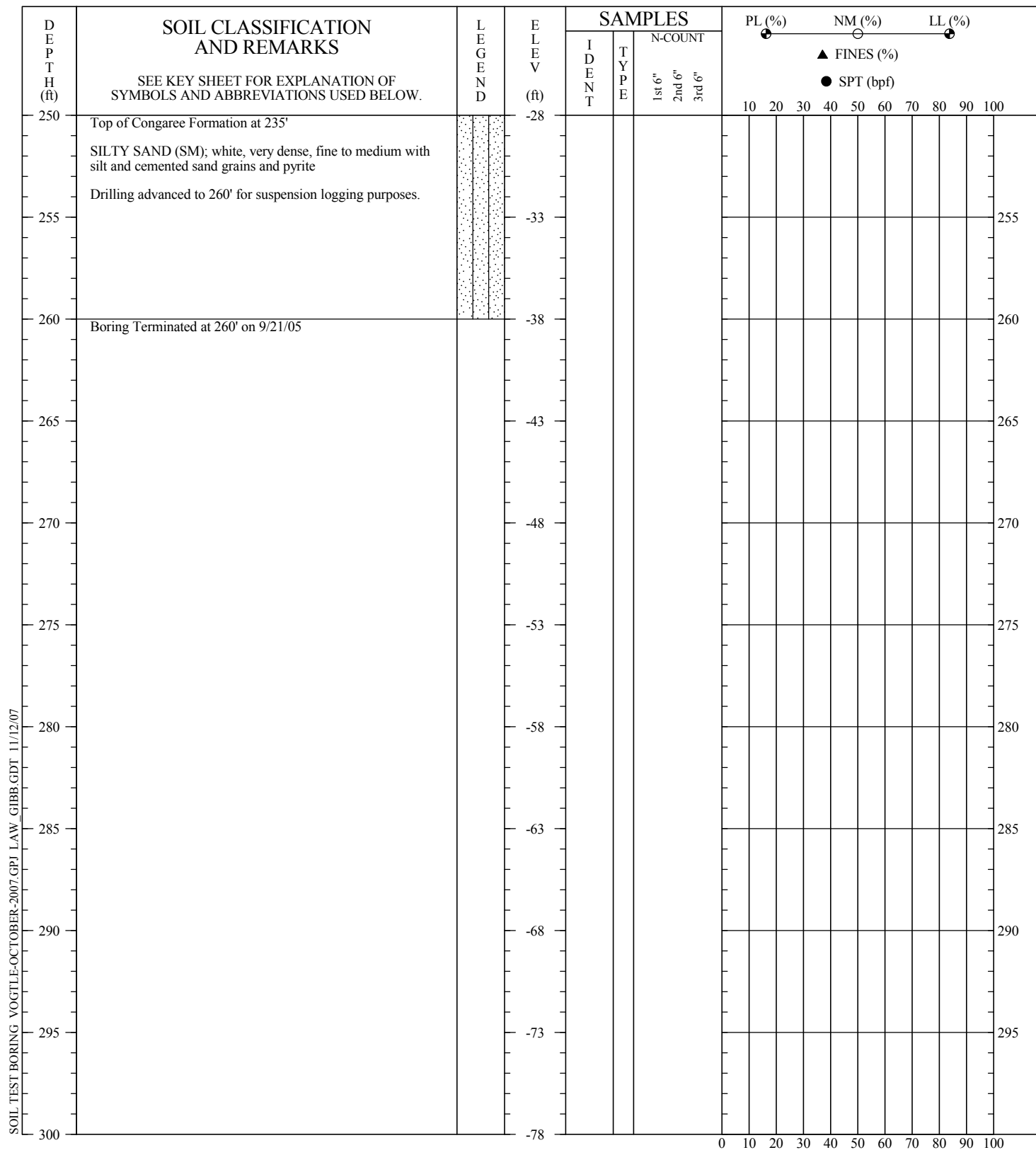
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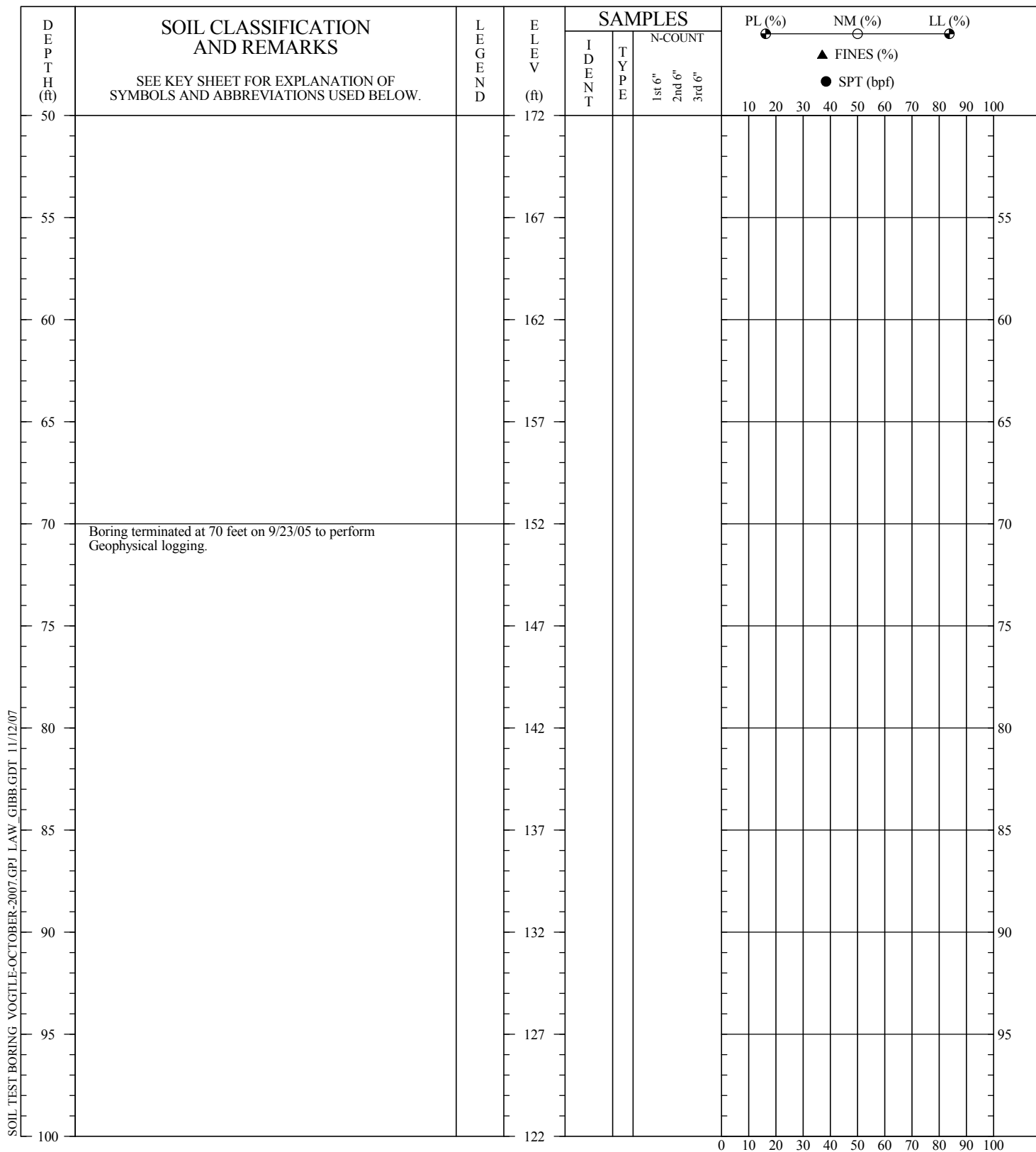
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 ELEVATION (ft) = 221.98  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

SOIL TEST BORING RECORD	
<b>BORING NO.:</b>	B-1002
<b>PROJECT:</b>	ALWR - ESP
<b>LOCATION:</b>	PLANT VOGTLE, BURKE COUNTY, GA
<b>DRILLED:</b>	September 14, 2005
<b>PROJECT NO.:</b>	6141-05-0227
<b>PAGE 6 OF 6</b>	

[illegible]

DRILLER:	Robert Banks (MACTEC)
EQUIPMENT:	CME-55 (Auto-Hammer)
METHOD:	Rotary Wash with Mud
HOLE DIA.:	6 inches
REMARKS:	Plant Grid: N 7985.62, E 6986.07 Water depth represents depth of water and mud as measured on 10/5/05. Hole caved to 56 feet 10/5/05.



DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7985.62, E 6986.07  
 Water depth represents depth of water and mud as measured on 10/5/05. Hole caved to 56 feet 10/5/05.

ELEVATION (ft) = 222.27  
 ELEVATION DATUM = NAVD 88

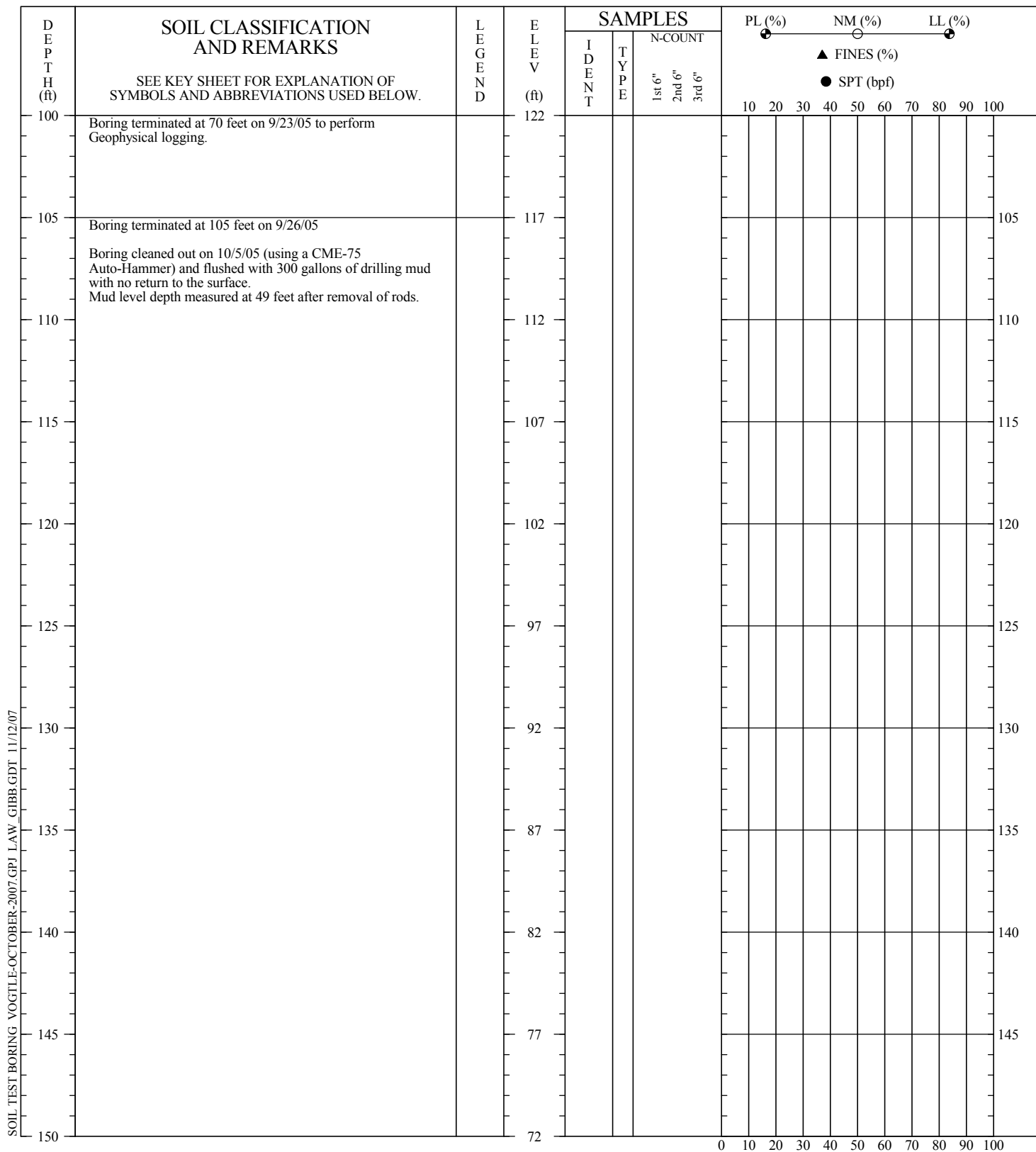
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### SOIL TEST BORING RECORD

**BORING NO.:** B-1002A  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 23, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 2 OF 3





DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7985.62, E 6986.07  
 Water depth represents depth of water and mud as measured on 10/5/05. Hole caved to 56 feet 10/5/05.

ELEVATION (ft) = 222.27  
 ELEVATION DATUM = NAVD 88

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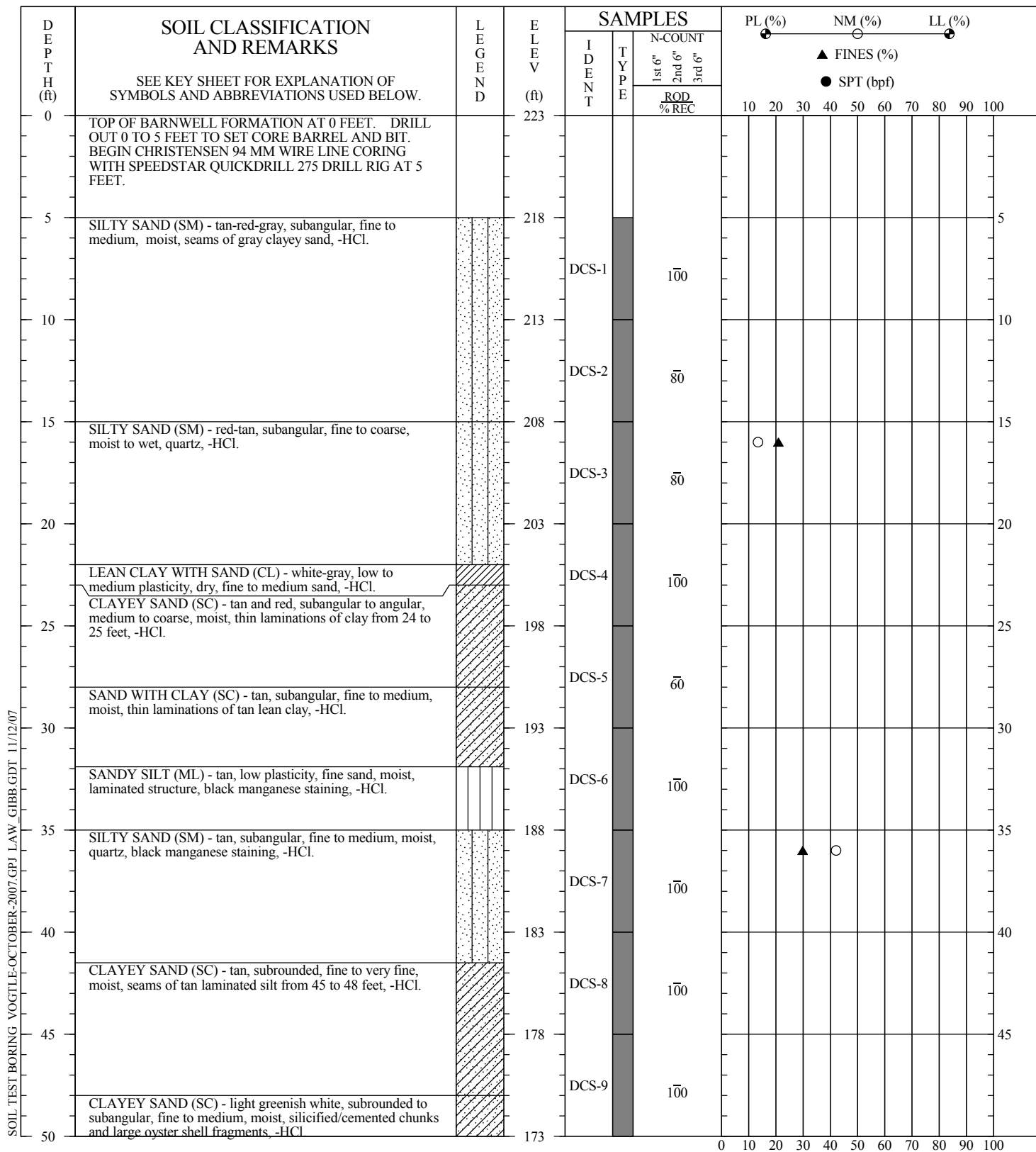
### SOIL TEST BORING RECORD

**BORING NO.:** B-1002A  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 23, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 223.21  
 ELEVATION DATUM = NAVD 88

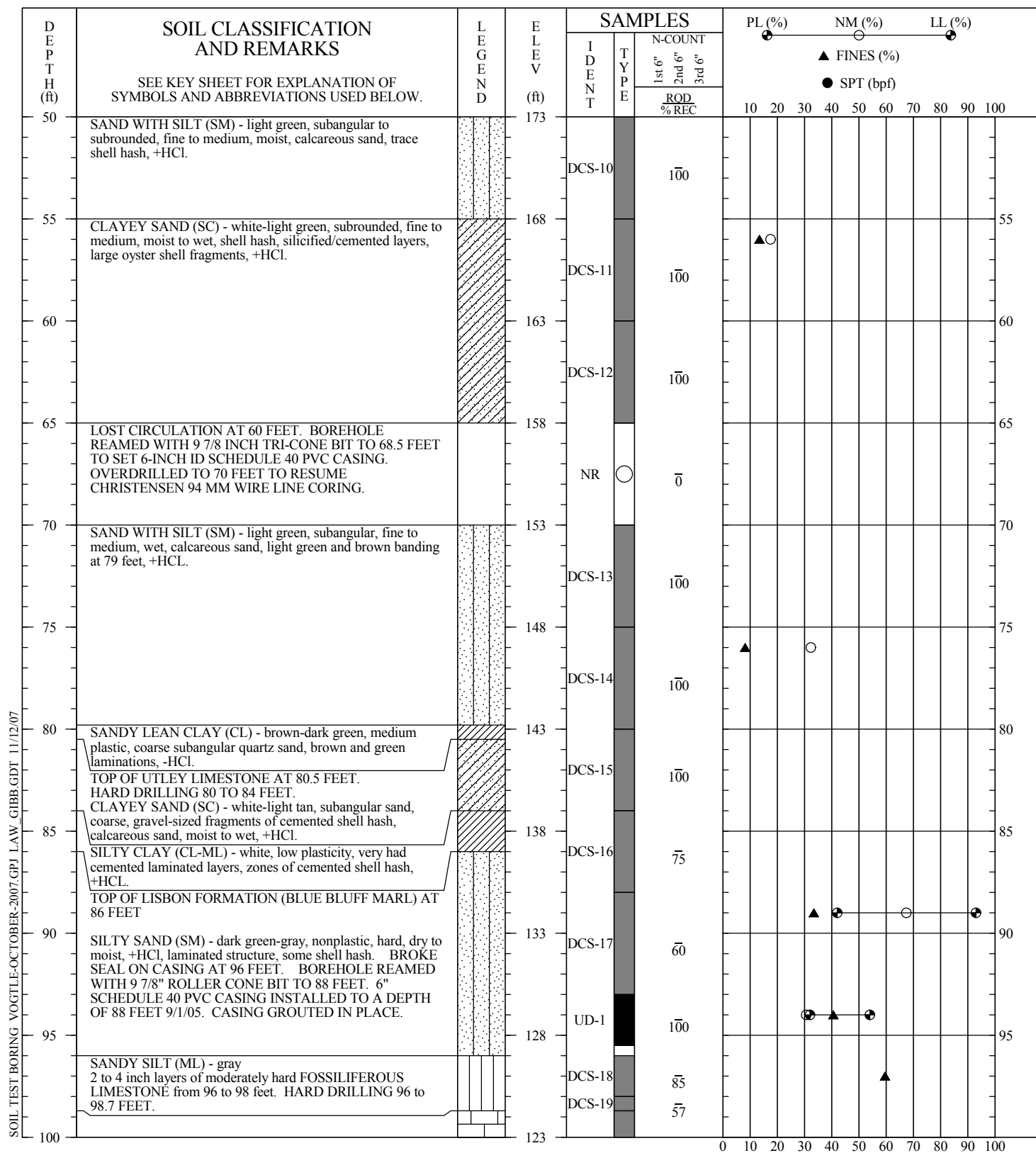
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
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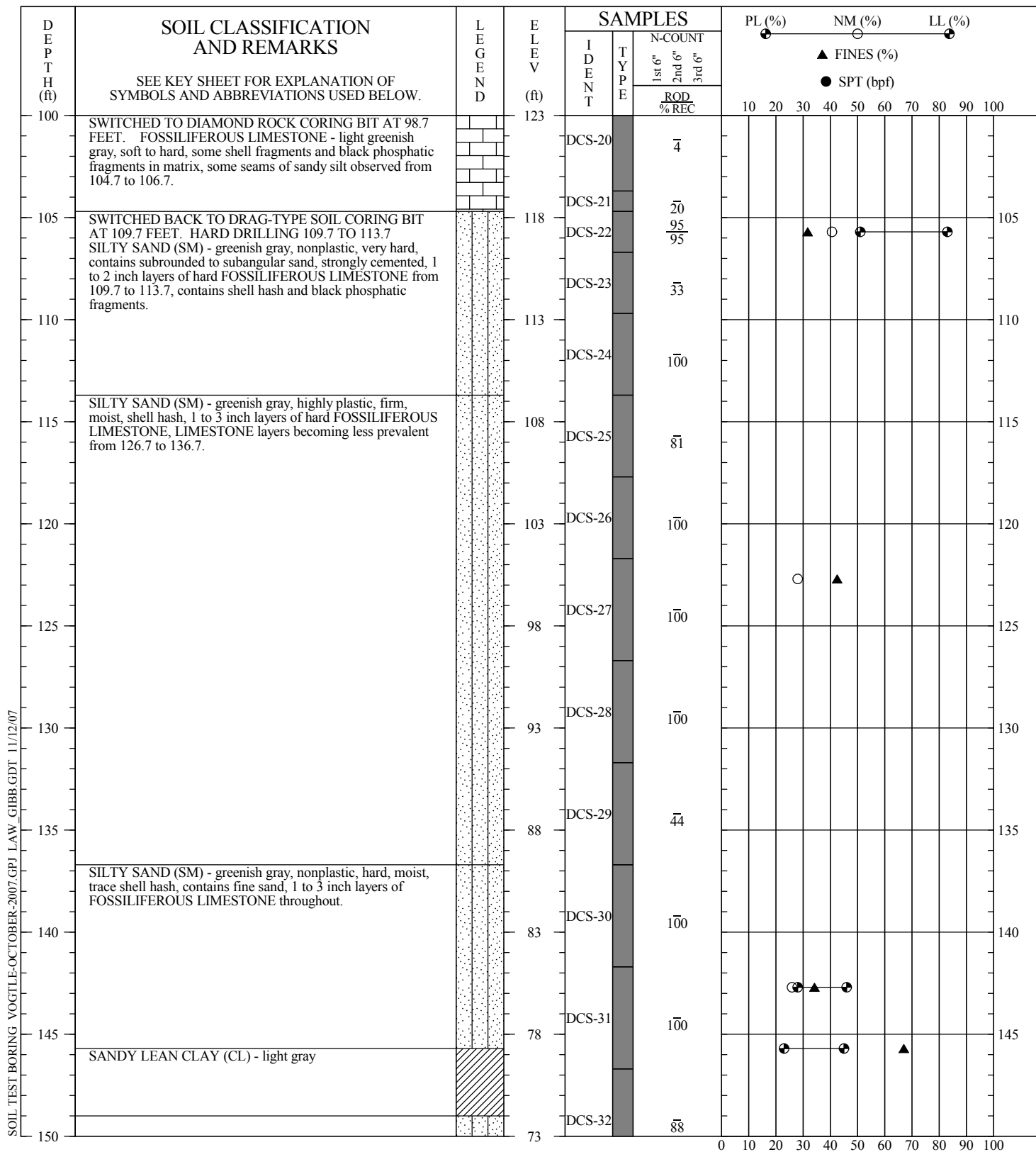
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**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
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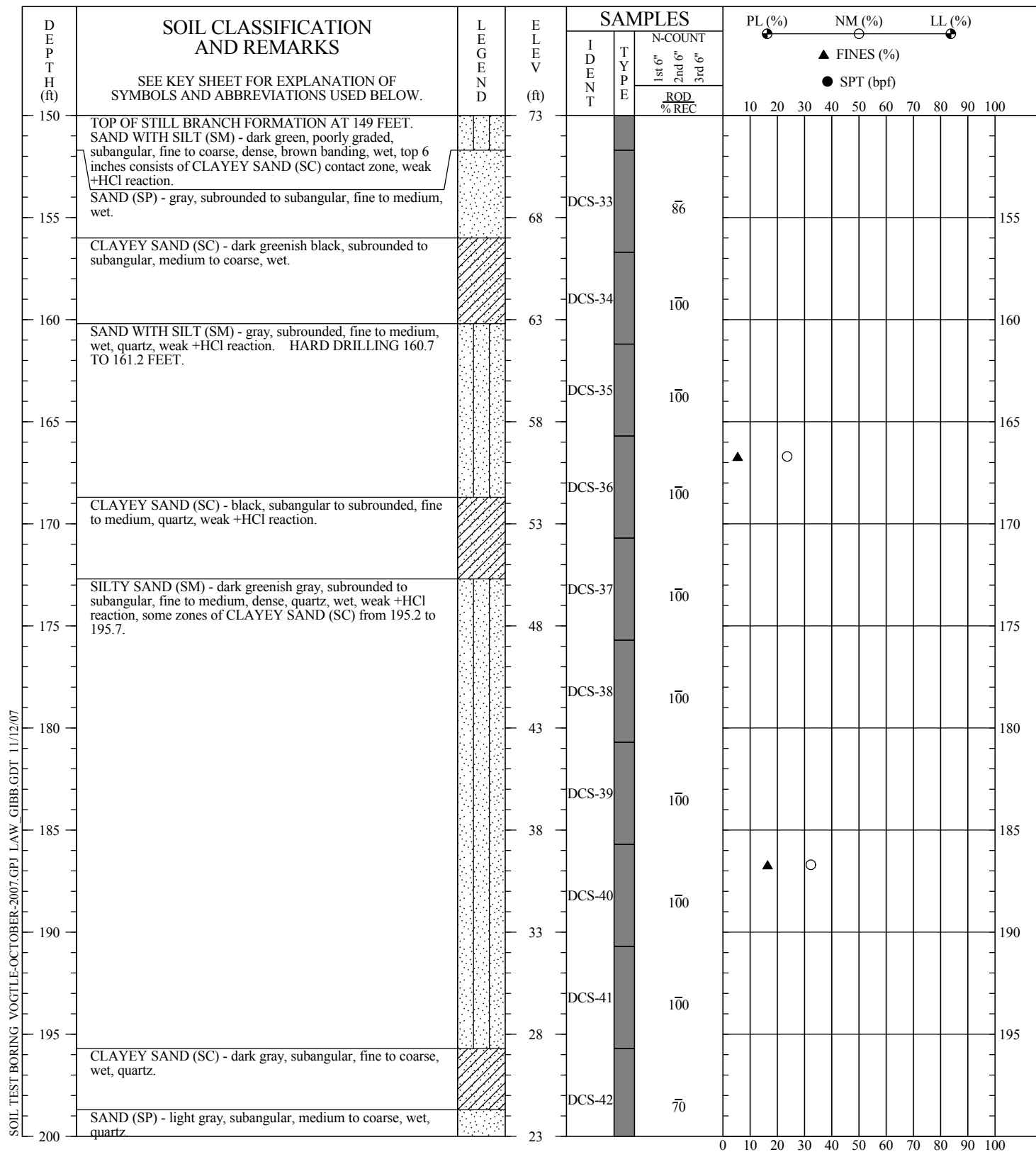
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
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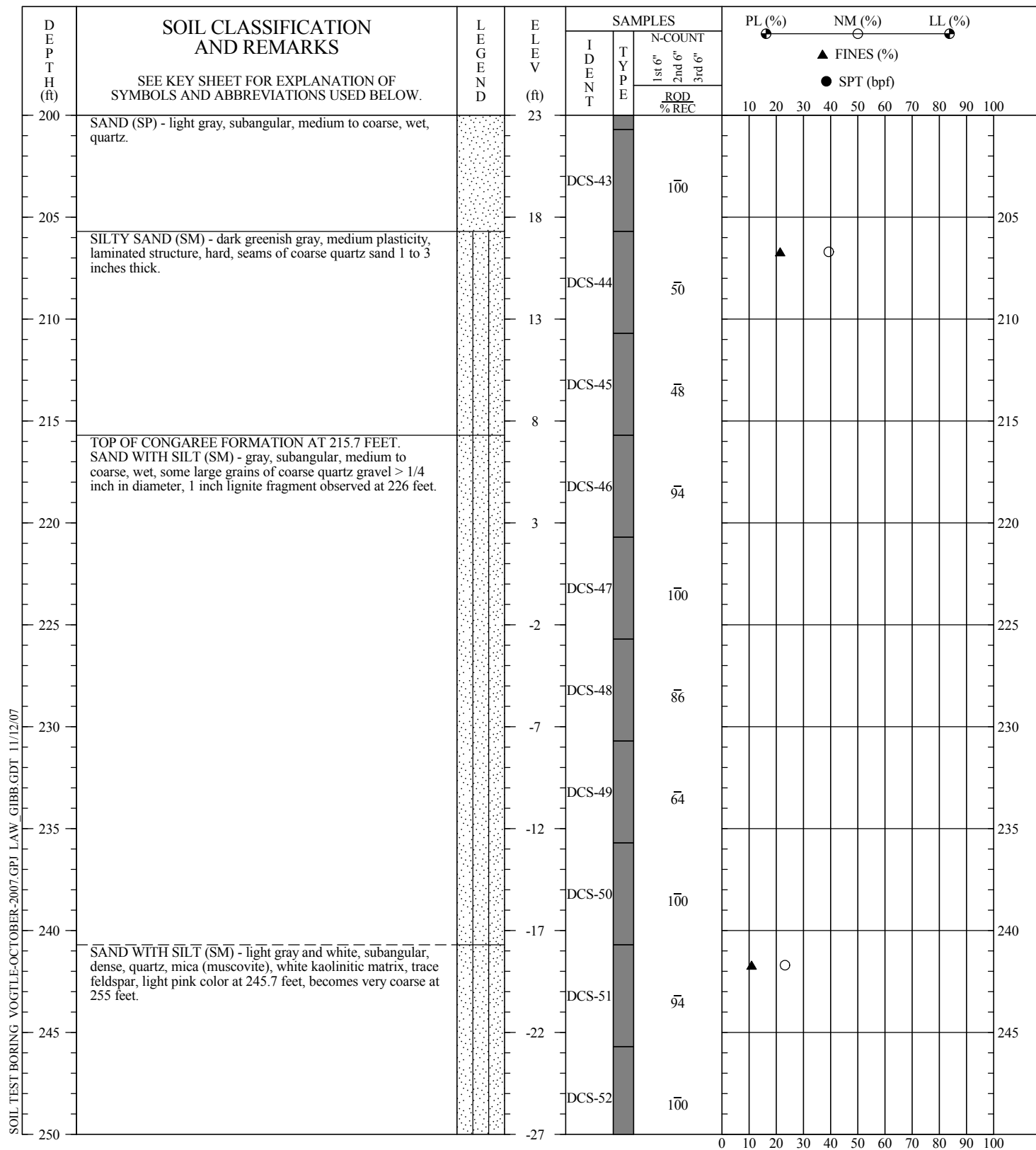
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
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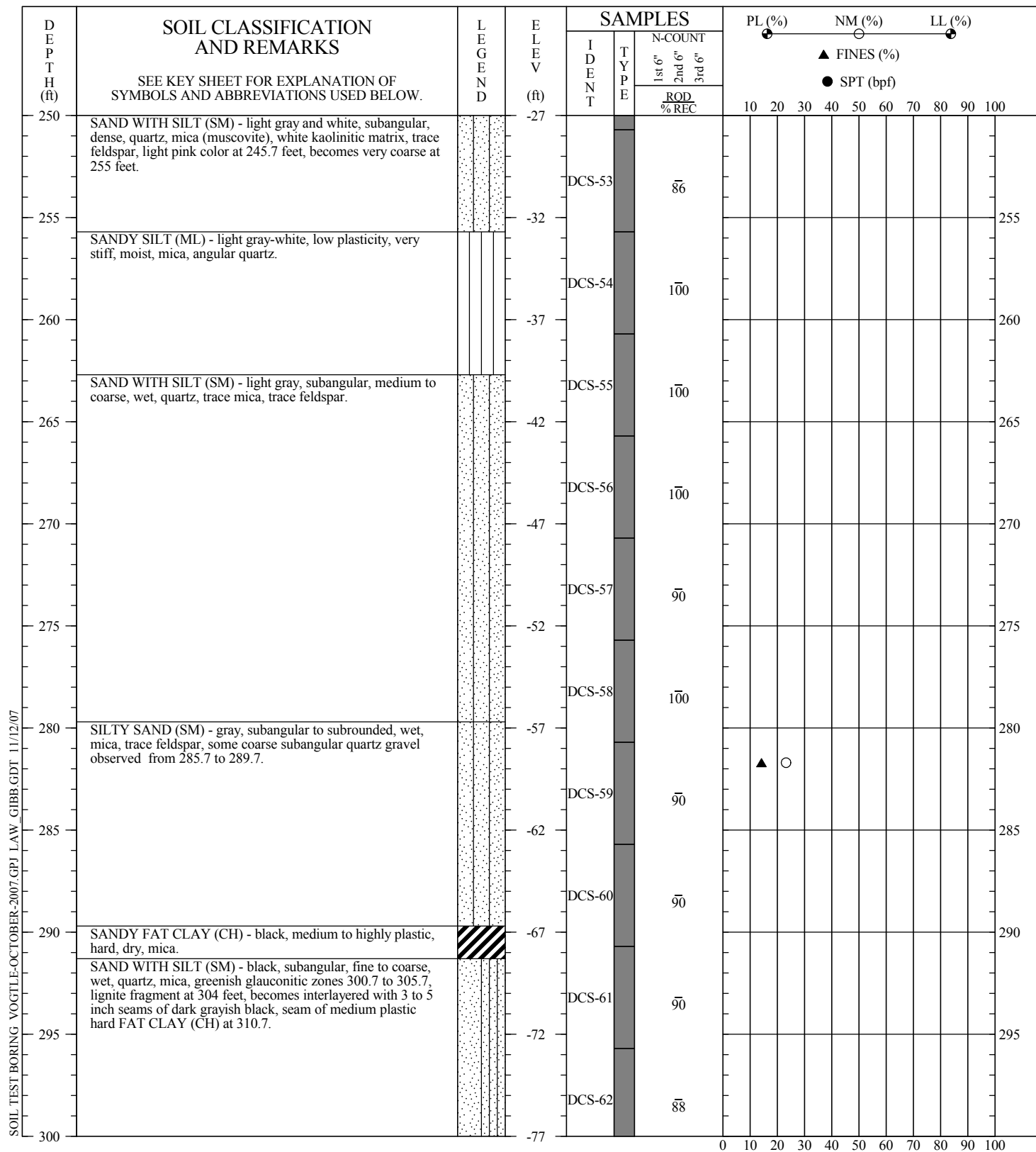
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
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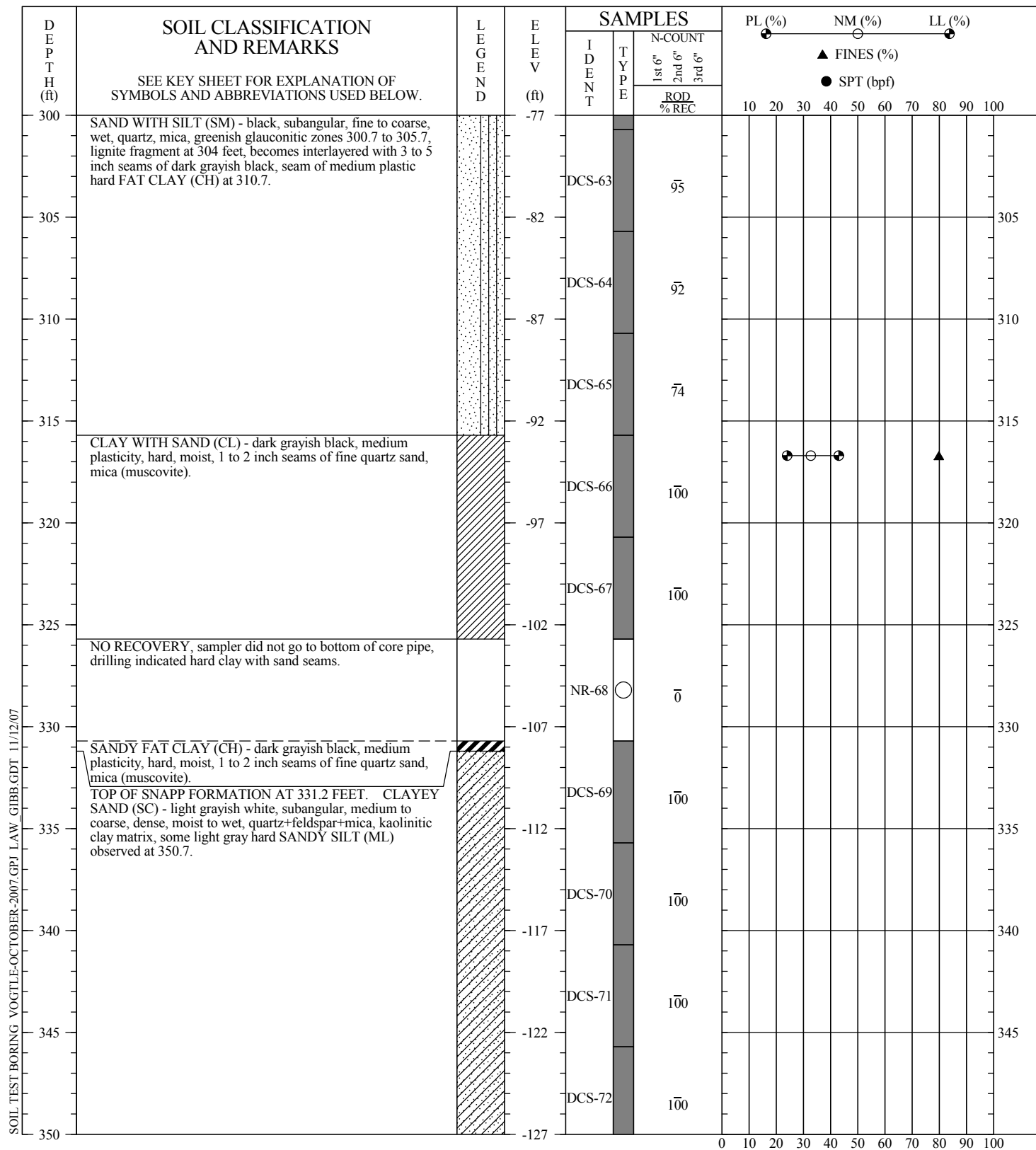
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
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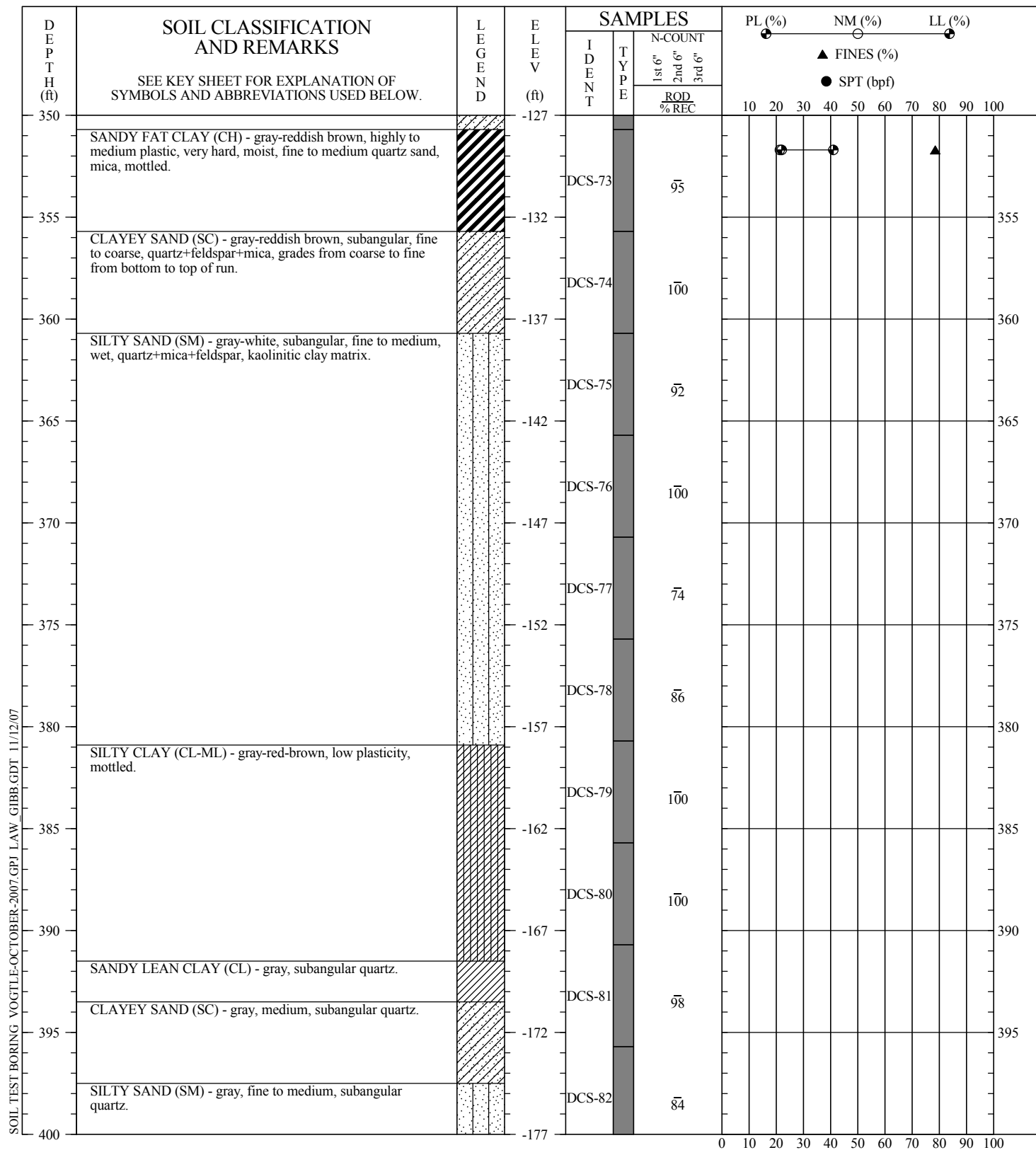
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
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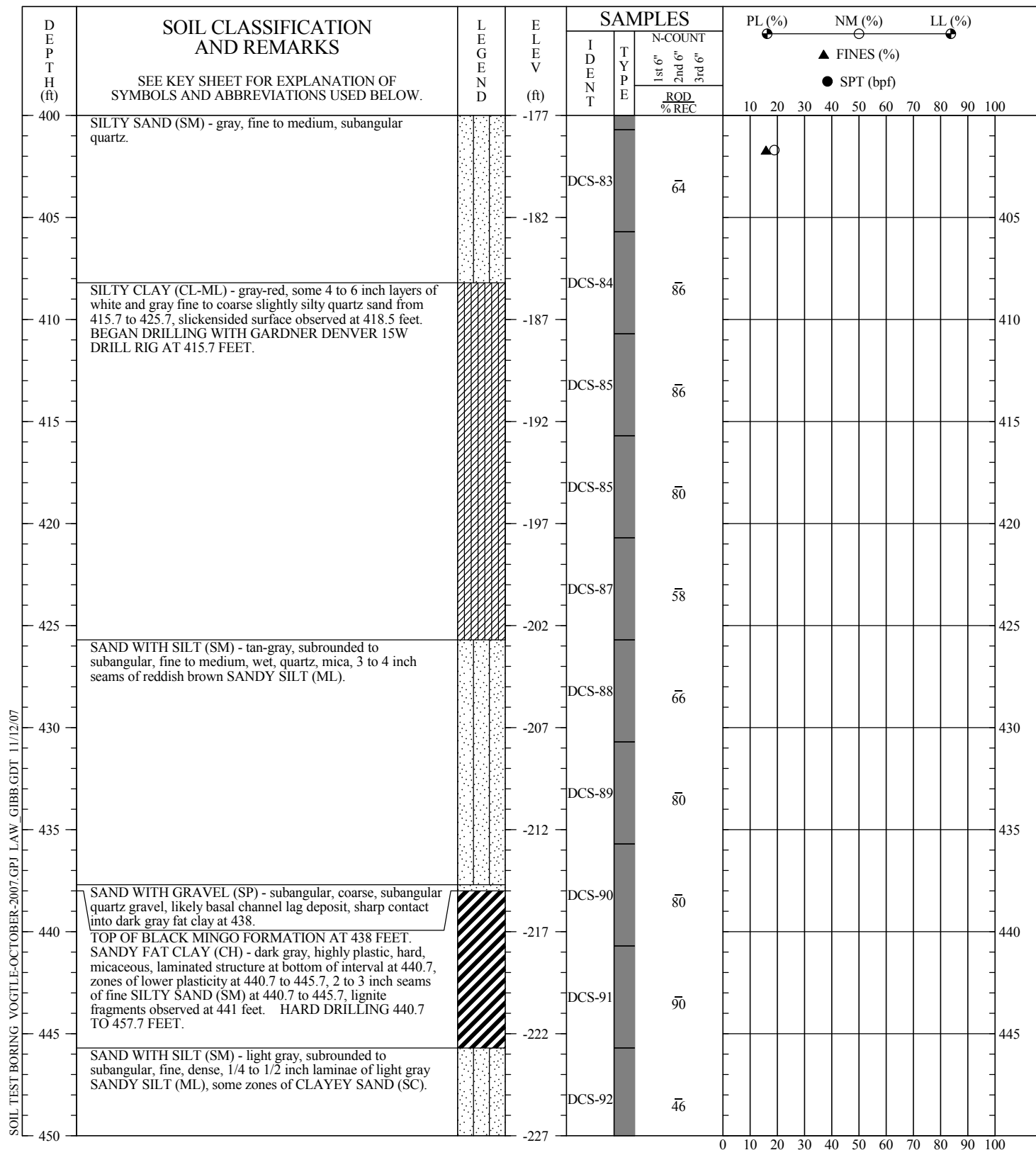
## SOIL TEST BORING RECORD

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**PROJECT:** ALWR - ESP  
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**DRILLED:** September 1, 2005  
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
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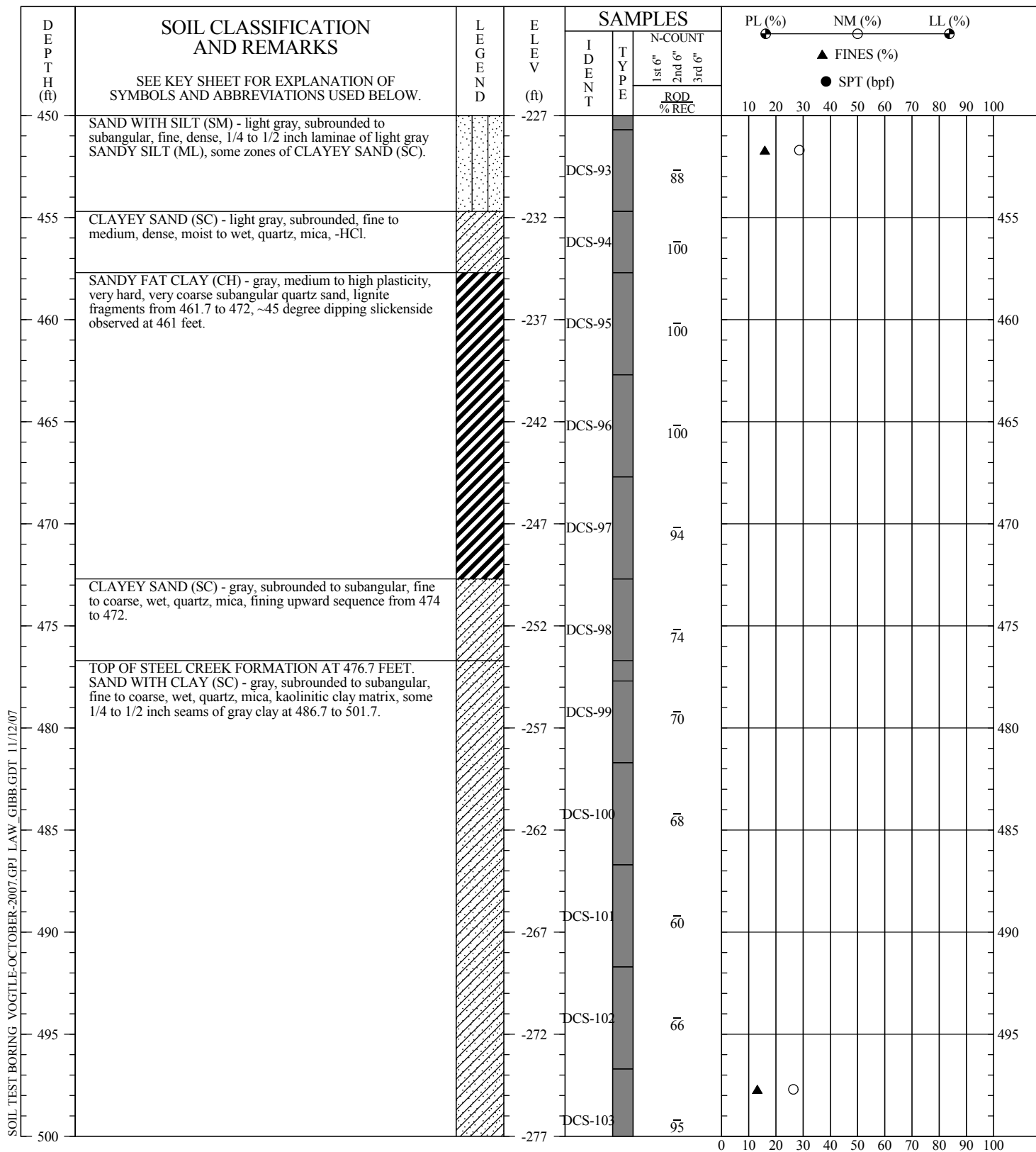
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
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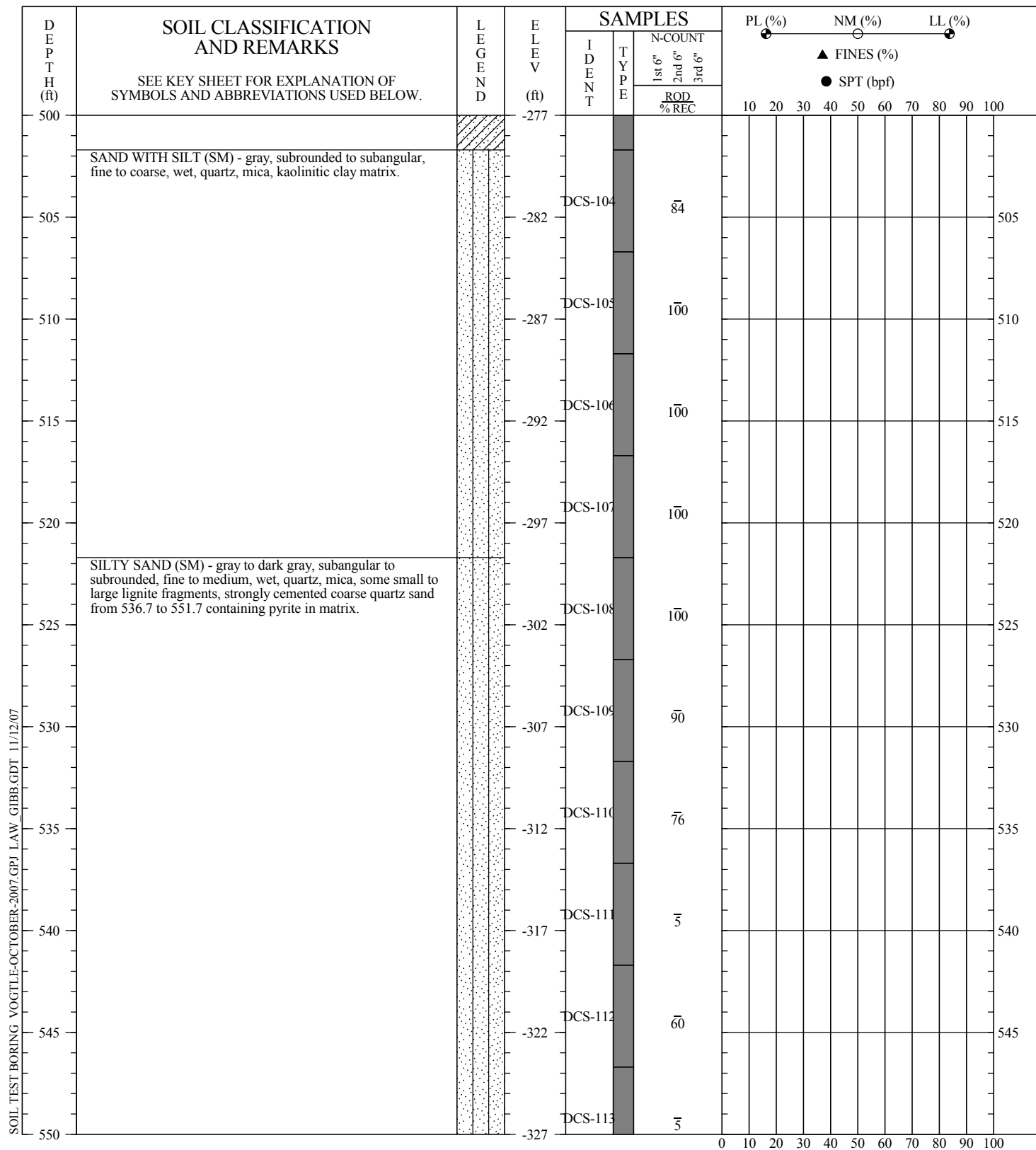
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
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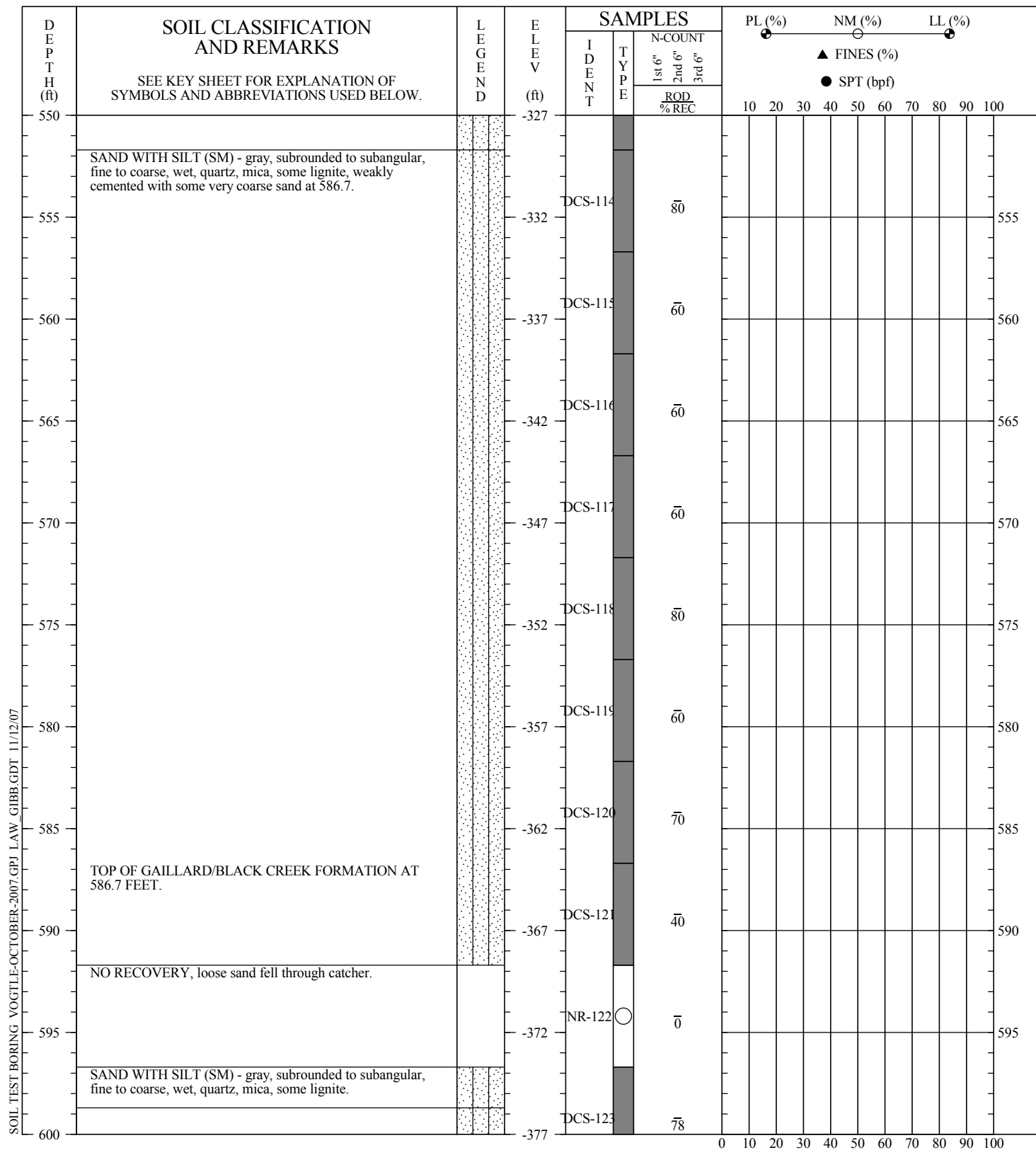
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**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
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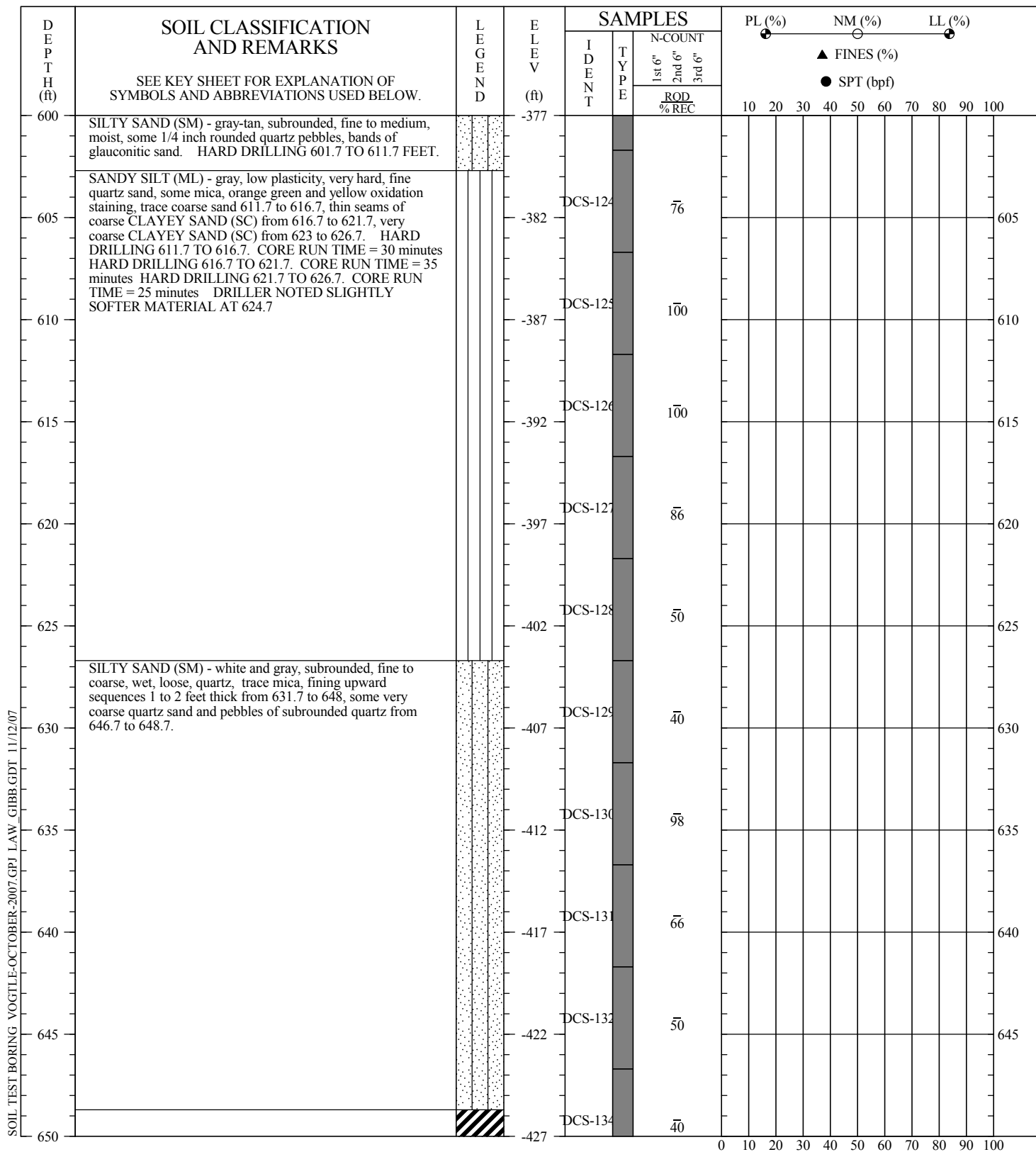
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## SOIL TEST BORING RECORD

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**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
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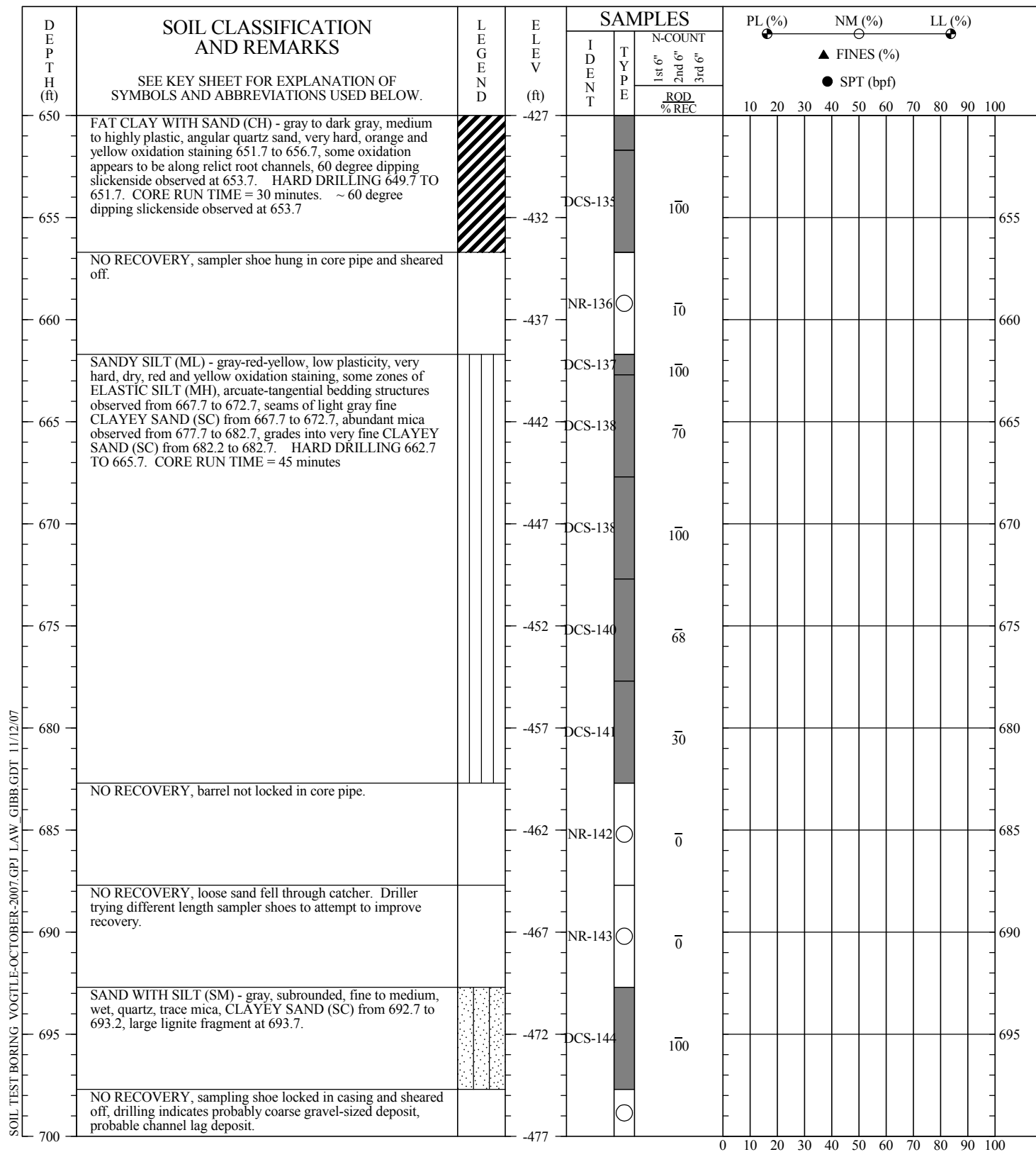
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### SOIL TEST BORING RECORD

