REPORT OF

GEOTECHNICAL INVESTIGATION
GOOSE POINT/POINT PLATTE (PO-33)
ST. TAMMANY PARISH, LOUISIANA

FOR

LOUISIANA DEPARTMENT OF
NATURAL RESOURCES
BATON ROUGE, LOUISIANA

AND

GEC, INC.
9357 INTERLINE AVENUE
BATON ROUGE, LOUISIANA 70809

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April 20, 2006

Louisiana Department of Natural Resources
c/o GEC, Inc.
9357 Interline Road
Baton Rouge, Louisiana 70809

Attn: Mr. Thomas Johnson, P.E.

Re: Geotechnical Report
Engineering Assistance for Coastal Restoration Projects
Goose Point/ Point Platte (PO-33)
St. Tammany Parish, Louisiana
STE File: 06-1001

Gentlemen:

Soil Testing Engineers, Inc. (STE) has completed the geotechnical investigation for this project and is pleased to submit the findings of the investigation together with the resulting evaluations and recommendations. Settlement due to self weight consolidation will be discussed in an addendum report.

Should you have any questions concerning this report, please contact this office. We appreciate the opportunity to serve you on this project, and look forward to working with you again in the future.

Sincerely,
Soil Testing Engineers, Inc.

Keith Spampneto, P.E.
Senior Engineer

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The findings of this investigation, together with the analyses and conclusions based on them, are discussed below. The field and laboratory procedures, description of terms and symbols used on soil boring logs, boring logs, consolidation test curves, consolidation parameters table, boring location plan, soil profiles, slope stability drawings, time rate of settlement curves, marsh elevations as provided by LDNR, and column test results are included in the appendix.

1.0 INTRODUCTION

1.1 General. Project information was provided by the LDNR. We understand that approximately 440 acres of marsh will be created along the north shore of Lake Pontchartrain within the confines of the Big Marsh National Wildlife Refuge and the St. Tammany State Wildlife Refuge by dredging material from Lake Pontchartrain and placing it in cells within interior march ponds. The cells will be formed by constructing earthen dikes around the boundaries of the ponds. In addition, approximately 120 acres of degraded marsh will be nourished with the dredged material.

Information on elevations of the marsh and water was furnished by the Louisiana Department of Natural Resources, Coastal Engineering Division (LDNR-CED). This information is attached in the appendix.

1.2 Scope of Work. STE's scope of work consisted of the following items:

- Drill eleven (11) soil borings to depths of twenty (20) to sixty (60) feet below mudline at the locations selected by DNR as shown on the Boring Location Plan, Attachment 1, provided in the appendix,
- Perform laboratory tests to determine classification, strength, and compressibility characteristics for engineering analyses,
- Perform slope stability and settlement analyses for the proposed levees
- Analyze settlements which will be caused by placement of the hydraulic fill.

1.3 Limitations. The analyses and recommendations presented in this report are based on the results of the investigation, and the furnished information as provided by the Louisiana Department of Natural Resources. It is always possible that variations can occur between or away from the borehole locations. If it becomes apparent during construction that subsurface conditions differing significantly from those discussed in Section 2 are being encountered, this office should be notified at once so that their effects can be determined and any remedial measures necessary prescribed. Also, should the nature of the project change considerably, these recommendations may have to be re-evaluated.

This report has been prepared for the exclusive use of G.E.C, Inc., the Louisiana Department of

Natural Resources, Coastal Engineering Division and their consultants for the purpose of designing the proposed Goose Point/Point Platte (PO-33) project as generally described in Section 1.1. The recommendations provided are site specific and are not intended for use at any other site.

1.4 **Report Organization.** Based on the scope of work stated in Section 1.2, the main body of this report is separated into three sections. Section 1 provides an introduction to this project and describes the scope of work. Section 2 discusses the site, geology, and soil conditions. The results of the engineering analyses are presented in Section 3. There is also an Appendix which includes the field and laboratory programs, a description of terms and symbols used on the boring logs, boring logs, consolidation test curves, consolidation parameters table, boring location plan, soil profiles, slope stability drawings, time rate of settlement curves, marsh elevations as provided by LDNR, and column test results are included in the appendix.

2.0 GEOLOGICAL AND SOIL CONDITIONS

The actual boring locations were recorded using a hand held GPS system. The coordinates are provided in the following chart:

Boring	Latitude	Longitude
VC-1	30° 14' 58.6"	89° 59' 50.4"
VC-2	30° 14' 38.6"	89° 58' 58.5"
VC-3	30° 14' 14.7"	89° 53' 46.4"
VC-4	30° 14' 18.3"	89° 52' 47.6"
B-1	30° 14' 50.6"	89° 59' 37.0"
B-2	30° 14' 16.0"	89° 53' 20.1"
B-3	30° 16' 26.2"	89° 58' 41.7"
B-4	30° 15' 54.6"	89° 58' 45.2"
B-5	30° 15' 12.7"	89° 55' 23.2"
B-6	30° 15' 14.0"	89° 54' 34.0"
B-7	30° 15' 34.2"	89° 53' 42.7"

2.1 **Site and Geology Conditions.** Based on geological maps, the area is underlain by the Holocene age soil deposits consisting of the Delta Plain, Saline Marsh sub unit. This deposit consists of gray to black clay of high organic content with some peat and areas of active and abandoned delta lobes of the Mississippi River. This is underlain by Pleistocene age soil deposits consisting of the Prairie Terrace sub unit. This deposit consists of light gray and light brown clay, consisting of the Prairie Terrace sub unit. This deposit consists of light gray and light brown clay, sandy clay, silt, and sand.

2.2 Soil. Borings B-1, B-2, VC-1, VC-2, VC-3, and VC-4 were drilled within the proposed borrow area. The location of these borings are shown on the Boring Location Plan, Attachment 1, provided in the appendix. According to these borings, there was ten (10) to fifteen (15) feet of water above the mudline at the time of drilling. Below the mudline very soft dark gray clay with shells and sand or very soft gray sandy clay with clay layers and shell fragments was encountered generally to depths of four (4) to ten (10) feet below the mudline. However, this very soft material was encountered to at least the boring completion depth of twenty (20) feet below mudline at boring location VC-3 with the exception of medium dense gray silty sand encountered from about two (2) to four (4) feet below the mudline. Below four (4) to ten (10) feet below mudline, generally medium to stiff gray and tan, gray, and greenish gray clay, sandy clay, and silty clay was encountered to at least the boring completion depth with the exception of loose brown clayey sand encountered from about sixteen (16) to eighteen (18) feet below mudline at boring location VC-1 and very soft gray and tan silty clay from about ten (10) to sixteen (16) feet below mudline at boring location VC-4.

Borings B-3 through B-7 were drilled in the marsh fill area. The location of these borings are shown on the Boring Location Plan, Attachment 1, provided in the appendix. One foot or less of water was encountered in these marsh areas. Very soft dark brown peat, loose dark brown to gray silt, loose dark brown silty sand, soft light gray sandy clay, or very soft gray silty sandy clay was encountered in the upper six (6) to nine (9) feet with the exception of boring location B-5. The soil conditions at boring location B-5 consist of medium dense to very dense gray and tan to gray silty sand, clayey sand, and sand extending to a depth of thirty-three (33) feet. Below this depth medium to stiff gray to greenish gray clay with intermittent silt and sand seams was encountered to at least the boring completion depth of sixty-one (61) feet with the exception of loose gray clayey sand from fifty-three (53) to fifty-five (55) feet. Below the loose and soft soils, which extend to a depth of six (6) to nine (9) feet at boring locations B-3, B-4, B-6, and B-7, generally stiff to medium gray and tan , gray, and greenish gray silty clay, sandy clay, and clay was encountered to the borings' completion depths of forty (40) to sixty (60) feet. However, soft gray sandy clay was encountered from thirty-one (31) to thirty-five(35) feet at boring location B-4, dense to very dense gray clayey sand and sand was encountered from twelve (12) to twenty-eight (28) feet at boring location B-7, and soft gray clay to sandy clay from twenty-eight (28) to thirty-six feet at boring location B-7.

Soil profiles are included on Figures 7 through 10 located in the appendix.

3.0 ENGINEERING ANALYSES AND ASSESSMENTS

3.1 Assignments. The engineering assignments given to STE were outlined in the document Scope of Services For Geotechnical Investigation provided by LDNR. They can be summarized as follows:

3.1.1 New Earthen Containment Levees. The most significant items for design are global slope stability and total settlement. These include maximum allowable construction elevation, crown width, and side slopes (stability) plus settlements (1) during a 1-year construction period and (2) time to settle to average marsh elevation. We understand that typical crown widths range from three (3) to five (5) feet.

3.1.2 Dredge Borrow and Fill. These are primarily settlement-related items such as fill settlements (maximum fill: 0.5 feet below as-built levee tops) over 20 years, and fill-related items such as suitability of the borrow area soils, dewatering recommendations, and cut/fill ratios. The minimum fill height should be at or above the average marsh elevation which is + 1.0 ft. NAVD 88.

These various items are covered in the following sections.

3.2 Levee Stability Analysis. This section presents the methodology used in the slope stability analyses for the levees, borrow excavation, the cases analyzed, and the results.

3.2.1 Slope Stability Analysis - General. A slope has two types of forces acting on it. The soil weight and any seepage forces try to make the soil slide; these are called the "driving forces." The weight of soil below the waterline is its "effective" or, buoyant weight. Therefore, a foot of soil above water has 2 to 3 times the driving force of a foot of soil below water. The strength of the soil tries to keep it from sliding; this is called the "resisting force." Both depend on the geometry of the situation: the "Failure surface." The procedure is to isolate a block of soil (mentally), and compute the resisting and driving forces. Their ratio is called the "global slope stability safety factor". In practice, one analyses many soil blocks until the block yielding the lowest safety factor is found. This is assumed to govern, and the safety factor for the slope is the lowest safety factor determined. The calculations for any but the simplest conditions are quite laborious. They are therefore now performed on a digital computer, using a proven code such as PCSTABL, XSTABL, UTEXAS3, etc. For this project, the slope stability analyses were performed using XSTABL marketed by Interactive Software Designs, Inc. This program evolved from PCSTABL by Purdue University. The program is capable of searching for the minimum safety factor with an easy to use interface. The Bishop method of analysis was used for this project. The accepted measure of a slope's stability is its "safety factor," as defined above. Typical acceptable safety factors common in practice are:

Low Water Condition:	1.3 - 1.5
Rapid Drawdown Condition:	1.0 - 1.1

The rapid drawdown case is not applicable for this project due to the nature of the tidal conditions at the proposed structures.

3.2.2 Cases Analysed. Since the soil strengths are the dominant factor in slope stability, we calculated slope stability of the containment berm at each boring location in the marsh fill area except for boring B-5, where the near surface soil conditions consist of medium dense sands and is not expected to govern. Slope stability of the borrow area to be used for the marsh fill was evaluated using boring VC-3 due to the very soft conditions encountered at this location. Both short term and long term stability was evaluated for the borrow area.

In each levee area, analyses were made for the following levee geometries:

Initial Freeboard:	1.0, 1.5, and 2.0 feet
Water Depth:	1.0 feet
Side Slopes:	1(V):4(H) and 1(V):3(H)
Crown Widths:	5 feet
Levee soil:	cohesion 200 psf and unit weight 105 pcf.

3.2.3 Results. The results of the stability analyses are presented on Figures 11 through 18 located in the appendix. The results can be summarized as in the table below:

Boring No.	**Initial Freeboard (ft.)**	**Safety Factor for Side Slope**	
		1(V):4(H)	**1(V):3(H)**
B-3	1.0 1.5 2.0	1.6 1.5 1.4	1.5 1.4 1.3
B-4	1.0 1.5 2.0	2.2 2.2 2.1	2.3 2.0 1.9
B-6	1.0 1.5 2.0	2.5 2.6 2.3	2.7 2.2 2.2
B-7	1.0 1.5 2.0	2.8 2.6 2.1	2.4 2.0 2.0

3.2.4 Levee Borrow. It is often desirable to obtain the borrow material for the levees using in-situ material near the levee. Excavating this material from too close to the levee toe can affect the stability of the levee adversely. It is therefore recommended that the edge of the borrow pit not be closer to the levee toe than about twenty (20) feet plus the depth of the borrow excavation.

Also, the near-surface soils at boring locations B-3 and B-7 are Peats (Pt) to around the two (2) to three (3) feet below ground surface. Peats should be spoiled or used in general fill and not used for levee construction.

3.2.5 *Borrow Area Stability.* Two (2) borrow areas have been identified located south of the proposed marsh areas to be filled. Three (3) soil borings were performed in each area, as identified in Section 2.2. The Boring Location Plan, Attachment 1, provided in the appendix shows the locations of the borings. An analysis to find a safe slope during excavation was evaluated. We assumed a maximum ten (10) foot cut depth. The soil conditions at boring location VC-3 revealed the weakest soils. Based on this, a 1(V):6(H) slope to a depth of ten (10) feet will have a minimum factor of safety of 1.6. This is shown on Figure 19 located in the appendix.

3.3 Levee Settlement Analyses. The assignments relative to levee settlements were given in Section 3.1.1. They require calculating both the total amounts of settlement and the time-rates at which these movements will occur. Levee settlement is composed of two parts:

- Settlement in the foundation soils due to the weight of the levee, and
- Settlement within the levee itself due to self-weight consolidation (minor due to the method of levee construction)

3.3.1 Analyses - Settlement due to Levee Weight. The consolidation settlement of the underlying soils depends on the geometry and intensity of the applied load (levee fill) and on the compressibilities of the underlying soil strata. As settlement progresses, the net intensity of the applied load decreases. This is especially true for levees built in water. The maximum possible settlement is that calculated without taking this phenomenon into account, and forms the basis for calculations which do use load intensity decrease. Note that this decrease occurs if the levees are not periodically rebuilt to their initial elevations.

The actual settlement calculations were performed using the computer code VSTRESS, originally developed by the Corps of Engineers. These programs calculate one-dimensional settlement based on either Boussinesq or Westergaard stress distributions. The Boussinesq stress distribution was used for these analyses. For the soil types that had consolidation tests, actual consolidation curves were used in the calculations. Published correlations for pre-consolidation pressure, coefficient of consolidation, and compression and re-compression indicies were used for other soil types to obtain consolidation indices using shear strength, Atterberg Limits, and moisture content values. These correlations are provided in NAVFAC Design Manual 7.1, May 1982. The consolidation curves, Figures 1 to 6, are provided in the appendix.

Calculations were made using the soil conditions at Borings B-3, B-4, B-5, B-6, and B-7. These borings were drilled in the marsh fill area. The water depth in this area was assumed to be 1-foot. A crown width of five (5) feet and a 1(V):3(H) side slope was used based on the results of the slope stability analysis. A freeboard of 1.0, 1.5, and 2.0 was evaluated. The levee settlements were calculated at the levee centerline.

Case	**Raw Centerline Ultimate Settlement, ft.**		
Freeboard (ft)	**1.0**	**1.5**	**2.0**
Water (ft)	**1**	**1**	**1**
B-3	0.90	1.01	1.11
B-4	0.10	0.13	0.16
B-5	0.06	0.08	0.10
B-6	0.15	0.20	0.25
B-7	0.63	0.70	0.76
Average	0.37	0.42	0.48
Std. Dev.	0.3	0.41	0.44

Notes: Raw calculation - no change in load intensity.

It should be noted that due to the large spacing between borings and the different areas that the borings represent, the average and standard deviation is provided for reference only. These statistical values are more useful when each boring represents an equal area of the total.

3.3.2 Analyses - Time Rate of Settlement. The time-rate of settlement as observed at the ground surface depends on several factors, as discussed below:

- Soil Rate Parameter (c_v). This is intrinsic to each soil type, but varies with the total vertical pressure in the soil layer.
- Drainage Path Length (L). Consolidation is a process of squeezing water out of the soil voids. The water has to go somewhere, and that is to either the surface or a relatively permeable layer (such as a silt layer in a clay mass).
- Vertical Distribution of the Total Settlement. The time rate applies to each layer; the contribution of each layer is its own ultimate settlement multiplied by its degree of consolidation at a particular time.

Like other problems in time-dependent flow in soils, the analysis for the time-rate of consolidation is inherently inaccurate. Normally, settlement occurs faster than the prediction.

Calculations were made for the soil conditions at each boring along the levee perimeter. The results were normalized by dividing the settlements at various times by the ultimate (long-term) settlement. Settlement rates were analyzed for the tallest and the lowest levee heights and averaged. In general, the lower levees settle slightly faster than the taller levees. This results from the distribution of settlements. The taller levees produce stresses deeper into the ground than do the lower levees. Thus, more of the tall levee settlements come from the deeper soils. At this project, the settlement rates are slower in the deeper soils than in the shallower soils. Hence, the settlement rate (as percentage of ultimate settlement) is faster for the lower levees than for the taller levees. Time rate of settlement curves for the centerline of levee are include in the appendix on Figures 20 and 21.

Boring No.	**Percentage of Settlement Complete at Time (yrs)**					
	0.25	**0.5**	**1.0**	**2.0**	**5.0**	**10.0**
B-3	52.5	70.4	88.1	97.4	100	100
B-4	87.4	90.8	92.0	100	100	100
B-5	86.9	92.5	100	100	100	100
B-6	78.7	82.2	85.2	90.4	98.7	100
B-7	74.2	91.4	99.5	100	100	100
Average	75.0	85.5	93.0	97.6	99.7	100
Std. Dev.	14	9	7	4	0.6	0

3.3.3 Time to Reach Marsh Elevation. The average marsh elevation was furnished by LDNR for this project as +1.0 feet NAVD88. It is assumed that the initial levee top elevation will be up to 2 feet above the site water level, or +3 feet NAVD. It is concluded that the top of the levee for initial heights of elevation +2.0 and +3.0 will not reach marsh elevation of +1.0 due to consolidation settlement of the underlying soils. This is shown on Figures 23, 23, and 24. Of course, this does not include self-weight consolidation.

3.4 Suitability of Borrow Soils. As mentioned, two borrow areas have been identified for use in marsh fill areas. As discussed, generally the containment levees are built using in-situ material located nearby the levee section. The soil conditions at these locations are discussed in section 2.2. Borings B-3 and B-7 located in the marsh fill area consist of 3.5 to 2 feet of peat soils at the surface.

The "more suitable" Clays (CH), Organic Clays (OH), and lower plasticity materials usually have water contents below their Liquid Limits. While some would not be considered as "select" borrow under normal circumstances, they are the best available for this project. It is recommended that:

- Peats (Pt) not be used for levee fill, although they could be used in the general area fills.
- Organic Clays (OH), if encountered, be excluded from the levee fills if possible. They can be used for the general fill.
- Clays (CH), Silty or Sandy Clays (CL), Very Silty Clays (CL-ML), and any Silts

(ML/MH) or silty sands (SM) should be used for levee fill to the extent possible. They can be used for the general fill. It should be noted that the silts and silty sands are more erodable than the other soils. Silty sands were encountered in the upper four (4) to six (6) feet at boring locations B-4 and B-5, respectively. Two (2) to four (4) feet thick silt layers were also encountered at the other borings performed in the marsh fill areas. It may be advisable to ensure that these more erodable soils be mixed with the clays, silty clays, and sandy clays to provide more resistance to erosion.

3.5 Dewatering Time for Area Fill. When soil particles are in suspensions with low concentration of solids, particles settle as individual entities, and there is no significant interaction with neighboring particles (Type I settling). With increasing solids concentration, the particles coalesce or flocculate. By coalescing, the particles increase in mass and settle at a faster rate (Type II settling). With further increase in concentration, the interparticle forces are sufficient to hinder the neighboring particles (Type III settling). Finally, the soil particles settle to form a structure (Type IV settling). The dredging operation typically creates a soil suspension with 5 to 10 percent solids. At this concentration range, the soils settles at a rate close to Type III. Types I and II settling are therefore not applicable for this project. These two types are typically used for sediment transport modeling. Type four settling is typically simulated using diffusion equation using either Terzaghi or Gibson consolidation theory and is discussed in Section 3.6. The dewatering time varies with type of soils and salinity of the water and is normally determined using a column test. According to the column test results performed by LSU, the soils will have a moisture content of approximately 226 percent at the end of Type III settling stage. This value is very similar to the moisture content at the borrow area. The settling velocity to reach this state is rather quick within one day of starting the test for an six-foot settling column height. The rate of movement of the interface between the Type III and Type IV determines the rate of dewatering settling. For solid concentrations between 5 to 12 percent, the interface settling velocity is approximately 0.10 feet per hour for initial Type III settling. It took approximately 35 hours to for the Type III settling to complete in the test. Using the test results and considering the transition time between Type III and Type IV settlement, we estimated that the dewatering type settlement should be completed within few days after placement, much shorter than the consolidation settlement. There is approximately 55% volume reduction from the dewatering process.

3.6 Settlements Induced by Marsh Fill. The marsh fill within the deposition areas will induce two types of settlements:

- Settlements within the deposition areas
- Additional settlements at the perimeter levees.

These are described below.

3.6.1 Method of Analyses. The calculations were made in the manner outlined in Section 3.3.1. The computations were performed for the soil conditions at Borings B-3 through B-7.

3.6.2 Settlements within Deposition Areas. The major consideration here is the loading which will occur as the soil grains settle out of suspension in the introduced water. It has been assumed that sediment-laden water will be added periodically until the sediment surface is approximately 0.5 feet below the design long-term levee crests. The applied loading will be the resulting sediment thickness multiplied by the unit weight of the sediment. The latter will be derived from the Column Tests described in the Appendix; the design value was 65 lb./cu.ft. The resulting settlement values are tabulated below

Boring	**Area Settlement (feet) for Elev.[a]**	
	+2.0	**+3.0**
B-3	0.9	1.06
B-4	0.23	0.33
B-5	0.16	0.24
B-6	0.29	0.40
B-7	0.65	0.76
Mean	0.45	0.56

[a]Design top of sediment (feet NAVD)

The values tabulated above are valid for relatively uniformly loaded areas at least 30 feet away from the toes of the levees. In the zones closer to the levees, the settlements can be approximated (if necessary) by interpolating between the values given above and those for additional levee settlements given in Section 3.6.3.

As described in Section 3.5, Type I and Type II settling do not occur at the solids concentration expected from the dredging operation. However, even if they occur, the time to complete the two process will be relatively short as compared to Type III settling process. The next step is dewatering (Type III), during which the unit weight of the sediments change from the buoyant to the total state. Given these complications, a time-rate analysis is only an approximation. However, it is estimated that the settlement rates will be approximately as follows. Upon completion of final filling (1 year estimate), about 40% of the tabulated settlement values will be completed, leaving 60 to 65% to take place after dewatering is complete.

3.6.3 Settlement Effects on Levees. The weight of the new sediments adjacent to the levees will cause additional settlements of these levees. These movements were calculated for the two borings showing the least and most compressible soil conditions along the levees in order to "bound" the movements. They indicated total, long-term centerline adjusted settlements of the levees of 0.1 feet and 0.2 feet. These movements will occur at approximately the rates given for the Depositional Areas.

3.7 Cut/Fill Ratios. Two cases should be considered here. The first is the amount of cut necessary to create a given amount of levee fill. The levee fill is assumed to be placed mechanically (i.e., with draglines or similar equipment), not hydraulically. The general fill will be placed hydraulically, and will therefore have a cut/fill ratio different from that applicable to mechanically placed fill. Both cases are described below.

3.7.1 Levee Fill. Reference is made to the descriptions of the soil conditions along the levees given in Section 2.2, and to the material use recommendations in Section 3.4. Overall, about 2 to 3 feet encountered at 2 out of the 5 boring locations of the cut material will be Peat (Pt), which is not recommended for levee construction. The shrinkage of the more suitable CH and CL soils from pit to levee will depend primarily on transport losses and loss of water content. The former (transport) is best obtained from experienced contractors, but is expected to be on the order of 25%. The water loss shrinkage is estimated as 10% to 20% of the pit volume. Overall, then, preliminary estimate can be based on about 1.5 to 2.0 cubic yards of suitable cut to produce 1.0 cubic yard of levee fill.

3.7.2 Area Fill. It is very difficult to determine the cut/fill ratios for the hydraulically placed marsh fill. As discussed in Section 3.5, sedimentation or settlement occur in stages, thereby the volume of fill changes. A reasonable assumption of the initial fill height is when the density of the fill reaches the end of Type III settling (fast) or beginning of the Type IV settling (slow). The fill soil volume then can be related to the density and cut/fill ratio determined. Based on the column test results, the density at the end of Type III settling is approximately 67.6 pounds per cubic foot, which is about 2/3 of the density of the borrow soil. Therefore the cut/fill ratio of 0.75 can be used. It should be noted that there will always be transport loss (see Section 3.7.1).

APPENDIX

REPORT OF GEOTECHNICAL INVESTIGATION
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ST. TAMMANY PARISH, LOUISIANA

FIELD AND LABORATORY PROCEDURES

The following paragraphs describe the field and laboratory procedures used for this investigation. Soil Boring Logs are included with this appendix. The boring logs and figures in this Appendix provide the field and laboratory data collected.

A.1 FIELD EXPLORATION

Eleven (11) soil borings were drilled for this project to depths of twenty (20) to sixty (60) feet below water or ground surface. These borings were drilled during the period February 3 through February 19, 2006. The approximate locations of the borings are shown on the Boring Plan, Figure 1, which was provided by the LDNR. This drawing provided the Northing and Easting coordinates based on NAD 83. These were converted to latitude and longitude for use in locating in the field with a hand held GPS. The locations were physically located by representatives of STE. The actual GPS coordinates are shown on the logs of borings. Logs of the borings including the lab test results are attached to this Appendix.

A.1.1 Sampling Procedures - Undisturbed Samples. In these cohesive and semi-cohesive soils, relatively undisturbed samples were secured using a three-inch diameter, thin wall steel tube sampler, essentially following ASTM D1587. In this sampling procedure, the borehole is advanced to the desired level, and the tube is lowered to the bottom of the boring. It is then pushed about two feet into the undisturbed soil in one continuous stroke. The sample and tube are retrieved from the borehole and detached from the drill string. The tube is then sealed to minimize disturbance and moisture loss, and protected for transportation to the laboratory.

Upon arrival in the lab, the samples were extruded by a hydraulic piston onto a rigid sample catcher to minimize disturbance. The sample is then visually classified. The classification includes description of soil color, strength estimates, identification of structural conditions (layering, seams, etc.) and variations (organics, oxide inclusions, etc.). A pocket penetrometer strength test is performed.

A.1.2 Sampling Procedures - Standard Penetration Tests. In the less cohesive materials, standard penetration tests were performed; these tests provide a measure of the in situ characteristics of the soil and secure a disturbed sample. In this test, a 2 inch OD, 1.37ID, heavy-walled "split Spoon" sampler is driven into the undisturbed soil at the bottom of the borehole with a drop hammer weighing 140 pounds and having a stroke of 30 inches. It is first seated 6 inches, then driven an additional two, 6-inch increments. The "Penetration Resistance" is the number of such blows required to drive the spoon the final 12 inches. It is recorded on the boring log in the following manner:

4 b/f
2-2-2

where the figures A-B-C indicate the number of blows required for each 6 inch increment.

A.1.3. Soil Classifications. The soil classifications are given on the attached logs. The materials' strength, color, and material type are presented. The material type is based on the primary and secondary constituents (gravel, sand, silt, clay). The letters in parenthesis represent the Unified Soil Classification (ASTM D2487 supplemented by ASTM D2488).

A.1.4 Grouting. Each borehole exceeding 25 feet in depth below mudline was grouted upon completion. After the grout was thoroughly mixed, it was pumped to the bottom of the borehole through the drill stem which was placed to the bottom of the hole. The grout mixture was circulated in the borehole to assure that the drilling fluid had been replaced with grout. After the circulation, the drill stem was withdrawn and grout fluid from the tub was used to replace the volume of the drill stem as it was withdrawn.

A.2 LABORATORY TESTING

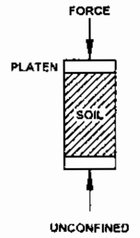
The various types of laboratory testing performed on samples from the boring program are described below. The samples actually tested were selected by the Project Engineer to provide the information necessary for both evaluation of the soils and design.

A.2.1 Classification Testing. These tests were necessary to determine the actual soil types more accurately than can be done by visual/manual methods. For these cohesive soils, only Atterberg Limits Determinations were necessary. These parameters are used in classifying the semi-cohesive and cohesive materials, i.e., SC, ML, CL, CH, OL and OH under ASTM D2487. The actual procedure followed ASTM D4318; it consists of determining the water content corresponding to:

- Liquid Limit (LL) - Where the soil changes behavior from that of a plastic solid to that of a viscous liquid.
- Plastic Limit (PL) - Where the soil changes behavior from that of an elastic (rigid) solid to that of a plastic (deformable) solid.
- Plasticity Index (PI)- The difference between the above limits: PI = LL - PL.

Fifty-seven of these tests were performed on the samples. The results are presented in the appropriate columns of the boring logs.

A.2.2 Strength Testing. The strength test program consisted of unconsolidated undrained (UU) triaxial compression tests and unconfined compression tests. These tests provided data for slope stability analysis/design. In the UU test, a cylindrical sample (typically 3 inches in diameter and 6 inches high) is encased in a rubber membrane and then placed between two solid, flat end pieces ("platens"). Lateral pressure is applied to the sample by air pressure acting against the membrane. Stress is applied parallel to the long axis of the sample by advancing the end platens in a strain-controlled manner. Both the stress and corresponding axial strain are measured. The peak strength is the maximum axial stress measured before the axial strain reaches the commonly accepted value of 10%. These procedures conform essentially to ASTM D2850.

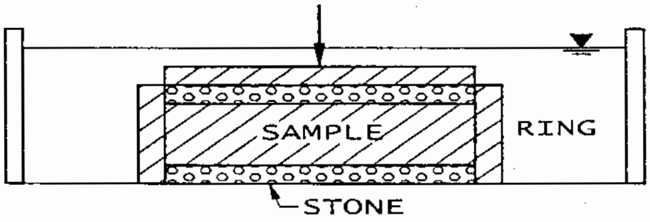


Twenty-four (24) unconfined compression tests and thirty-three (33) unconsolidated-undrained triaxial compression tests were performed on the samples.

The results of these tests are presented in the appropriate columns of the attached boring logs.

A.2.4 Consolidation Testing. These tests provide data on the compressibility and time-rate of settlement characteristics of the natural soils. In this test, a thin (0.8 inch) cylinder of the soil is trimmed into a 2.5 inch diameter, thick-walled ring. The sample and ring are submerged in water, and various one-dimensional vertical loads applied as illustrated in the sketch below.

