McCALLUM, P.C.

Geotechnical Engineering, Materials Testing & Environmental Services

SUBSURFACE EXPLORATION AND GEOTECHNICAL ENGINEERING

GREAT DISMAL SWAMP WEIR

MARTHA WASHINGTON CANAL

CAMDEN COUNTY, NORTH CAROLINA

MTL PROJECT #09-11773NC

Prepared for: Ducks Unlimited, Inc.
South Atlantic Field Office
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Attention: Billy Webster, P.E.
Regional Engineer

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1.0 PROJECT INFORMATION

The site for the proposed weir is located approximately 1000 ft. south of the Virginia-North Carolina line on the Martha Washington Canal just north of its intersection with the east-west Corapeake Ditch. The existing canal has a maximum depth of approximately 11 ft. and is approximately 55 ft. from top of bank to top of bank. At the present time the ground surface is overgrown with vegetation.

The proposed weir will be constructed of driven steel sheet piles and W14x30 piles, and the associated steel framework. It will have a total length of approximately 96 ft. and a maximum height at the center of approximately 14 ft. The top of the weir will include a catwalk and hoist monorail, approximately 12.6 ft. high, across the full length of the top of the weir. The center of the weir will include a system of stop logs for raising and lowering the canal water level upstream of the weir.

The proposed construction will be supported by a system of 28 W14x30 piles in two rows of 14, spaced 6 ft. apart. The upstream row of piles will support PZ 22 sheet piles. The sheet piles will be installed to a top of weir elevation of el 11.2 except for a 20 ft. wide center section installed to a top elevation of el. -1.8. In this center section, a series of stop logs will be installed within the flanges of the pile sections. The top elevation of the stop logs can then be varied to permit increasing or decreasing the water flow in the canal. The proposed weir design with the preliminary pile tip elevations is shown in the following plans prepared by Ducks Unlimited, Inc.

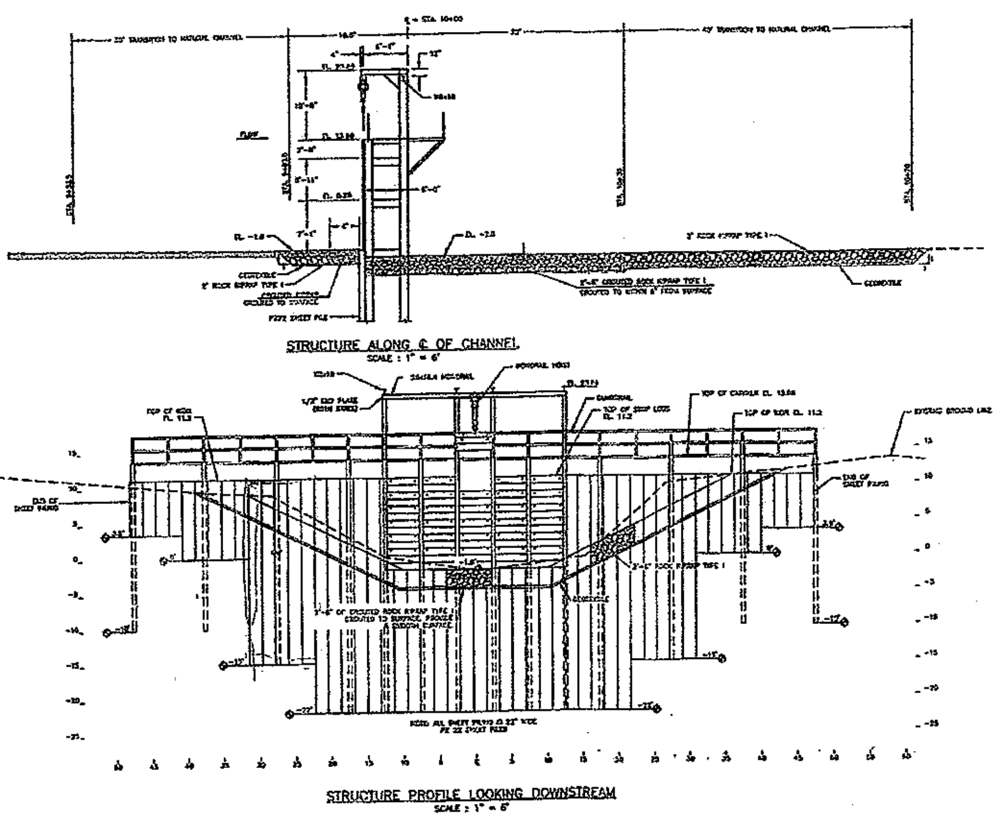


Figure 1: Proposed Weir Design

Based on the structural analyses performed by the McPherson Design Group, we understand the W14x30 piles have been increased in section to W14x43 piles. In addition, we understand these piles will have to support up to 30 tons in both compression and uplift.