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**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
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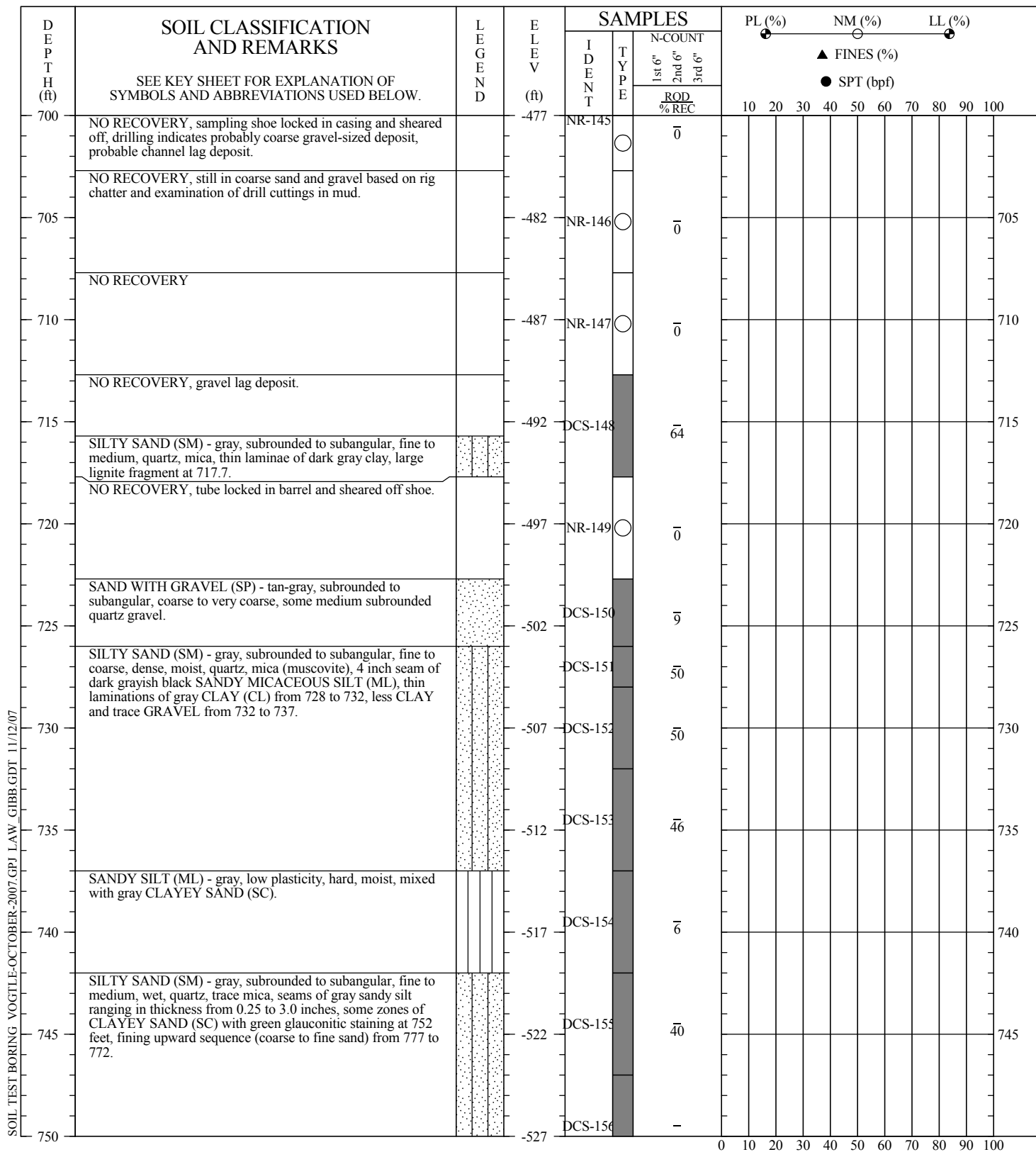
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**PROJECT:** ALWR - ESP  
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
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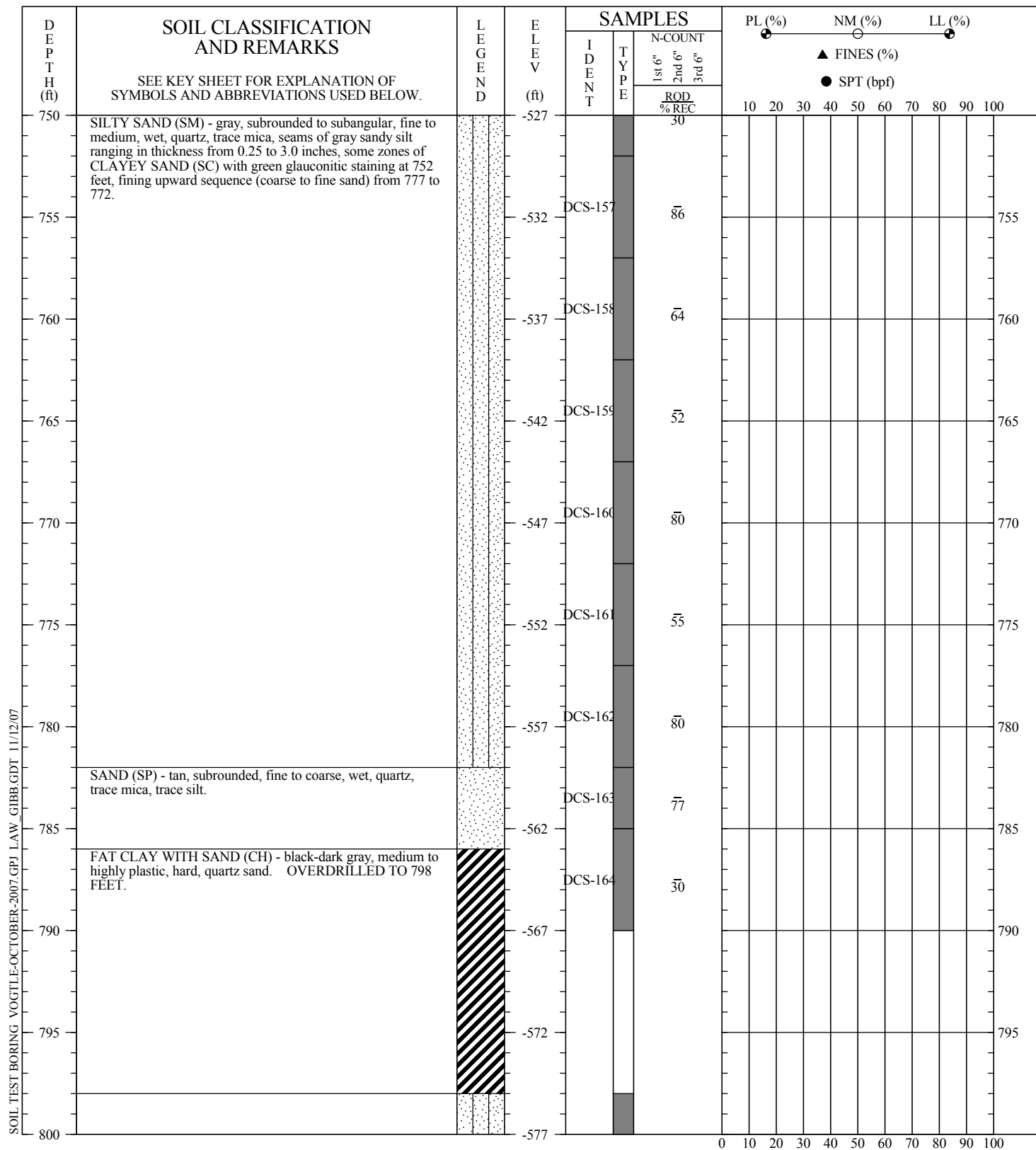
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
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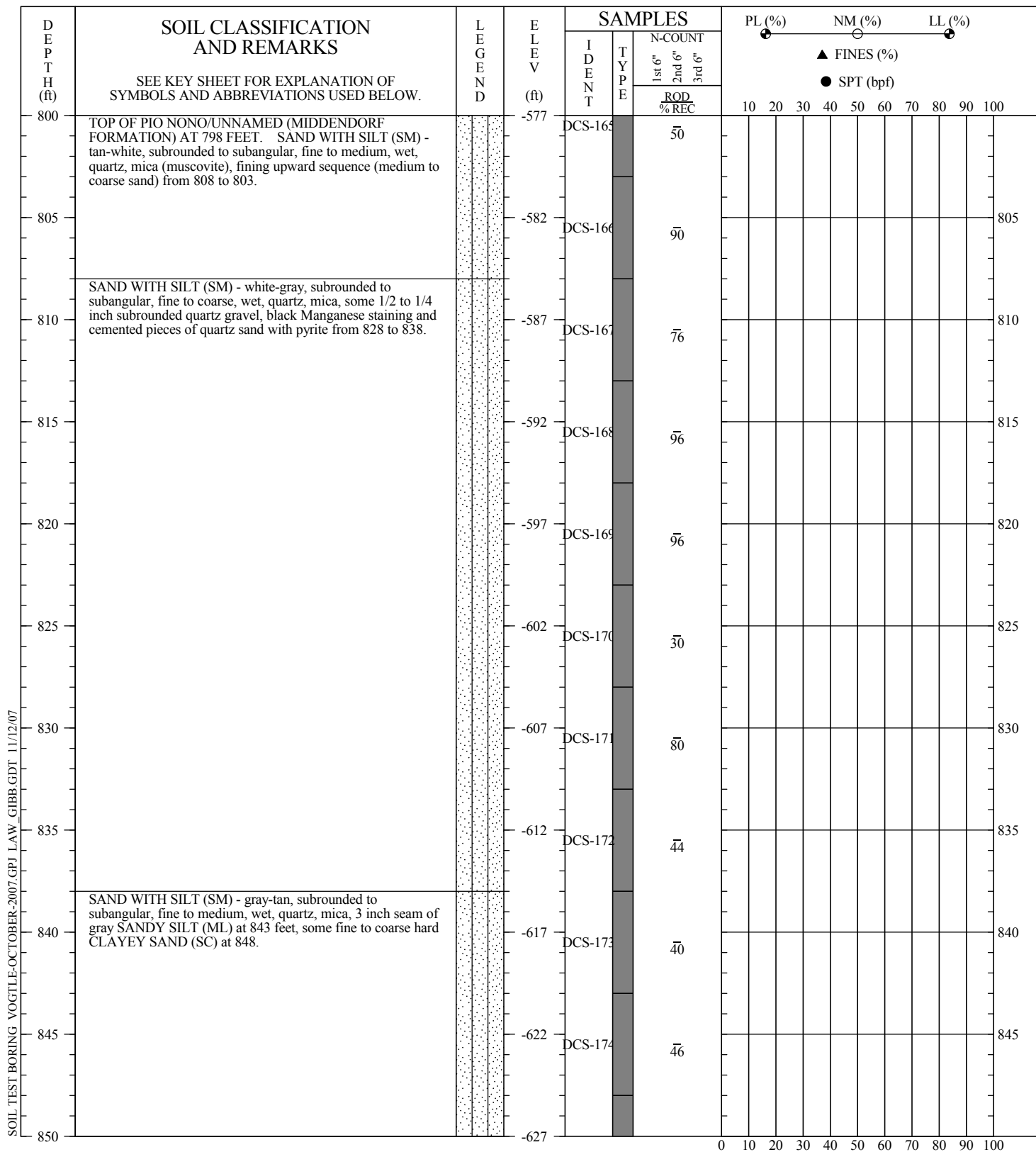
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
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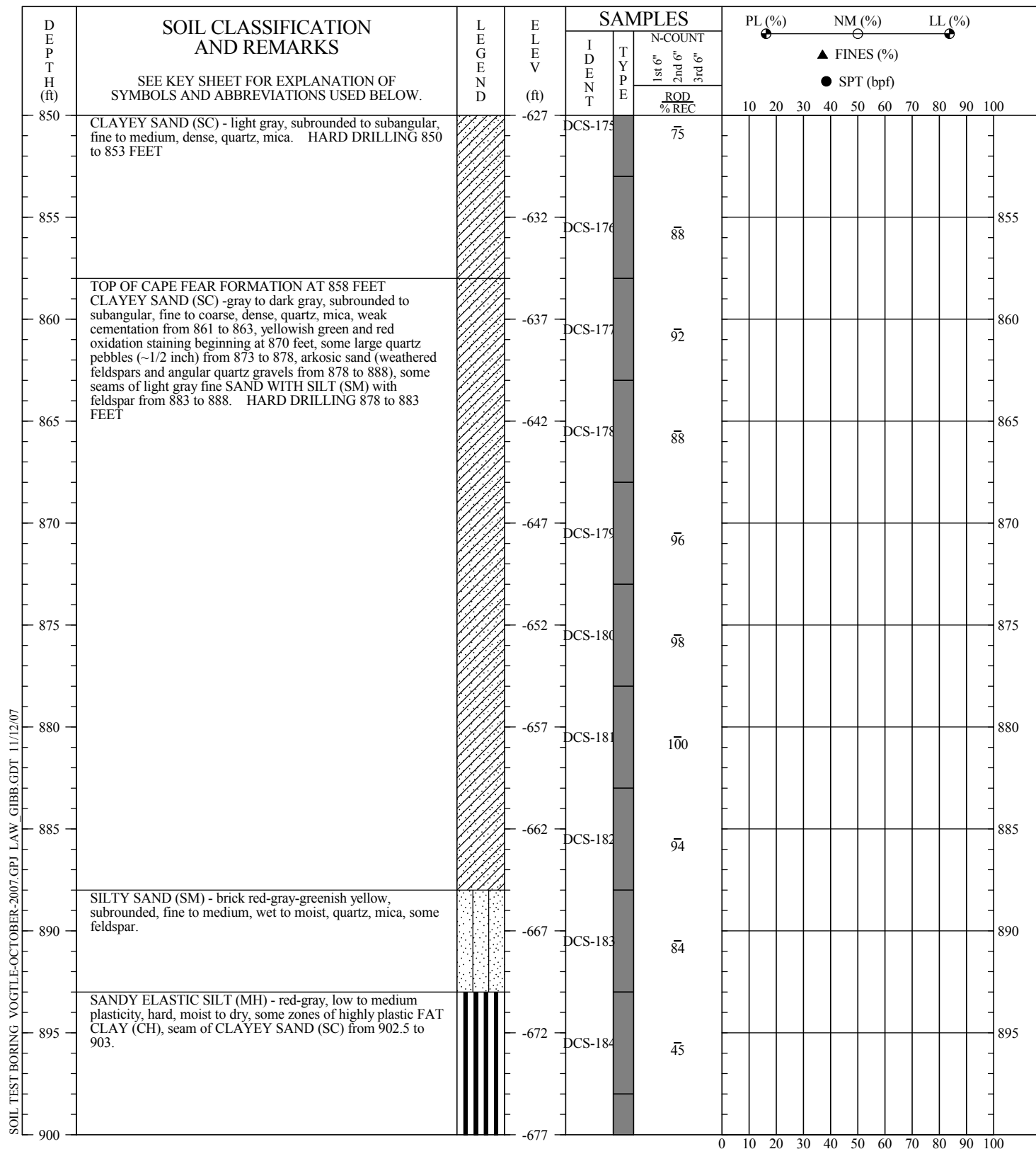
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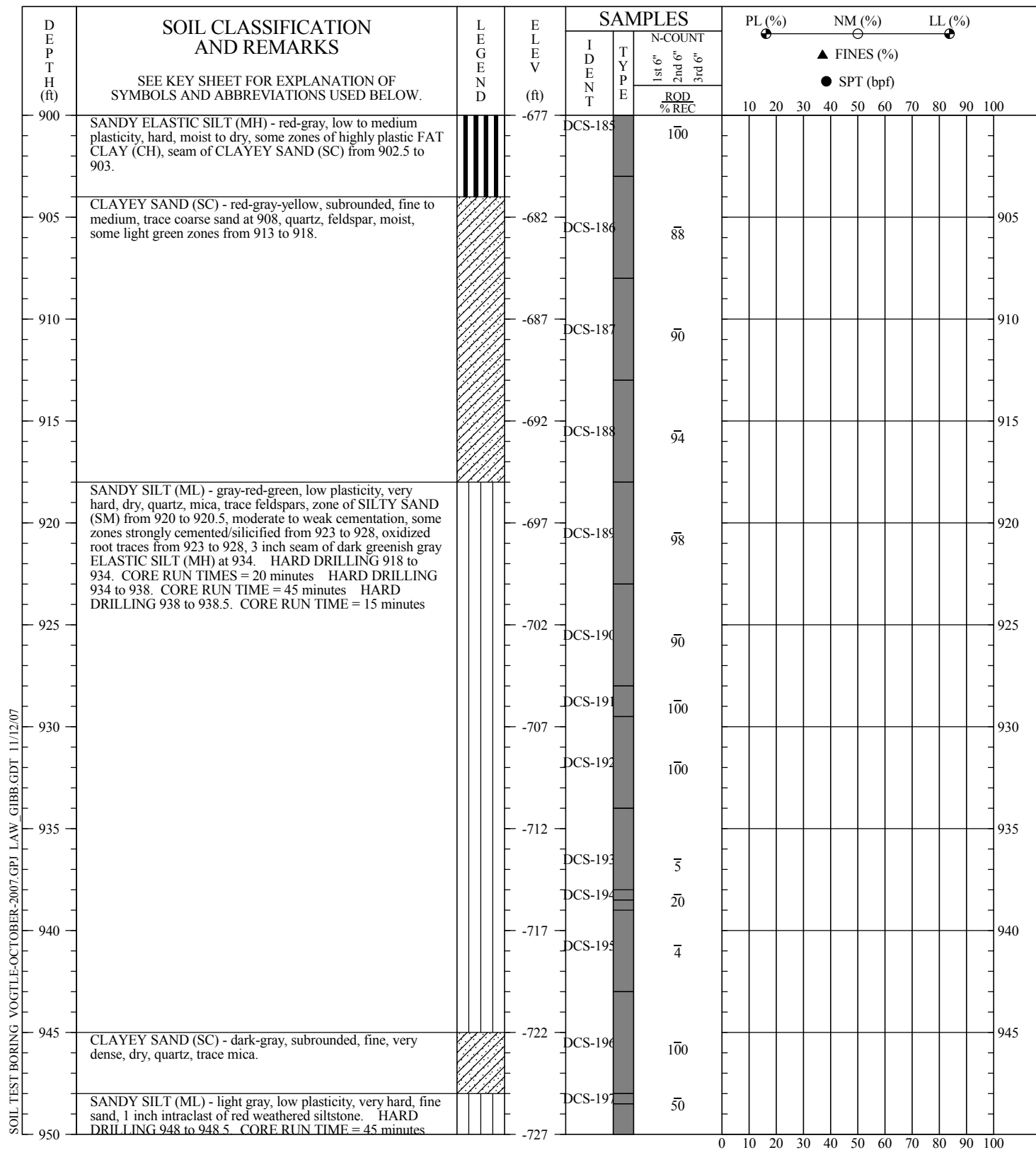
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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
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 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 223.21  
 ELEVATION DATUM = NAVD 88

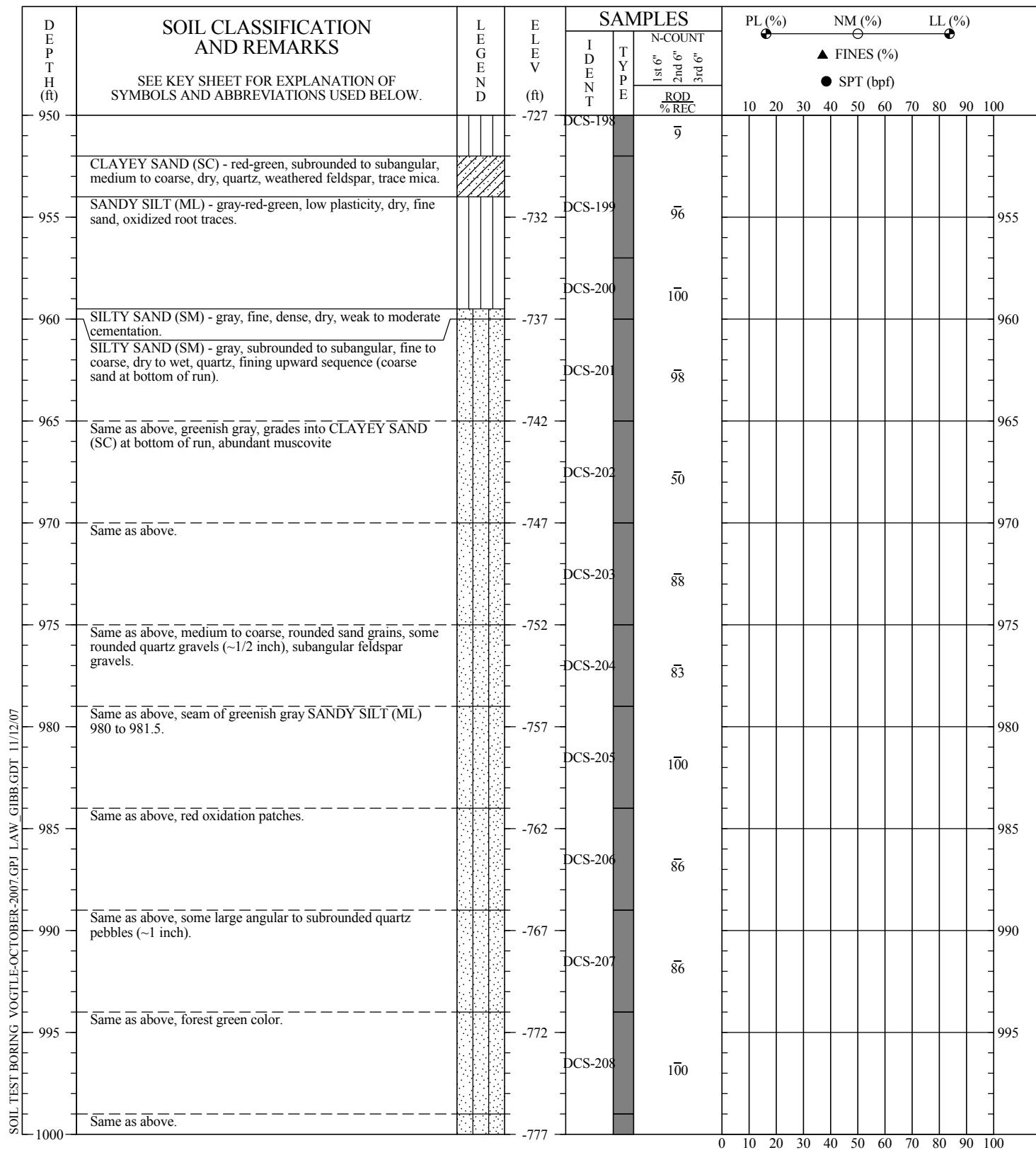
THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

## SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 223.21  
 ELEVATION DATUM = NAVD 88

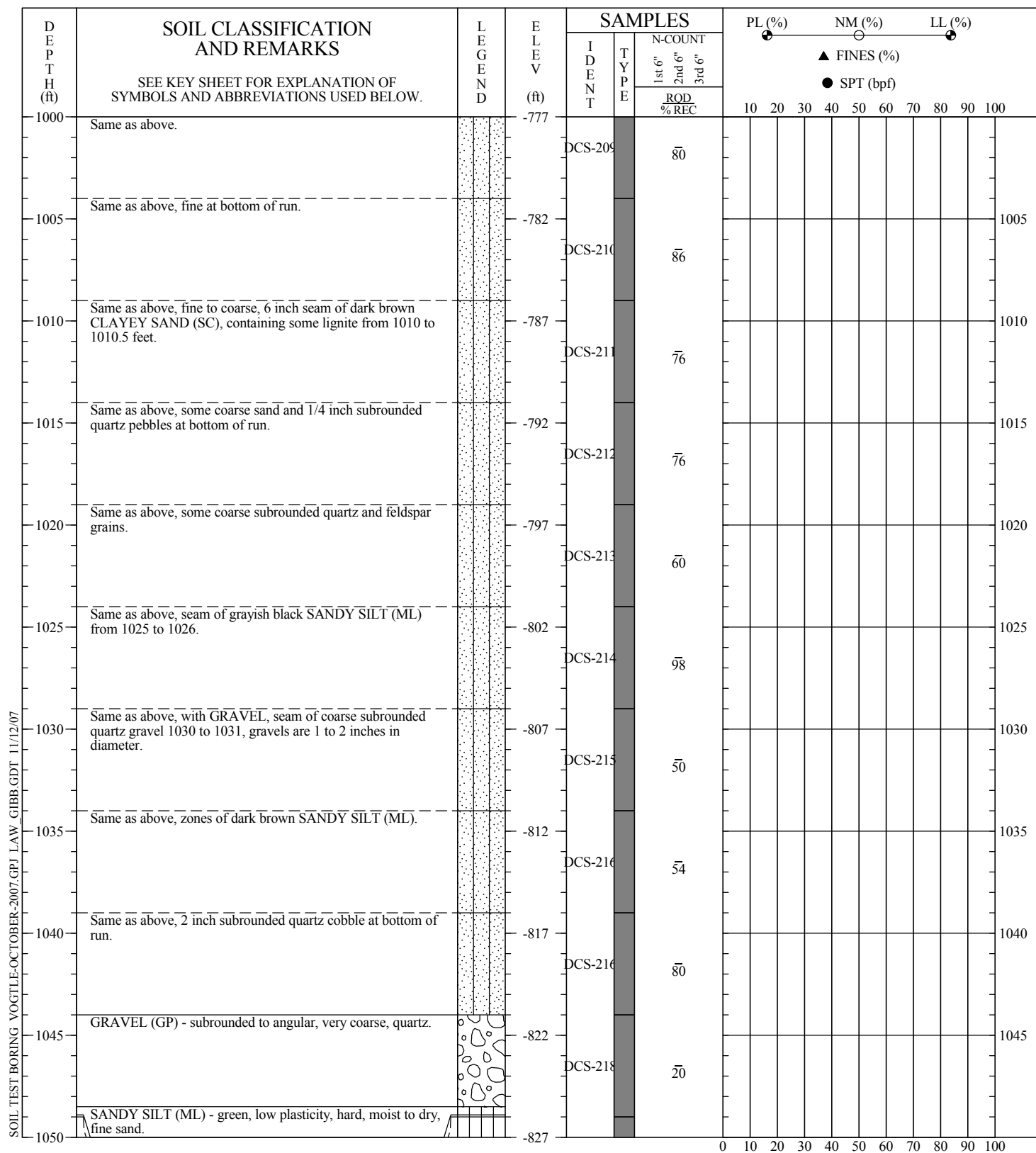
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 223.21  
 ELEVATION DATUM = NAVD 88

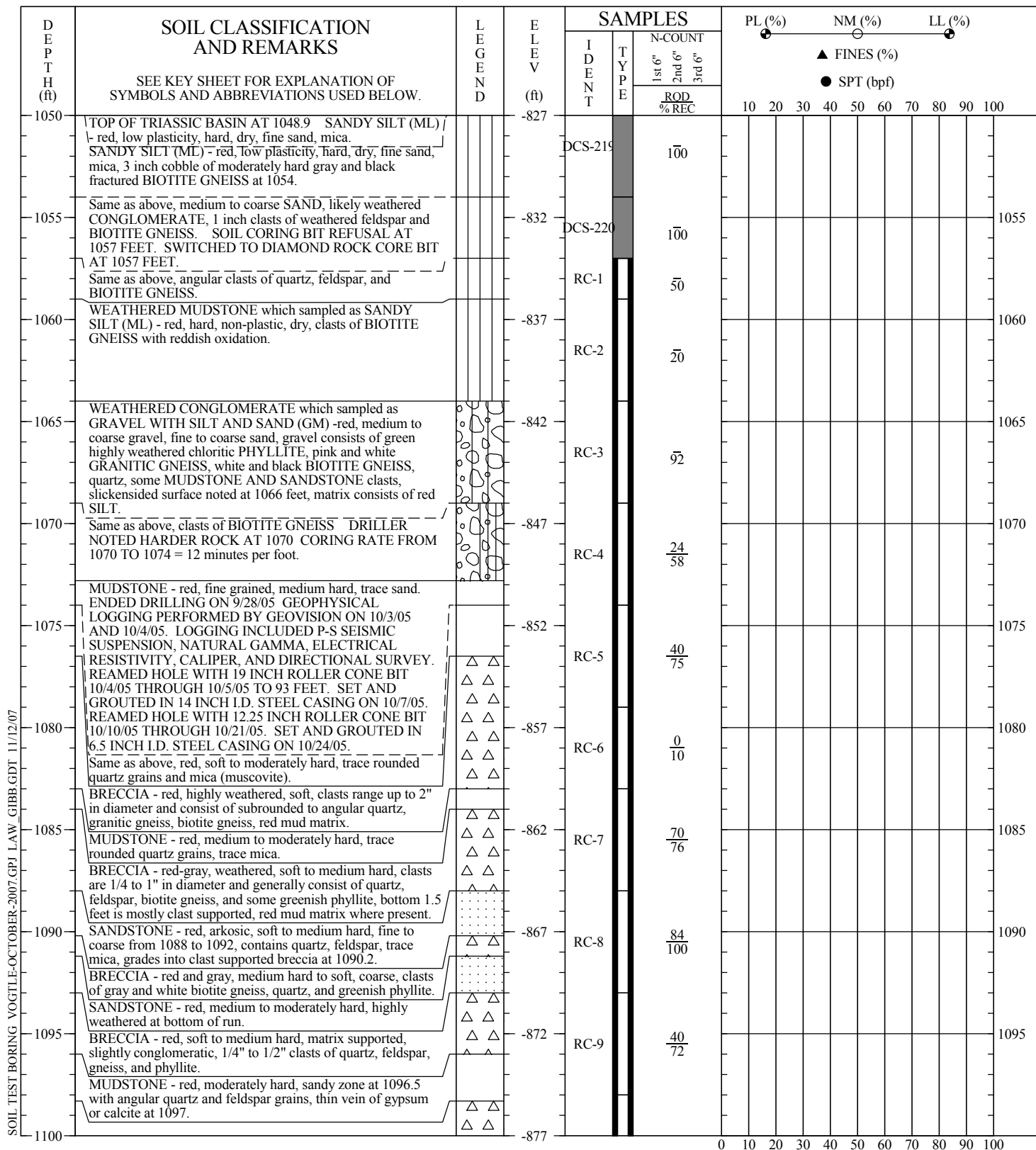
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 223.21  
 ELEVATION DATUM = NAVD 88

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## SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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SOIL TEST BORING VOGTLE-OCTOBER-2007 GPI LAW GIBB GDT 11/12/07

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

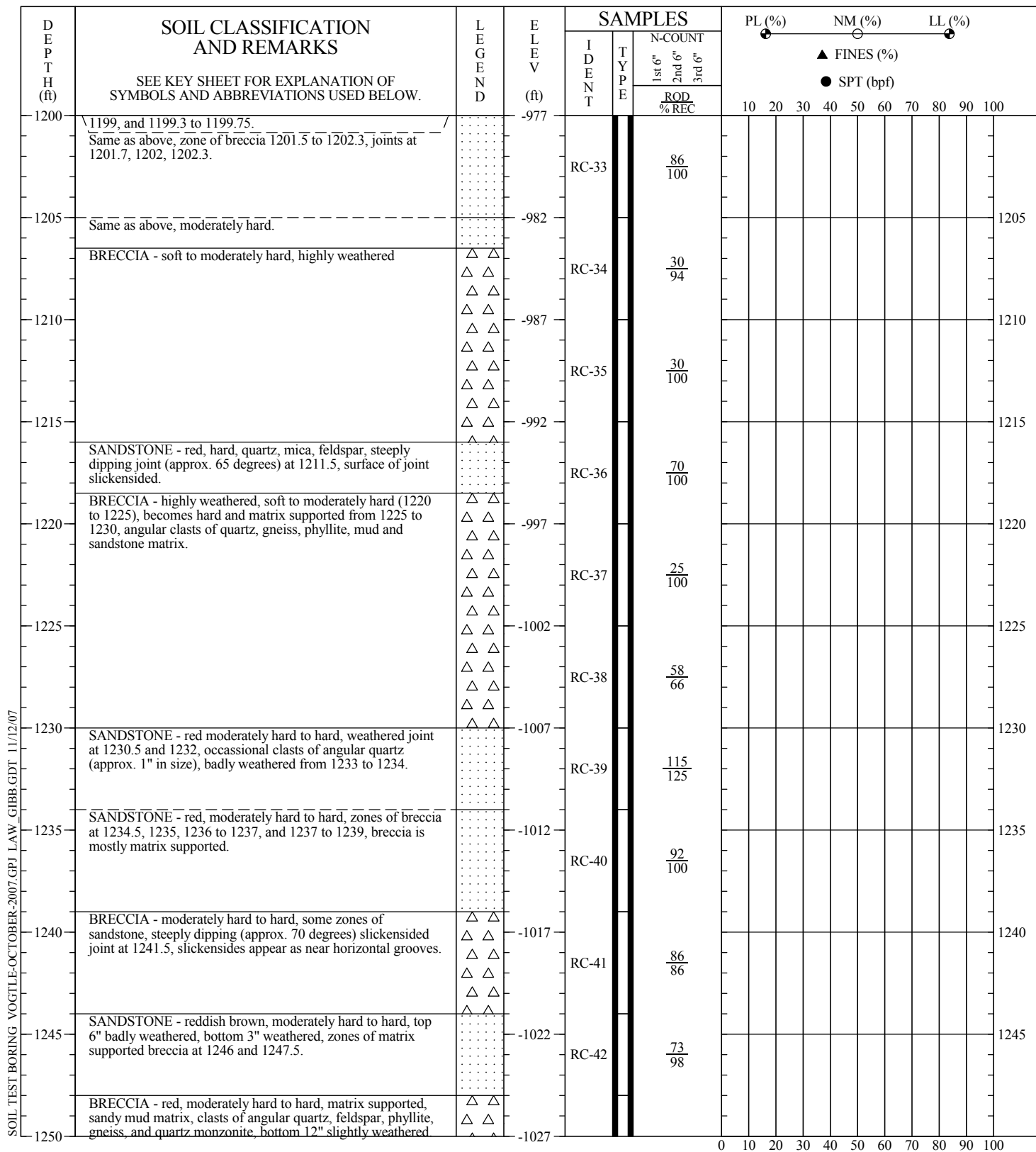
# SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227 **PAGE 24 OF**

**PAGE 24 OF 27**







DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 223.21  
 ELEVATION DATUM = NAVD 88

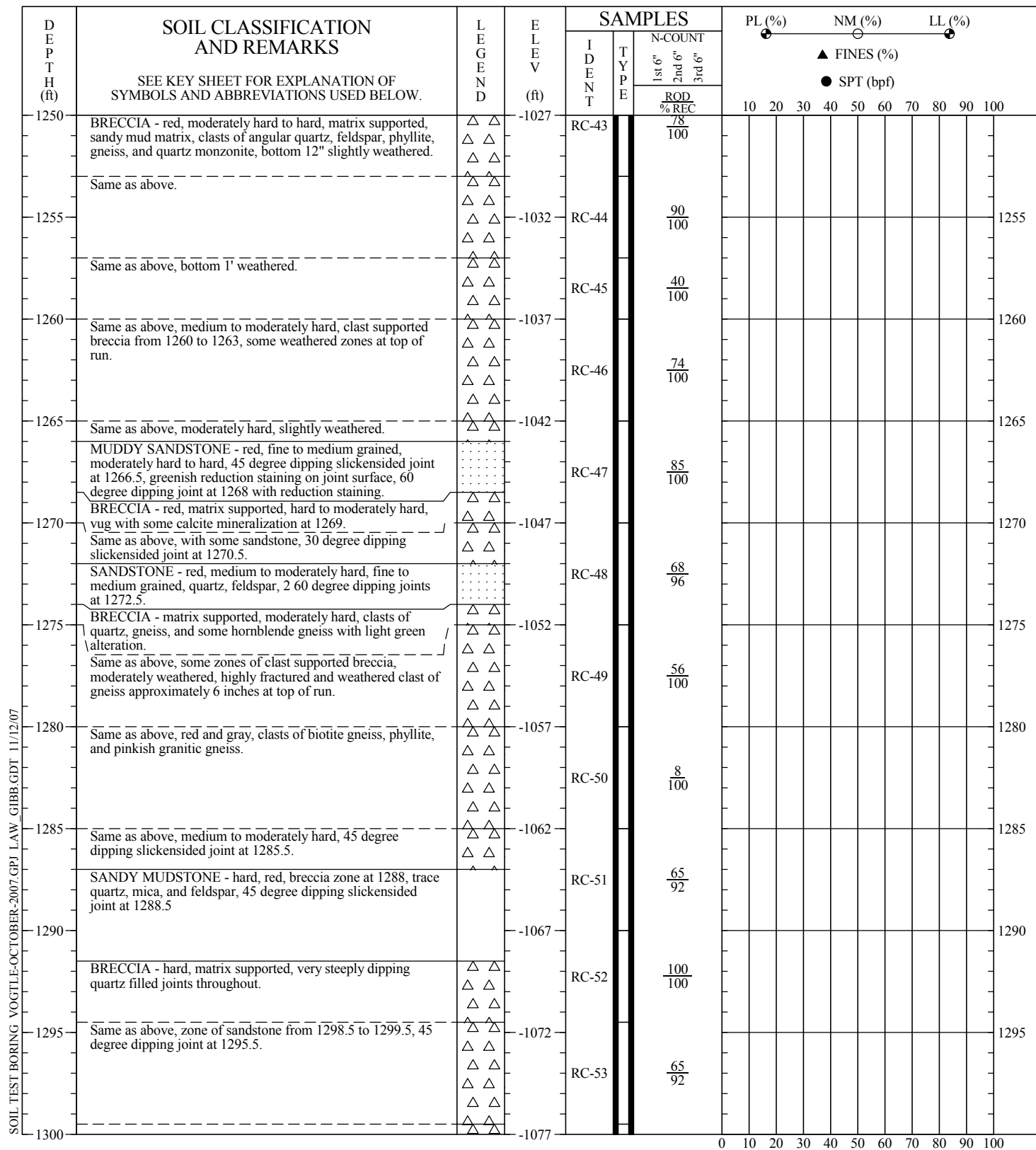
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 223.21  
 ELEVATION DATUM = NAVD 88

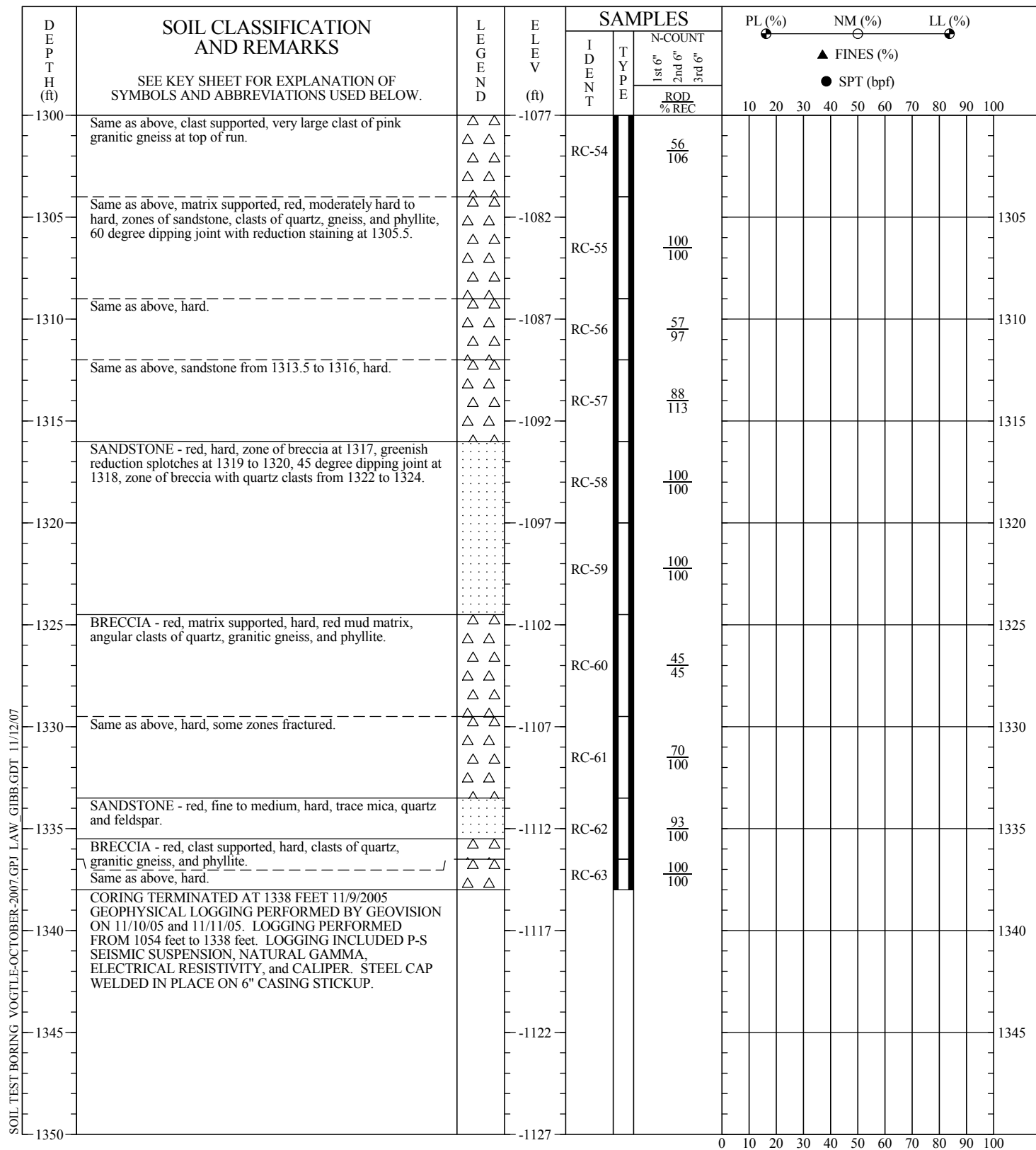
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: GRAVES DRILLING (STEVE RODGERS)  
 EQUIPMENT: Speedstar Quickdrill 275/Gardner Denver 15W  
 METHOD: Christensen Wire Line  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7974.36, E 7889.85  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 223.21  
 ELEVATION DATUM = NAVD 88

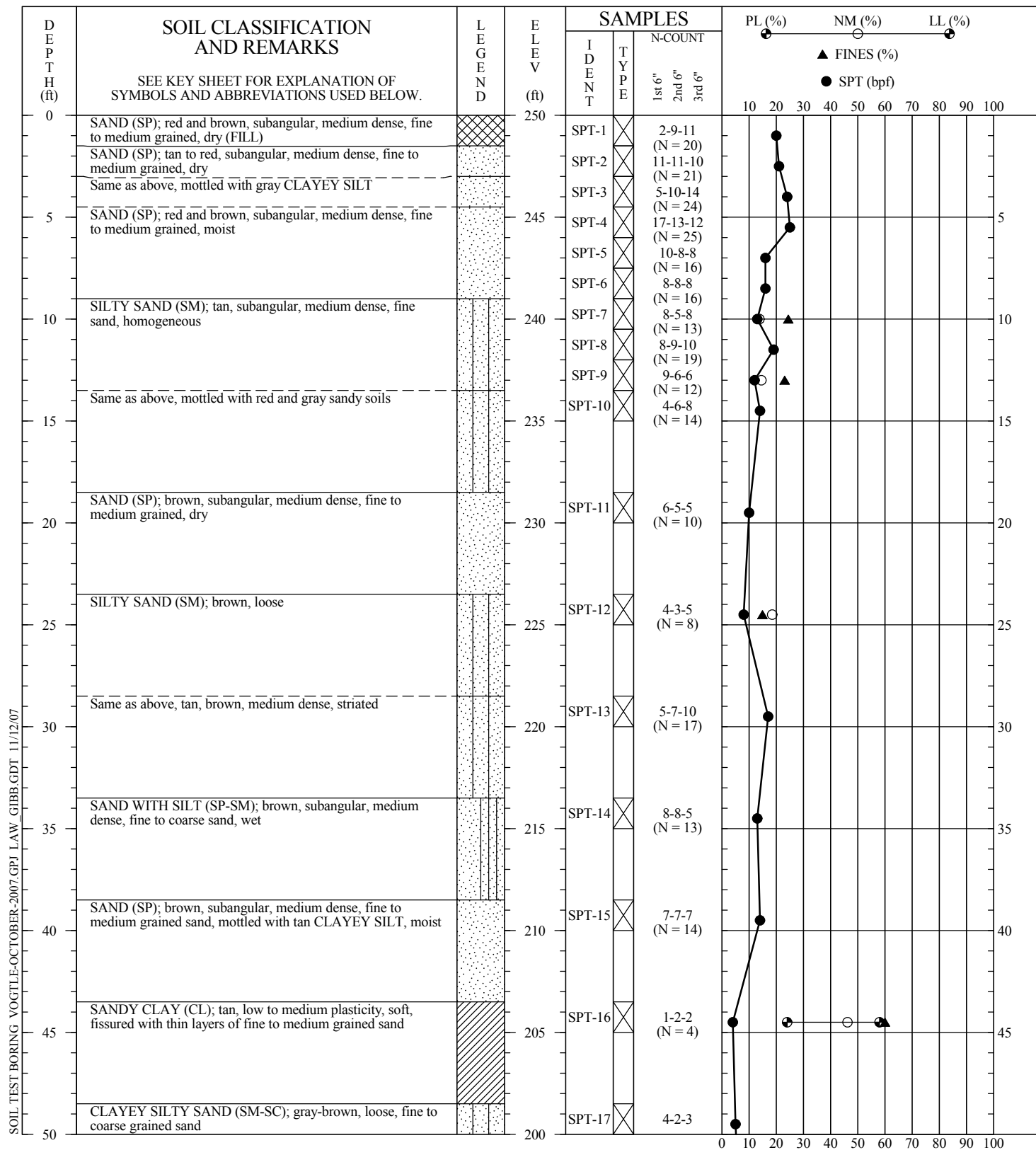
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1003  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7985.41, E 6131.44 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/15/05  
 ELEVATION (ft) = 249.78  
 ELEVATION DATUM = NAVD 88

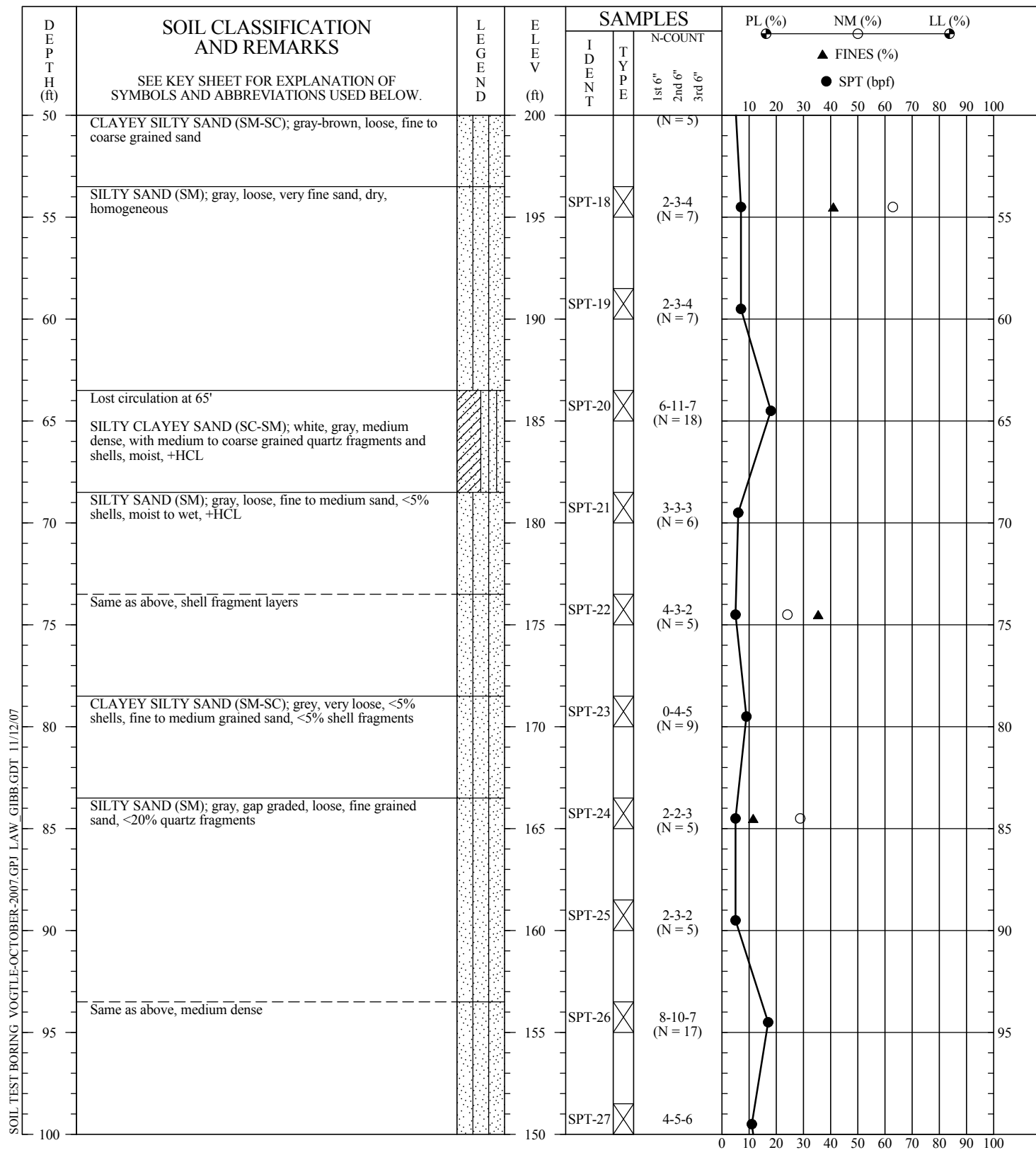
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1004  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 14, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 1 OF 7





DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7985.41, E 6131.44 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/15/05  
 ELEVATION (ft) = 249.78  
 ELEVATION DATUM = NAVD 88

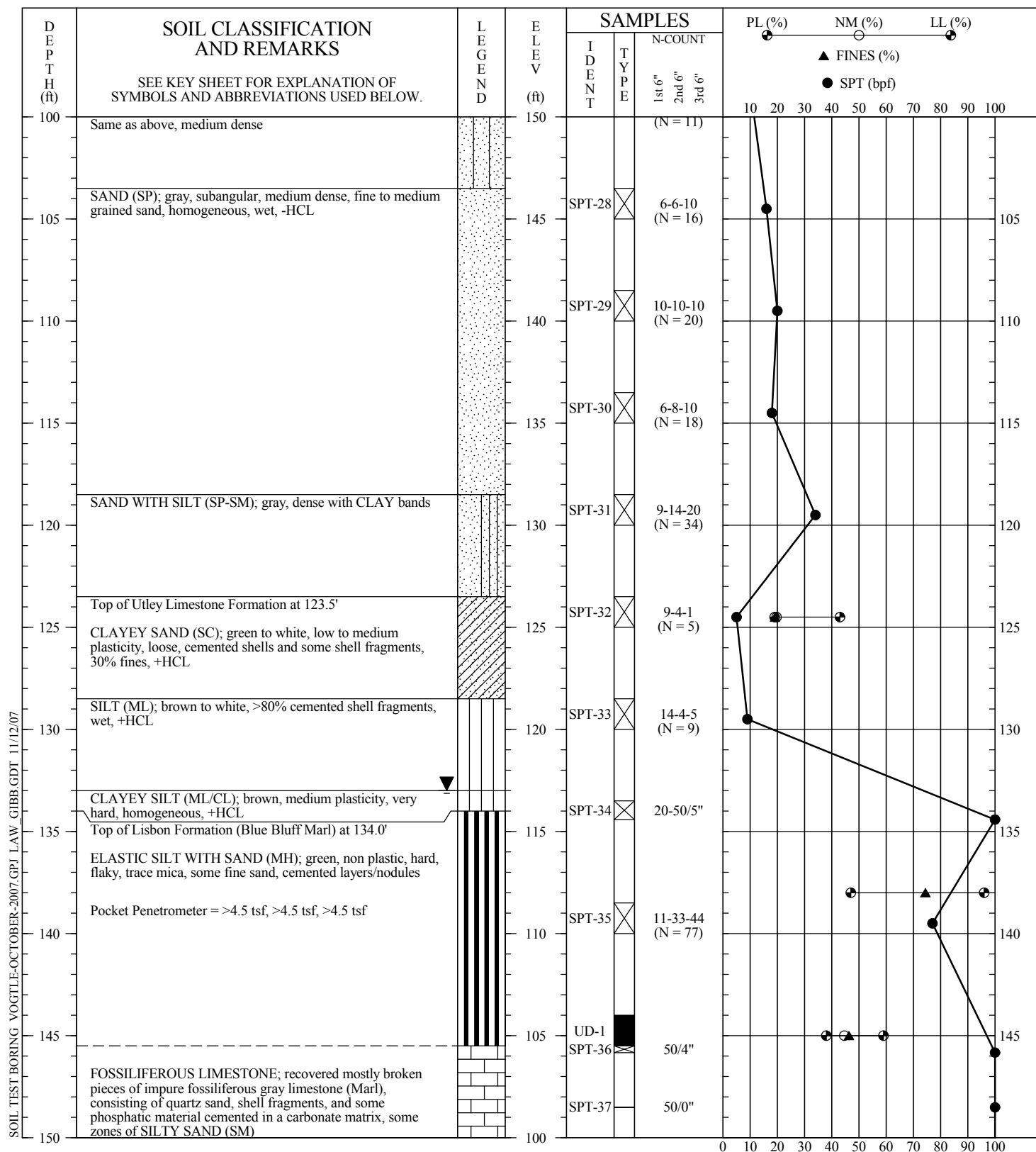
### SOIL TEST BORING RECORD

**BORING NO.:** B-1004  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 14, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 2 OF 7



THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.



DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7985.41, E 6131.44 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/15/05  
 ELEVATION (ft) = 249.78  
 ELEVATION DATUM = NAVD 88

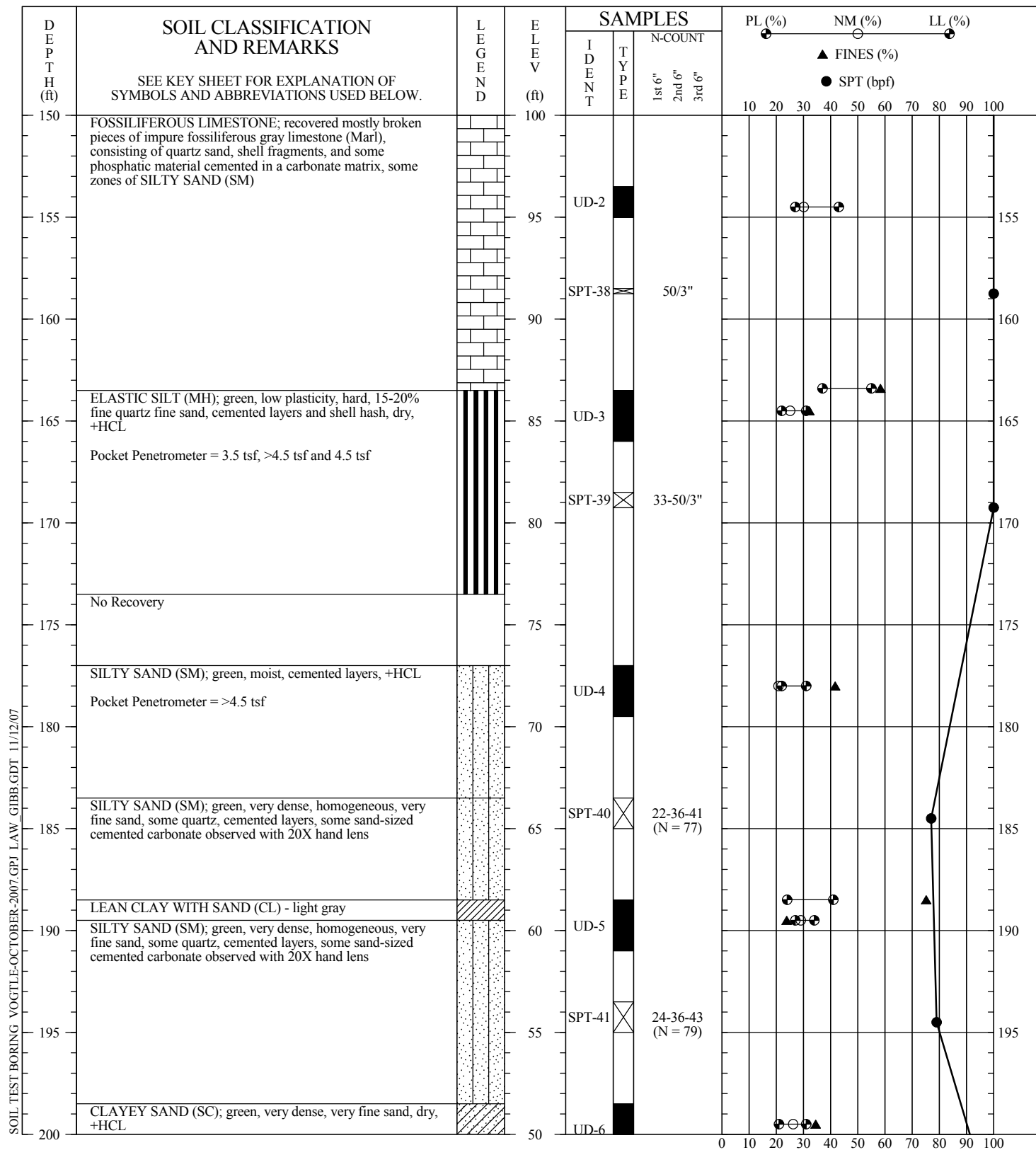
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1004  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 14, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 3 OF 7





DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7985.41, E 6131.44 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/15/05  
  
 ELEVATION (ft) = 249.78  
 ELEVATION DATUM = NAVD 88

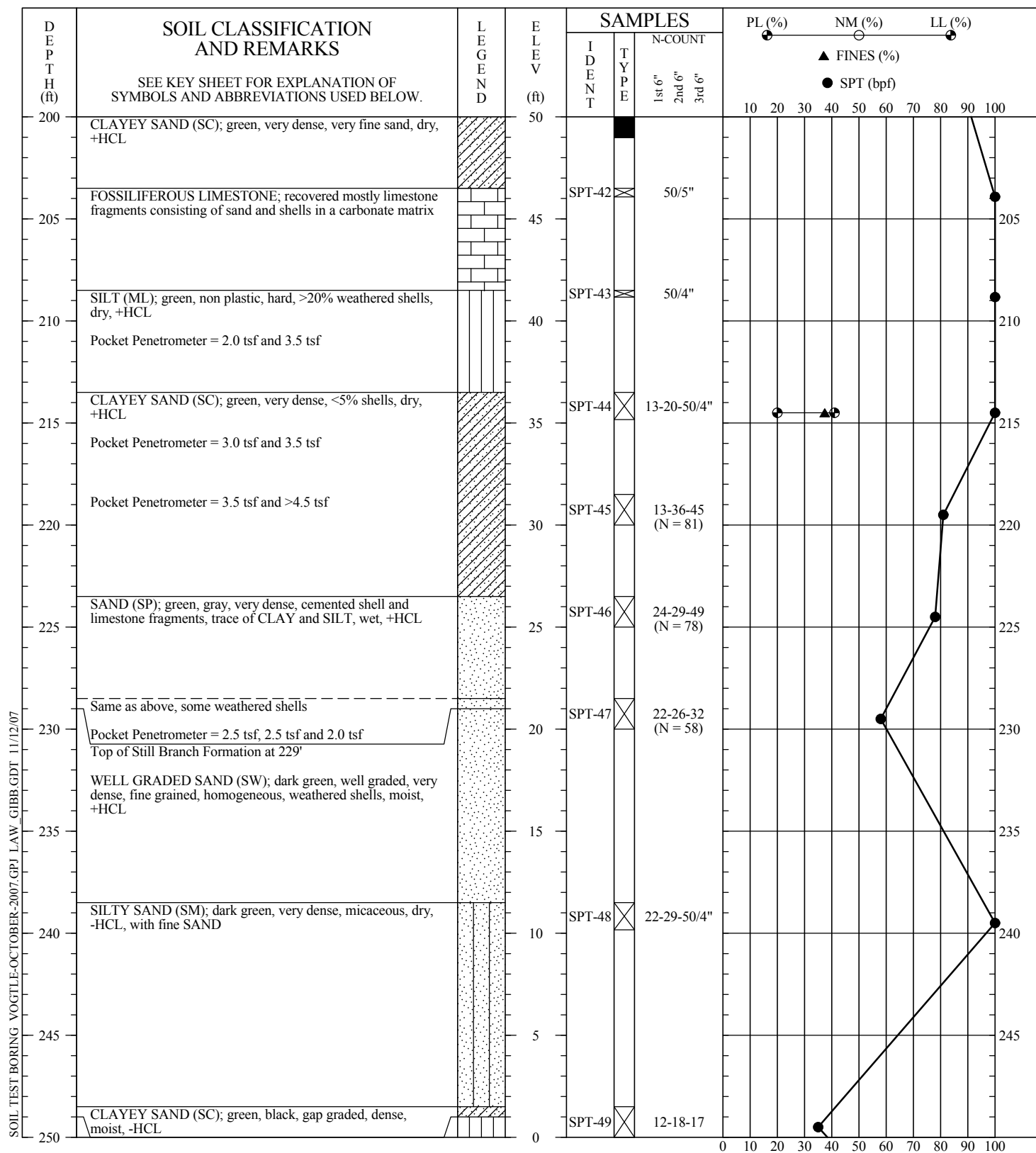
### SOIL TEST BORING RECORD

**BORING NO.:** B-1004  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 14, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 4 OF 7



THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.



DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7985.41, E 6131.44 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/15/05  
 ELEVATION (ft) = 249.78  
 ELEVATION DATUM = NAVD 88

### SOIL TEST BORING RECORD

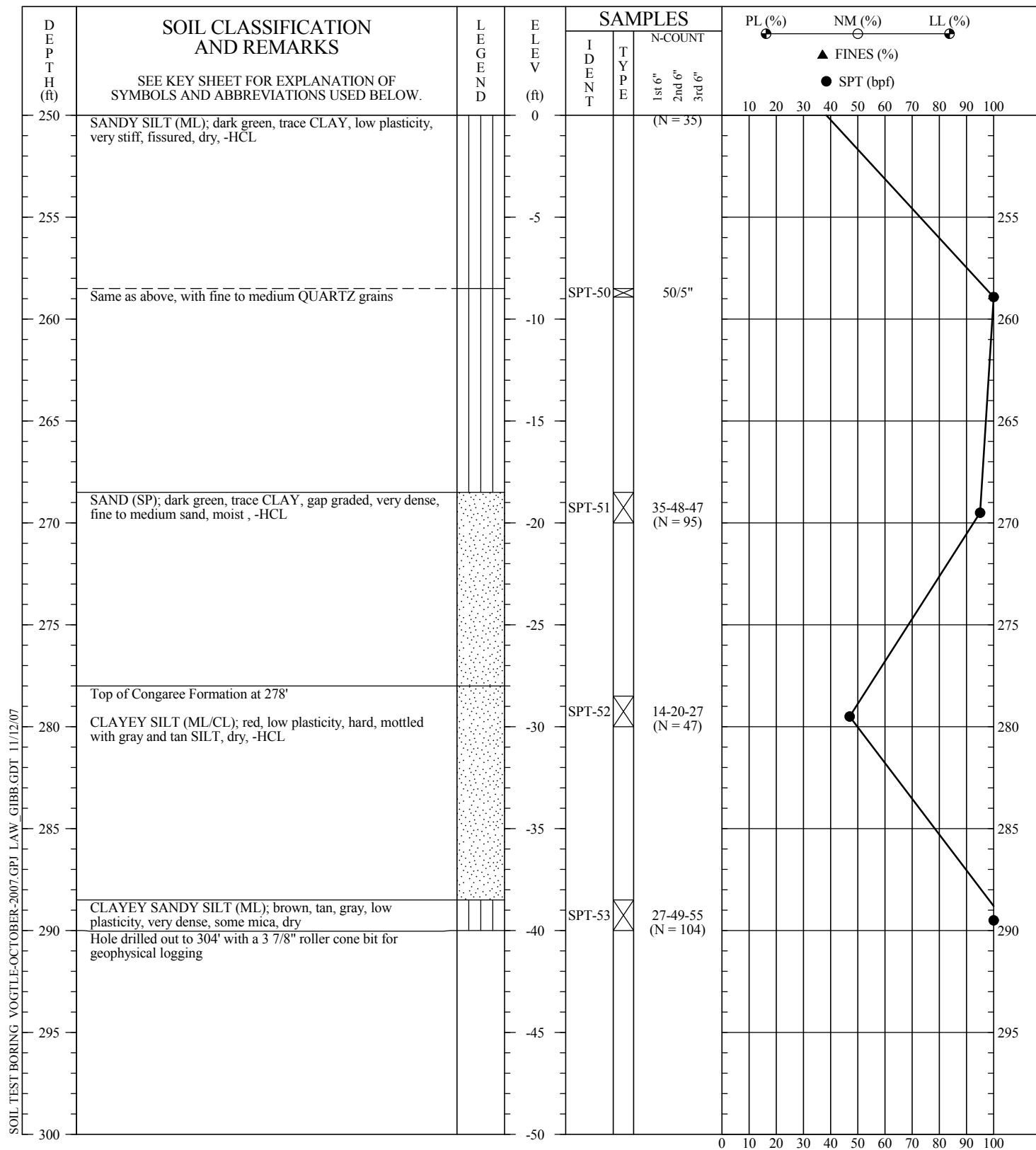
**BORING NO.:** B-1004  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 14, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 5 OF 7



THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.





DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7985.41, E 6131.44 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/15/05  
 ELEVATION (ft) = 249.78  
 ELEVATION DATUM = NAVD 88

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## SOIL TEST BORING RECORD

**BORING NO.:** B-1004  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 14, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 6 OF 7

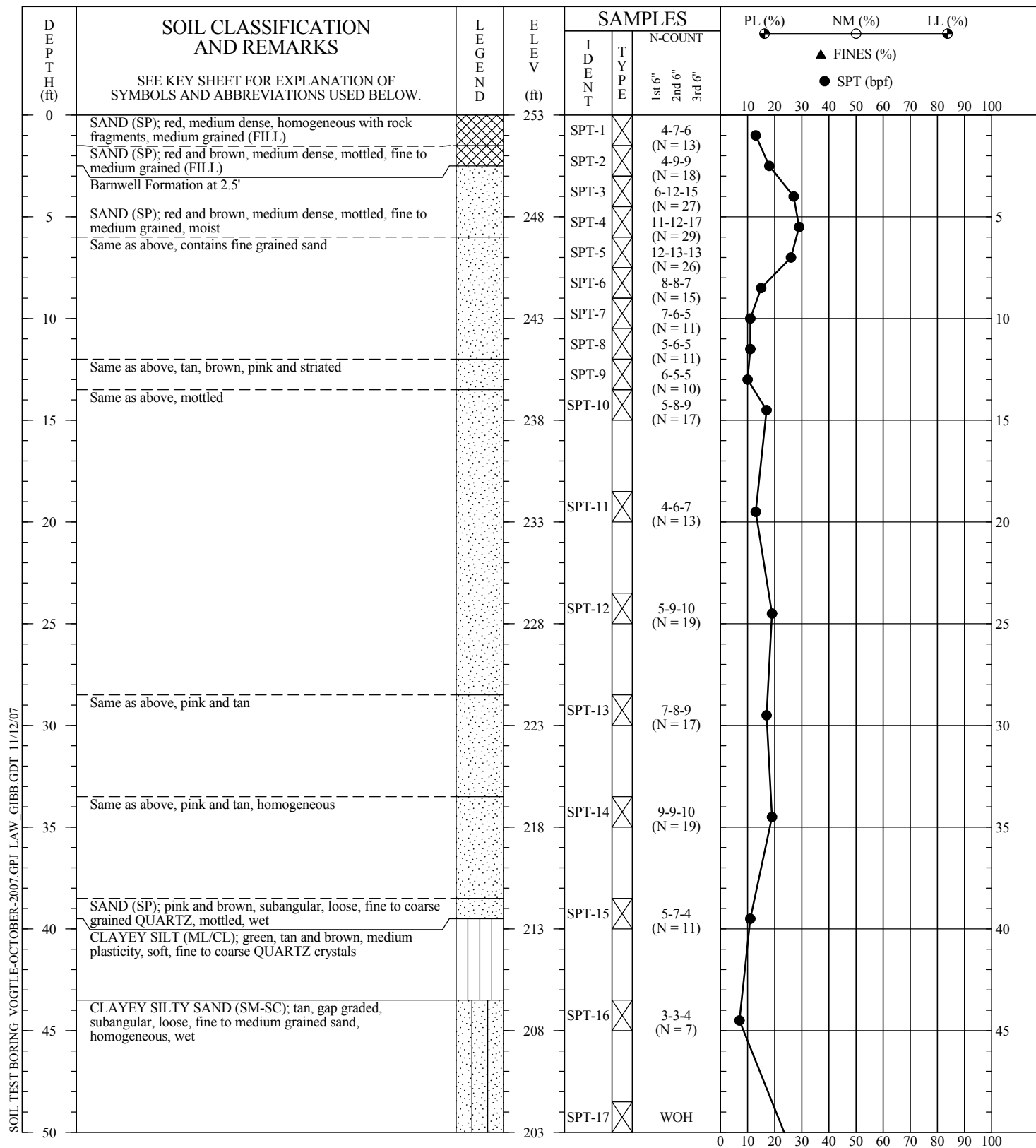


[illegible]

DRILLER:	Jimmy Oglesby (MACTEC)
EQUIPMENT:	CME-75 (Auto-Hammer)
METHOD:	Rotary Wash with Mud
HOLE DIA.:	4 inches
REMARKS:	Plant Grid: N 7985.41, E 6131.44    +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL    Water depth represents depth of water and mud as measured on 9/15/05
	ELEVATION (ft) = 249.78
	ELEVATION DATUM = NAVD 88

# SOIL TEST BORING RECORD





DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8991.57, E 6155.35  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 253.14  
 ELEVATION DATUM = NAVD 88

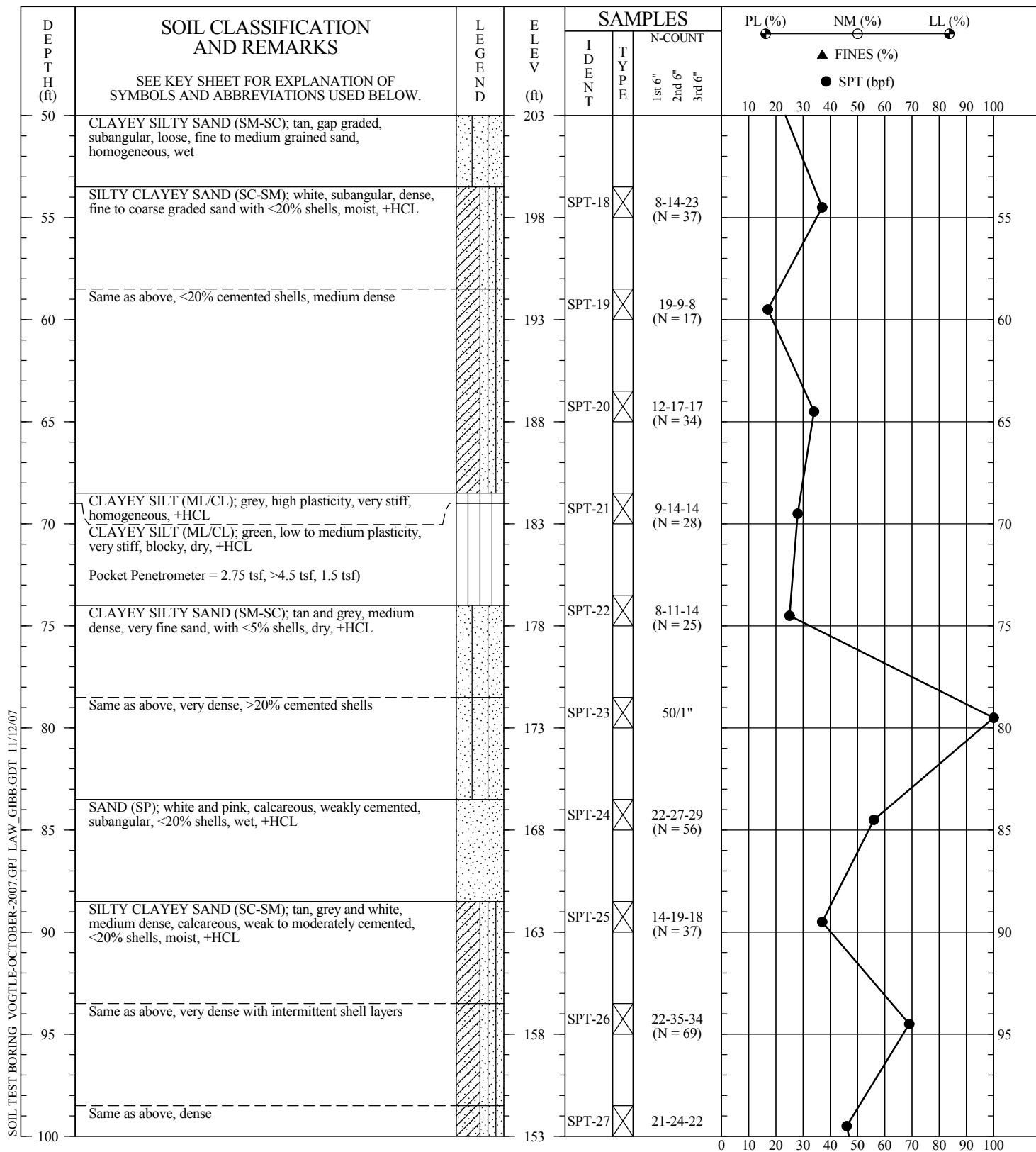
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1005  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 8, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 1 OF 4





DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8991.57, E 6155.35  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 253.14  
 ELEVATION DATUM = NAVD 88

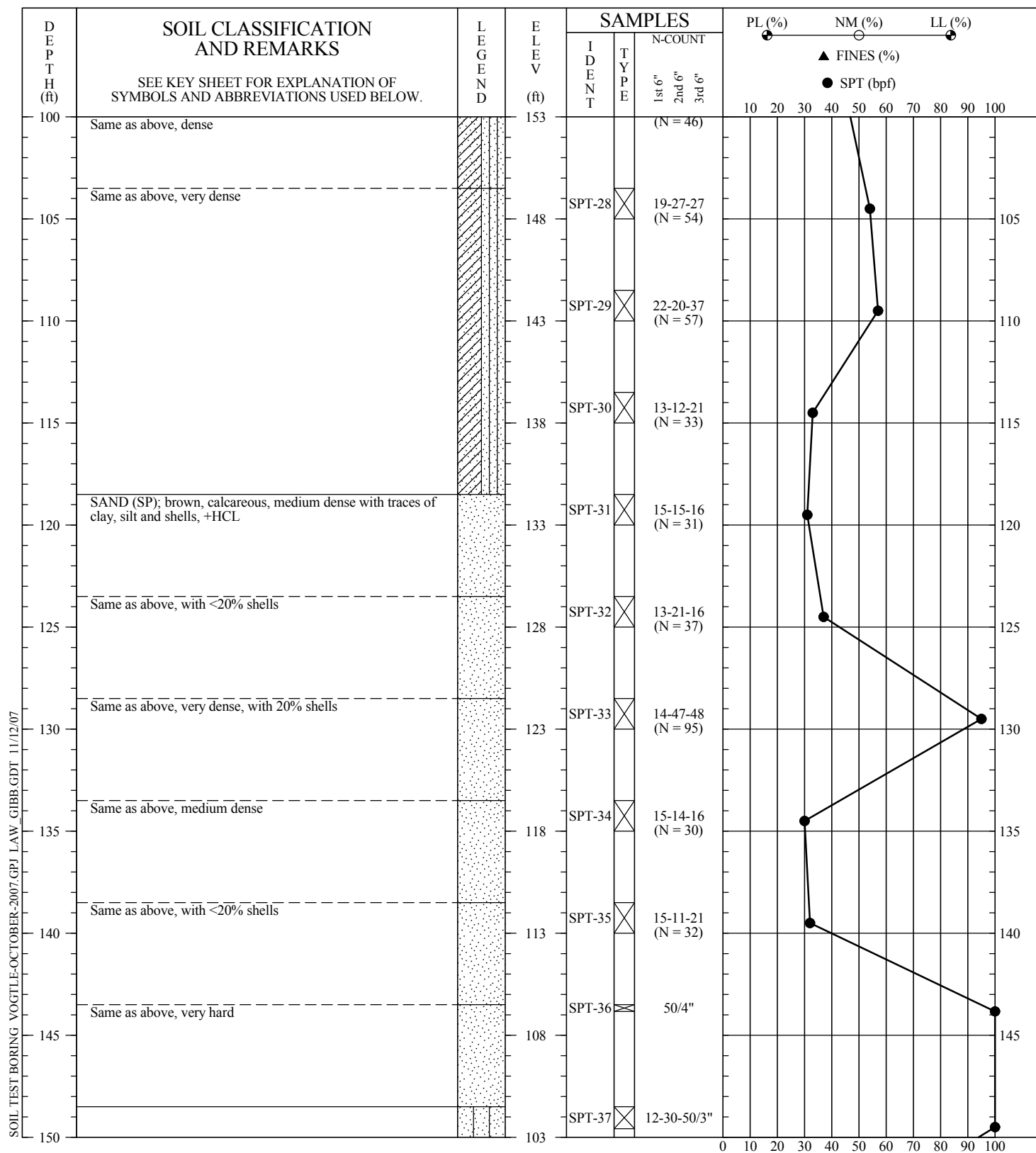
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**BORING NO.:** B-1005  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 8, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 2 OF 4





DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8991.57, E 6155.35  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 253.14  
 ELEVATION DATUM = NAVD 88

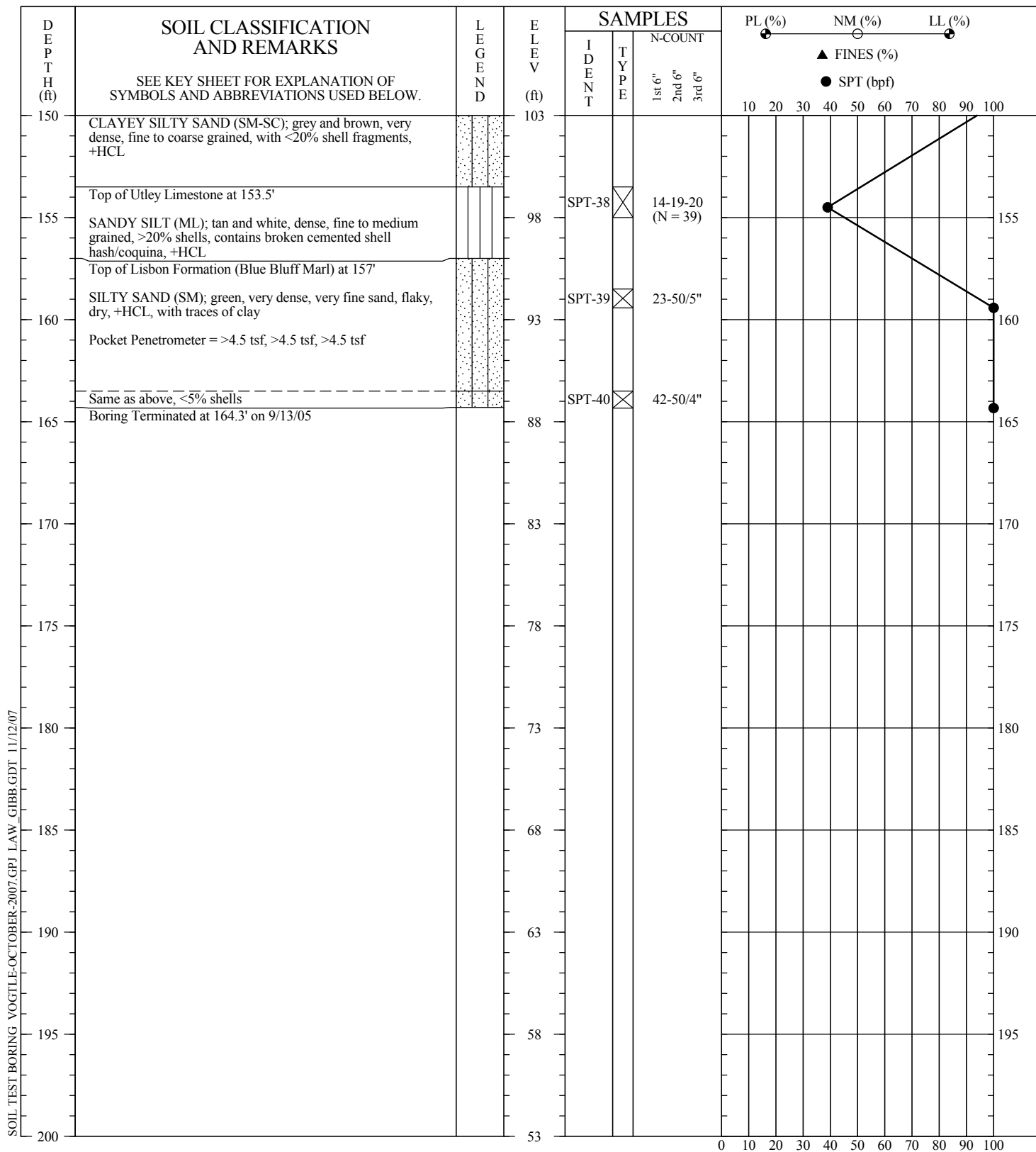
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**BORING NO.:** B-1005  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 8, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 3 OF 4





DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8991.57, E 6155.35  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 253.14  
 ELEVATION DATUM = NAVD 88

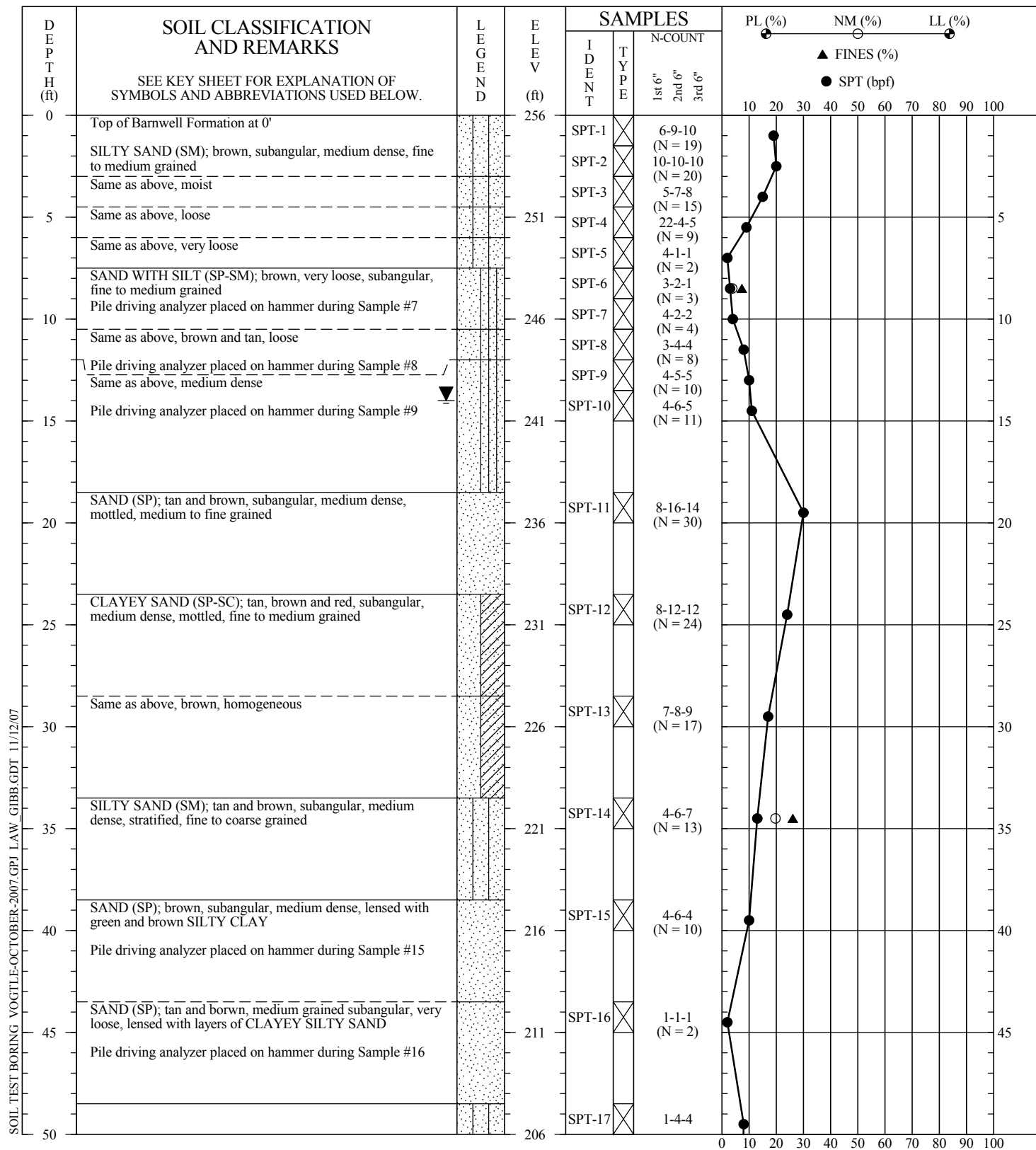
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**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 8, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 4 OF 4

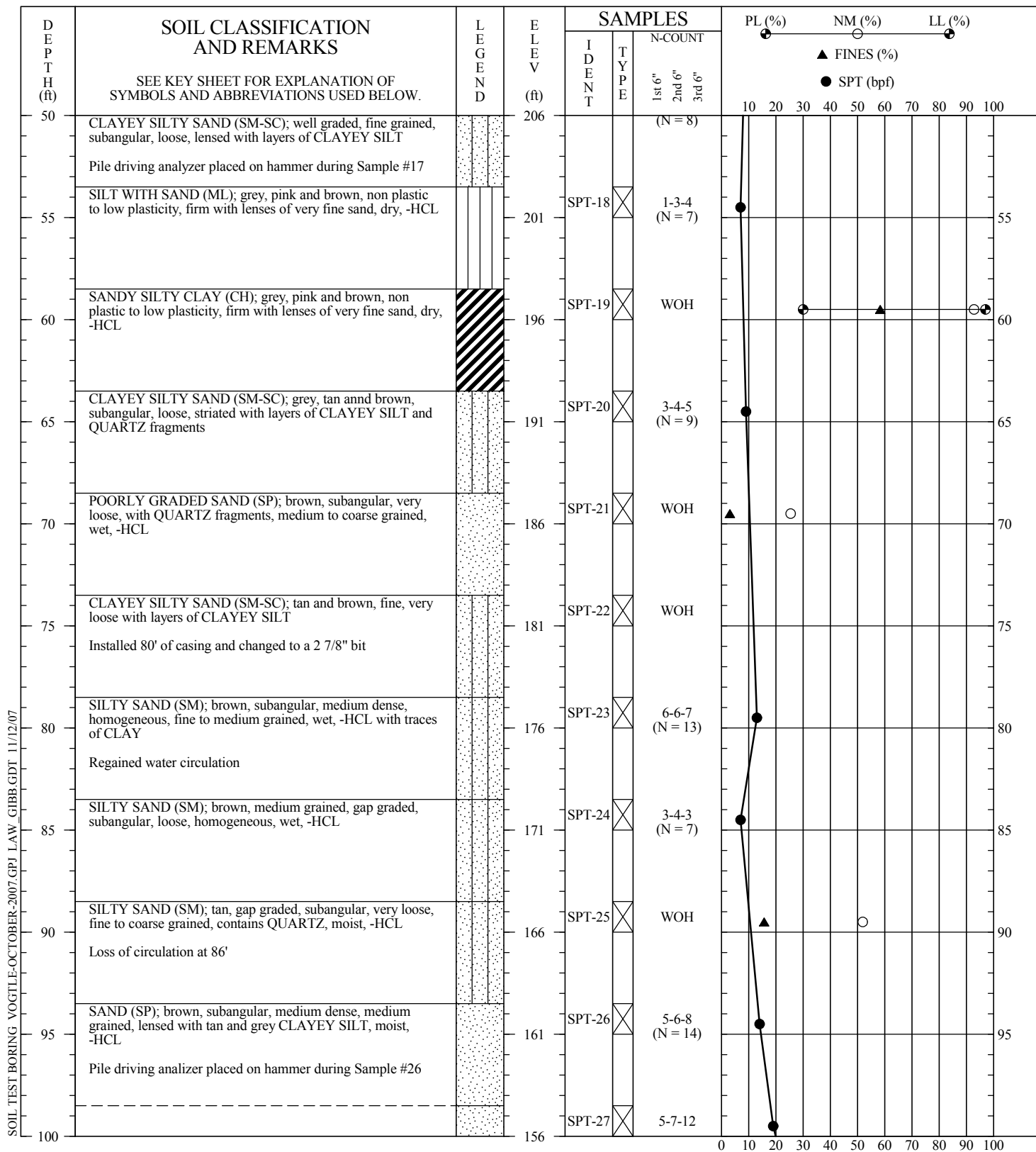




DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8810.26, E 7342.90 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/7/05  
 ELEVATION (ft) = 255.95  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

SOIL TEST BORING RECORD	
<b>BORING NO.:</b>	B-1006
<b>PROJECT:</b>	ALWR - ESP
<b>LOCATION:</b>	PLANT VOGTLE, BURKE COUNTY, GA
<b>DRILLED:</b>	September 6, 2005
<b>PROJECT NO.:</b>	6141-05-0227
<b>PAGE 1 OF 3</b>	



DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8810.26, E 7342.90 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/7/05

ELEVATION (ft) = 255.95  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

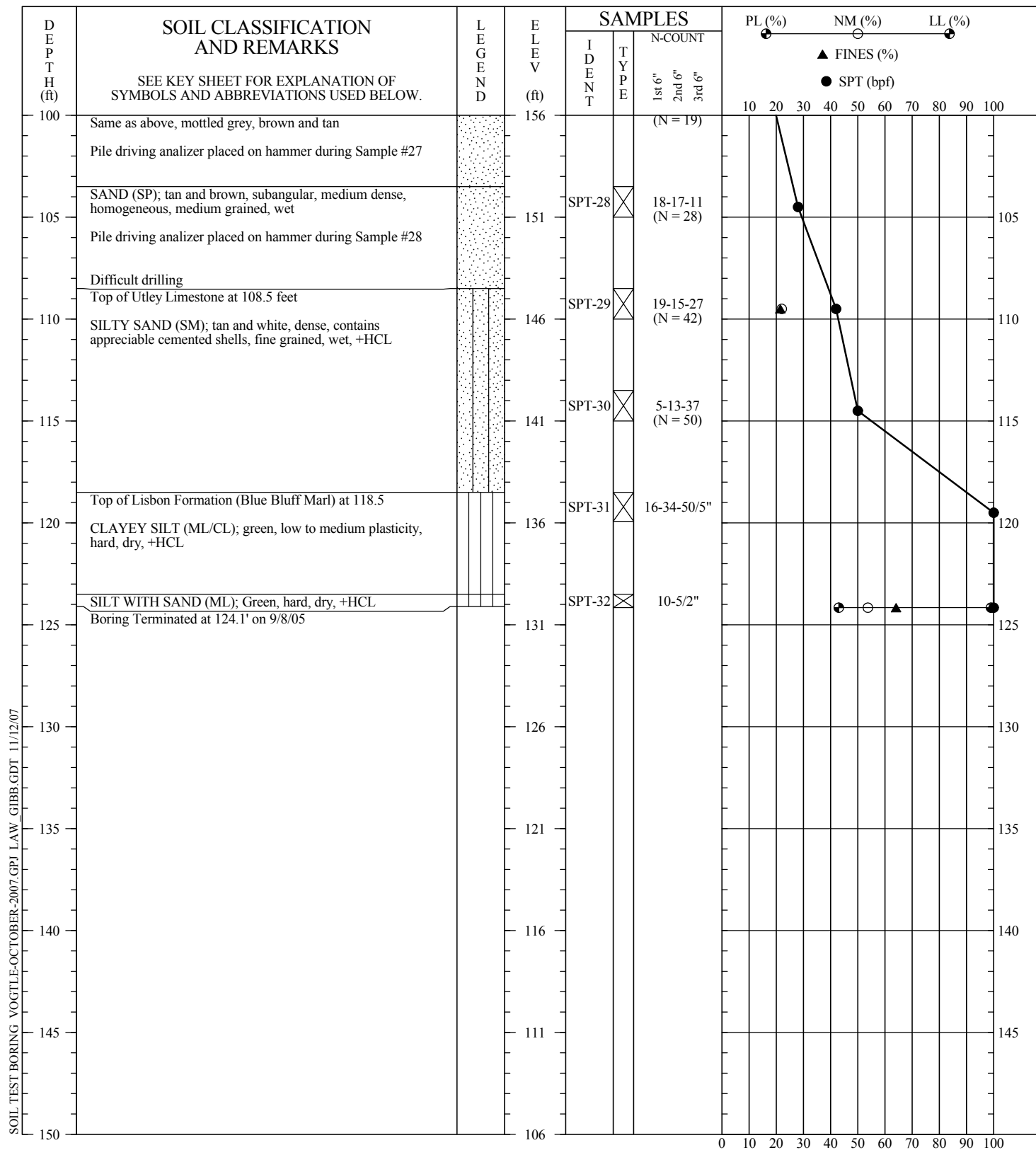
## SOIL TEST BORING RECORD

**BORING NO.:** B-1006  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 6, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 2 OF 3







DRILLER: Jimmy Oglesby (MACTEC)  
EQUIPMENT: CME-75 (Auto-Hammer)  
METHOD: Rotary Wash with Mud  
HOLE DIA.: 4 inches  
REMARKS: Plant Grid: N 8810.26, E 7342.90 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/7/05

ELEVATION (ft) = 255.95  
ELEVATION DATUM = NAVD 88

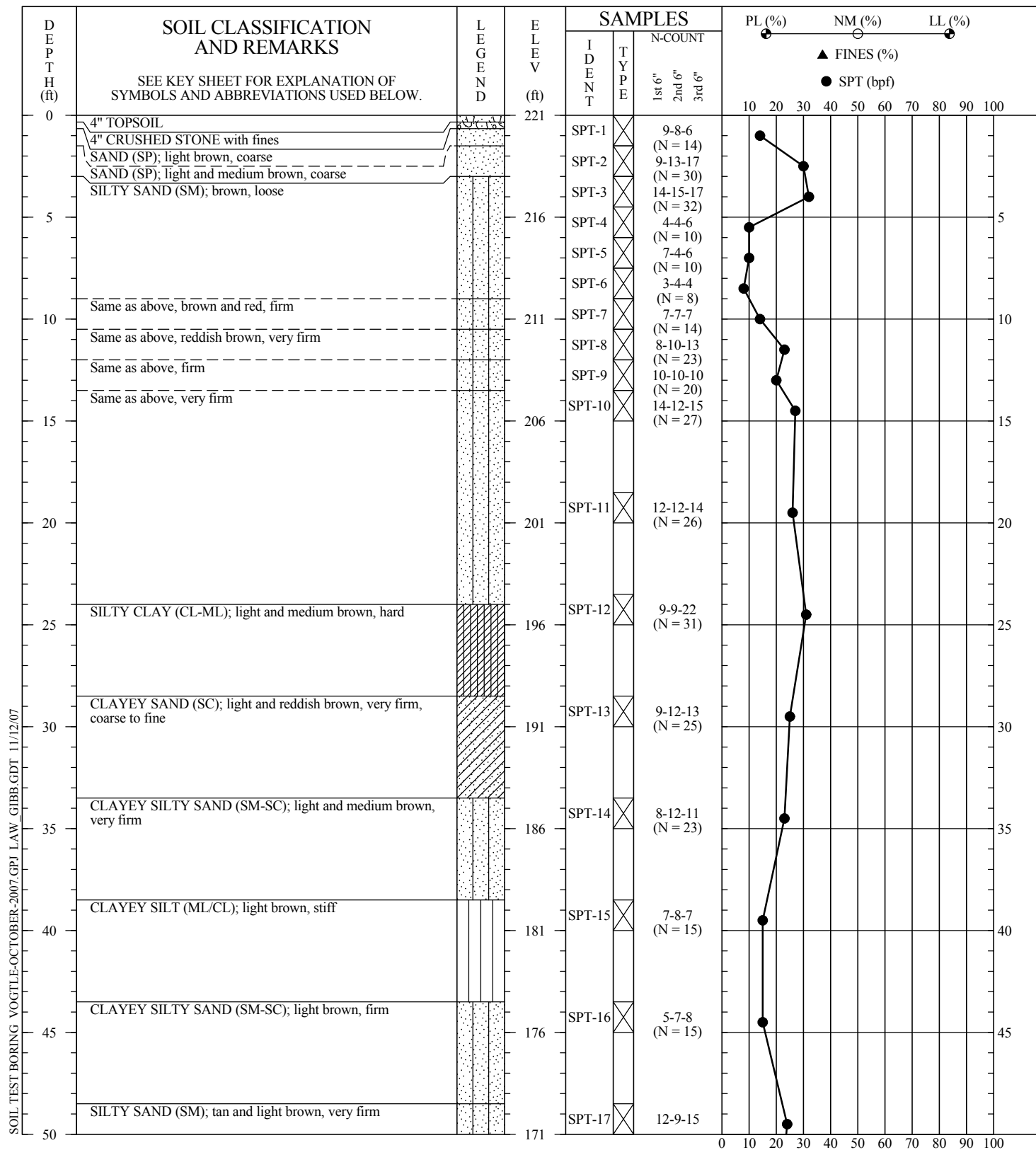
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**BORING NO.:** B-1006  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 6, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7662.29, E 7120.13 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 8/31/05  
 ELEVATION (ft) = 221.02  
 ELEVATION DATUM = NAVD 88

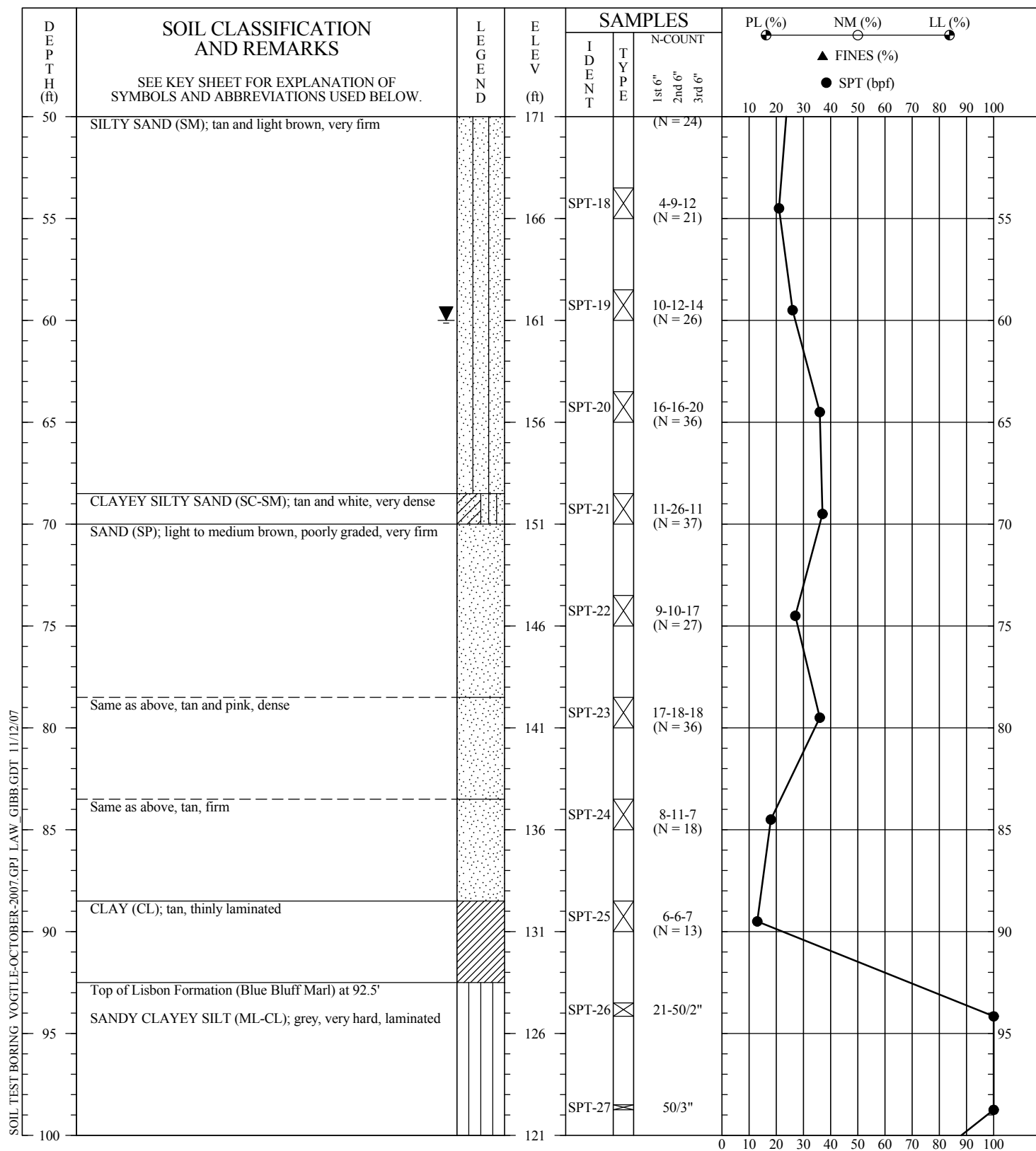
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1007  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** August 30, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 1 OF 3





DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7662.29, E 7120.13 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 8/31/05  
 ELEVATION (ft) = 221.02  
 ELEVATION DATUM = NAVD 88

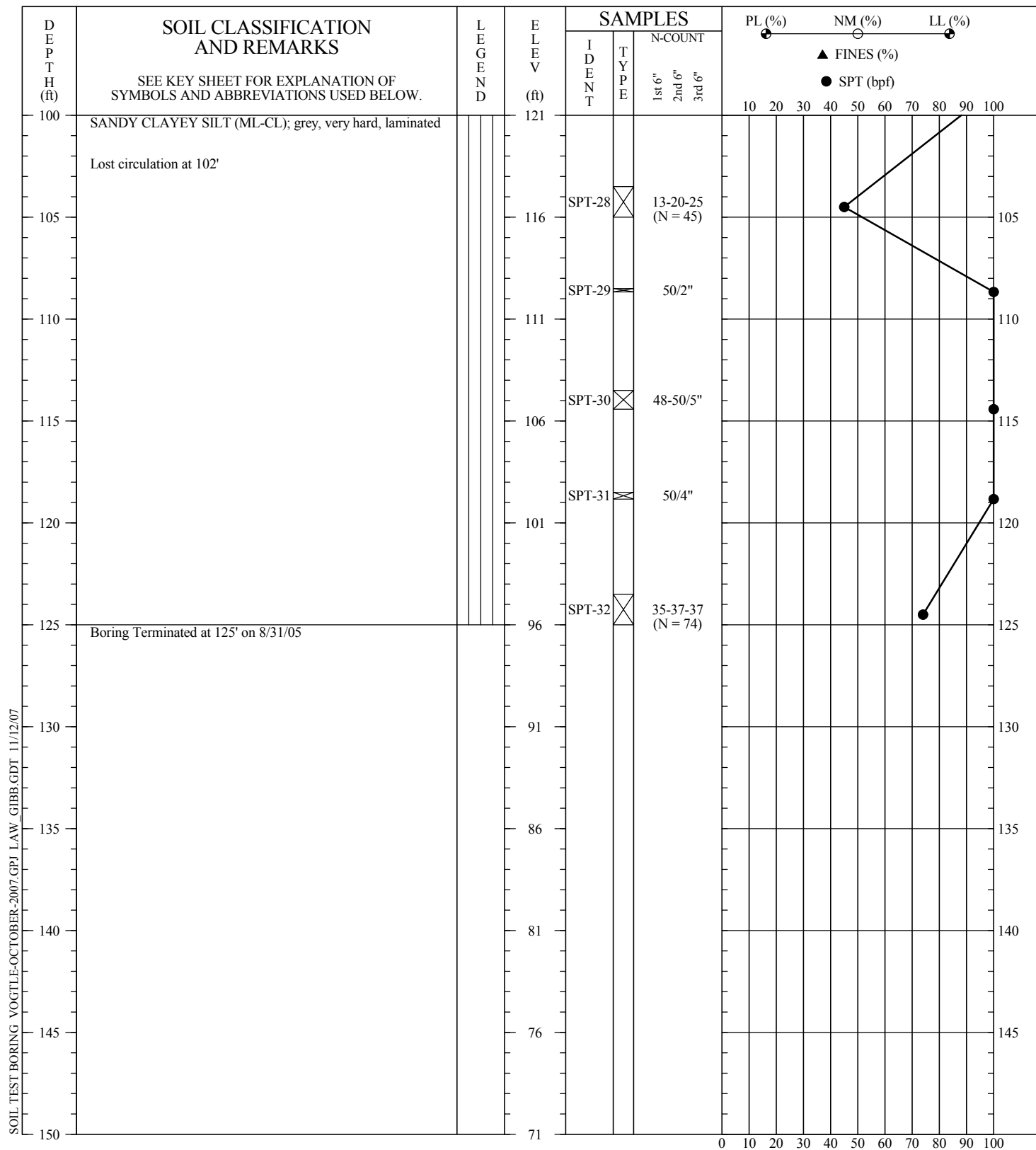
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1007  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** August 30, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7662.29, E 7120.13 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 8/31/05  
 ELEVATION (ft) = 221.02  
 ELEVATION DATUM = NAVD 88

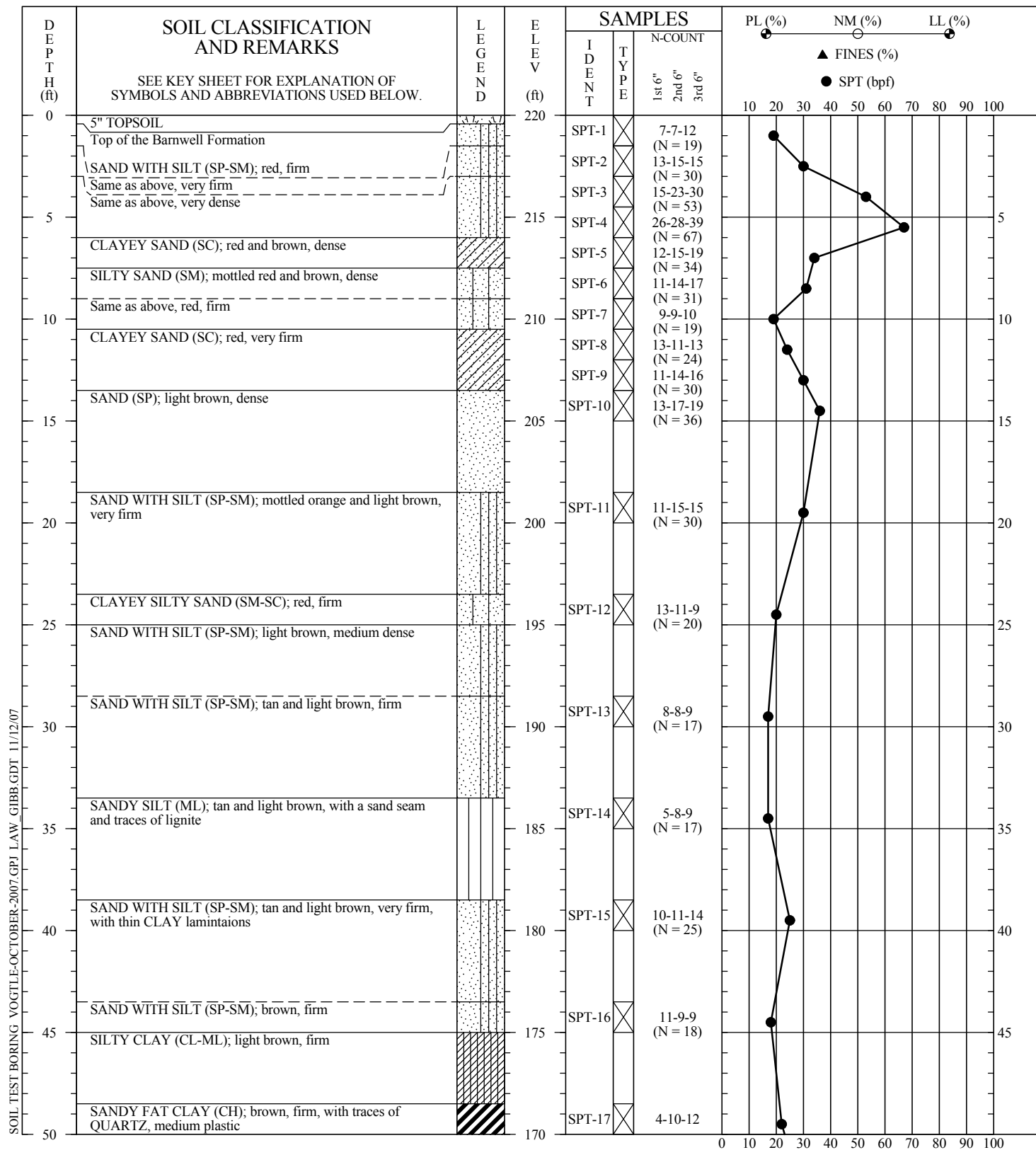
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1007  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** August 30, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7670.93, E 7996.15 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/2/05  
 ELEVATION (ft) = 219.51  
 ELEVATION DATUM = NAVD 88

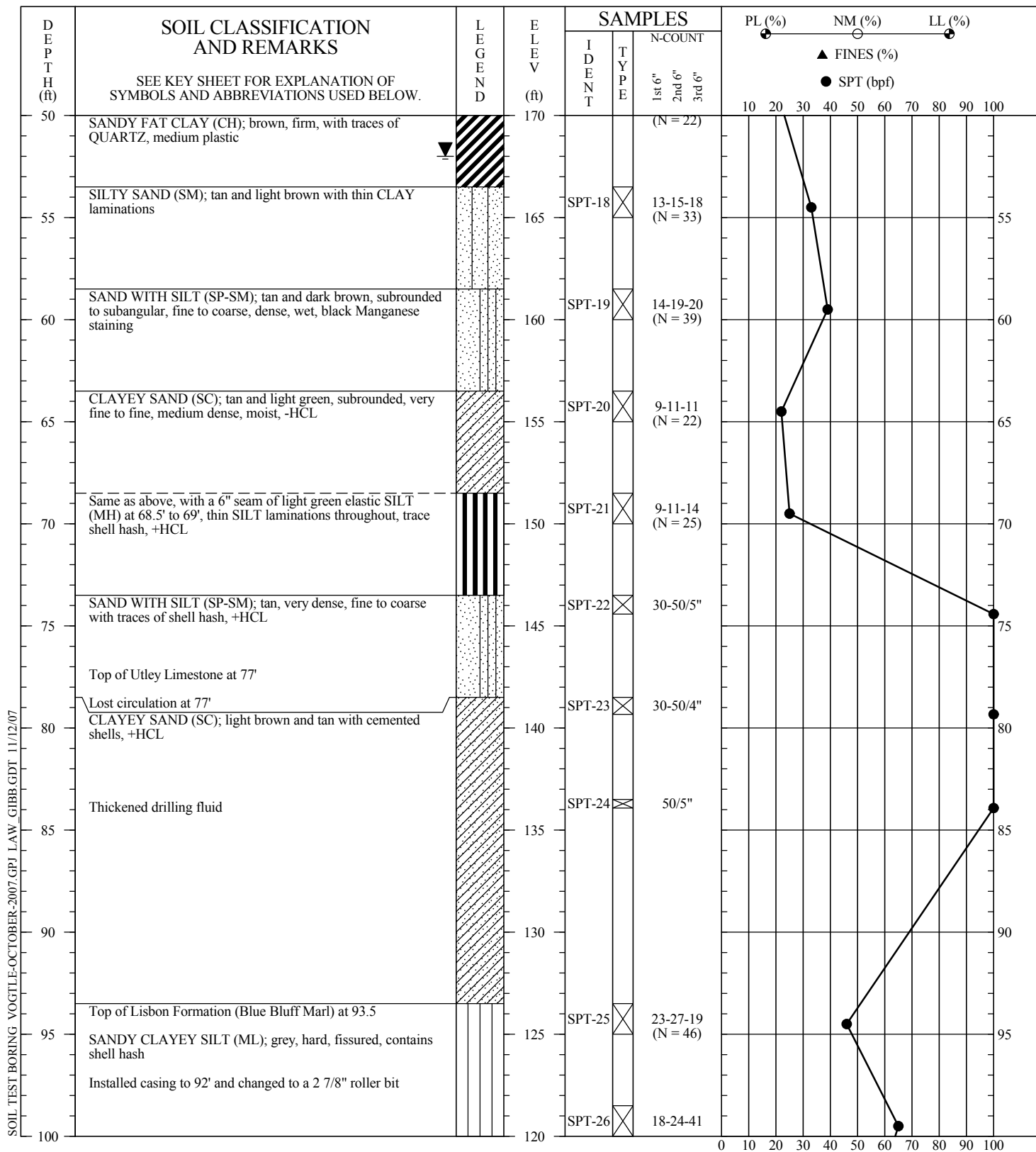
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1008  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

PAGE 1 OF 3





DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7670.93, E 7996.15 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/2/05

ELEVATION (ft) = 219.51  
 ELEVATION DATUM = NAVD 88

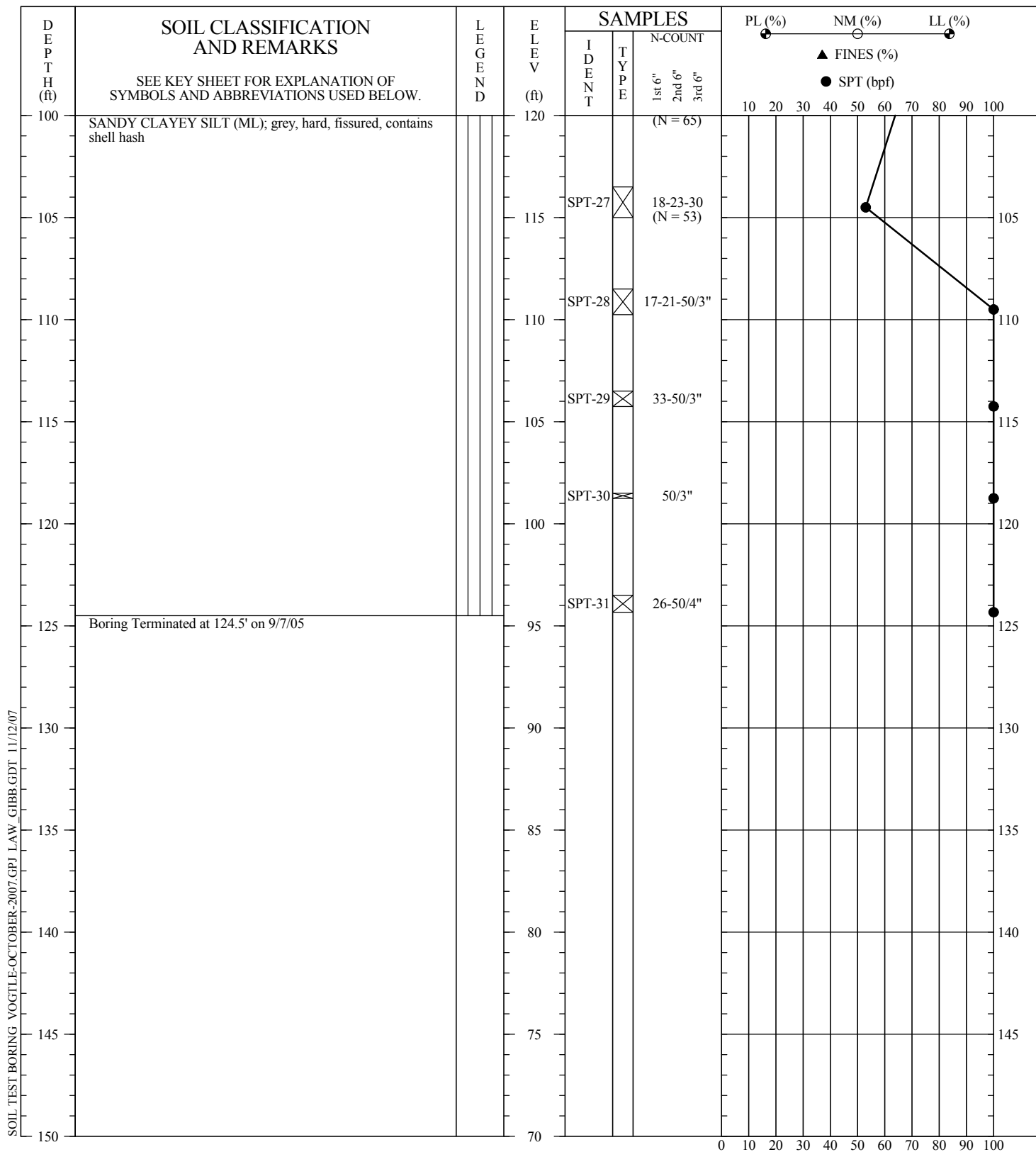
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1008  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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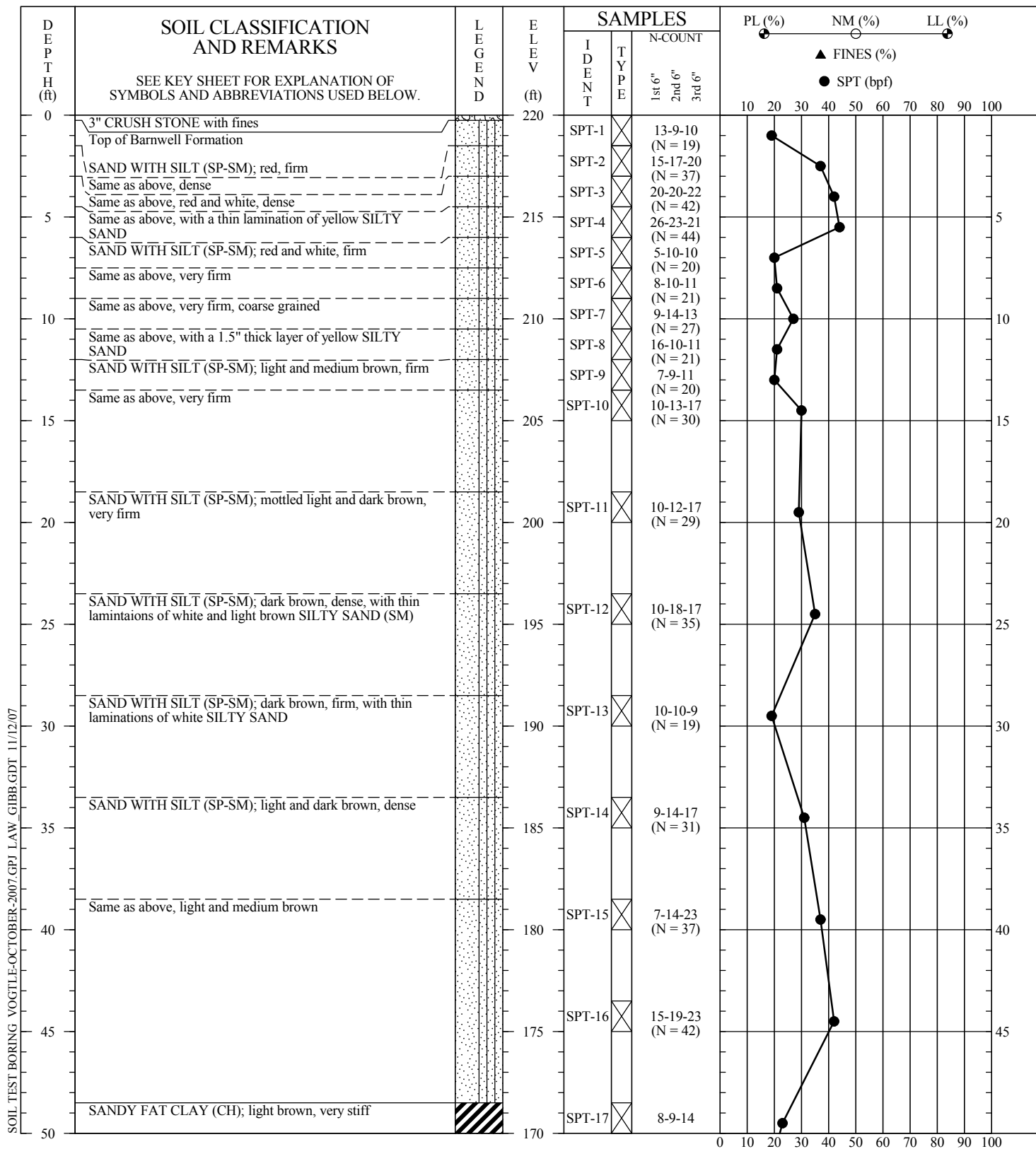




DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 7670.93, E 7996.15 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/2/05  
  
 ELEVATION (ft) = 219.51  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

SOIL TEST BORING RECORD	
<b>BORING NO.:</b>	B-1008
<b>PROJECT:</b>	ALWR - ESP
<b>LOCATION:</b>	PLANT VOGTLE, BURKE COUNTY, GA
<b>DRILLED:</b>	September 1, 2005
<b>PROJECT NO.:</b>	6141-05-0227
<b>PAGE 3 OF 3</b>	



DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 6000.54, E 6361.26  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 220.39  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

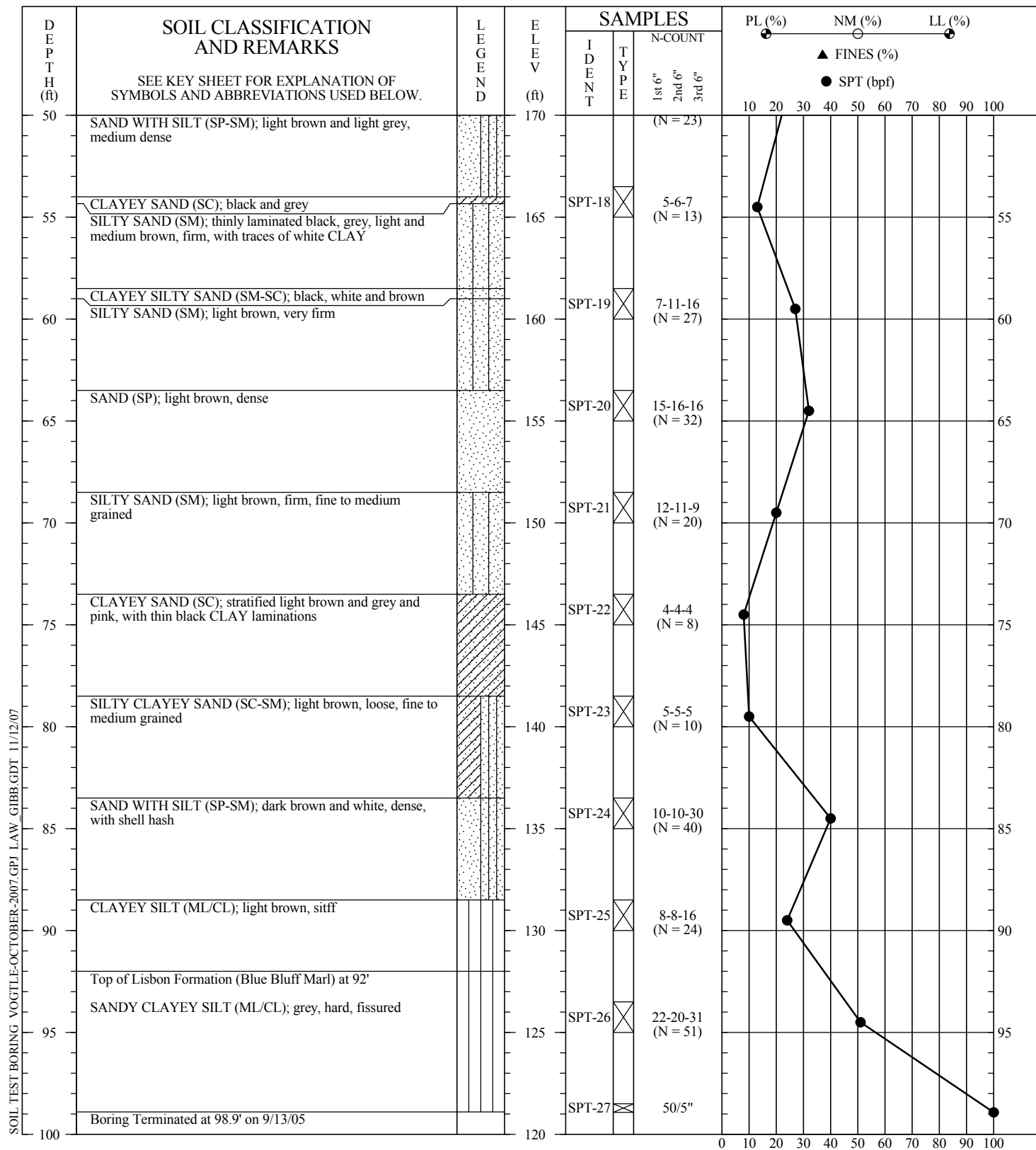
## SOIL TEST BORING RECORD

**BORING NO.:** B-1009  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 13, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 6000.54, E 6361.26  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 220.39  
 ELEVATION DATUM = NAVD 88

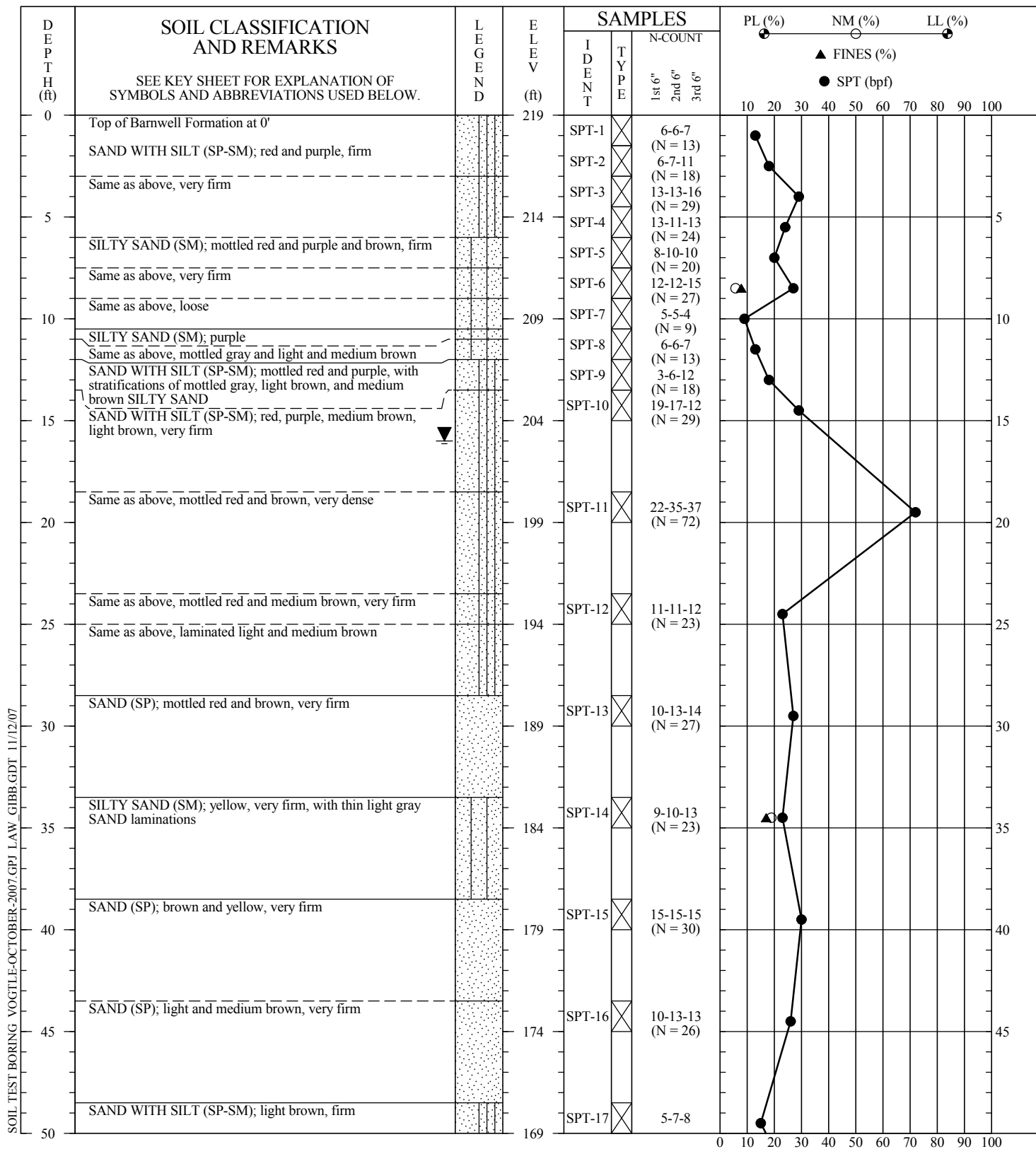
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1009  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 13, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
EQUIPMENT: CME-55 (Auto-Hammer)  
METHOD: Rotary Wash with Mud  
HOLE DIA.: 4 inches  
REMARKS: Plant Grid: N 6000.12, E 7279.68 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/9/05

ELEVATION (ft) = 218.60  
ELEVATION DATUM = NAVD 88

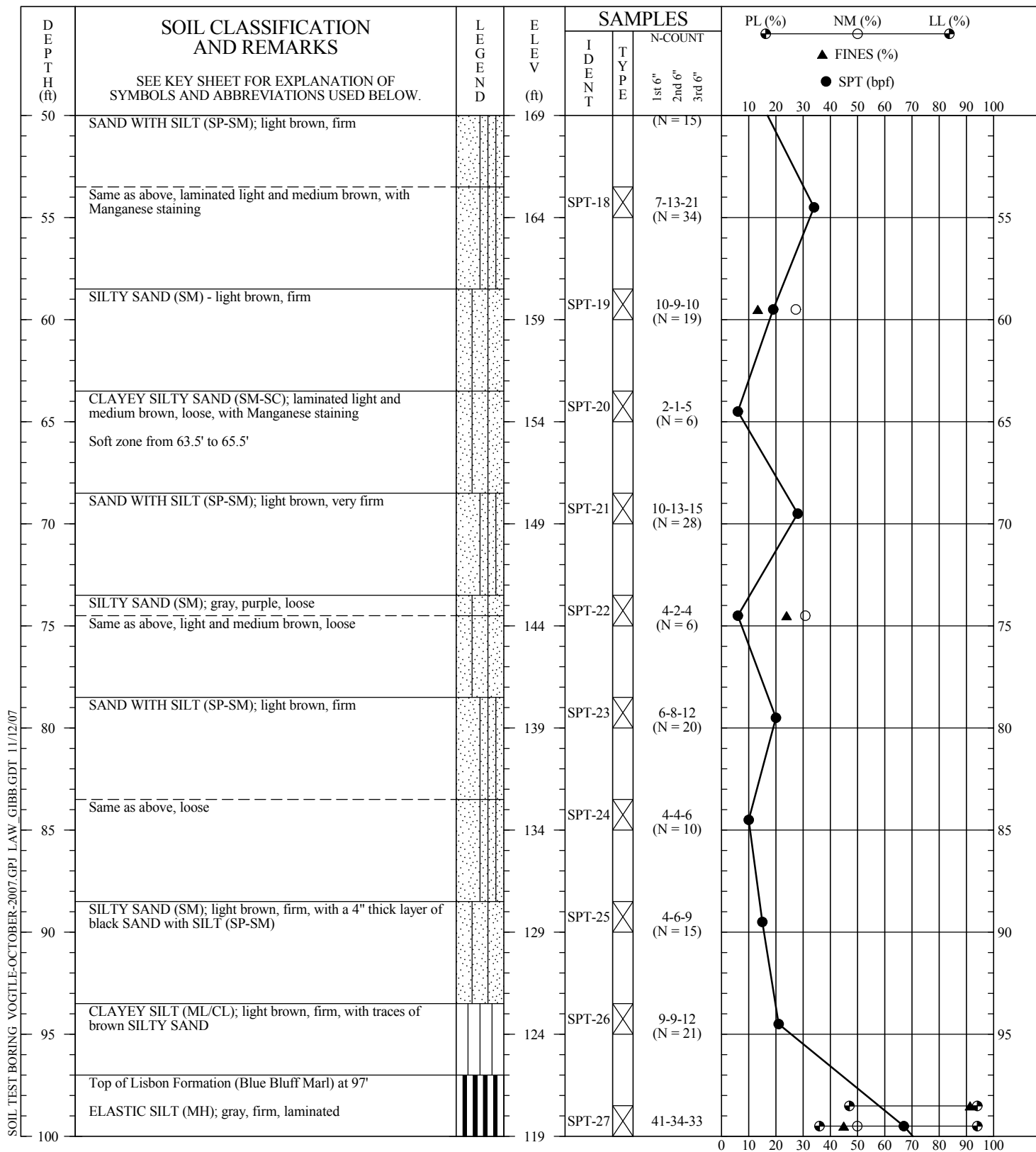
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### SOIL TEST BORING RECORD

**BORING NO.:** B-1010  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 8, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 6000.12, E 7279.68 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/9/05