Each load is maintained until 100% consolidation occurs under that load; the next load is then applied. This procedure conforms essentially to ASTM D2435. The results of the six (6) such tests performed on the samples are presented graphically on Figures 1 through 6 and are summarized on Table 1.



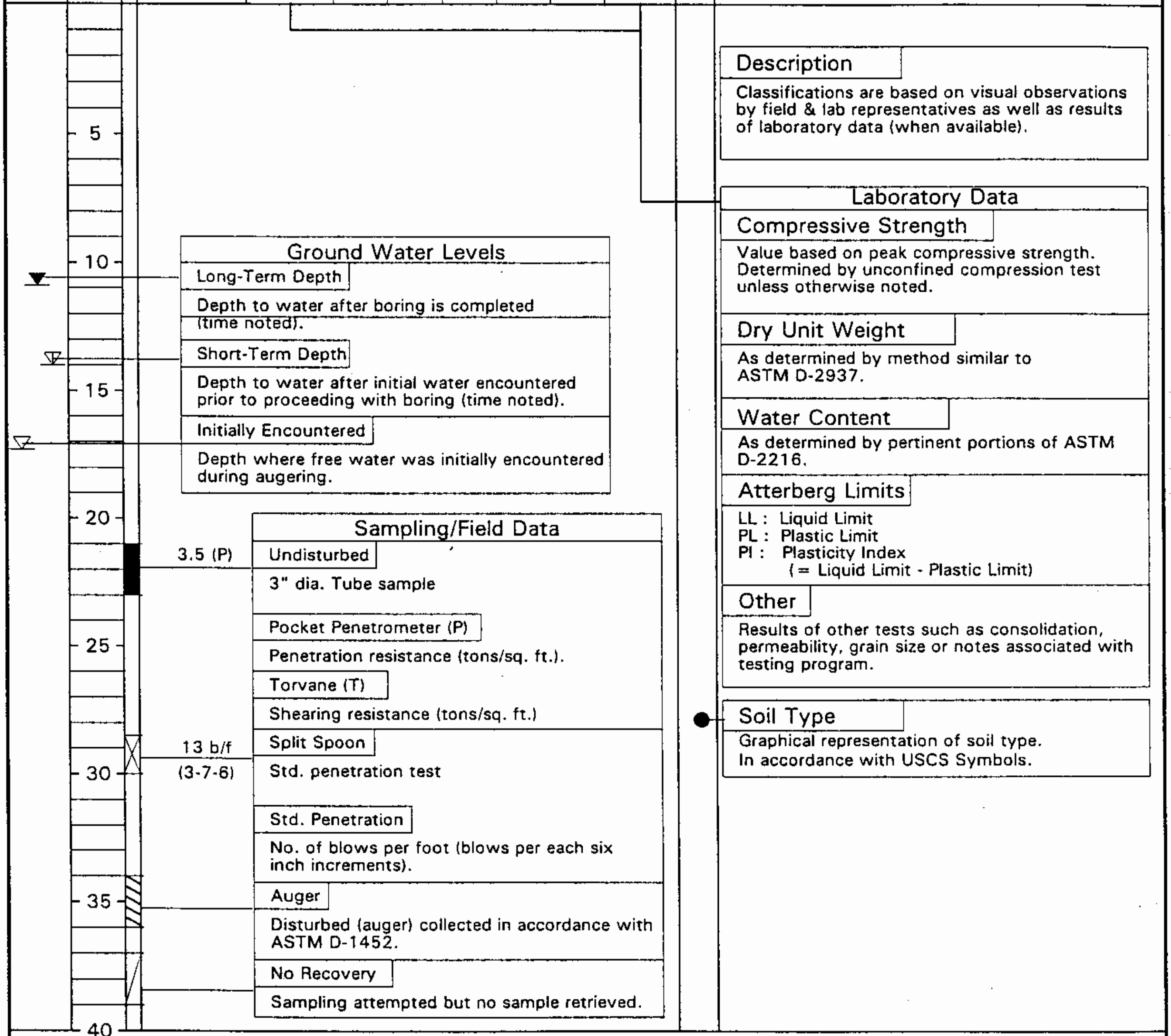
SKETCH A-2 - CONSOLIDATION TESTING

DESCRIPTION OF TERMS AND SYMBOLS USED ON SOIL BORING LOG

STE

Soil Testing Engineers, Inc.

FIELD DATA				LABORATORY DATA								
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	Other	Soil Type	DESCRIPTION



Description

Classifications are based on visual observations by field & lab representatives as well as results of laboratory data (when available).

Laboratory Data

Compressive Strength

Value based on peak compressive strength. Determined by unconfined compression test unless otherwise noted.

Dry Unit Weight

As determined by method similar to ASTM D-2937.

Water Content

As determined by pertinent portions of ASTM D-2216.

Atterberg Limits

LL : Liquid Limit
PL : Plastic Limit
PI : Plasticity Index
(= Liquid Limit - Plastic Limit)

Other

Results of other tests such as consolidation, permeability, grain size or notes associated with testing program.

Soil Type

Graphical representation of soil type. In accordance with USCS Symbols.

Ground Water Levels

Long-Term Depth

Depth to water after boring is completed (time noted).

Short-Term Depth

Depth to water after initial water encountered prior to proceeding with boring (time noted).

Initially Encountered

Depth where free water was initially encountered during augering.

Sampling/Field Data

Undisturbed

3" dia. Tube sample

Pocket Penetrometer (P)

Penetration resistance (tons/sq. ft.).

Torvane (T)

Shearing resistance (tons/sq. ft.)

Split Spoon

Std. penetration test

Std. Penetration

No. of blows per foot (blows per each six inch increments).

Auger

Disturbed (auger) collected in accordance with ASTM D-1452.

No Recovery

Sampling attempted but no sample retrieved.

Ground Water Level Data	Boring Advancement Method	Notes
	Boring Abandonment Method	

Form LOGTERMS

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-1

STE
Soil Testing Engineers, Inc.
Sheet 1 of 1
LELAP Certificate No. 02052

File: 06-1001
Date: 02/17/06
Logged by: M. Machen
Driller: Specialty Environmental
Rig: Jack-Up Barge

Location: Lat. 30° 14' 50.6"
Long. 89° 59' 31.0"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	Other	Soil Type	Description
												WATER
	5											
	10											
												MUDLINE
	15	■	0.0 (P)								▨	Very soft dark gray CLAY (CH) with shells and sand
		■	0.0 (P)	0.04t1	45	68	57	18	39		▨	
		■	0.25 (P)								▨	
	20	■									▨	
		■	0.25 (P)	0.07t2	41	74	49	15	34		▨	
		■	1.25 (P)								▨	Medium gray SANDY CLAY (CL) w/ yellowish tan mottling
	25	■	2.25 (P)	1.05	21	106	38	11	27		▨	Stiff to very stiff greenish gray and tan SANDY CLAY (CL)
		■	4.25 (P)								▨	Medium to stiff gray and tan CLAY (CH) w/ trace of shells
		■	2.75 (P)	0.87	29	92	71	21	50		▨	
	30	■									▨	
		■	4.0 (P)								▨	
		■	1.0 (P)		26	95	50	15	35		▨	- w/ numerous shells, 32 to 34 ft.
												Boring completed at 34 ft.
	35											
	40											

Ground Water Level Data

Boring Advancement Method

4" Dia. Rotary Wash:
0 to 34 feet

Boring Abandonment Method

Notes

t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure
t1=2.1 psi
t2=4.9 psi

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-2

STE
Soil Testing Engineers, Inc.

Sheet 1 of 1

LELAP Certificate No. 02052

File: 06-1001
Date: 02/19/06
Logged by: M. Machen
Driller: Specialty Environmental
Rig: Jack-Up Barge

Location: Lat. 30° 14' 16.0"
Long. 89° 53' 20.1"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
							Atterberg Limits					
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	LL	PL	PI	Other	Soil Type	Description
												WATER
	5											
												MUDLINE
	10	▮	0.25 (P)								▨	Very soft dark gray CLAY (CH) w/ sand and shells
		▮	2.0 (P)	0.14t1	32	94	36	13	23		▨	Soft to very soft light gray SANDY CLAY (CL) w/ shells and organics
	15	▮	2.5 (P)								▨	Stiff to medium gray to light gray CLAY (CH) w/ silt seams
		▮	1.75 (P)	1.17	27	97	66	23	43		▨	
		▮	1.5 (P)								▨	
	20	▮	1.5 (P)	0.83	32	86	71	24	47		▨	- silt layers, 20 to 22 ft.
		▮	1.25 (P)								▨	
	25	▮	1.75 (P)	1.07	38	83	81	25	56		▨	
		▮	2.0 (P)								▨	- trace organic material, 26 to 30 ft.
		▮	2.25 (P)								▨	
	30											Boring completed at 30 ft.
	35											
	40											

Ground Water Level Data	Boring Advancement Method	Notes
	4" Dia. Rotary Wash: 0 to 30 feet	t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure t1=2.1 psi
	Boring Abandonment Method	

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-3

STE
Soil Testing Engineers, Inc.
Sheet 1 of 1
LELAP Certificate No. 02052

File:	06-1001
Date:	02/10/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Airboat

Location: Lat. 30° 16' 26.2"
Long. 89° 58' 41.7"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	Other	Soil Type	Description
												8" WATER
			0.0 (P)									Very soft dark brown PEAT (PT)
			0.0 (P)		201		688	268	420	CS		
	5		0.25 (P)									Loose dark brown SILT (ML) w/ organics
			0.75 (P)									Medium gray and tan SANDY CLAY (CL)
			1.25 (P)	0.66t1	24	100	43	11	32			
	10		1.0 (P)									Medium to stiff light gray and tan CLAY (CH) - w/silt and sand lenses, 10 to 14 ft.
			1.5 (P)									
	15		1.25 (P)	0.94	39	82	69	24	45			- some silty clay seams, 14 to 16 ft.
			1.25 (P)									- slightly slickensided, 16 to 18 ft.
			1.5 (P)									- trace shell and shell fragments, 18 to 20 ft.
	20											
			1.5 (P)									- trace silt laminations, 20 to 22 ft.
			1.25 (P)	1.07	44	77	88	27	61			
	25		1.0 (P)									
			1.25 (P)									
			0.75 (P)	0.81	44	74						- trace shell and shell fragments, 28 to 30 ft.
	30											
			0.75 (P)									- some wood, 30 to 32 ft.
			1.25 (P)									- becomes gray to greenish gray at 32 ft.
	35		1.5 (P)	0.83t2	41	81	58	17	41			- some silt seams and shell fragments, 34 to 40 ft.
			1.5 (P)									
			1.25 (P)									
	40											Boring completed at 40 ft.

Ground Water Level Data

Boring Advancement Method

4" Dia. Rotary Wash:
0 to 40 feet

Boring Abandonment Method

Borehole grouted with cement/
bentonite upon completion

Notes

CS: Consolidation Test
t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure
t1=6.3 psi
t2=24.5 psi

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-4

STE
Soil Testing Engineers, Inc.

Sheet 1 of 2

LELAP Certificate No. 02052

File:	06-1001
Date:	02/15/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Airboat

Location: Lat. 30° 15' 54.6"
Long. 89° 58' 45.2"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
							Atterberg Limits					
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	LL	PL	PI	Other	Soil Type	Description
												WATER
			0.0 (P)									Loose dark brown SILTY SAND (SM) w/ organic material
			0.25 (P)		38					-200a		- w/ sand, 3 to 5 ft.
	5											
			0.5 (P)									Soft to very soft light gray SANDY CLAY (CL) w/ clayey sand lenses
			0.5 (P)	0.14t1	21	105	27	10	17			
	10		1.5 (P)									Medium light gray SILTY CLAY (CL) w/ sand pockets - trace organic material, 9 to 11 ft.
			2.0 (P)	0.82	26	100	36	10	26			
			2.25 (P)	0.40	24	98	54	15	39			Medium to stiff light gray CLAY (CH) - w/ silt seams, 13 to 23 ft.
	15											
			2.5 (P)									
			1.25 (P)									- gray and tan, 17 to 25 ft.
	20		2.0 (P)	1.06	29	89	76	41	35			
			1.75 (P)									
			1.25 (P)									
	25											
			2.25 (P)									
			1.0 (P)	1.33	36	82	84	26	58	CS		
	30		1.0 (P)									
			0.5 (P)									Soft gray SANDY CLAY (CL) w/ shells
			0.5 (P)	0.44	33	88						
	35											
			2.0 (P)									Stiff gray CLAY (CH) w/ silt seams
			1.5 (P)									
	40											Soft to medium gray CLAY (CH)

Continued Next Page

Ground Water Level Data	Boring Advancement Method	Notes
	4" Dia. Rotary Wash: 0 to 61 feet	-200: Percent Passing the #200 Sieve a=39% b=20% t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure t1=4.9 psi CS: Consolidation Test
	Boring Abandonment Method	
	Borehole grouted with cement/ bentonite upon completion	

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-4

STE
Soil Testing Engineers, Inc.
Sheet 2 of 2
LELAP Certificate No. 02052

File:	06-1001
Date:	02/15/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Airboat

Location: Lat. 30° 15' 54.6"
Long. 89° 58' 45.2"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
							Atterberg Limits					
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	LL	PL	PI	Other	Soil Type	Description
			0.75 (P)	0.33	37	83	69	18	51		▨	Soft to medium gray CLAY (CH) - trace shell fragments, 41 to 43 ft.
			0.75 (P)								▨	
			4.0 (P)								▨	Very stiff gray CLAY (CH) w/ trace shell fragments - hard peat layer, 44 to 45 ft.
	45		1.0 (P)	1.03	30	95	45	13	32	CS	▨	Stiff to medium greenish gray SILTY CLAY (CL) w/ sand pockets
			1.5 (P)								▨	
	50		1.25 (P)								▨	
			2.0 (P)	0.87	28	95					▨	Medium bluish to greenish gray CLAY (CH) - w/ shell fragments, 51 to 53 ft. - w/ sand seams and pockets, 53 to 57 ft.
			1.0 (P)								▨	
	55		1.25 (P)								▨	
			1.72 (P)								▨	
	60		1.25 (P)	0.44	24 43	79	67	22	45	-200b	▨	- sand layer, 59 to 60 ft.
												Boring completed at 61 ft.
	65											
	70											
	75											
	80											

Ground Water Level Data	Boring Advancement Method	Notes
	4" Dia. Rotary Wash: 0 to 61 feet	
	Boring Abandonment Method	
	Borehole grouted with cement/ bentonite upon completion	Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-5

STE
Soil Testing Engineers, Inc.

Sheet 1 of 2

LELAP Certificate No. 02052

File:	06-1001
Date:	02/03/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Airboat

Location: Lat. 30° 15' 12.7"
Long. 89° 55' 23.2"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits			Other	Soil Type	
							LL	PL	PI			Description
												WATER
				1.37t1	17	111	17	14	3			Medium gray and tan SILTY SAND (SM) w/ trace organic material
	5											
			0.5 (P)	0.67t2	18	112	18	12	6			
			2.0 (P)									Medium gray CLAYEY SAND (SC) w/ some sandy clay layers
	10		1.75 (P)	0.72t3	20	105	27	14	13			
			0.75 (P)									
			1.5 (P)									
	15											
			0.25 (P)	0.41t4	18	108	20	10	10	CS		
			1.75 (P)									
	20		22 b/f 12-12-10									Medium gray SAND (SP) w/ clay
			70+ b/f 10-20-50@4"		17					-200		Very dense gray fine to medium SAND (SP)
			15 b/f 8-4-11									- w/ clay layers, 23 to 26 ft.
	25		52 b/f 11-20-32									
			94+ b/f 16-44-50@3"									
	30		19 b/f 4-6-13									-clay layers @ 30 ft.
			0.5 (P)	2.02t5	27	99	14	12	2			Dense gray SILTY SAND (SM) w/ clay
			1.0 (P)									Medium to stiff gray to greenish gray CLAY (CH) w/ intermittent silt and sand seams
	35											
			0.5 (P)									
			0.75 (P)	0.85t6	47	72	63	29	34			
	40											

Continued Next Page

Ground Water Level Data

Boring Advancement Method

4" Dia. Rotary Wash:
0 to 61 feet

Boring Abandonment Method

Borehole grouted with cement/
bentonite upon completion

Notes

t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure
t1=0.7 psi, t2=3.5 psi
t3=6.3 psi, t4=10.5 psi
t5=22 psi, t6=24.5 psi
t7=37.1 psi
CS: Consolidation Test
-200: Percent Passing the #200 Sieve = 5%

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-5

STE
Soil Testing Engineers, Inc.
Sheet 2 of 2

LELAP Certificate No. 02052

File:	06-1001
Date:	02/03/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Airboat

Location: Lat. 30° 15' 12.7"
Long. 89° 55' 23.2"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	Other	Soil Type	Description
		█	0.75 (P)								▨	Medium to stiff gray to greenish gray CLAY (CH) w/ intermittent silt and sand seams
		█	0.5 (P)								▨	
		█	1.25 (P)								▨	
	45	█									▨	
		█	3.25 (P)	1.20	36	86	68	22	46		▨	
		█	1.25 (P)								▨	
	50	█	1.5 (P)								▨	- some 1/2" to 3/4" calcareous nodules, 49 to 53 ft.
		█	1.75 (P)								▨	
		█	2.5 (P)	0.31t7	36	85					▒	Loose gray CLAYEY SAND (SC) w/ shell fragments
	55	█										
		█	1.75 (P)								▨	Stiff greenish gray CLAY (CH) w/ some silt - some shell fragments, 55 to 57 ft.
		█	2.0 (P)								▨	
	60	█	2.25 (P)								▨	
												Boring completed at 61 ft.
	65											
	70											
	75											
	80											

Ground Water Level Data	Boring Advancement Method	Notes
	4" Dia. Rotary Wash: 0 to 61 feet	

Boring Abandonment Method

Borehole grouted with cement/ bentonite upon completion

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-6

STE
Soil Testing Engineers, Inc.
Sheet 1 of 1
LELAP Certificate No. 02052

File:	06-1001
Date:	02/07/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Airboat

Location: Lat. 30° 15' 14.0"
Long. 89° 54' 34.0"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	Other	Soil Type	Description
		■	0.25 (P)								▥	2" WATER Very soft dark brown SILT (ML) w/ organics
		■		0.12t1	40	82	25	17	8		▨	Very soft to soft gray VERY SILTY SANDY CLAY (CL-ML)
	5	■	0.5 (P)									
		■	1.5 (P)								▨	Stiff light gray SANDY CLAY (CL)
		■	1.75 (P)								▨	Stiff light gray to light greenish gray CLAY (CH) w/ yellowish brown mottling - trace wood, 8 to 10 ft.
	10	■	1.25 (P)	1.38t2	23	100	50	14	36			
		■	1.5 (P)									
	15	■	1.75 (P)									- some sand seams, 14 to 18 ft.
		■	1.75 (P)									
		■	2.0 (P)									
	20	■	2.25 (P)									
		■	1.75 (P)	0.86t3	38	87					▨	Medium greenish gray CLAY (CH)
	25	■	0.75 (P)									
		■	1.25 (P)	0.49	49	70	87	29	58			
		■	1.0 (P)									
	30	■	0.5 (P)	0.16	50	69						- some silt and sand seams, 30 to 36 ft. - trace shell fragments, 30 to 32 ft.
		■	1.25 (P)									
	35	■	1.0 (P)									
		■	0.75 (P)	0.55t4	35	87	45	18	27		▨	Medium dark greenish gray SILTY CLAY (CL) w/ silt laminations and shell fragments
		■	1.0 (P)								▨	Medium dark greenish gray CLAY (CH)
	40											Boring completed at 40 ft.

Ground Water Level Data

Boring Advancement Method

4" Dia. Rotary Wash:
0 to 40 feet

Boring Abandonment Method

Borehole grouted with cement/ bentonite upon completion

Notes

t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure,
t1=2.1 psi
t2=7.7 psi
t3=16.1 psi
t4=25.9 psi

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING B-7

STE
Soil Testing Engineers, Inc.
Sheet 1 of 1
LELAP Certificate No. 02052

File:	06-1001
Date:	02/06/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Airboat

Location: Lat. 30° 15' 34.2"
Long. 89° 53' 42.7"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
							Atterberg Limits					
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	LL	PL	PI	Other	Soil Type	Description
					600		310	116	194			Very soft dark brown and gray PEAT (PT) w/ clay
			0.25 (P)									Loose dark brown to gray SILT (ML) w/silty clay layers
	5		0.25 (P)	0.23t1	15	86	18	15	3	CS		- w/ silt layers, 4 to 6 ft.
			2.0 (P)									Stiff VERY SANDY CLAY (CL) w/ clayey sand layers
			1.5 (P)	1.41t2	18	111	25	10	15			
	10											
			1.0 (P)									
												Dense to very dense light gray CLAYEY SAND (SC)
	15		76+ b/f 27-26-50@3"		23					-200a		- trace wood @15ft.
			35 b/f 6-15-20									Dense light gray SAND (SP) w/ trace clay layers
			73+ b/f 10-23-50@2"									Very dense to dense light gray SAND (SP) w/ trace clay layers
	20		30-50@4"		21					-200b		
			16-50@2"									
	25		63 b/f 15-23-40									
			43 b/f 9-20-23		21					-200c		
			5 b/f 2-2-3									Soft gray CLAY (CH) w/ trace organic material
	30											
			1.5 (P)	0.28t3	33	86	36	15	21	CS		Soft gray SANDY CLAY (CL) w/ sand pockets
			1.0 (P)									
	35		0.5 (P)									
			1.25 (P)	0.61t4	46	74	46	22	24			Medium gray SILTY CLAY (CL) w/ silt lenses and layers
			0.75 (P)									
	40											Boring completed at 40 ft.

Ground Water Level Data

Boring Advancement Method

4" Dia. Rotary Wash:
0 to 40 feet

Boring Abandonment Method

Borehole grouted with cement/ bentonite upon completion

Notes

CS: Consolidation Test
t: Unconsolidated-Undrained Triaxial Compression, Lateral Pressure
t1=3.5 psi
t2=6.3 psi
t3=21.7 psi
t4=25.9 psi
-200: Percent Passing the #200 Sieve
a=29%
b=4%
c=3%

Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING VC-1

STE
Soil Testing Engineers, Inc.
Sheet 1 of 1
LELAP Certificate No. 02052

File:	06-1001
Date:	02/17/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Jack-Up Barge

Location: Lat. 30° 14' 58.6"
Long. 89° 59' 50.4"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
							Atterberg Limits					
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	LL	PL	PI	Other	Soil Type	Description
												WATER
	5											
	10											MUDLINE
	15	☒	WOH		46		48	15	33		▨	Very soft gray SANDY CLAY (CL) w/ clay layers, shells, and shell fragments
		☒	WOH								▨	
	20	■	0.25 (P)		57		62	15	47		▨	- w/ oyster shells, 19 to 21 ft.
		■	0.25 (P)								▨	
		■	0.25 (P)	0.07t1	33	77	46	14	32		▨	
	25	■	0.75 (P)								▨	Medium greenish gray SILTY CLAY (CL) w/ yellowish tan mottling and trace silt and sand seams
		■	3.0 (P)	0.84	22	104	49	13	36		▨	
	30	■	0.5 (P)								▨	
		■									▒	Loose brown CLAYEY SAND (SC)
		■	1.75 (P)	0.32t2	32	91	38	15	23		▨	Soft gray SILTY CLAY (CL) w/ sand pockets and silt seams
	35											Boring completed at 35 ft.
	40											

Ground Water Level Data	Boring Advancement Method	Notes
	4" Dia. Rotary Wash: 0 to 35 feet	t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure t1=6.3 psi t2=13.3 psi
	Boring Abandonment Method	
		Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING VC-2

S T E
Soil Testing Engineers, Inc.
Sheet 1 of 1
LELAP Certificate No. 02052

File:	06-1001
Date:	02/19/06
Logged by:	M. Machen
Driller:	Specialty Environmental
Rig:	Jack-Up Barge

Location: Lat. 30° 14' 38.6"
Long. 89° 58' 58.5"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
							Atterberg Limits					
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	LL	PL	PI	Other	Soil Type	Description
												WATER
	5											
	10											MUDLINE
		■	0.0 (P)	0.05t1	73	57	40	16	24		▨	Very soft dark gray CLAY (CH)
	15	■	0.25 (P)								▨	- w/ shell fragments, 15 to 17 ft.
		■	0.25 (P)	0.05t2	33	74	83	20	63		▨	- trace of sand, 17 to 19 ft.
	20	■	1.0 (P)								▨	Medium gray SANDY CLAY (CL) w/ clayey sand layers
		■	1.75 (P)								▨	
		■		0.81	22	106	34	11	23		▨	
	25	■									▨	
		■	1.0 (P)								▨	
	30	■	0.5 (P)	0.16t3	22	97	24	13	11		▨	
		■	1.25 (P)								▨	
												Boring completed at 33 ft.
	35											
	40											

Ground Water Level Data	Boring Advancement Method	Notes
	4" Dia. Rotary Wash: 0 to 33 feet	t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure t1=0.7 psi t2=3.5 psi t3=11.9 psi
	Boring Abandonment Method	
		Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING VC-3

STE
Soil Testing Engineers, Inc.
Sheet 1 of 1
LELAP Certificate No. 02052

File: 06-1001
Date: 02/19/06
Logged by: M. Machen
Driller: Specialty Environmental
Rig: Jack-Up Barge

Location: Lat. 30° 14' 14.7"
Long. 89° 53' 46.4"
Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
							Atterberg Limits					
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	LL	PL	PI	Other	Soil Type	Description
												WATER
	5											
	10											MUDLINE
		■	0.0 (P)								▨	Very soft dark gray CLAY (CH) w/ sand and shells
		■	0.25 (P)	0.76t1	26	90	24	24	0		░	Medium dense gray SILTY SAND (SM) w/ clay and shell fragments
	15	■	0.25 (P)								▨	Very soft dark gray to gray CLAY (CH)
		■	0.25 (P)	0.07t2	34	74	58	20	38		▨	- some large shells, 16 to 18 ft.
		■	0.25 (P)								▨	
	20	■									▨	
		■	0.25 (P)	0.05t3	41	74	48	17	31		▨	
		■	0.25 (P)								▨	
	25	■	0.25 (P)	0.08t4	57	66	52	17	35		▨	
		■	0.25 (P)								▨	
		■	2.25 (P)	0.12t5	39	76	61	18	43		▨	
	30											Boring completed at 30 ft.
	35											
	40											

Ground Water Level Data	Boring Advancement Method	Notes
	4" Dia. Rotary Wash: 0 to 30 feet	t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure t1=2.1 psi t2=4.9 psi t3=7.7 psi t4=10.5 psi t5=13.3 psi
	Boring Abandonment Method	
		Strata Boundaries May Not Be Exact

Goose Point/Point Platte (PO-33)
Marsh Creation Project
St. Tammany Parish, Louisiana

G.E.C., Inc.
Baton Rouge, Louisiana

LOG OF SOIL BORING VC-4

STE
Soil Testing Engineers, Inc.
Sheet 1 of 1
LELAP Certificate No. 02052

File: 06-1001
Date: 02/19/06
Logged by: M. Machen
Driller: Specialty Environmental
Rig: Jack-Up Barge

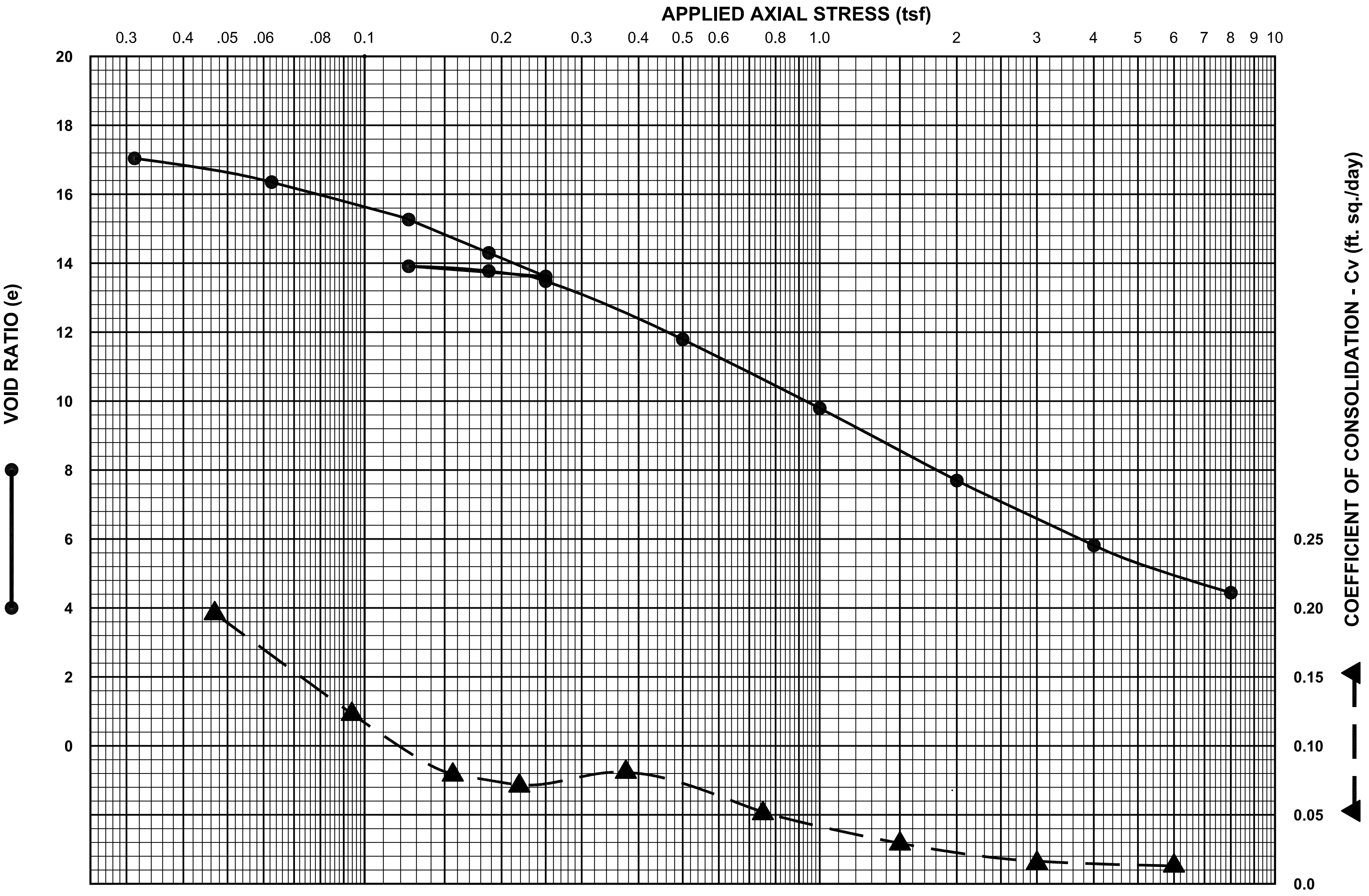
Location: Lat. 30° 14' 18.3"
Long. 89° 52' 47.6"