2.0 SCOPE OF SERVICES

The evaluation of the site for the planned weir required the collection of subsurface data, laboratory testing and the performance of various geotechnical analyses. These analyses were based on our experience with local conditions and pile foundation designs. All work was directed and supervised by a Professional Engineer specializing in geotechnical design and construction. This written report which describes the exploration and provides our recommendations for the design and construction of the H-piles and sheet piles was prepared after reviewing the project information provided to us and analyzing the subsurface data collected for the project.

McCallum P.C. drilled one soil test boring extending to a depth of 75 ft. beneath the existing ground surface. Standard Penetration Tests (SPT's) were performed at 2 ft. intervals in the upper 10 ft. of boring and at 5 ft. intervals below 10 ft. All drilling and sampling was performed in accordance with applicable ASTM Standards. At the completion of drilling, water level measurements were made within the completed bore holes. All samples obtained from the borings were visually examined by a Geotechnical Engineer and visually classified according to the Unified Soils Classification System. Selected samples were subjected to Natural Moisture Content, Percent Finer Than a No. 200 Sieve and Atterberg Limits testing in the laboratory.

A Site Location Plan, a Boring Location Plan, a Subsurface Profile, a Weir Profile and the detailed results of field sampling and testing are presented in Appendix A. The results of all laboratory testing performed for this study are presented in Appendix B.

3.0 SUBSURFACE CONDITIONS

3.1 Stratigraphy

Directly beneath a surface veneer of topsoil 4 inches thick, the borings encountered Coastal Plain Sediments. A summarization of the subsurface conditions encountered is presented in the following tabulation:

TABLE 3.1 – SUBSURFACE CONDITIONS

STRATUM	APPROXIMATE ELEVATION (FT)	DESCRIPTION	STANDARD PENETRATION RESISTANCE (BLOWS/FT)
1	15 to 9	Loose to very loose, moist, brown, silty, fine sand (SM)	5 to 3, Decreasing With Depth
2	9 to 7	Fibrous peat (Pt)	4
3	7 to -17	Compact to very loose, moist to wet, brown to gray, silty, fine sand (SP-SM)	32 to 3
4	-17 to -27	Medium compact to compact, wet, gray, clayey, silty, fine sand (SC)	18 to 34
5	-27 to -60*	Medium compact to compact, wet, gray, silty, fine sand with traces of shell fragments, SM, SP-SM	19 to 37

* **Maximum Depth of Exploration.**

3.2 Groundwater

Our water level measurements made at the completion of drilling operations indicated the level of groundwater to be approximately 14 ft. below the existing ground surface. Seasonal groundwater level fluctuations on the order of 2 to 3 feet are not uncommon in this area. Lowest groundwater levels normally occur in late summer and early fall while the highest levels generally occur in late winter and early spring. Groundwater levels at this location are also affected by the fluctuation of the canal water level. At the time of our study, we believe groundwater levels were between their seasonal high and low elevations.

4.0 RECOMMENDATIONS

4.1 Basis

The following recommendations are based on data obtained by this subsurface exploration program, the structural and site orientation data given previously and our past experience within the area. If the project information presented is incorrect or changed in the final design or if site or subsurface conditions encountered during construction differ appreciably from those indicated by this report, this office should be notified to determine the applicability of our recommendations in light of the changed conditions.

4.2 Foundation Discussion

Below the loose and very loose sands of Stratum 1 and the peaty soils of Stratum 2, the soils encountered to the 75 ft. maximum depth of drilling consist of compact to very loose to medium compact and compact silty sands (SP-SM, SM). However, between depths of 32 ft. and 42 ft. (el -17 to el -27) the boring encountered a layer of clayey sands (SC).

Based on the loading conditions to be exerted as indicated by the geometry of the weir structure shown on the provided drawings, the W14x43 piles will have to be extended to a sufficient depth to anchor the piles under the lateral loads to be exerted by approximately 14 ft. of water. As such, based on the soil conditions, the W14x43 piles were evaluated for "fixity" depth using LPILE Plus for Window, Version 4.0. Fixity is defined as that pile depth where essentially no lateral movement of the pile occurs.

The evaluation of the weir structure basically assumed that essentially all lateral load will be resisted by the W14x43 piles. The load would initially be picked up by the sheet piles or stop logs and be transferred to the W14x43 piles. As such, the critical depth of the PZ 22 sheet pile is the depth required to prevent boiling and piping. This can occur when the uplift forces due to the differential head across the weir exceed the buoyant weight of the downstream soil. When this occurs, the downstream soil becomes unstable and the soil at the pile tips can be eroded to the ground surface and affect the integrity of the structure.