ELEVATION (ft) = 218.60  
 ELEVATION DATUM = NAVD 88

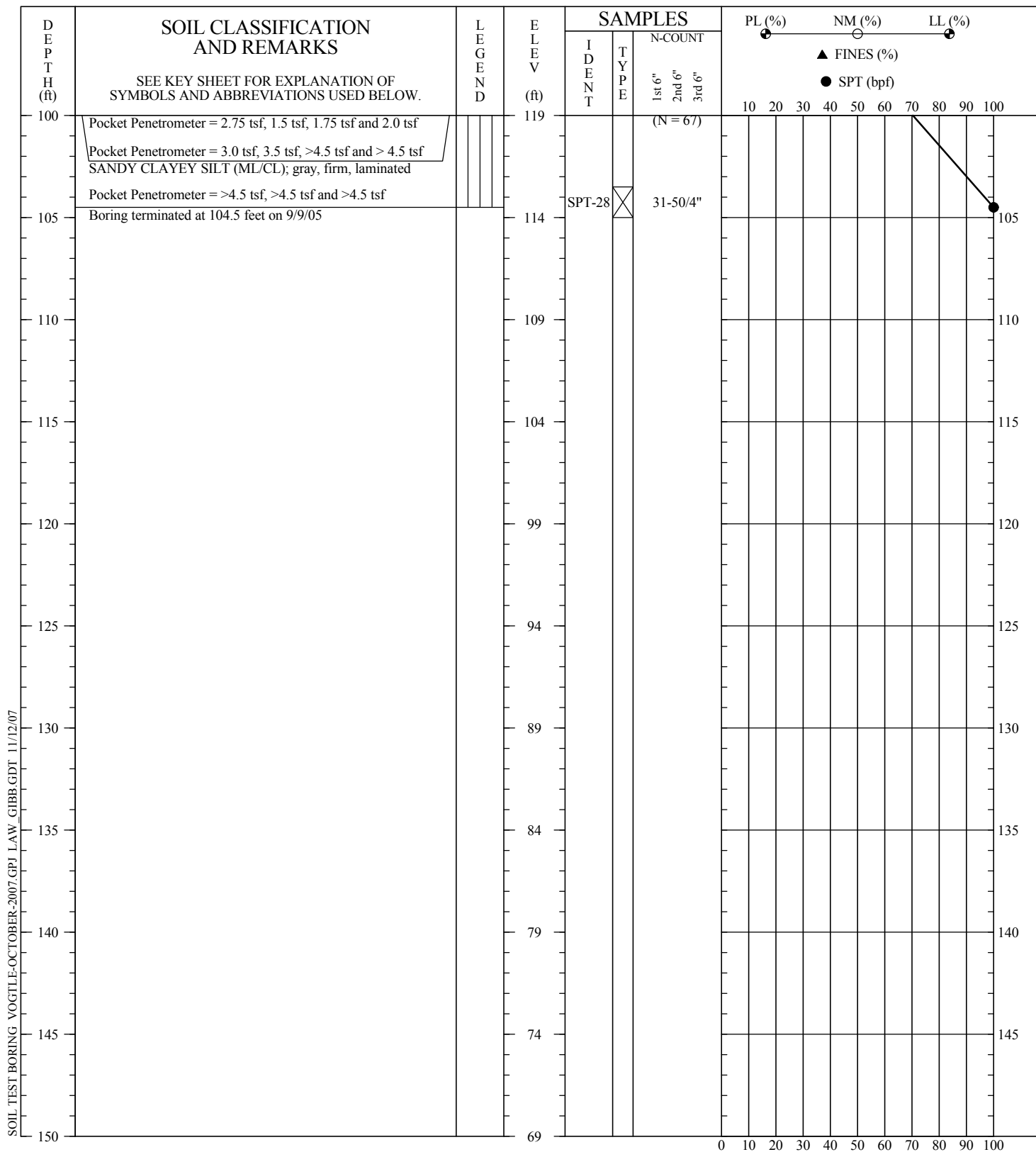
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1010  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 8, 2005  
**PROJECT NO.:** 6141-05-0227


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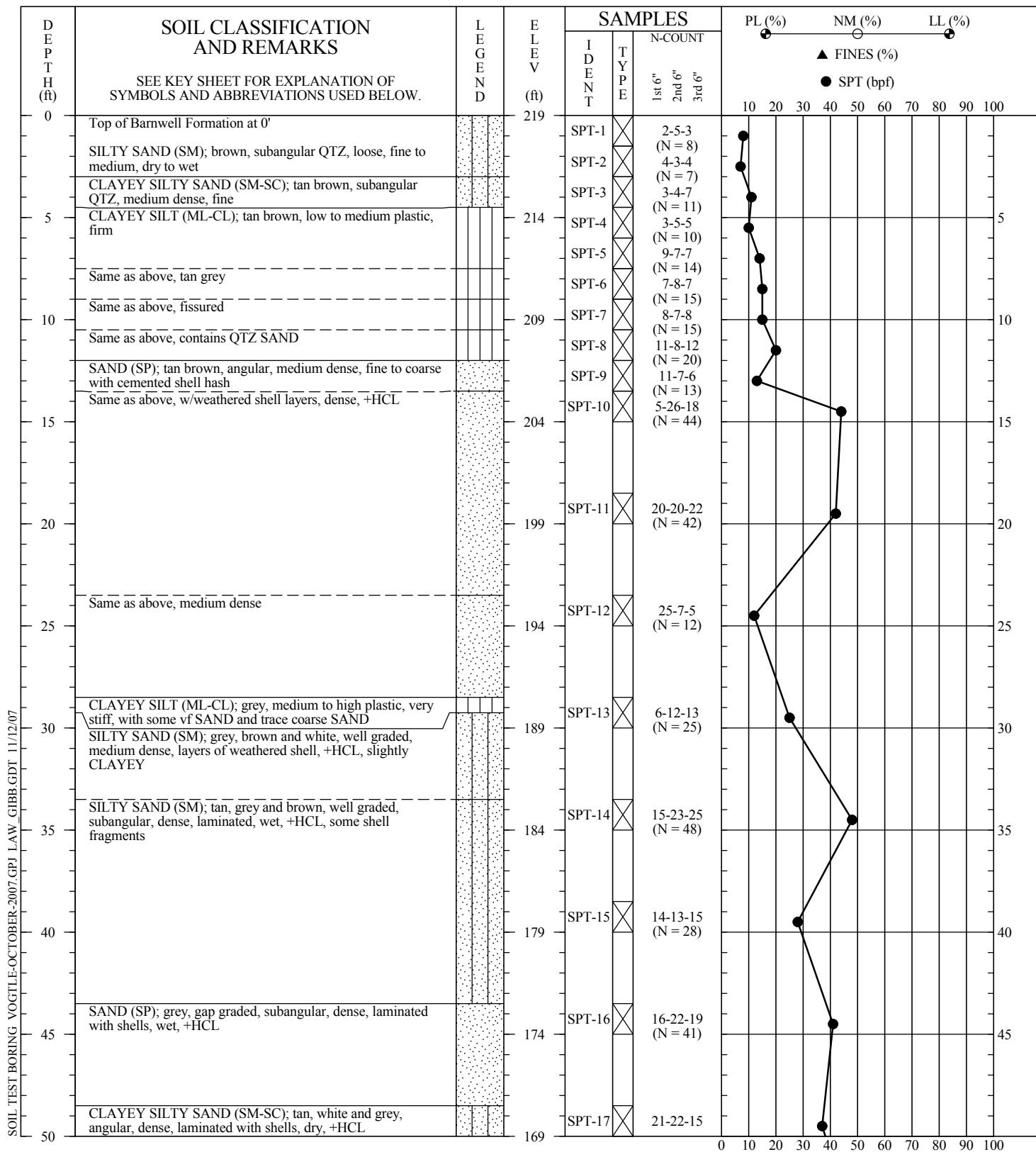




DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 6000.12, E 7279.68 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL Water depth represents depth of water and mud as measured on 9/9/05  
  
 ELEVATION (ft) = 218.60  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

SOIL TEST BORING RECORD	
<b>BORING NO.:</b>	B-1010
<b>PROJECT:</b>	ALWR - ESP
<b>LOCATION:</b>	PLANT VOGTLE, BURKE COUNTY, GA
<b>DRILLED:</b>	September 8, 2005
<b>PROJECT NO.:</b>	6141-05-0227
<b>PAGE 3 OF 3</b>	
	



DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8741.13, E 8378.01  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 219.38  
 ELEVATION DATUM = NAVD 88

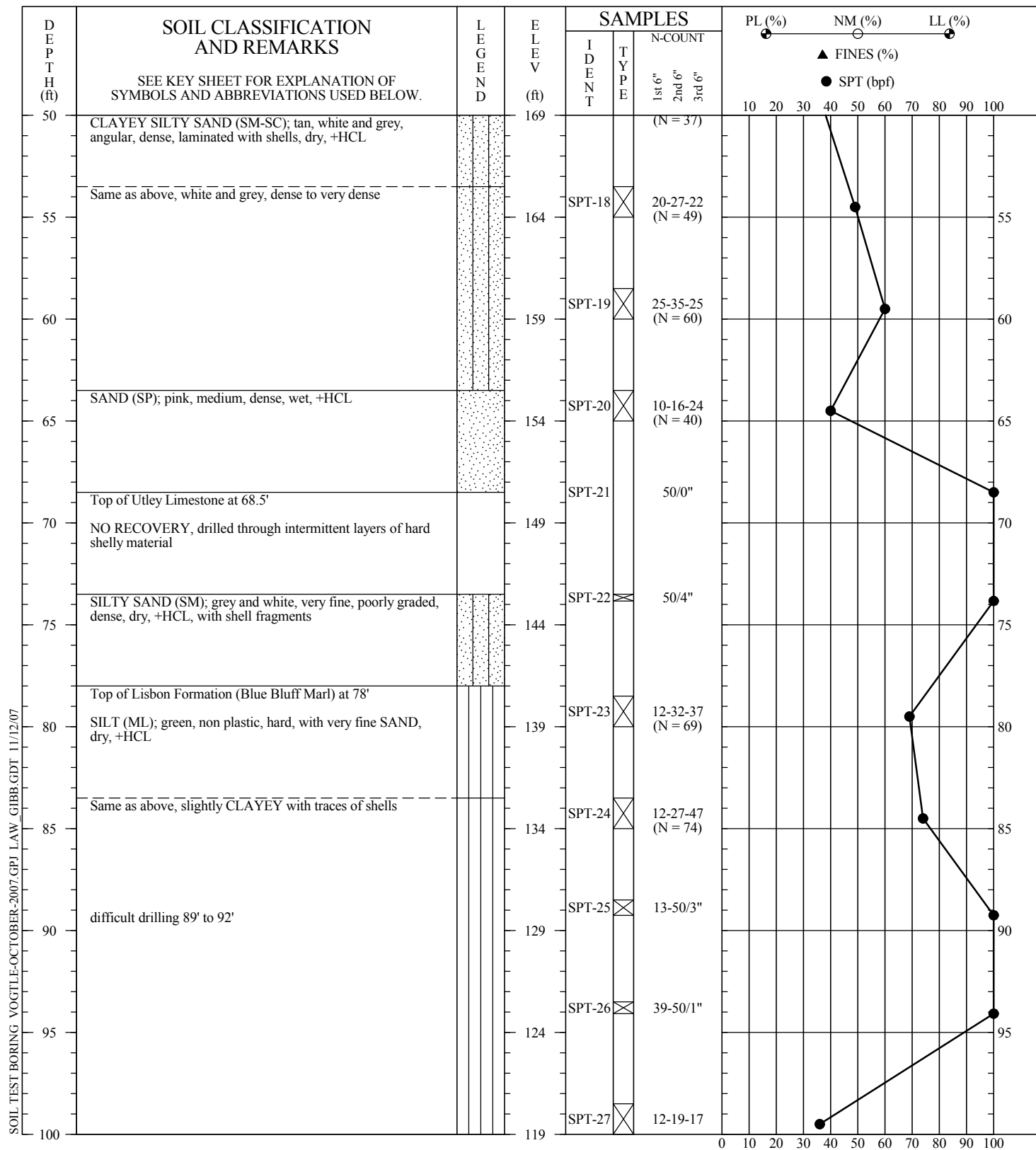
THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

## SOIL TEST BORING RECORD

**BORING NO.:** B-1011  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8741.13, E 8378.01  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 219.38  
 ELEVATION DATUM = NAVD 88

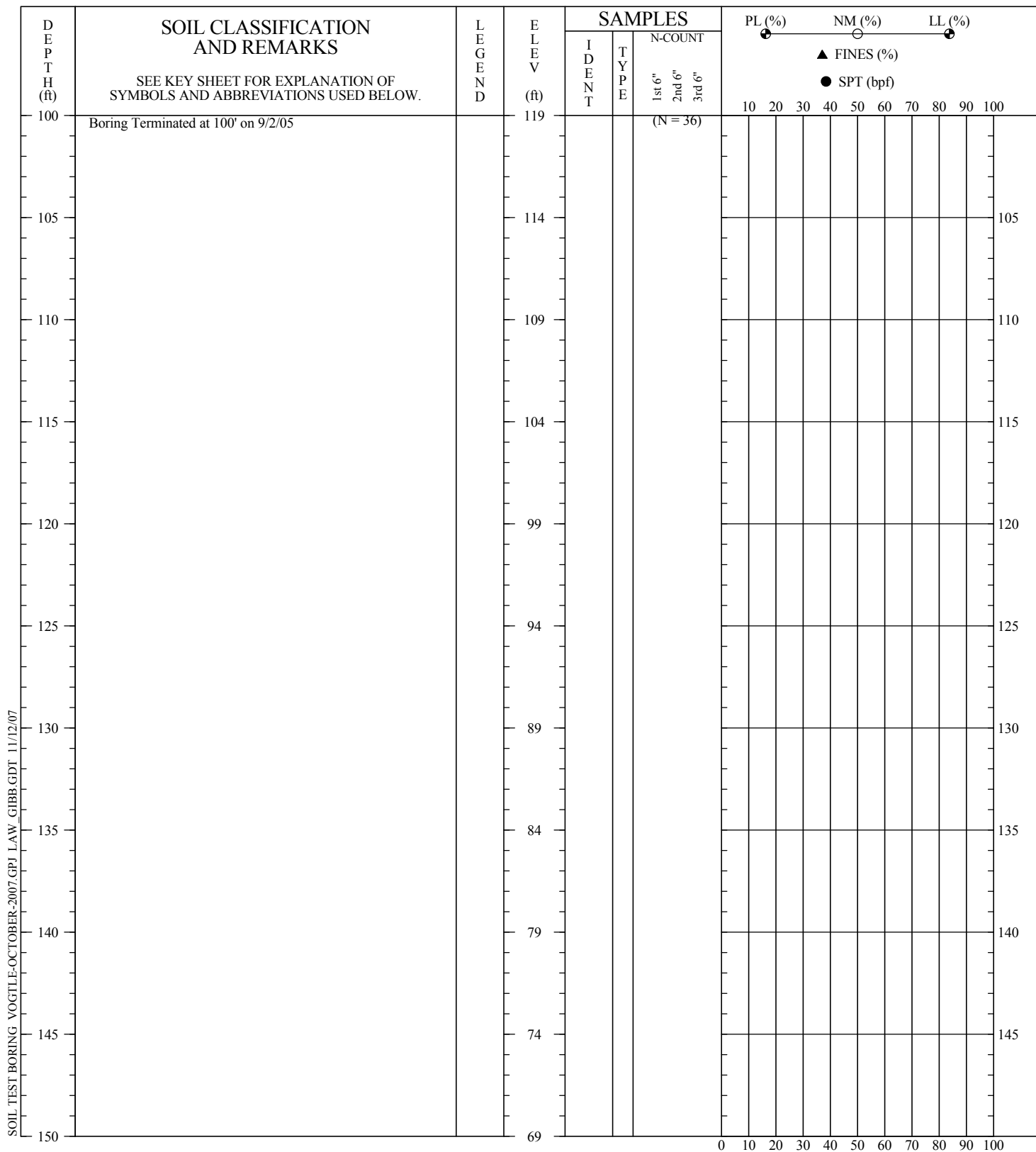
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## SOIL TEST BORING RECORD

**BORING NO.:** B-1011  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 8741.13, E 8378.01  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 219.38  
 ELEVATION DATUM = NAVD 88

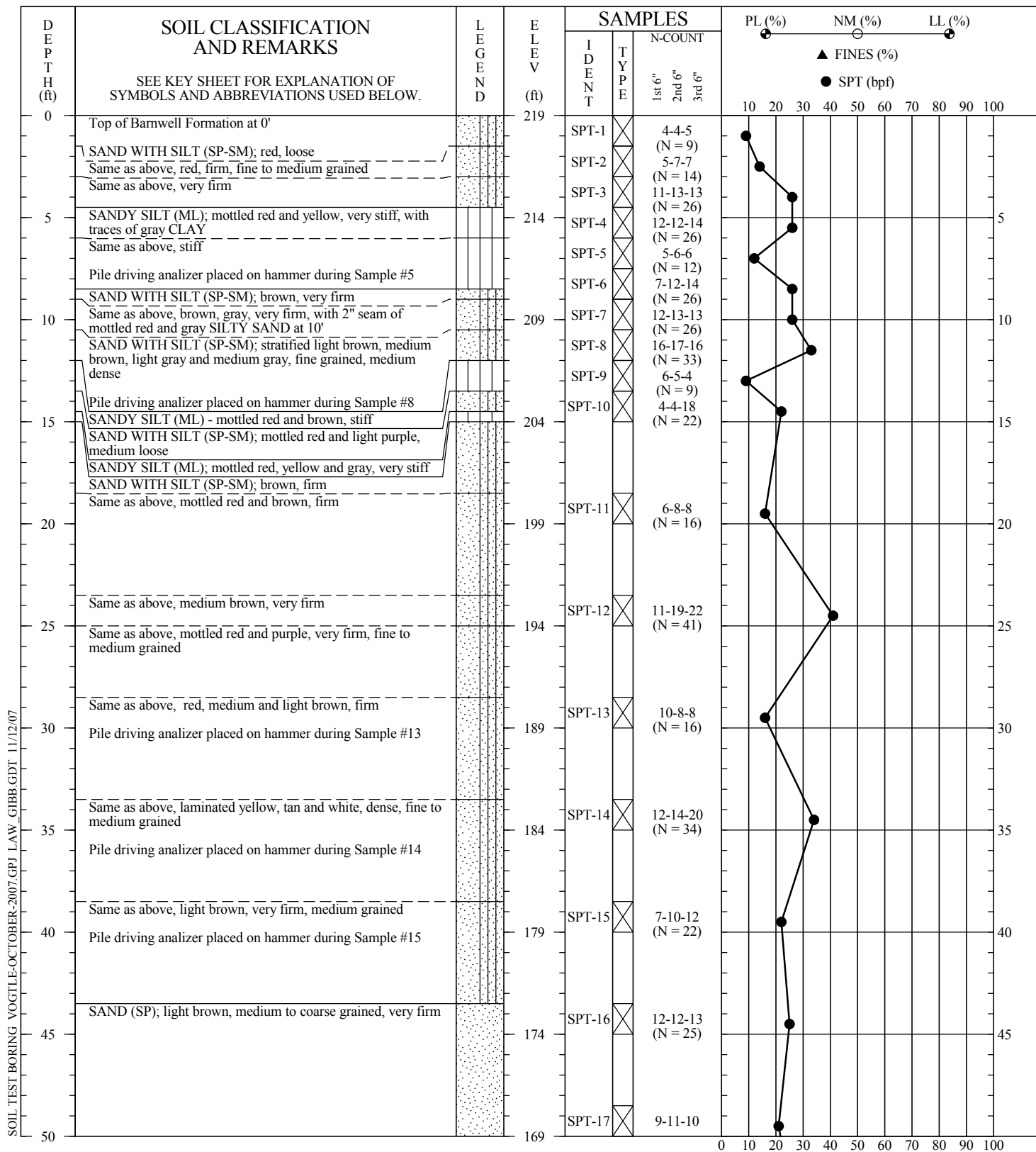
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### SOIL TEST BORING RECORD

**BORING NO.:** B-1011  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 1, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 5976.08, E 8272.50  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 218.62  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

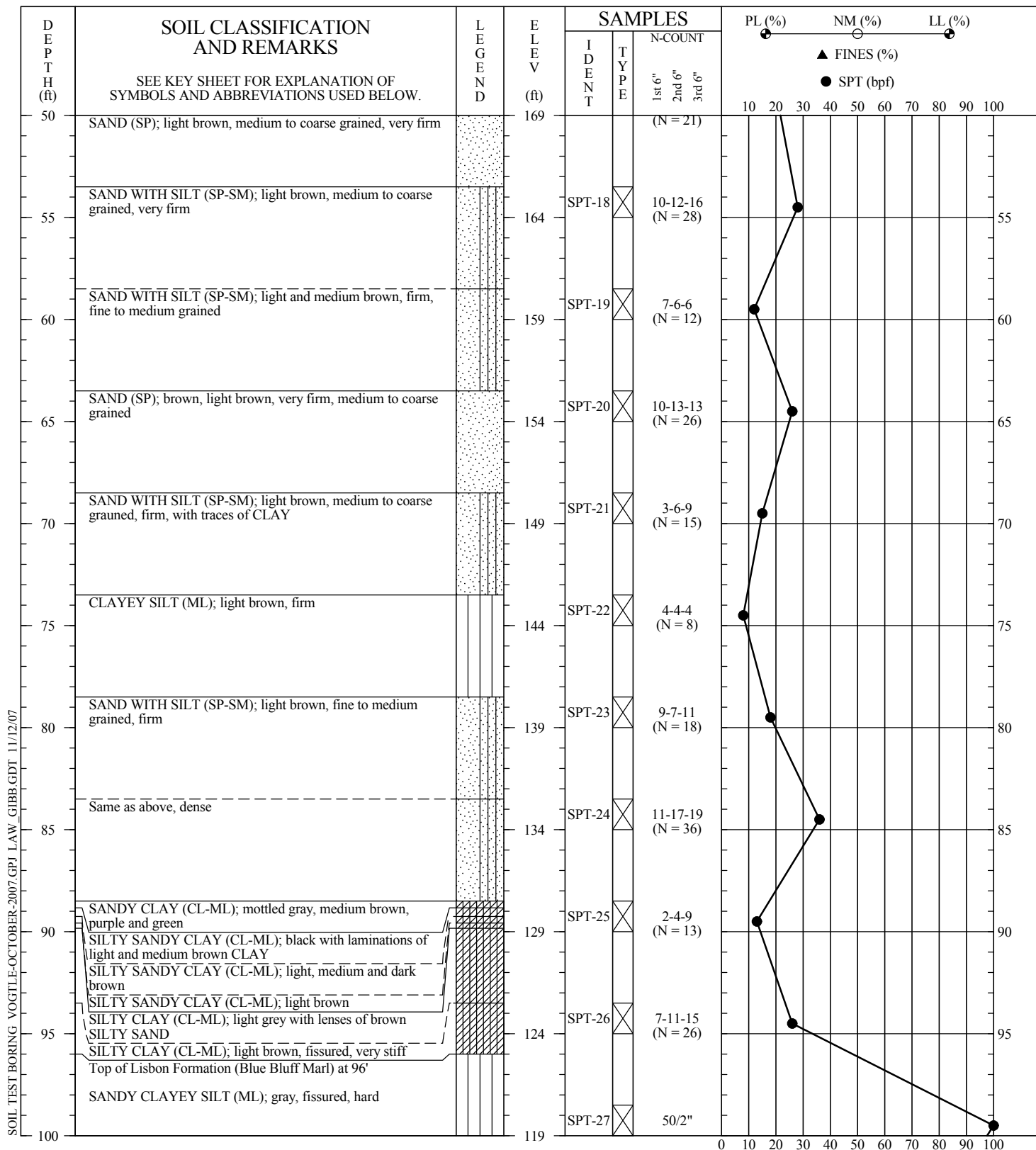
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**BORING NO.:** B-1013  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 7, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 5976.08, E 8272.50  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 218.62  
 ELEVATION DATUM = NAVD 88

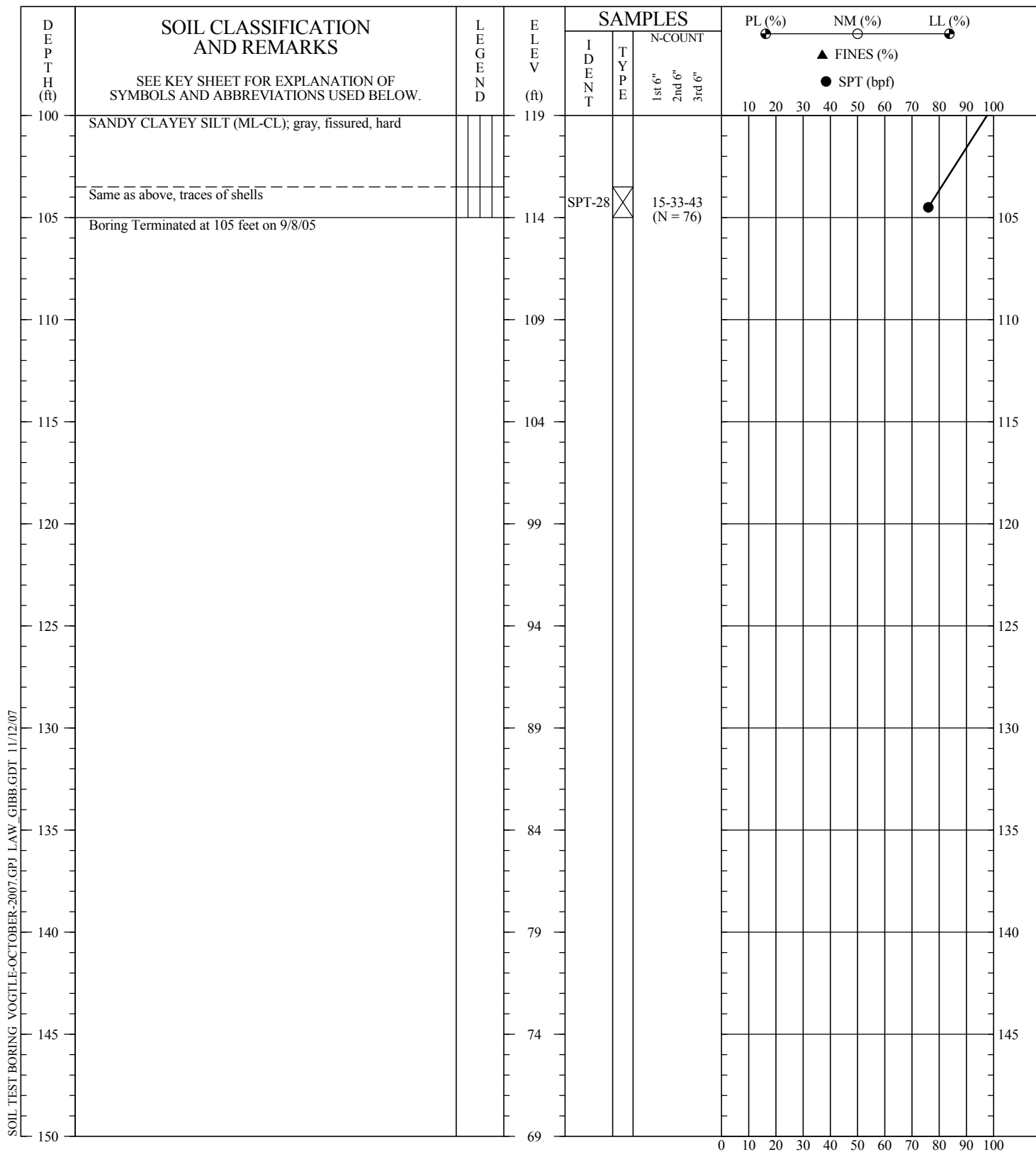
THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

## SOIL TEST BORING RECORD

**BORING NO.:** B-1013  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 7, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Robert Banks (MACTEC)  
 EQUIPMENT: CME-55 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 4 inches  
 REMARKS: Plant Grid: N 5976.08, E 8272.50  
 +HCL denotes a visible reaction with Hydrochloric Acid (HCL), -HCL denotes no visible reaction with HCL

ELEVATION (ft) = 218.62  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

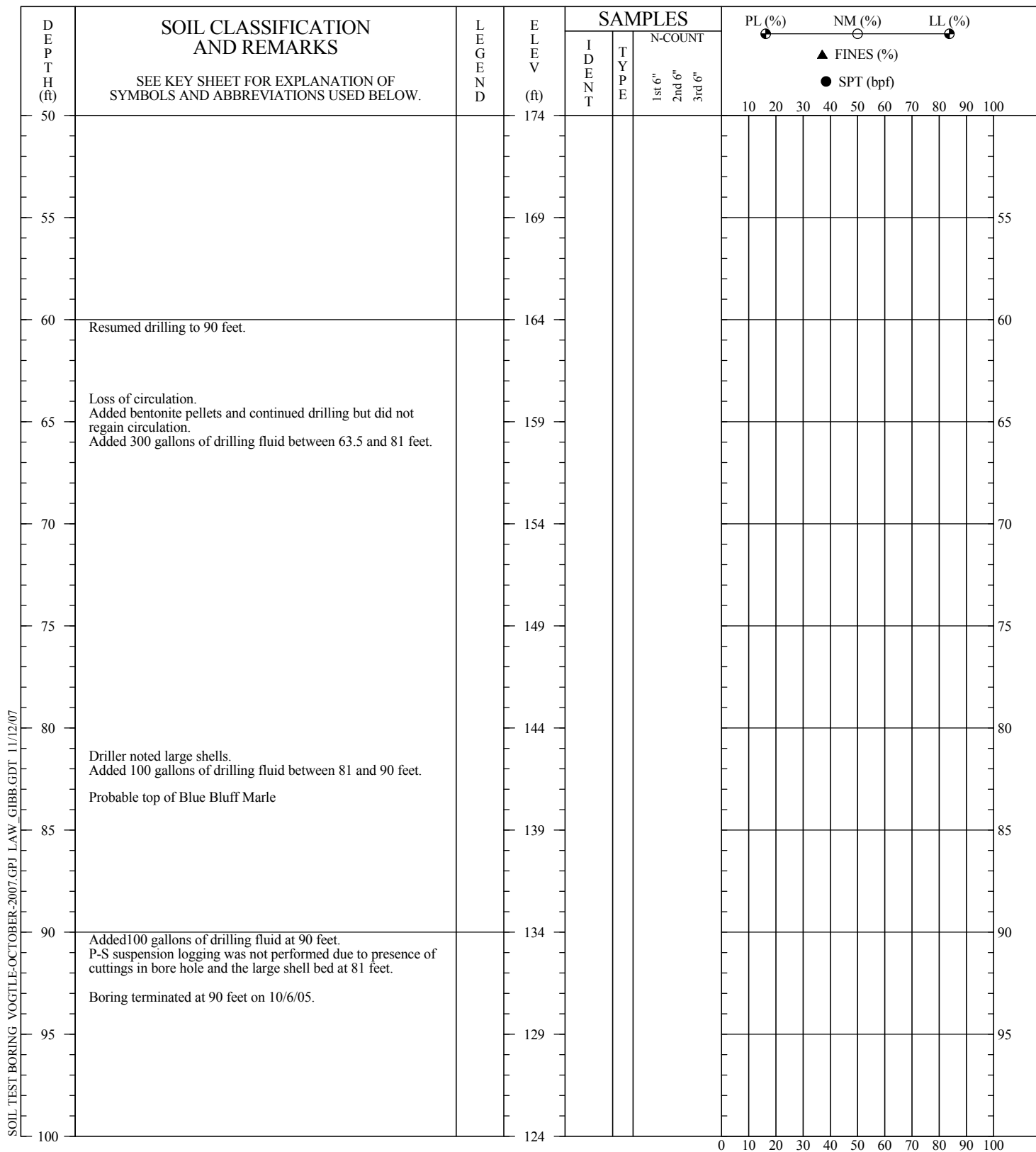
### SOIL TEST BORING RECORD

**BORING NO.:** B-1013  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** September 7, 2005  
**PROJECT NO.:** 6141-05-0227

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DRILLER: Jimmy Oglesby (MACTEC)  
 EQUIPMENT: CME-75 (Auto-Hammer)  
 METHOD: Rotary Wash with Mud  
 HOLE DIA.: 6 inches  
 REMARKS: Plant Grid: N 7989.75, E 8179.26  
 Boring is offset 7 feet SSE from C-1005.

ELEVATION (ft) = 223.66  
 ELEVATION DATUM = NAVD 88

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT  
 THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND  
 AT OTHER TIMES MAY DIFFER. INTERFACES BETWEEN STRATA ARE APPROXIMATE.  
 TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

## SOIL TEST BORING RECORD

**BORING NO.:** C-1005A  
**PROJECT:** ALWR - ESP  
**LOCATION:** PLANT VOGTLE, BURKE COUNTY, GA  
**DRILLED:** October 6, 2005  
**PROJECT NO.:** 6141-05-0227

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# **APPENDIX B**

**CPT TESTING REPORT FROM  
APPLIED RESEARCH SERVICES**



**CONE PENETRATION TESTING  
SUBSURFACE INVESTIGATION FOR SOUTHERN NUCLEAR  
OPERATING COMPANY, INC.**

**ADVANCED LIGHT WATER REACTOR EARLY SITE PERMIT**

**ALVIN W. VOGTLE NUCLEAR PLANT  
WAYNESBORO, GEORGIA**

**Prepared for:**

**MACTEC Engineering and Consulting, Inc.  
396 Plasters Avenue  
Atlanta, Georgia**

**Prepared by:**

**Applied Research Associates, Inc.  
New England Division  
415 Waterman Road  
South Royalton, Vermont 05068**

**ARA Report No. 17087**

**February 10, 2006**

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## **SECTION 1**

### **CONE PENETROMETER TESTING SUBSURFACE INVESTIGATION FOR ALVIN W. VOGTLE NUCLEAR PLANT WAYNESBORO, GEORGIA**

#### **SOUTHERN NUCLEAR OPERATING COMPANY, INC. ADVANCED LIGHT WATER REACTOR EARLY SITE PERMIT INVESTIGATION**

## **INTRODUCTION**

Applied Research Associates, Inc. (ARA) under contract to MACTEC Engineering and Consulting, Inc., conducted Electric Cone Penetration Tests with seismic measurements (S-CPT) in support of the subsurface investigation for Southern Nuclear Operating Company, Inc.'s Alvin W. Vogtle Nuclear Plant's Advanced Light Water Reactors Early Site Permit, in Waynesboro, Georgia. This report documents ARA's site investigation efforts, test techniques, and analysis of the data for fieldwork conducted September 1 through September 8, 2005. Presented in this report are the field-testing methods, data analysis techniques, and hardcopies of the test results.

## **TEST LOCATIONS**

Twelve cone penetrometer test soundings were conducted at the site. Two additional soundings (C-1001A and C-1009A) from were offset and conducted due to shallow refusal at (C-1001 and C-1009). All the soundings were advanced from ground surface. Tip stress, sleeve stress, and penetration pore pressure were measured in all the CPTs. Seismic shear wave measurements were obtained at five-foot intervals at three locations. Compression wave measurements were not obtained as part of this investigation.

Table 1 lists the penetrations and relevant information about each location. All locations were grouted upon retraction of the rod string using a standard tremie grout method. The surveyed coordinates and elevations for all CPTs are listed on Figure 1. MACTEC Engineering and Consulting, Inc. provided the site map and survey data.

## **REPORT OUTLINE**

This report is organized into 4 Sections and 3 Appendices. Section 2 discusses the CPT

equipment, field procedures, and daily calibrations. Section 3 describes the methods used to interpret the CPT results. Section 4 lists references. Appendix A presents the piezo-cone data. Seismic test wave histories and velocities are located in Appendix B. Appendix C contains pore pressure dissipation plots and a summary of these data, along with estimated values of constrained modulus, coefficient of lateral consolidation, and coefficient of lateral permeability.

**Table 1. Summary of CPT testing at the Alvin W. Vogtle Nuclear Plants Subsurface Investigation**

**Project :** MACTEC Engineering & Consulting, Inc.  
Southern Nuclear Operating Company, inc.  
Advanced Light Water Reactor Early Site Permit

Probe  
Diameter: 1.75 (in)

Test ID	Surface Elevation (ft)	Predrilled Depth	Depth of CPT (ft)	Seismic CPT	Water Table Depth (ft)	Water Table Elev (ft)	Test Depth (ft)	Test Elev (ft)	Static Pressure (psi)	Maximum Pressure (psi)	50 % Pressure (psi)	Tip Stress (tsf)	Tip Stress (psi)	Alpha	Constrained Modulus (psi)	Time 50% (min)	Lateral Consolidation (in2/s)	Lateral Consolidation (cm2/sec)	Lateral Permeability (cm/s)
C-1001	248.57	0.0	13.0	No	NA	NA	NA	NA											
C-1001A	248.57	0.0	116.7	No	NA	NA	NA	NA											
C-1002	222.13	0.0	78.5	No	NA	NA	NA	NA											
C-1003	219.80	0.0	80.0	Yes	44.6	175.20	68.31	151.5	10.3	10.45	10.4	487.3	6768.1	1.0	6768.1	0.09	7.80E-01	5.03E+00	1.06E-05
C-1003	219.80	0.0	80.0	Yes	51.8	168.00	79.07	140.7	11.8	13.68	12.7	198.1	2751.4	1.0	2751.4	1.0	6.95E-02	4.48E-01	2.32E-06
C-1004	220.82	0.0	77.0	No	NA	NA	66.25	154.6	NA	317.44	158.72	43.3	601.4	1.0	601.39	10.61	6.61E-03	4.27E-02	1.01E-06
C-1005	223.81	0.0	82.0	Yes	34.01	189.80	56.08	167.7	9.6	86.59	48.1	12.0	166.7	1.0	166.67	4.44	1.58E-02	1.02E-01	8.70E-06
C-1005	223.81	0.0	82.0	Yes	47.84	175.97	73.14	150.7	11.0	75.19	43.1	12.5	173.6	1.0	173.6	8.37	8.38E-03	5.41E-02	4.43E-06
C-1005	223.81	0.0	82.0	Yes	NA	NA	81.97	141.8											
C-1006	222.80	0.0	74.0	No	NA	NA	NA	NA											
C-1007	222.81	0.0	81.7	No	NA	NA	NA	NA											
C-1008	221.30	0.0	76.0	No	NA	NA	NA	NA											
C-1009	218.93	0.0	6.0	Yes	NA	NA	NA	NA											
C-1009A	218.93	0.0	99.0	Yes	49.97	168.96	60.12	158.8	4.4	4.45	4.4	128.6	1786.1		1786.1				
C-1009A	218.93	0.0	99.0	Yes	49.53	169.40	77.04	141.9	11.9	11.96	11.9	292.7	4065.3		4065.28				
C-1009A	218.93	0.0	99.0	Yes	NA	NA	90.07	128.9	39.0	283.76	141.88	68.2	1.89	1.0	947.22	16.28	4.31E-03	2.78E-02	4.17E-07
C-1009A	218.93	0.0	99.0	Yes	44.9	15.97	99.07	119.9	23.5	710.47	367.0	140.3	1948.6	1.0	1948.61	2.31	3.04E-02	1.96E-01	1.43E-06
C-1010	219.06	0.0	96.0	No	NA	NA	NA	NA	0.0										

**Note 1:** Dissipation analysis conducted on profiles exhibiting classic dissipation profile only.

**Note 2:** Dissipation tests C-1005.82, C-1009A-60, and C-1009A-77 exhibit a dilating condition not appropriate for permeability estimate.

MACTEC Engineering and Consulting, Inc.  
and  
Bechtel Corporation, Inc.

September 1 - 8, 2005

Alvin W. Vogtle Nuclear Plant  
Cone Penetrometer Testing (CPT) Geotechnical Investigation

Southern Nuclear Operating Company, Inc.  
Waynesboro, Georgia

Test Identification	Type of Test	ARA Filename	Northing	Easting	Elevation	Final Depth
C-1001	PCPT	202S0503	8028.12	6355.96	248.57	13.00
C-1001A	PCPT	202S0504	NA	NA	NA	116.70
C-1002	PCPT	206S0501	7667.64	6574.64	222.13	78.50
C-1003	SCPT	207L0506	7669.31	7477.87	219.80	80.00
C-1004	PCPT	201S0501	7646.13	8361.84	220.82	77.00
C-1005	SCPT	208S0501	7995.26	8174.60	223.81	82.00
C-1006	PCPT	201S0504	8001.46	7261.58	222.80	74.00
C-1007	PCPT	202S0502	8270.62	8055.05	222.81	81.70
C-1008	PCPT	202S0501	8268.48	6930.89	221.30	76.00
C-1009	SCPT	207S0501	5979.62	6798.49	218.93	6.00
C-1009A	SCPT	207S0505	NA	NA	NA	99.00
C-1010	PCPT	208S0502	6008.34	7754.15	219.06	96.00

**Note:** PCPT: Peizo-Cone Penetrometer Test; SCPT: Seismic Cone Penetrometer Test;  
CPT locations C-1001A and C-1009A were offset by approximately 5-10 feet due to refusal. MACTEC to provide elevations and coordinates for these soundings.

**Figure 1. CPT Locations Table**

## **SECTION 2**

### **TESTING EQUIPMENT AND PROCEDURES**

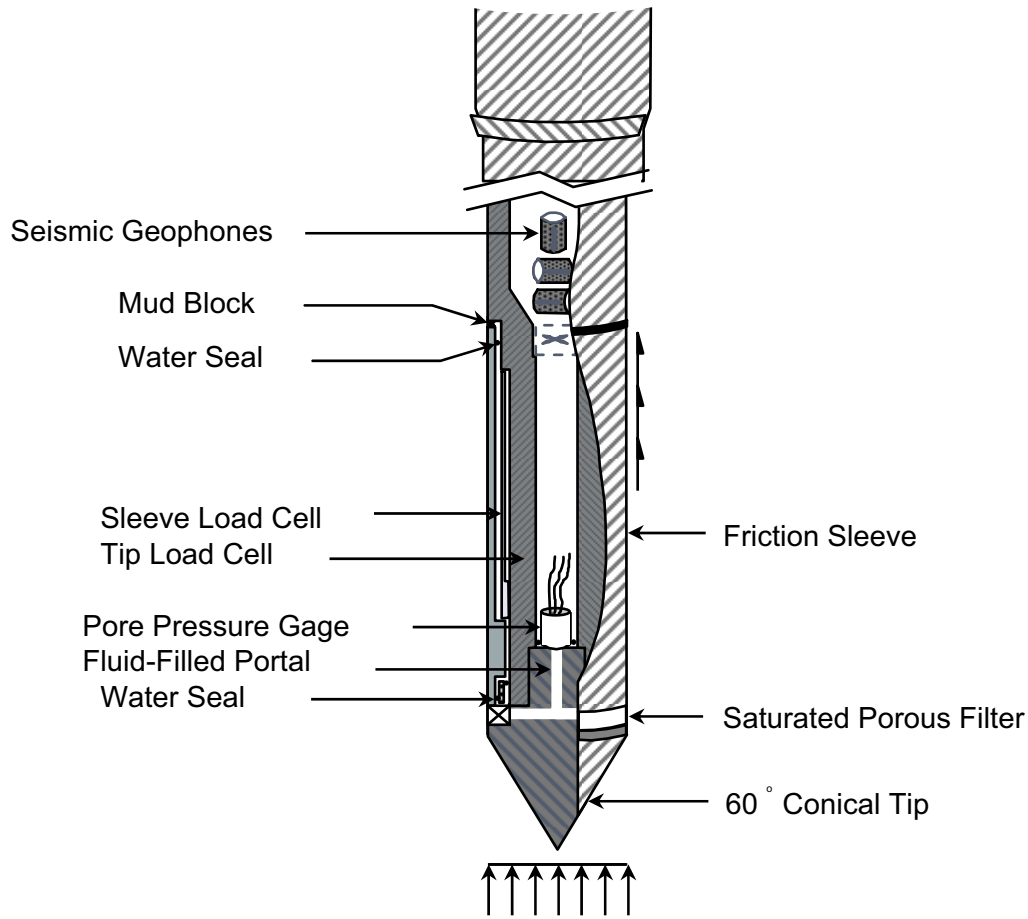
#### **INTRODUCTION**

The electric cone penetrometer test (CPT) was originally developed for use in soft soil. Over the years, cone and push system designs have evolved to the point where they can now be used in strong cemented soils and even soft rock. ARA's penetrometer consists of an instrumented probe that is forced into the ground using a hydraulic load frame mounted on a heavy truck with the weight of the truck providing the necessary reaction mass. The probe has a conical tip and a friction sleeve that independently measure vertical resistance beneath the tip as well as frictional resistance on the side of the probe as a function of depth. A schematic view of ARA's penetrometer probe is shown in Figure 2. A pressure transducer in the cone is used to measure the pore water pressure as the probe is pushed into the ground (P-CPT). This probe also includes three geophones aligned along the X, Y, and Z-axis for measuring shear and compressional waves velocities.

#### **PIEZO-ELECTRIC CONE PENETROMETER EQUIPMENT AND TEST**

The cone penetrometer tests were conducted using the ARA penetrometer truck (Mack 1). The penetrometer equipment is mounted inside a van body attached to a ten-wheel truck chassis. Ballast in the form of weights is added to the truck to achieve an overall push capacity of 60,000 lbs. Penetration force is supplied by a pair of large hydraulic cylinders bolted to the truck frame. If the push cylinders measure 15,000 to 20,000 pounds per square inch (psi), ARA's crew chief may declare a sounding refusal. Multiple attempts to penetrate the identified stratigraphy will be conducted prior to abandoning the sounding within the subject area.

A 15-cm<sup>2</sup> penetrometer probe (which has 1.75-inch diameter, 60° conical tip, and a 1.75-inch diameter by 6.5-inch long friction sleeve) was used on this project. This probe size is in conformance with ASTM D 5778 (Ref. 1). The shoulder between the base of the tip and the porous filter, shown in Figure 2, is 0.08 inch long. The penetrometer is advanced vertically into the soil at a constant rate of 48 inches/minute (2 cm/second), although this rate must sometimes be reduced as hard layers are encountered. The electric cone penetrometer test is conducted in accordance with ASTM D 5778 (Ref. 1).



**Figure 2. Schematic of ARA's Piezo-Electric Cone Penetrometer**

Inside the probe, two load cells independently measure the vertical resistance against the conical tip and the side friction along the sleeve. Each load cell is a cylinder of uniform cross section instrumented with four strain gages in a full-bridge circuit. The forces are sensed by the load cells and the data are transmitted from the probe assembly via a cable running through the push rods. The analog data are digitized, recorded, and plotted by computer in the penetrometer truck. A set of data is normally recorded each second, for a minimum resolution of about one data point every 0.8 inch of cone advance. The depth of penetration is measured using a string

potentiometer mounted on the push frame.

Electronic data acquisition equipment for the cone penetrometer consists of a computer with a graphics monitor and eight signal conditioners. Analog signals are transmitted from the probe to the signal conditioners where the CPT data are amplified and filtered at 1 Hz. Once amplified, the analog signals are transmitted to a high-speed analog-to-digital converter board, where the signals are digitized, usually at the rate of one sample per second for the penetration data. The digital data are then read into memory and written to the internal hard disk for future processing. Upon completion of the test, the penetration data are plotted. The digital data are brought to ARA's New England Division in South Royalton, Vermont, for analysis and preparation of report plots.

### **Saturation of the Piezo-Cone**

Penetration pore pressure is measured with a pressure transducer located behind the tip in the lower end of the probe. Water pressures in the soil are sensed through a 250 micro-inch porous polyethylene filter that is 0.25-inch high and 0.202-inch thick. The pressure transducer is connected to the porous filter through a fluid-filled pressure port as shown in Figure 2.

In order for the pressure transducer to respond rapidly and correctly to changing pore pressures during the penetration, the filter and pressure port must be saturated with silicone oil upon assembly of the probe. A vacuum pump is used to de-air the silicone oil before use and also to saturate the porous filters with oil. The probe is assembled with the pressure transducer facing upwards and the cavity above the pressure transducer is filled with de-aired oil. A previously saturated filter is then placed on a tip and oil is poured over the threads. When the cone tip is screwed into place, excess oil is ejected through the pressure port and filter, thereby forcing out any trapped air. The high viscosity of the silicone oil, coupled with the small pore space in the filter, prevents the loss of saturation as the cone is pushed through dry soils. Saturation of the cone is verified with a calibration check at the completion of the penetration. Extensive field experience has proven the reliability of this technique.



## **Field Calibrations**

Many factors can effectively change the calibration factors used to convert the raw instrument readouts, measured in volts, to units of force or pressure. As a quality control measure, as well as a check for instrument damage, the load cells and the pressure transducer are routinely calibrated in the field. Calibrations are performed at the start of each day when the probe is ready to insert into the ground so that any factor affecting any component of the instrumentation system will be included and detected during the calibration.

The tip and sleeve load cells are calibrated with the conical tip and friction sleeve in place on the probe. For each calibration, the probe is placed in the push frame and loaded onto a precision reference load cell. The reference load cell is periodically calibrated in ARA's laboratory against instruments traceable to NIST standards. To calibrate the pore pressure transducer, the saturated probe is inserted into a pressure chamber with air pressure supplied by the compressor on the truck. The reference transducer in the pressure chamber is also periodically calibrated against an NIST-traceable instrument in ARA's laboratory. Additionally, the linear displacement transducer used to measure the depth of penetration is periodically checked against a tape measure. All records of device and load cell calibrations are maintained at ARA's New England Division.

Each instrument is calibrated using a specially developed computer code that displays the output from the reference device and the probe instrument in graphical form. During the calibration procedure, the operator checks for linearity and repeatability in the instrument output. At the completion of each calibration, this code computes the calibration factors using a linear regression algorithm. At a minimum, each probe instrument is calibrated at the beginning of each day of field-testing. Furthermore, the pressure transducer is recalibrated each time the porous filter is changed and the cone re-saturated. Calibrations are also performed to verify the operation of any instrument if any damage is suspected.

## **Penetration Data Format**

Figure 3 presents a typical CPT profile from the A.W. Vogtle Nuclear Plant site investigation. This plot presents friction sleeve stress, tip stress, friction ratio, and penetration pore pressure. Additionally, presented on the second page of the plot profile is probe inclination, soil behavior type and stratigraphy based on corrected friction ratio. As shown in Figure 2, the piezo-cone probe senses the pore pressure immediately behind the tip. Currently, there is no accepted standard for the location of the pore pressure sensing element. ARA chose to locate this sensing element behind the tip to protect the filter from the direct thrust of the penetrometer and so that the measured pore pressure can be used to correct the tip resistance data as recommended in Reference 2. The magnitude of the penetration pore pressure is a function of the soil compressibility and, most importantly, permeability. In freely draining soil layers, the measured pore pressures will be very close to the hydrostatic pressure computed from the elevation of the water table. When low permeability soil layers are encountered, excess pore pressures generated by the penetration process cannot dissipate rapidly and this results in measured pore pressures that are significantly higher than the hydrostatic pressures. Whenever the penetrometer is stopped to add another section of push pipe or when a pore pressure dissipation test is run, the excess pore pressure may begin to dissipate. When the penetration is resumed, the pore pressure quickly rises to the level measured before the penetrometer was stopped. This process causes some of the spikes that appear in the penetration pore pressure data.

## **Pore Pressure Correction of Tip Stress**

Cone penetrometers, by necessity, must have a joint between the tip and sleeve. Pore pressure acting behind the tip decreases the total tip resistance that would be measured if the penetrometer was without joints. The influence of pore pressure in these joints is compensated for by using the net area concept (Ref. 2).

The corrected tip resistance is given by:

$$q_t = q_c + u [1 - A_n / A_T] \quad (2.1)$$

where:

- $q_t$  = corrected tip resistance (psi)
- $q_c$  = measured tip resistance (psi)
- $u$  = penetration pore pressure measured behind the tip (psi)
- $A_n$  = net area behind the tip not subjected to the pore pressure (1.897 in<sup>2</sup>)
- $A_T$  = projected area of the tip (2.351 in<sup>2</sup>).

Hence, for the ARA cone design, the tip resistance is corrected as:


$$q_t = q_c + u(0.1931) \quad (2.2)$$

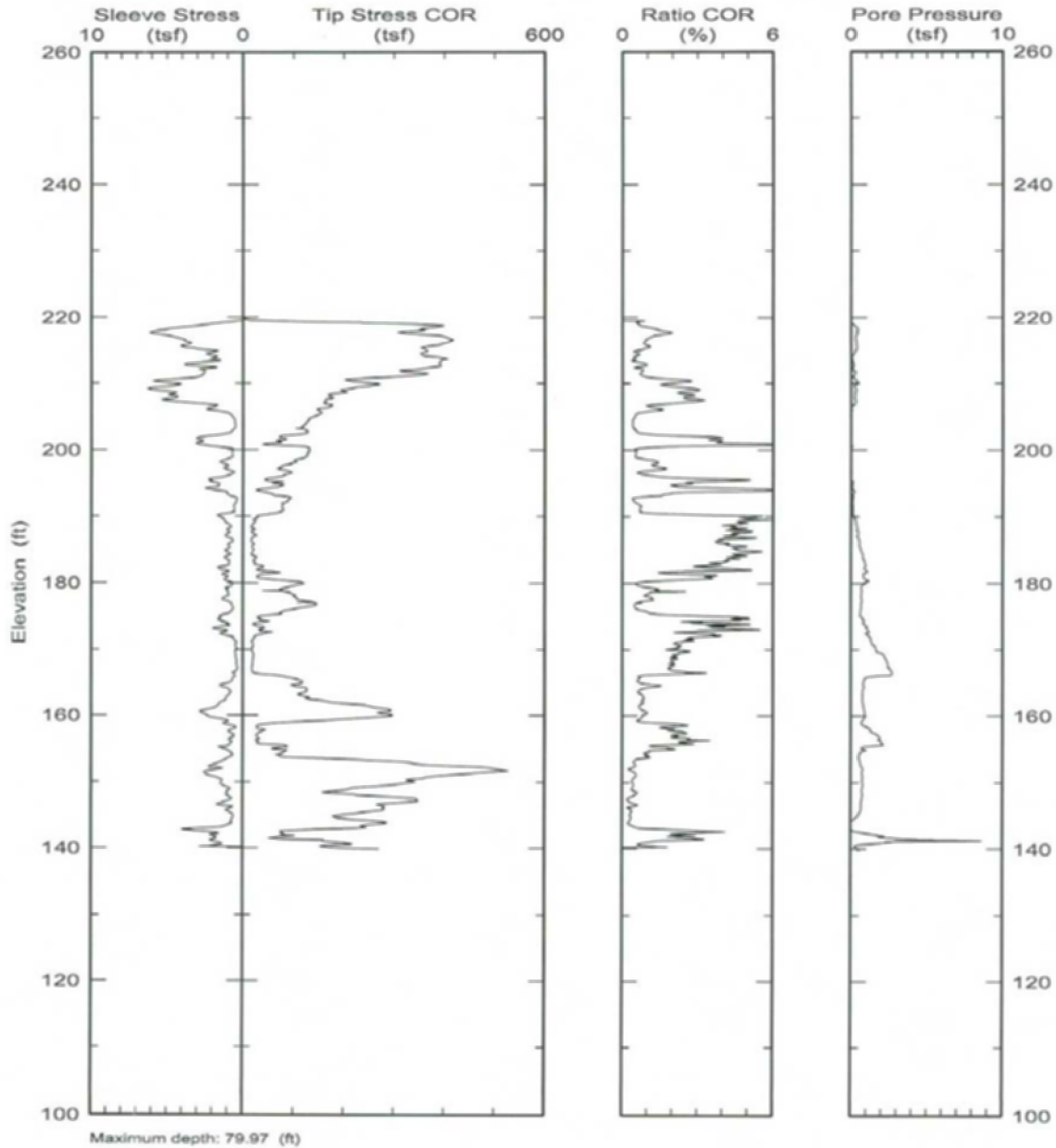
Laboratory calibrations have verified Equation 2.2 for ARA's piezo-cone design.

A joint also exists behind the top of the friction sleeve (see Figure 2). However, since the sleeve is designed to have the same cross sectional area on both ends, the pore pressures acting on the sleeve cancel out. Laboratory tests have verified that the sleeve is not subjected to unequal end area effects. Thus, no correction for pore pressure is needed for the friction sleeve data.

The net effect of applying the pore pressure correction is to increase the tip resistance. Generally, this correction is only significant when the measured tip resistance is very low.

The following figure graphically displays versus elevation a typical CPT sounding from the Alvin W. Vogtle Nuclear Plant limited investigation. Sleeve friction, (Sleeve Stress) is presented inversely of corrected tip resistance (Tip Stress COR) column. The friction ratio is defined as the ratio between sleeve friction and cone resistance (Ratio COR). The measured insitu pore pressures are displayed adjacently. The continuation of the Figure 3 depicts the CPT probes north-south inclination (X inclination) and east-west (Y inclination) as it is advanced. The following columns are Soil Behavior Type (SBT) based on Normalized Friction Ratio Classification Chart (Class. Fr, (Robertson 1990)) and the correlating stratigraphy are depicted.

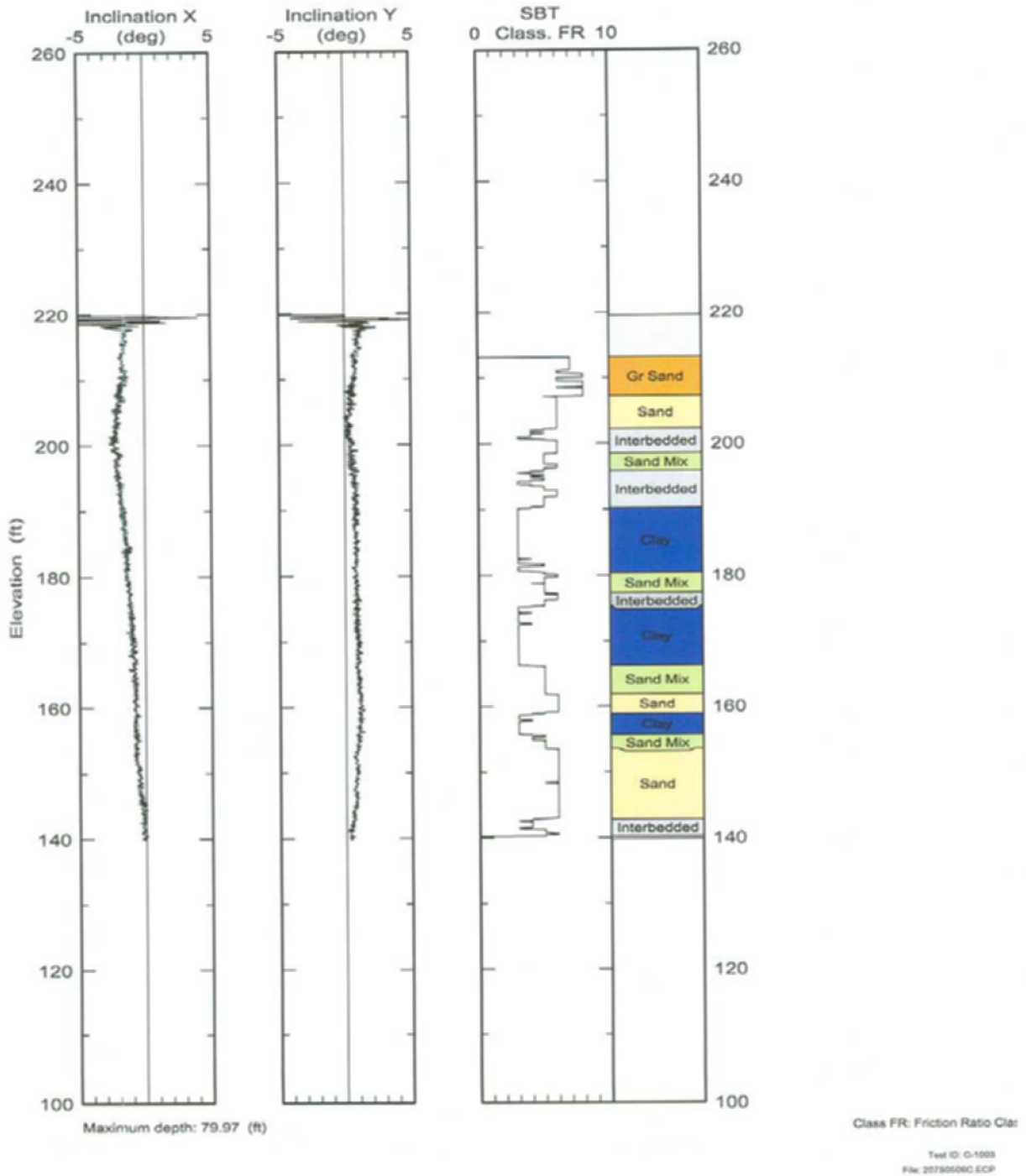
	Applied Research Associates, Inc. South Royalton, VT 05068 802-763-8348 cpt@ned.ara.com www.ara.com	Date: 07/Sep/2005 Test ID: C-1003
		Northing: 7669.31 Easting: 7477.87 Elevation: 219.80



Test ID: C-1003  
File: 20780506C ECP

**Figure 3. Typical CPT Profile from the A. W. Vogtle Site**

	Applied Research Associates, Inc. South Royalton, VT 05068 802-763-8348 cpt@ned.ara.com www.ara.com	Date: 07/Sep/2005 Test ID: C-1003
		Northing: 7669.31 Easting: 7477.87 Elevation: 219.80



**Figure 3. Typical CPT Profile from the A. W. Vogtle Site (concluded)**

## **Numerical Editing of the Penetration Data**

Any time that the cone penetrometer is stopped or pulled back during a test, misleading data can result. For instance, when the probe is stopped to add the next push rod section or when a pore pressure dissipation test is run, the excess pore pressures will dissipate towards the hydrostatic pore pressure. When the penetration is resumed, the pore pressure rises very quickly to the pressures experienced prior to the pause in the test. In addition, to penetrate stronger layers, the probe is sometimes pulled back and cycled up and down at intervals in deep holes to reduce soil friction on the push tubes. This results in erroneous tip stress data when the cone is advanced in the previously penetrated hole.

To eliminate this misleading data from the penetration profile, the data are numerically edited before plotting or use in further analysis. Each time the penetrometer stops or backs up, as apparent from the depth data, the penetration data are not plotted. Plotting of successive data is resumed only after the tip is fully re-engaged in the soil by one tip length of new penetration. In addition, each time the probe stops, the previous 0.5 inch of penetration data is filtered out. This filter is required to remove data that were recorded while the operator was in the process of stopping the probe. This algorithm also eliminates any data acquired at the ground surface before the tip has been completely inserted into the ground. The sleeve data are similarly treated and this results in the first data point not occurring at the ground surface. These procedures ensure that all of the penetration data that are plotted and used for analysis were acquired with the probe advancing fully into undisturbed soil. All raw measurements are subjected to this procedure. An undefined value is represented by (-99) in data columns.

## **SEISMIC CONE PENETROMETER EQUIPMENT AND TEST**

The seismic cone penetrometer test was developed in the early 1980s and is gaining rapid acceptance in the geotechnical community. As with the conventional electric cone penetrometer test, initial development work was concentrated in weak materials. ARA's seismic cone equipment and field procedures were developed specifically for both weak soils and strong, dry, cemented soils. The seismic cone penetrometer test utilizes three geophones (Geospace Model GS-14-L9 velocity gages) mounted inside the penetrometer probe to detect the arrival at depth of seismic waves generated on the surface. Two horizontal transducers monitor shear wave (S-

wave) arrivals from which the shear wave velocity can be determined. A third geophone, mounted vertically, is used to measure the compression wave (P-wave) arrivals and to subsequently derive the compression wave velocity.

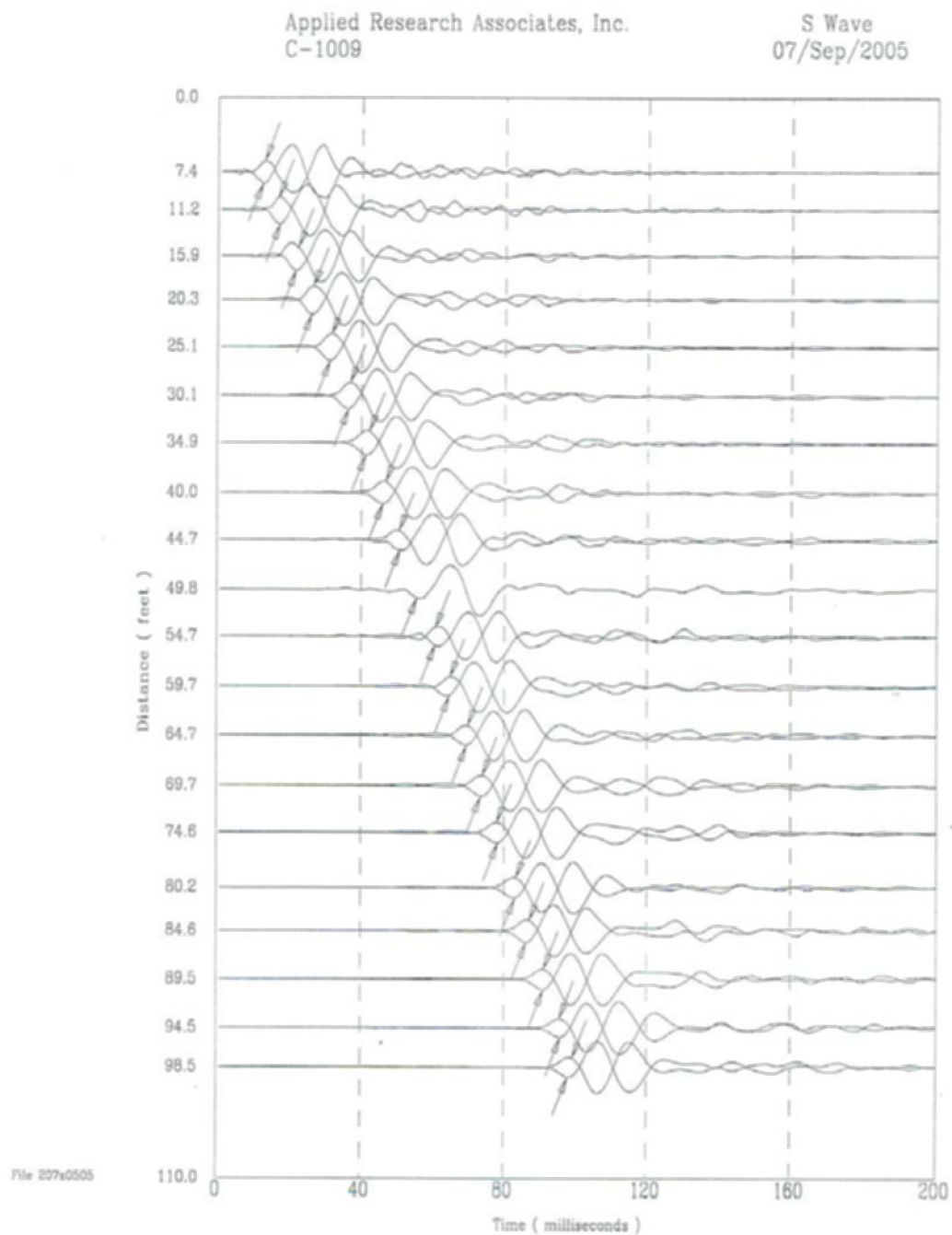
In the Seismic Cone Penetrometer Test (S-CPT), the cone is stopped at prescribed depth intervals, and S- and P-waves are generated on the ground surface near the push tubes. Both average downhole velocities and velocities between the depth intervals can be computed from the arrival time or time of peak data. High-energy shear waves are generated by an automated shear wave source in the front pad of the CPT rig (Figure 4). This system consists of a double-acting hydraulic cylinder used to



**Figure 4. High Energy Shear Wave Hammer**

horizontally move a large hammer. The hammer impacts either end of the front lifting pad of the penetrometer truck and induces a horizontal shear wave. By striking the pad on either end, polarized shear waves can be generated. This pad is 1 ft wide and about 8 ft long and oriented parallel to the axles of the truck. The point of impact of the shear hammers is located 36 inches

horizontally from the penetrometer push rod. Typical seismic traces for this investigation are shown in Figure 5, where time of first peak shear wave motions are indicated.