Surface Elevation: N/A (ft., NGVD)

FIELD DATA				LABORATORY DATA								
Ground Water Level	Depth (feet)	Samples	Field Test Results	Compressive Strength (tsf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	Other	Soil Type	Description
	0–10 5											WATER
	10											MUDLINE
		■									▨	Very soft dark gray CLAY (CH) w/ shells
		■	1.5 (P)		27	96	38	14	24		▨	Medium greensih gray SANDY CLAY (CL)
		■	1.25 (P)								▨	Medium to stiff greenish gray CLAY (CH) with silt seams and brown mottling
	15	■	1.0 (P)	1.33	25	98	53	15	38		▨	
		■	0.75 (P)								▨	
		■	1.0 (P)								▨	
	20	■	0.25 (P)	0.21t1	27	95	44	17	27		▨	Very soft gray and tan SILTY CLAY (CL)
		■	0.5 (P)								▨	
	25	■	0.5 (P)	0.25t2	31	88	33	20	13		▨	
		■	1.75 (P)								▨	Stiff gray and tan CLAY (CH)
		■	1.5 (P)	1.15	45	75	89	28	61		▨	- trace silt seams, 28 to 30 ft.
	30											Boring completed at 30 ft.
	35											
	40											

Ground Water Level Data	Boring Advancement Method	Notes
	4" Dia. Rotary Wash: 0 to 30 feet	t: Unconsolidated-Undrained Triaxial Compression Test, Lateral Pressure t1=7.7 psi t2=10.5 psi
	Boring Abandonment Method	

Strata Boundaries May Not Be Exact



CONSOLIDATION TEST

SAMPLE IDENTIFICATION

BORING NO.: B-3
DEPTH (feet): 2-4
MATERIAL: Dark brown PEAT

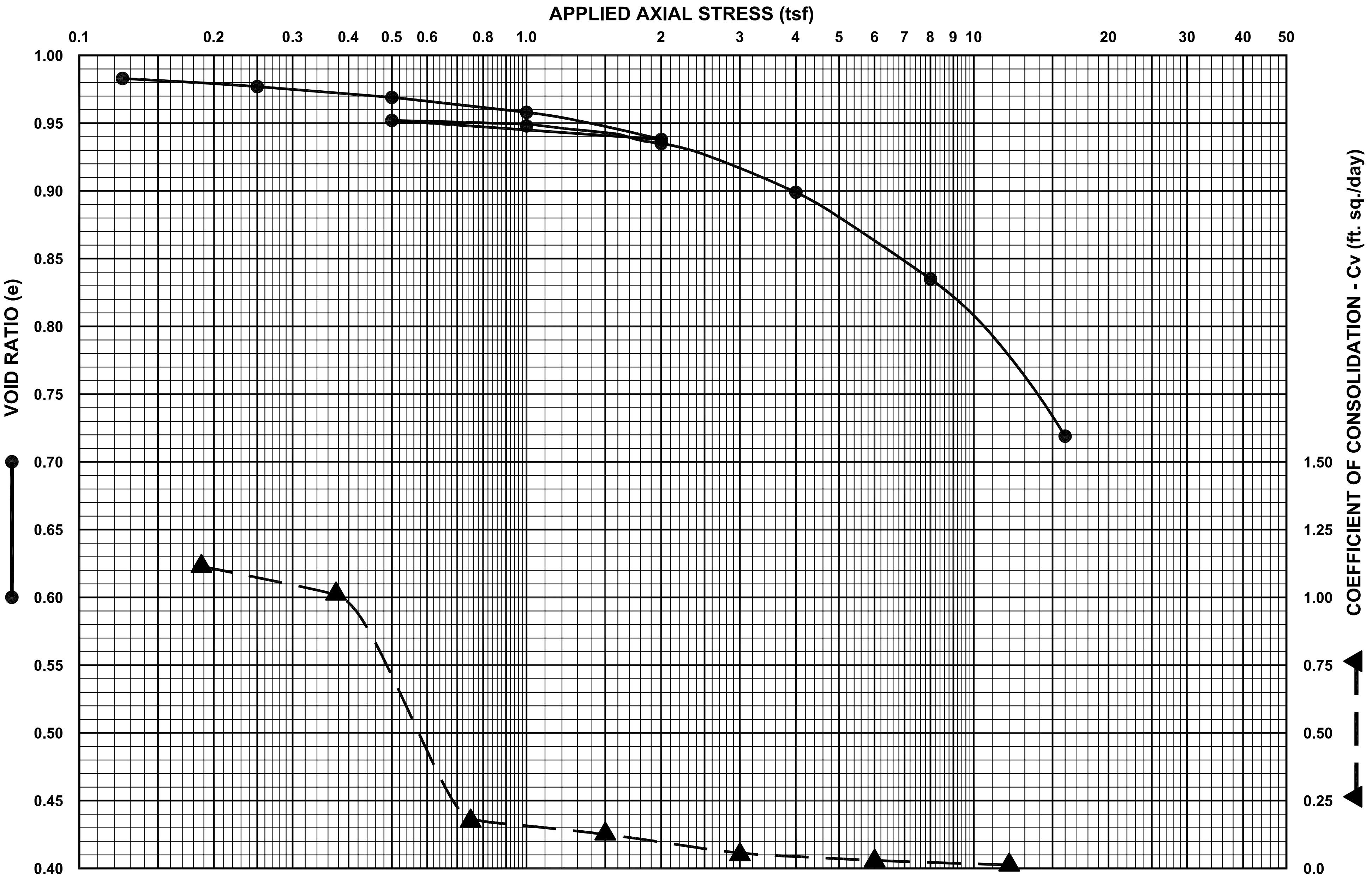
FILE NO.: 06-1001

CLASSIFICATION DATA

INITIAL MOISTURE CONTENT (%) = 725.8 LL = 688
INITIAL DRY DENSITY (lbs./cu.ft.) = 7.5 PL = 268
FINAL MOISTURE CONTENT (%) = 209.6 PI = 420
Eo = 17.631 Gs = 2.25
Assumed

STE
Soil Testing Engineers, Inc.

FIGURE NO.: 1



CONSOLIDATION TEST

SAMPLE IDENTIFICATION

BORING NO.: B-4
DEPTH (feet): 27-29
MATERIAL: Light gray CLAY

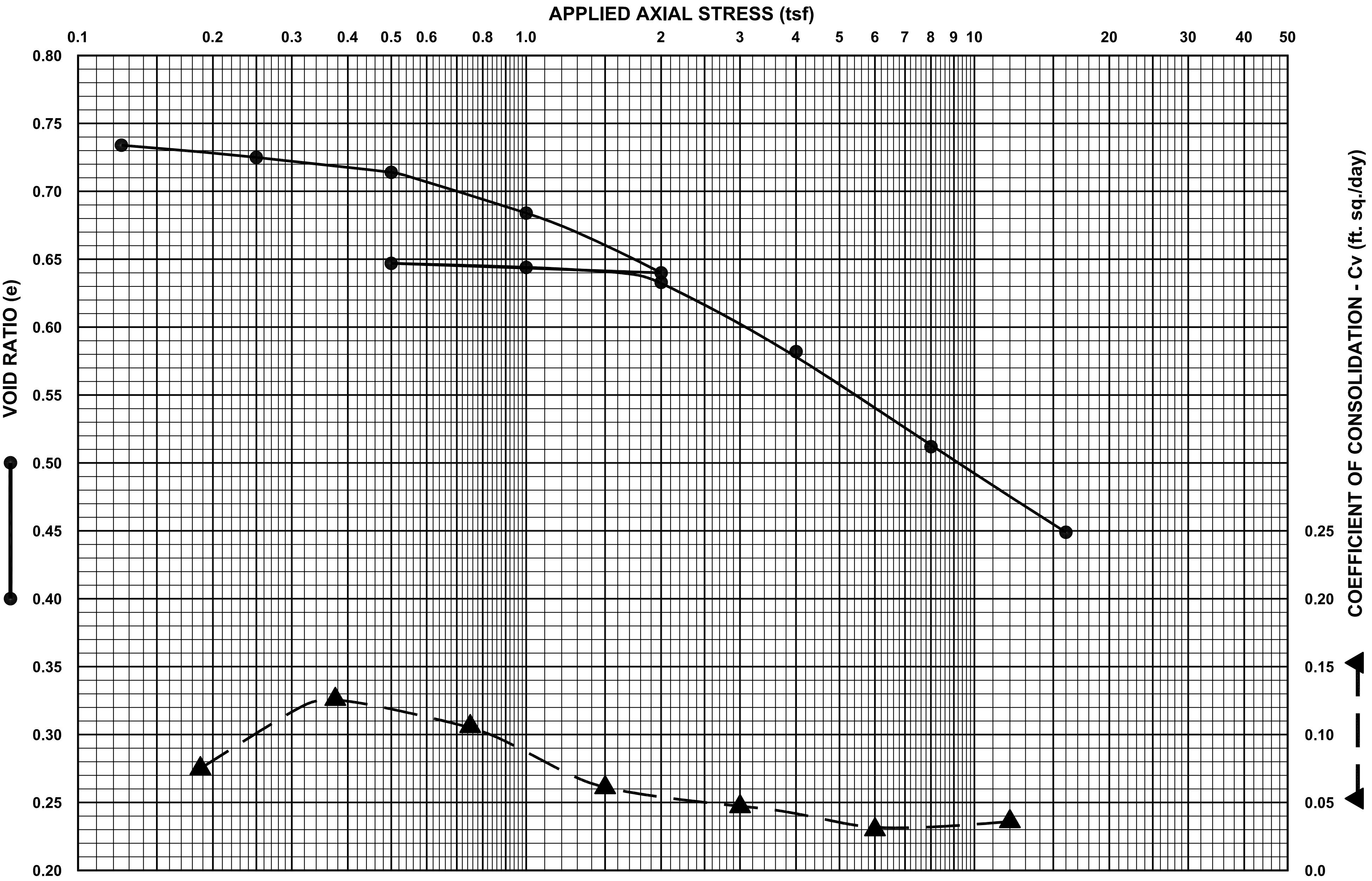
FILE NO.: 06-1001

STE
Soil Testing Engineers, Inc.

CLASSIFICATION DATA

INITIAL MOISTURE CONTENT (%) = 36.2 LL = 84
INITIAL DRY DENSITY (lbs./cu.ft.) = 83.3 PL = 26
FINAL MOISTURE CONTENT (%) = 29.3 PI = 58
Eo = 0.986 Gs = 2.65
Assumed

FIGURE NO.: 2



CONSOLIDATION TEST

SAMPLE IDENTIFICATION

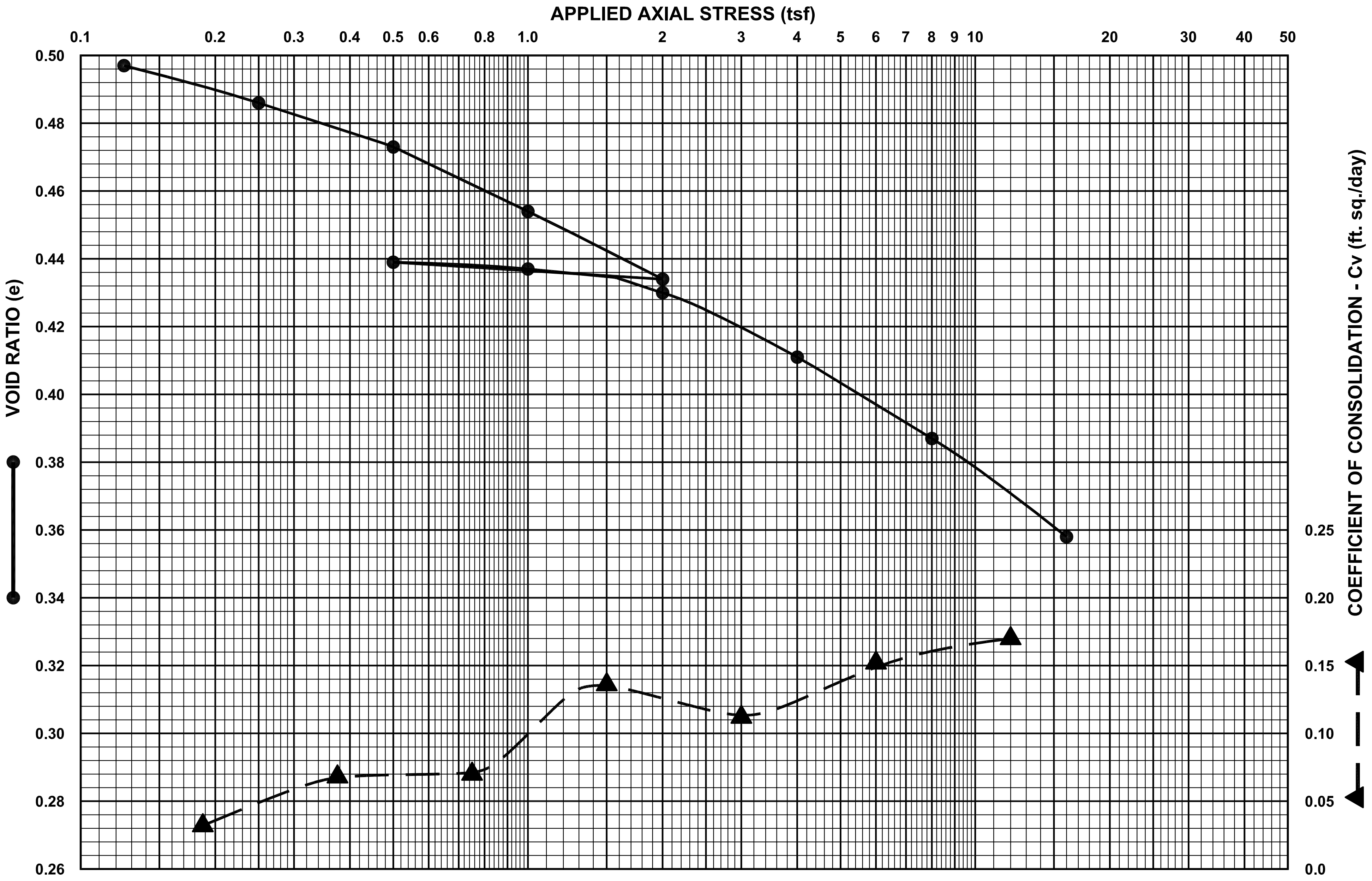
BORING NO.: B-4
DEPTH (feet): 45-47
MATERIAL: Greenish-gray SILTY CLAY w/sand pockets
FILE NO.: 06-1001

STE
Soil Testing Engineers, Inc.

CLASSIFICATION DATA

INITIAL MOISTURE CONTENT (%) = 25.9 **LL = 45**
INITIAL DRY DENSITY (lbs./cu.ft.) = 92.3 **PL = 13**
FINAL MOISTURE CONTENT (%) = 19.2 **PI = 32**
Eo = 0.735 **Gs = 2.65 Assumed**

FIGURE NO.: 3



CONSOLIDATION TEST

SAMPLE IDENTIFICATION

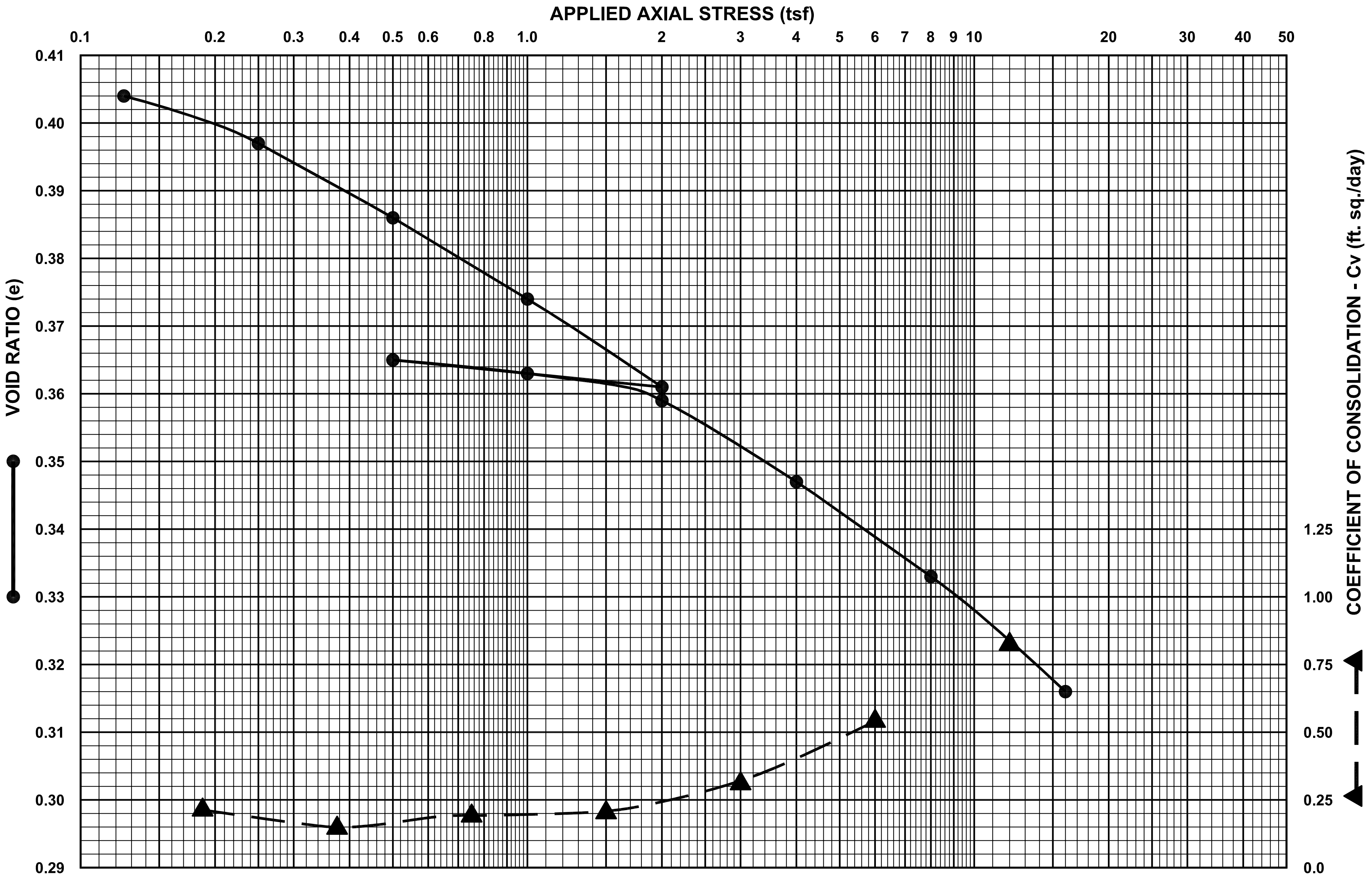
BORING NO.: B-5
DEPTH (feet): 15-17
MATERIAL: Gray CLAYEY SAND
w/sandy clay layers
FILE NO.: 06-1001

STE
Soil Testing Engineers, Inc.

CLASSIFICATION DATA

INITIAL MOISTURE CONTENT (%) = 17.4 LL = 20
INITIAL DRY DENSITY (lbs./cu.ft.) = 108.8 PL = 10
FINAL MOISTURE CONTENT (%) = 14.3 PI = 10
Eo = 0.520 Gs = 2.65
Assumed

FIGURE NO.: 4



CONSOLIDATION TEST

SAMPLE IDENTIFICATION

BORING NO.: B-7
DEPTH (feet): 4-6
MATERIAL: Gray SILT

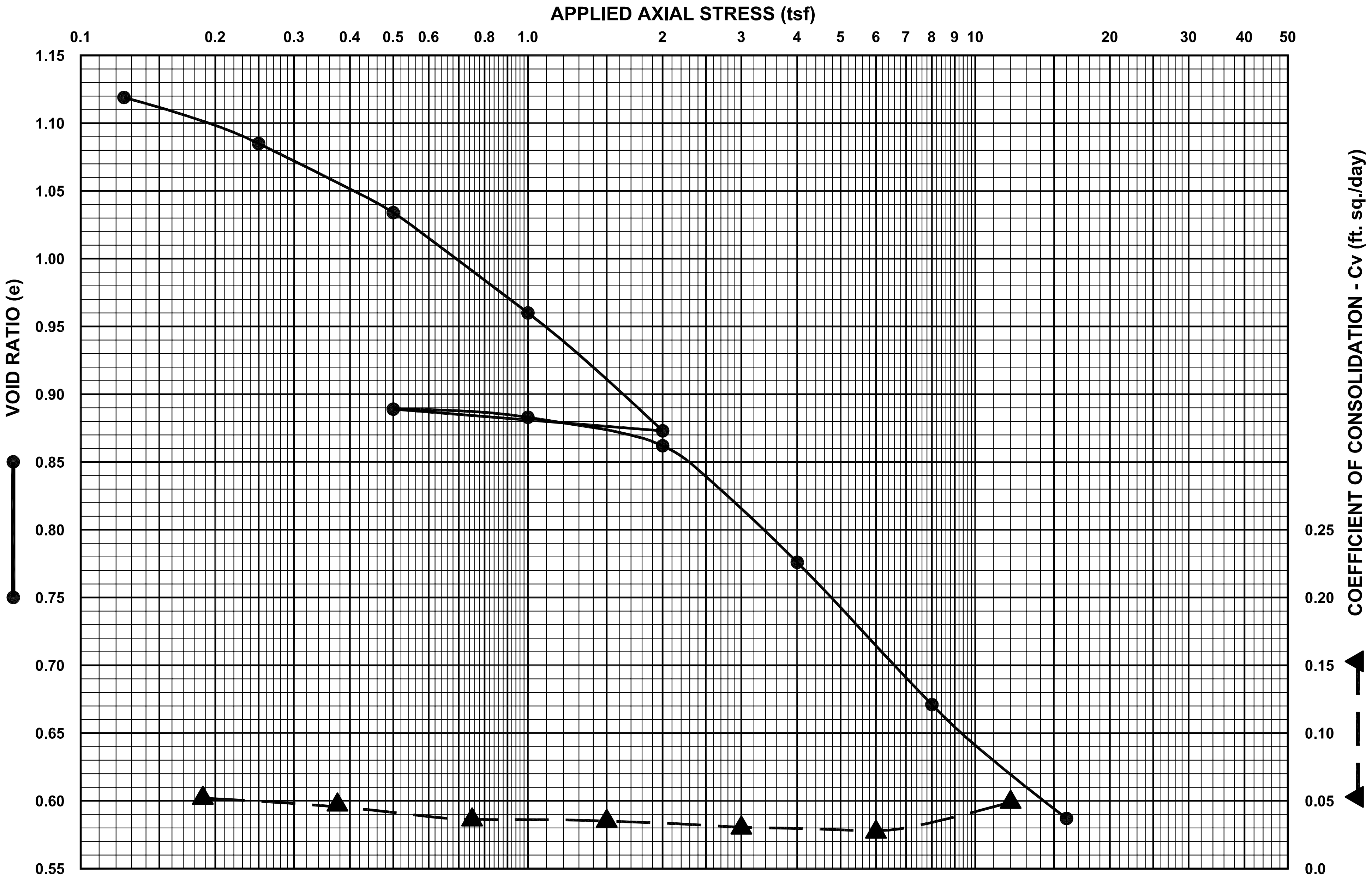
FILE NO.: 06-1001

STE
Soil Testing Engineers, Inc.

CLASSIFICATION DATA

INITIAL MOISTURE CONTENT (%) = 15.1 **LL = 18**
INITIAL DRY DENSITY (lbs./cu.ft.) = 116.8 **PL = 15**
FINAL MOISTURE CONTENT (%) = 12.9 **PI = 3**
Eo = 0.415 **Gs = 2.65**
Assumed

FIGURE NO.: 5



CONSOLIDATION TEST

SAMPLE IDENTIFICATION

BORING NO.: B-7
DEPTH (feet): 30-32
MATERIAL: Gray SANDY CLAY w/sand pockets
FILE NO.: 06-1001

STE
Soil Testing Engineers, Inc.

CLASSIFICATION DATA

INITIAL MOISTURE CONTENT (%) = 44.5 LL = 36
INITIAL DRY DENSITY (lbs./cu.ft.) = 77.4 PL = 15
FINAL MOISTURE CONTENT (%) = 21.9 PI = 21
Eo = 1.137 Gs = 2.65 Assumed

FIGURE NO.: 6

TABLE 1
Consolidation Parameters

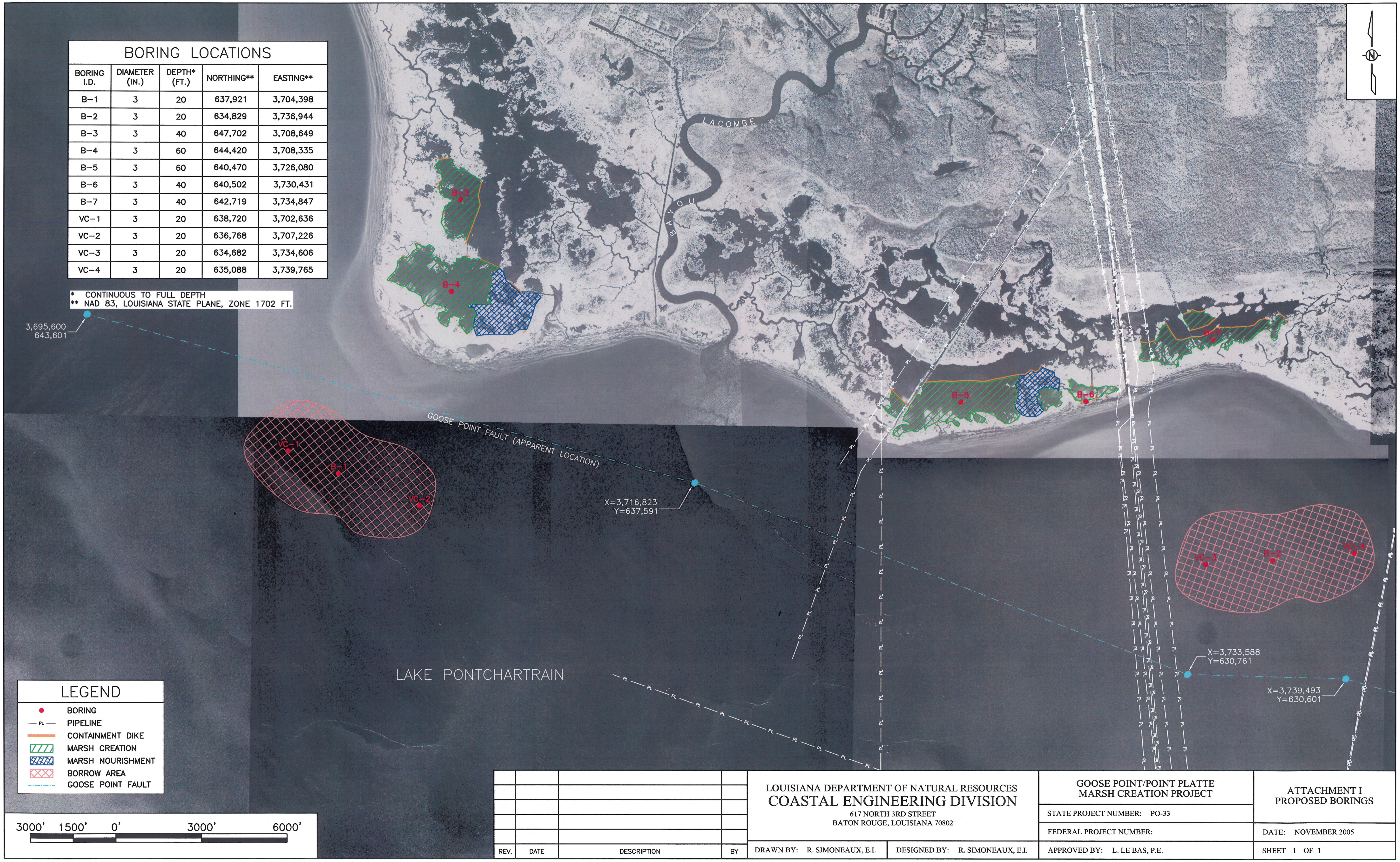
Boring	Depth ft.*	Cc	Pc psf	Initial Void Ratio
B-3	2 to 4	4.56	180	17.6
B-4	27 to 29	0.3	6,000	0.99
B-4	45 to 47	0.22	2,600	0.74
B-5	15 to 17	0.09	2,000	0.52
B-7	4 to 6	0.05	800	0.42
B-7	30 to 32	0.3	1,200	1.14

* Depth from top of water surface at time of drilling.

BORING LOCATIONS

BORING I.D.	DIAMETER (IN.)	DEPTH* (FT.)	NORTHING**	EASTING**
B–1	3	20	637,921	3,704,398
B–2	3	20	634,829	3,736,944
B–3	3	40	647,702	3,708,649
B–4	3	60	644,420	3,708,335
B–5	3	60	640,470	3,726,080
B–6	3	40	640,502	3,730,431
B–7	3	40	642,719	3,734,847
VC–1	3	20	638,720	3,702,636
VC–2	3	20	636,768	3,707,226
VC–3	3	20	634,682	3,734,606
VC–4	3	20	635,088	3,739,765

* CONTINUOUS TO FULL DEPTH
** NAD 83, LOUISIANA STATE PLANE, ZONE 1702 FT.