4.3 W14x43 Pile Fixity and Tip Elevation Requirements

Based on our LPILE evaluation of the W14x43 piles under the previously outline conditions, we recommend the following fixity evaluation for each of the Pile Lines shown on Drawing 4 in Appendix A.

Table 4.3.1 - W14x43 Piles	
Pile Line	Fixity Elevation (ft)
1 & 2	-5
3	-9
4 to 11	-19
12	-9
13 & 14	-5

In order to resist the compression and uplift forces on the individual piles, we recommend tip elevations be selected in accordance with the following table:

Table 4.3.2 - Pile Capacities (W14x43)		
Pile Tip Elevation (ft.)	Compression (tons)	Uplift (tons)
-10	1	0.2
-15	2	1
-20	4	2
-25	9	4
-30	20	7
-35	20	12
-40	30	15
-45	40	20
-50	45	30
-55	55	35

4.4 PZ 22 Sheet Pile Tip Elevations

Based on our critical gradient calculations, we recommend the following sheet pile tip elevations for the panel numbers indicated on Drawing 4 of Appendix A.

Table 4.4 PZ 22 Sheet Piles	
Panel Number	**Tip Elevation (ft)**
1	+3.5
2	0
3	- 15
4	- 25
5	- 15
6	0
7	+3.5

4.5 Indicator Piles and Pile Load Tests

Indicator piles and pile load tests are normally fundamental to a properly designed pile foundation system. However, due to the relatively low design capacity of the individual piles, a load test will likely not be required. If possible an indicator pile can be installed at a production pile location. The indicator pile should be at least 5 ft. longer than the anticipated production pile length. The results of indicator pile driving will likely provide sufficient information to allow for a knowledgeable selection of production pile tip elevations and will help identify potential pile installation problems. The results of indicator pile driving should be evaluated by the Geotechnical Engineer to determine if a pile load test is required. If deemed necessary, load tests should be run to failure, if at all possible, in accordance with ASTM D 1143 - 81, Section 5.6, Quick Load Test Method, no sooner than one week after installation. The actual production pile lengths and capacities should then be determined based on the results of the indicator pile installations, the available subsurface data and the results of any required load tests.

4.6 Pile Installations

Compatibility of the driving equipment and the pile type being driven is an essential element in achieving the required penetration and a satisfactory pile foundation. We recommend that a pile driving rig be utilized for the W14X43 piles that is equipped with fixed leads and a pile hammer with a minimum energy of 21,000 ft-lbs.

The required driving resistance for production piles should be determined in accordance with a pile driving formula in conjunction with the results of indicator pile driving and any required load tests. However, the driving of piles in saturated sands can cause densification and an increase in porewater pressure at the tip, resulting in a temporary reduction of the driving resistance and pile capacity. Therefore, due to the effect of the excess porewater pressure, it may not be strictly possible to assign an initial minimum pile driving resistance for production piles. Where low driving resistances are encountered, piles should be restruck the following day to confirm that the final set of individual production piles does not vary significantly from that indicated by pile driving formulae. Should such a variation occur, the matter should immediately be brought to the attention of the Geotechnical and Structural Engineers for their evaluation.

The use of a vibratory pile hammer can be economical for the sheet pile installations. However, even if the soil conditions are know and the pile type specified, the actual vibratory pile hammer required to advance the pile to a specified depth cannot be calculated with certainty. Should a vibratory hammer be utilized, the actual equipment selected by the contractor must be capable of installing the piles to the design tip elevations without damaging the piles. It is anticipated that a medium frequency driver exerting vibration frequencies on the order of 10 to 30 H_z will be required.

Piles should be installed to the minimum elevations shown in Tables 4.3.2 and 4.4. Should refusal to pile penetration be encountered prior to reaching the indicated tip elevations, the Geotechnical and Structural Engineers should be contacted for guidance.

4.7 Pile Installation Inspection

Even the most knowledgeable contractor working with a well written set of specifications will not ordinarily be cognizant of detailed design assumptions. It is best to retain an independent inspector to observe the pile installation procedure and verify the compliance with the intent of the pile installation specifications. This inspection requires a person capable of making decisions concerning the pile installation operations. Therefore, we recommend the Geotechnical Engineer be retained to approve the pile installations and to revise installation procedures should varying soil conditions be encountered.