**Figure 5. Typical Shear Wave Traces**



The first major shear wave is used to select the shear time of peak as denoted by the arrows. The use of polarized shear waves clarifies this time of peak. Compression wave traces and/or analysis were not part of this investigation.

As discussed in Section 2, the seismic cone penetrometer utilizes two shear wave geophones and one compression wave geophone. When a seismic shear wave is generated at the surface it is recorded by both horizontal geophones. The geophone positioned in the most optimal orientation to record the cleanest seismic wave is selected by the operator and written to the seismic data file. Often times, no one trace stands out as being optimal, an occurrence that may be caused by geologic conditions or testing conditions (i.e., geophone orientation). When this occurs, the operator selects the seismic time history he feels is most optimal.

Prior to reporting, all seismic time histories are plotted, as they appear in Appendix B, and reviewed. When anomalous seismic waves are identified, and it is obvious the trace is not consistent with other traces from the same sounding, it is removed from the plot so as not to affect data analysis. Consequently, some seismic wave time history plots will have gaps where seismic waves were removed.

## **PORE PRESSURE DISSIPATION RESULTS**

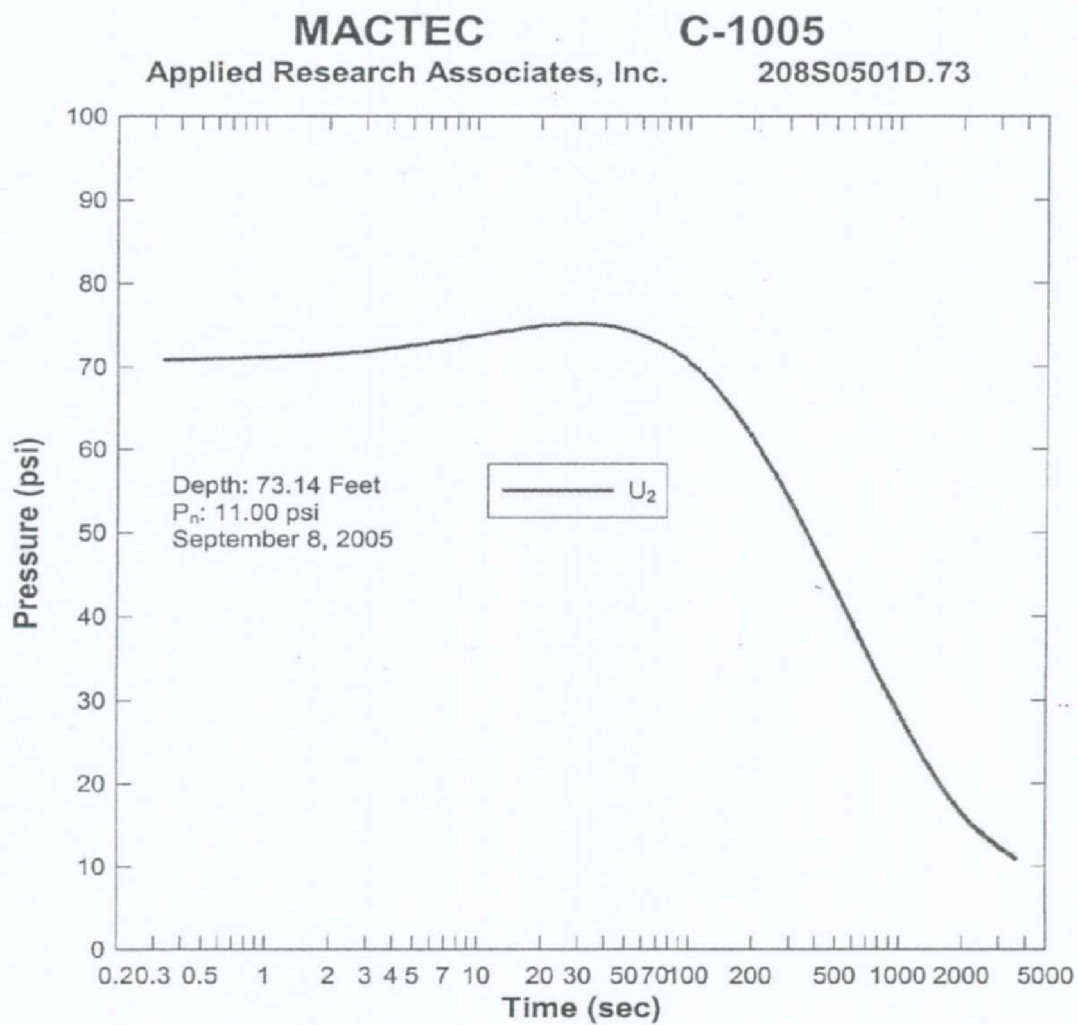
At selected depths, penetration of the penetrometer is stopped and the dissipation of excess pore pressure is observed. Pore pressures, as sensed by the pressure transducer, are recorded at regular time intervals (typically 1 second, but the sample rate can be adjusted for local site conditions) and plotted on the graphics monitor. Dissipation tests are usually run until at least 50 percent of the excess pore pressure has dissipated. This length of time,  $t_{50}$ , can be used to estimate the lateral coefficient of consolidation and permeability in the given soil layer. Depending on site conditions,  $t_{50}$  can range from a few minutes to several hours. These tests are sometimes run to complete dissipation to measure the hydrostatic pore pressure.

During the dissipation test, the penetrometer is stationary with no downward force applied by the penetrometer truck.

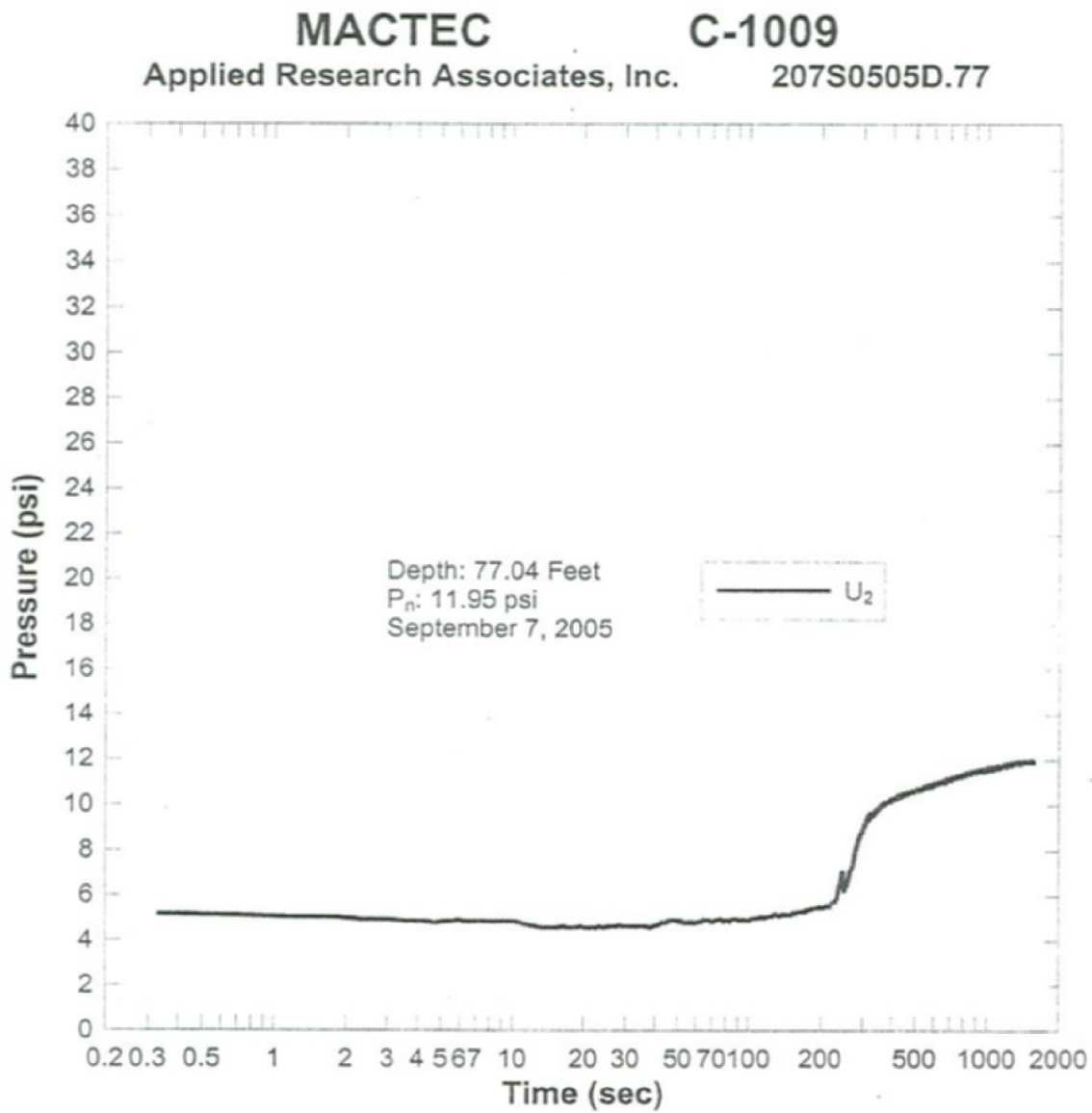
A classic dissipation profile in a clay soil is shown in Figure 6. Total pore pressure is

presented on a semi-log plot versus time, and the value of  $P_n$  at the top of Figure 6 is the average of the last ten pore pressure measurements. The classic dissipation curve will show a dissipation rate that decreases with time. If the dissipation test is allowed to run long enough,  $P_n$  will be equal to the static pore pressure. This value can also be determined from the water table elevation at some sites. Knowing the static pore pressure,  $u_o$ , as well as the peak pressure observed during the test,  $u_p$ , the pore pressure at 50 percent of dissipation,  $u_{50}$ , can be determined. Time to 50% dissipation,  $t_{50}$ , can then be read directly from the dissipation profile.

Some of the penetration profiles from the work at the A. W Vogtle Nuclear Plant site exhibit the classic shape as depicted in Figure 6. At some locations, however, the dissipations start with a vacuum condition due to dilatation occurring during the penetration. From this condition the pore pressures increase as presented in Figure 7. This curve shape does not permit the traditional dissipation analysis algorithms used to determine hydraulic conductivity or depth of groundwater surface. Therefore, hydraulic conductivities for these dissipation tests are not included in the analysis table presented in Appendix C.



**Figure 6. Classic Dissipation Profile from the A. W. Vogtle Plant Site**



**Figure 7. Dissipation Test Showing a Dilating Condition**

## **SECTION 3**

### **DATA ANALYSIS TECHNIQUES**

#### **OVERVIEW**

Presented in this section is a description of analysis techniques used to determine engineering parameters. The methods used to determine the soil type information from the CPT are also discussed.

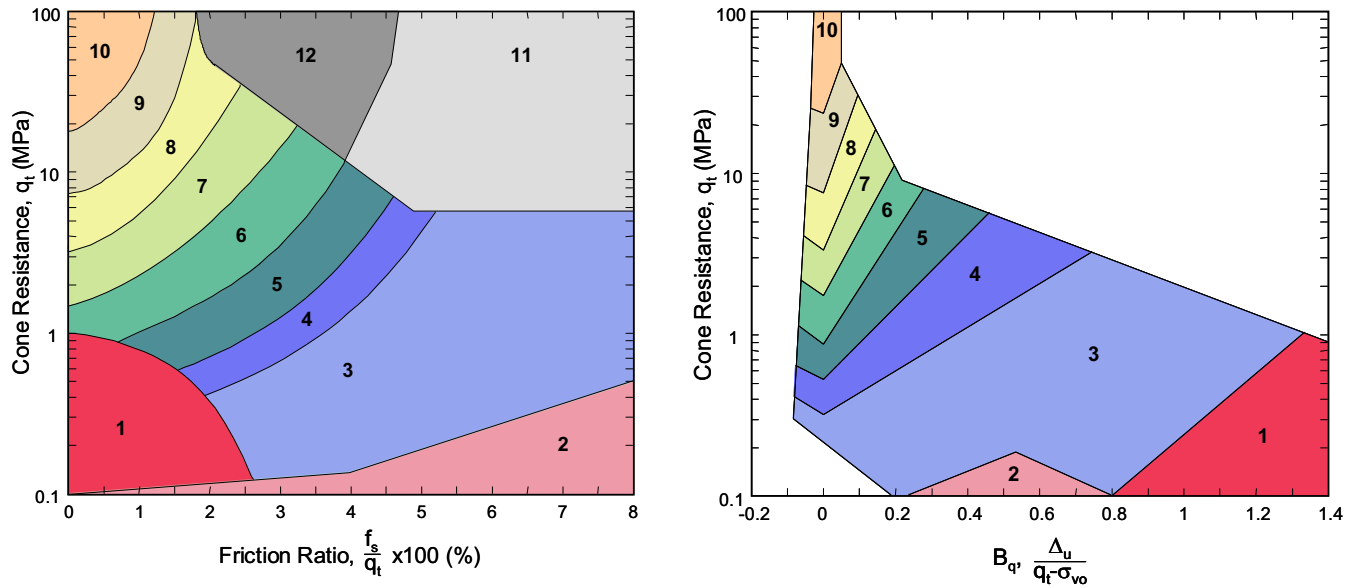
#### **LOCATION OF THE SITE WATER TABLE**

Generally, the static water table at a given site can be identified from the penetration pore pressures, since it will be equal to the hydrostatic pore pressure in freely draining soil layers. When no such layers are present, pore pressure dissipation tests can be performed to determine hydrostatic pressures. This information is used in the soil classification routines for the calculation of effective stress of the soil materials. Bechtel Corporation personnel supplied ARA with values for saturated unit weights for soil density ((pcf) per cubic foot)). The design dry density for the upper sands is 94 pcf, and the moisture content is 25%. This results in a saturated unit weight of 117.5 pcf. The values of the marl are 88 pcf and 35%, resulting in a saturated unit weight of 118.8 pcf.

#### **SOIL BEHAVIOR TYPE**

The tip resistance, friction ratio, and pore pressure values from CPT profiles can be used to determine a soil stratigraphy profile. To estimate soil behavior type, empirical charts were developed by Robertson and Campanella (Ref. 2) showing the relationship between tip resistance ( $q_t$ ) versus friction ratio ( $f_s$ ) and tip resistance ( $q_t$ ) versus pore pressure ratio ( $B_q$ ) Figure 8. The charts were later refined by Robertson (Ref. 5) to utilize normalized tip resistance ( $Q_t$ ) versus normalized friction ratio ( $F_r$ ) and normalized tip stress ( $Q_t$ ) versus pore pressure ratio ( $B_q$ ) Figure 9.

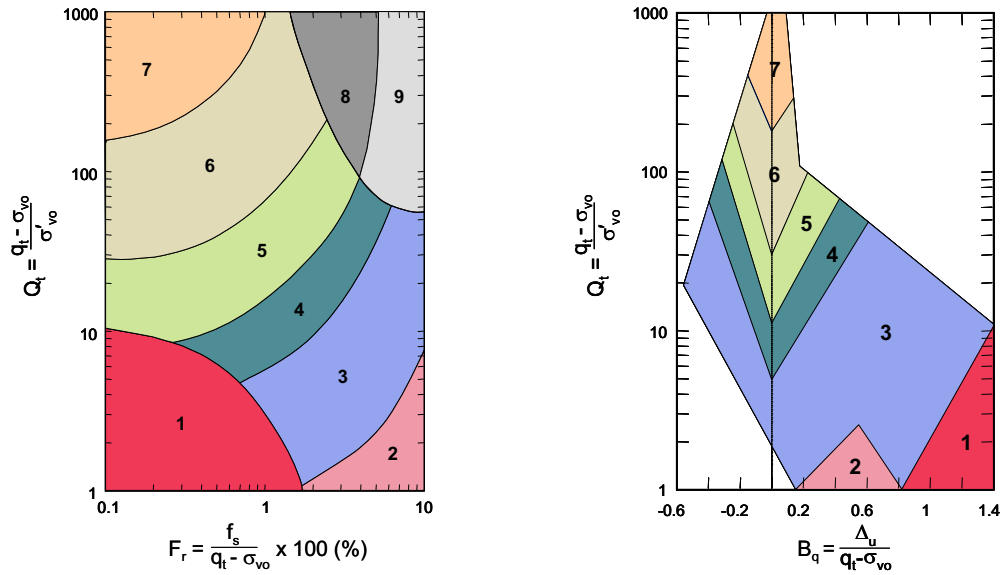
## CPT Soil Behavior Type Legend (Robertson et al. 1986)



Zone	Soil Behavior Type
1	Sensitive, Fine Grained
2	Organic Material
3	Clay
4	Silty Clay to Clay
5	Clayey Silt to Silty Clay
6	Sandy Silt to Clayey Silt
7	Silty Sand to Sandy Silt
8	Sand to Silty Sand
9	Sand
10	Gravelly Sand to Sand
11	Very Stiff Fine Grained*
12	Sand to Clayey Sand*
*Overconsolidated or Cemented	

**Figure 8. 1986 Soil Behavior Charts**

## CPT Soil Behavior Type Legend (Robertson 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 Sands to Silty Sands
7	Gravelly Sand to Sand
8	Very Stiff Sand to Clayey Sand*
9	Very Stiff Fine Grained*

\*Overconsolidated or Cemented

**Figure 9. 1990 Soil Behavior Charts**

The normalized tip resistance is defined as:

$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \quad (3.1)$$

The normalized friction ratio is defined as:

$$F_r = \frac{f_s}{q_t - \sigma_{vo}} \times 100 \quad (3.2)$$

where:  $f_s$  = sleeve friction  
 $q_t$  = corrected tip resistance  
 $\sigma_{vo}$  = total overburden stress  
 $\sigma'_{vo}$  = effective overburden stress

The intersection point of the  $Q_t$  and  $F_r$  values normally falls in a classification zone. Each zone corresponds to a Soil Behavior Type (SBT), which is identified by the descriptions shown in Figures 8 and 9. The graphical representation of zone numbers and the corresponding soil behavior types are plotted numerically and are identified in Figures 8 and 9. At some depths, the CPT data will fall outside of the range of the chart. When this occurs, the SBT is undefined and a break is seen in the SBT profile. This occasionally occurs at the top of a penetration where the effective vertical stress is very small, which results in normalized cone resistances greater than 1000.

The classification profiles are very detailed due to the high rate of data acquisition every 2 cm (0.8 in) for CPT profiles. Frequently significant variability in soil types over small changes in elevation can be observed in the profiles. To provide a simplified soil stratigraphy for comparison to standard boring logs, a layering and generalized classification system was implemented. Layer thicknesses are determined based on the variability of the SBT profile. The layering sequence is begun at the ground surface and layer thicknesses are determined by changes in the soil behavior type. The friction ratio is used to identify potential changes in soil layering. The SBT modal value for each potential layer is compared to the previous layer. Whenever the modal value changes, a new layer is started. The SBT for the layer is the mode of



the SBT values of the complete layer.

Although not presented on the CPT profiles included in Appendix A, the electronic text and/or numerical files contain classification values based on the pore pressure ratio. This method uses the normalized corrected tip stress in bars and the pore pressure ratio  $B_q$ . (Ref. 2).

$$B_q = \frac{u_{meas} - u_o}{q_t - \sigma_{vo}} \quad (3.3)$$

where:  $u_{meas}$  = measured penetration pore pressure

$u_o$  = static pore pressure, determined from the water table elevation

$q_t$  = corrected tip resistance

$\sigma_{vo}$  = total overburden stress

The intersection point of the  $Q_t$  and  $B_q$  values normally fall in a SBT zone. The SBT zone number corresponds to a soil behavior type as shown in Figure 9. when this occurs, the SBT is undefined and a break is seen in the SBT profile. Close analysis of this chart indicates that as the zone numbers vary, so does the soil grain size. What is missing in these charts are mixed soils, such as sandy clays or clayey sands. This type of mixed soil represents special cases, which may be misclassified as silts.

## STANDARD PENETRATION TEST

Data correlations between the cone penetrometer tip stress measurements,  $q_c$ , and standard penetration test blow count, (N), have been made by a number of researchers. Robertson and Campanella (Ref. 2) summarized many of these studies and presented a relationship between  $q_c$ , N, and soil type. The blow count corresponding to 60 percent of the energy transferred to the sampler can be estimated from a ratio based on the soil behavior type number applicable for the soil behavior type. Robertson and Campanella used the 1986 soil behavior chart (Figure 8) when determining these ratios. These SBT values are included in the electronic files. The ratios used to compute the N value were as follows:

<b>Zone</b>	<b>Soil Behavior Type</b> <i>(Robertson et al. 1986)</i>	<b>(<math>q_c/p_a</math>)/N Ratio</b>
1	Sensitive fine grained	2
2	Organic material	1
3	Clay	1
4	Silty clay to clay	1.5
5	Clayey silt to silty clay	2
6	Sandy silt to clayey silt	2.5
7	Silty sand to sandy silt	3
8	Sand to silty sand	4
9	Sand	5
10	Gravelly sand to sand	6
11	Very stiff fine grained	1
12	Sand to clayey sand	2

The correlation between  $q_c$  and  $N_{60}$  should be considered an estimate only, because rapid fluctuations in tip stress can result in large variations in the calculated blow count. Also, the techniques used in performing the SPT test in any geographical area need to be considered. If the energy level normally transferred to the sampler is not nearly 60 percent of the theoretical maximum, the local correlation will be either higher or lower than the data presented in this report.

### **FRICTION ANGLE ( $\phi'$ )**

The effective stress friction angle in granular soils can be estimated from the tip resistance data using an empirical correlation derived between laboratory triaxial tests on sands and penetration tests performed through sands in large calibration chambers. The triaxial tests were performed at confining stresses equal to the horizontal effective stress in the calibration chamber.

The tip stress data were then correlated with peak effective friction angle as (Ref. 2):

$$\tan \phi' = 0.38 \left[ \log_{10} \frac{q_c}{\sigma'_{vo}} \right] + 0.1 \quad (3.4)$$

where:  $\phi'$  = effective internal friction angle (deg)  
 $q_c$  = total measured tip stress  
 $\sigma'_{vo}$  = effective overburden stress

### UNDRAINED SHEAR STRENGTH ( $S_u$ )

Estimates of the undrained shear strength in fine grained saturated soils can be made using the empirical relationship (Ref.2):

$$S_u = \frac{q_c - \sigma_{vo}}{N_k} \quad (3.5)$$

where:  $S_u$  = undrained shear strength  
 $q_c$  = total measured tip stress  
 $\sigma_{vo}$  = total overburden stress  
 $N_k$  = cone factor, assumed to be 15 for A. W. Vogtle Nuclear Plant site data

The cone factor,  $N_k$  falls between 11 and 19 with an average of 15. In the absence of field vane shear data, as is the case for the A. W. Vogtle Nuclear Plant investigation, Robertson and Campanella (Ref. 2) recommend assuming  $N_k$  to be 15. If  $N_k$  is 19 for a given material, using  $N_k$  of 15 overestimates the undrained shear strength by 27%; and if  $N_k$  is 11, the strength is underestimated by 27%.

### PRESENTATION OF $\phi$ AND $S_u$ VALUES

Conventional engineering considers only friction angles ( $\phi$ ) to be appropriate in granular soil deposits such as sands. Similarly, undrained shear strength ( $S_u$ ) values are used in saturated, low permeability layers such as clays. The distinction between which parameter is appropriate at

a given depth is based on the soil behavior type. When the average SBT number is greater than 4, the granular material is assumed to dominate and the friction angle is plotted. Conversely, if the SBT number is less than or equal to 5, the fine-grained material is assumed to dominate and the undrained shear strength is plotted. These SBT numbers are found in the electronic files supplied with this report. Both values are plotted for SBT values of 4 and 5. When the data do not fall within the range of the classification system, neither  $\phi'$  or  $S_u$  values are presented.

### ESTIMATES OF OVERCONSOLIDATION RATIO (OCR)

A soil is termed normally consolidated if the current stress is the maximum to which the material has ever been subjected. The overconsolidation ratio (OCR) is defined as:

$$\text{OCR} = \frac{(\sigma'_{vo})_{\text{max.past}}}{(\sigma'_{vo})_{\text{present}}} \quad (3.6)$$

where:  $(\sigma'_{vo})_{\text{max.past}}$  = maximum past vertical effective overburden pressure  
 $(\sigma'_{vo})_{\text{present}}$  = present effective vertical overburden pressure

For a normally consolidated soil,  $(\sigma'_{vo})_{\text{max.past}} = (\sigma'_{vo})_{\text{present}}$  and  $\text{OCR} = 1$ , while an overconsolidated soil has an  $\text{OCR} > 1$ .

OCR calculations for the A. W. Vogtle Nuclear Plant investigation were reported for all soil behavior types and are based on a publication by Mayne (Ref. 3) where OCR is directly correlated to excess pore pressure measured on the cone tip and only apply to cohesive soils. As determined from a linear regression of published data, this equation is:

$$\text{OCR} = 0.33 \left[ \frac{u_{\text{meas}} - u_o}{\sigma'_{vo}} \right]^{1.42} \quad (3.7)$$

### COEFFICIENT OF LATERAL CONSOLIDATION ( $C_H$ )

Horizontal coefficients of consolidation can be calculated from the pore pressure

dissipation tests using a theoretical model developed by Baligh and Levadoux (Ref. 4) and measured dissipation rates. Calculations are performed at 50% of the excess pore pressure dissipation,  $U_{50}$ . Using the theoretical curves in Figure 10,  $C_H$  is calculated as:

$$C_H = \frac{T_{50} R^2}{t_{50}} \quad (3.8)$$

where:  $T_{50}$  = theoretical time factor at 50% dissipation  
 $R$  = radius of cone in centimeters, 2.22 cm for the 1.75-inch diameter cone used at the A. W. Vogtle Nuclear Plant site  
 $t_{50}$  = measured time at 50% dissipation in seconds

Pore pressure measurements are made just behind the tip; hence, curve 3 in Figure 10 is used to determine  $T_{50}$  equals 5.5. Estimates of  $C_H$  for the applicable dissipation test locations are contained in the summary table in Appendix C.

### COEFFICIENT OF LATERAL PERMEABILITY ( $K_H$ )

The coefficient of lateral permeability is calculated based on the coefficient of lateral consolidation estimated from the pore pressure dissipation test described above and an estimate of the in situ constrained modulus,  $M$ , obtained from measured tip resistance values and soil classification according to:

$$K_H = \frac{C_H \gamma_w}{M} \quad (3.9)$$

where:  $C_H$  = coefficient of lateral consolidation  
 $\gamma_w$  = unit weight of water  
 $M$  = constrained modulus

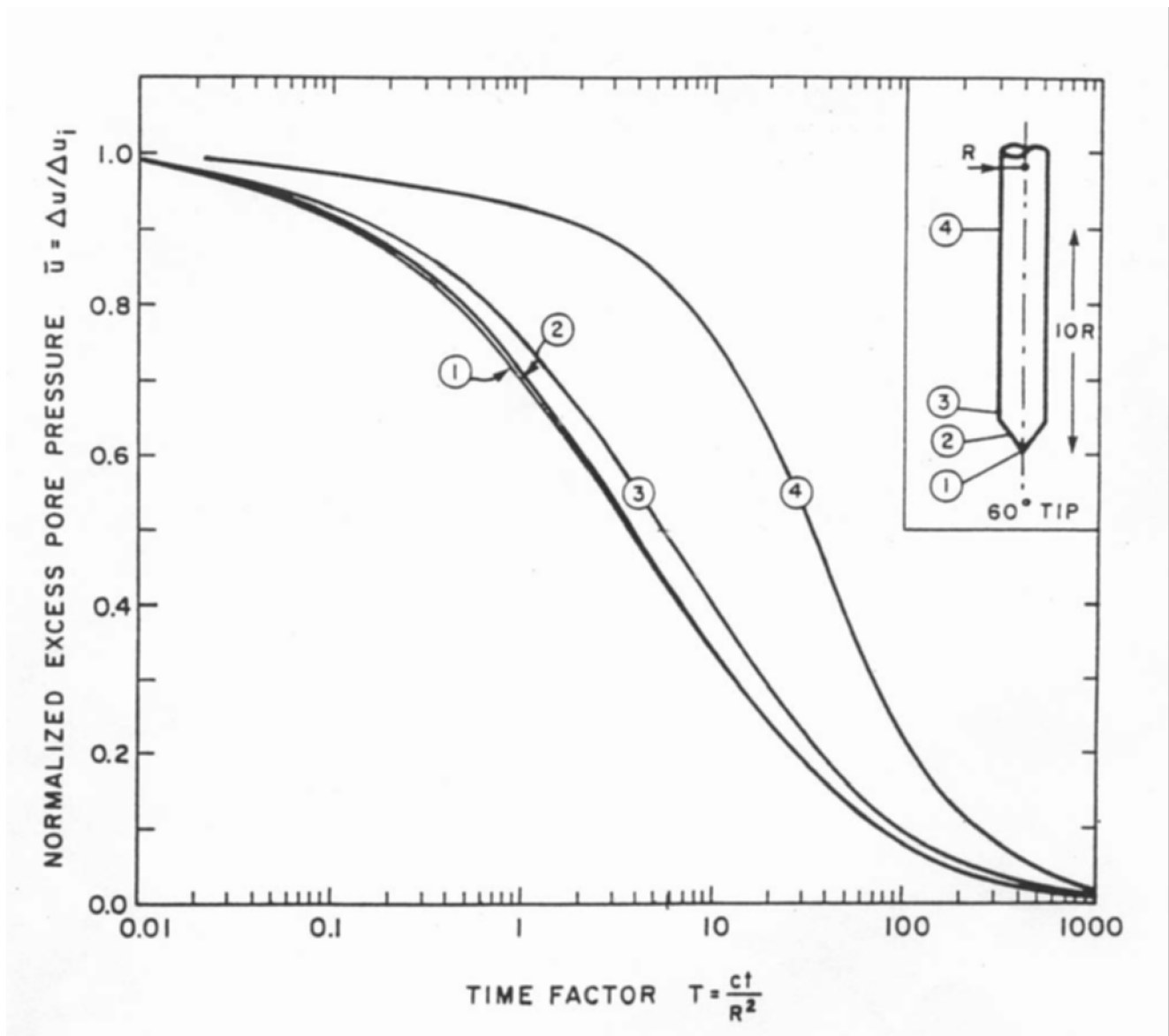
The constrained modulus,  $M$ , can be estimated using the empirical relationship:

$$M = \alpha q_c = \frac{1}{m_v} \quad (3.10)$$

This method is discussed by Robertson and Campanella (Ref. 2).

where:  $\alpha$  = empirical factor  
 $q_c$  = measured tip resistance, not corrected for pore pressure effects  
 $m_V$  = volumetric compressibility.

The factor  $\alpha$  is obtained from (Ref. 2) is based on the uncorrected tip resistance and soil type. Estimates of  $M$  and  $K_H$  are contained in the summary table in Appendix C. Values for  $q_c$  are obtained from the depth interval closest to the depth of dissipation test.



**Figure 10. Dissipation Curves for a 60° Cone According to Linear Isotropic Uncoupled Solution (after Baligh and Levadoux, 1980)**

$M = \frac{1}{m_v} = \alpha \cdot q_c$		
$q_c < 7 \text{ bar}$	$3 < \alpha < 8$	
$7 < q_c < 20 \text{ bar}$	$2 < \alpha < 5$	Clay of low plasticity (CL)
$q_c > 20 \text{ bar}$	$1 < \alpha < 2.5$	
$q_c > 20 \text{ bar}$	$3 < \alpha < 6$	Silts of low plasticity (ML)
$q_c < 20 \text{ bar}$	$1 < \alpha < 3$	
$q_c < 20 \text{ bar}$	$2 < \alpha < 6$	Highly plastic silts & clays (MH, CH)
$q_c < 12 \text{ bar}$	$2 < \alpha < 8$	Organic silts (OL)
$q_c < 7 \text{ bar:}$		
$50 < w < 100$	$1.5 < \alpha < 4$	Peat and organic clay ( $P_t$ , OH)
$100 < w < 200$	$1 < \alpha < 1.5$	
$w > 200$	$0.4 < \alpha < 1$	

**Figure 11. Estimation of the Constrained Modulus, M, for Clays (after Robertson and Campanella, 1988)**

## SECTION 4

### LIST OF REFERENCES

1. American Society for Testing and Materials, "Standard Test Method for Performing Electric Friction Cone and Piezo-Cone Penetration Testing of Soil," ASTM Designation: D5778, 1995.
2. Robertson, P. K. and R. G. Campanella, *Guidelines for Using the CPT, CPTU and Marchetti DMT for Geotechnical Design*, Vol. II, University of British Columbia, Vancouver, BC, Canada, March 1988.
3. Mayne, P.W., "CPT Indexing of In Situ OCR in Clays," included in *Use of In Situ Test in Geotechnical Engineering*, S. P. Clemence, ed., Geotechnical Special Publications No. 6, proceedings of In Situ '86 Conference, sponsored by Geotechnical Engineering Division of the American Society of Civil Engineers, Blacksburg, VA, June 1986.
4. Baligh, M. M. and J. N. Levadoux, Pore Pressure Dissipation After Cone Penetration, Massachusetts Institute of Technology, Cambridge, MA, April 1980.
5. Robertson, P.K., "Soil classification using the cone penetration test," Canadian Geotechnical Journal, 27(1).



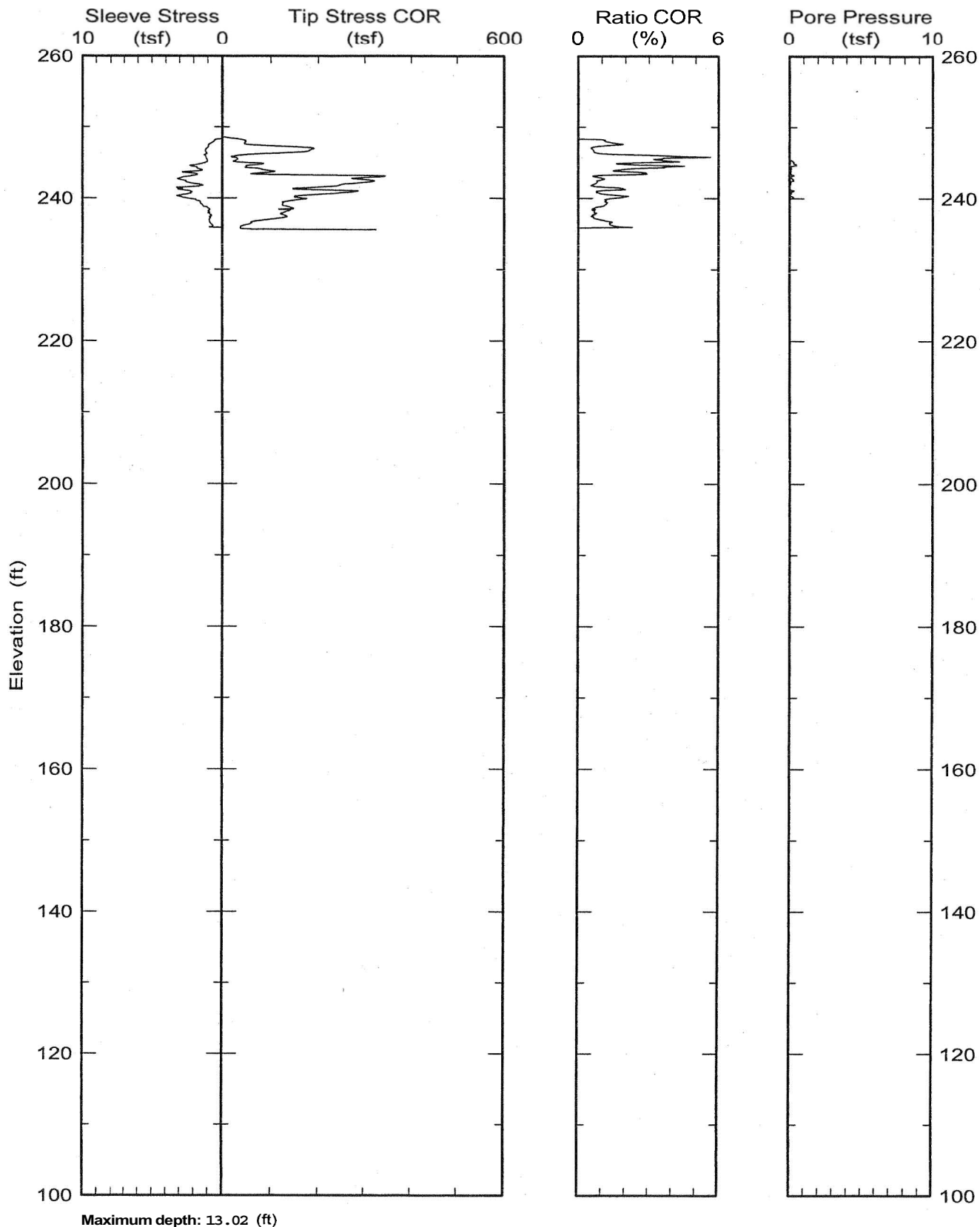
**APPENDIX A**

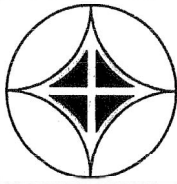
**PIEZO-CONE PROFILES**



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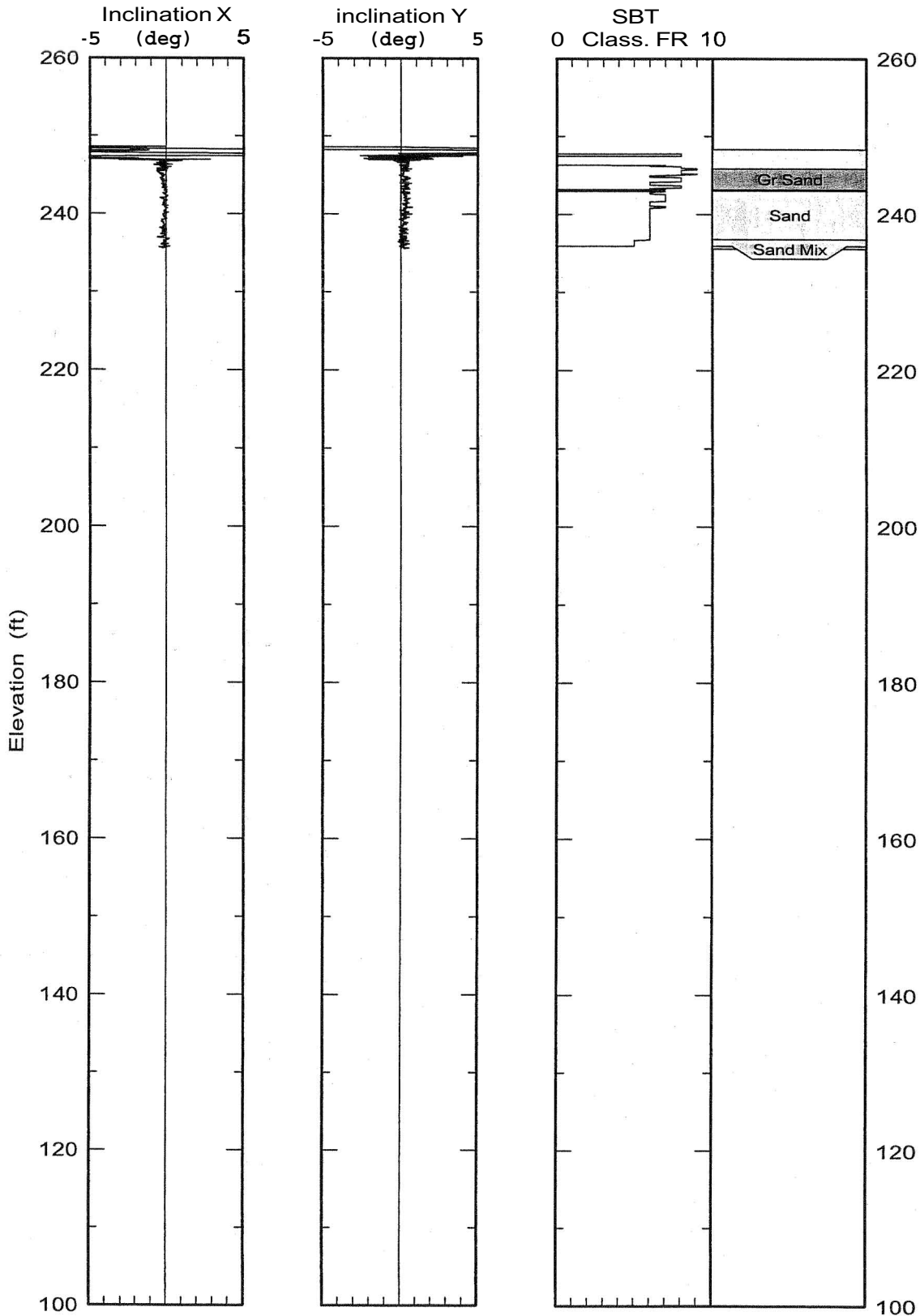
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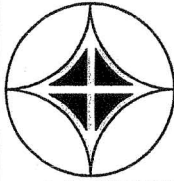
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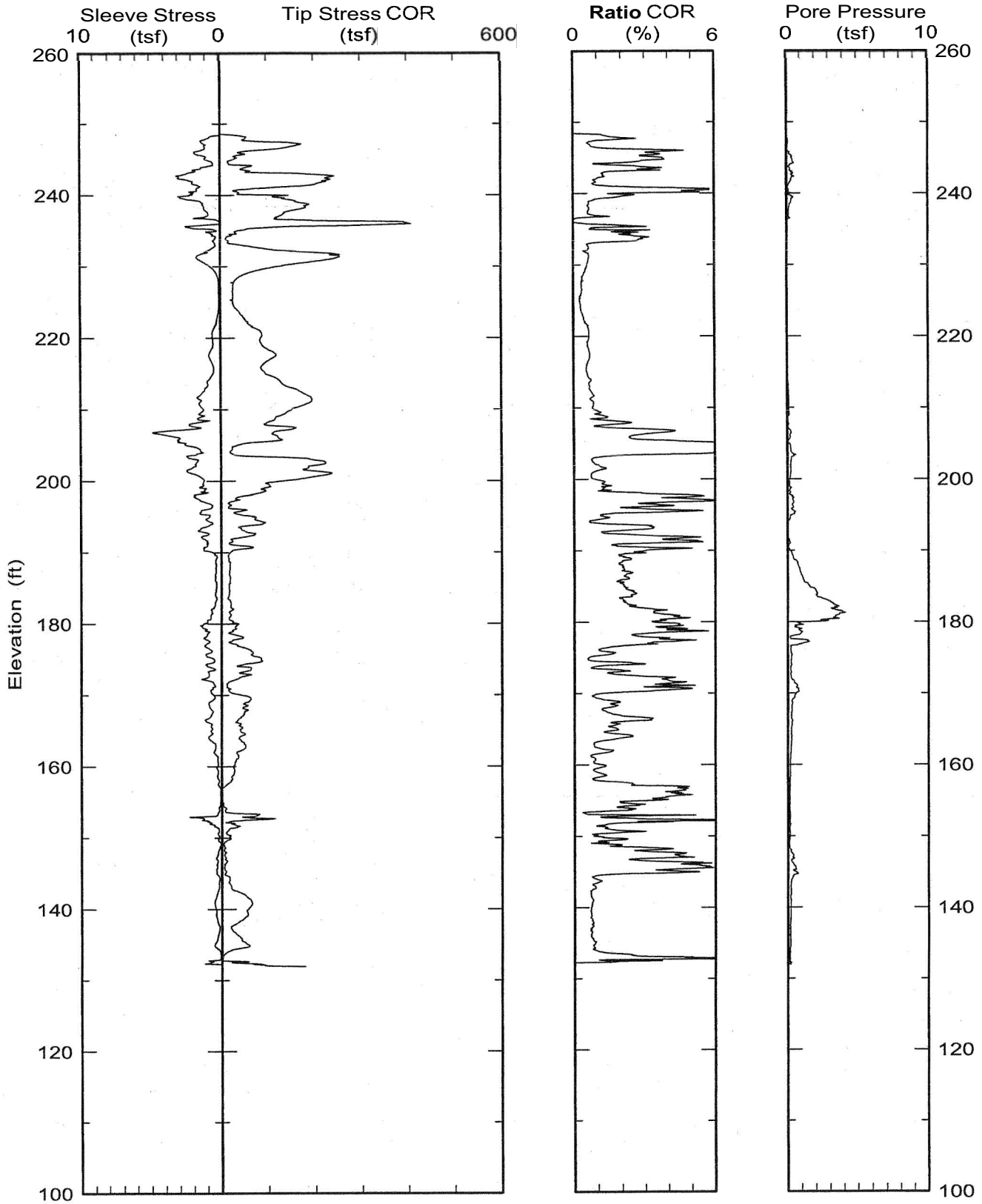
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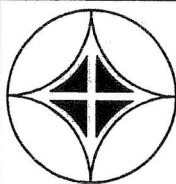


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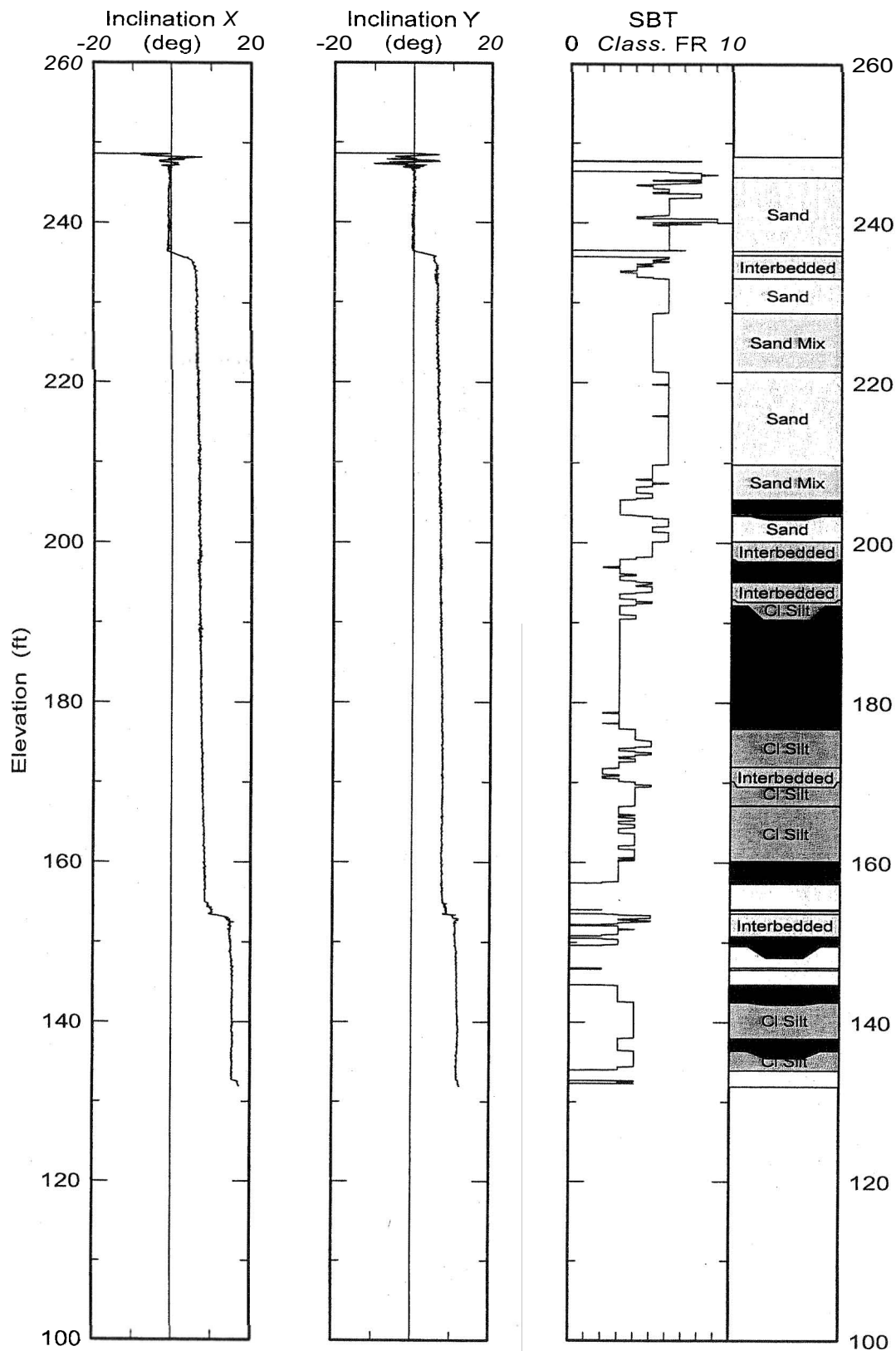


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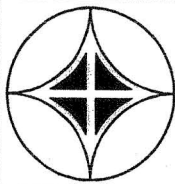


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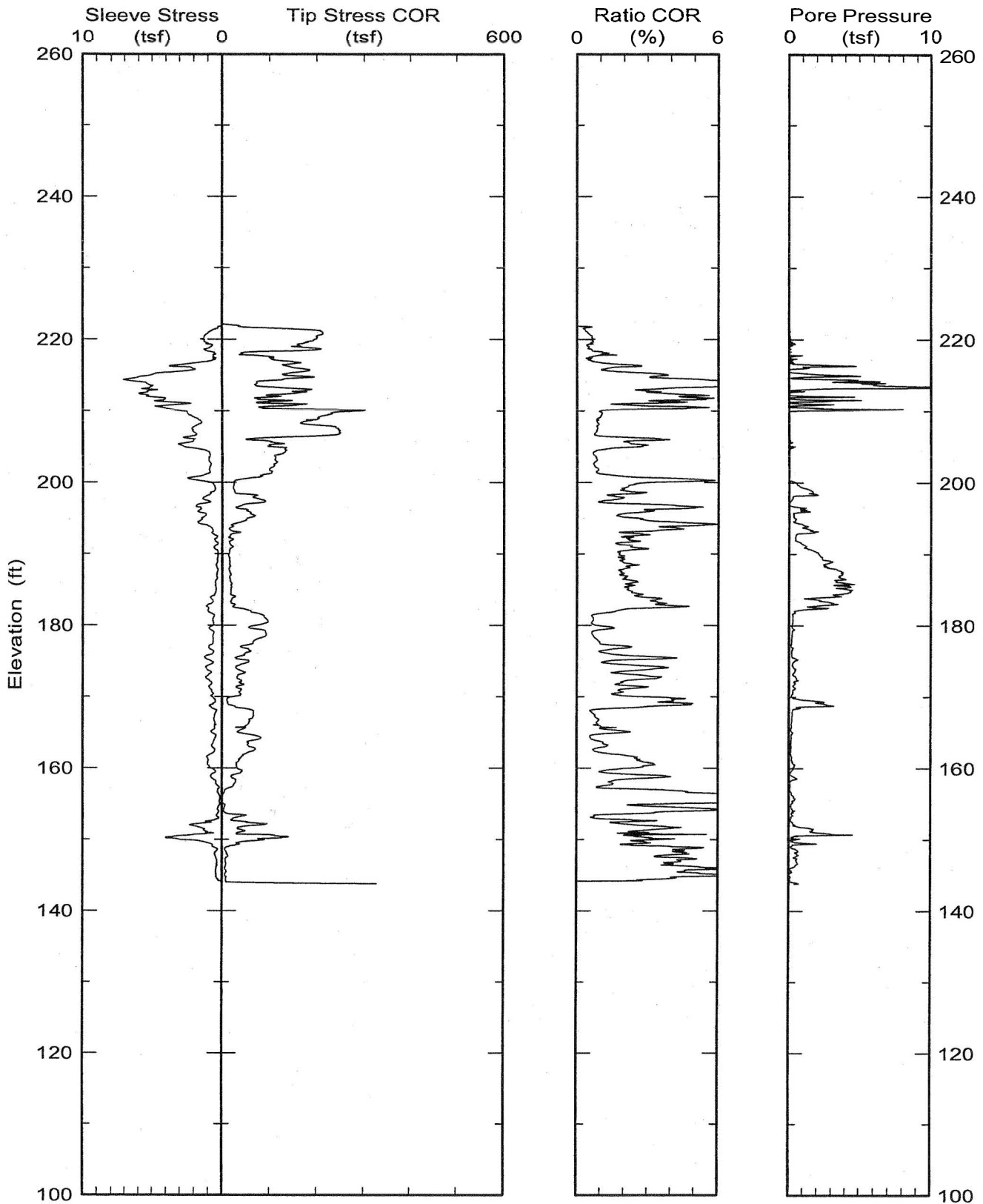


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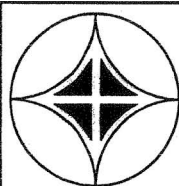


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Elevation: 222.13



Maximum depth: 78.33 (ft)



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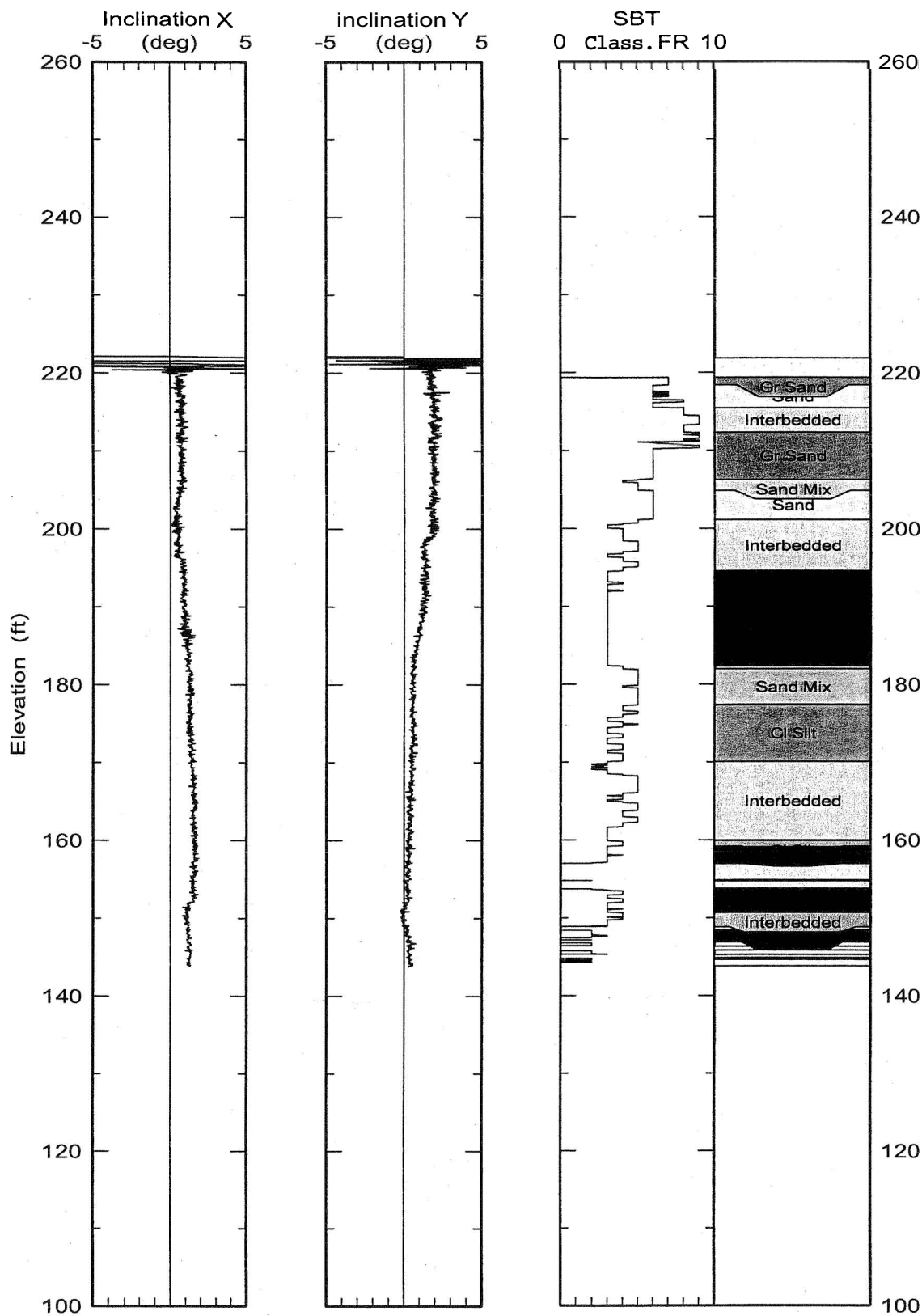
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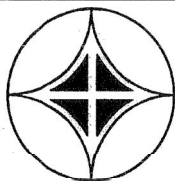
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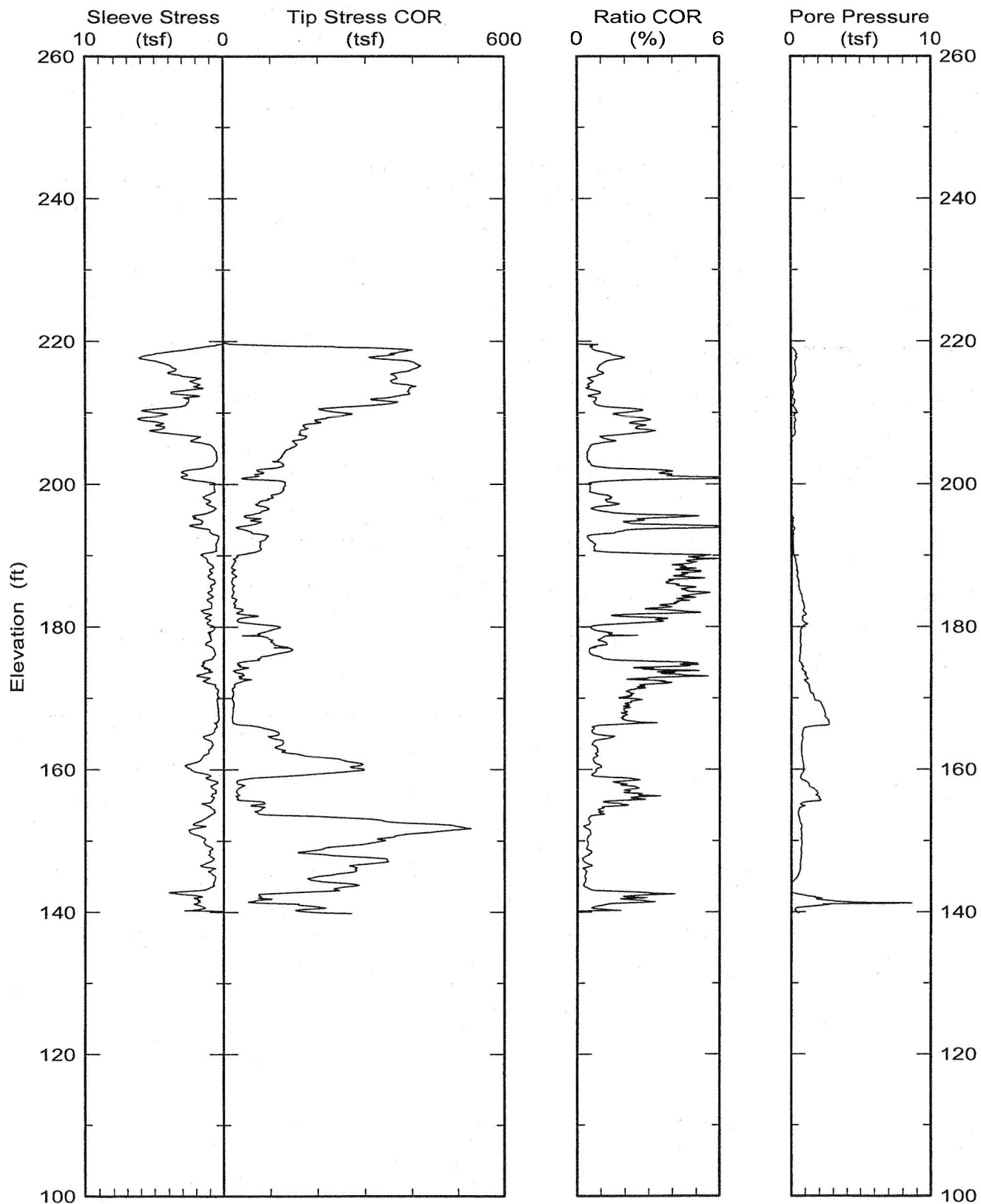
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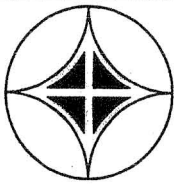
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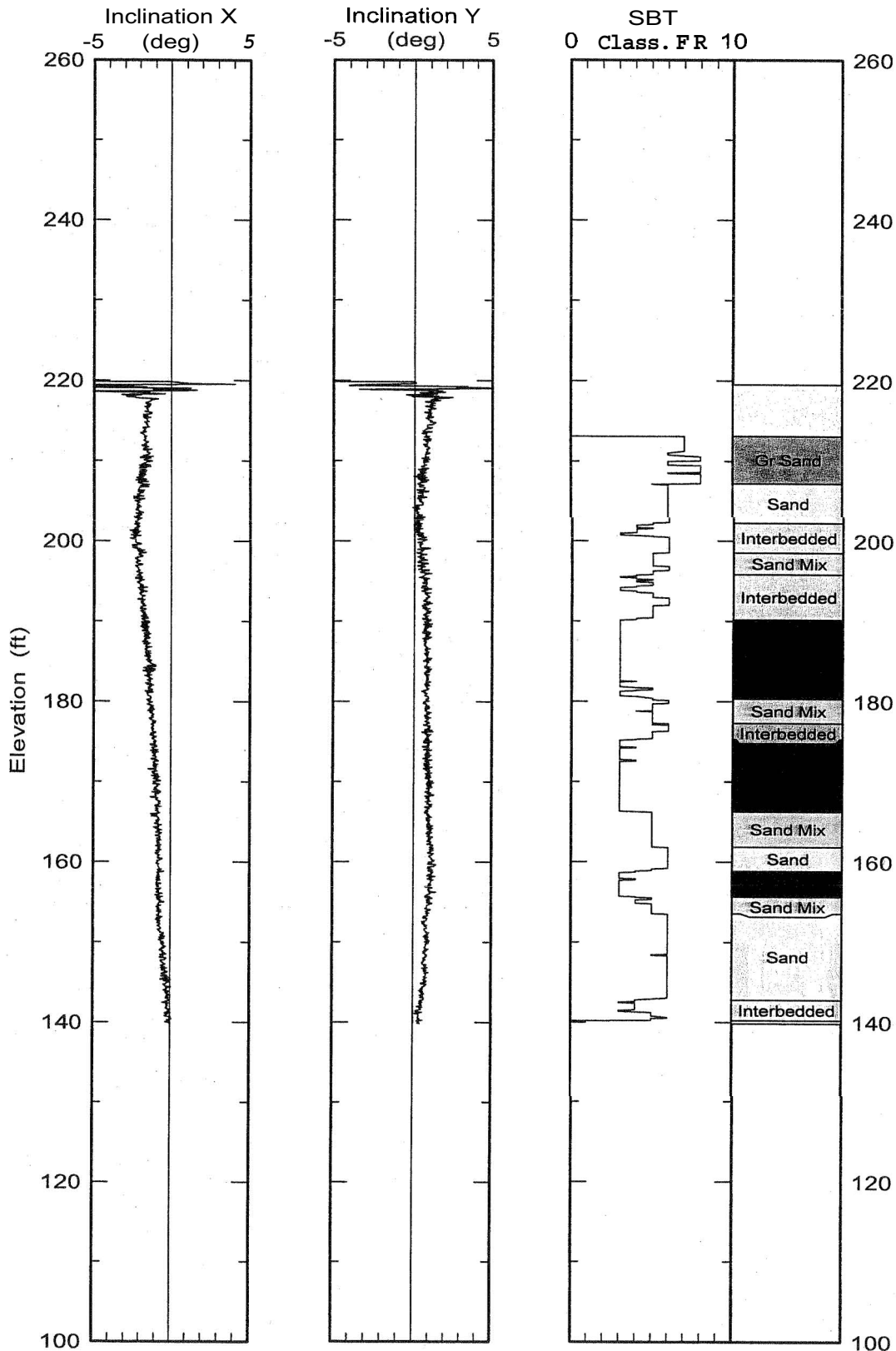
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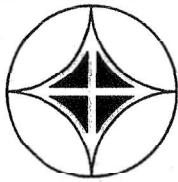
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Easting: 7477.87  
Elevation: 219.80



Maximum depth: 79.97 (ft)