REV.	DATE	DESCRIPTION	BY

LOUISIANA DEPARTMENT OF NATURAL RESOURCES
COASTAL ENGINEERING DIVISION
617 NORTH 3RD STREET
BATON ROUGE, LOUISIANA 70802

GOOSE POINT/POINT PLATTE
MARSH CREATION PROJECT

STATE PROJECT NUMBER: PO-33

FEDERAL PROJECT NUMBER:

ATTACHMENT I
PROPOSED BORINGS

DATE: NOVEMBER 2005

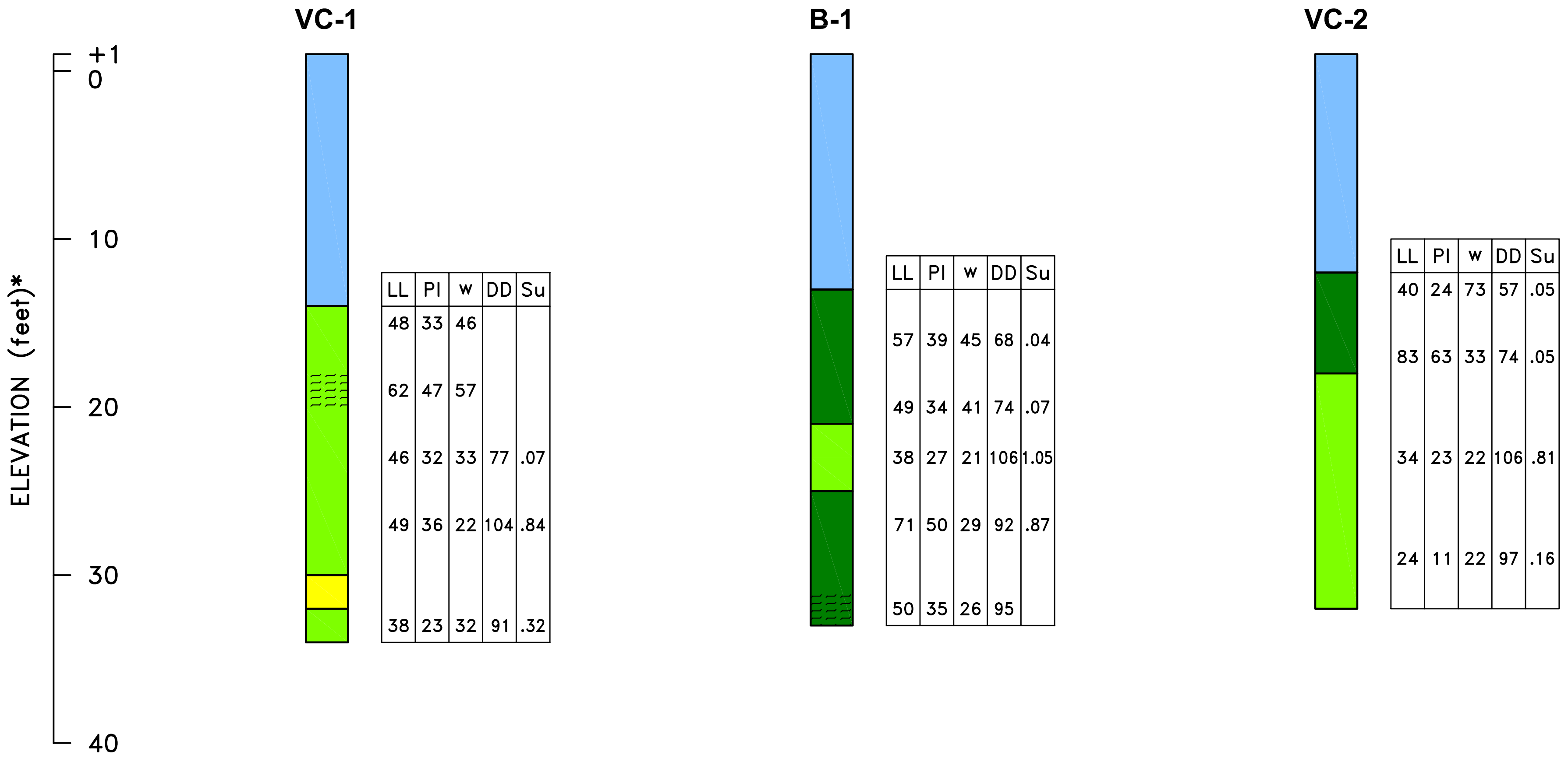
DRAWN BY: R. SIMONEAUX, E.I.

DESIGNED BY: R. SIMONEAUX, E.I.

APPROVED BY: L. LE BAS, P.E.

SHEET 1 OF 1

Apr 20, 2006 - 10:40am



VC-1

LL	PI	w	DD	Su
48	33	46		
62	47	57		
46	32	33	77	.07
49	36	22	104	.84
38	23	32	91	.32

B-1

LL	PI	w	DD	Su
57	39	45	68	.04
49	34	41	74	.07
38	27	21	106	1.05
71	50	29	92	.87
50	35	26	95	

VC-2

LL	PI	w	DD	Su
40	24	73	57	.05
83	63	33	74	.05
34	23	22	106	.81
24	11	22	97	.16

*Water surface assumed to be at Elevation +1.0 NGVD.

LEGEND

LL = LIQUID LIMIT (%)
PI = PLASTICITY INDEX
W = WATER CONTENT (%)
DD = DRY DENSITY (pcf)
SU = UNDRAINED SHEAR STRENGTH (ksf)
(XX) = STD. PENET. RES. (blows/ft.)

SYMBOL	SOIL TYPE
🟦	WATER
⬜	PEAT (PT)
🟩	CLAY (CH)
🟩	SILTY CLAY, SANDY CLAY (CL)
🟧	SILT, CLAYEY SILT (ML)
🟨	SAND, SILTY SAND, CLAYEY SAND (SP,SM,SC)
▤	SHELLS

NOTE:
See Soil Boring Logs for detailed description.

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GOOSE POINT/POINT PLATTE
(PO-33)
MARSH CREATION PROJECT
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer:	Drawn by:	Checked by:
K. Spampneto	DMS	
File No.: 06–1001	Date: 4–12–06	Figure No.: 7

Title:
SOIL PROFILE - BORROW AREA

Apr 20, 2006 - 10:42am

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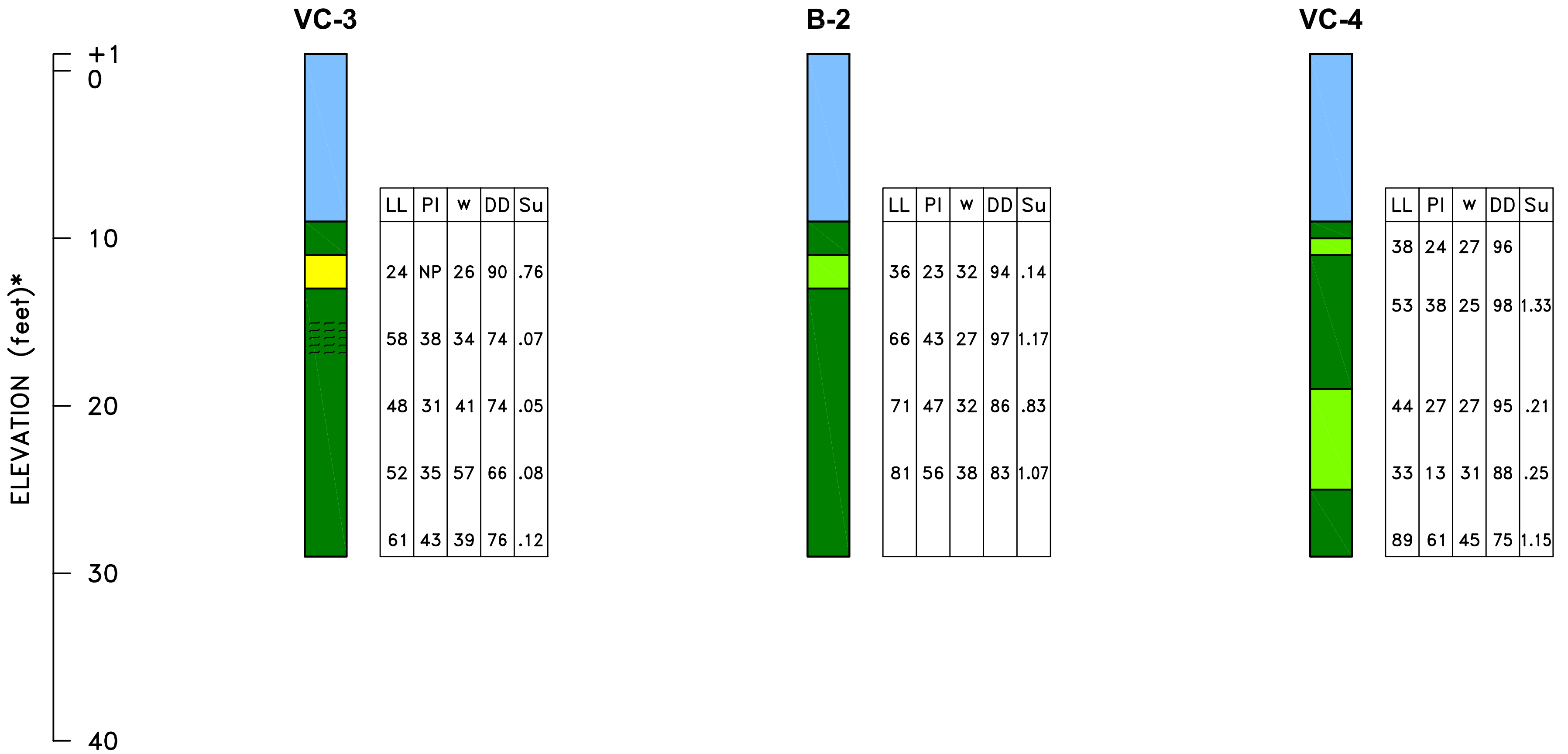

VC-3

LL	PI	w	DD	Su
24	NP	26	90	.76
58	38	34	74	.07
48	31	41	74	.05
52	35	57	66	.08
61	43	39	76	.12

B-2

LL	PI	w	DD	Su
36	23	32	94	.14
66	43	27	97	1.17
71	47	32	86	.83
81	56	38	83	1.07

VC-4

LL	PI	w	DD	Su
38	24	27	96	
53	38	25	98	1.33
44	27	27	95	.21
33	13	31	88	.25
89	61	45	75	1.15

*Water surface assumed to be at Elevation +1.0 NGVD.

LEGEND

LL = LIQUID LIMIT (%)
PI = PLASTICITY INDEX
W = WATER CONTENT (%)
DD = DRY DENSITY (pcf)
SU = UNDRAINED SHEAR STRENGTH (ksf)
(XX) = STD. PENET. RES. (blows/ft.)

SYMBOL	SOIL TYPE
🟦	WATER
⬜	PEAT (PT)
🟩	CLAY (CH)
🟩	SILTY CLAY, SANDY CLAY (CL)
🟧	SILT, CLAYEY SILT (ML)
🟨	SAND, SILTY SAND, CLAYEY SAND (SP,SM,SC)
▤	SHELLS

NOTE:
See Soil Boring Logs for detailed description.

GOOSE POINT/POINT PLATTE
(PO-33)
MARSH CREATION PROJECT
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06–1001	Date: 4–12–06	Figure No.: 8

Title:
SOIL PROFILE - BORROW AREA

Apr 20, 2006 - 10:37am

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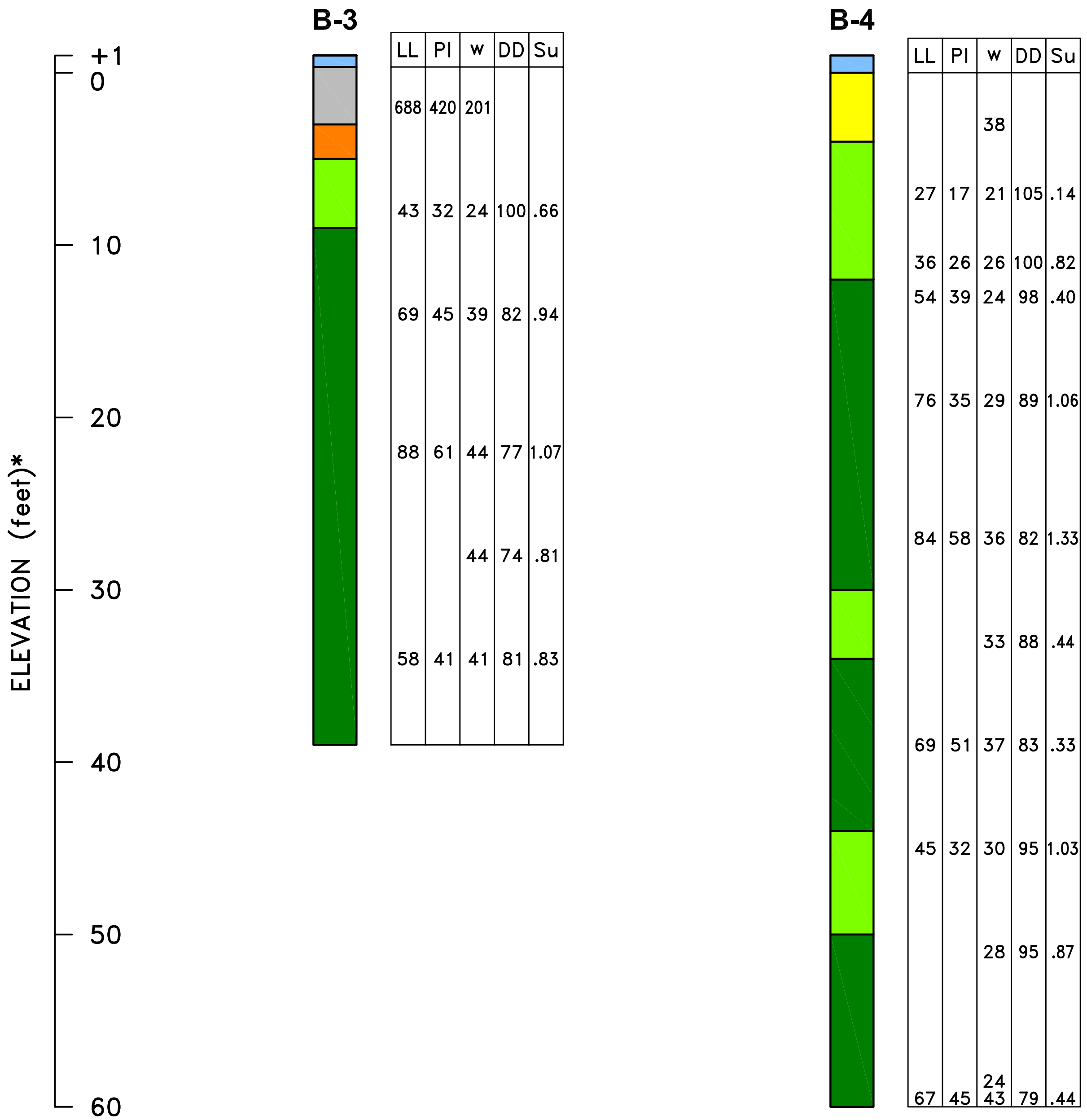


B-3

LL	PI	w	DD	Su
688	420	201		
43	32	24	100	.66
69	45	39	82	.94
88	61	44	77	1.07
		44	74	.81
58	41	41	81	.83

B-4

LL	PI	w	DD	Su
		38		
27	17	21	105	.14
36	26	26	100	.82
54	39	24	98	.40
76	35	29	89	1.06
84	58	36	82	1.33
		33	88	.44
69	51	37	83	.33
45	32	30	95	1.03
		28	95	.87
67	45	24 43	79	.44

*Water or marsh surface assumed to be at Elevation +1.0 NGVD.

LEGEND

LL = LIQUID LIMIT (%)
PI = PLASTICITY INDEX
W = WATER CONTENT (%)
DD = DRY DENSITY (pcf)
SU = UNDRAINED SHEAR STRENGTH (ksf)
(XX) = STD. PENET. RES. (blows/ft.)

SYMBOL	SOIL TYPE
🟦	WATER
▒	PEAT (PT)
🟩	CLAY (CH)
🟩	SILTY CLAY, SANDY CLAY (CL)
🟧	SILT, CLAYEY SILT (ML)
🟨	SAND, SILTY SAND, CLAYEY SAND (SP,SM,SC)
▤	SHELLS

NOTE:
See Soil Boring Logs for detailed description.

GOOSE POINT/POINT PLATTE
(PO-33)
MARSH CREATION PROJECT
ST. TAMMANY PARISH, LOUISIANA

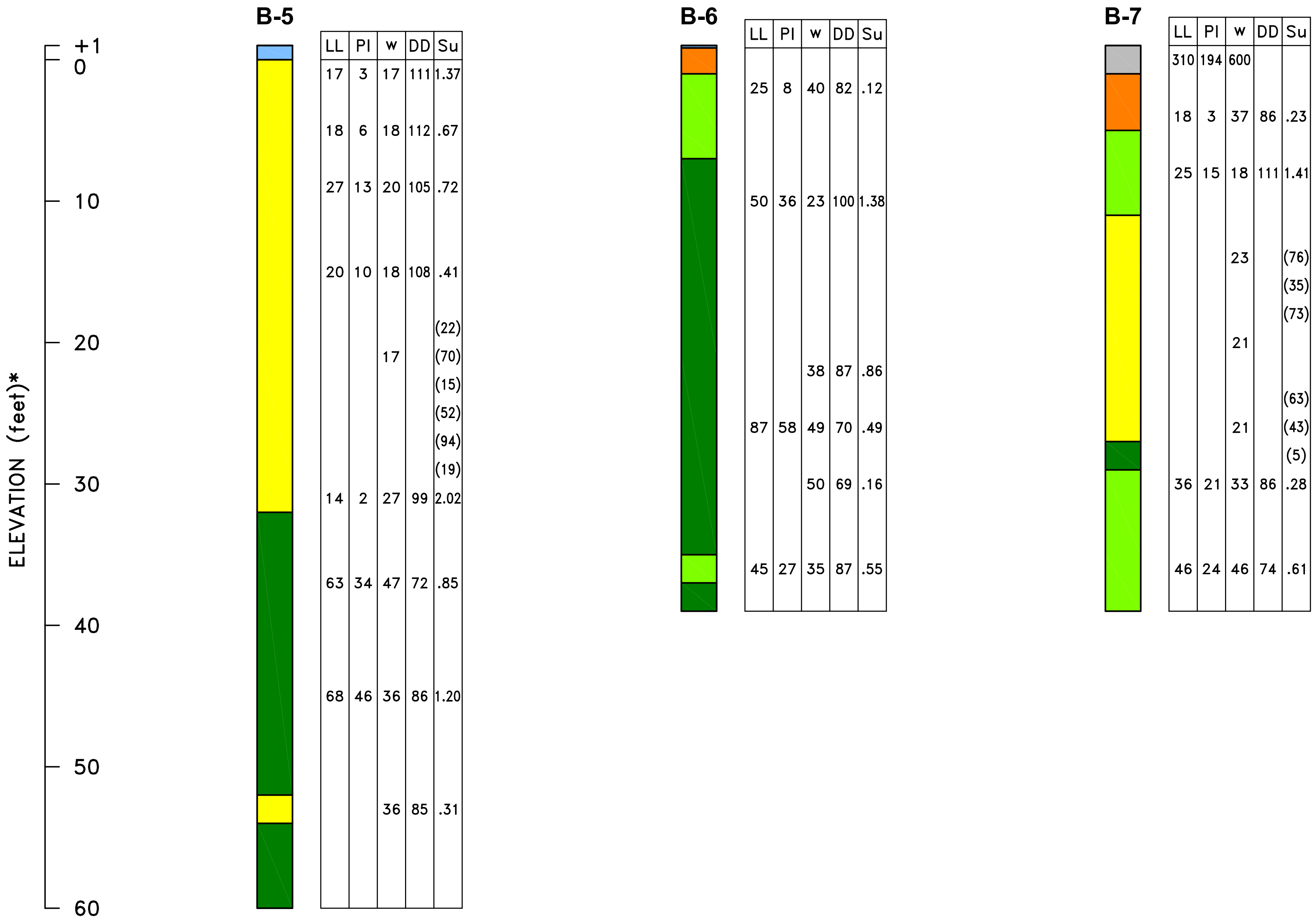
for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer:	Drawn by:	Checked by:
K. Spampneto	DMS	
File No.: 06–1001	Date: 4–12–06	Figure No.: 9

Title:
SOIL PROFILE - MARSH FILL

Apr 20, 2006 - 10:45am



B-5

LL	PI	w	DD	Su
17	3	17	111	1.37
18	6	18	112	.67
27	13	20	105	.72
20	10	18	108	.41
				(22)
		17		(70)
				(15)
				(52)
				(94)
				(19)
14	2	27	99	2.02
63	34	47	72	.85
68	46	36	86	1.20
		36	85	.31

B-6

LL	PI	w	DD	Su
25	8	40	82	.12
50	36	23	100	1.38
		38	87	.86
87	58	49	70	.49
		50	69	.16
45	27	35	87	.55

B-7

LL	PI	w	DD	Su
310	194	600		
18	3	37	86	.23
25	15	18	111	1.41
		23		(76)
				(35)
				(73)
		21		
				(63)
		21		(43)
				(5)
36	21	33	86	.28
46	24	46	74	.61

*Water or marsh surface assumed to be at Elevation +1.0 NGVD.

LEGEND

LL = LIQUID LIMIT (%)
PI = PLASTICITY INDEX
W = WATER CONTENT (%)
DD = DRY DENSITY (pcf)
SU = UNDRAINED SHEAR STRENGTH (ksf)
(XX) = STD. PENET. RES. (blows/ft.)

SYMBOL	SOIL TYPE
🟦	WATER
⬜	PEAT (PT)
■	CLAY (CH)
🟩	SILTY CLAY, SANDY CLAY (CL)
🟧	SILT, CLAYEY SILT (ML)
🟨	SAND, SILTY SAND, CLAYEY SAND (SP,SM,SC)
▤	SHELLS

NOTE:
See Soil Boring Logs for detailed description.

GOOSE POINT/POINT PLATTE
(PO-33)
MARSH CREATION PROJECT
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

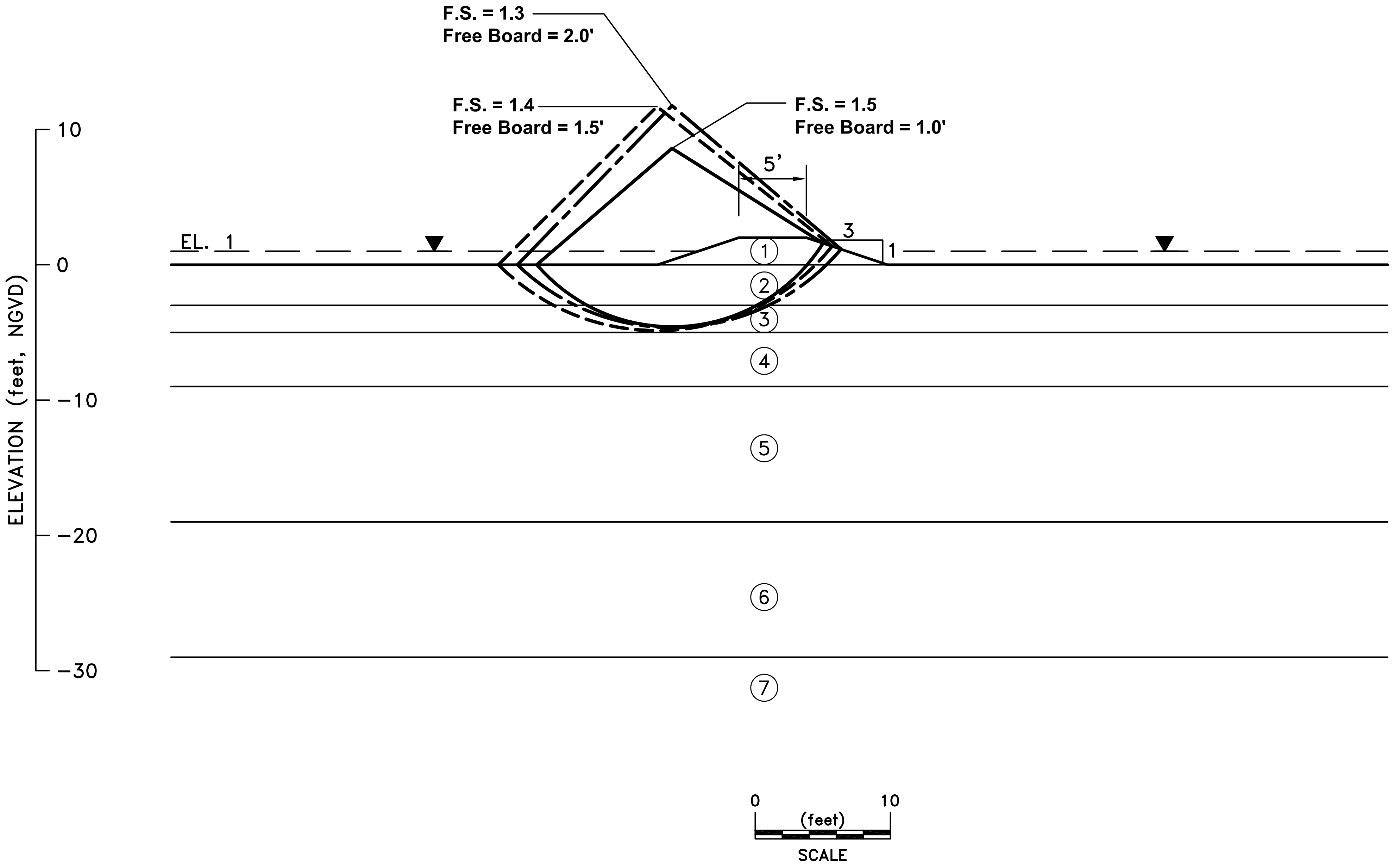
Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06-1001	Date: 4-12-06	Figure No.: 10

Title:
SOIL PROFILE - MARSH FILL

P:\2006\06-1001\cadd\061001 PROFILE B05 B06 B07.dwg

Apr 20, 2006 - 11:03am

P:\2006\06-1001\cadd\061001-11 B-3 1 to 3 Slope Stability.dwg



SOIL PARAMETERS (BORING B−3)			
LAYER	UNIT WEIGHT (pcf)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	105	200	0
2	70	50	0
3	110	0	22
4	124	660	0
5	114	940	0
6	111	1000	0
7	114	830	0

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION

ST. TAMMANY PARISH, LOUISIANA

for

GEC, INC.

BATON ROUGE, LOUISIANA

STE

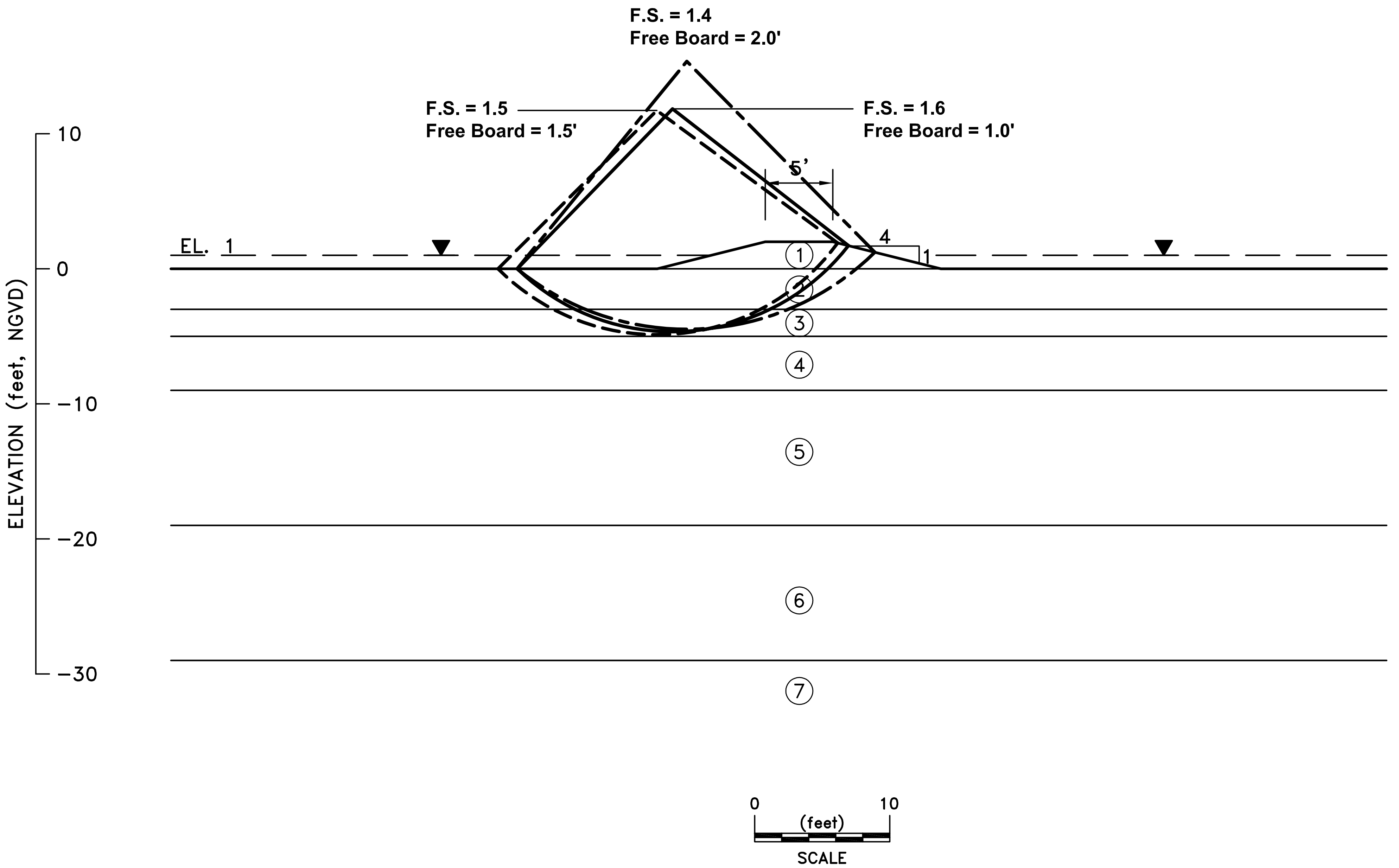
Soil Testing Engineers, Inc.

Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer:	Drawn by:	Checked by:
K. Spampneto	DMS	
File No.: 06−1001	Date: 4−17−06	Figure No.: **11**

Title: **SLOPE STABILITY ANALYSIS CONTAINMENT BERM**

Apr 20, 2006 – 11:05am



SOIL PARAMETERS (BORING B–3)			
LAYER	UNIT WEIGHT (pcf)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	105	200	0
2	70	50	0
3	110	0	22
4	124	660	0
5	114	940	0
6	111	1000	0
7	114	830	0

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION

ST. TAMMANY PARISH, LOUISIANA

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GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

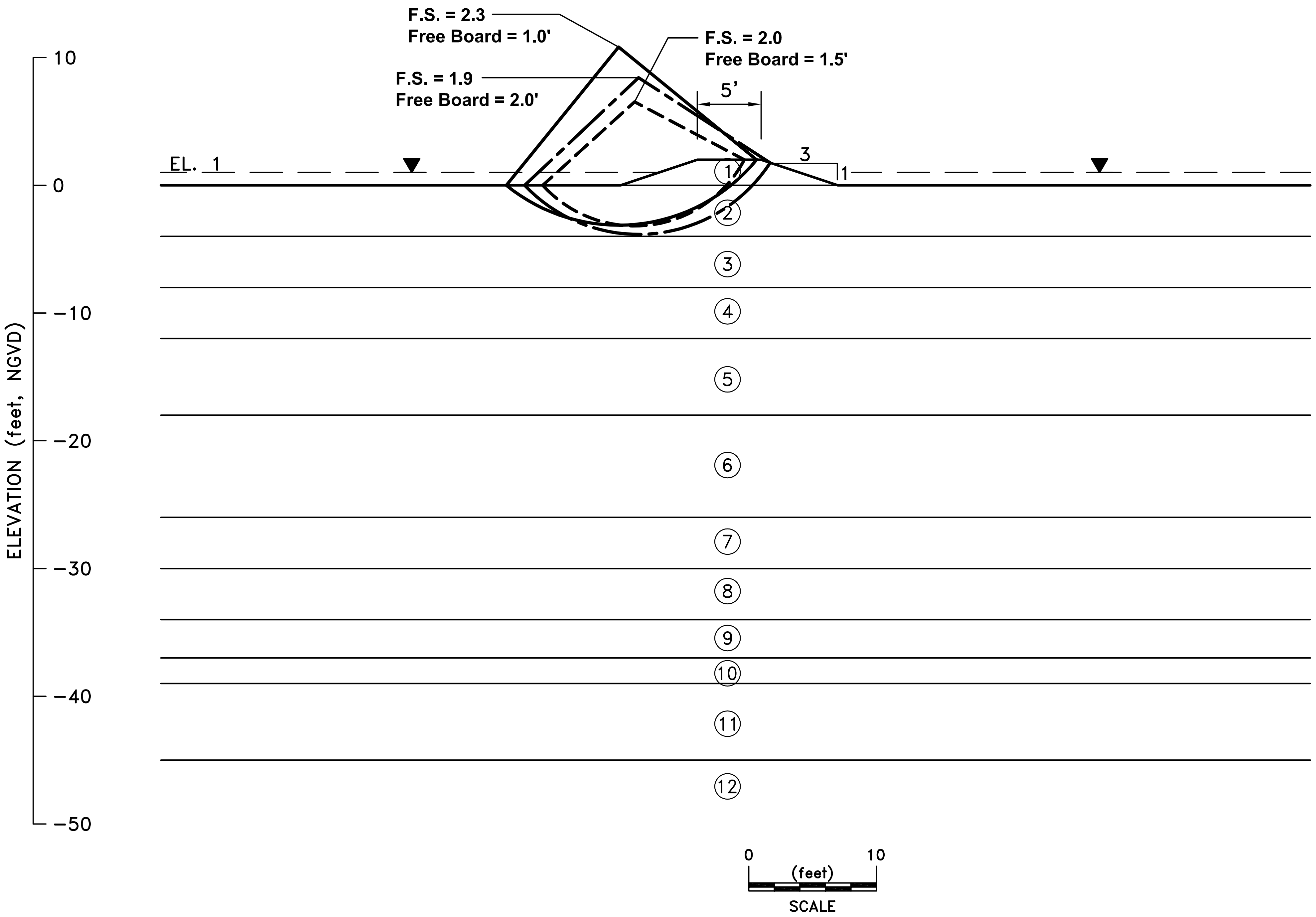
Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06–1001	Date: 4–17–06	Figure No.: **12**

Title: **SLOPE STABILITY ANALYSIS CONTAINMENT BERM**

P:\2006\06–1001\cadd\061001–12 B–3 1 to 4 Slope Stability.dwg

Apr 20, 2006 - 11:06am

P:\2006\06-1001\cadd\061001-13 B-4 1 to 3 Slope Stability.dwg



SOIL PARAMETERS (BORING B−4)			
LAYER	UNIT WEIGHT (pcf)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	105	200	0
2	110	0	24
3	127	140	0
4	126	820	0
5	121	400	0
6	115	1060	0
7	117	440	0
8	120	750	0
9	114	330	0
10	125	1500	0
11	124	1030	0
12	122	655	0

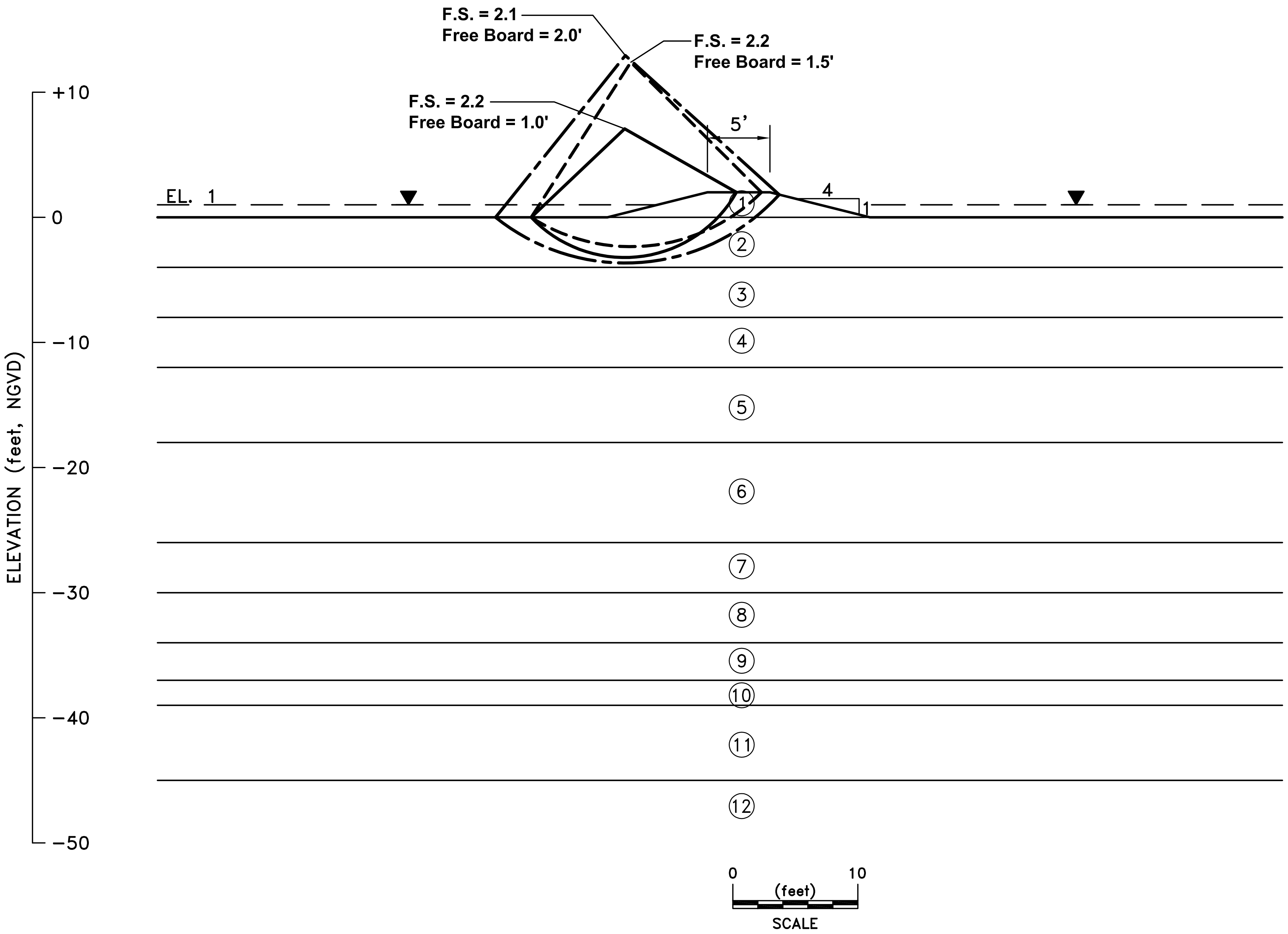
GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer:	Drawn by:	Checked by:
K. Spampneto	DMS	
File No.:	Date:	Figure No.:
06−1001	4−17−06	13

Title: **SLOPE STABILITY ANALYSIS CONTAINMENT BERM**



SOIL PARAMETERS (BORING B−4)			
LAYER	UNIT WEIGHT (pcf)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	105	200	0
2	110	0	24
3	127	140	0
4	126	820	0
5	121	400	0
6	115	1060	0
7	117	440	0
8	120	750	0
9	114	330	0
10	125	1500	0
11	124	1030	0
12	122	655	0

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION

ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

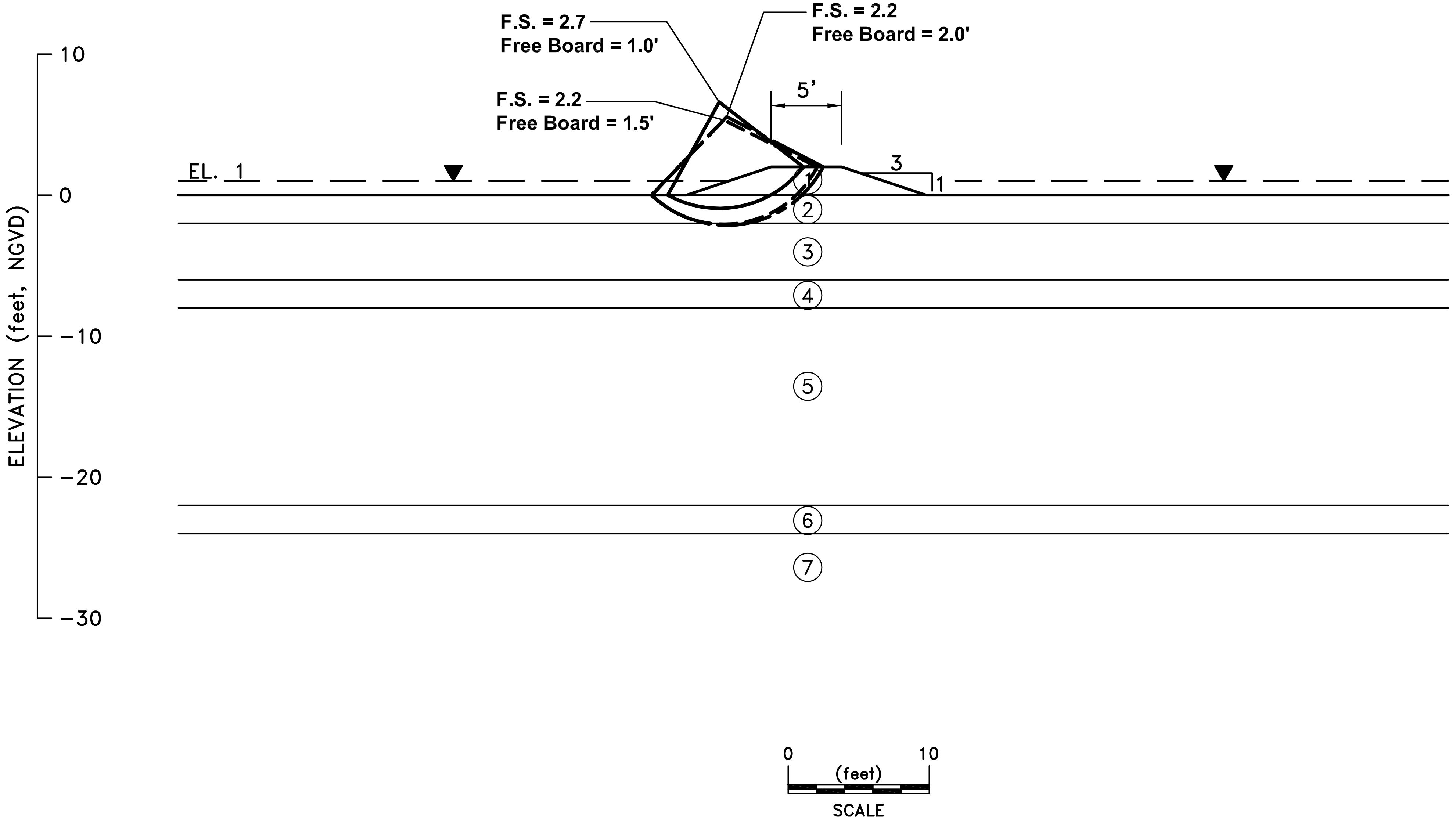
Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06−1001	Date: 4−17−06	Figure No.: 14

Title: **SLOPE STABILITY ANALYSIS CONTAINMENT BERM**

Apr 20, 2006 − 11:07am

P:\2006\06−1001\cadd\061001−14 B−4 1 to 4 Slope Stability.dwg

Apr 20, 2006 - 11:08am



SOIL PARAMETERS (BORING B-6)			
LAYER	UNIT WEIGHT (pcf)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	105	200	0
2	110	0	22
3	115	120	0
4	124	700	0
5	123	1380	0
6	120	860	0
7	104	500	0

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION

ST. TAMMANY PARISH, LOUISIANA

for

GEC, INC.

BATON ROUGE, LOUISIANA

STE

Soil Testing Engineers, Inc.

Baton Rouge, LA Jefferson, LA Biloxi, MS

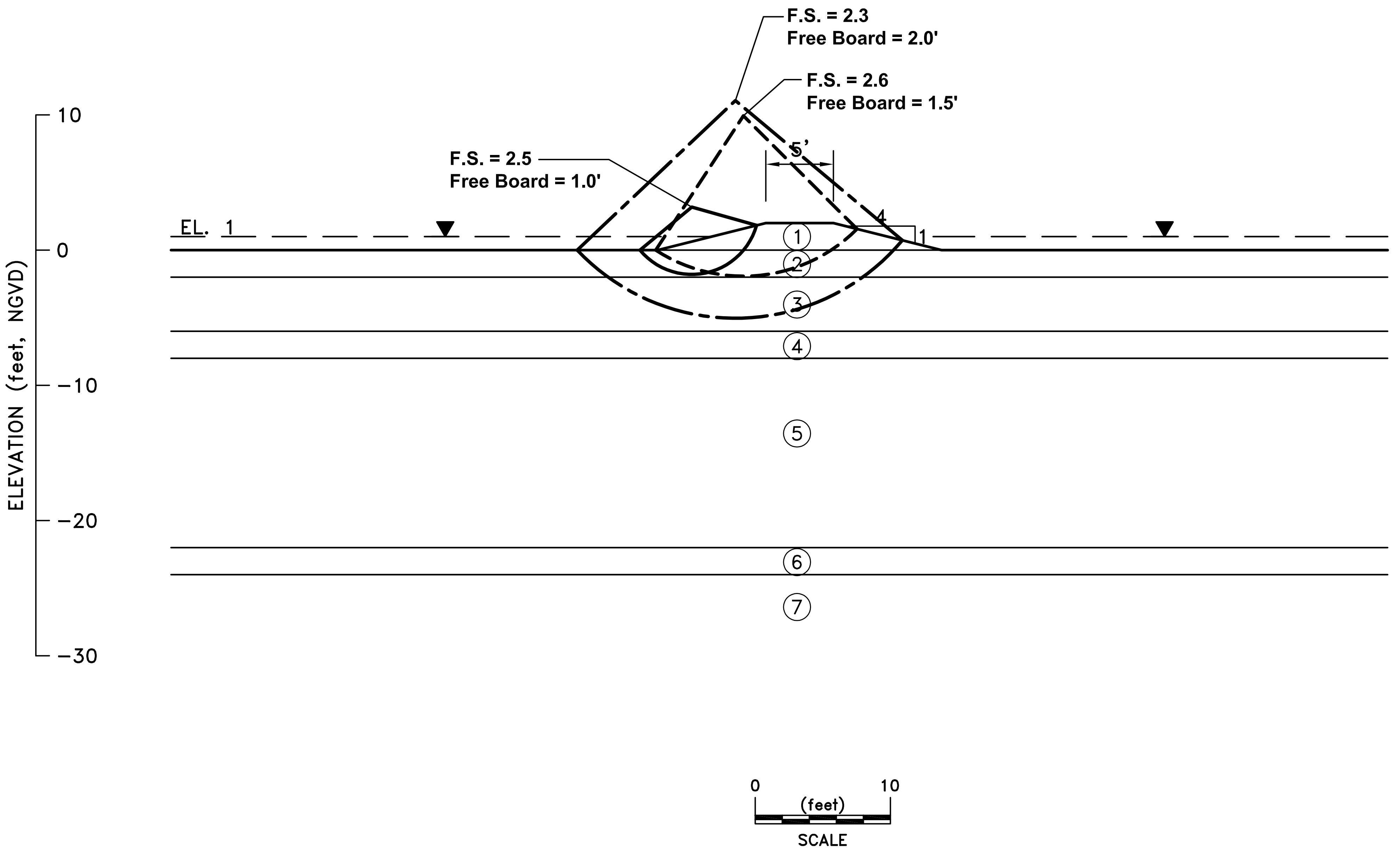
Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06-1001	Date: 4-17-06	Figure No.: **15**

Title: **SLOPE STABILITY ANALYSIS CONTAINMENT BERM**

P:\2006\06-1001\cadd\061001-15 B-6 1 to 3 Slope Stability.dwg

Apr 20, 2006 - 11:09am

P:\2006\06-1001\cadd\061001-16 B-6 1 to 4 Slope Stability.dwg



SOIL PARAMETERS (BORING B-6)			
LAYER	UNIT WEIGHT (pcf)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	105	200	0
2	110	0	22
3	115	120	0
4	124	700	0
5	123	1380	0
6	120	860	0
7	104	500	0

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

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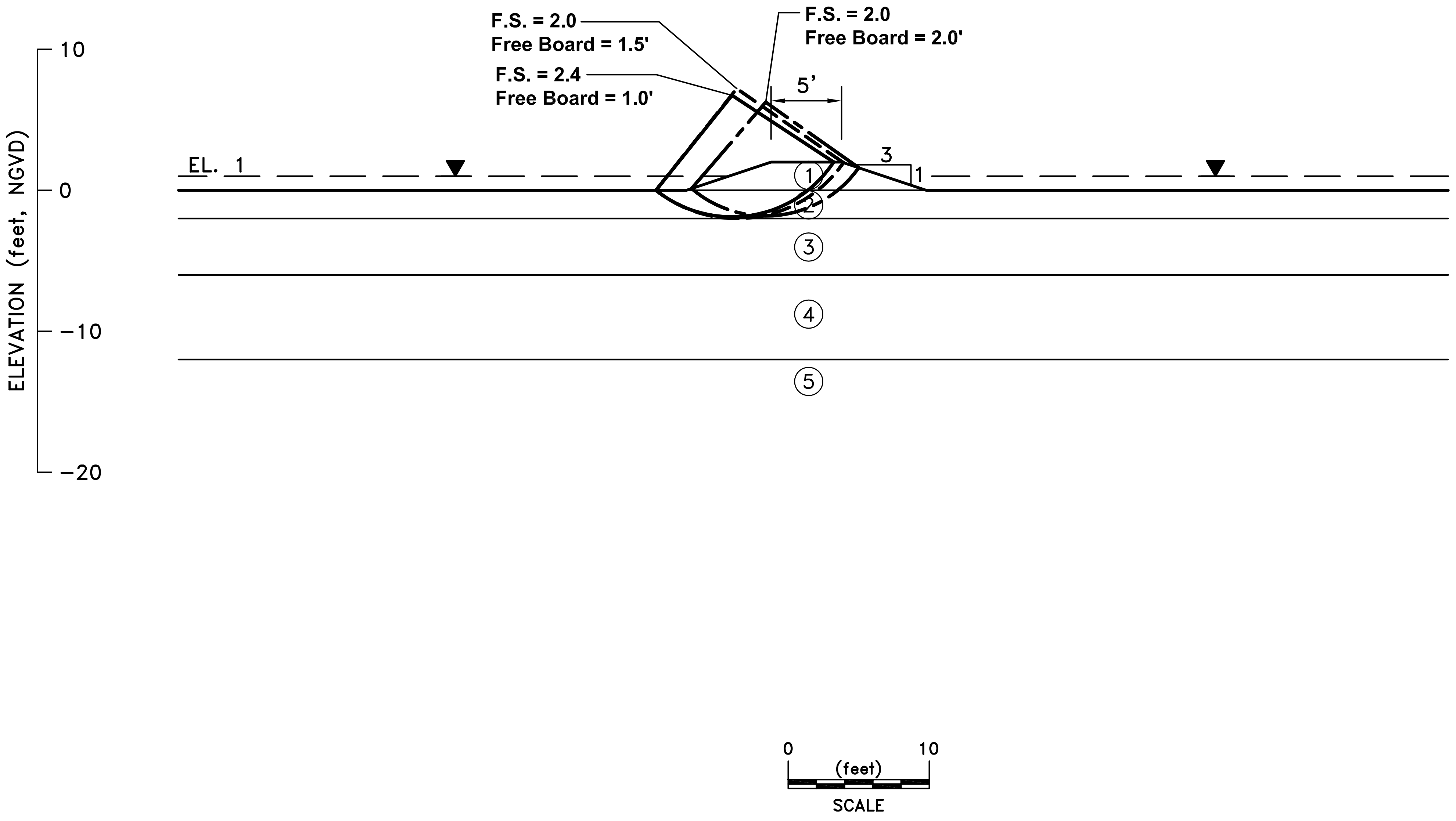
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06-1001	Date: 4-17-06	Figure No.: **16**

Title: **SLOPE STABILITY ANALYSIS CONTAINMENT BERM**

Apr 20, 2006 - 11:09am

P:\2006\06-1001\cadd\061001-17 B-7 1 to 3 Slope Stability.dwg



SOIL PARAMETERS (BORING B-7)			
LAYER	UNIT WEIGHT (pcf)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	105	200	0
2	70	50	0
3	118	230	0
4	130	1400	0
5	125	0	30

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

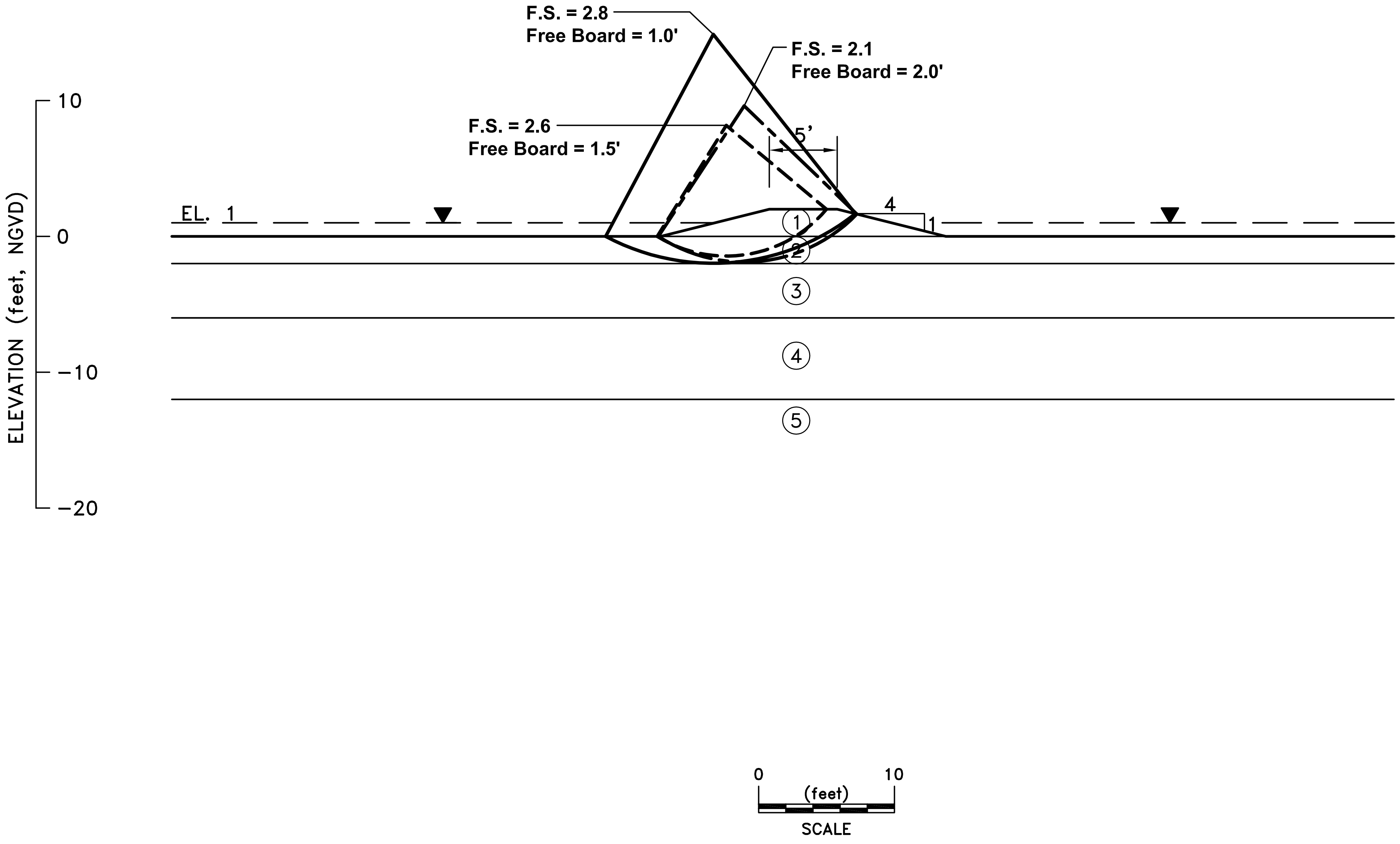
for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06-1001	Date: 4-17-06	Figure No.: **17**

Title: **SLOPE STABILITY ANALYSIS CONTAINMENT BERM**

Apr 20, 2006 – 11:10am



SOIL PARAMETERS (BORING B–7)			
LAYER	UNIT WEIGHT (pcf)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	105	200	0
2	70	50	0
3	118	230	0
4	130	1400	0
5	125	0	30

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

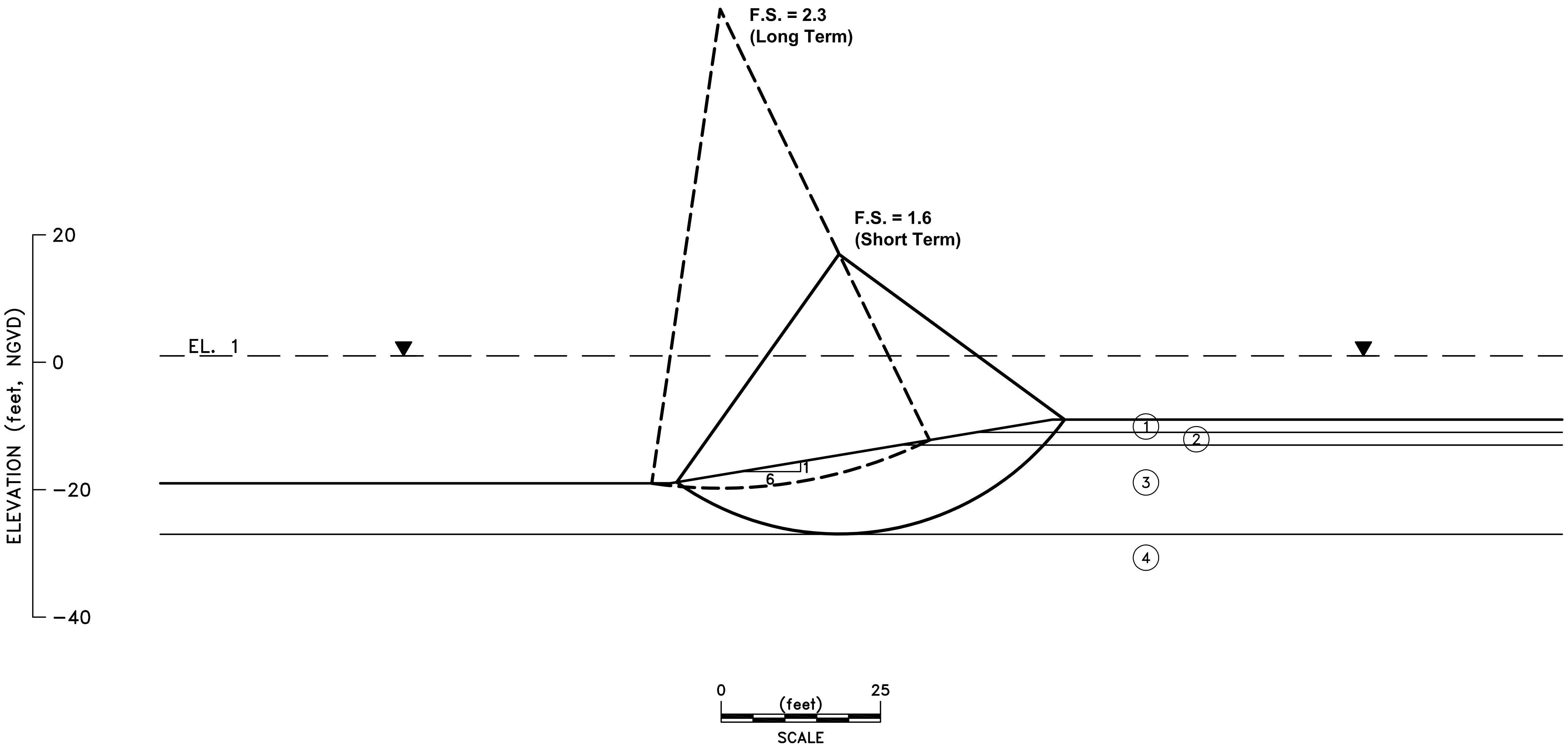
STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06–1001	Date: 4–17–06	Figure No.: **18**

Title: **SLOPE STABILITY ANALYSIS CONTAINMENT BERM**

P:\2006\06–1001\cadd\061001–18 B–7 1 to 4 Slope Stability.dwg

Apr 20, 2006 - 11:11am



SOIL PARAMETERS (BORING VC-3)					
LAYER	UNIT WEIGHT (pcf)	SHORT TERM		LONG TERM	
		SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)	SHEAR STRENGTH (psf)	FRICTION ANGLE (degrees)
1	102	80	0	0	20
2	120	0	30	0	30
3	102	80	0	0	20
4	105	500	0	0	20

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION

ST. TAMMANY PARISH, LOUISIANA

for

GEC, INC.

BATON ROUGE, LOUISIANA

STE

Soil Testing Engineers, Inc.