APPENDIX A

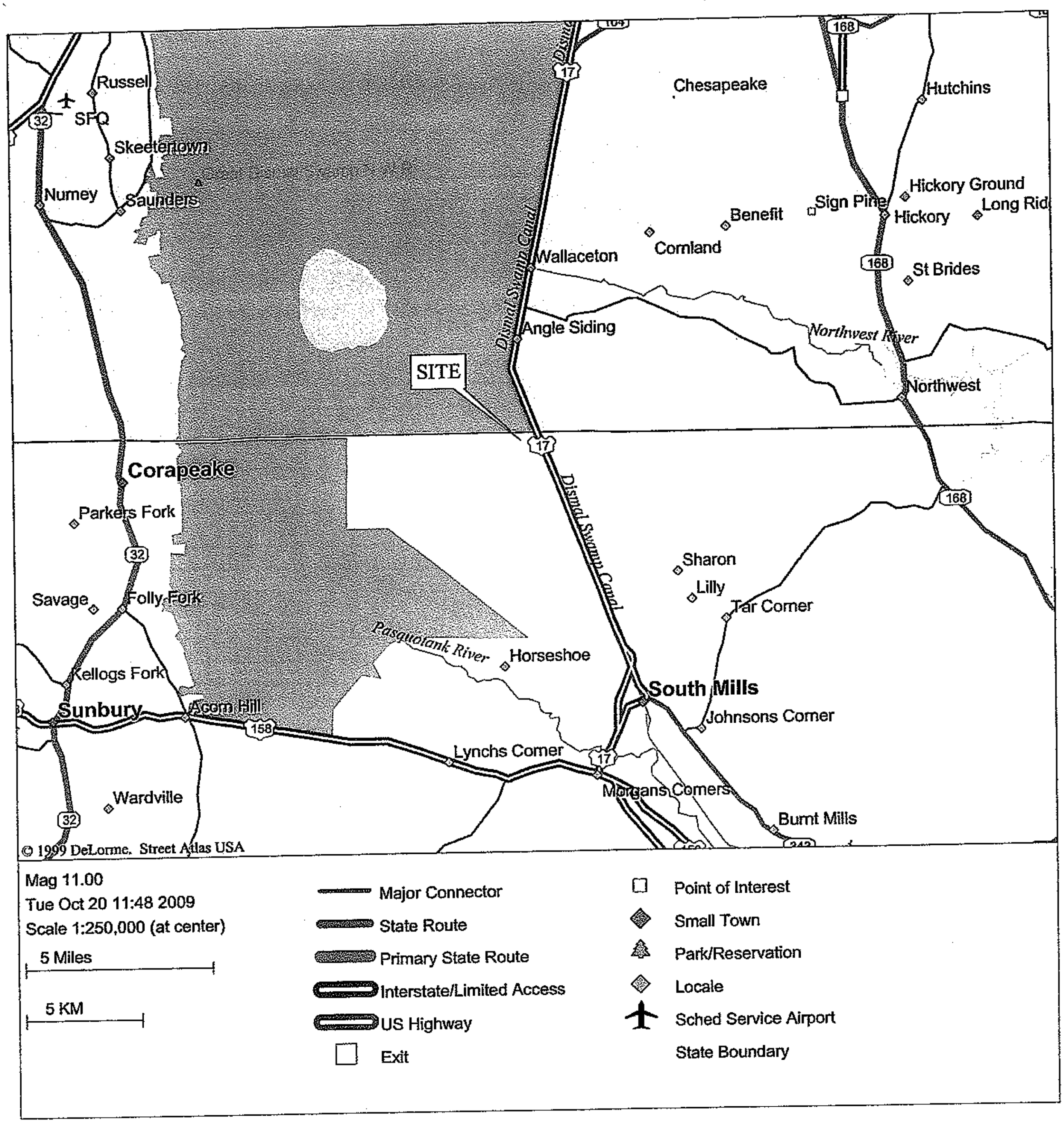
Site Location Plan

Boring Location Plan

Subsurface Profile

Weir Profile

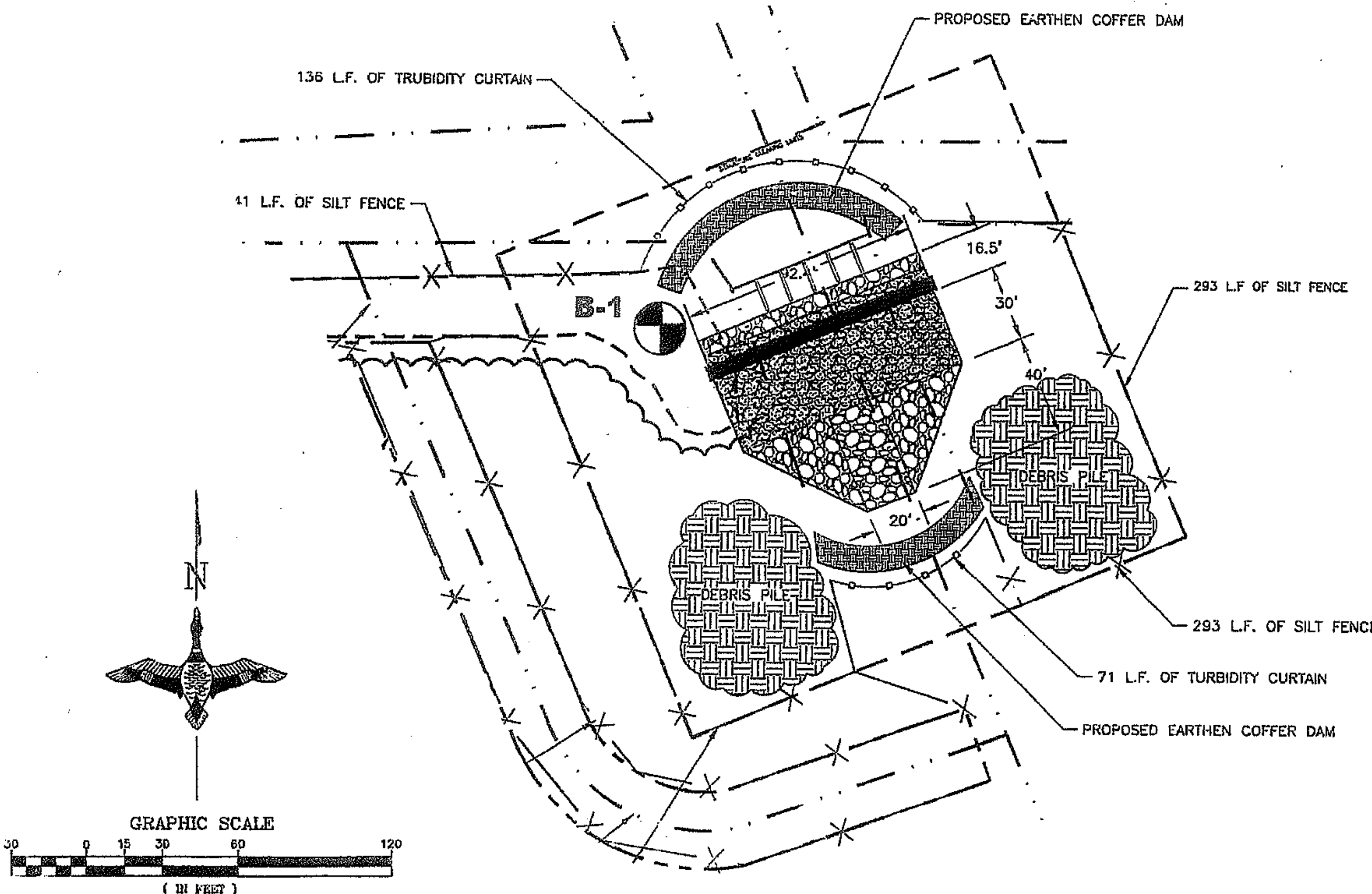
Test Boring Records