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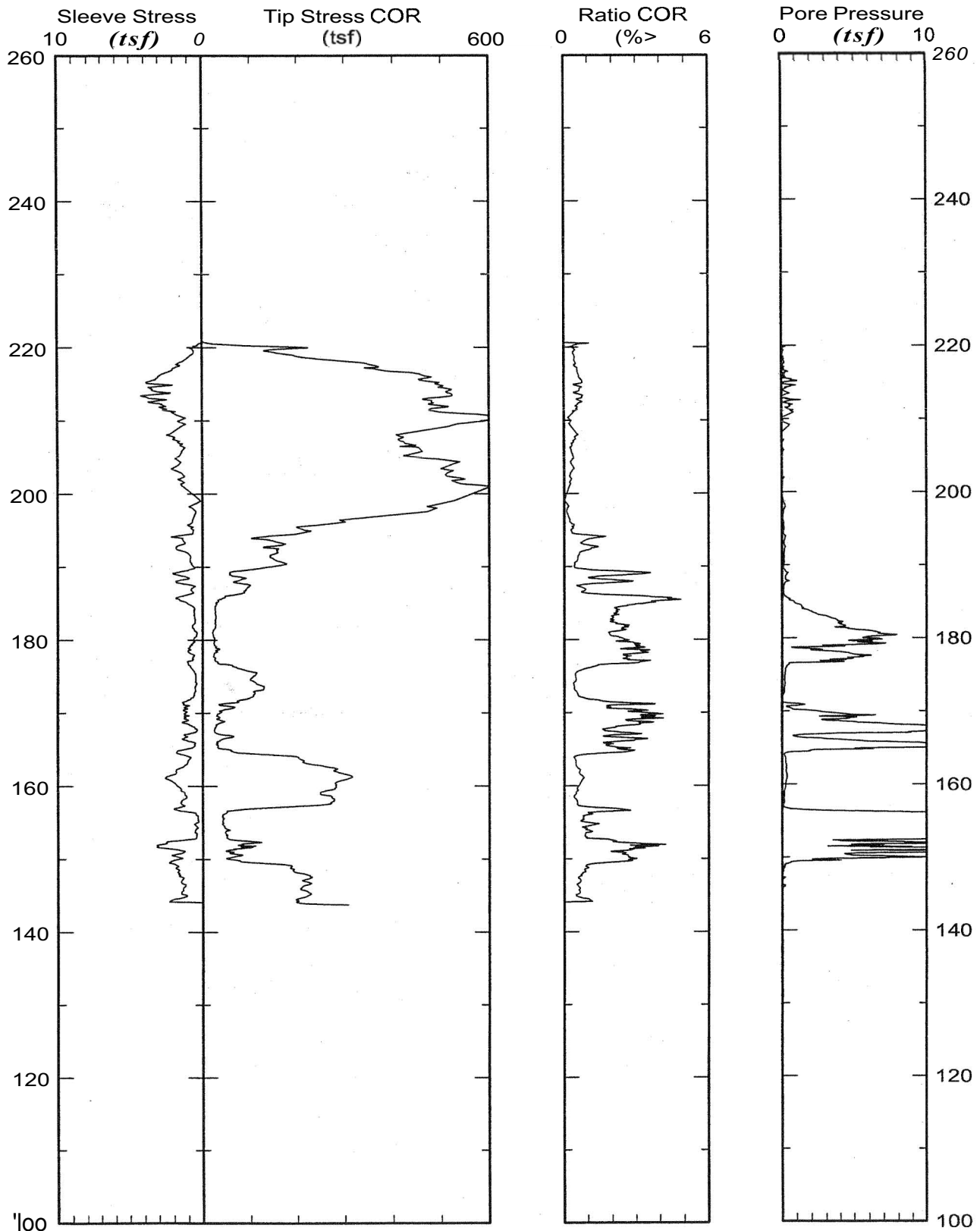
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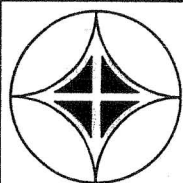
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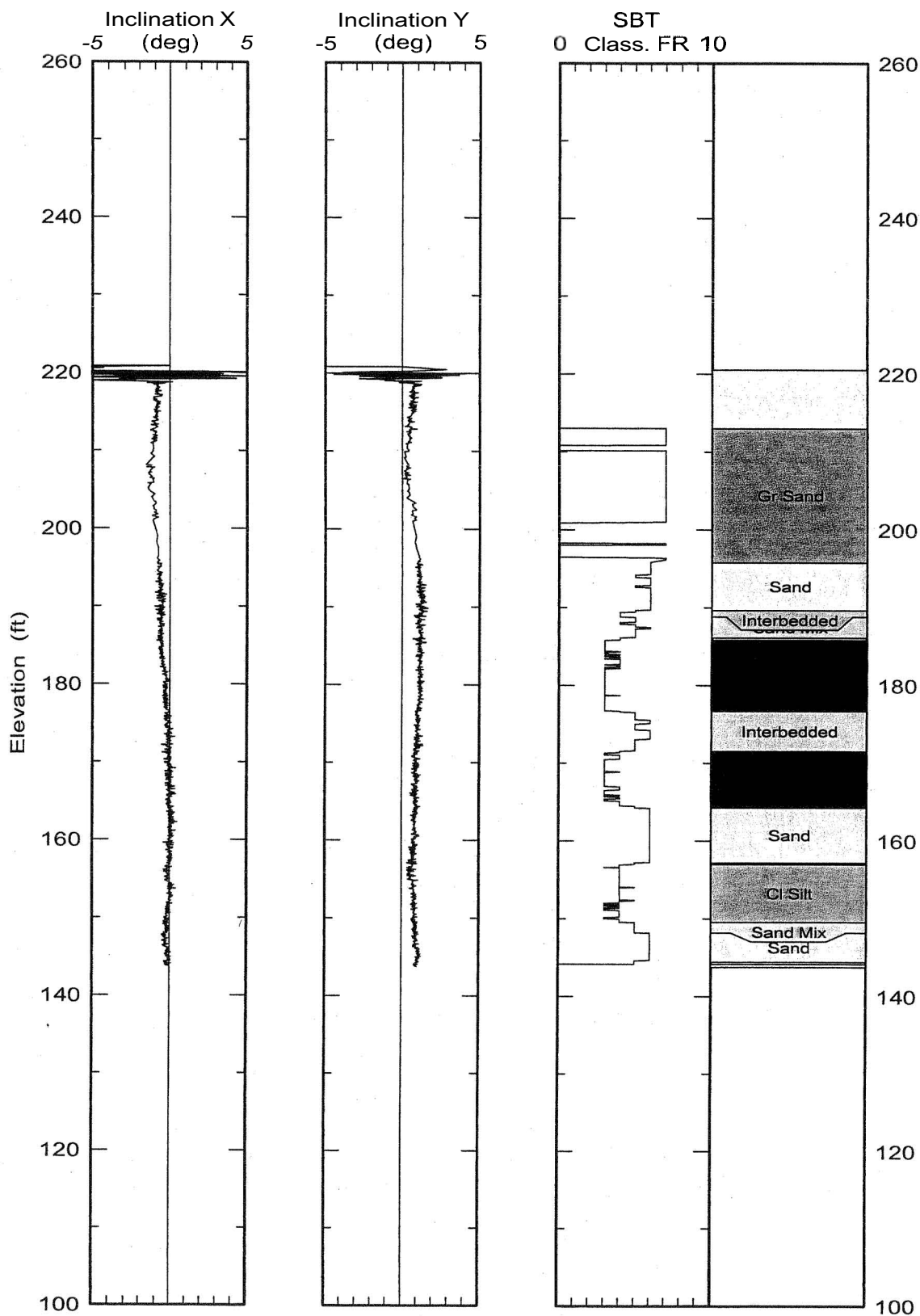


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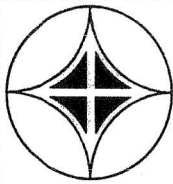
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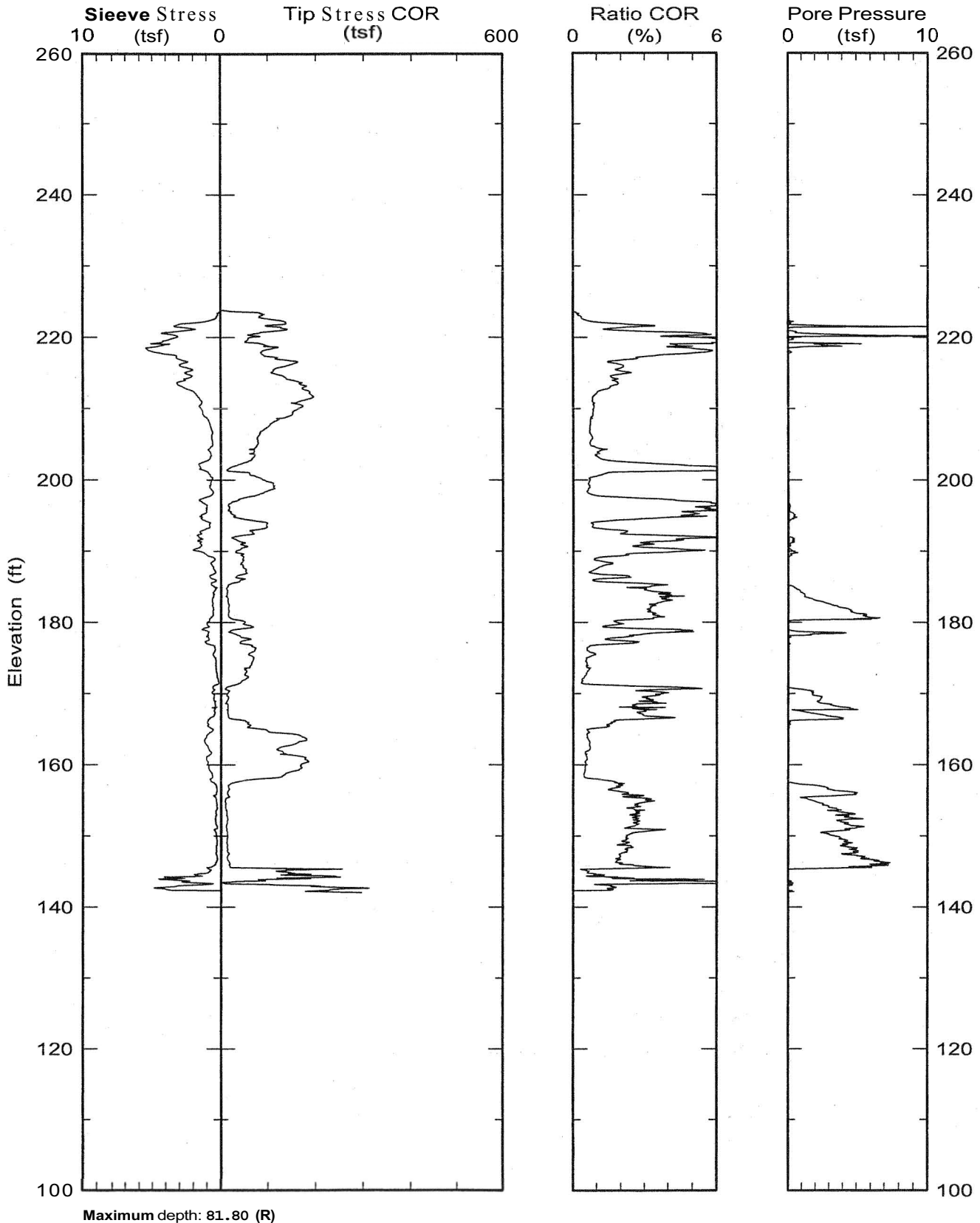
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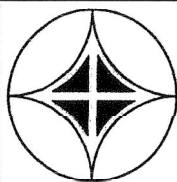
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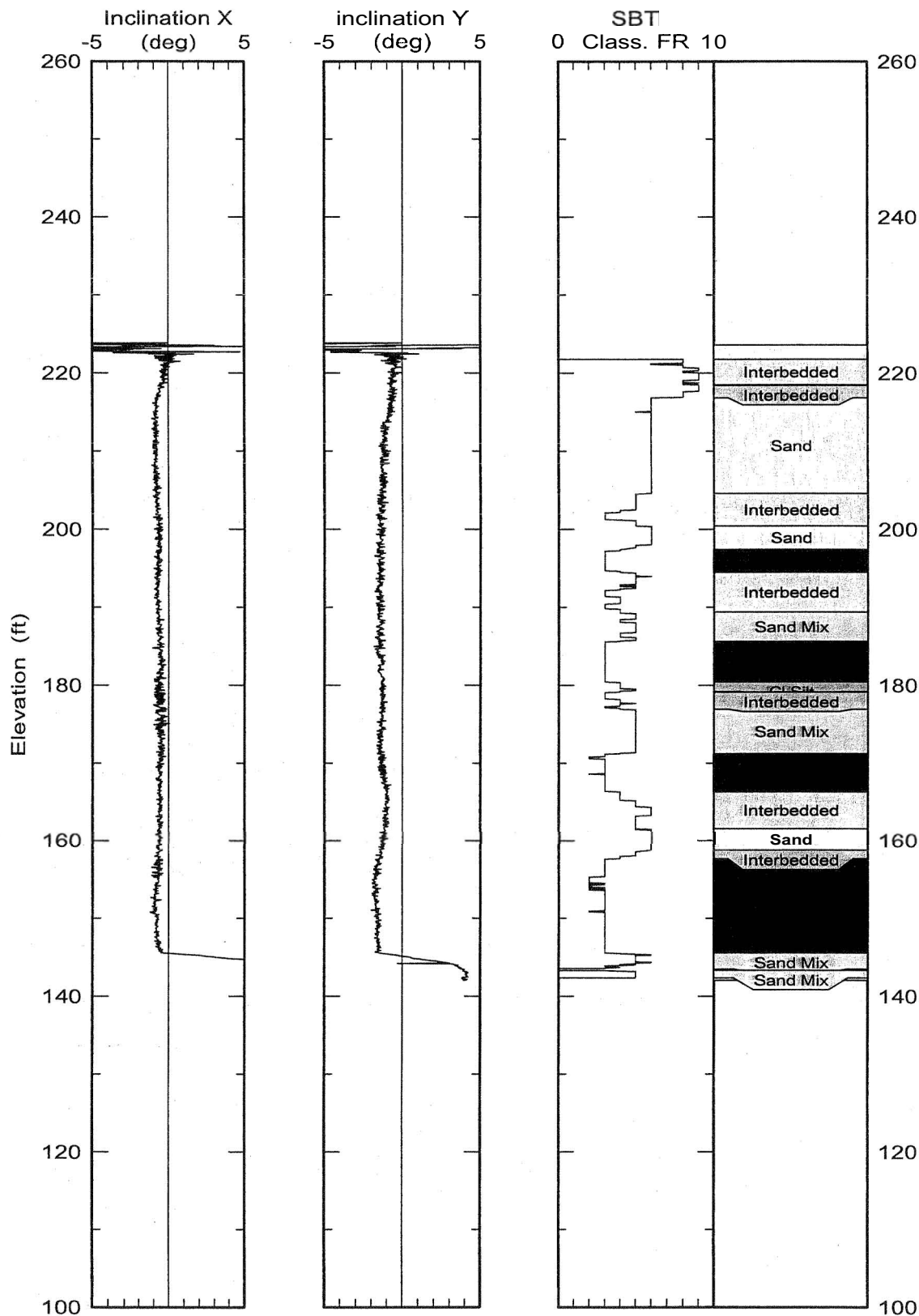
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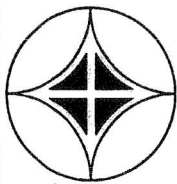
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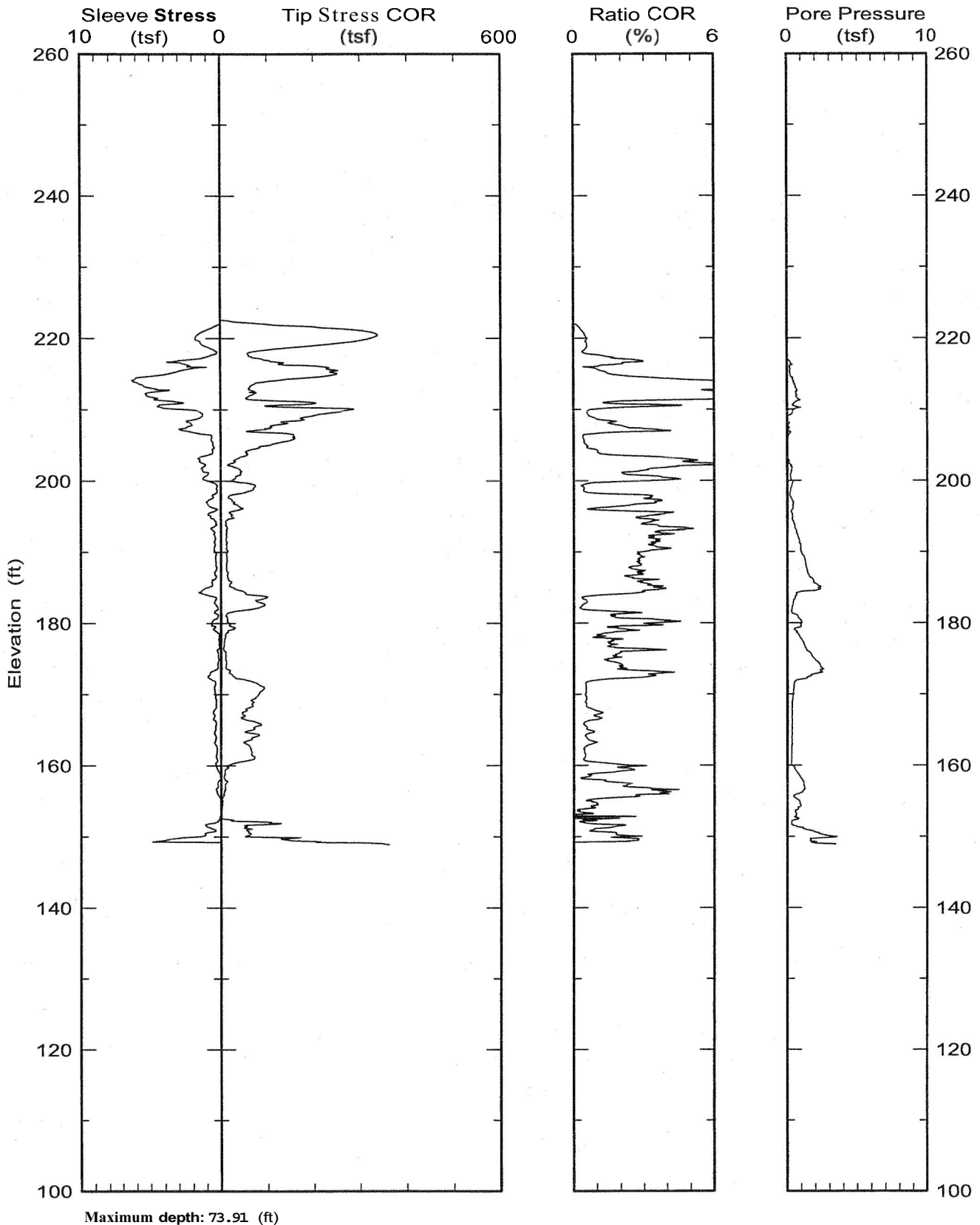
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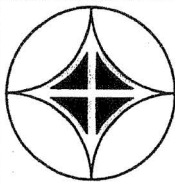
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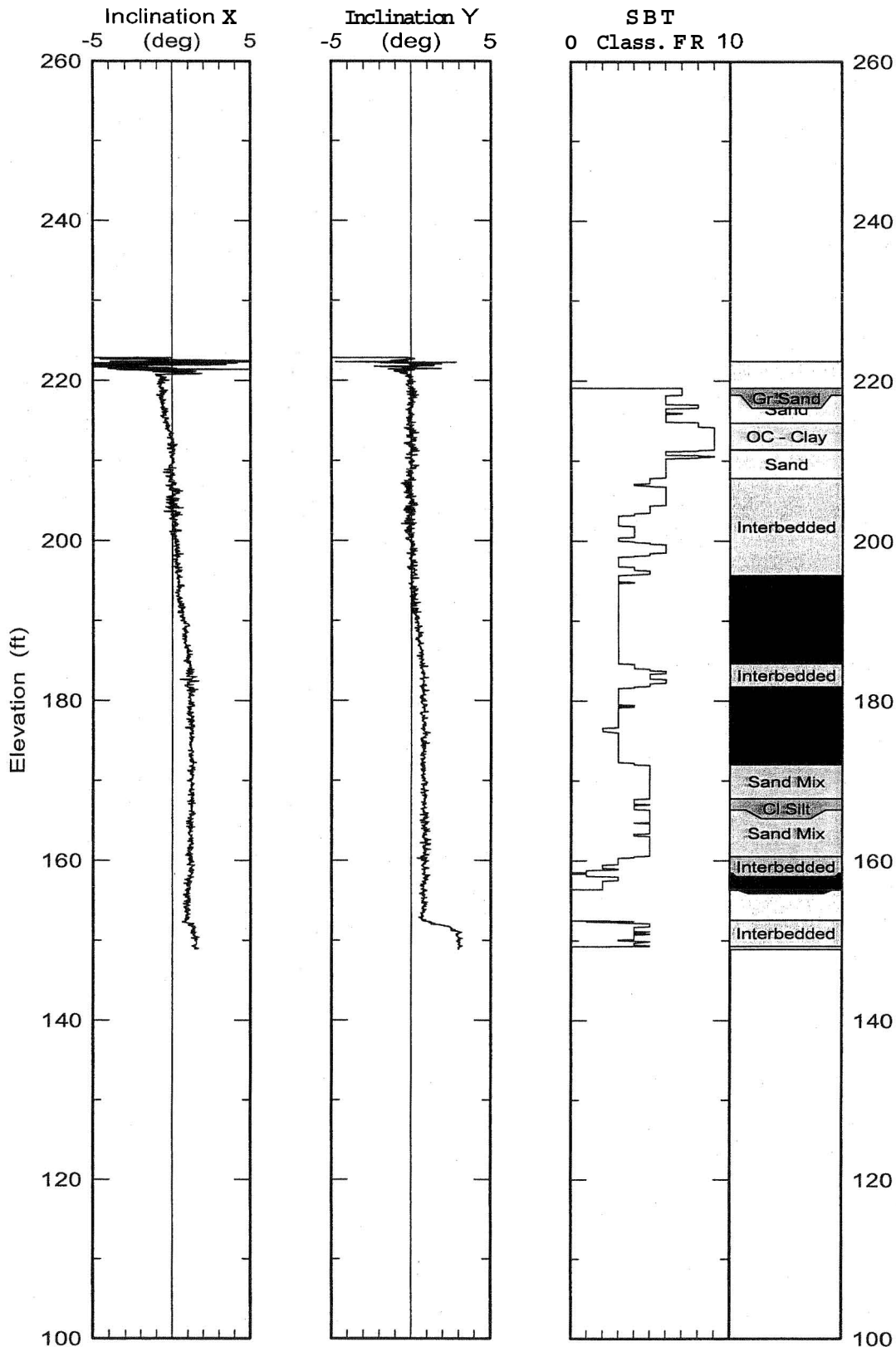
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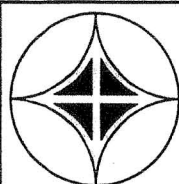
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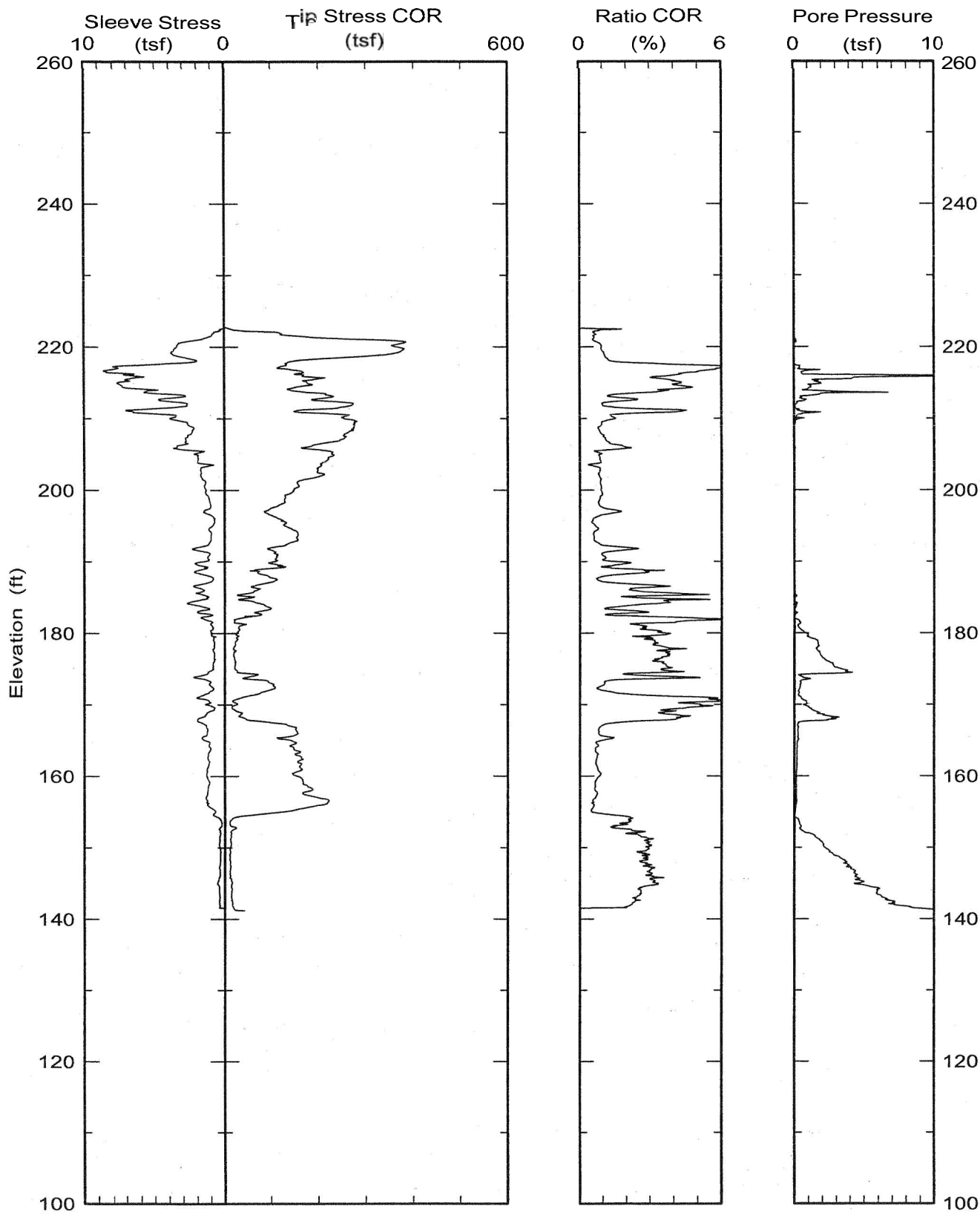
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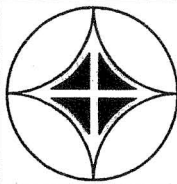
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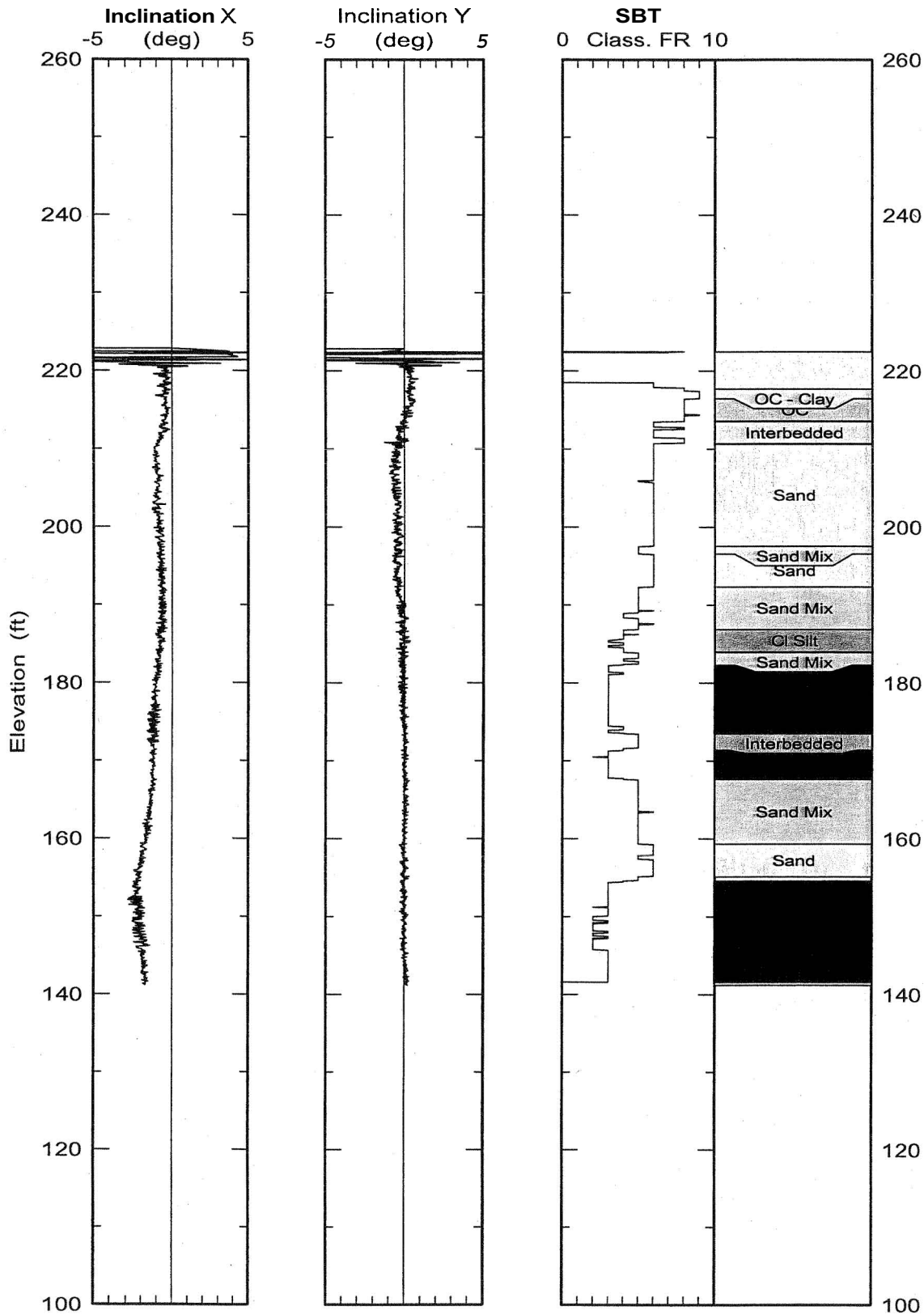
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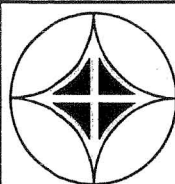
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Elevation: 222.81



Maximum depth: 81.62 (R)

Class FR: Friction Ratio Cla



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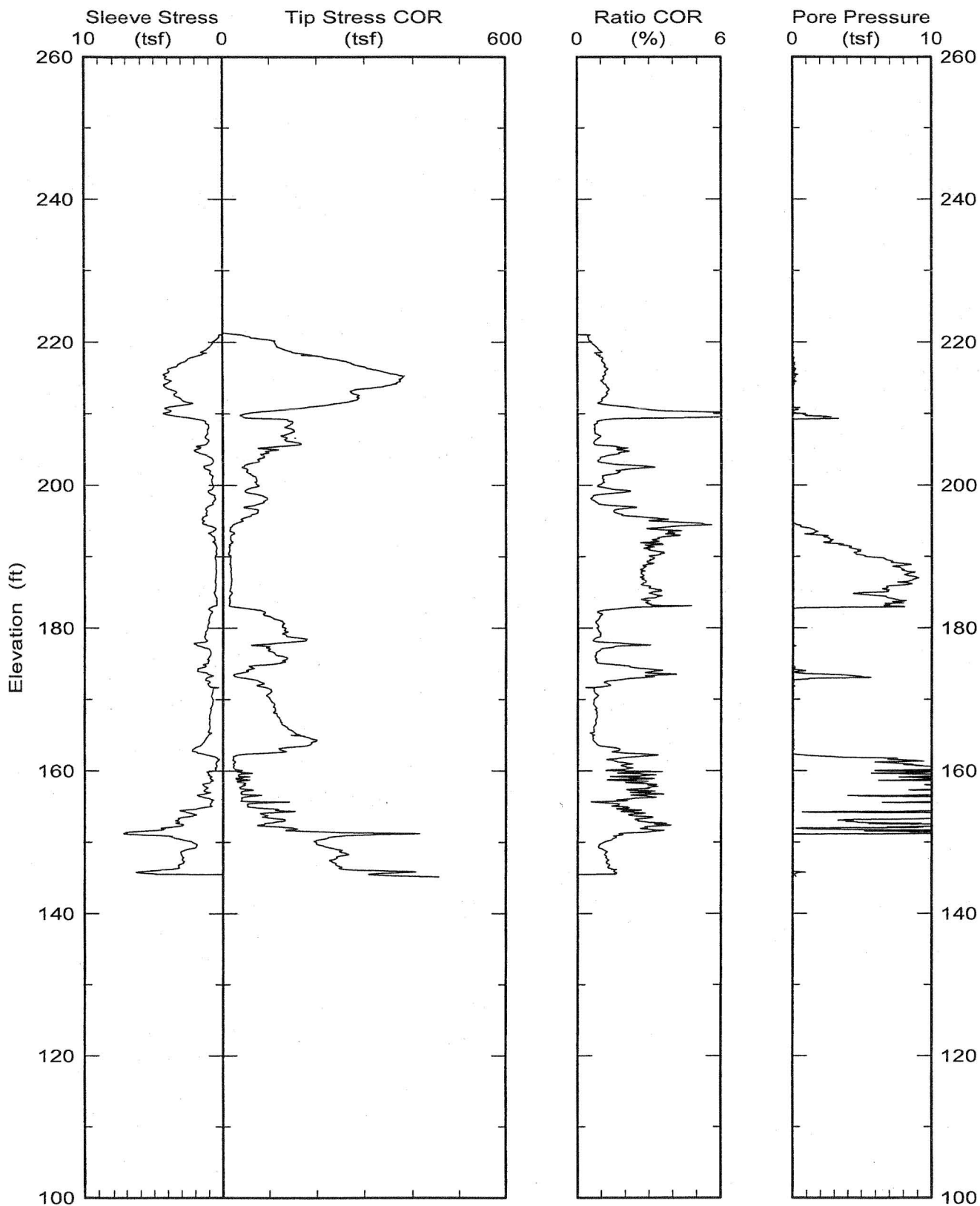
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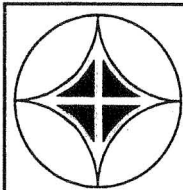
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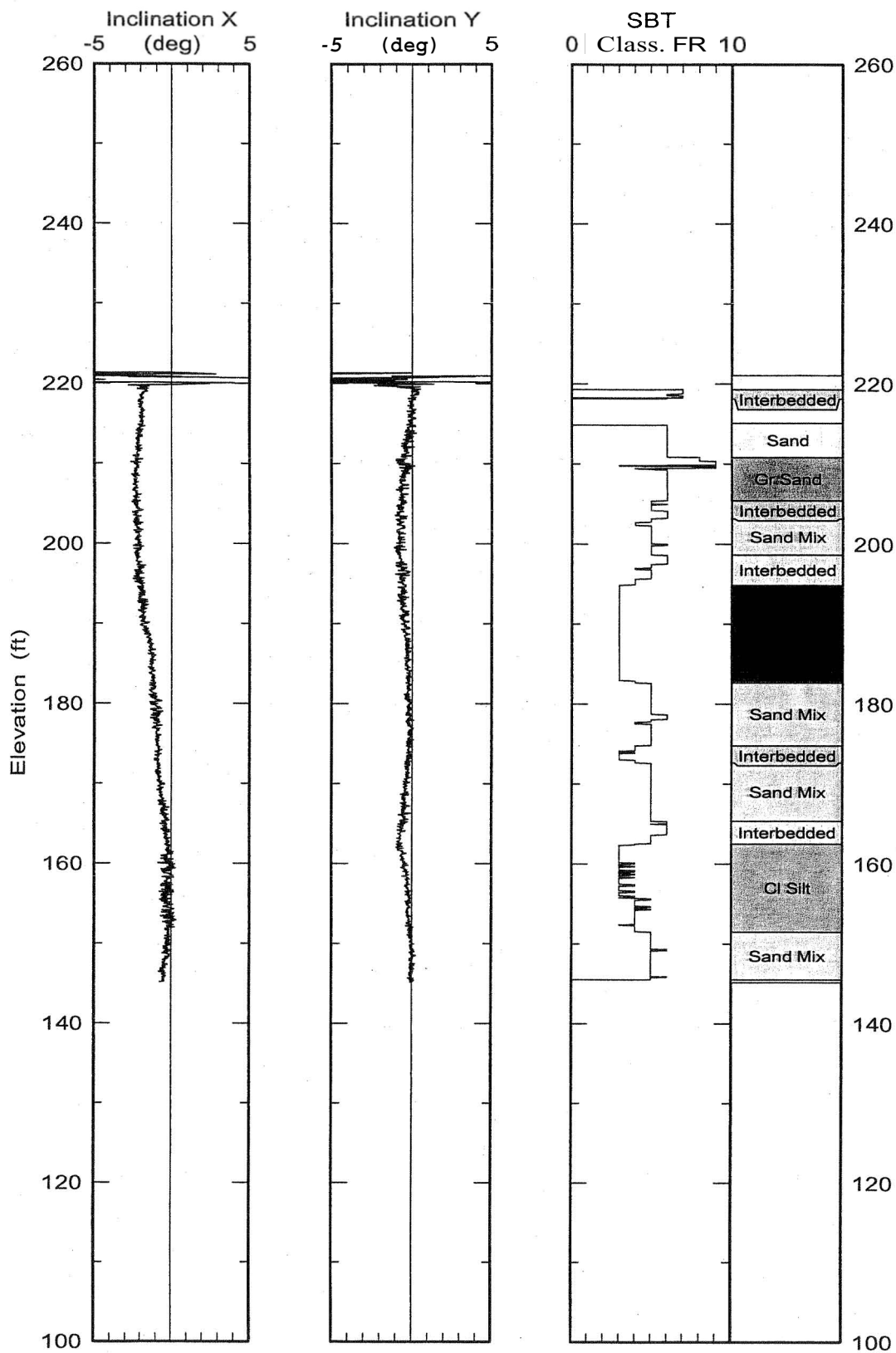


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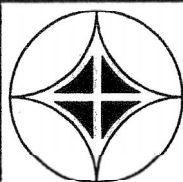
Applied Research Associates, Inc.  
South Royalton, VT 05068  
802-763-8348  
cpt@ned.ara.com  
www.ara.com

Date: 02/Sep/2005  
Test ID: C-1008  
Northing: 8268.48  
Easting: 6930.89  
Elevation: 221.30



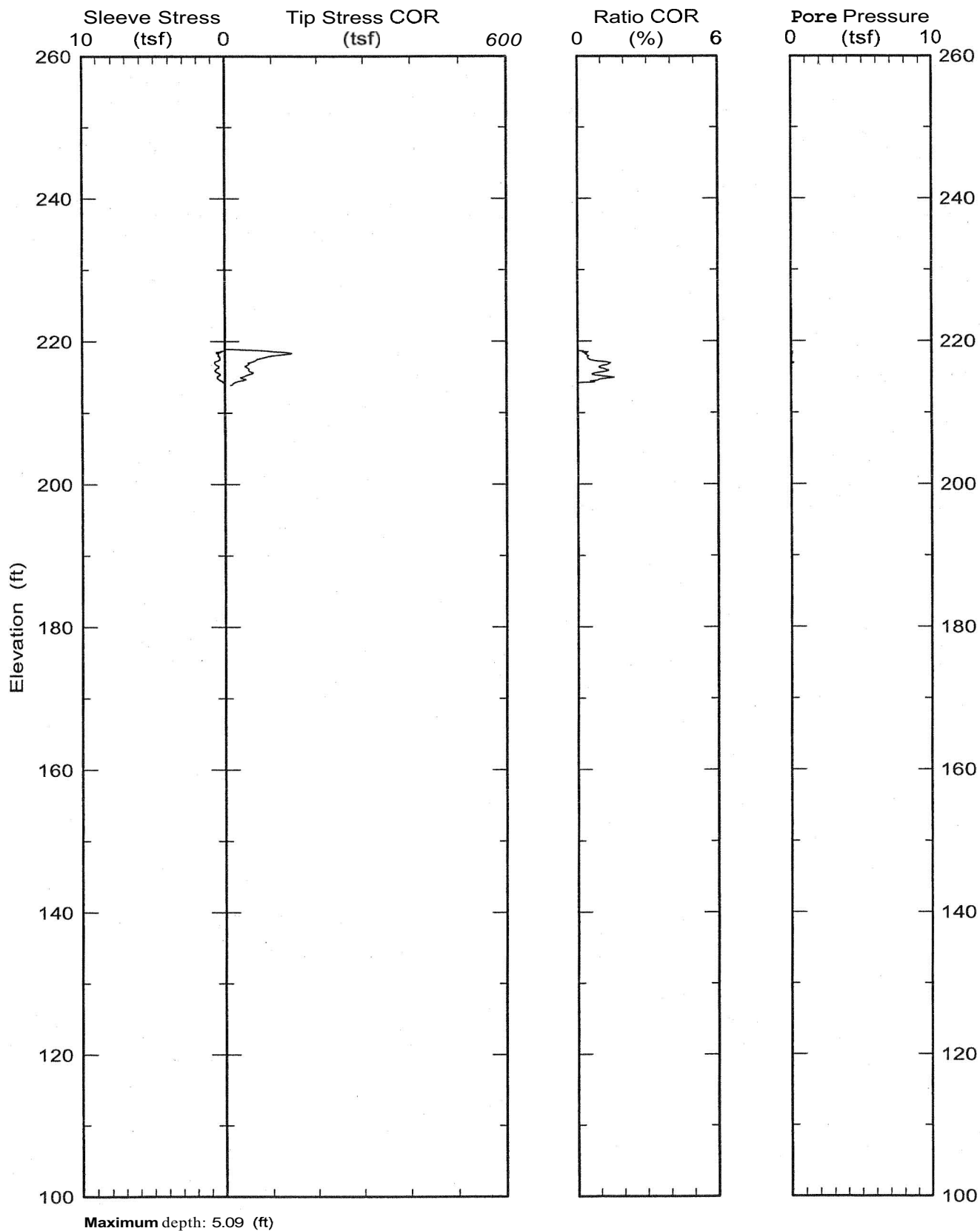
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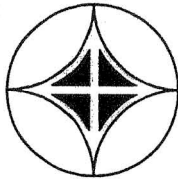
Class FR: Friction Ratio Class



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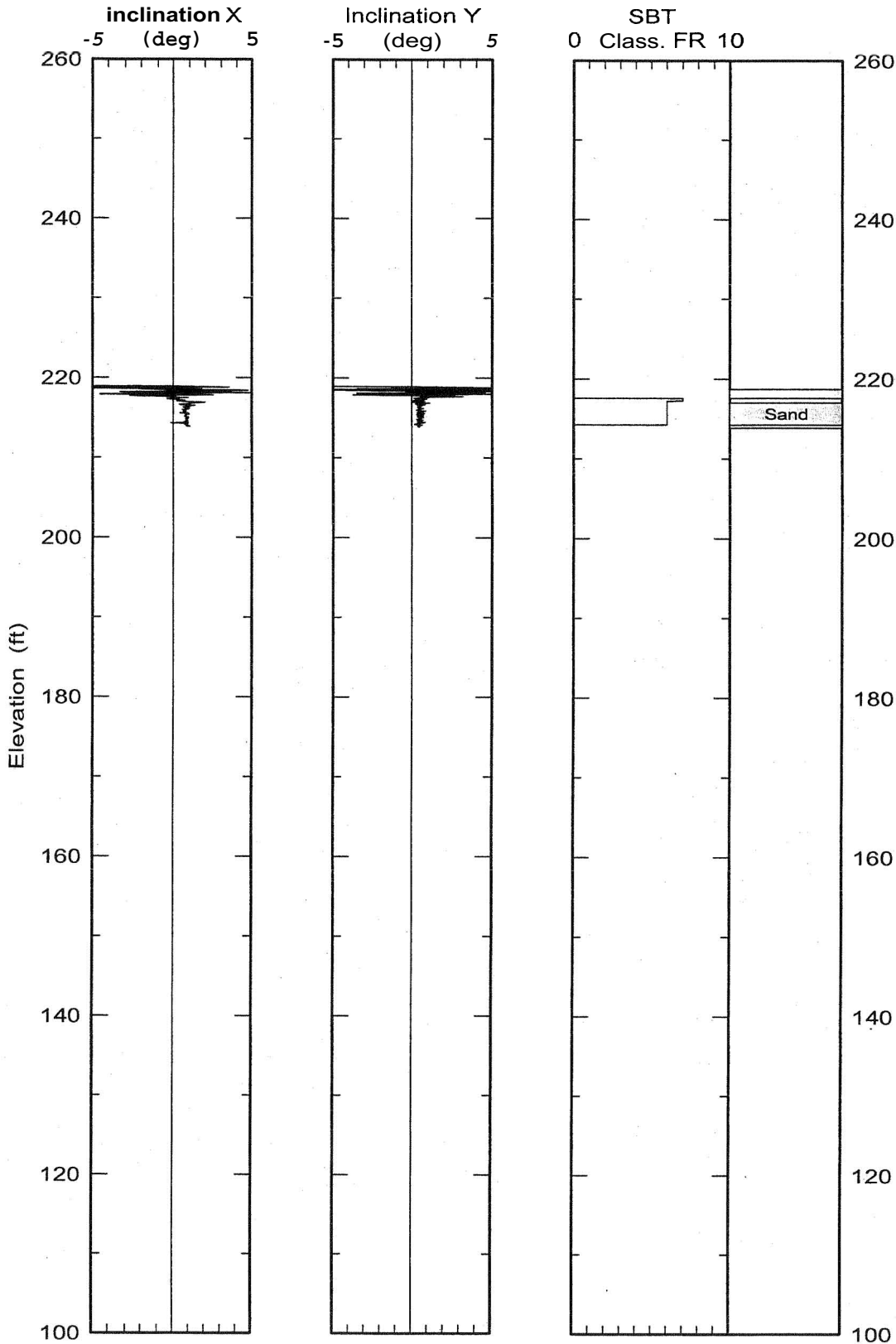
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Elevation: 218.93





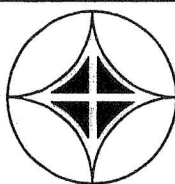
Applied Research Associates, Inc.  
South Royalton, VT 05068  
802-763-8348  
cpt@ned.ara.com  
www.ara.com

Date: 07/Sep/2005  
Test ID: C-1009  
Northing: 5979.62  
Easting: 6798.49  
Elevation: 218.93



Maximum depth: 5.09 (ft)

Class FR: Friction Ratio Cla



Applied Research Associates, Inc.  
South Royalton, VT 05068  
802-763-8348  
cpt@ned.ara.com  
www.ara.com

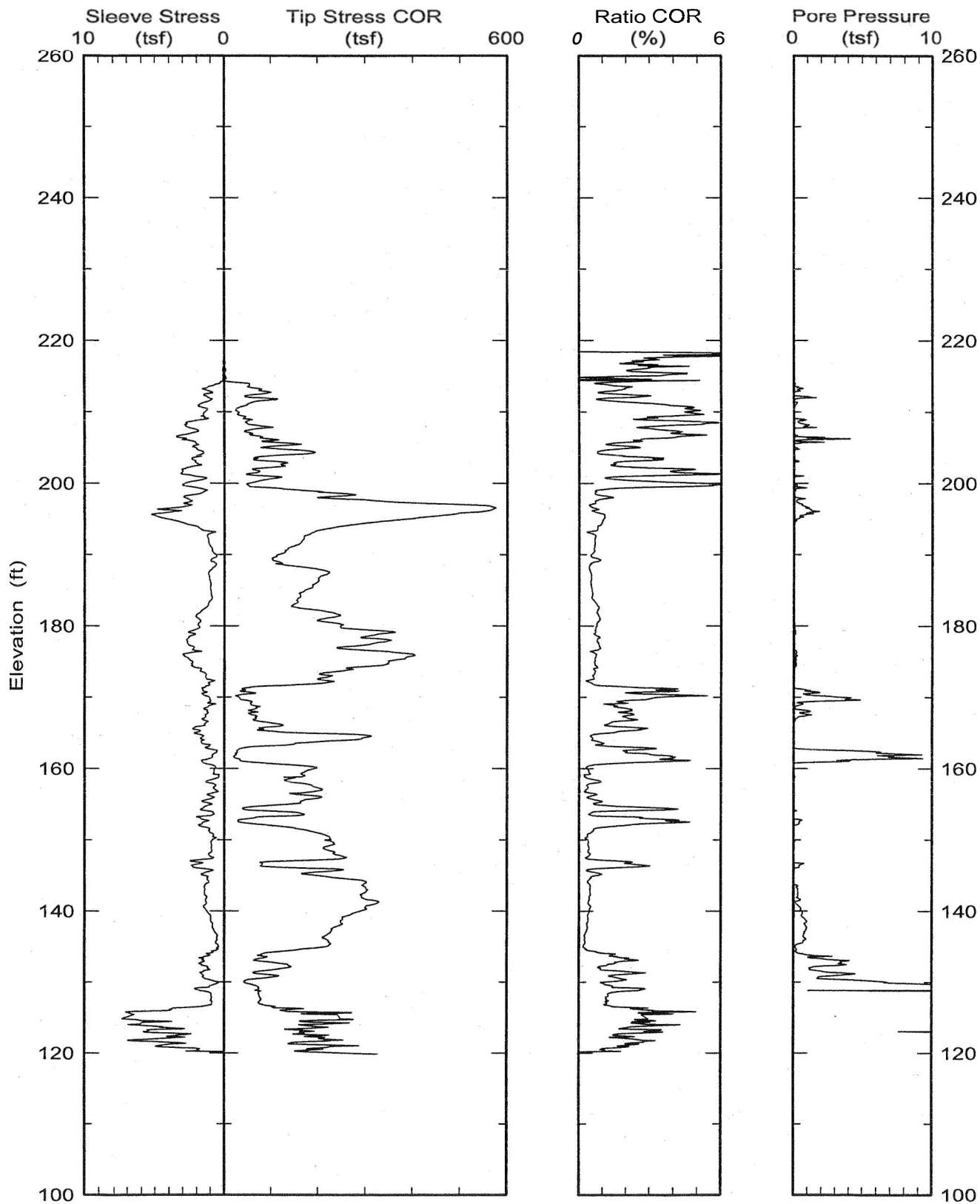
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Test ID: C-1009A

Northing: 5979.62

Easting: 6798.49

Elevation: 218.93

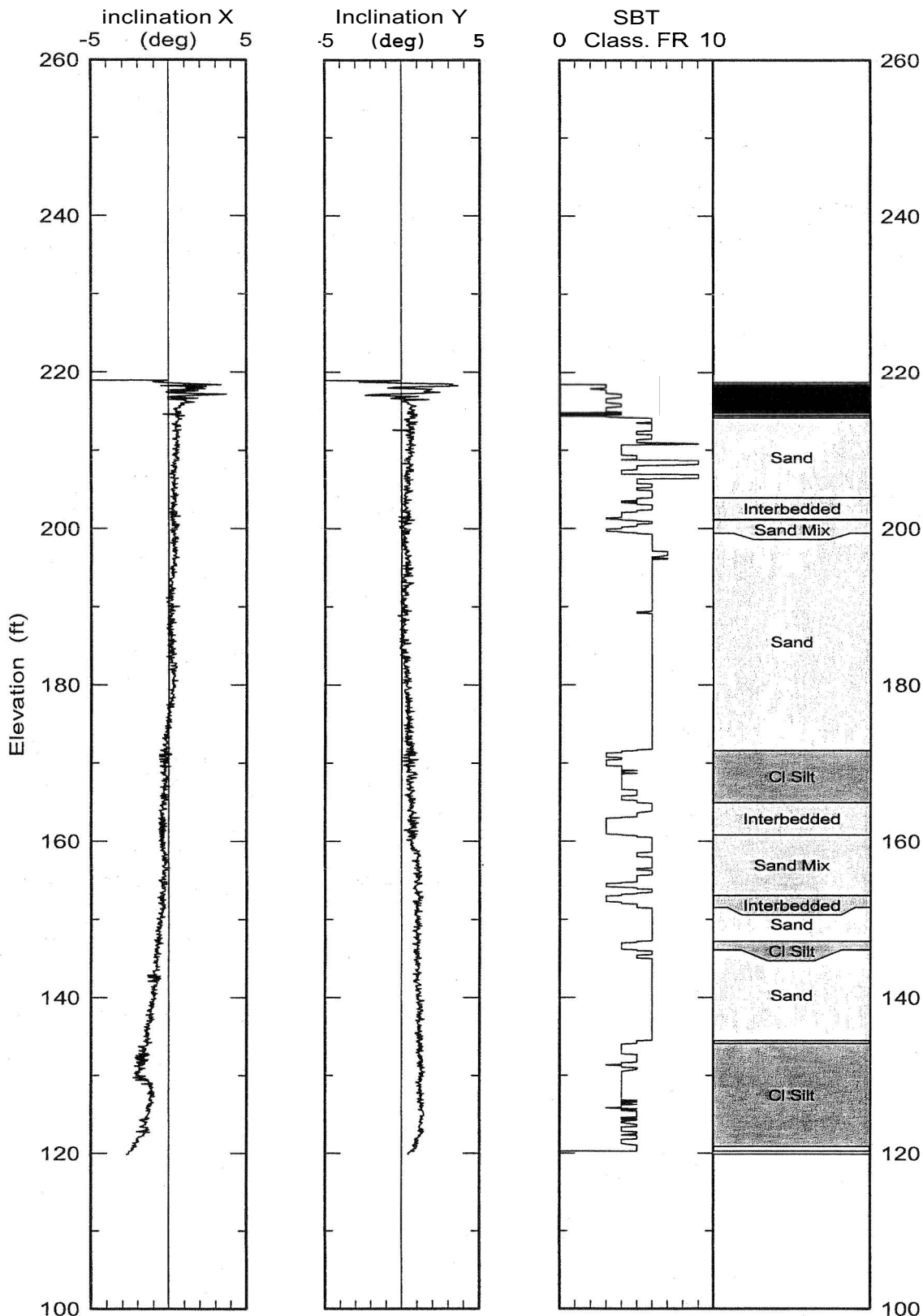


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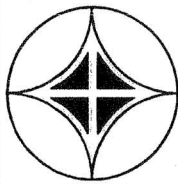
Applied Research Associates, Inc.  
South Royalton, VT 05068  
802-763-8348  
cpt@ned.ara.com  
www.ara.com

Date: 07/Sep/2005  
Test ID: C-1009A  
Northing: 5979.62  
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Elevation: 218.93



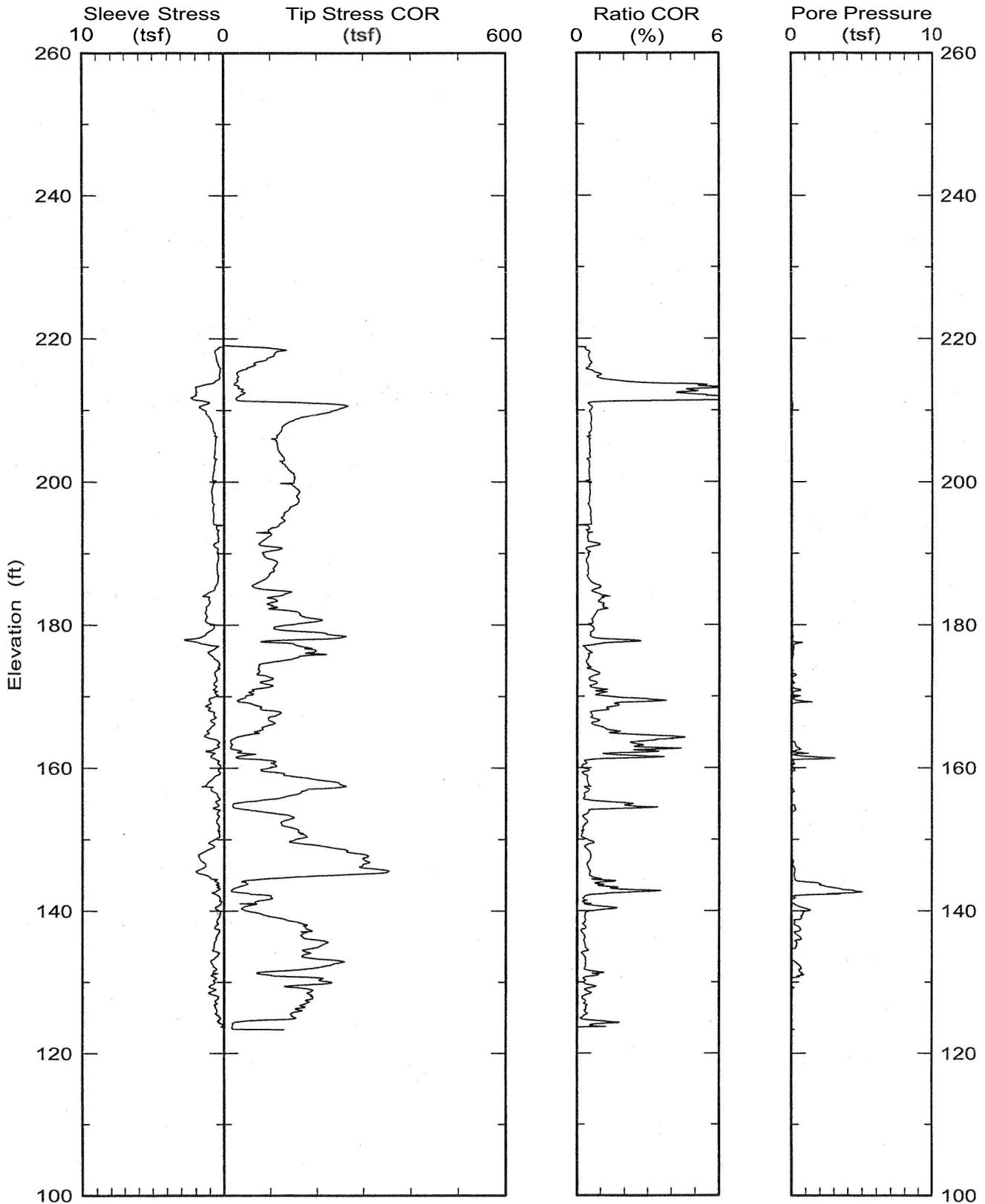
Maximum depth: 99.08 (ft)

Class FR: Friction Ratio Cla



Applied Research Associates, Inc.  
South Royalton, VT 05068  
802-763-8348  
cpt@ned.ara.com  
www.ara.com

Date: 08/Sep/2005  
Test ID: C-1010  
Northing: 6008.34  
Easting: 7754.15  
Elevation: 219.06



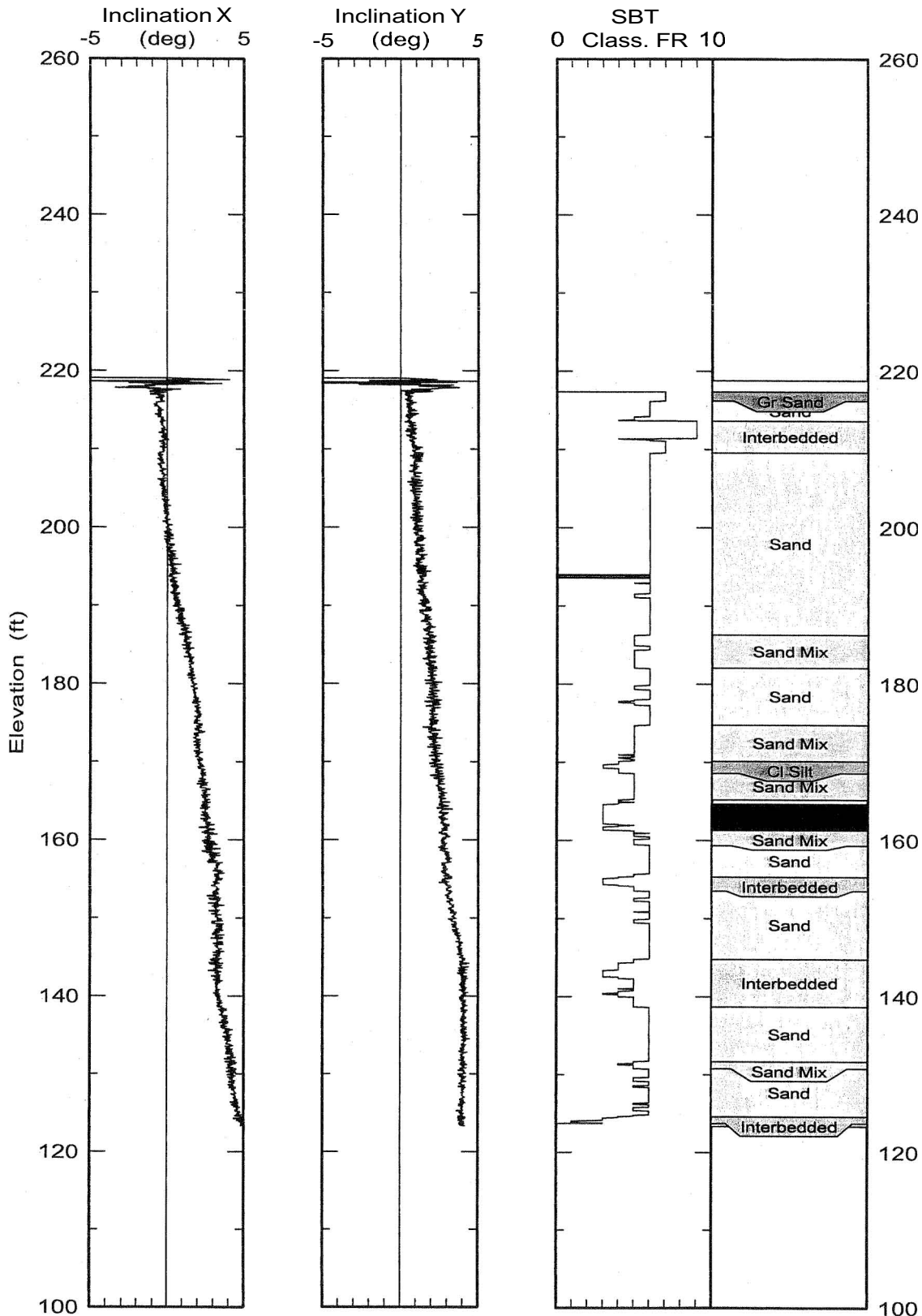
Maximum depth: 95.74 (R)





Applied Research Associates, Inc.  
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802-763-8348  
cpt@ned.ara.com  
www.ara.com

Date: 08/Sep/2005  
Test ID: C-1010  
Northing: 6008.34  
Easting: 7754.15  
Elevation: 219.06



Maximum depth: 95.74 (R)

Class FR: Friction Ratio Cla:

## **APPENDIX B**

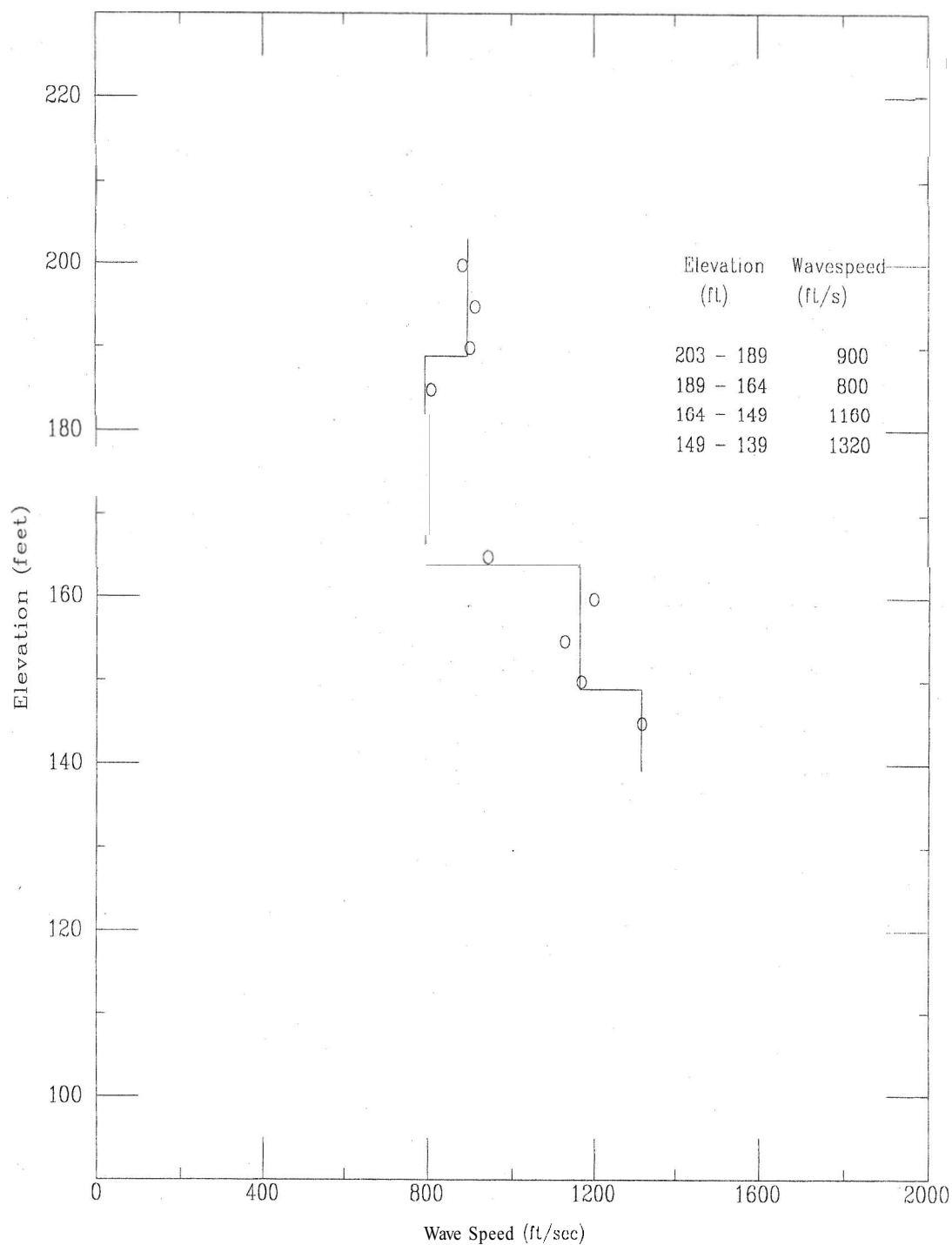
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C-1003

APPLIED RESEARCH ASSOCIATES, INC.