Baton Rouge, LA Jefferson, LA Biloxi, MS

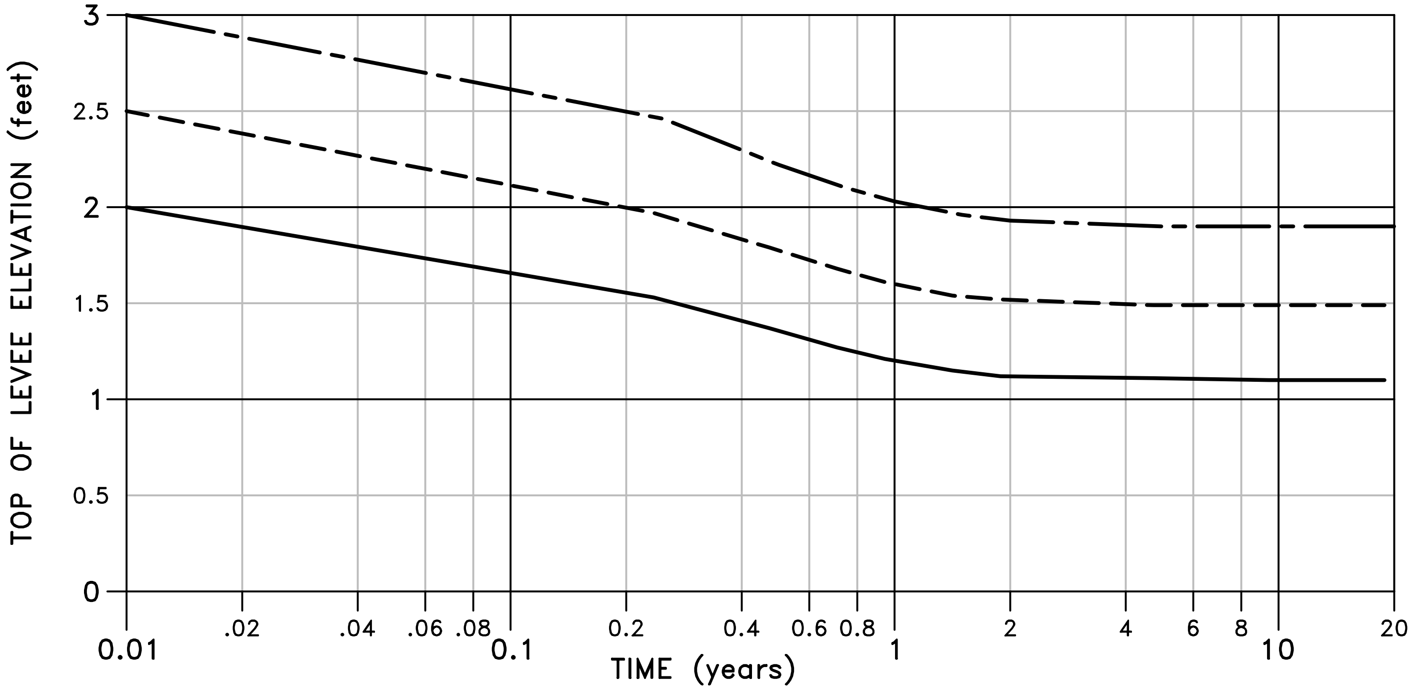
Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06-1001	Date: 4-17-06	Figure No.: **19**

Title: **SLOPE STABILITY ANALYSIS BORROW AREA**

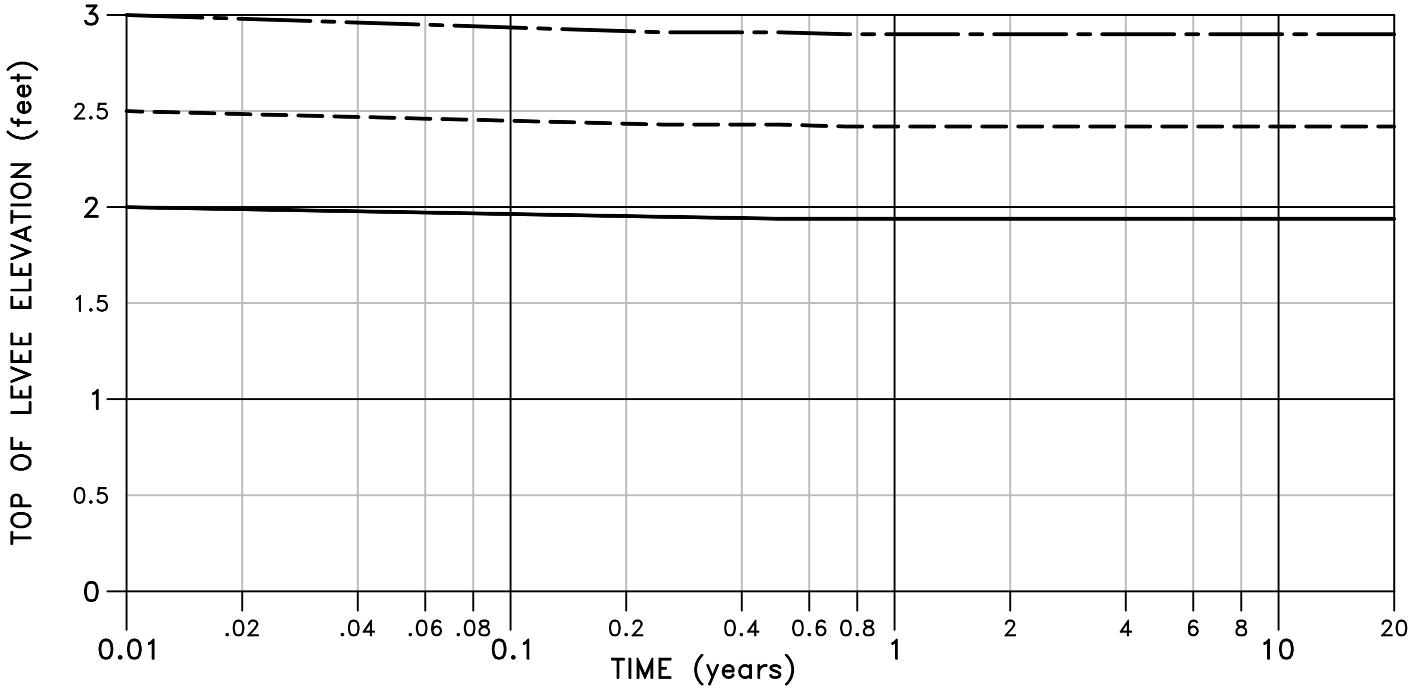
P:\2006\06-1001\cadd\061001-19 VC-3 Slope Stability.dwg

Apr 20, 2006 - 11:54am

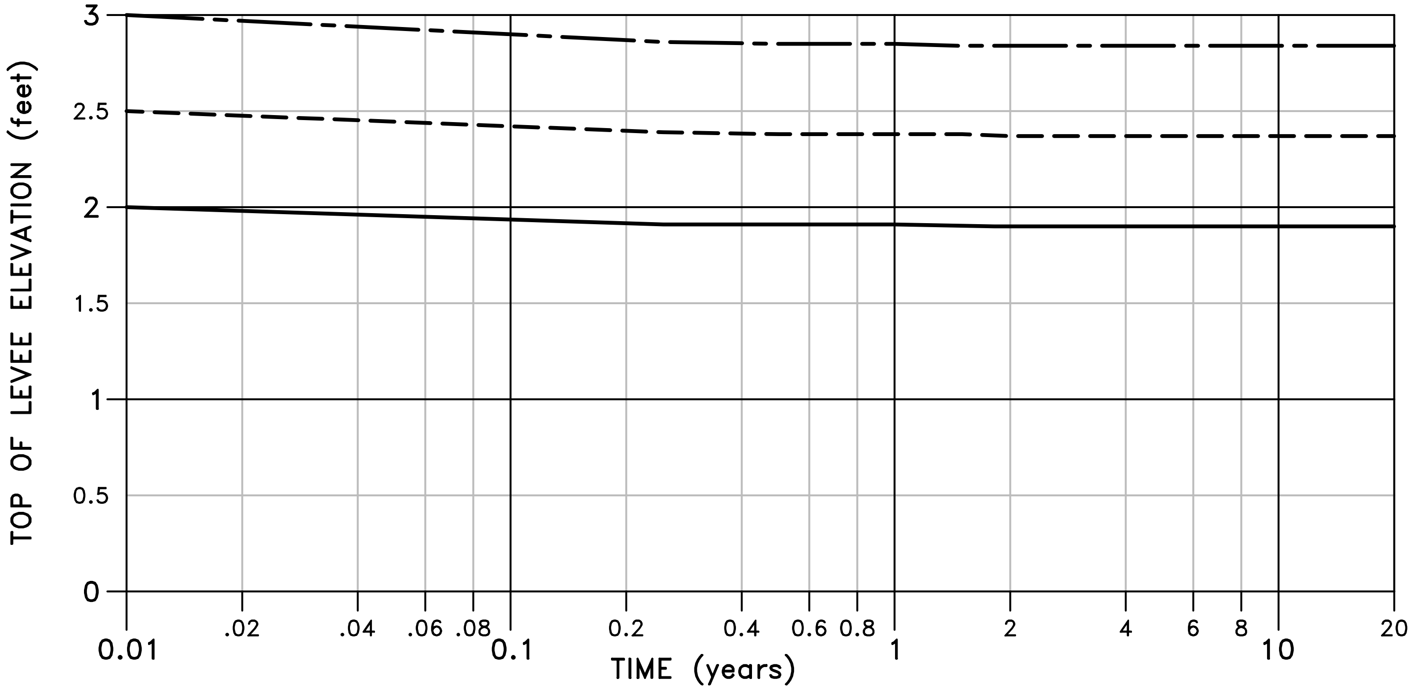
P:\2006\06-1001\cadd\061001-20 Ctrline Settlement B-3 B-4 B-5 B-6.dwg



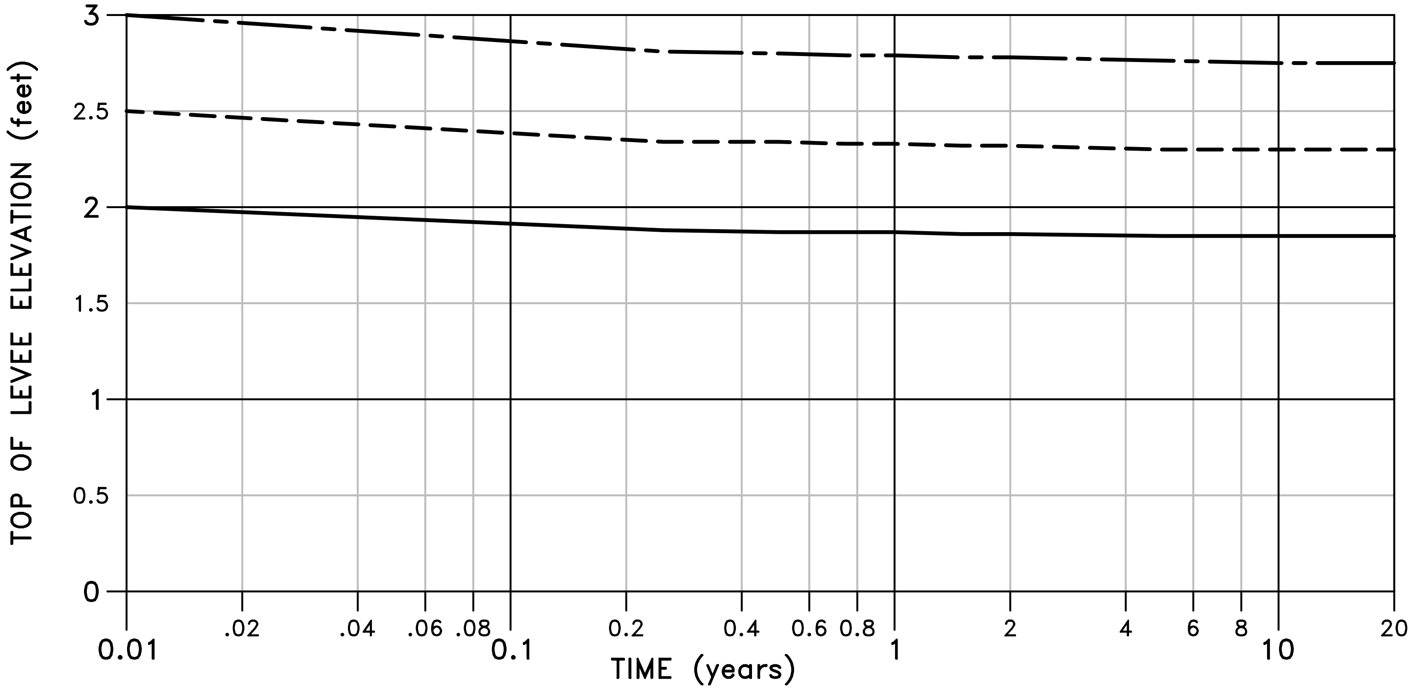
BORING B-3



BORING B-5



BORING B-4



BORING B-6

LEGEND:

——— SETTLEMENT FOR FREE BOARD OF 1.0 FT.
– – – – SETTLEMENT OF FREE BOARD OF 1.5 FT.
—·— SETTLEMENT OF FREE BOARD OF 2.0 FT.

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

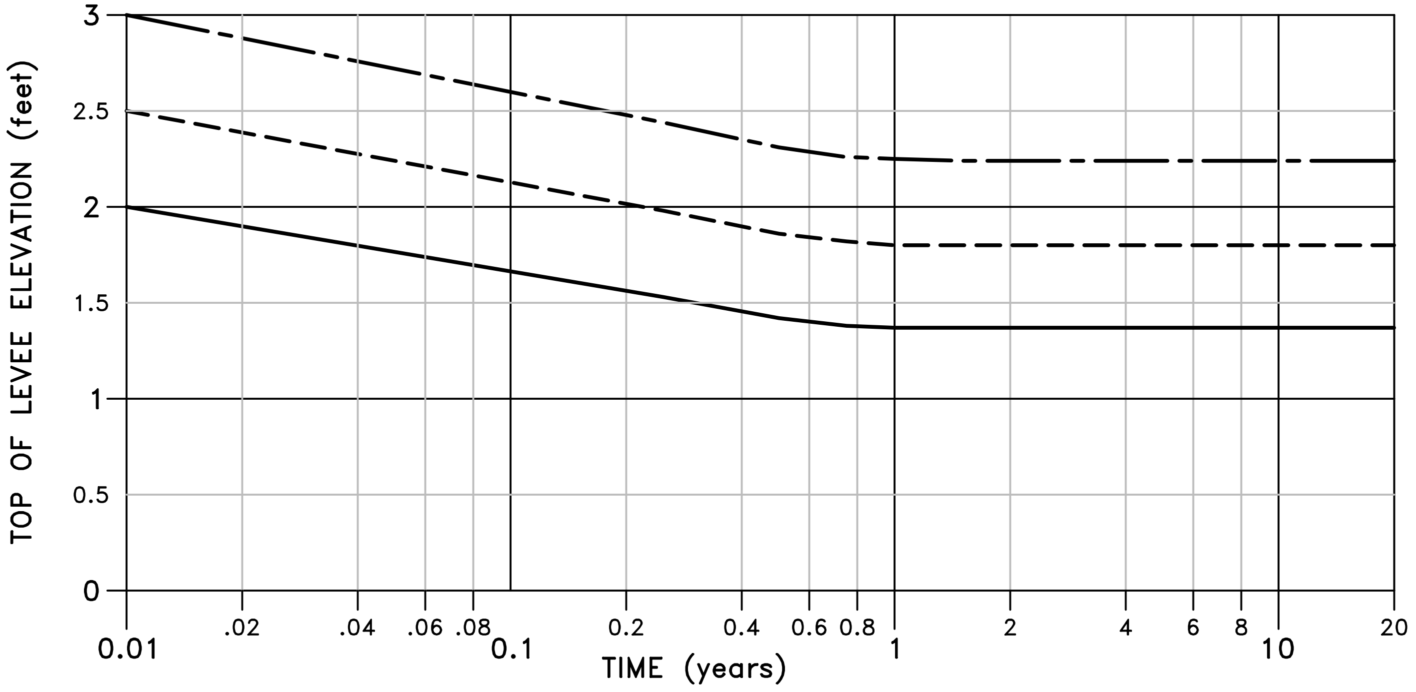
STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06-1001	Date: 4-17-06	Figure No.: **20**

Title: **CENTERLINE LEVEE SETTLEMENT**
BORINGS B-3, B-4, B-5 & B-6

Apr 20, 2006 - 11:55am

P:\2006\06-1001\cadd\061001-21 Ctrline Settlement B-7.dwg



BORING B-7

LEGEND:

——— SETTLEMENT FOR FREE BOARD OF 1.0 FT.

— — — SETTLEMENT OF FREE BOARD OF 1.5 FT.

—·— SETTLEMENT OF FREE BOARD OF 2.0 FT.

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

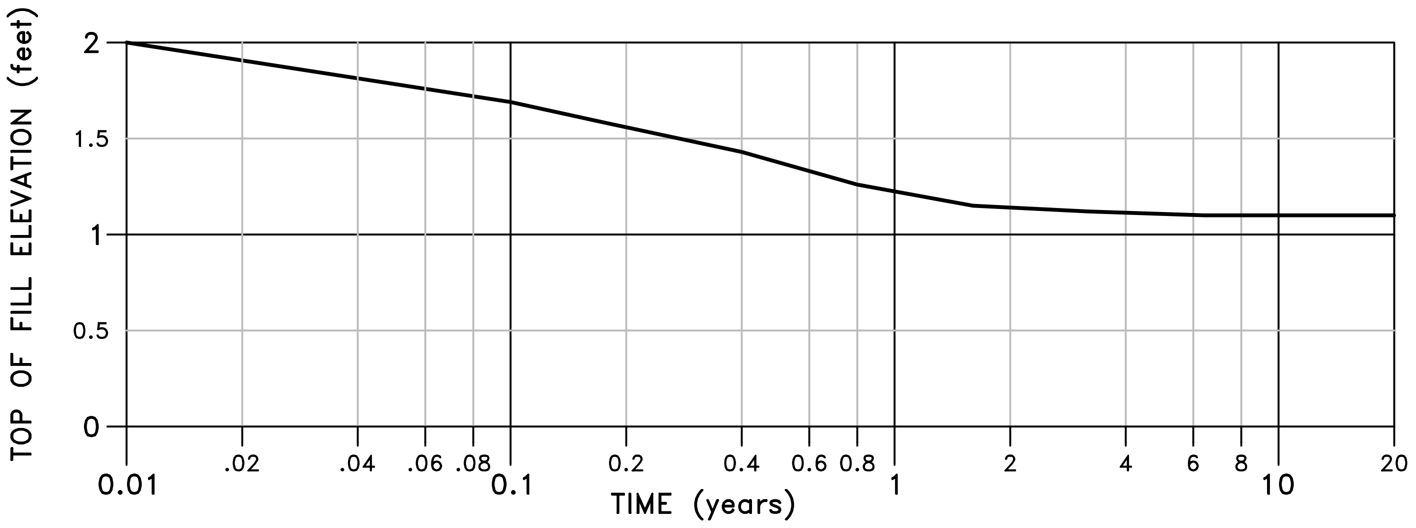
STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06-1001	Date: 4-17-06	Figure No.: **21**

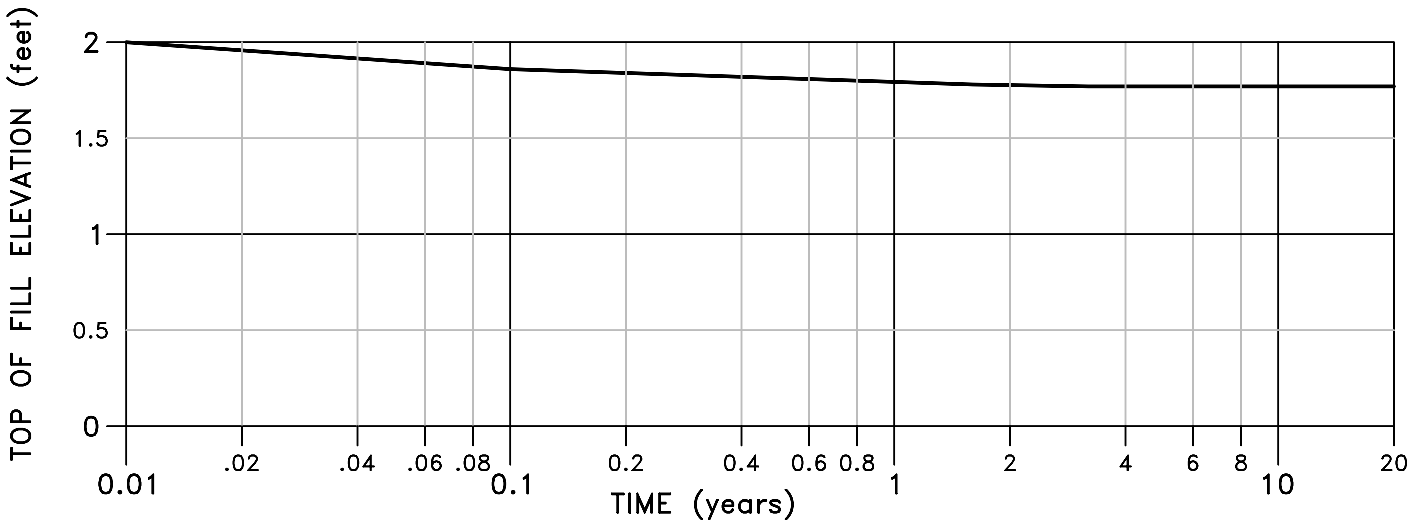
Title: **CENTERLINE LEVEE SETTLEMENT**
BORING B-7

Apr 20, 2006 – 11:49am

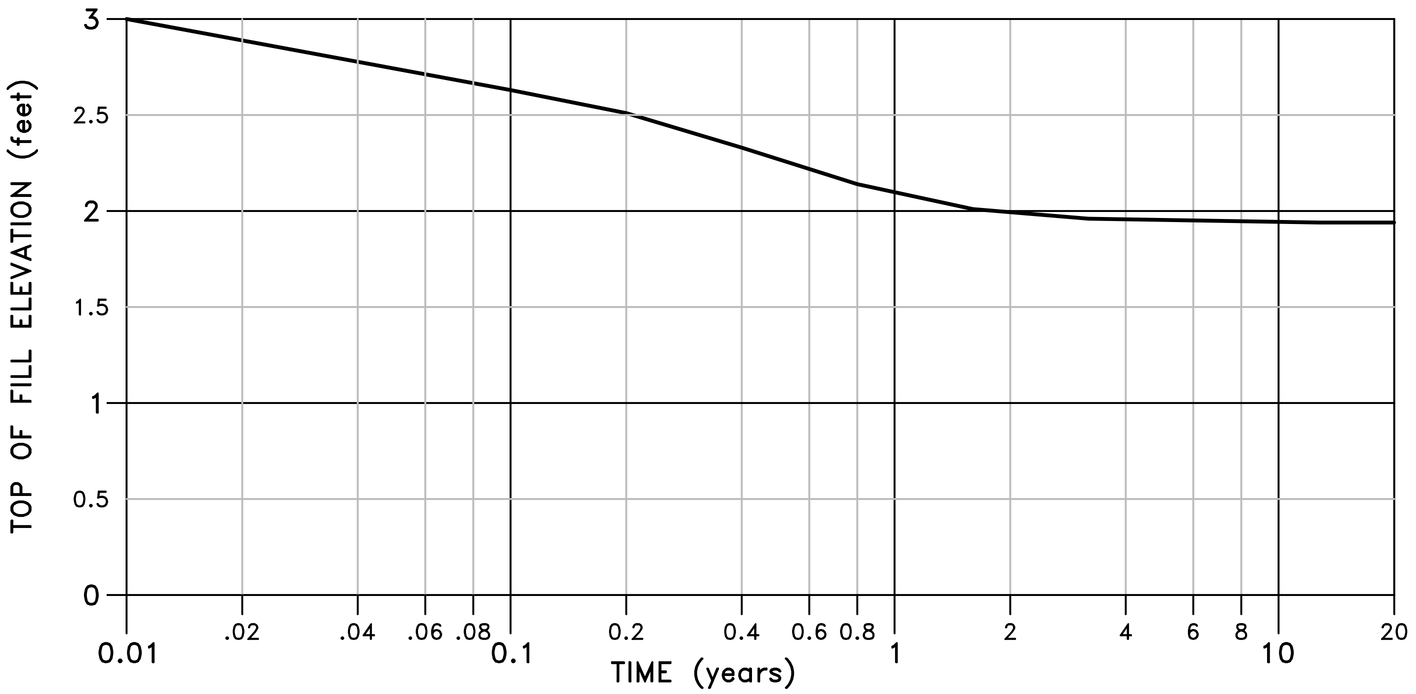
P:\2006\06–1001\cadd\061001–22 Marsh Settlement B–3 B–4.dwg



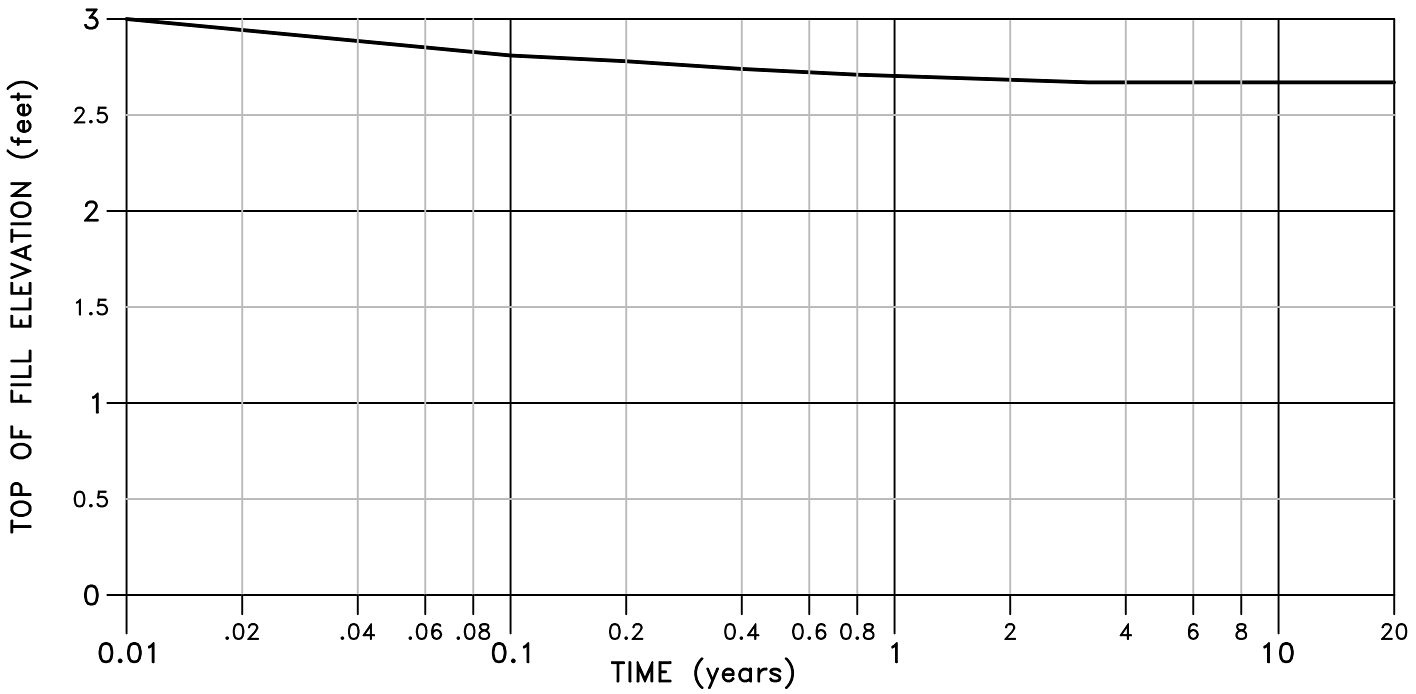
BORING B-3, 2 FT. FILL



BORING B-4, 2 FT. FILL



BORING B-3, 3 FT. FILL



BORING B-4, 3 FT. FILL

NOTE:
Settlement includes only consolidation settlement of underlying soils. Self weight settlement not included.