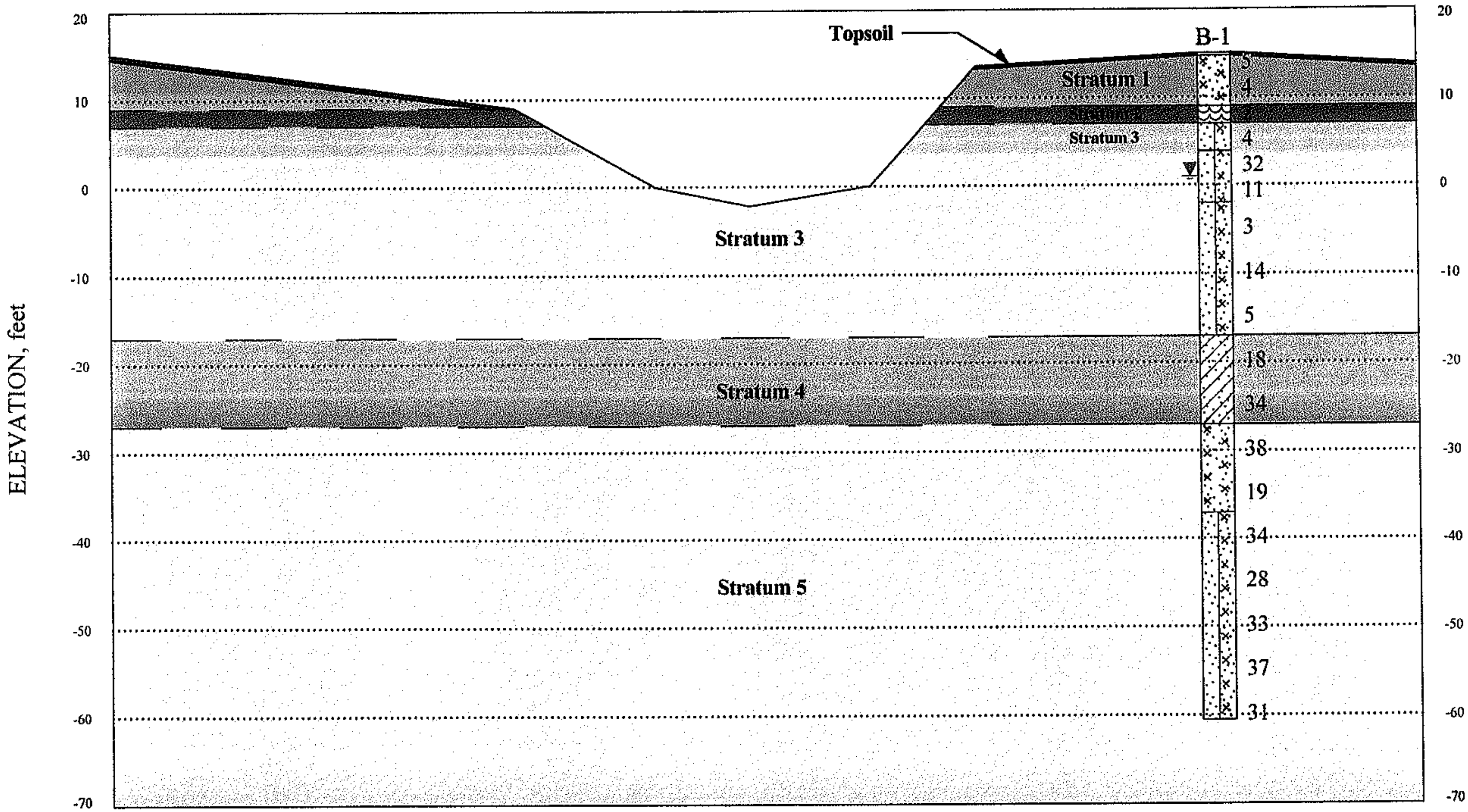
McCALLUM, P.C.

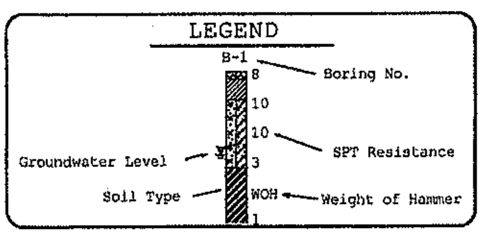
1808 Hayward Avenue
Chesapeake, Virginia 23320

Scale:	As Shown	Approved By:	Douglas S. Kinloch, P.E.	Date:	9/23/09
Project:	Great Dismal Swamp Weir Martha Washington Canal Camden County, North Carolina				
Drawing Title:	SITE LOCATION PLAN			Drawing Number:	1