07/Sep/2005

# Shear Wave Speeds

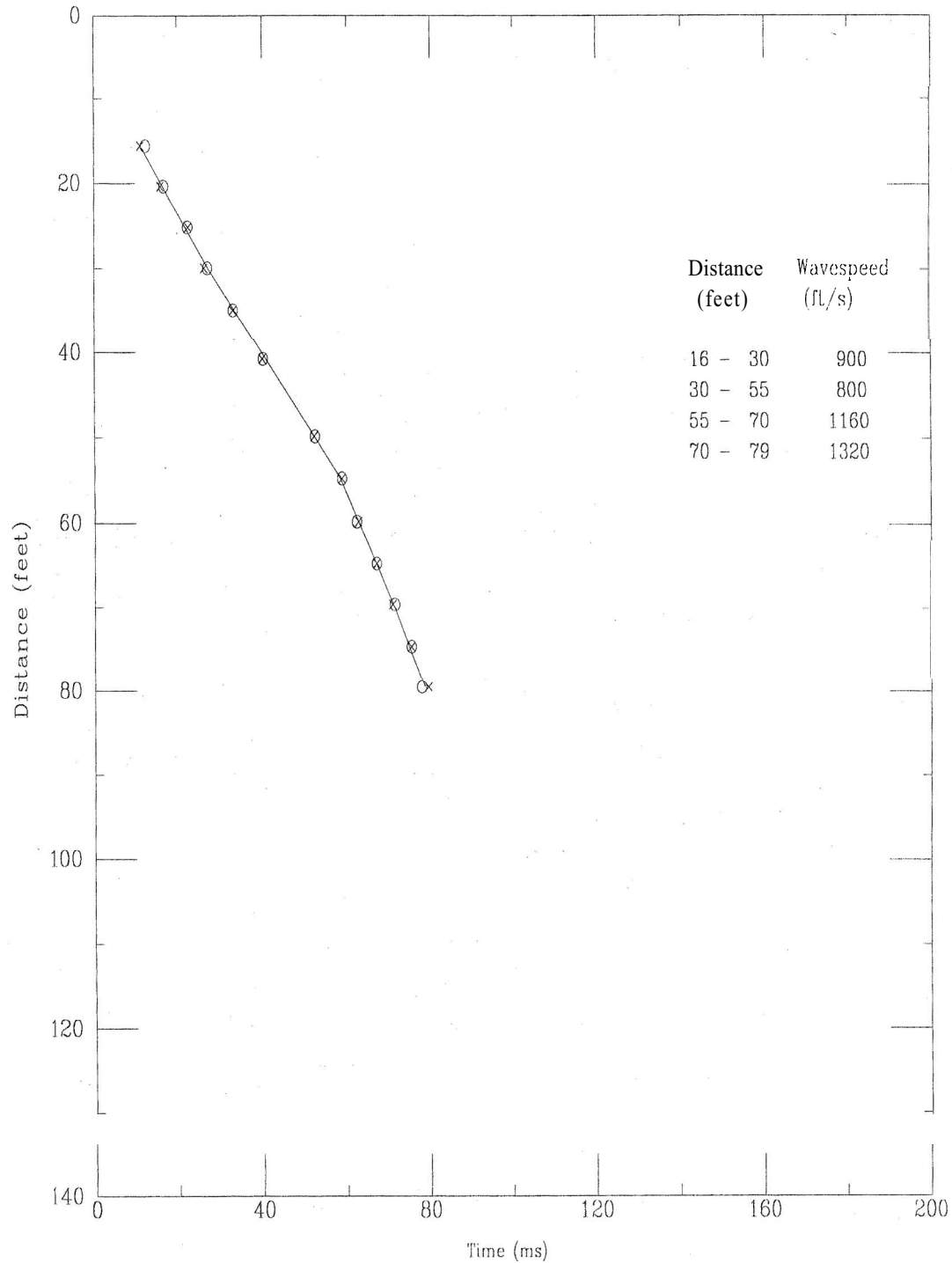


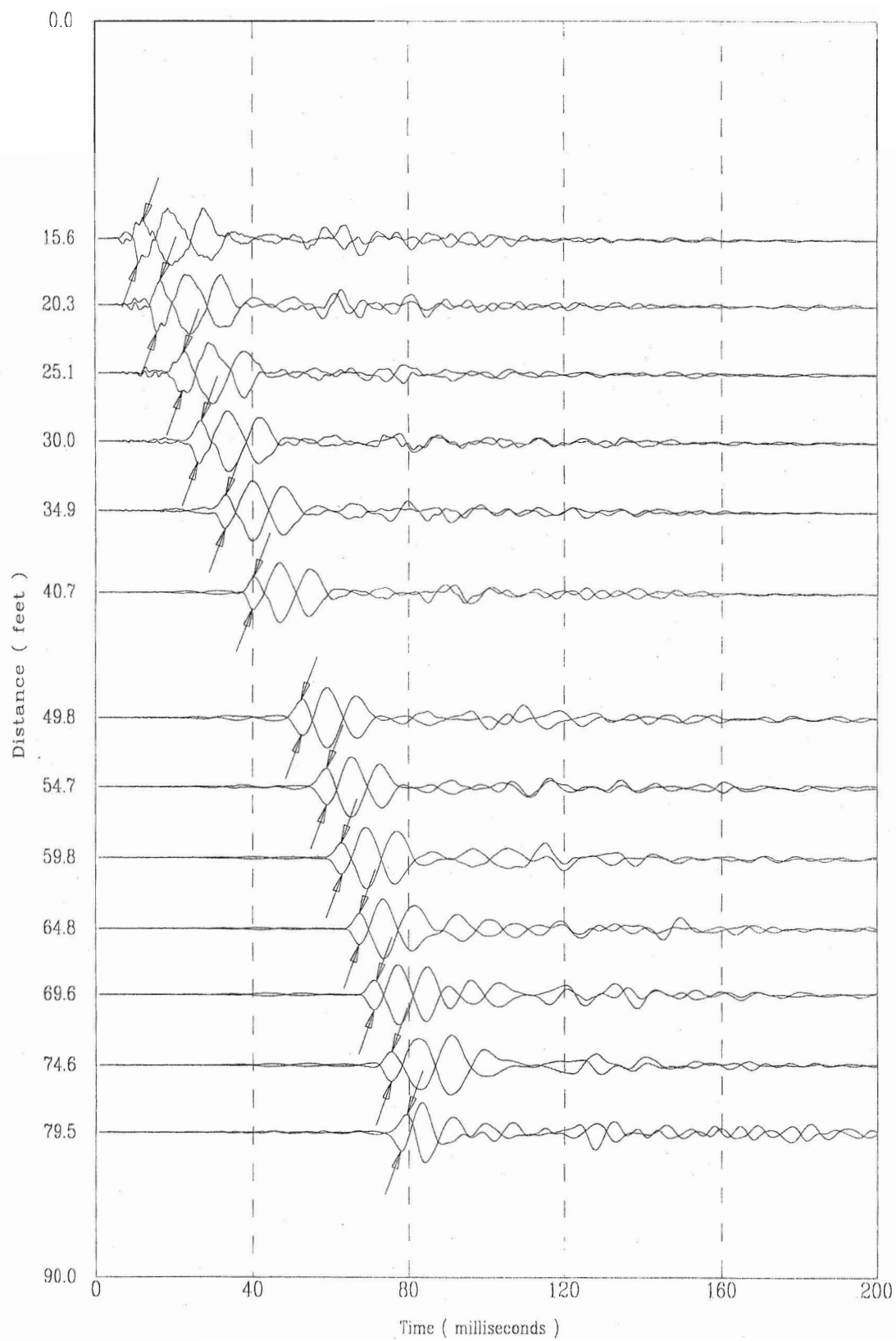
C-1003

APPLIED RESEARCH ASSOCIATES, INC.

07/Sep/2005

### Shear Wave Time of Peak



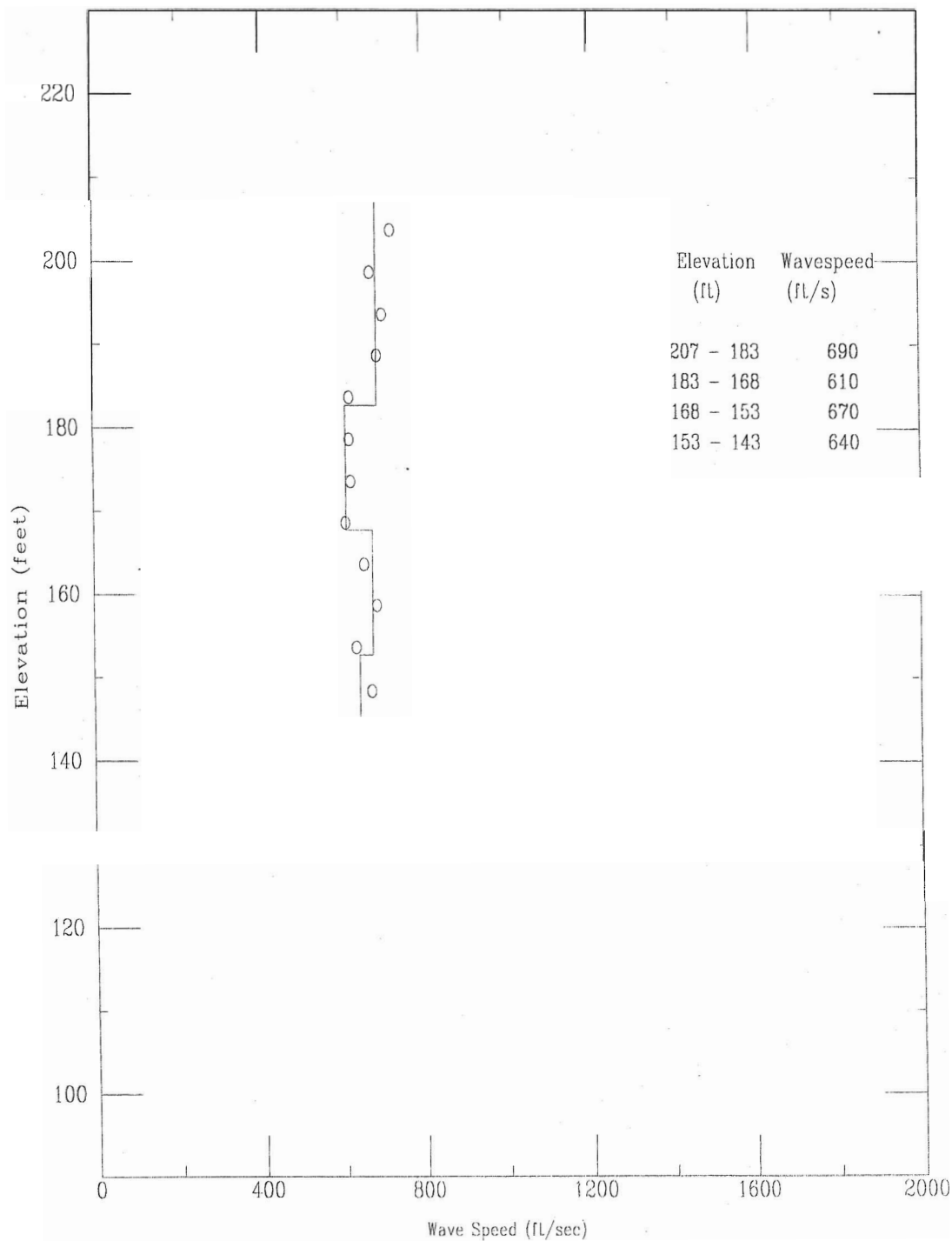


C-1005

APPLIED RESEARCH ASSOCIATES, INC

08/Sep/2005

# Shear Wave Speeds

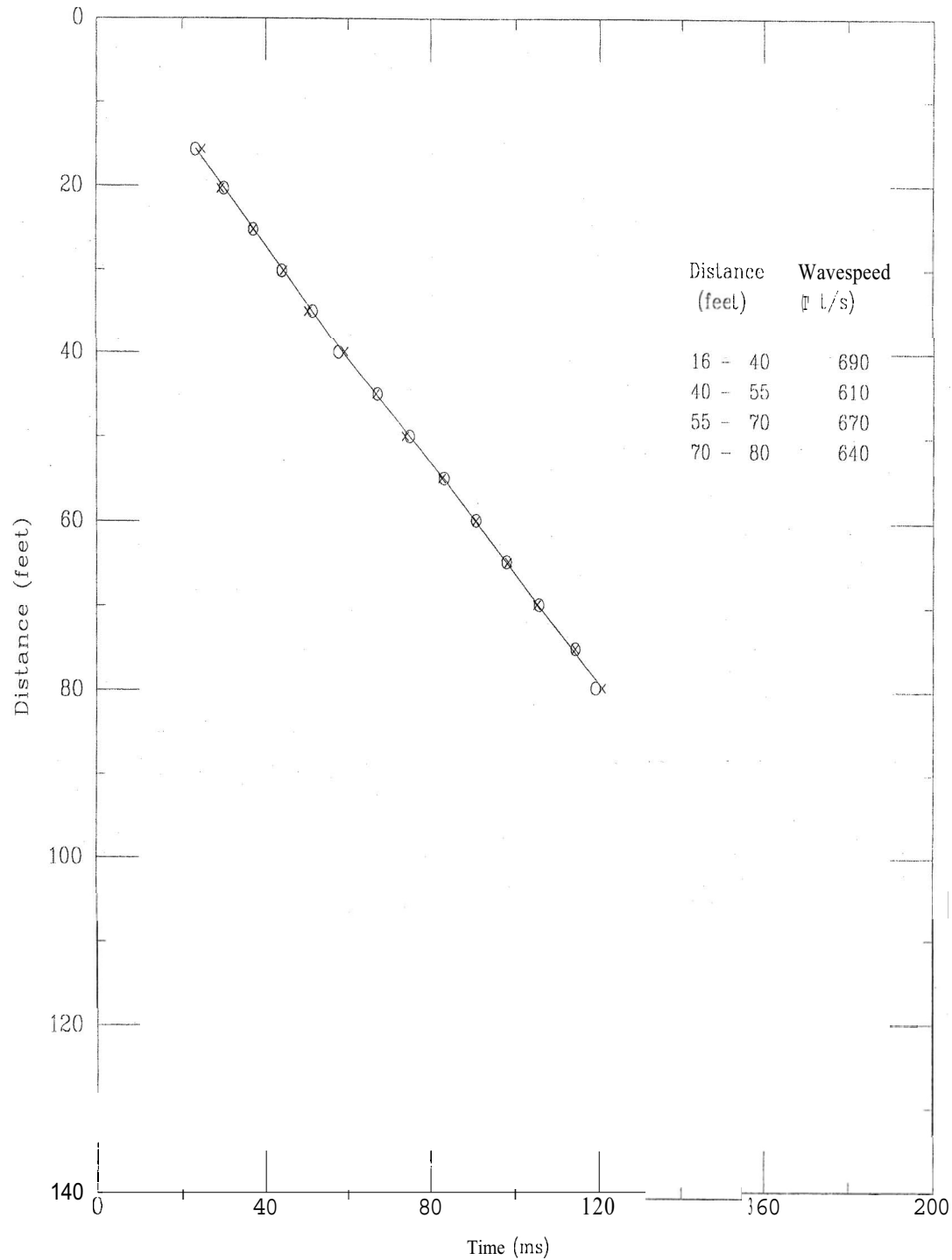


C-1005

APPLIED RESEARCH ASSOCIATES, INC.

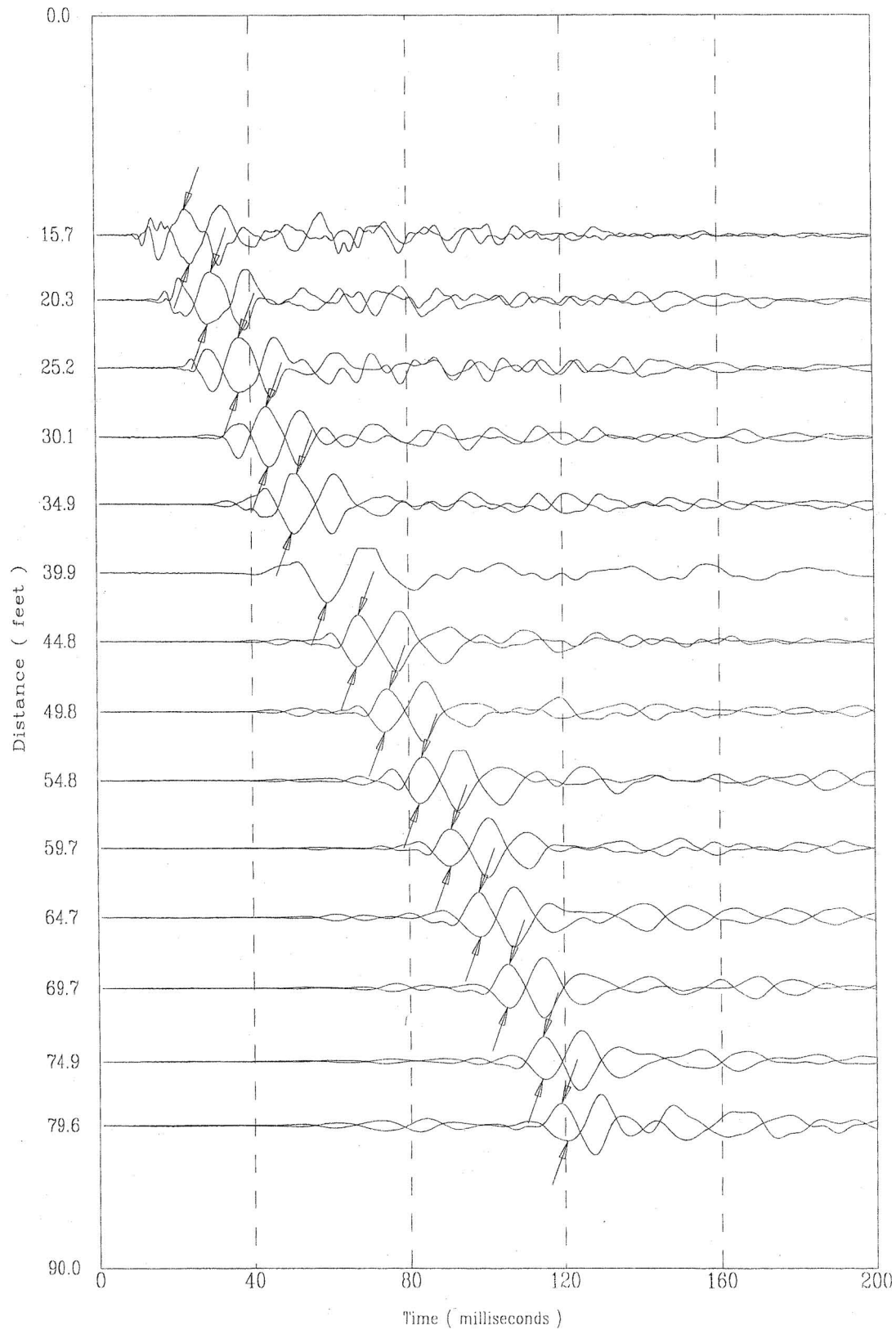
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Shear Wave Time of Peak



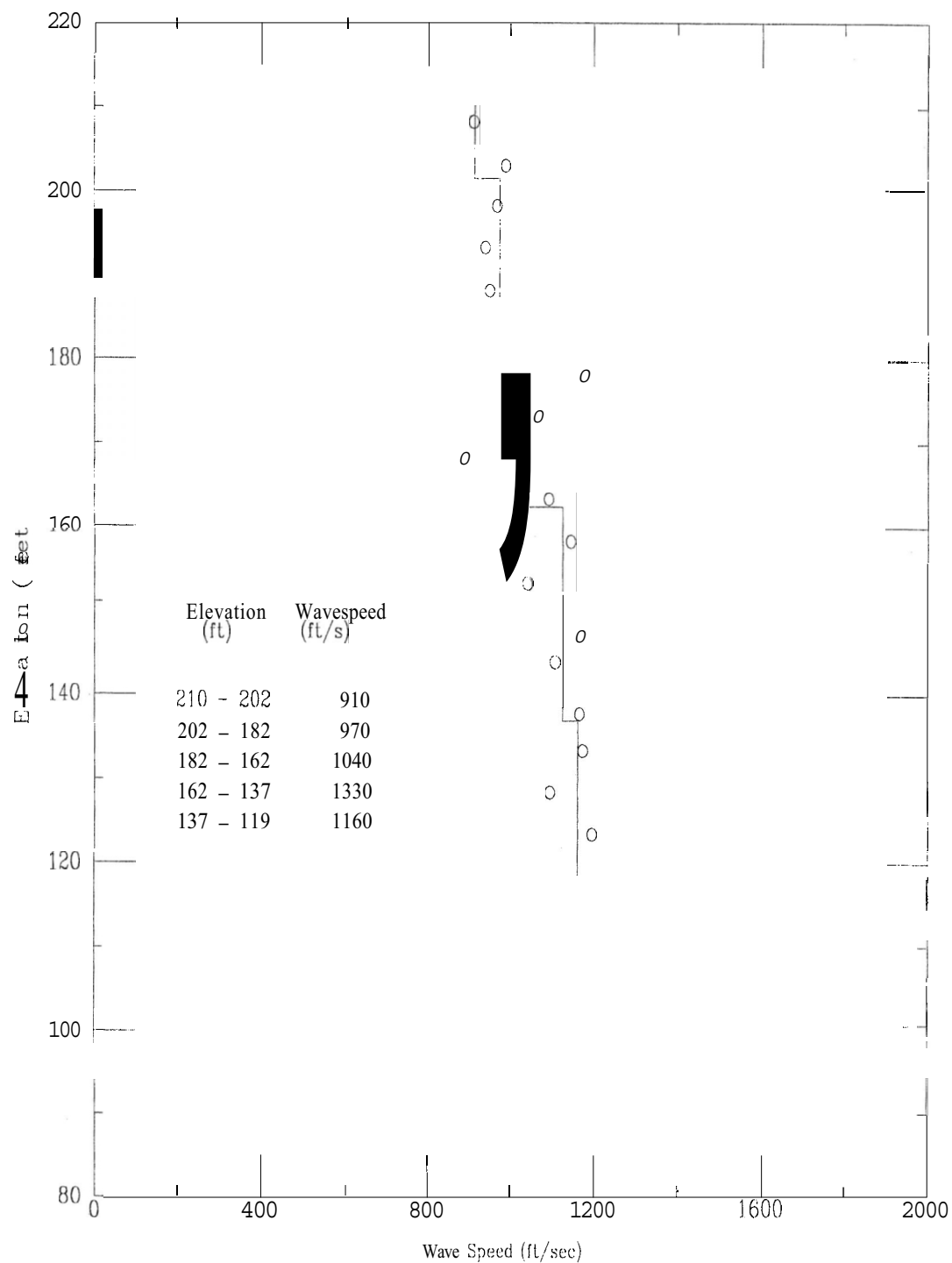
Applied Research Associales, Inc.  
C-1005

S Wave  
08/Sep/2005





## Shear Wave Speeds

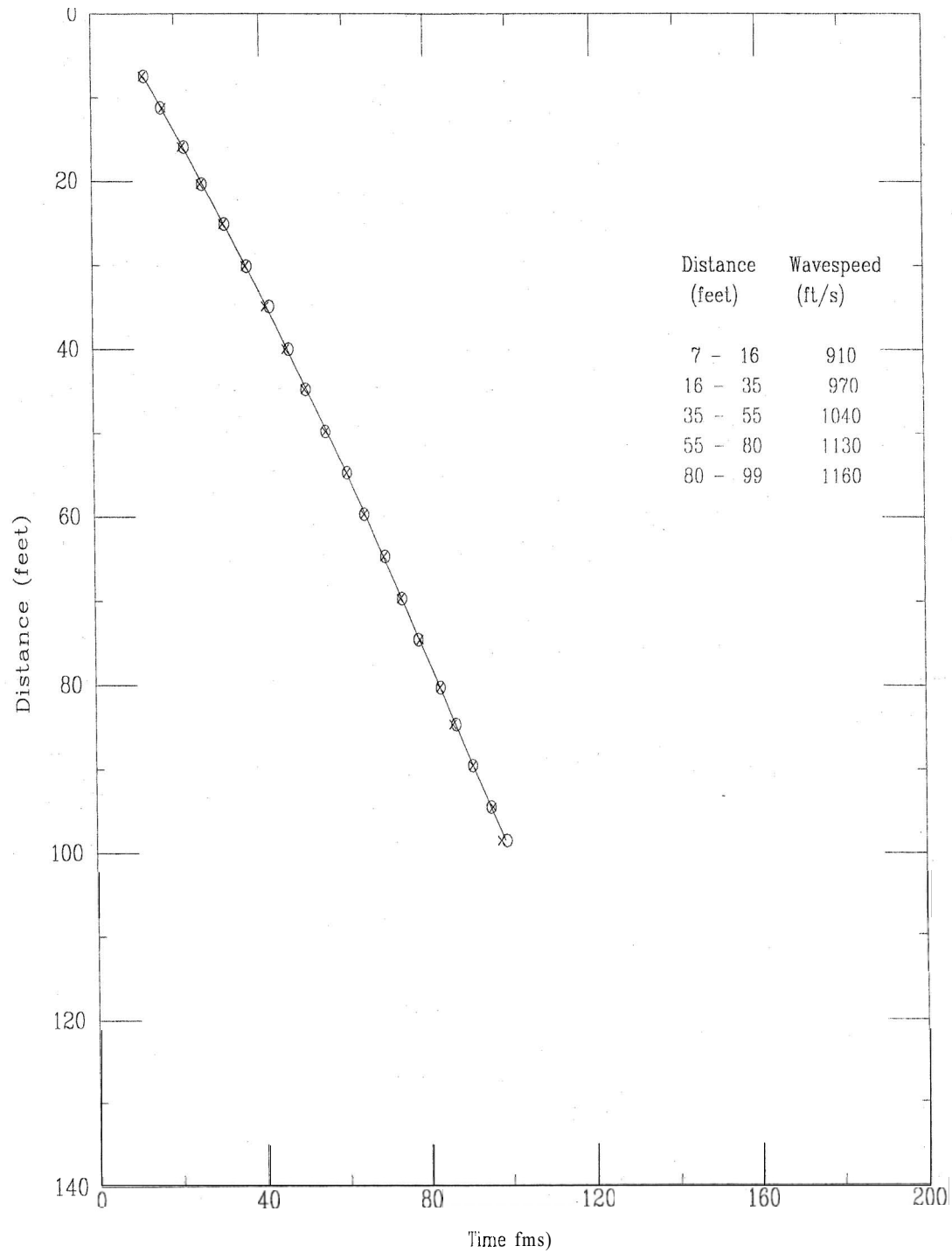


C-1009

APPLIED RESEARCH ASSOCIATES, INC.

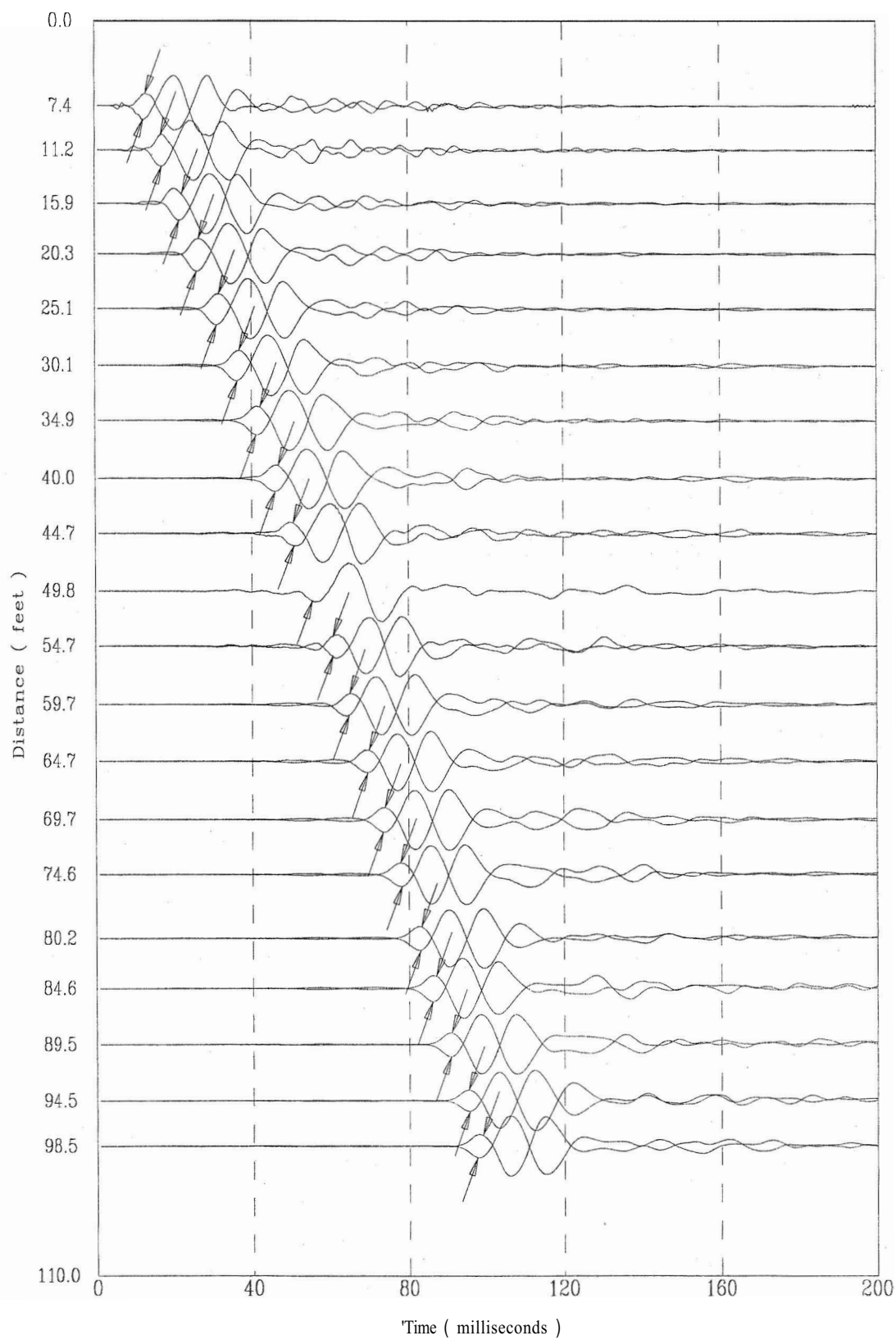
07/Sep/2005

Shear Wave Time of Peak



Applied Research Associates, Inc.  
C-1009

S Wave  
07/Sep/2005



**APPENDIX C**

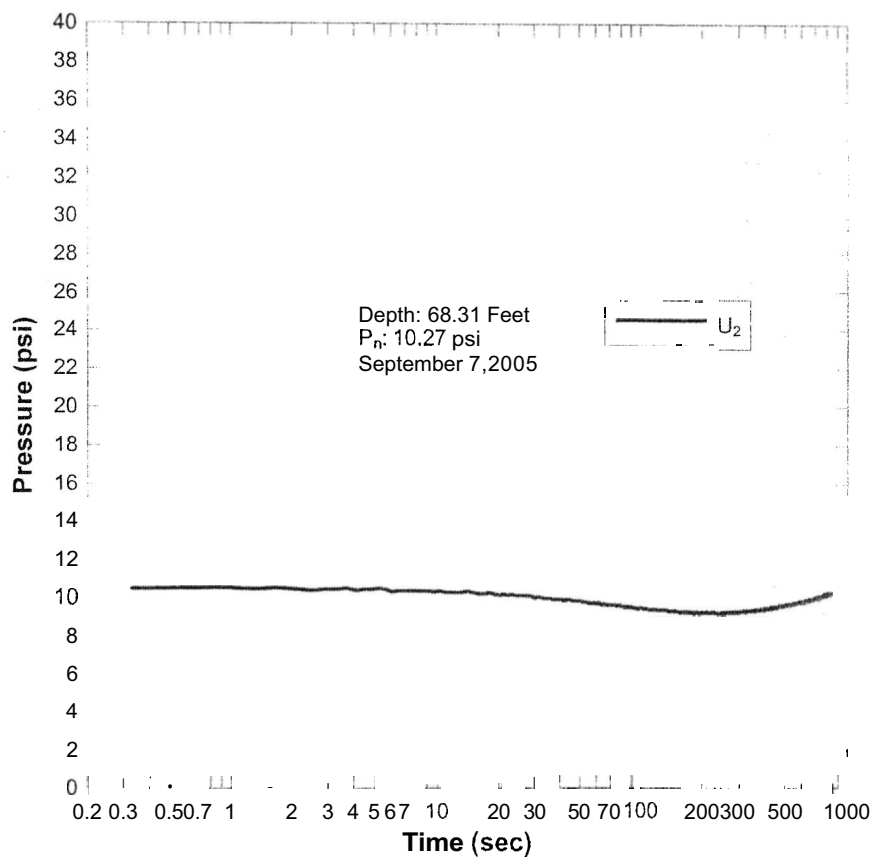
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**MACTEC**

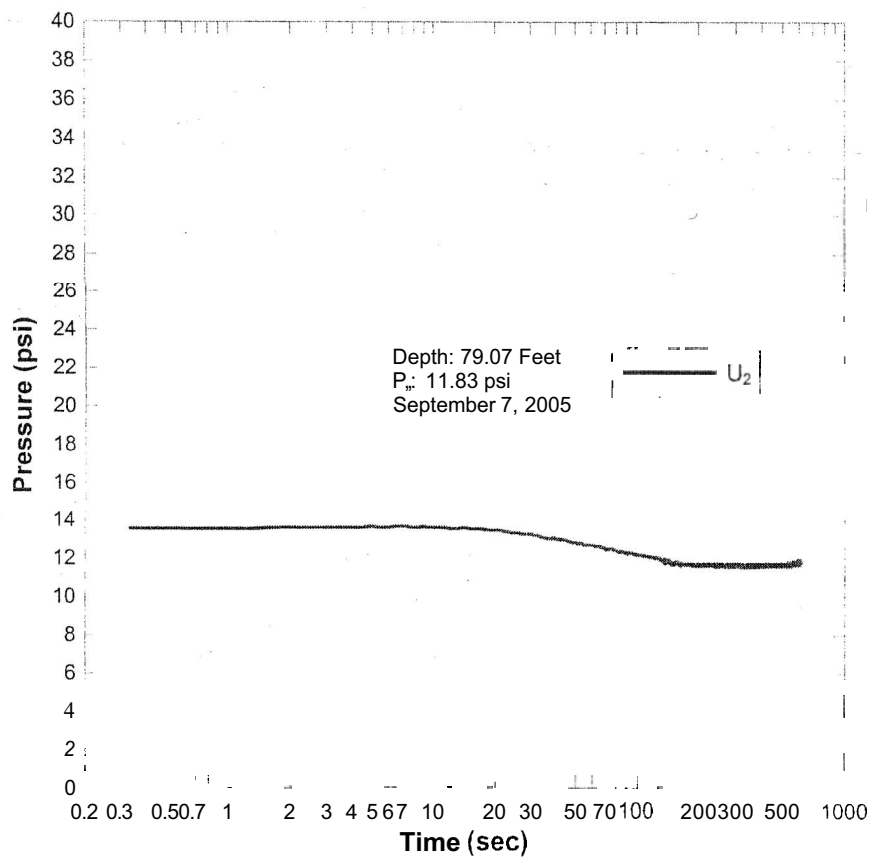
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Applied Research Associates, inc.

207S0506D.68



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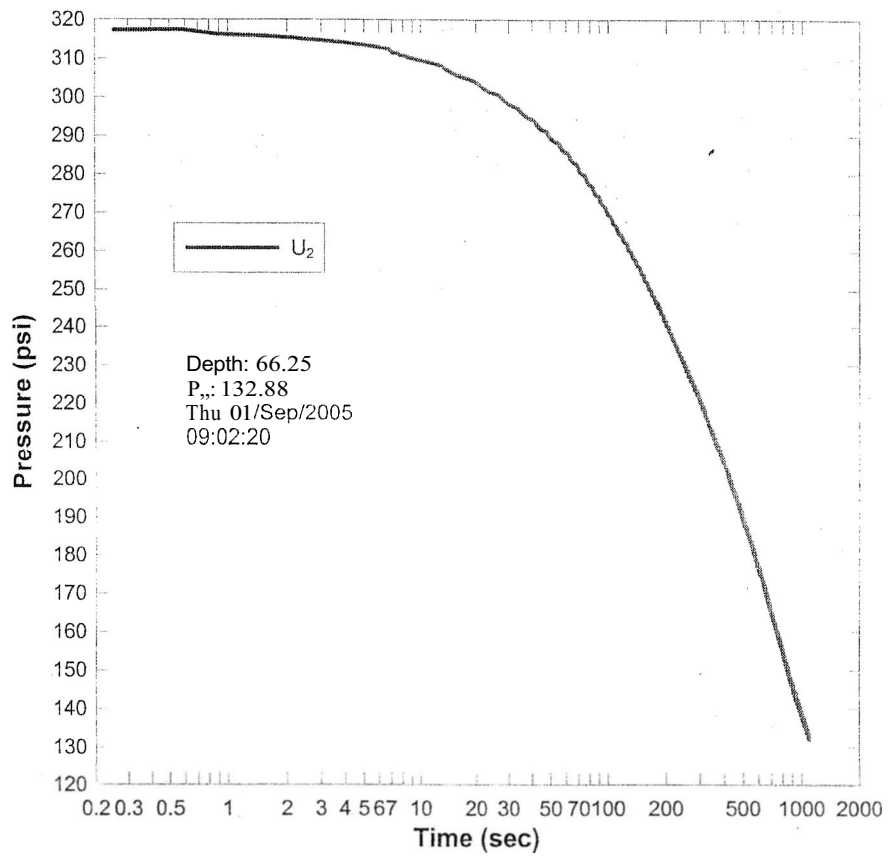


**MACTEC**

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Applied Research Associates, Inc.

201S0501D.66

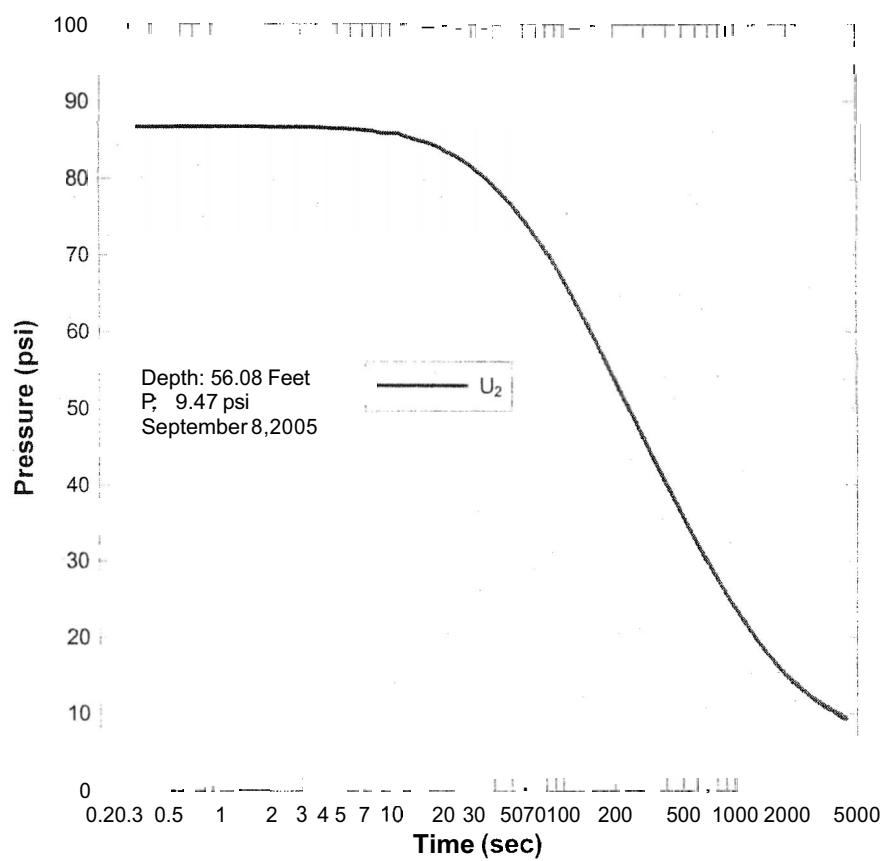


**MACTEC**

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Applied Research Associates, Inc.

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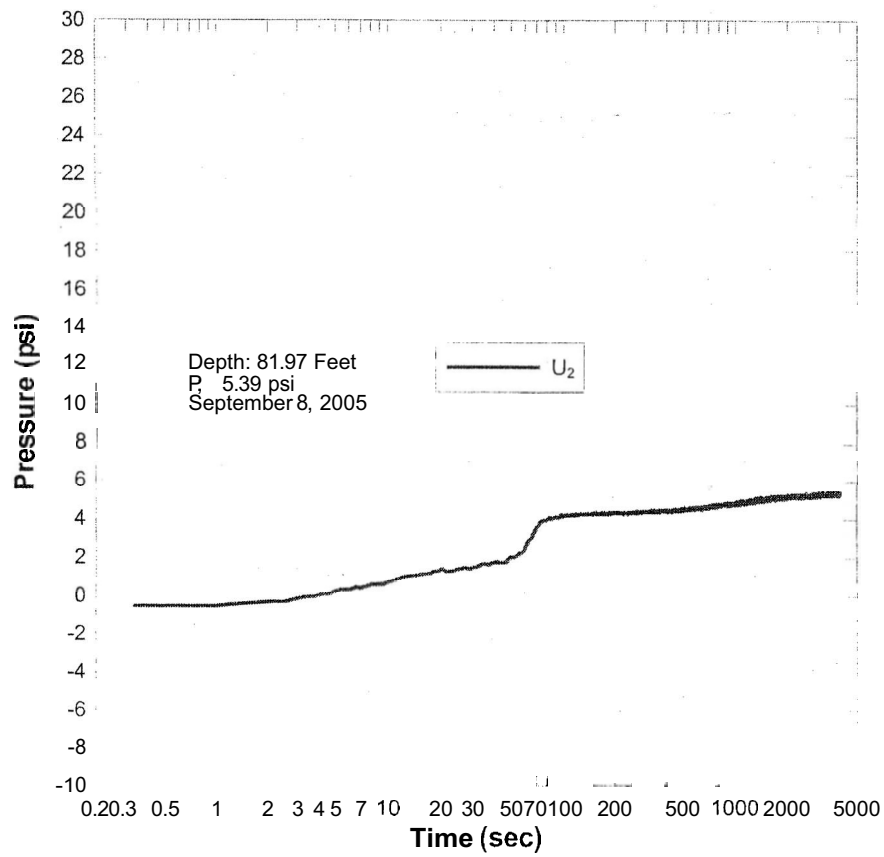


MACTEC

C-1005

Applied Research Associates, Inc.

208S0501D.82

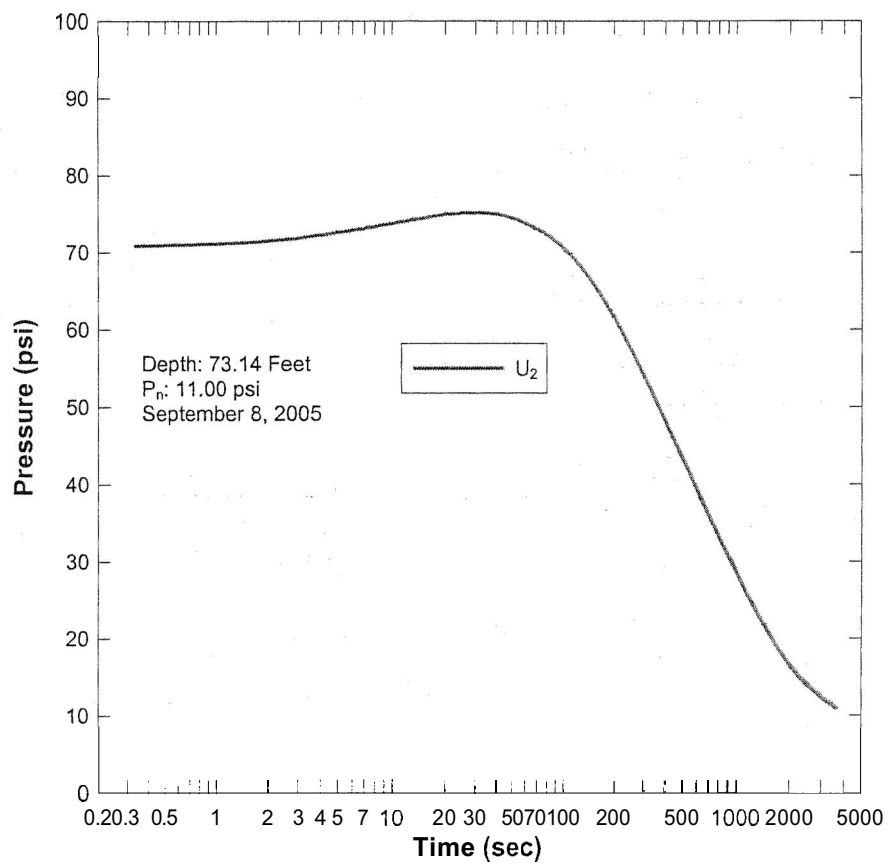


MACTEC

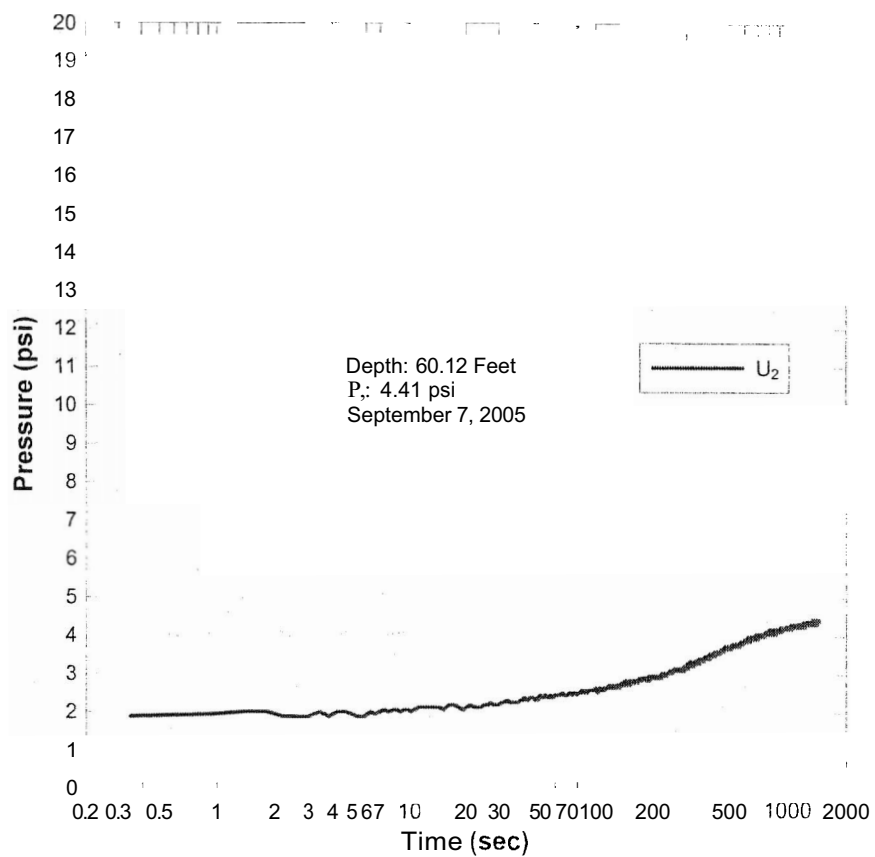
C-1005

Applied Research Associates, Inc.

208S0501D.73



**MACTEC** **C-1009**  
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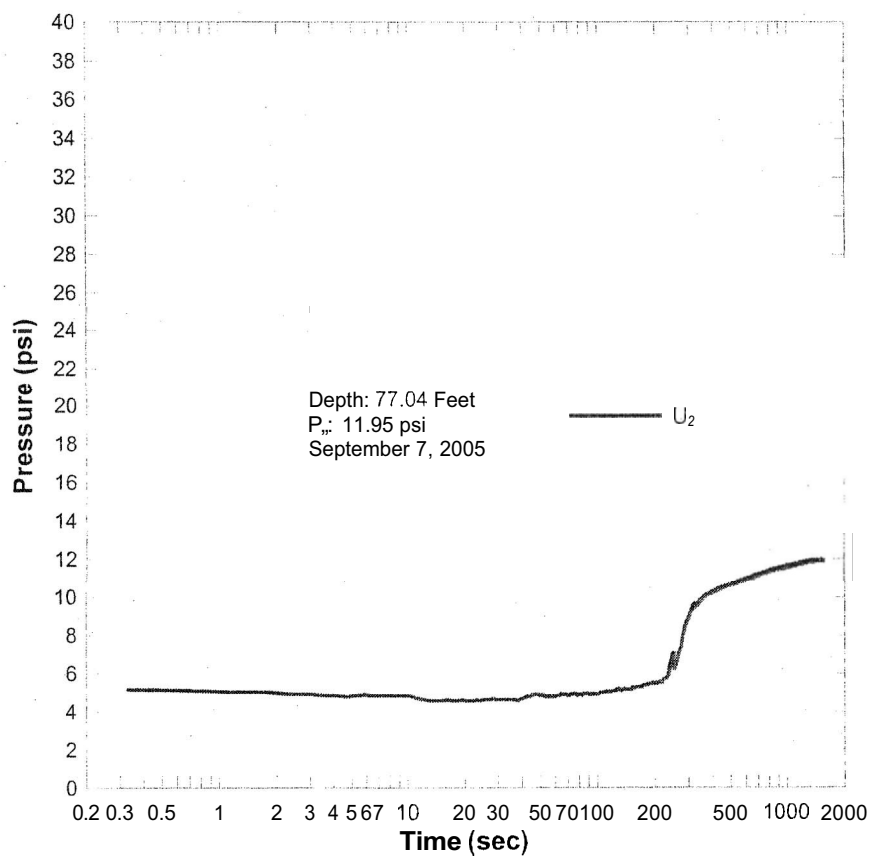


**MACTEC**

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Applied Research Associates, Inc.

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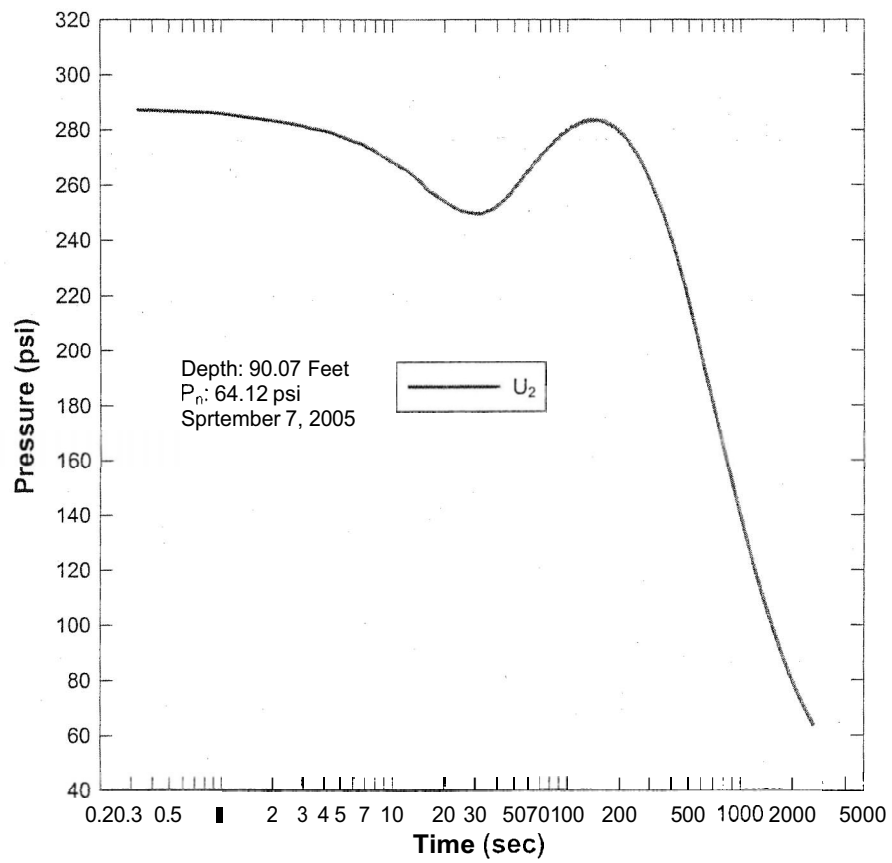


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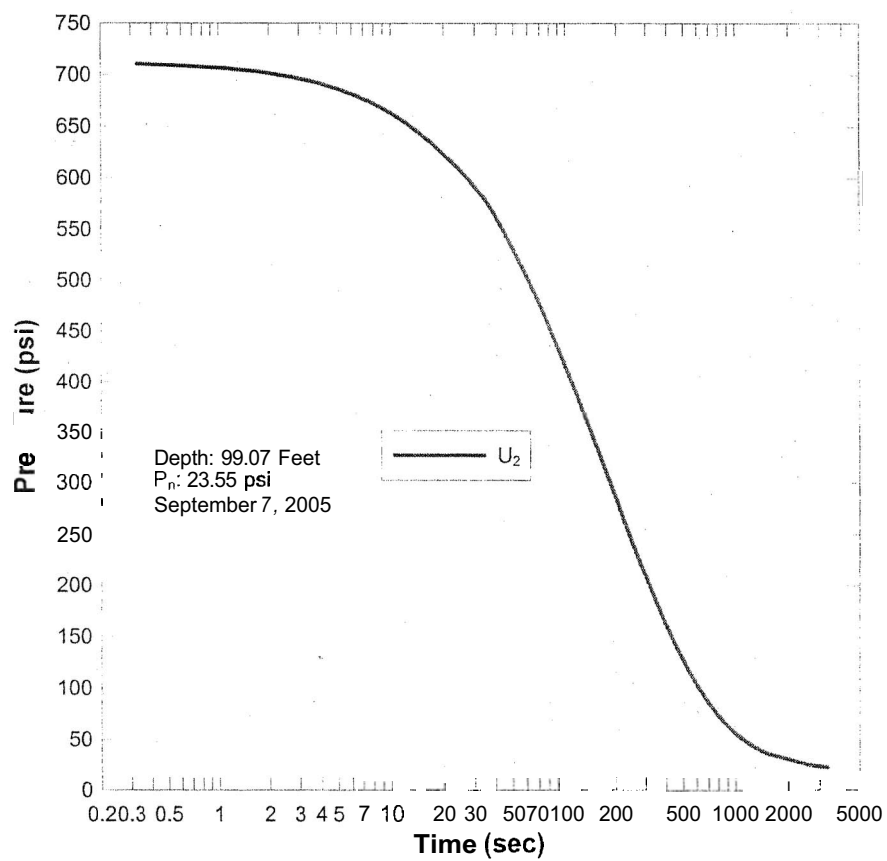
**C-1009**

**Applied Research Associates, Inc.**

**207S0505D.90**



**MACTEC** **C-1009**  
**Applied Research Associates, Inc.** **207S0505D.99**





# **APPENDIX C**

**REPORT OF  
BOREHOLE GEOPHYSICS  
By GEOVISION Geophysical Services**

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**VOGTLE ELECTRIC GENERATING PLANT,  
BOREHOLES B-1002, B-1002A,  
B-1003, B-1004 AND C-1005A  
BOREHOLE GEOPHYSICS**

**December 19, 2005  
Report 5492-01 rev a  
Volume 4 sf 2 \***

**\* NOTE: VOLUME 2 OF THIS REPORT IS A CDROM CONTAINING THIS REPORT  
WITH APPENDICES AND DATA IN ELECTRONIC FORMAT.**



**VOGTLE ELECTRIC GENERATING PLANT,  
BOREHOLES B-1002, B-1002A,  
B-1003, B-1004 AND C-1005A  
BOREHOLE GEOPHYSICS**

**Prepared for**

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Atlanta, Georgia 30342  
(404) 873-4761  
Job 6141-05-0227**

**Prepared by**

**GEOVision Geophysical Services  
1151 Pomona Road, Unit P  
Corona, California 92882  
(951) 549-1234  
Project 5492**

**December 19, 2005  
Report 5492-01 rev a  
Volume 1 of 2**

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## INTRODUCTION

Boring geophysical measurements were collected in five uncased borings located at the Vogtle Electric Generating Plant Advanced Light Water Reactor, located south of Augusta, Georgia. Suspension logging data acquisition was performed between September 22 and November 11, 2005 by Rob Steller of GEOVision. The work was performed under subcontract with MACTEC, Inc., with Matt Cooke serving as the point of contact for MACTEC.

This report describes the field measurements, data analysis, and results of this work.



## SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between September 22 and November 11, 2005, in five uncased borings, as detailed below. The purpose of these studies was to supplement stratigraphic information obtained during MACTEC's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth, as a component of the Vogtle Electric Generating Plant Advanced Light Water Reactor Early Site Permit Project.

BORING DESIGNATION	DATES LOGGED	ELEVATION	COORDINATES	
			NORTHING	EASTING
B-1002	9/22/05, 9/23/05	221.98	7998.524	6985.474
B-1002A	10/05/05	222.27	7985.618	6986.068
B-1003	10/03/05, 10/22/05, 11/10/05, 11/11/05	223.21	7974.364	7889.853
B-1004	10/04/05	249.78	7985.411	6131.444
C-1005A	10/06/05	223.66	7989.752	8179.263

Table 1. Boring locations and logging dates

The OYO Model 170 Suspension Logging Recorder and Suspension Logging Probe were used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6 or 3.3 ft intervals. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

Guidelines for Determining Design Basis Ground Motions, Report TR-102293,  
Electric Power Research Institute, Palo Alto, California, November 1993,  
Sections 7 and 8.

## INSTRUMENTATION

### Suspension Instrumentation

Suspension soil velocity measurements were performed using the Model 170 suspension logging system, S/N 19029, manufactured by OYO Corporation. This system directly determines the average velocity of a 3.3 ft high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source ( $S_H$ ) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 ft, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. Initial runs were performed in B-1002 using a shorter 19 ft probe configuration on September 22, 2005, but due to observed high amplitude signals, and the possibility of saturation of the receivers by those high amplitude signals, the longer 22 ft configuration was used for all subsequent measurements. Throughout the text, dimensions for the longer 22 ft configuration, as shown in Figure 1, will be given, followed by dimensions for the shorter configuration, as shown in Figure 2, enclosed in parenthesis. The total length of the probe as used in these surveys is 22 (19) ft, with the center point of the receiver pair 15.4 (12.1) ft above the bottom end of the probe.

The probe receives control signals from, and sends the amplified receiver signals to, instrumentation on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 ft diameter sheave fitted with a digital rotary encoder.

The entire probe is suspended by the cable and centered in the boring by nylon "whiskers", therefore, source motion is not coupled directly to the boring walls; rather, the source motion

creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and  $S_H$ -waves in the surrounding soil and rock as it passes through the casing and grout annulus and impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and  $S_H$ -waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded  $S_H$  -wave signals.
2. At each depth,  $S_H$ -wave signals are recorded with the source actuated in opposite directions, producing  $S_H$ -wave signals of opposite polarity, providing a characteristic  $S_H$ -wave signature distinct from the P-wave signal.
3. The 10.4 (7.02) ft separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower  $S_H$ -wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and  $S_H$ -wave signals.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received  $S_H$ -wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe (meter versus centimeter scale), preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and  $S_H$ -wave arrivals; reversal of the source changes the polarity of the  $S_H$ -wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Model 170 has six channels (two simultaneous recording channels), each with a 12 bit 1024 sample record. The recorded data is displayed on a CRT display and on paper tape output as six channels with a common time scale. Data is stored on 3.5 inch floppy diskettes for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the CRT or paper tape allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Model 170 digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

### **Caliper / Natural Gamma Instrumentation**

Caliper and natural gamma data were collected using a Model 3ACS 3-leg caliper probe, S/N 2915, manufactured by Robertson Geologging, Ltd. With the short arm configuration used in these surveys, the probe permits measurement of boring diameters between 1.6 - 12 in., concurrent with measurement of natural gamma emission from the boring walls. The probe is 6.82 ft long, and 1.5 inches in diameter.

This probe is useful in the following studies:

- Measurement of boring diameter and volume
- Location of hard and soft formations
- Location of fissures, caving, pinching and casing damage
- Bed boundary identification
- Strata correlation between borings

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II, S/N 5310, on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 ft diameter sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

The caliper consists of three arms, each with a toothed quadrant at their base, pivoted in the lower probe body. A toothed rack engages with each quadrant, thus constraining the arms to move together. Linear movement of the rack is converted to opening and closing of the arms. Springs hold the arms open in the operating position. A motor drive is provided to retract the arms, allowing the probe to be lowered into the boring. The rack is coupled to a potentiometer which converts movement into a voltage sensed by the probe's microprocessor.

Natural gamma measurements rely upon small quantities of radioactive material contained in all rocks to emit gamma radiation as they decay. Trace amounts of Uranium and Thorium are present in a few minerals, where potassium-bearing minerals such as feldspar, mica and clays will include traces of a radioactive isotope of Potassium. These emit gamma radiation as they decay with an extremely long half-life. This radiation is detected by scintillation - the production of a tiny flash of light when gamma rays strike a crystal of sodium iodide. The light is converted into an electrical pulse by a photomultiplier tube. Pulses above a threshold value of 60 KeV are counted by the probe's microprocessor. The measurement is useful because the radioactive elements are concentrated in certain rock types e.g. clay or shales, and depleted in others e.g. sandstone or coal.

## **Resistivity / Spontaneous Potential Instrumentation**

Resistivity, spontaneous potential and natural gamma data were collected using a Model ELXG electric log probe, S/N 3040, manufactured by Robertson Geologging, Ltd. This probe measures Single Point Resistance (SPR), short normal resistivity (16"), long normal resistivity (64"), Spontaneous Potential (SP) and natural gamma. The probe is 8.20 ft long, and 1.73 inches in diameter.

This probe is useful in the following studies:

- Bed boundary identification
- Strata correlation between borings
- Strata geometry and type (shale indication)

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II, S/N 5310, on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 ft diameter sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

The resistivity section of the probe operates by driving an alternating current into the formation from the central SPR/DRIVE electrode. The current returns via the logging cable armor. To ensure adequate penetration of the formation the logging cable is insulated for approximately 30 feet from the cablehead. Voltages are measured between the 16" and 64" electrodes and the remote earth connection at surface, as noted below:

- Single Point Resistance (SPR): The current flowing to the cable armor is measured along with the voltage at the SPR electrode. The voltage divided by current gives resistance.
- Spontaneous Potential (SP): This is the DC bias of the 16" electrode with respect to the voltage return at the surface (ground stake).

Data quality depends upon good grounding at the surface. This is achieved with a metal stake driven into the mud-pit.

Natural gamma data was collected during the caliper data run, so this function, though present in this probe, was not used during these logging runs.

## **Boring Deviation Instrumentation**

Boring deviation data were collected using a Model HIRAT High Resolution Acoustic Televiewer probe, S/N 5174, manufactured by Robertson Geologging, Ltd. This probe is generally used to acquire acoustic images of the boring wall, but may also be used to collect boring deviation data. The probe is 7.58 ft long, and 1.9 inches in diameter, and is fitted with upper and lower four-arm centralizers.

This probe is useful in the following studies:

- Measurement of boring diameter and volume
- Location of hard and soft formations
- Location of fissures, caving, pinching and casing damage
- Bed boundary identification
- Strata correlation between borings

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II, S/N 5310, on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 ft diameter sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

## **MEASUREMENT PROCEDURES**

### **Suspension Measurement Procedures**

All five borings were logged as uncased borings, filled with bentonite or polymer based drilling mud. Measurements followed the GEOVision standard field procedures, as presented in Appendix C. Prior to use, the measuring sheave and rotary encoder function were checked using a steel tape by Jay Fagan of MACTEC. In each boring, the probe was positioned with the mid-point of the receiver spacing at grade, and the electronic depth counters were set to zero. The probe was lowered to the bottom of the boring, and then returned to the surface, stopping at 1.6 ft or 3.3 ft intervals to collect data, as summarized in Table 2, below.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth was printed on paper tape, checked, and recorded on diskette before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at grade was verified prior to removal from the boring.

### **Caliper / Natural Gamma Measurement Procedures**

Caliper and natural gamma data were collected in Borings B-1002, B-1003 and B-1004. No caliper or natural gamma data was collected in C-1005A. No caliper data was collected in B-1002A either, however, natural gamma data for the shallow (dry) sections of B-1002 and B-1004 were collected through the PVC casing, as summarized in Table 2, below. With the preceding two exceptions, the borings were logged as uncased borings, filled with bentonite or polymer based drilling mud.

Prior to use, the caliper tool was calibrated, using the supplied three point calibration jig, which is a circular plate with a series of holes in the top surface into which the tips of the caliper arms fit. This has circles of diameters from 2" to 12", as verified using a NIST traceable caliper by



Jay Fagan of MACTEC. Alternatively, it is possible to use pipe sections of known internal diameter. The calibration jig is placed over a bucket with the probe standing upright with its nose section passing through the jig's central hole. The caliper probe arms are opened under program control, and the tips of the arms are placed in the holes marked with the required diameter. the value of the current calibration point, as stamped on the jig, is entered via the control computer. The system counts for 15 seconds to make an average of the response. The procedure is repeated for the second and third required openings.

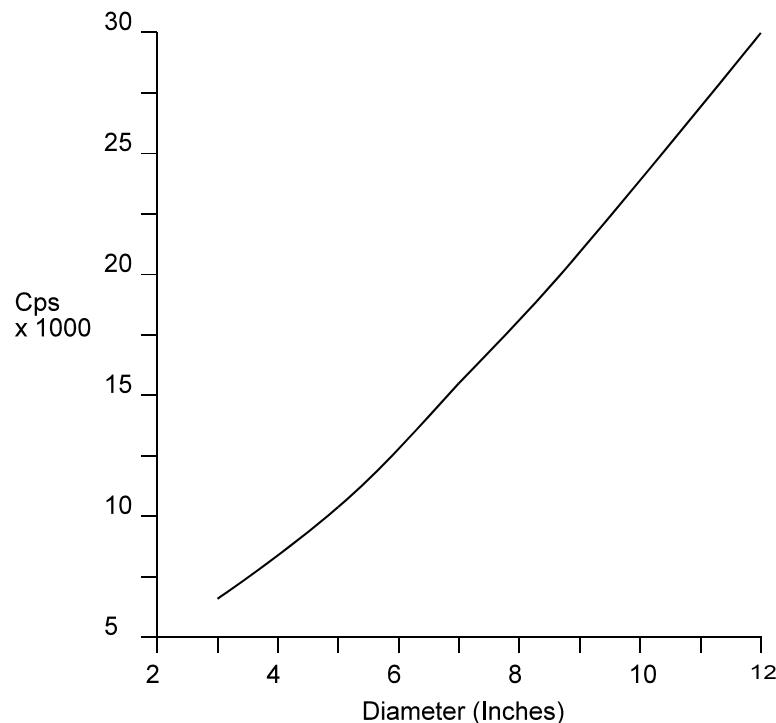


Figure 1. Example Calibration Curve for Caliper Probe

The computation and generation of the calibration coefficient file is entirely automatic. The calibration file is simply the set of coefficients of a quadratic curve which fits the three data points. Figure 1 shows the response of a caliper probe using data gathered during calibration. In addition, the caliper calibration is effectively checked at the end of each run by measuring the inside diameter of the casing at the top of the boring. Natural gamma was not calibrated in the field, as it is a qualitative measurement, not a quantitative value, and is used only to assist in picking transitions between stratigraphic units.

In each boring, the probe was positioned with the top of the probe at grade, and the electronic depth counter was set to 6.82 ft, the specified length of the probe, as verified with a tape measure. The probe was lowered to the bottom of the boring, where the caliper legs were opened, and data collection begun. The probe was then returned to the surface at 9.8 ft/sec, collecting data continuously at 0.033 ft spacing, as summarized in Table 2, below.

Upon completion of the measurements, the probe zero depth indication at grade was verified prior to removal from the boring, as summarized in Table 3, below.

### **Resistivity / Spontaneous Potential Measurement Procedures**

Resistivity and spontaneous potential data were collected in Borings B-1002, B-1003 and B-1004. No resistivity or spontaneous potential data was collected in B-1002A or C-1005A.

After attaching the probe to the logging cable, the probe head was insulated by wrapping all exposed metal of the cablehead and probe with self-amalgamating insulation tape. The 30 ft insulating sleeve on the logging cable was checked for any damage, and repaired with self-amalgamating insulation tape as needed.

The reference ground stake was driven firmly into the mud pit, and connected to the ground socket on the winch switch box.

This sonde measures real units downhole, so there is no calibration procedure to be followed for these channels.

In each boring, the probe was positioned with the top of the probe at grade, and the electronic depth counter was set to 8.2 ft, the specified length of the probe, as verified with a tape measure. The probe was lowered to the bottom of the boring, where data collection was begun. The probe was then returned to the surface at 16.4 ft/sec, collecting data continuously at 0.033 ft spacing, as summarized in Table 2, below. The natural gamma data collected in this log is redundant with

the data collected in the caliper / natural gamma log, so the slower 9.8 ft/sec speed used to optimize natural gamma data resolution was not employed for this log.