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

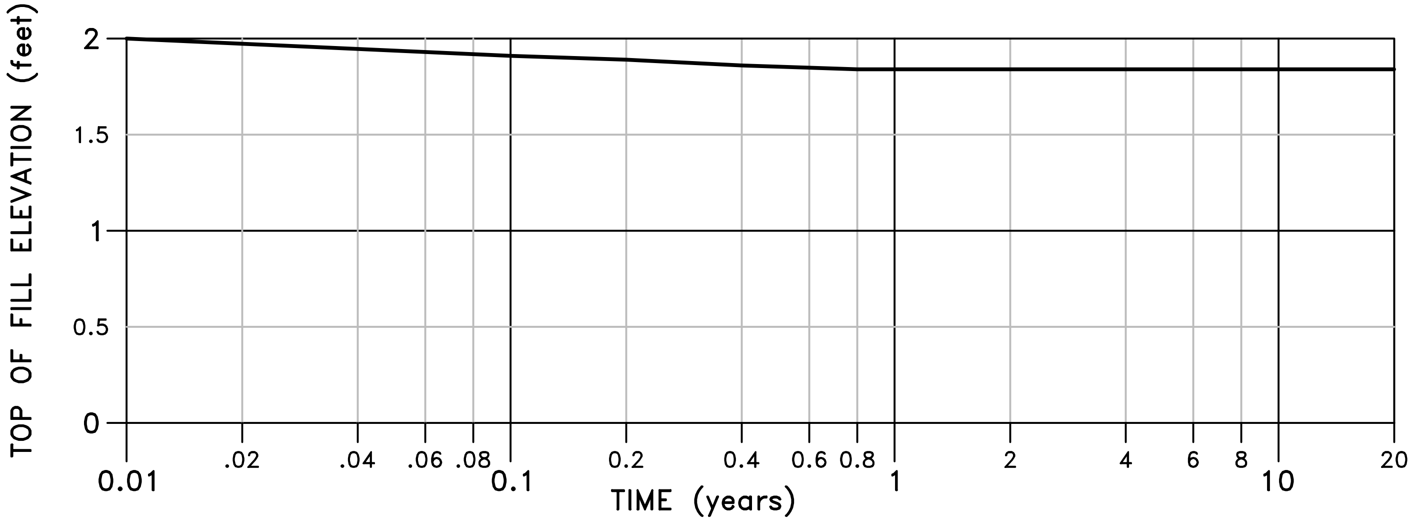
STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer:	Drawn by:	Checked by:
K. Spampneto	DMS	
File No.:	Date:	Figure No.:
06–1001	4–17–06	**22**

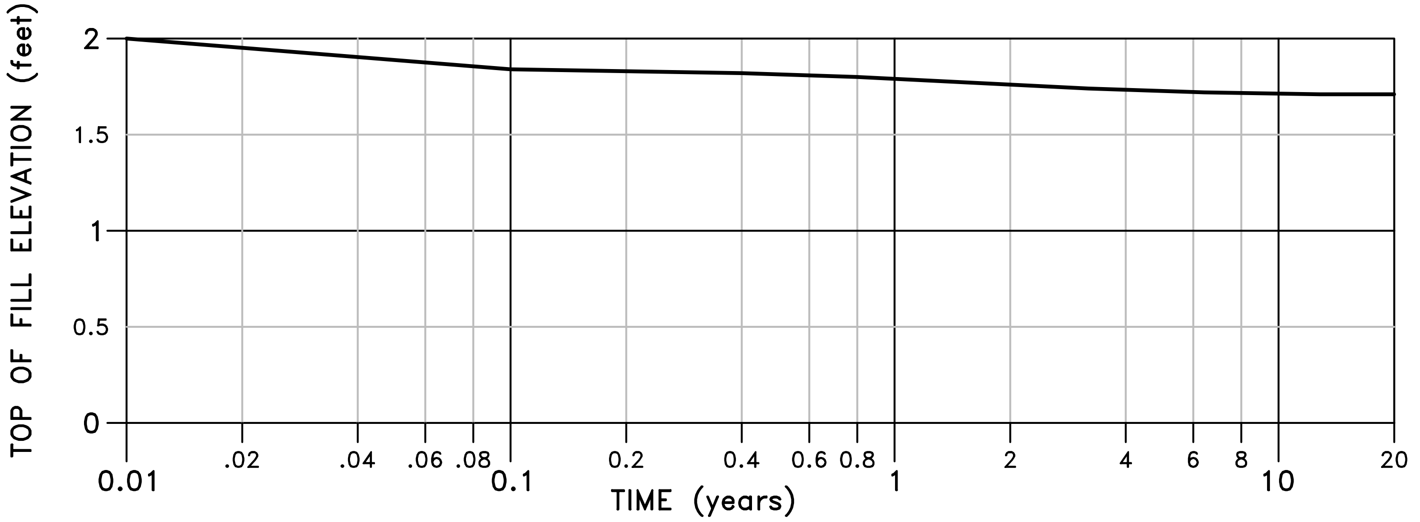
Title: **MARSH FILL SETTLEMENT**
BORINGS B-3 & B-4

Apr 20, 2006 – 11:50am

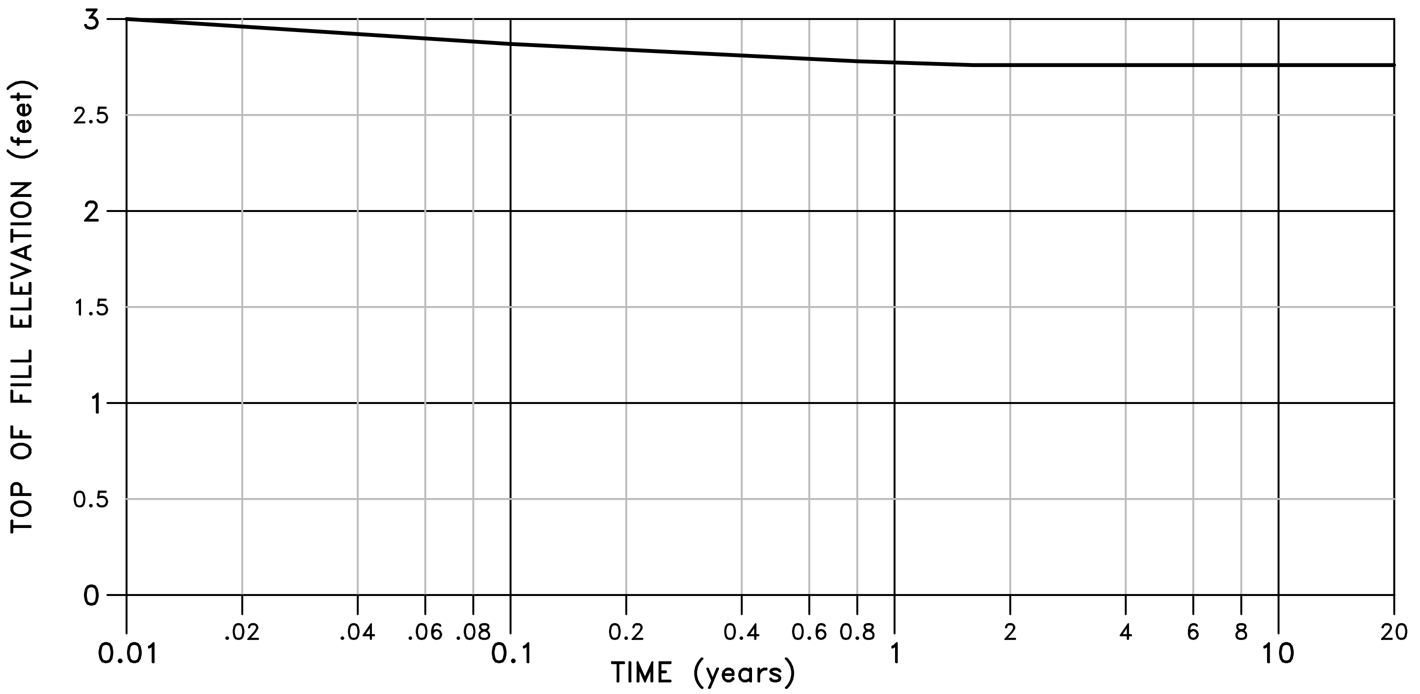
P:\2006\06–1001\cadd\061001–23 Marsh Settlement B–5 B–6.dwg



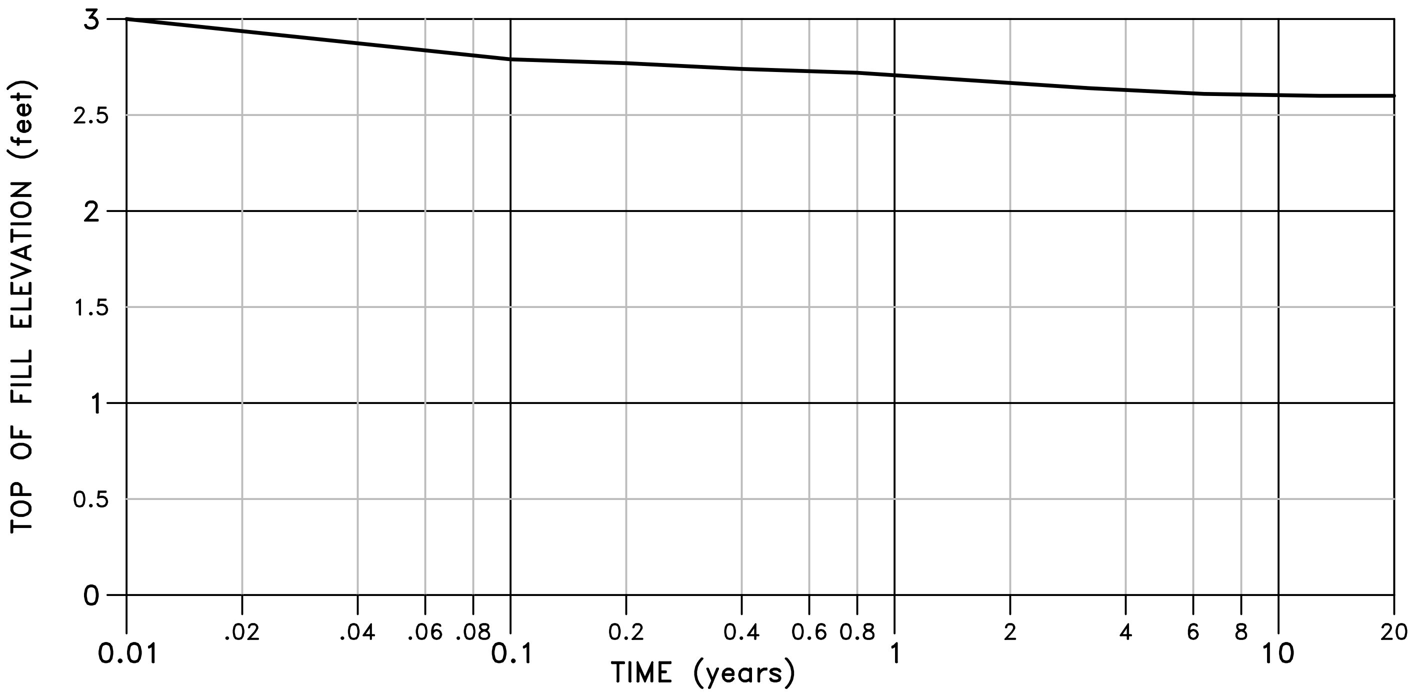
BORING B-5, 2 FT. FILL



BORING B-6, 2 FT. FILL



BORING B-5, 3 FT. FILL



BORING B-6, 3 FT. FILL

NOTE:
Settlement includes only consolidation settlement of underlying soils. Self weight settlement not included.

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

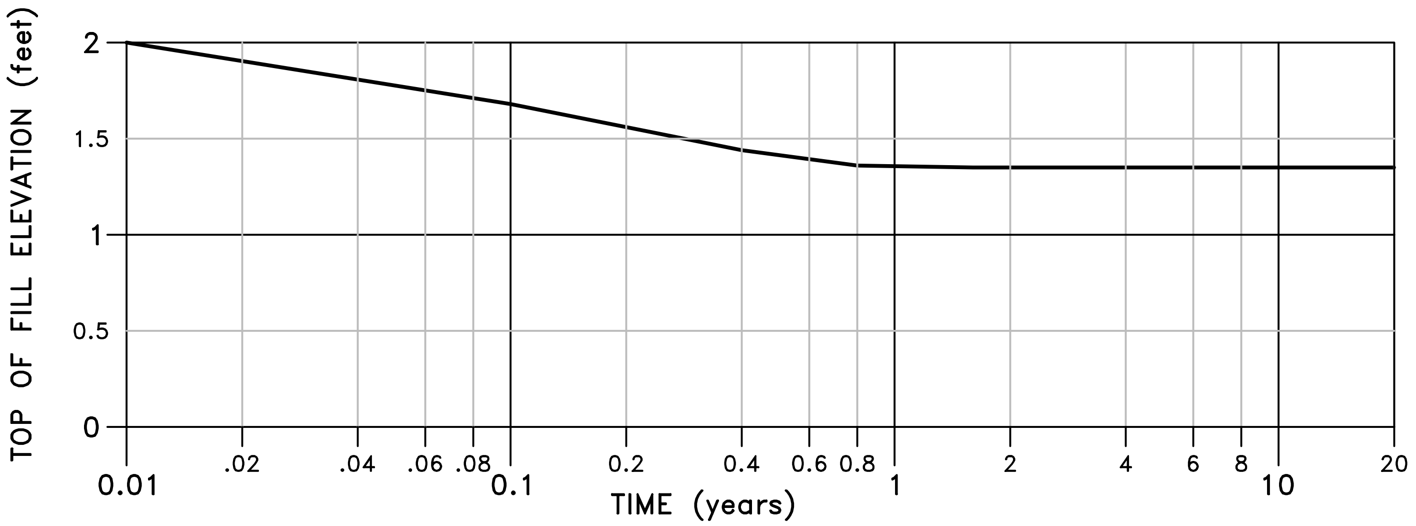
for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

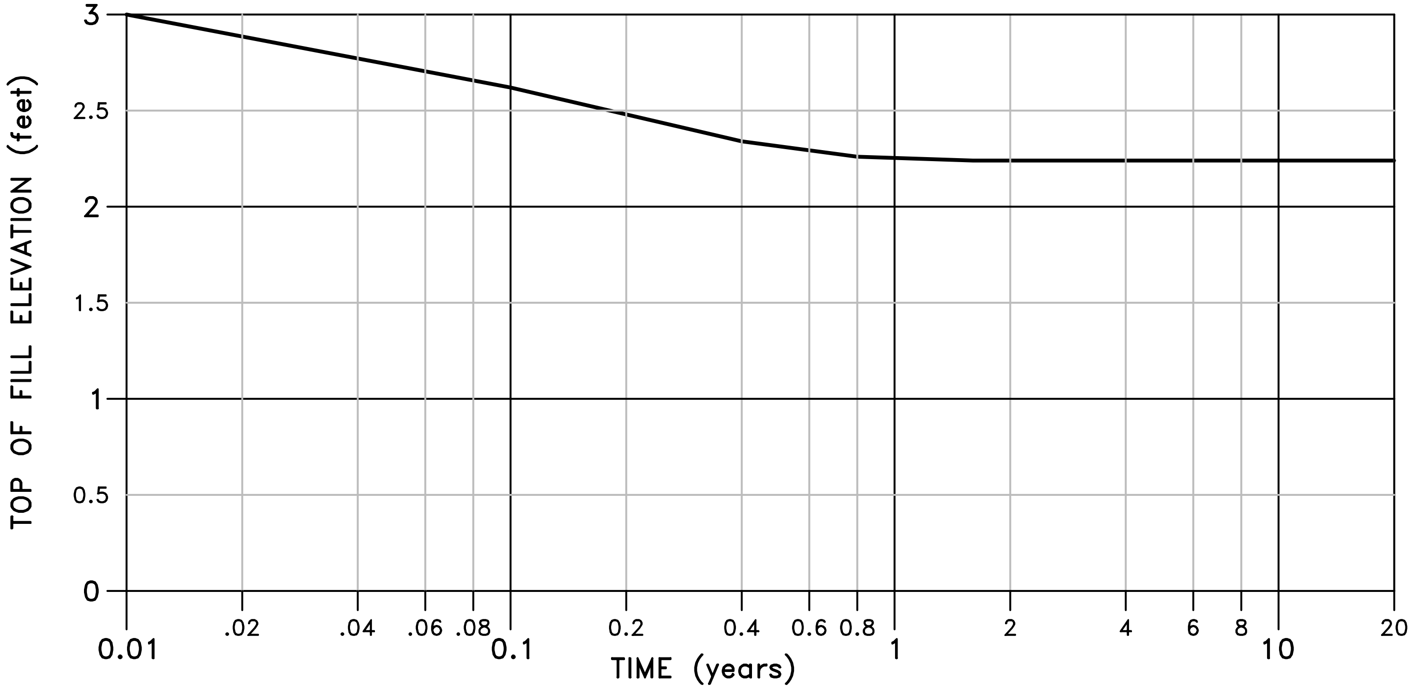
Project Engineer: K. Spampneto	Drawn by: DMS	Checked by:
File No.: 06–1001	Date: 4–17–06	Figure No.: 23

Title: **MARSH FILL SETTLEMENT BORINGS B-5 & B-6**

Apr 20, 2006 - 11:53am



BORING B-7, 2 FT. FILL



BORING B-7, 3 FT. FILL

NOTE:
Settlement includes only consolidation settlement of underlying soils. Self weight settlement not included.

GOOSE POINT/POINT PLATTE (PC-33) MARSH RESTORATION
ST. TAMMANY PARISH, LOUISIANA

for
GEC, INC.
BATON ROUGE, LOUISIANA

STE
Soil Testing Engineers, Inc.
Baton Rouge, LA Jefferson, LA Biloxi, MS

Project Engineer:	Drawn by:	Checked by:
K. Spampneto	DMS	
File No.: 06-1001	Date: 4-17-06	Figure No.: **24**

Title: **MARSH FILL SETTLEMENT BORING B-7**

P:\2006\06-1001\cadd\061001-24 Marsh Settlement B-7.dwg

GOOSE POINT			POINT PLATTE		
POINT NO. 1 Lat=30° 16' 40.5" Long=89° 58' 38.3"	POINT NO. 2 Lat=30° 16' 07.7" Long=89° 58' 46.0"	POINT NO. 3 Lat=30° 15' 38.0" Long=89° 58' 32.6"	POINT NO. 4 Lat=30° 15' 28.2" Long=89° 55' 18.4"	POINT NO. 5 Lat=30° 15' 21.5" Long=89° 54' 34.7"	POINT NO. 6 Lat=30° 15' 44.3" Long=89° 53' 44.5"
0.75	1.05	1.22	1.80	1.22	0.88
0.96	0.81	0.76	0.36	1.07	0.93
1.30	1.08	1.00	0.15	0.97	0.97
1.11	0.99	0.67	0.63	0.96	1.14
1.04	1.17	1.11	0.72	1.16	0.84
1.06	1.03	0.66	0.62	0.83	0.94
0.88	0.77	1.10	0.72	1.22	0.86
1.04	1.00	0.85	0.65	0.95	0.85
0.64	0.94	0.93	0.98	1.20	0.91
1.01	1.18	1.02	1.67	0.63	0.34
0.88	0.62	0.88	0.71	1.14	1.10
0.78	0.88	1.11	0.95	0.90	0.72
0.98	0.92	1.02	0.99	1.20	0.85
1.05	0.95	1.06	0.73	1.12	0.98
1.01	1.15	1.16	0.85	0.82	0.86
0.96	1.20	0.96	1.02	0.92	0.90
1.07	0.98	1.03	0.98	1.22	0.90
0.94	1.28	1.09	0.92	1.06	1.09
0.97	1.16	0.95	1.03	1.10	0.89
1.03	1.18	1.15	1.10	1.29	0.93
19.46	20.34	19.73	17.58	20.98	17.88
0.97	1.02	0.99	0.88	1.05	0.89

Final Report:

Settling Properties of Dredged Sediments from Goose Point, Louisiana

Submitted to:

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March 28, 2006

1.0 Introduction, Scope, and Objectives

The objective of the study reported herein was to evaluate zone settling and compression settling properties of soil/sediment expected to be dredged from a location near Goose Point, Louisiana.

2.0 Experimental Procedures and Results

Working with soil/sediment and water from the proposed dredging area (both received from Dr. Ching Tsai, Soil Testing Engineers, Inc., on March 2, 2006), a small-scale column pilot test was conducted using a 4.0 L graduated cylinder to determine if flocculent or zone settling process best describes the initial settling. This test was conducted using an initial sediment concentration of 150 g/L in slurry created using water from the proposed dredging area as recommended by EM 1110-2-5027.[1] Within two hours after the start of the small-scale column settling test, a clear interface had formed, indicating zone settling.

Zone settling and compression settling of soil/sediments was then assessed in a pilot-scale column using procedures described in the US Army Corps of Engineers Manual No. 1110-2-5027[1]. Suspended solids concentrations in the pilot-scale settling column at the start of settling were measured following *Standard Methods*[2]. The slurry concentration at the start of the settling test was determined to be 138 g/L, slightly lower than but close to the recommended concentration of 150 g/L. The depth of the sediment-water interface above the bottom of the column was measured and recorded over a period lasting a total of 15 days as depicted in Figure 1 (see Appendix A for tabulated data).

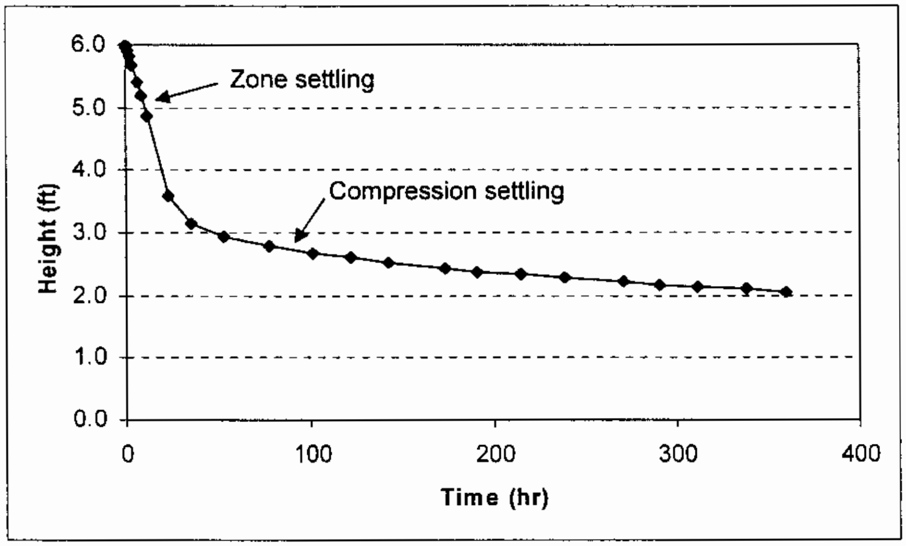

Figure 1: Interface height as a function of time during the pilot-scale settling test.

Data for the first day of the settling test, during which zone settling was observed, is depicted separately in Figure 2. A linear regression was performed with the resulting equation and correlation coefficient depicted on the graph. The slope of the regression line, which corresponds to the zone settling velocity, is 0.102 ft/hour.

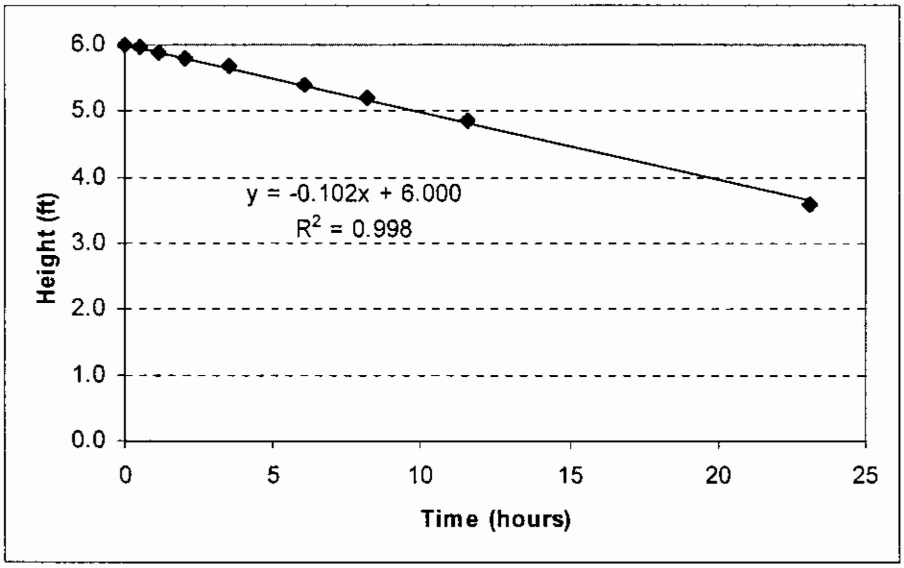

Figure 2: Interface height as a function of time during the zone settling portion of the pilot-scale settling test.

For the portion of the settling test during which compression settling was observed, the concentration in the settled solids at each time interval was calculated using the following equation (equation 3-11 in ref. 1).

$$C = \frac{C_o H_i}{H_t}$$

Where:

C = slurry concentration at time t (g/L)
C_o = initial slurry concentration (g/L)
H_i = initial slurry height (ft)
H_t = height of the interface at time t (ft)

The corresponding slurry concentration as a function of time during compression settling is depicted in Figure 3.

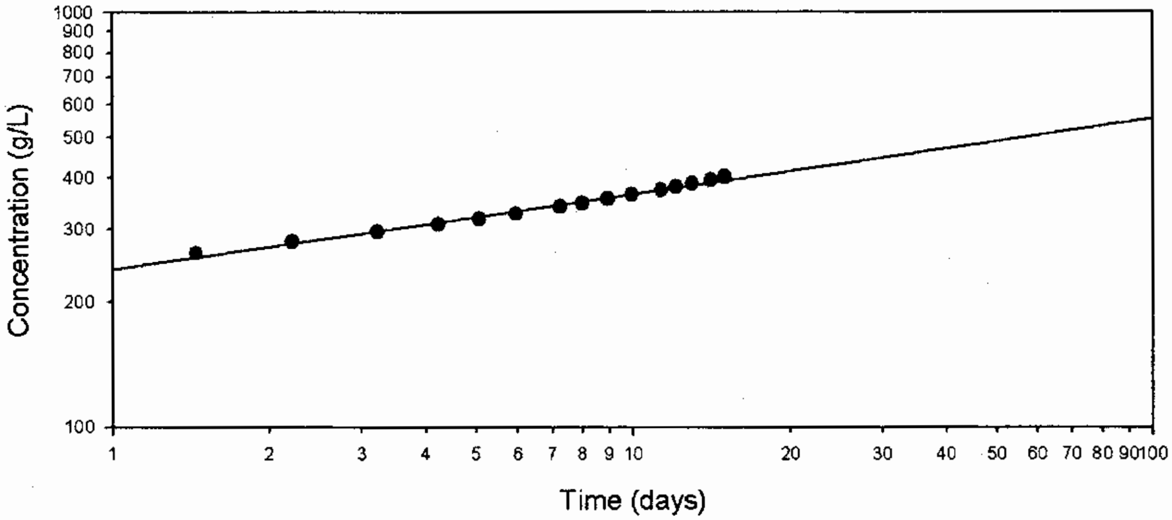

Figure 3: Concentration of settled solids as a function of time during the compression settling portion of the pilot-scale settling test.

In addition, the total dissolved solids (TDS) concentration in water used to prepare the slurry was measured using *Standard Methods*.[2] The TDS concentration in the water provided by STE was determined to be 8,030 mg/L.

3.0 References

[1] US Army Corps of Engineers (1987) *Engineering and Design - Confined Disposal of Dredged Material*, Engineer Manual No. 1110-2-5027.

[2] American Public Health Association (1998) *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, American Water Works Association, Water Pollution Control Federation, Washington, DC.

Appendix A: Interface height as a function of time during the pilot-scale column settling test.

The column settling test was started at 10:15 a.m. on March 11, 2006. The depth of the interface above the bottom of the column was recorded as a function of time as summarized in the table below.

Elapsed duration (hr)	Interface Height (ft)
0.0	6.00
0.5	5.97
1.2	5.90
2.1	5.81
3.5	5.68
6.1	5.41
8.2	5.20
11.6	4.86
23.1	3.60
34.8	3.15
53.2	2.95
77.2	2.80
101.3	2.68
121.5	2.60
142.5	2.53
174	2.43
191.5	2.39
214.5	2.33
238.5	2.28
271	2.22
290	2.18
311	2.14
338	2.10
360	2.06

APPENDIX C

EXAMPLE DESIGN CALCULATIONS FOR RETENTION OF SOLIDS AND INITIAL STORAGE

C-1. General. This appendix presents example calculations for containment area designs for the retention of suspended solids and initial storage. The examples are presented to illustrate the use of field and laboratory data and include designs for sedimentation, weir design, and requirements for initial storage capacity. Only those calculations necessary to illustrate the procedure are included in the examples.

C-2. Example I: Containment Area Design Method for Sediments Exhibiting Flocculent Settling.

a. Project Information.

(1) Each year an average of 300,000 cubic yards of fine-grained channel sediment is dredged from a harbor. A new in-water containment area is being constructed to accommodate the long-term dredged material disposal needs in this harbor. However, the new containment area will not be ready for approximately 2 years. One containment area in the harbor has some remaining storage capacity, but it is not known whether the remaining capacity is sufficient to accommodate the immediate disposal requirements. Design procedures must be followed to determine the residence time needed to meet effluent requirements of 4 grams per litre and the storage volume required for the 300,000 cubic yards of channel sediment. These data will be used to determine if the existing containment area storage capacity is sufficient for the planned dredged material disposal activity. The existing containment area is about 3 miles from the dredging activity.

(2) Records indicate that for the last three dredgings, an 18-inch pipeline dredge was contracted to do the work. The average working time was 17 hours per day, and the dredging rate was 600 cubic yards of in situ channel sediment per hour. The project depth in the harbor is 50 feet.

b. Results of Containment Area Survey. The existing containment area has the following dimensions:

(1) Size: 96 acres.

(2) Shape: length-to-width ratio of about 3.

(3) Volume: 1,548,800 cubic yards (average depth, from surveys, is 10 feet).

(4) Weir length: 24 feet (rectangular weir).

(5) Minimum ponding depth: 2 feet (assumed).

c. Results of Laboratory Tests and Analysis of Data. Sediment and dredging-site water characterization was conducted as described in Chapter 3.

A pilot settling test was conducted, and no interface was observed during the first 4 hours of the test. An 8-inch column test was then run to determine flocculent and compression settling properties. The following data were obtained from the laboratory tests:

(1) Salinity of dredging site water: <1 part per thousand.

(2) Channel sediment in situ water content w : 85 percent.

(3) Specific gravity G_s : 2.69.

(4) Grain size analysis indicates approximately 20 percent of the sediment is coarse grained.

(5) Observed flocculent settling concentrations as a function of depth (see Table C-1).

(6) Percent of initial concentration with time (see Table C-2). This is determined as follows:

(a) Column concentration at the beginning of tests is 132 grams per litre.

(b) Concentration at 1-foot level at time = 30 minutes is 46 grams per litre (Table C-1).

(c) Percent of initial concentration = 46 ÷ 132 = 0.35 = 35 percent.

(d) These calculations are repeated for each time and depth to develop Table C-2.

(7) Plot the percent of initial concentration versus the depth profile for each time interval from data given in Table C-2 (see Figure C-1).

(8) Determine concentration as a function of time (15-day settling column data) (see Table C-3).

(9) Plot time versus concentration from data in Table C-3 as shown in Figure C-2.

d. Design Concentration. Compute the design concentration as follows:

(1) The project information is:

(a) Dredge size: 18 inches.

(b) Volume to be dredged: 300,000 cubic yards.

(c) Average operating time: 17 hours per day.

(d) Production: 600 cubic yards per hour.

(2) Estimate the time of dredging activity:

Table C-1
Observed Flocculent Settling Concentrations with Depth, in Grams per Litre*

	Depth from Top of Settling Column, ft						
Time, min	1	2	3	4	5	6	7
0	132.0	132.0	132.0	132.0	132.0	132	132
30	46.0	99.0	115.0	125.0	128.0	135	146
60	25.0	49.0	72.0	96.0	115.0	128	186
120	14.0	20.0	22.0	55.0	78.0	122	227
180	11.0	14.0	16.0	29.0	75.0	119	
240	6.8	10.2	12.0	18.0	65.0	117	
360	3.6	5.8	7.5	10.0	37.0	115	
600	2.8	2.9	3.9	4.4	14.0	114	
720	1.01	1.6	1.9	3.1	4.5	110	
1,020	0.90	1.4	1.7	2.4	3.2	106	
1,260	0.83	1.14	1.2	1.4	1.7	105	
1,500	0.74	0.96	0.99	1.1	1.2	92	
1,740	0.63	0.73	0.81	0.85	0.94	90	

---

* Note: Although a 6-foot test depth is recommended, an 8-foot depth was used in this test.

Table C-2

Percent of Initial Concentration with Time*

Time T, min	Depth from Top of Settling Column, ft 1	2	3
0	100.0	100.0	100.0
30	35.0	75.0	87.0
60	19.0	37.0	55.0
120	11.0	15.0	17.0
180	8.0	11.0	12.0
240	5.0	8.0	9.0
360	3.0	4.0	6.0
600	2.0	2.2	3.0
720	1.0	1.2	1.4

* Note: Initial suspended solids concentration = 132 grams per litre.