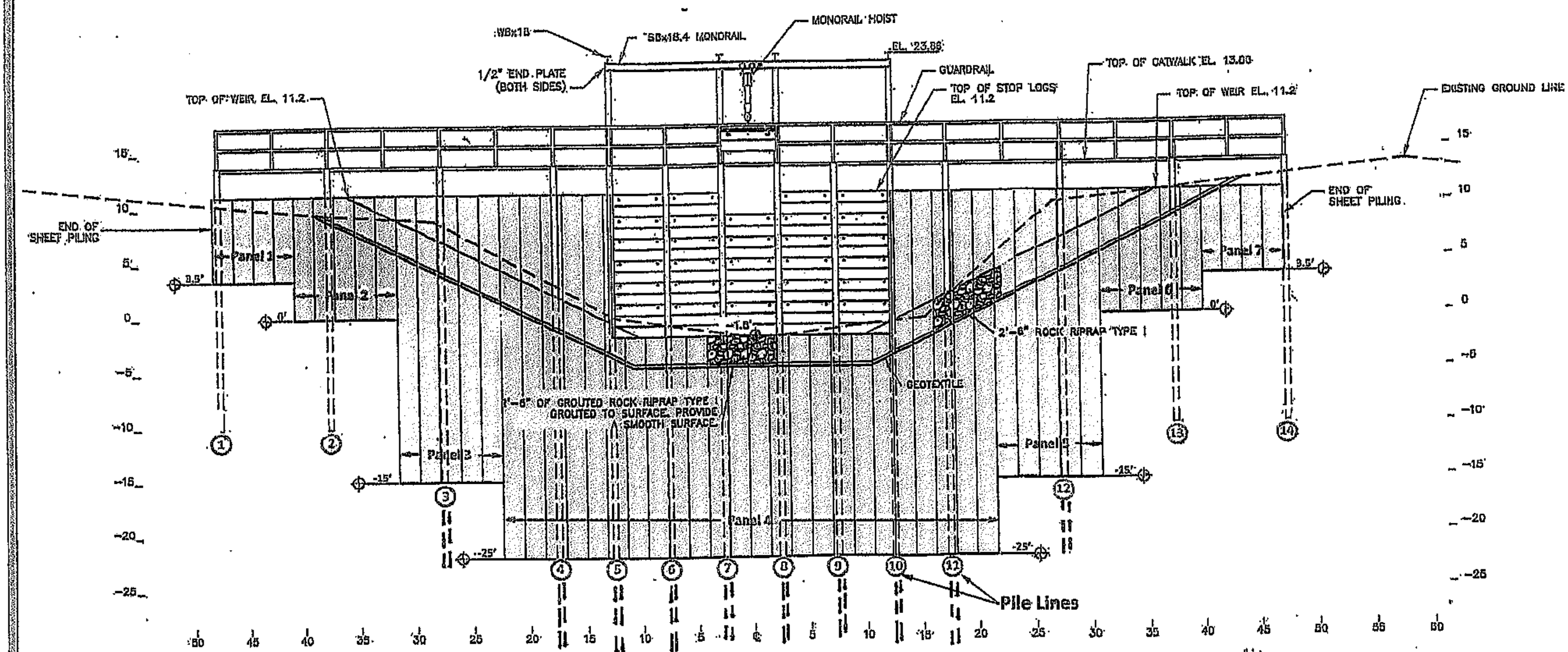


McCALLUM, P.C. 1808 Hayward Avenue Chesapeake, Virginia 23320			
Scale: As Shown	Approved By: Douglas S. Kinloch, P.E.		Date: 9/23/09
Project:	Great Dismal Swamp Weir Martha Washington Canal Camden County, North Carolina		
Drawing Title:	Boring Location Plan		Drawing Number: 2





Subsurface Profile	
Drawing 3	
PROJECT	Great Dismal Swamp Weir
PROJECT NO.	09-11773NC
McCALLUM TESTING LABORATORIES, INC.	



STRUCTURE PROFILE LOOKING DOWNSTREAM

Original Drawing Provided By Ducks Unlimited, Inc.

McCALLUM, P.C. 1808 Hayward Avenue Chesapeake, Virginia 23320			
Scale: —	Approved By: Douglas S. Kinloch, P.E.	Date:	09/23/09
Project:	Great Dismal Swamp Weir Martha Washington Canal Camden County, North Carolina		
Drawing Title:	Weir Profile	Drawing Number:	4

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Geotechnical Engineering, Materials Testing & Environmental Services

Unified Soil Classification System
ASTM Designation D 2487

Major Division	Subdivision	Symbol	Description
Coarse Grained Soils (More than 50% of material retained on the No. 200 Sieve)	Gravels (more than 50% retained the No. 4 Sieve)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	Sands (more than 50% passing the No. 4 Sieve)	SW	Well graded sands, gravelly sands, little or no fines
		SP	Poorly graded sands, 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 passes on the No. 200 Sieve)	Silts & Clays (LL less than 50)	ML	Inorganic silts, very fine sands, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts & Clays (LL greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, plastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity
	Highly Organic Soil	PEAT	Peat and other highly organic soils

Standard Pentration Test (SPT)
Resistance Correlations

Coarse Grained Soils

SPT
vs.
Relative Density

Blows/Ft	Relative Density
0 - 4	Very Loose
5 - 10	Loose
11 - 30	Medium Compact
31 - 50	Compact
Over 50	Very Compact

Fine Grained Soils

SPT
vs.
Consistency

Blows/Ft	Consistency
0 - 2	Very Soft
3 - 4	Soft
5 - 8	Medium Stiff
9 - 15	Stiff
16 - 30	Very Stiff
31 - 50	Hard
Over 50	Very Hard