When the uninsulated section of the logging cable left the boring fluid, or entered steel casing, the log was terminated, as the sonde does not function under these conditions.

Upon completion of the measurements, the probe zero depth indication at grade was verified prior to removal from the boring, as summarized in Table 3, below.

### **Boring Deviation Measurement Procedures**

Boring deviation data was collected only in B-1003, to a depth of 1072.8 ft. The deeper section of B-1003 was not logged with this tool due to the significant voids and fractures observed on the caliper log of that section. It was decided that the risk of probe loss was too great to justify attempting such a log. Data was collected in a bentonite based drilling mud.

Prior to use, the deviation probe tiltmeters and compass function were checked by hanging from the drill rig and by comparison with a Brunton surveyors' compass.

The probe was positioned with the tip of the probe at grade, and the electronic depth counter was set to 0.0 ft. The probe was lowered to the bottom of the boring, and data collection begun. The probe was then returned to the surface at 9.8 ft/sec, collecting data continuously at 0.033 ft spacing, as summarized in Table 2, below.

Upon completion of the measurements, the probe zero depth indication at grade was verified prior to removal from the boring, as summarized in Table 3, below.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	OPEN HOLE (FEET)	DEPTH TO BOTTOM OF CASING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
B-1002	SUSPENSION 1	88.6 – 242.8	258	88.5	1.6	9/22/05
B-1002	CALIPER 1	0 – 254.8	258	88.5	0.033	9/22/05
B-1002	ELOG 1	86.3 – 256.5	258	88.5	0.033	9/23/05
B-1002	SUSPENSION 2	1.64 - 54.1	70	NO CASING	1.6	9/23/05
B-1002	ELOG 2	3.3 – 69.9	70	NO CASING	0.033	9/23/05
B-1002A	SUSPENSION 1	49.2 – 68.9	85	NO CASING	1.6	10/5/05
B-1003	SUSPENSION 1	64.0 – 157.5	1074	88.0	1.6	10/3/05
B-1003	SUSPENSION 1	157.5 – 1033.5	1074	88.0	3.3	10/3/05
B-1003	SUSPENSION 1	1033.5 – 1061.4	1074	88.0	1.6	10/3/05
B-1003	CALIPER 1	0 – 1076.3	1074	88.0	0.033	10/3/05
B-1003	ELOG 1	DATA LOST	1074	88.0	0.033	10/3/05
B-1003	DEVIATION 1	0 – 1072.8	1074	88.0	0.033	10/3/05
B-1003	ELOG 2	82.9 – 1062.1	1065	88.0	0.033	10/22/05
B-1003	SUSPENSION 2	1053.2 – 1309.1	1324	1054	1.6	11/10/05
B-1003	CALIPER 2	1051.7 – 1324.2	1324	1054	0.033	11/10/05
B-1003	ELOG 3	1050.1 – 1324.0	1324	1054	0.033	11/10/05
B-1003	SUSPENSION 3	1302.5 – 1327.1	1338	1054	1.6	11/11/05
B-1004	SUSPENSION 1	134.5 – 285.8	302	135	1.6	10/4/05
B-1004	CALIPER 1	0 – 303.4	302	135	0.033	10/4/05
B-1004	ELOG 1	118.2 – 303.4	302	135	0.033	10/4/05
C-1005A	SUSPENSION 1	3.3 – 32.8	48	NO CASING	1.6	10/6/05

Table 2. Logging dates and depth ranges

BORING NUMBER	TOOL AND RUN NUMBER	TOOL HIT BOTTOM (FT)	DRILLER DEPTH (FT)	START DEPTH (FT)	END DEPTH (FT)	DEPTH BUST (FT)
B-1002	SUSPENSION 1	254.9	260	0.0	0.07	0.07
B-1002	CALIPER 1	254.8	260	6.82	6.89	0.07
B-1002	ELOG 1	256.5	260	8.20	8.20	0.0
B-1002	SUSPENSION 2	69.5	70	0.0	0.0	0.0
B-1002	ELOG 2	69.9	70	8.20	8.20	0.0
B-1002A	SUSPENSION 1	84.3	105	0.0	0.0	0.0
B-1003	SUSPENSION 1	1076.8	1074	6.56	5.94	-0.38
B-1003	CALIPER 1	1079.1	1074	6.82	6.61	-0.22
B-1003	ELOG 1	1078.4	1074	8.20	8.07	-0.13
B-1003	DEVIATION 1	1072.8	1074	0.0	0.3	0.3
B-1003	ELOG 2	1062.1	1060	8.20	8.02	-0.18
B-1003	SUSPENSION 2	1324.5	1324	172.08	171.82	-0.26
B-1003	CALIPER 2	1324.2	1324	172.34	172.01	-0.33
B-1003	ELOG 3	1324.2	1324	173.72	173.23	-0.49
B-1003	SUSPENSION 3	1342.5	1338	168.5	168.0	-0.5
B-1004	SUSPENSION 1	301.2	302	0.0	0.0	0.0
B-1004	CALIPER 1	304.1	302	6.82	6.80	-0.02
B-1004	ELOG 1	304.1	302	8.20	8.20	0.0
C-1005A	SUSPENSION 1	48.2	90	0.0	0.0	0.0

Table 3. Boring Bottom Depths and Start / Stop Depth Errors

## DATA ANALYSIS

### Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, included in volume 2 of 2 (CDR) of this report, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3 ft segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based upon the arrival

time picks made in PSLOG. The PSLOG pick files and the EXCEL analysis files are included in the boring specific directories on volume 2 of 2 (CDR) of this report.

The P-wave velocity over the 10.4 (7.02) ft interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 6.79 (5.15) ft to correspond to the mid-point of the 10.4 (7.02) ft S-R1 interval, as illustrated in Figure 1. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 3.0 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear  $S_H$ -wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the  $S_H$ -wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering was used to remove the higher frequency P-wave signal from the  $S_H$ -wave signal. Different filter cutoffs were used to separate P- and  $S_H$ -waves at different depths, ranging from 600 Hz in the slowest zones to 4000 Hz in the regions of highest velocity. At each depth, the filter frequency was selected to be at least twice the fundamental frequency of the  $S_H$ -wave signal being filtered.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data,  $S_H$ -wave velocity calculated from the travel time over the 10.4 ft interval from source to receiver 1 was calculated and plotted for verification of the velocity

derived from the travel time between receivers. In this analysis, the depth values were increased by 6.79 (5.15) ft to correspond to the mid-point of the 10.4 (7.02) ft S-R1 interval. Travel times were obtained by picking the first break of the  $S_H$ -wave signal at the near receiver and subtracting 3.0 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by John Diehl as a component of GEOVision's in-house QA-QC program, and by Dr. Richard Lee, as an independent expert review.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3 ft interval of 1.88 milliseconds for the horizontal signals is equivalent to an  $S_H$ -wave velocity of 1745 ft/sec. Whenever possible, time differences were determined from several phase points on the  $S_H$ -waveform records to verify the data obtained from the first arrival of the  $S_H$ -wave pulse. Figure 3 displays the same record before filtering of the  $S_H$ -waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency  $S_H$ -wave by residual P-wave signal.

### **Caliper / Natural Gamma Analysis**

No analysis is required with the caliper or natural gamma data. The data are converted to LAS format and transmitted to the client.

### **Resistivity / Spontaneous Potential Analysis**

No analysis is required with the resistivity or spontaneous potential data. The data are converted to LAS format and transmitted to the client.

## **Boring Deviation Analysis**

The collected Acoustic Televiwer data was processed with Robertson Geologging's RGLDIP program, version 6.1, to extract the deviation data and produce an ASCII file and plots of deviation data.

## **RESULTS**

### **Suspension Results**

Suspension R1-R2 P- and  $S_H$ -wave velocities are plotted in Figures 5 - 8. The suspension velocity data presented in these figures are presented in Tables 3 - 6. The PSLOG and EXCEL analysis files for each boring are included in the boring specific directories on volume 2 of 2 (CDR) of this report, along with the raw and filtered waveforms.

P- and  $S_H$ -wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A1 –A4 to aid in visual comparison. It must be noted that R1-R2 data is an average velocity over a 3.3 ft segment of the soil column; S-R1 data is an average over 10.4 (7.02) ft, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A1 – A4, and included in the EXCEL analysis files for each boring on volume 2 of 2 (CDR) of this report.

Calibration procedures and records for the suspension measurement system are presented in Appendix B.

The GEOVision standard field procedures are reproduced in Appendix C.

The GEOVision standard field log sheets for all borings are reproduced in Appendix D.



## **Caliper/ Natural Gamma Results**

Caliper and natural gamma data is presented in combined log plots with resistivity and spontaneous potential in Appendix E. LAS 2.0 data and Acrobat files for each boring are included in the boring specific sub-directories in the data directory on volume 2 of 2 (CDR) of this report.

## **Resistivity / Spontaneous Potential Results**

Resistivity and spontaneous potential data is presented in combined log plots with caliper and natural gamma data in Appendix E. LAS 2.0 data and Acrobat files for each boring are included in the boring specific sub-directories in the data directory on volume 2 of 2 (CDR) of this report.

## **Boring Deviation Results**

Boring deviation data is presented graphically in Figure 8. Deviation data is provided in EXCEL and Acrobat formats in the B-1003 sub-directory in the data directory on volume 2 of 2 (CDR) of this report.

## SUMMARY

### Discussion of Suspension Results

Suspension PS velocity data is ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods. Due to the difficult drilling conditions at this site, some portions of the borings would not stay open above water table, and some significant wash-outs of the borings occurred below water table, as shown in the caliper logs. Despite these washouts, the quality of these data ranged from good to excellent. Each boring is discussed in more detail below.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and  $S_H$ -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and  $S_H$ -wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

B-1002, B-1002A: These data show excellent correlation between R1 – R2 and S – R1 data, as well as excellent correlation between P-wave and  $S_H$ -wave velocities, with the exception of a region between 30 and 40 ft, which appears to be a perched water table. P-wave and  $S_H$ -wave onsets are generally clear, and later oscillations are well damped. This is an excellent data set.

B-1003: These data show excellent correlation between R1 – R2 and S – R1 data, as well as excellent correlation between P-wave and  $S_H$ -wave velocities. P-wave and  $S_H$ -wave onsets are clear, and later oscillations are well damped. The data from this boring is in very close agreement with the velocities obtained in B-1002. This is an exceptional data set.

B-1004: These data show excellent correlation between R1 – R2 and S – R1 data, as well as excellent correlation between P-wave and S<sub>H</sub>-wave velocities. P-wave and S<sub>H</sub>-wave onsets are clear, and later oscillations are well damped. This is an excellent data set.

C-1005A: These data show good correlation between R1 – R2 and S – R1 data, as well as good correlation between P-wave and S<sub>H</sub>-wave velocities. P-wave and S<sub>H</sub>-wave onsets are generally clear, though later oscillations are not well damped. The data from this boring is in fair agreement with the velocities obtained in B-1002. This is a fair to good data set.

### **Discussion of Caliper / Natural Gamma Results**

B-1002: This is a excellent data set for the entire depth of the boring, though caliper data is only useful below the bottom of the PVC casing at 88.5 ft.

B-1003: This is a excellent data set for the entire depth of the boring, though caliper data is only useful below the bottom of the PVC casing at 88 ft.

B-1004: This is a excellent data set for the entire depth of the boring, though caliper data is only useful below the bottom of the PVC casing at 135 ft,

C-1005A: No caliper / natural gamma data was collected in this boring.

### **Discussion of Resistivity / Spontaneous Potential Results**

B-1002: These data show good correlation between the different logs below 92 ft. The data is degraded above 128 ft, as the insulated cable moved into the PVC casing at this point on run 1, and the shallower run 2 data was degraded by fluid loss in the uncased boring.

B-1003: These data show good correlation between the different logs below 128 ft. The data is degraded above 128 ft, as the insulated cable moved into the casing at this point on run 2. Also, on run 3, the insulated cable moved into the casing at 1084 ft, degrading the data from this run above this depth.

B-1004: Spontaneous potential measurements did not appear to be successful in this boring, and resistivity data was poor. Despite several different placements of the ground rod, the data continued to be anomalous on four attempts to collect data. The most plausible explanation is due to currents induced in the ground by ground cables from nearby power lines. The resistivity data may still be useful in validating unit boundaries.

C-1005A: No resistivity / spontaneous potential / natural gamma data was collected in this boring.

### **Discussion of Boring Deviation Results**

B-1003: These data show a fairly constant slope of the boring of roughly 1 degree to the east for the entire depth of the boring, placing the 1050 ft depth mark 13 ft east of the boring collar.

### **Quality Assurance**

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under GEOVision quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs

- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

### **Suspension Data Reliability**

P- and  $S_H$ -wave velocity measurement using the Suspension Method gives average velocities over a 3.3 ft interval of depth. This high resolution results in the scatter of values shown in the graphs. Individual measurements are very reliable with estimated precision of  $\pm 5\%$ . Standardized field procedures and quality assurance checks contribute to the reliability of these data.

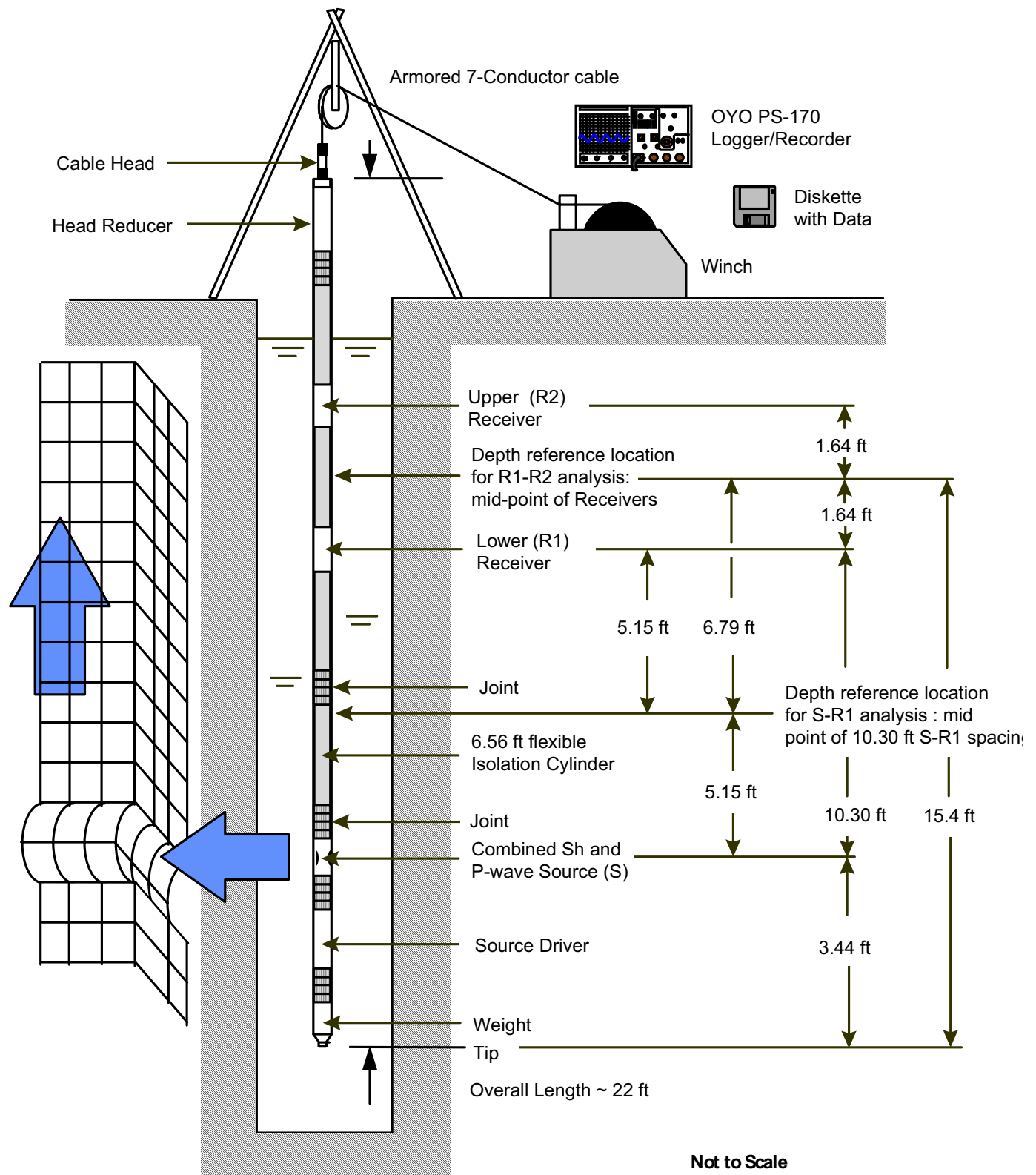


Figure 2. Concept illustration of long P-S logging system

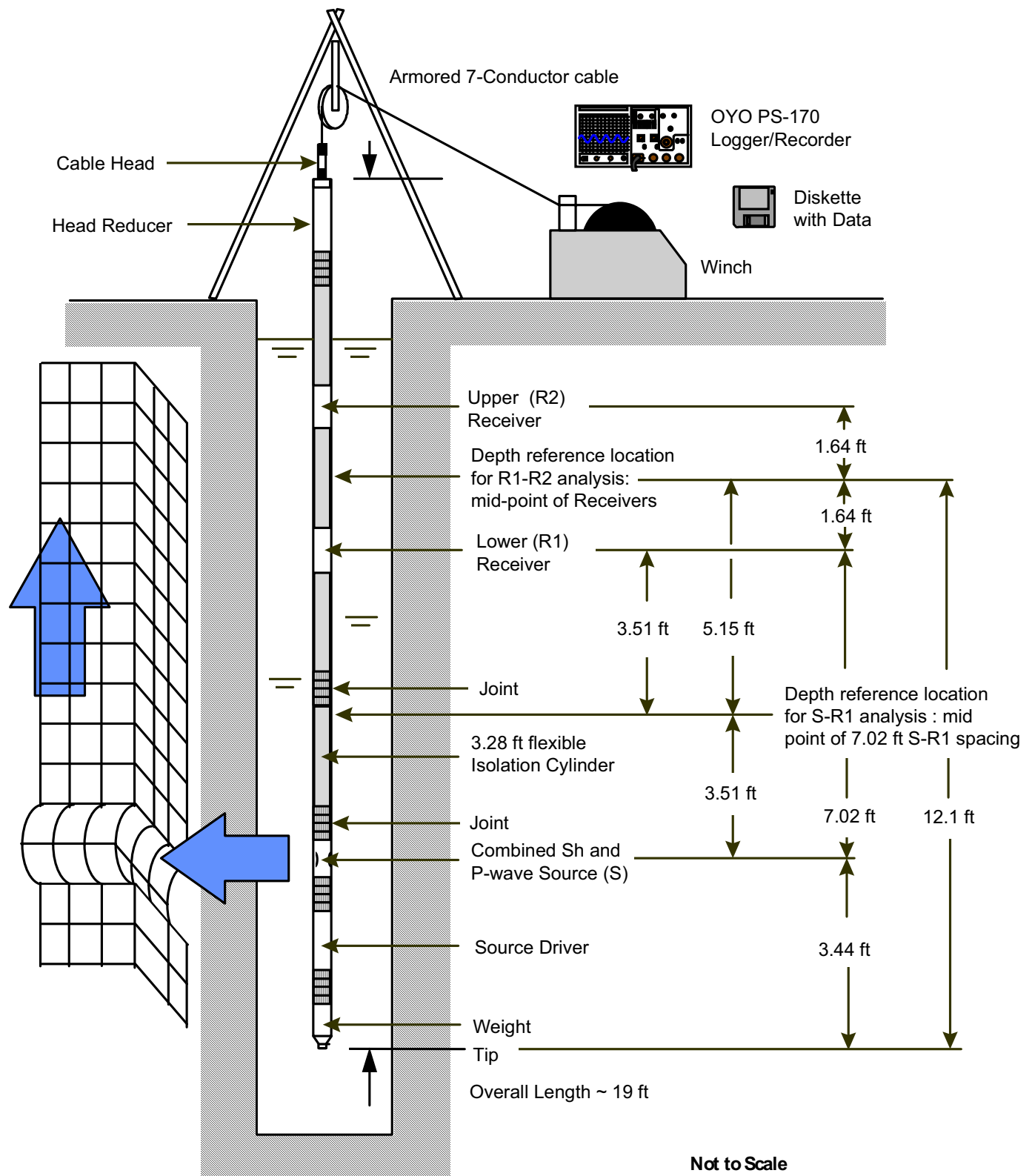


Figure 3. Concept illustration of short P-S logging system

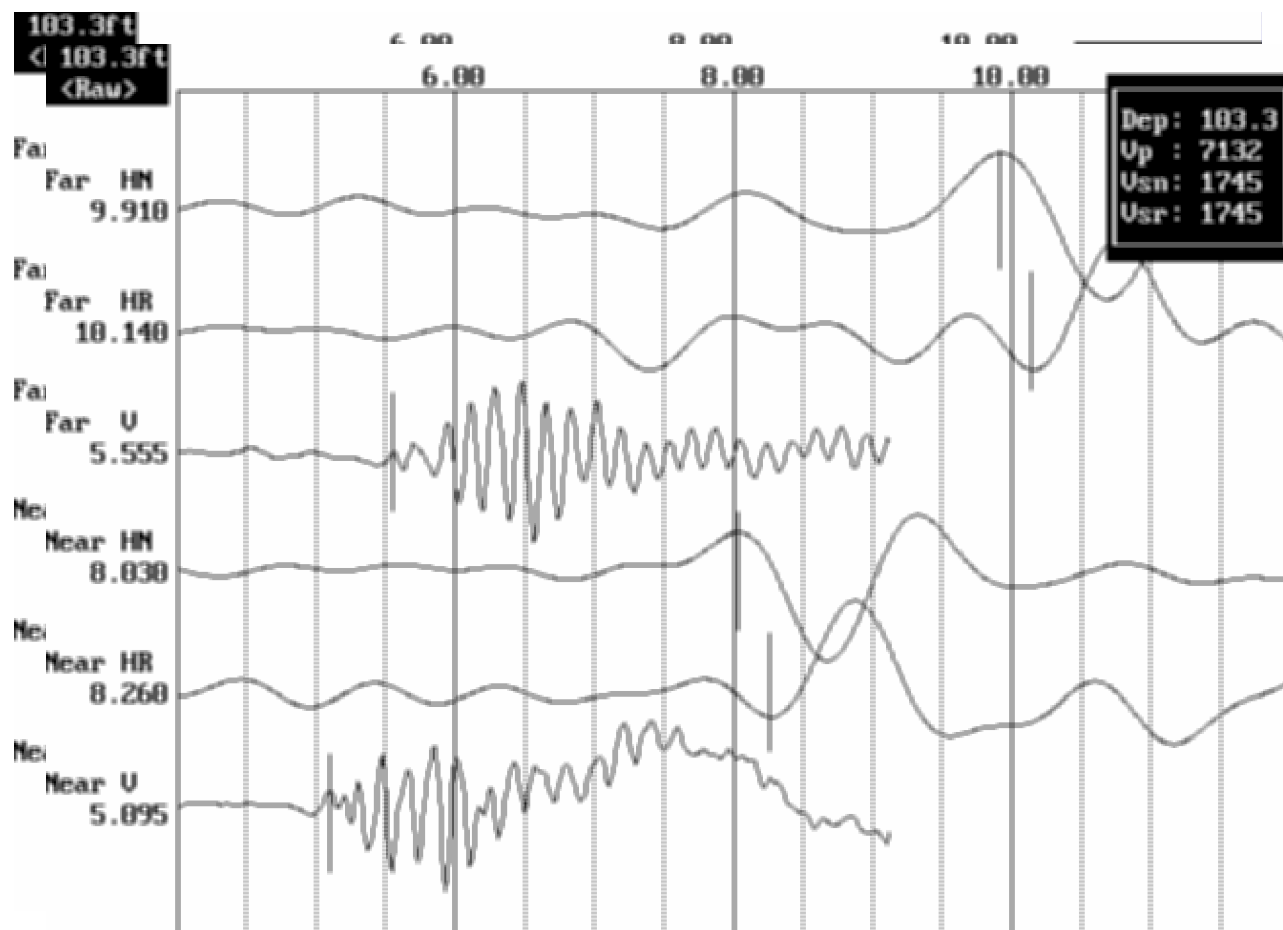


Figure 4. Example of filtered (1400 Hz lowpass) record



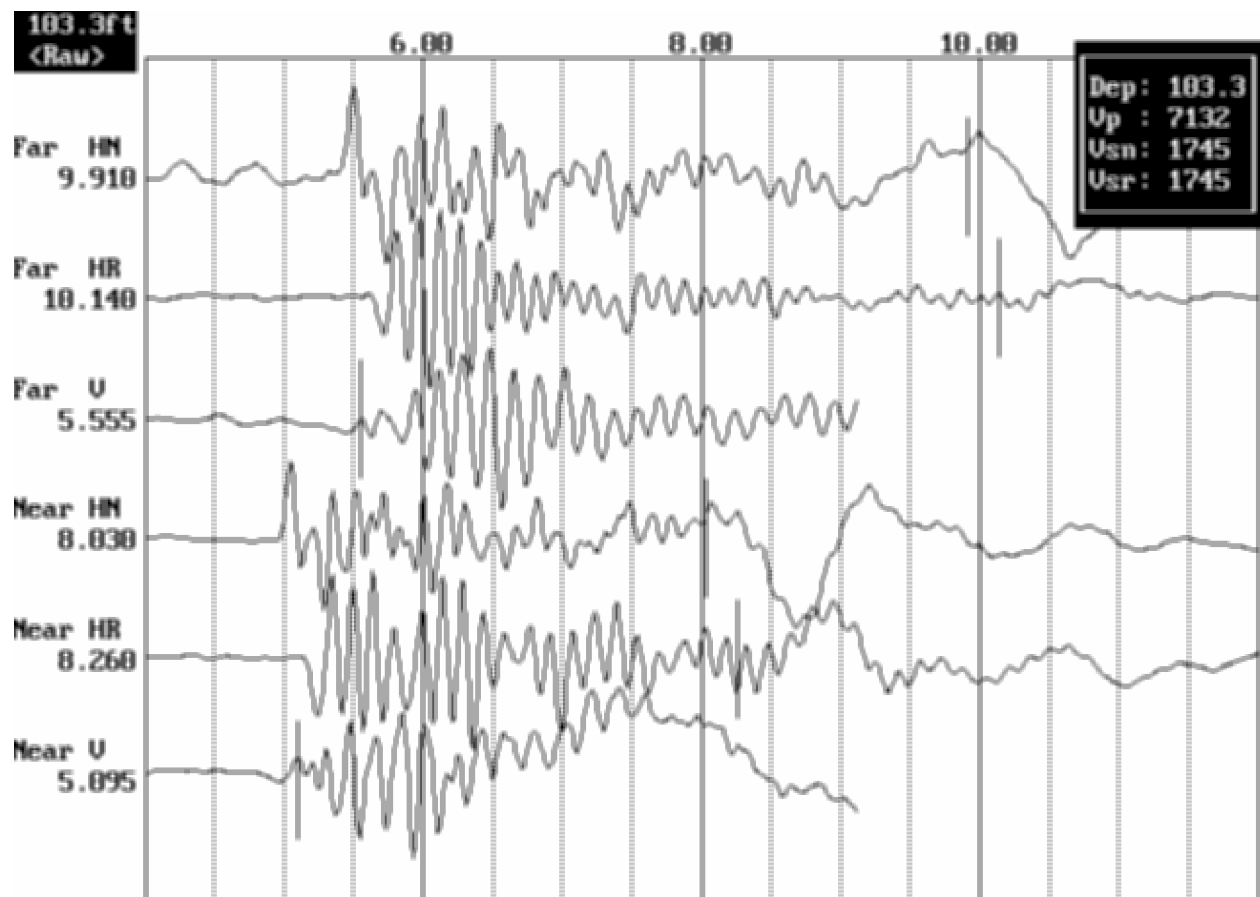


Figure 5. Example of unfiltered record

### Plant Vogtle Boreholes B-1002 & B-1002A Receiver to Receiver $V_s$ and $V_p$ Analysis

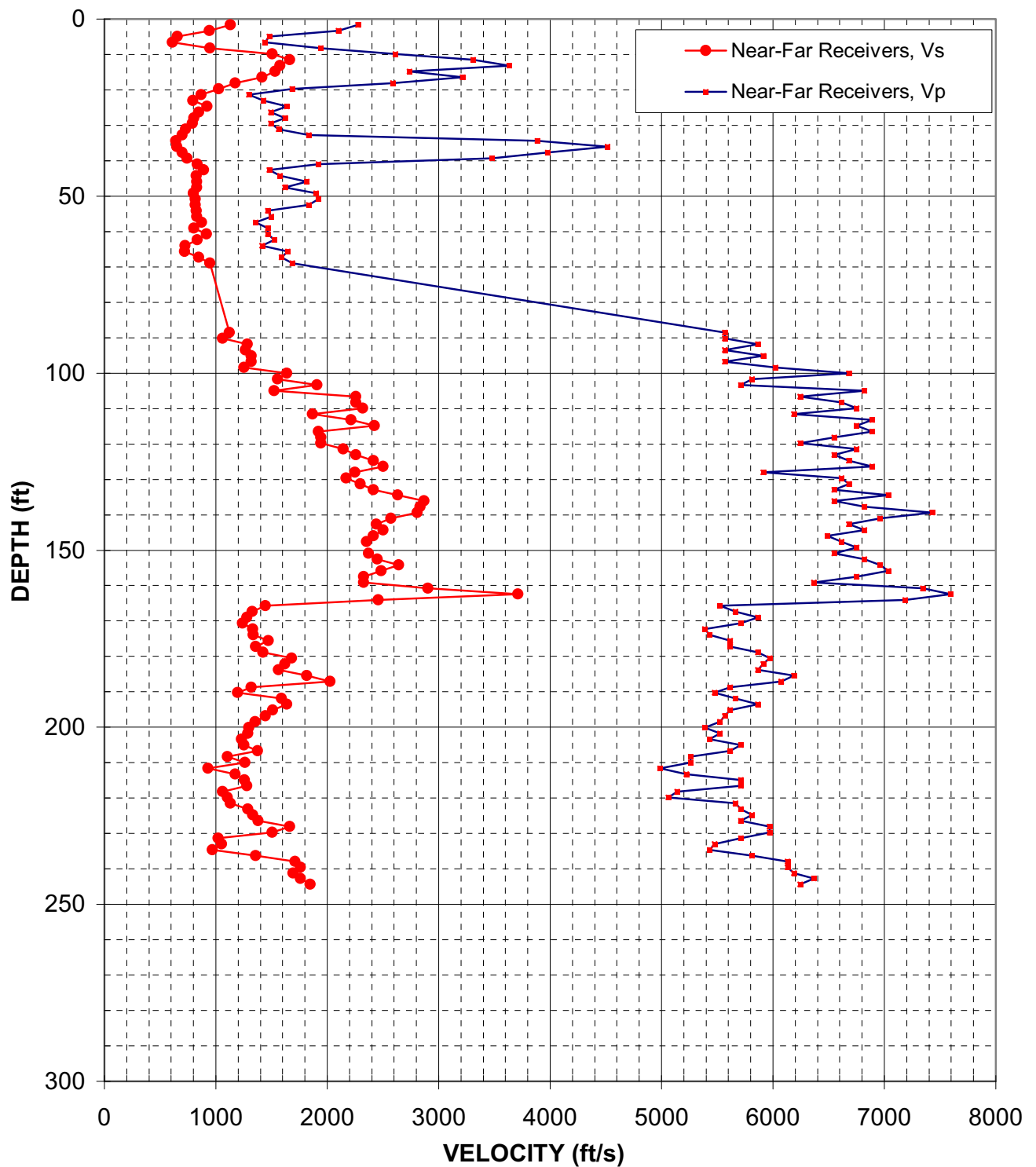


Figure 6. Boring B-1002 and B-1002A, Suspension R1-R2 P- and  $S_H$ -wave velocities

Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)
1.6	1130	2270	101.7	1550	5810	183.7	1560	5860
3.3	940	2100	103.4	1910	5710	185.4	1820	6190
4.9	650	1480	105.0	1530	6820	187.0	2030	6080
6.6	610	1440	106.6	2260	6250	188.7	1320	5620
8.2	950	1940	108.3	2260	6620	190.3	1200	5480
9.8	1510	2610	109.9	2320	6750	191.9	1590	5660
11.5	1660	3310	111.6	1870	6190	193.6	1640	5860
13.1	1580	3630	113.2	2210	6890	195.2	1510	5620
14.8	1530	2740	114.8	2420	6750	196.9	1450	5570
16.4	1420	3210	116.5	1920	6890	198.5	1350	5520
18.0	1180	2590	118.1	1940	6550	200.1	1300	5390
19.7	1030	1690	119.8	1940	6250	201.8	1290	5520
21.3	870	1300	121.4	2140	6750	203.4	1230	5430
23.0	800	1430	123.0	2260	6550	205.1	1250	5710
24.6	920	1640	124.7	2410	6680	206.7	1380	5620
26.3	850	1490	126.3	2500	6890	208.3	1100	5260
27.9	810	1620	128.0	2250	5910	210.0	1260	5260
29.5	790	1490	129.6	2170	6620	211.6	930	4990
31.2	730	1560	131.2	2300	6680	213.3	1170	5220
32.8	700	1840	132.9	2410	6550	214.9	1260	5710
34.5	640	3890	134.5	2630	7040	216.5	1280	5710
36.1	650	4520	136.2	2870	6550	218.2	1060	5140
37.7	700	3980	137.8	2830	6820	219.8	1110	5060
39.4	740	3480	139.4	2810	7430	221.5	1130	5660
41.0	840	1920	141.1	2570	6960	223.1	1290	5710
42.7	890	1480	142.7	2440	6680	224.7	1330	5810
44.3	830	1580	144.4	2500	6820	226.4	1380	5710
45.9	830	1820	146.0	2410	6490	228.0	1660	5970
47.6	830	1620	147.6	2350	6620	229.7	1510	5970
49.2	800	1900	149.3	-	6750	231.3	1020	5710
50.9	820	1920	150.9	2370	6550	232.9	1050	5480
52.5	820	1840	152.6	2450	6820	234.6	970	5430
54.1	830	1470	154.2	2640	6960	236.2	1360	5810
55.8	830	1500	155.8	2480	7040	237.9	1710	6130
57.4	870	1360	157.5	2330	6750	239.5	1760	6130
59.1	810	1470	159.1	2330	6370	241.1	1700	6190
60.7	920	1470	160.8	2910	7340	242.8	1760	6370
62.3	840	1530	162.4	3710	7590	244.4	1850	6250
64.0	730	1420	164.0	2460	7190			
65.6	720	1650	165.7	1450	5520			
67.3	850	1590	167.3	1330	5660			
68.9	950	1690	169.0	1280	5860			
88.6	1120	5570	170.6	1240	5710			
90.2	1060	5570	172.2	1330	5390			
91.9	1290	5860	173.9	1340	5430			
93.5	1270	5570	175.5	1470	5620			
95.1	1320	5910	177.2	1360	5620			
96.8	1320	5570	178.8	1420	5860			
98.4	1250	6020	180.5	1680	5970			
100.1	1640	6680	182.1	1620	5910			

Table 4. Boring B-1002 and B-1002A, Suspension R1-R2 depths and P- and S<sub>H</sub>-wave velocities

**Plant Vogtle Borehole B-1003**  
**Receiver to Receiver  $V_s$  and  $V_p$  Analysis**

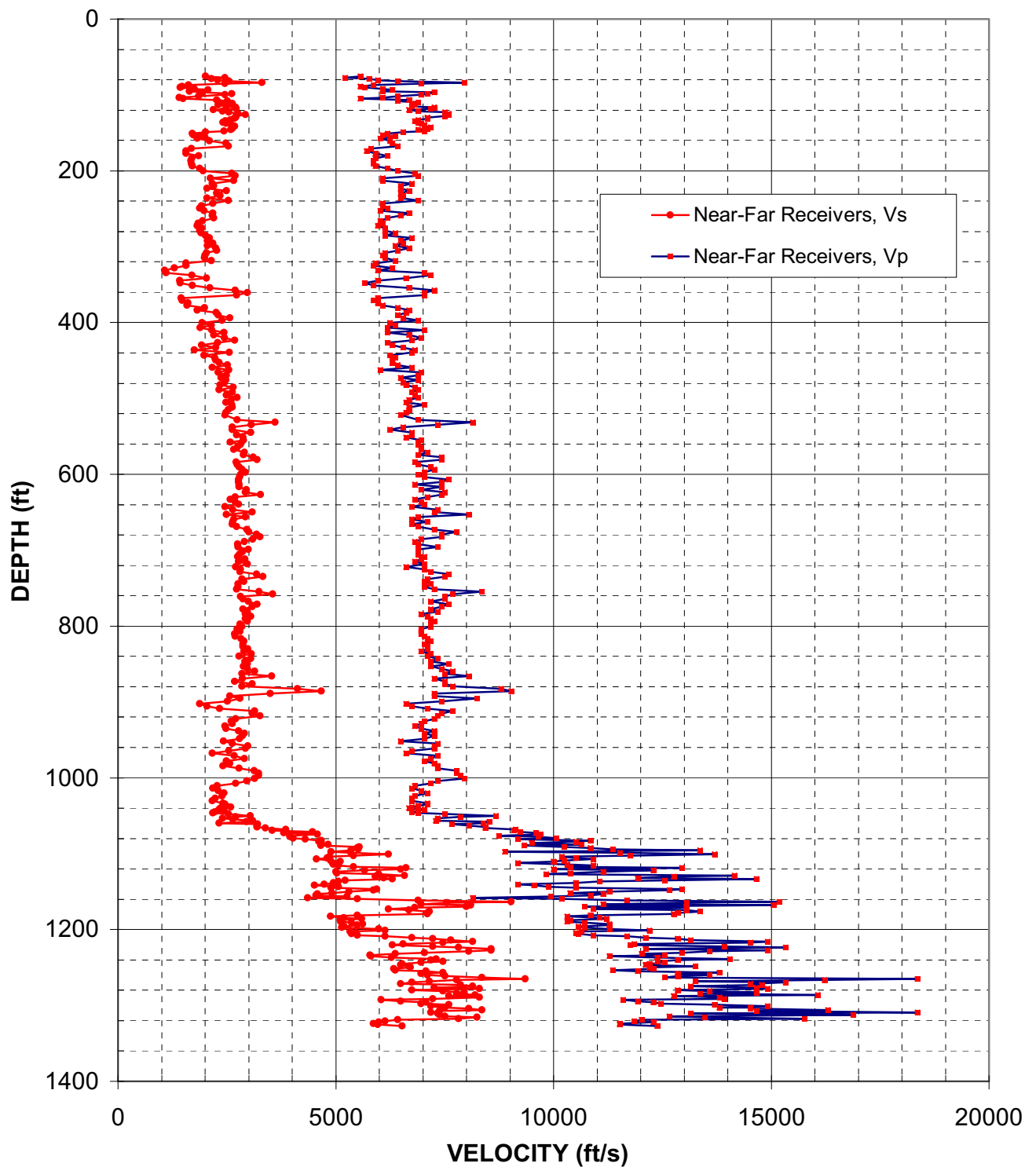


Figure 7. Boring B-1003, Suspension R1-R2 P- and  $S_H$ -wave velocities

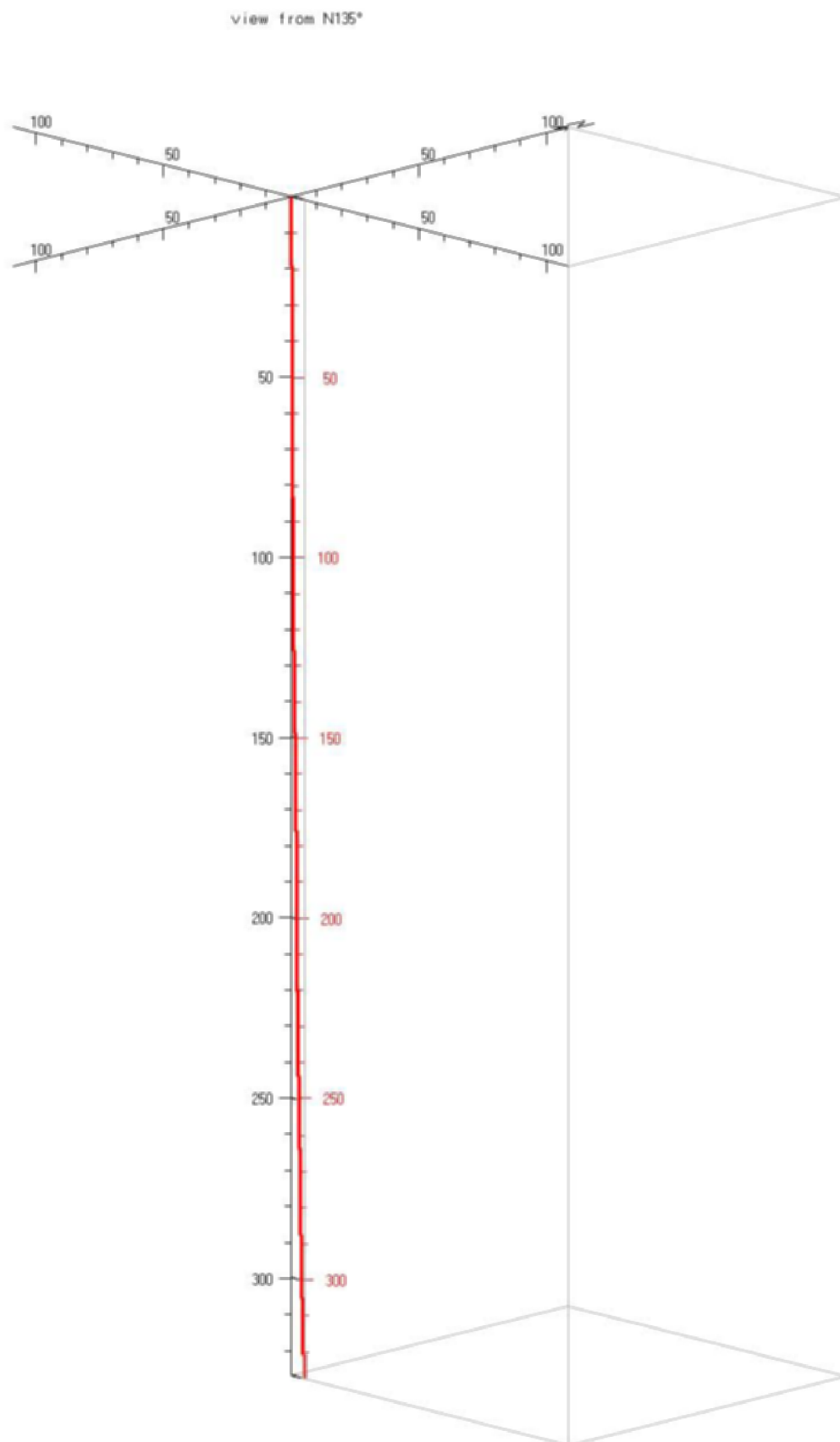


Figure 8. Boring B-1003, Deviation Projection (dimensions in meters)

Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)
75.5	2010	5570	157.5	1820	6020	321.5	1570	5910
77.1	2460	5220	160.8	2100	6250	324.8	1570	5860
78.7	2140	5760	164.0	2480	6310	328.1	1300	6310
80.4	2290	5970	167.3	2540	6430	331.4	1070	5970
82.0	2550	6430	170.6	1680	5810	334.7	1100	7040
83.7	3310	7960	173.9	1560	5710	337.9	1700	7190
85.3	2460	6960	177.2	1570	5910	341.2	2040	6620
86.9	1620	5860	180.5	1860	6190	344.5	1420	5970
88.6	1470	5570	183.7	1700	5910	347.8	1430	5660
90.2	1430	5660	187.0	1670	5860	351.1	1710	5860
91.9	1760	6080	190.3	1690	5860	354.3	2110	6680
93.5	2060	6310	193.6	1700	5910	357.6	2690	7260
95.1	1650	6080	196.9	1880	6190	360.9	2970	7040
96.8	1940	7260	200.1	1950	6430	364.2	2730	7040
98.4	2610	7110	203.4	2610	6820	367.5	1450	5970
100.1	2460	6960	206.7	2690	6890	370.7	1480	5860
101.7	1860	6430	210.0	2130	6080	374.0	1610	5970
103.4	1400	6080	213.3	2660	6080	377.3	1580	6080
105.0	1490	5570	216.5	2170	6750	380.6	1990	6430
106.6	2270	6680	219.8	2200	6490	383.9	1830	6680
108.3	2510	6430	223.1	2040	6490	387.1	2260	6620
109.9	2330	6890	226.4	2490	6680	390.4	2300	6430
111.6	2630	6750	229.7	2270	6490	393.7	2570	6550
113.2	2300	6820	232.9	2350	6550	397.0	2400	6890
114.8	2490	6750	236.2	2040	6490	400.3	1940	6250
116.5	2710	7260	239.5	2530	6890	403.5	2150	6370
118.1	2720	7190	242.8	2180	6080	406.8	1890	6190
119.8	2190	6680	246.1	1930	6080	410.1	2160	7040
121.4	2400	6890	249.3	1880	6190	413.4	2430	6190
123.0	2550	7510	252.6	1980	6020	416.7	2210	6680
124.7	2760	7590	255.9	2180	6680	420.0	2450	6960
126.3	2930	7590	259.2	2160	6490	423.2	2680	6750
128.0	2720	7510	262.5	2200	6190	426.5	2290	6190
129.6	2710	7110	265.8	1950	6020	429.8	1920	6310
131.2	2670	7110	269.0	1850	6080	433.1	2250	6550
132.9	2580	6890	272.3	1820	5970	436.4	1760	6820
134.5	2470	6820	275.6	1920	6130	439.6	2560	6750
136.2	2410	6890	278.9	1880	6130	442.9	1980	6250
137.8	2480	6960	282.2	1910	6370	446.2	2220	6370
139.4	2600	7040	285.4	2010	6130	449.5	2240	6310
141.1	2680	7040	288.7	2100	6750	452.8	2330	6310
142.7	2620	7190	292.0	2060	6490	456.0	2510	6430
144.4	2630	7110	295.3	2180	6550	459.3	2170	6750
146.0	2590	6890	298.6	2060	6370	462.6	2550	6020
147.6	2440	7040	301.8	2240	6680	465.9	2300	6960
149.3	2010	6550	305.1	2270	6430	469.2	2490	6890
150.9	1710	6190	308.4	2030	6130	472.4	2370	6490
152.6	1730	6080	311.7	2000	6080	475.7	2480	6890
154.2	1890	6370	315.0	1990	6130	479.0	2450	6550
155.8	2000	6250	318.2	2140	6370	482.3	2350	6620

Table 5. Boring B-1003, Suspension R1-R2 depths and P- and S<sub>H</sub>-wave velocities

Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)
485.6	2650	6820	652.9	2490	8050	816.9	2830	7110
488.9	2330	6890	656.2	2930	6890	820.2	2890	7190
492.1	2620	6750	659.5	2660	6750	823.5	2870	7040
495.4	2490	6820	662.7	2640	7110	826.8	2870	7110
498.7	2740	6890	666.0	2620	6750	830.1	2980	7110
502.0	2600	6680	669.3	2730	6890	833.3	2890	6960
505.3	2480	6620	672.6	2960	7260	836.6	3070	7190
508.5	2610	7040	675.9	3010	7770	839.9	2780	7110
511.8	2620	6680	679.1	3180	7430	843.2	3050	7340
515.1	2530	6680	682.4	3260	7430	846.5	2920	7190
518.4	2480	6620	685.7	3090	6960	849.7	2970	7590
521.7	2460	6490	689.0	2910	6820	853.0	2880	7190
528.2	2740	6890	692.3	2750	6890	856.3	2970	7430
531.5	3610	8150	695.5	2760	7340	859.6	3140	7680
534.8	3070	7340	698.8	3000	6890	862.9	2840	7510
538.1	2620	6550	702.1	2860	6890	866.1	3540	8050
541.3	2630	6250	705.4	2800	6890	869.4	2860	7260
544.6	3050	6750	708.7	2750	7040	872.7	2680	7510
547.9	2730	6750	711.9	2920	6960	876.0	3080	7510
551.2	2870	6620	715.2	2770	6820	879.3	2840	7680
555.5	2880	6960	718.5	2970	7040	882.6	4130	8790
557.7	2580	6890	721.8	2710	6620	885.8	4670	9030
561.0	2820	6890	725.1	2820	7040	889.1	3500	7260
564.3	2750	6960	728.4	2810	7190	892.4	2570	7260
567.6	2660	6960	731.6	3180	7590	895.7	2810	8250
570.9	2910	7110	734.9	3330	7510	899.0	2510	7430
574.2	2880	6890	738.2	2840	7110	902.2	1880	6620
577.4	3110	7430	741.5	2890	7040	905.5	2040	6750
580.7	3200	7430	744.8	2760	7190	908.8	2340	7110
584.0	2720	6820	748.0	2760	7040	912.1	3140	7680
587.3	2740	6890	751.3	2730	7260	915.4	3080	7430
590.6	2780	7190	754.6	3240	8350	918.6	3260	7340
593.8	2840	7260	757.9	3550	7680	922.2	2710	7260
597.1	2930	7040	761.2	2820	7510	925.2	2600	7040
600.4	2820	6890	764.4	2870	7510	928.5	2620	6960
603.7	2800	7040	767.7	3000	7190	931.8	2460	6820
607.0	2770	7590	771.0	3200	7590	935.0	2480	6960
610.2	2770	7430	774.3	3080	7430	938.3	2770	7260
613.5	2780	6820	777.6	2870	7190	941.6	2910	7040
616.8	2780	7430	780.8	2970	7340	944.9	2860	7260
620.1	2940	6960	784.1	2930	6960	948.2	2800	7040
623.4	2930	7510	787.4	3050	7110	951.4	2420	6490
626.6	3280	7430	790.7	2930	7190	954.7	2620	7340
629.9	2690	7110	794.0	2970	7260	958.0	2980	7260
633.2	2580	6820	797.2	2810	7190	961.3	2930	7260
636.5	2690	6960	800.5	2840	7190	964.6	2550	6750
639.8	2770	7040	803.8	2740	6960	967.9	2170	6620
643.0	2460	6750	807.1	2810	6960	971.1	2670	7340
646.3	2640	7340	810.4	2680	6960	974.4	2910	7190
649.6	3080	7260	813.7	2690	7040	977.7	2490	7040

Table 5, continued. Boring B-1003, Suspension R1-R2 depths and P- and S<sub>H</sub>-wave velocities

Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)
981.0	2570	7260	1089.2	4660	9330	1171.3	6820	13050
984.3	2410	7340	1090.9	5550	10250	1172.9	6220	10920
987.5	2780	7340	1092.5	5500	10850	1174.5	6680	13050
990.8	3120	7770	1094.2	5520	11370	1176.2	7150	13370
994.1	3230	7770	1095.8	5350	13370	1177.8	7110	12850
997.4	3230	7860	1097.4	4900	8890	1179.5	7110	12750
1000.7	3140	7960	1099.1	5350	11520	1181.1	5500	10850
1003.9	2960	7340	1100.7	6220	13700	1182.7	4880	10310
1007.2	2710	7190	1102.4	5410	11770	1184.4	5180	11070
1010.5	2280	6820	1104.0	4860	10190	1186.0	5590	11210
1013.8	2180	6750	1105.6	4810	10510	1187.7	5100	10380
1017.1	2300	6960	1107.3	4560	10920	1189.3	5120	10310
1020.3	2430	7110	1108.9	4880	10250	1190.9	5370	10710
1023.6	2400	6820	1110.6	5100	10000	1192.6	5620	11290
1026.9	2240	6750	1112.2	4930	9180	1194.2	5500	11290
1030.2	2160	6750	1113.9	4950	10310	1195.9	5200	10570
1033.5	2410	7110	1115.5	5060	10920	1197.5	5140	10710
1035.1	2460	7110	1117.1	5410	10380	1199.2	5990	11290
1036.8	2480	6890	1118.8	6620	12950	1200.8	6130	12200
1038.4	2590	6750	1120.4	6490	10000	1202.4	5330	10640
1040.0	2360	6680	1122.1	5660	12290	1204.1	5480	10510
1041.7	2330	7040	1123.7	5010	11140	1205.7	5370	10570
1043.3	2430	6890	1125.3	5030	10380	1207.4	5500	10920
1045.0	2230	6750	1127.0	5990	9830	1209.0	6130	11680
1046.6	2180	6890	1128.6	6580	14160	1210.6	6750	12110
1047.9	2530	7510	1130.3	5910	12750	1212.3	7230	12850
1049.9	3040	8680	1131.9	6100	11930	1213.9	7640	13160
1051.5	2710	7860	1133.5	6310	14660	1215.6	8150	14920
1053.2	2400	7340	1135.2	5220	12560	1217.2	7470	14530
1054.8	2640	7340	1136.8	5060	11070	1218.8	6550	11850
1056.4	3090	7300	1138.5	4950	10510	1220.5	6310	11770
1058.1	2940	8520	1140.1	4740	9180	1222.1	7230	13920
1059.7	2320	8400	1141.7	4520	9550	1223.8	7820	15330
1061.4	3210	7660	1143.4	5060	9890	1225.4	8570	12110
1063.0	3190	8070	1145.0	4900	10510	1227.0	8570	14920
1064.6	3200	8440	1146.7	5940	12950	1228.7	8050	13580
1066.3	3380	8440	1148.3	5860	12660	1230.3	7040	12950
1067.9	3850	9130	1149.9	5300	11290	1232.0	6370	12020
1069.6	3550	9080	1151.6	4910	10380	1233.6	5790	12560
1071.2	4470	9230	1153.2	4580	11140	1235.2	5810	11290
1072.8	3810	9600	1154.9	4550	10850	1236.9	6280	12380
1074.5	4580	9710	1156.5	5260	9950	1238.5	7300	14040
1076.1	3940	8750	1158.1	4350	8150	1240.2	7190	12850
1077.8	3950	9660	1159.8	5500	10190	1241.8	7470	12380
1079.4	4030	10070	1161.4	6890	11680	1243.4	6960	12560
1081.0	4300	9180	1163.1	9030	15190	1245.1	6520	12200
1082.7	4670	10850	1164.7	7550	13050	1246.7	6490	12110
1084.3	4610	10510	1166.3	6960	11140	1248.4	6680	13260
1086.0	4670	9490	1168.0	8100	15050	1250.0	6720	12200
1087.6	4830	10640	1169.6	8000	10710	1251.6	6330	12290

Table 5, continued. Boring B-1003, Suspension R1-R2 depths and P- and S<sub>H</sub>-wave velocities



Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)
1253.3	6370	11370
1254.9	7070	11930
1256.6	7470	13810
1258.2	6960	12850
1259.8	7110	13580
1261.5	7510	12850
1263.1	8350	12560
1264.8	9350	18360
1266.4	7770	16220
1268.0	7150	13260
1269.7	6750	15330
1271.3	6490	14530
1273.0	7860	14790
1274.6	8150	13160
1276.3	7260	14660
1277.9	8300	14920
1279.5	6750	12850
1281.2	7470	13580
1282.8	7960	14660
1284.5	7770	13370
1286.1	8200	16070
1287.7	7590	12750
1289.4	8300	13810
1291.0	7230	13920
1292.7	6050	11600
1294.3	6490	11930
1295.9	7070	12290
1297.6	6960	12470
1299.2	7590	13700
1300.9	7190	14920
1302.5	7430	13810
1302.5	7510	14530
1304.1	8050	14530
1305.8	8350	16300
1307.4	7380	14660
1309.1	7190	18360
1310.7	7340	13160
1312.3	7380	16880
1314.0	7510	12660
1315.6	8250	13470
1317.3	7820	15760
1318.9	6430	12020
1320.5	6130	11850
1322.2	5990	12290
1323.8	5860	11520
1325.5	5970	11520
1327.1	6520	12380

Table 5, continued. Boring B-1003, Suspension R1-R2 depths and P- and S<sub>H</sub>-wave velocities

**Plant Vogtle Borehole B-1004**  
**Receiver to Receiver  $V_s$  and  $V_p$  Analysis**

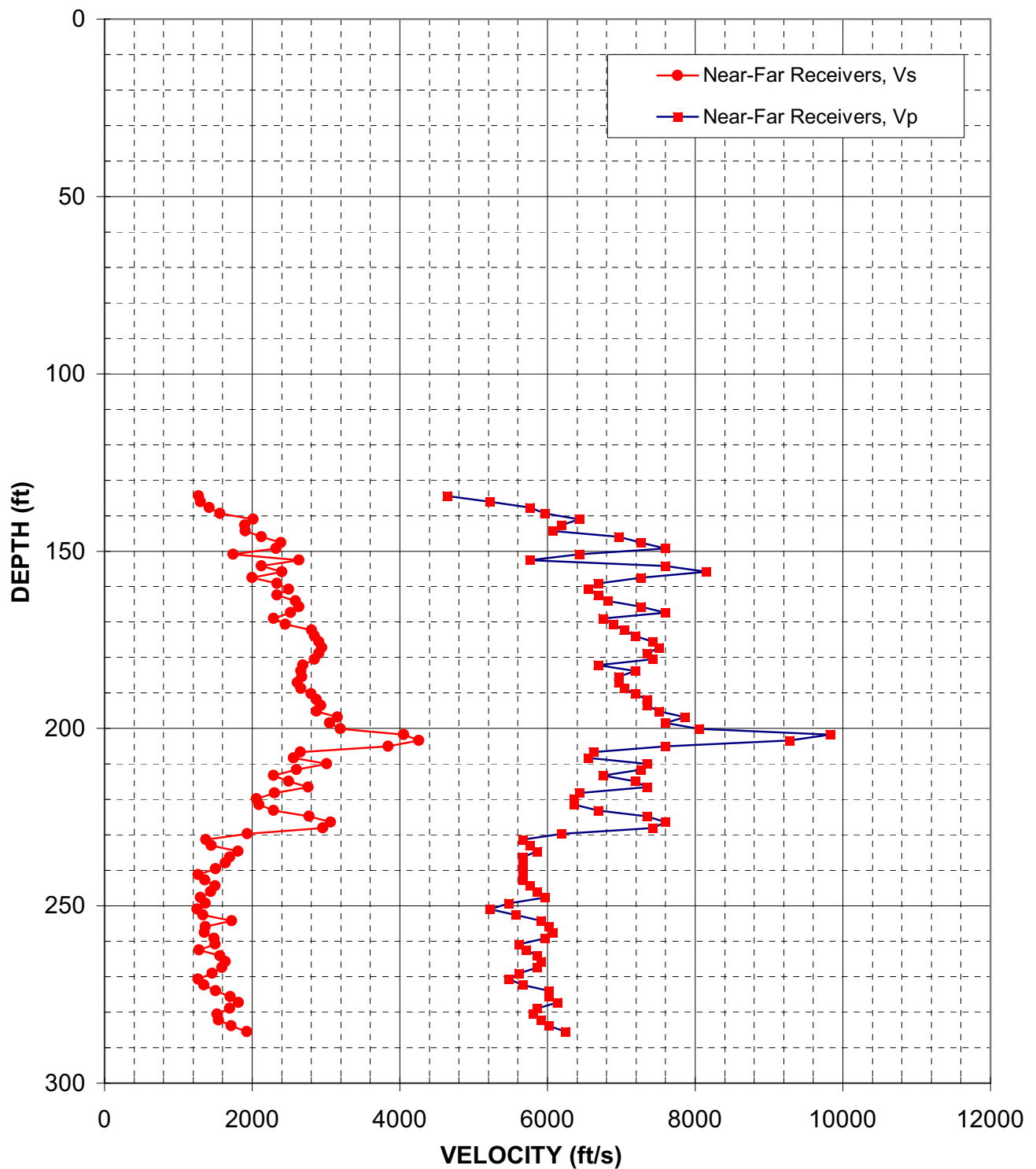


Figure 9. Boring B-1004, Suspension R1-R2 P- and  $S_H$ -wave velocities

Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)	Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)
134.5	1270	4640	216.5	2760	7340
136.2	1300	5220	218.2	2300	6430
137.8	1420	5760	219.8	2060	6370
139.4	1560	5970	221.5	2100	6370
141.1	2010	6430	223.1	2290	6680
142.7	1900	6190	224.7	2770	7340
144.4	1910	6080	226.4	3070	7590
146.0	2130	6960	228.0	2960	7430
147.6	2390	7260	229.7	1930	6190
149.3	2320	7590	231.3	1380	5660
150.9	1740	6430	232.9	1450	5760
152.6	2630	5760	234.6	1810	5860
154.2	2130	7590	236.2	1700	5660
155.8	2400	8150	237.9	1640	5660
157.5	2000	7260	239.5	1510	5660
159.1	2340	6680	241.1	1270	5660
160.8	2490	6550	242.8	1360	5660
162.4	2340	6680	244.4	1500	5760
164.0	2590	6820	246.1	1440	5860
165.7	2630	7260	247.7	1300	5970
167.3	2520	7590	249.3	1370	5480
169.0	2290	6750	251.0	1250	5220
170.6	2450	6890	252.6	1330	5570
172.2	2810	7040	254.3	1720	5910
173.9	2840	7190	255.9	1360	6020
175.5	2910	7430	257.6	1350	6080
177.2	2940	7510	259.2	1490	5970
178.8	2910	7340	260.8	1500	5620
180.5	2840	7430	262.5	1280	5710
182.1	2680	6680	264.1	1560	5860
183.7	2660	7190	265.8	1640	5910
185.4	2670	6960	267.4	1590	5860
187.0	2610	6960	269.0	1460	5620
188.7	2660	7040	270.7	1270	5480
190.3	2800	7190	272.3	1350	5660
191.9	2870	7340	274.0	1510	6020
193.6	2930	7340	275.6	1700	6020
195.2	2870	7510	277.2	1820	6130
196.9	3150	7860	278.9	1700	5860
198.5	3050	7590	280.5	1530	5810
200.1	3200	8050	282.2	1540	5910
201.8	4050	9830	283.8	1720	6020
203.4	4260	9280	285.4	1930	6250
205.1	3840	7590			
206.7	2650	6620			
208.3	2560	6550			
210.0	3010	7340			
211.6	2600	7260			
213.3	2290	6750			
214.9	2490	7190			

Table 6. Boring B-1004 Suspension R1-R2 depths and P- and S<sub>H</sub>-wave velocities

**Plant Vogtle Borehole C-1005A**  
**Receiver to Receiver  $V_s$  and  $V_p$  Analysis**

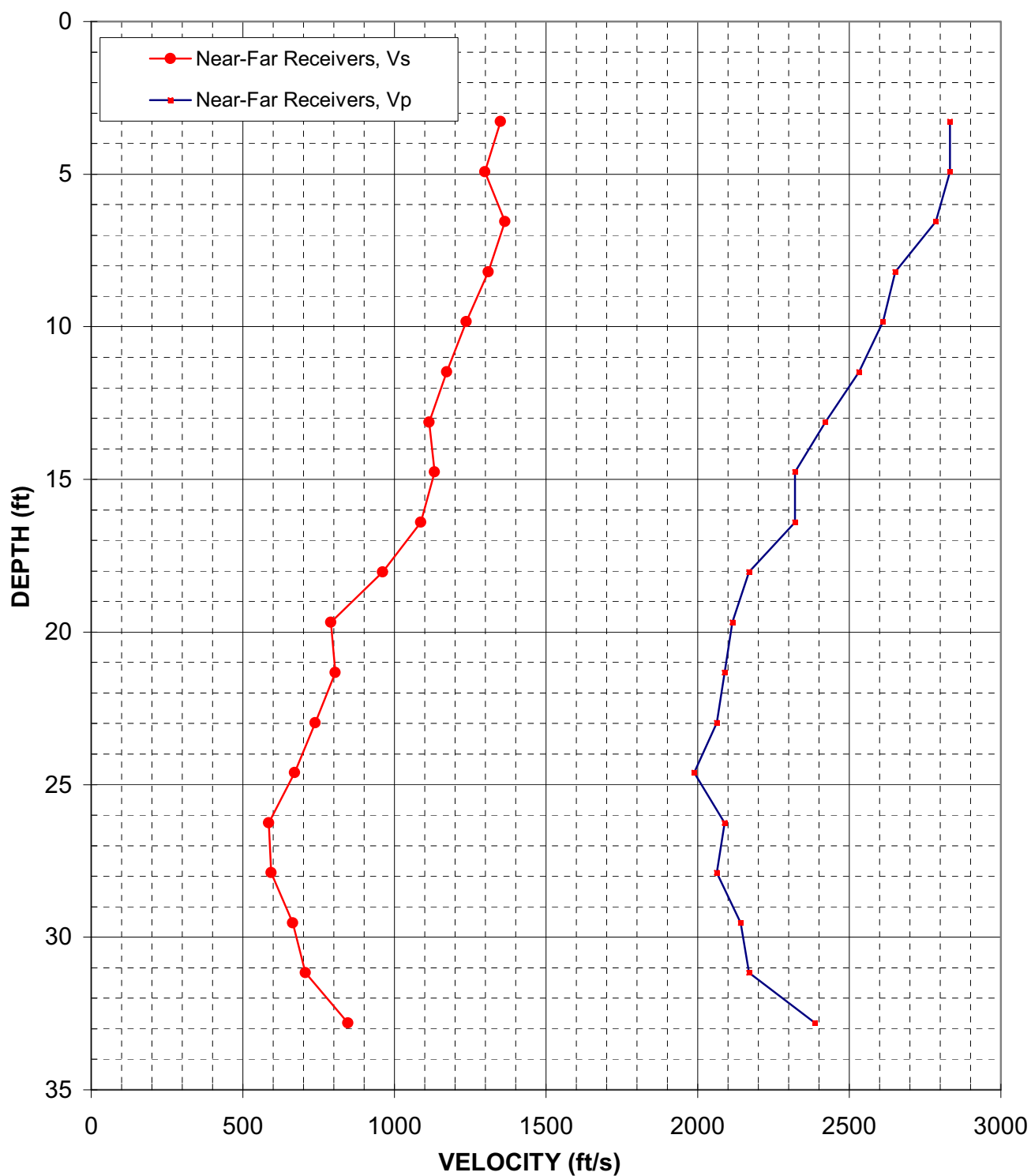


Figure 10. Boring C-1005A, Suspension R1-R2 P- and  $S_H$ -wave velocities

Depth (ft)	V <sub>s</sub> (ft/sec)	V <sub>p</sub> (ft/sec)
3.3	1350	2830
4.9	1300	2830
6.6	1360	2780
8.2	1310	2650
9.8	1240	2610
11.5	1170	2530
13.1	1110	2420
14.8	1130	2320
16.4	1090	2320
18.0	960	2170
19.7	790	2110
21.3	810	2090
23.0	740	2060
24.6	670	1990
26.3	590	2090
27.9	590	2060
29.5	670	2140
31.2	710	2170
32.8	850	2390

Table 7. Boring C-1005A, Suspension R1-R2 depths and P- and S<sub>H</sub>-wave velocities

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