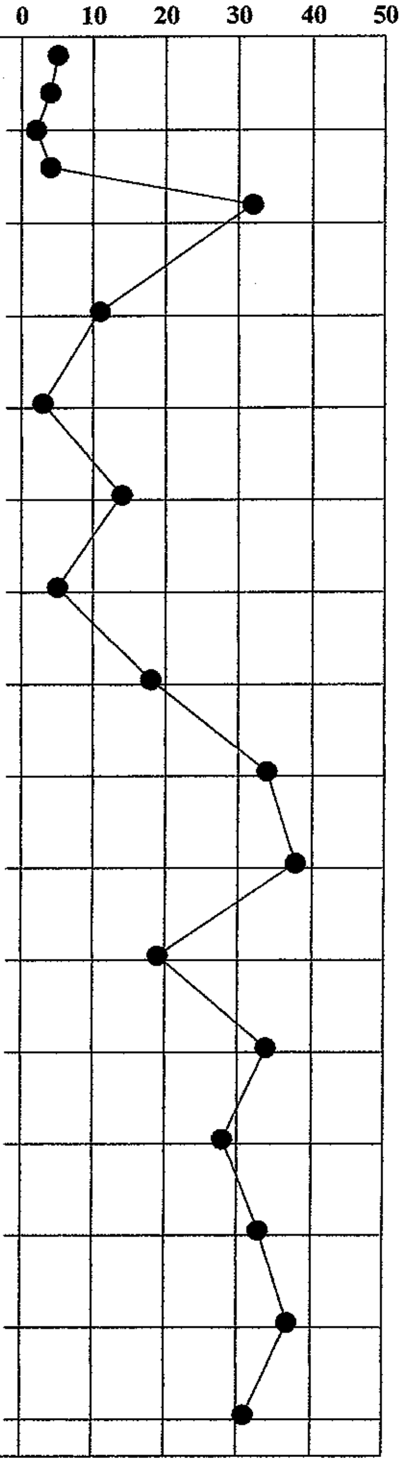
APPENDIX B

Laboratory Test Results

DEPTH (FT.)	DESCRIPTION
0.0	
0.3	Topsoil - 4"
	Brown, silty fine sand with traces of clay, moist, loose, SM
	Same - very loose
6.0	Same - with traces of organics
8.0	Brown, fibrous and amorphous peat, PT
	Brown, silty fine sand, moist, compact, SP-SM
	Same - gray, wet, medium compact
17.0	Gray, silty fine sand with traces of shell fragments, wet, very loose, SP-SM
	Same - medium compact
	Same - loose
32.0	Gray, clayey silty fine sand with traces of shell fragments, wet, medium compact, SC
	Same
42.0	Gray, silty fine sand with traces of clay and shell fragments, wet, compact, SM
	Same - medium compact
52.0	Gray, silty fine sand with traces of shell fragments, wet, compact, SP-SM
	Same - medium compact
	Same - compact
	Same
75.5	Same
	BORING TERMINATED AT 75.5 FEET

APPROX. ELEVATION (FT.)	STANDARD PENETRATION RESISTANCE (BLOWS/6 IN)
14.0	2-2-3-4
12.0	3-2-2-2
10.0	2-1-1-2
8.0	2-2-2-2
6.0	13-16-16-13
0.0	8-6-5
-5.0	2-1-2
-10.0	3-5-9
-15.0	3-3-2
-20.0	8-9-9
-25.0	10-10-24
-30.0	12-17-21
-35.0	6-9-10
-40.0	6-14-20
-45.0	7-9-19
-50.0	7-14-19
-55.0	8-16-21
-60.0	7-13-18

STANDARD PENETRATION RESISTANCE (BLOWS/FT)



NOTES:

Legend	
··········	Gradual Stratum Change
— — —	Approximate Stratum Change
●	Penetration Resistance (N - value)
⊠	Standard Penetration Test
▌	Undisturbed Sample
▼	Water Table at Time of Boring
▽	24 Hour Water Table Reading

TEST BORING RECORD

BORING NUMBER	B-1
DATE DRILLED	September 23, 2009
PROJECT NUMBER	09-11773NC
PROJECT	Great Dismal Swamp Weir
LOCATION	Martha Washington Canal., Camden Cty, NC

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LABORATORY TEST RESULTS
GREAT DISMAL SWAMP WEIR - MARTHA WASHINGTON CANAL
CAMDEN COUNTY, NORTH CAROLINA
MTL PROJECT 09-11773NC

BORING NO.	SAMPLE DEPTH (FT.)	NATURAL MOISTURE PERCENT (ASTM D 2216)	ATTERBERG LIMITS (ASTM D 4318)			PERCENT FINER THAN A #200 SIEVE TEST (ASTM D 1140)	SOIL CLASSIFICATION (ASTM D 2487)
			LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX		
B-1	14.0 - 15.5	22.6	18	NP[1]	NP[1]	5.3	SP-SM
B-1	24.0 - 25.5	22.0	17	NP[1]	NP[1]	9.4	SP-SM
B-1	34.0 - 35.5	22.3	27	19	8	22.1	SC
B-1	49.0 - 50.5	23.3	18	NP[1]	NP[1]	13.7	SM
B-1	59.0 - 60.5	26.8	18	NP[1]	NP[1]	11.3	SP-SM

Notes: 1) Denotes Non-Plastic Soils