Table C-3

Concentration of Settled Solids as a Function of Time

Time days	Concentration g/ℓ
1	190
2	217
3	230
4	237
5	240
6	242
7	244
9	249
10	247
15	256

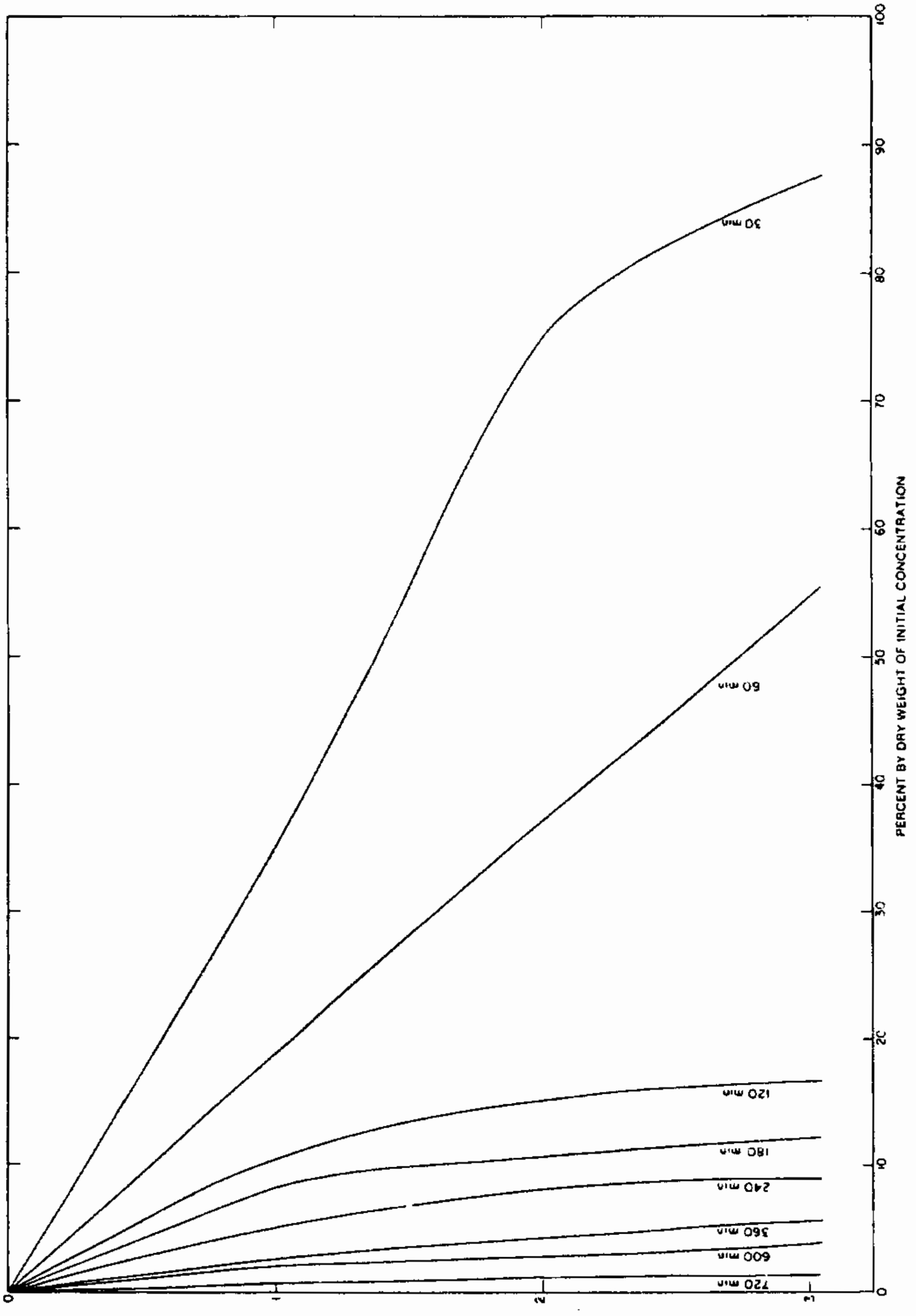

Figure C-1. Percent of initial concentration versus depth profile

$$\frac{300{,}000\ \text{yd}^3}{600\ \text{yd}^3/\text{hr}} = 500\ \text{hr}$$

$$\frac{500\ \text{hr}}{17\ \text{hr/day}} = 29.4 \quad 30\ \text{days}$$

(3) Average time for initial dredged material consolidation is:

$$\frac{30\ \text{days}}{2} = 15\ \text{days}$$

(4) Design solids concentration C_d is the concentration shown in Figure C-2 at 15 days:

$$C_d = 253\ \text{grams per litre}$$

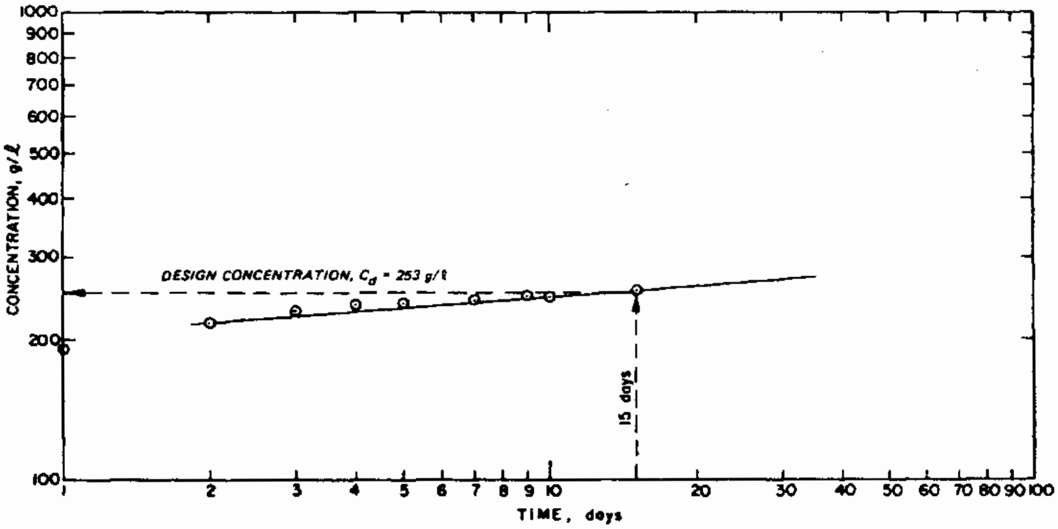

Figure C-2. Time versus concentration

e. Volume Required for Dredged Material. Estimate the volume required for dredged material as follows:

(1) Compute the average void ratio e_o using Equation 4-2:

$$e_o = \frac{G_s \gamma_w}{C_d} - 1$$

where $G_s = 2.69$, $\gamma_w = 1{,}000$ grams per litre, and $C_d = 253$ grams per litre. Thus,

$$e_o = \frac{2.69(1{,}000)}{253} - 1$$

$$e_o = 9.63$$

(2) Laboratory tests indicate that 20 percent of the sediment is coarse-grained material; therefore, the volume of coarse-grained material V_{sd} is

$$V_{sd} = 300{,}000(0.20) = 60{,}000 \text{ cubic yards}$$

and the volume of fine-grained material V_i is:

$$V_i = 300{,}000 - 60{,}000 = 240{,}000 \text{ cubic yards}$$

(3) Compute the volume of fine-grained channel sediments after disposal in the containment area using Equation 4-3:

$$V_f = V_i \left[\frac{e_o - e_i}{1 + e_i} + 1\right]$$

$$e_i = \frac{wG_s}{S_D}$$

$$= \frac{(85/100)(2.69)}{1.00}$$

$$e_i = 2.29$$

$$V_i = 240{,}000 \text{ cubic yards}$$

$$V_f = \left[\frac{9.63 - 2.29}{1 + 2.29} + 1\right](240{,}000)$$

$$V_f = 775{,}440 \text{ cubic yards}$$

(4) Estimate the total volume required in the containment area using Equation 4-4:

$$V = V_f + V_{sd}$$

$$V_{sd} = 60{,}000 \text{ cubic yards}$$

$$V = 775{,}440 + 60{,}000$$

$$V = 835{,}440 \text{ cubic yards}$$

(5) Determine the maximum height of dredged material. Foundation conditions limit dike heights to 10 feet. A ponding depth of 2 feet is assumed using Equation (4-4b):

$$H_{dm_{(max)}} = H_{dk_{(max)}} - H_{pd} - H_{fb}$$

$$H_{dm_{(max)}} = 10 \text{ feet} - 2 \text{ feet} - 2 \text{ feet}$$

$$H_{dm_{(max)}} = 6 \text{ feet}$$

(6) The minimum surface area that could be used must be compared to the available surface area of 96 acres. Using Equation 4-4c:

$$A_{ds_{(min)}} = \frac{V}{H_{dm_{(max)}}}$$

$$A_{ds_{(min)}} = \frac{835{,}440 \text{ yd}^3}{6 \text{ ft}} \times \frac{27 \text{ ft}^3}{\text{yd}^3}$$

$$A_{ds_{(min)}} = 3{,}759{,}480 \text{ ft} = \text{approximately } 86 \text{ acres}$$

Since the minimum required surface area is less than the available 96 acres, the dredged material can physically be stored during the dredging operation.

f. Residence Time Required for Sedimentation. The design residence time is computed as in the following example:

(1) Calculate removal percentages for the assumed ponding depth of 2 feet. Calculating the total area down to a depth of 2 feet from Figure C-1 gives an area of 200 (scale units), Calculating the area to the right of the 30-minute time line down to a depth of 2 feet gives 124 (scale units). These areas could also have been determined by planimetering the plot. Compute removal percentages as follows (see Equation 4-7):

$$R = \frac{124}{200} \times 100 = 62$$

For a settling time of 30 minutes, 62 percent of the suspended solids are removed from the water column above the 2-foot depth.

(2) The calculations illustrated in step (1) are repeated for each time, and the results are tabulated in Table C-4.

(3) Plot the data in Table C-4 as shown in Figure C-3.

(4) Determine the mean residence time required to meet the 4-grams-per-litre effluent suspended solids requirements.

$$\text{Required Solids Removal} = \frac{C_i - C_{eff}}{C_i}$$

Table C-4

Removal Percentages as Function of Settling Time

Time, min	Removal, percentage
30	62.0
60	81.0
120	90.2
180	93.1
240	95.5
360	97.0
600	98.4
720	99.3

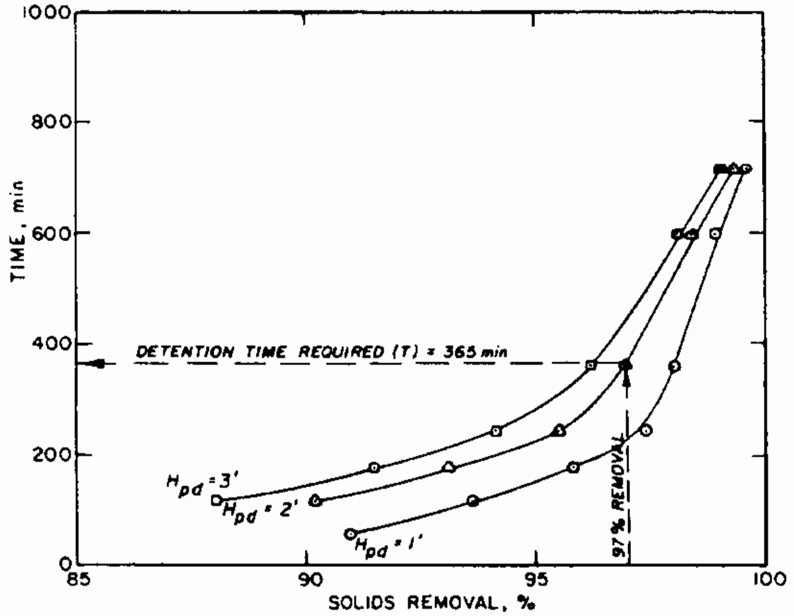

Figure C-3. Solids removal versus time

$$= \frac{132 - 4}{132} = 0.97 \text{ or } 97 \text{ percent}$$

(5) From Figure C-3, T = 365 minutes.

(6) No specific data on hydraulic efficiency exist for this site. Therefore, the hydraulic efficiency correction factor will be estimated using Equation 4-14.

$$\frac{T_d}{T} = 0.9 \left[1 - \exp\left(-0.3 \frac{L}{W}\right)\right]$$

$$= 0.9 \left|1 - \exp\left[-0.3\ (3)\right]\right|$$

$$= 0.53$$

$$\text{HECF} = \frac{T}{d}$$

$$= \frac{1}{0.53}$$

$$= 1.87$$

$$T = \text{HECF}\ (T_d)$$

$$= 1.87\ (365)$$

$$= 683 \text{ min}$$

The required theoretical or volumetric retention time equals 683 minutes or 11.4 hours.

g. Design Surface Area Required for Flocculent Sedimentation. Compute this value using Equation 4-13 as follows:

$$Q_i = \frac{\left(\frac{18 \text{ in.}}{12}\right)^2 \pi}{4} \times 15 \text{ ft/sec}$$

$$= 26.5 \text{ ft}^3\text{/sec}$$

$$A_{df} = \frac{T\ Q_i}{H_{pd}\ (12.1)}$$

$$= \frac{11.4\ (26.5)}{2\ (12.1)}$$

$$= 12 \text{ acres}$$

h. Design Surface Area. Since both the A_{ds} and A_{df} are smaller than the available 96 acres, use 96 acres as the design surface area A_d .

$$A_d = 96 \text{ acres} \times 43{,}560 \text{ ft}^2/\text{acre}$$

$$A_d = 4{,}181{,}760 \text{ ft}^2$$

i. Thickness of Dredged Material Layer. Determine the thickness of the dredged material layer from:

$$H_{dm} = \frac{V}{A_d}$$

$$= \frac{835{,}440 \text{ yd}^3 \times 27}{4{,}181{,}760 \text{ ft}^2}$$

$$H_{dm} = 5.4 \text{ ft}$$

j. Required Containment Area Depth (Dike Height). The required containment area depth is determined from:

$$H_{dk} = H_{dm} + H_{pd} + H_{fb}$$

$$= 5.4 + 2 + 2$$

$$H_{dk} = 9.4 \text{ feet}$$

D = 9.4 feet is less than the maximum allowable dike height of 10 feet.

k. Weir Length.

(1) The existing effective weir length L_e equals the weir crest length L for rectangular weirs:

$$L_e = 24 \text{ feet}$$

$$Q_i = 26.5 \text{ cubic feet per second}$$

$$H_{pd} = 2 \text{ feet}$$

Using Figure 4-7 from the main text, a 2-foot ponding depth at the weir requires an effective weir length of approximately 60 feet. The existing 24-foot weir length is therefore inadequate, and additional weir length should be provided.

(2) The remaining volume of 1,548,800 cubic yards in the existing containment area is sufficient to accommodate disposal of the 300,000 cubic yards of maintenance channel sediment into the basin under a continuous disposal operation. Since the required basin depth is less than the existing depth, no upgrading will be necessary to accommodate the first dredging operation.

C-3. Example II: Containment Area Design Method for Sediments Exhibiting Zone Settling.

a. Project Information. Fine-grained maintenance dredged material is scheduled to be dredged from a harbor maintained to a project depth of 50 feet. Channel surveys indicate that 500,000 cubic feet of channel sediment must be dredged. All available disposal areas are filled near the dredging activity, but an available tract of 80 acres is available for a new site 2 miles from the dredging project. An evaluation of the foundation conditions indicate that the maximum allowable dike height is 15 feet. The containment area must be designed to accommodate initial storage requirements while meeting effluent suspended solids levels of 75 milligrams per litre. In the past, the largest dredge contracted for the maintenance dredging has been a 24-inch pipeline dredge. This is the largest size dredge located in the area.

b. Results of Laboratory Tests. Sediment and dredging site water characterization was conducted as described in Chapter 3. A pilot settling test was conducted, and an interface was observed within a few hours. A column settling test for zone settling was then conducted as described in Chapter 3. Flocculent settling data were collected above the interface. The test was also continued for 15 days for purposes of evaluating initial storage requirements. The following data were obtained from the laboratory tests:

(1) Salinity: 15 parts per thousand.

(2) Channel sediment in situ water content w : 92.3 percent.

(3) Specific gravity G_s : 2.71.

(4) Depth to suspended solids interface as a function of time for a series of zone settling tests (see Table C-5).

(5) Concentration of settled material as a function of time data (15-day settling column data) (see Table C-6).

(6) Concentration of settled solids versus time curve (see Figure C-4).

(7) Representative samples of channel sediments tested in the laboratory indicate that 15 percent of the sediment is coarse-grained material (> No. 200 sieve).

$$V_{sd} = 500,000(0.15) = 75,000 \text{ cubic yards}$$

$$V_i = 500,000 - 75,000 = 425,000 \text{ cubic yards}$$

(8) Suspended solids concentration data for port samples taken above the interface for the flocculent test (Table C-7).

(9) Concentration profile diagram plotted from data in Table C-7 (Figure C-5). The initial supernatant suspended solids concentration C_o was assumed equal to the highest concentration of the first port samples taken,

Table C-5

Depth to Solids Interface (Feet) as a Function of Settling Time (Hours) at C_i = 150 grams per litre

Time, hr	Depth, ft
0	0
0.25	0.050
0.50	0.090
0.75	0.170
1.0	0.230
2.0	0.420
3.0	0.475
4.0	0.505
5.0	0.530
6.0	0.553
7.0	0.565
8.0	0.575
10.0	0.595
20.0	0.655
30.0	0.690

---

* From plot of depth versus time V_s = 0.24 feet per hour.

Table C-6

Concentration of Settled Solids as a Function of Time*

Time Days	Concentration g/ℓ
1	192
2	215
3	219
4	140
5	251
6	272
8	280
10	290
15	320

* See Figure C-3.

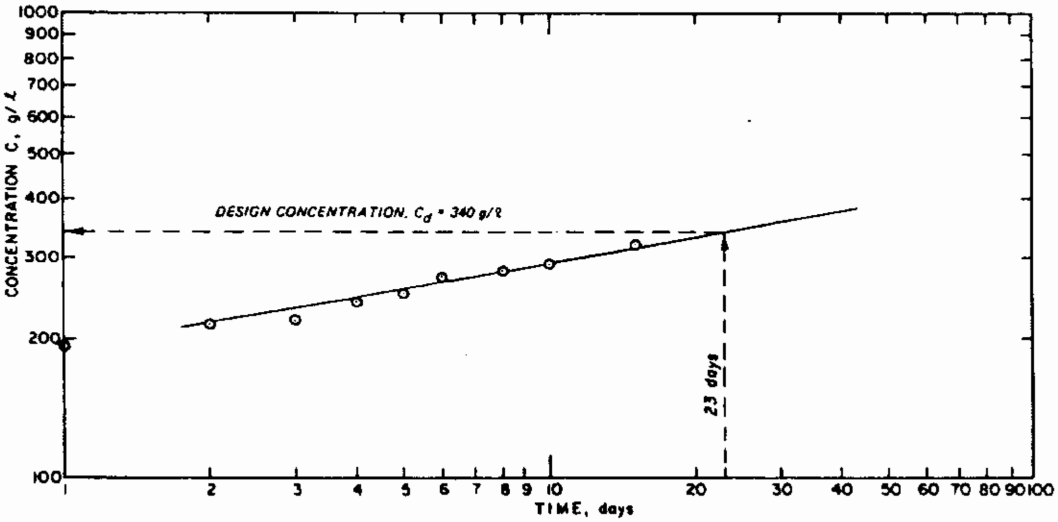

Figure C-4. Concentration of settled solids versus time

Table C-7

Observed Flocculent Settling Data

Sample Extraction Time t (hr)	Depth of Sample Extraction z (ft)	Total Suspended Solids, C (mg/ℓ)	Fraction of Initial, Ø (percent)
3	0.2	93	55
3	1.0	169	100
7	1.0	100	59
7	2.0	105	62
14	1.0	45	27
14	2.0	43	25
14	3.0	50	30
24	1.0	19	11
24	2.0	18	11
24	3.0	20	12
48	1.0	15	9
48	2.0	7	4
48	3.0	14	8

169 milligrams per litre. The concentration profile diagram was therefore constructed using 169 milligrams per litre as Ø = 100 percent.

C. Design Concentration. Compute this value as follows:

(1) The project information is as follows:

(a) Dredge size: 24 inches.

(b) Volume to be dredged: 500,000 cubic yards.

(2) Good records are available from past years of maintenance dredging in this harbor. They show that each time a 24-inch dredge was used, the dredge operated an average of 12 hours per day and dredged an average of 900 cubic yards per hour.

(3) Estimate the time of dredging activity:

$$\frac{500{,}000\ \text{yd}^3}{900\ \text{yd}^3/\text{hour}} = 556\ \text{hours}$$

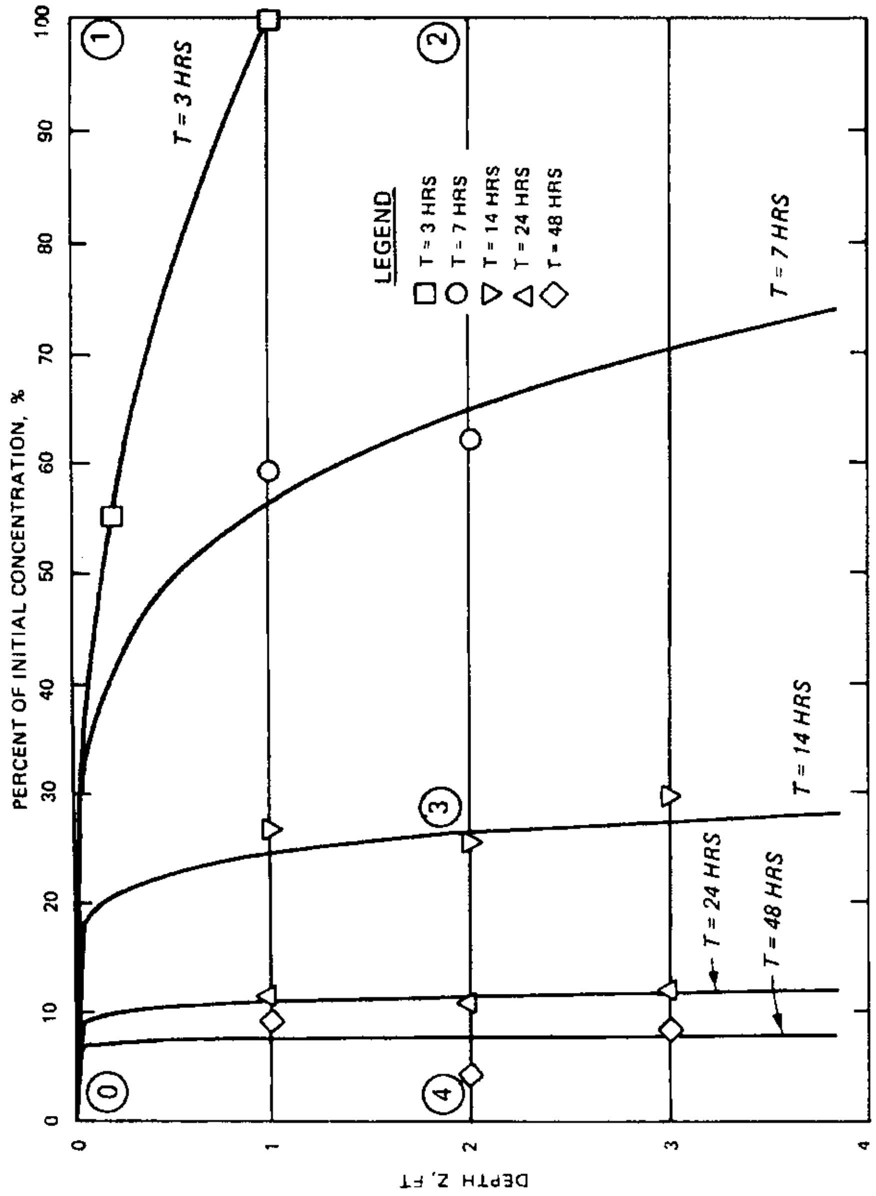

Figure C-5. Suspended solids concentration profile diagram where operating time per day = 12 hours. Thus,

$$\frac{556 \text{ hours}}{12 \text{ hours/day}} = 46 \text{ days}$$

(4) Average time for dredged material consolidation:

$$\frac{46 \text{ days}}{2} = 23 \text{ days}$$

(5) Design concentration is the solids concentration of settled solids shown in Figure C-4 at 23 days:

C_d = 340 grams per litre or 21.1 pounds per cubic feet

d. Volume Required for Dredged Material. This volume is estimated as follows:

(1) Compute the average void ratio using Equation 4-2:

$$e_o = \frac{G_s \gamma_w}{\gamma_d} - 1$$

G_s = 2.71

γ_w = **1,000 grams per litre**

γ_d = 340 grams per litre = design concentration C_d
(See Figure C-4)

$$e_o = \frac{2.71(1,000)}{340} - 1$$

e_o = 6.97

(2) Compute the volume of fine-grained channel sediments after disposal in containment area using Equation 4-3:

$$V_f = V_i \frac{e_o - e_i}{1 + e_i} + 1$$

where, using Equation 4-1, $e_i = \frac{wG_s}{S_D}$

$$e_i = \frac{\left(\frac{92.3}{100}\right)\left(2.71\right)}{1.00}$$

$$e_i = 2.5$$

$$V_i = 425{,}000 \text{ cubic yards}$$

$$V_f = \left(\frac{6.97 - 2.50}{1 + 2.50}\right) + 1 \ (425{,}000)$$

$$= 967{,}785 \text{ cubic yards}$$

(3) Estimate the volume required by dredged material in containment area using Equation 4-4:

$$v = V_f + V_{sd}$$

$$V_{sd} = 75{,}000 \text{ cubic yards}$$

$$V = 967{,}785 + 75{,}000$$

$$= 1{,}042{,}785 \text{ cubic yards}$$

e. Maximum Possible Thickness of Dredged Material at End of Disposal Operation.

(1) Because of foundation problems, dike heights are limited to 15 feet. Therefore, the disposal area must be increased to accommodate the storage requirements. Use Equation 4-4b to determine the allowable dredged material height:

$$H_{dm_{(max)}} = H_{dk_{(max)}} - H_{pd} - H_{fb}$$

$$H_{dk_{(max)}} = 15 \text{ feet}$$

$$H_{pd} = 2 \text{ feet}$$

$$H_{fb} = 2 \text{ feet}$$

$$H_{dm_{(max)}} = 15 - 2 - 2$$

$$H_{dm_{(max)}} = 11 \text{ feet}$$

(2) Compute the minimum possible surface area using Equation 4-4c:

$$A_{ds} = \frac{V}{H_{d_{(max)}}}$$

$$A_{ds} = \frac{1,042,785 \text{ yd}^3 \times \frac{27 \text{ ft}^3}{\text{yd}^3}}{11 \text{ ft}}$$

$$A_{ds} = 2,559,563 \text{ ft}^2$$

$$A_{ds} = 59 \text{ acres}$$

Since this value is less than the 80-acre tract available, the dredged material can be physically stored.

f. Minimum Area Required for Zone Sedimentation. This value is computed as follows:

(1) From data in Table C-5, V_s = 0.24 feet per hour.

(2) Compute the area requirement using Equation 4-5:

$$A_z = \frac{Q_i \ (3600)}{V_s}$$

$$Q_i = A_p V_d$$

$$V_p = 15 \text{ ft/sec}$$

$$Q_i = \frac{\left(\frac{24 \text{ in.}}{12}\right)^2 \pi}{4} \times 15 \text{ ft/sec}$$

$$= 47.12 \text{ ft}^3\text{/sec}$$

$$A_z = \frac{47.12 \ (3600)}{0.24}$$

$$= 706,800 \text{ ft}^2$$

$$A_z = \frac{706,800}{43,560} = 16.22 \text{ acres}$$

(3) Increase the area by a factor of 1.87 (from Equation 4-14) to account for hydraulic inefficiencies (assuming the containment area can be constructed with a length-to-width ratio of approximately 3):

$$A_{dz} = 1.87(16.22\text{ acres})$$

$$A_{dz} = 30.3\text{ acres}$$

Thus, the minimum area required for effective zone settling is 30.3 or approximately 30 acres. This is less than the 80 acres available at the site.

g. Retention Time for Suspended Solids Removal.

(1) A relationship of suspended solids remaining versus retention time was developed using the laboratory data in Figure C-5. Ratios of suspended solids removed as a function of time were determined graphically using the step-by-step procedure described in Chapter 4. The lower horizontal boundary for the determined areas corresponded to the minimum average ponding depth of 2 feet. An example calculation for removal ratio for the concentration profile at T = 14 hours and ponding depth of 2 feet using Equation 4-9 is as follows:

$$R_{14} = \frac{\text{Area right of the profile}}{\text{Area total}} = \frac{\text{Area 1,230}}{\text{Area 1,240}} = 0.78$$

The areas were determined by planimeter. The portion remaining at T = 14 hours is found using Equation 4-10 as follows:

$$P_{14} = 1 - R_{14} = 1 - 0.78 = 0.22$$

The concentration of suspended solids remaining is found using Equation 4-11 as follows:

$$C_{14} = P_{14}\, C_o = 0.22\ (169\text{ milligrams per litre}) = 37\text{ milligrams per litre}$$

Values at other times were determined in a similar manner. The data were arranged in Table C-8. A curve was fitted to the data for total suspended solids versus retention time and is shown in Figure C-6.

Table C-8

Percentage of Initial Concentration and Suspended Solids Concentrations versus Time, Ponding Depth of 2 Feet

Sample Extraction Time, t (hr)	Removal Percentage R_t	Remaining Percentage P_t	Suspended Solids (mg/ℓ)
3	14	86	145
7	47	53	90
14	78	22	37
24	90	10	17
48	94	6	10

(2) Since the final site configuration is not known beforehand, an appropriate value should be selected from Table 4-1 for the resuspension factor. The minimum ponding depth of 2 feet required by the site design is used. A resuspension factor of 1.5 was selected corresponding to an available area <100 acres and ponding depth of 2 feet.

(3) The value of effluent suspended solids of 75 milligrams per litre must be met at the point of discharge and considers anticipated resuspension. The corresponding value for total suspended solids concentration under quiescent settling conditions is determined using Equation 4-12 as follows:

$$C_{col} = \frac{C_{eff}}{RF} = \frac{75 \text{ mg}/\ell}{1.5} = 50 \text{ mg}/\ell$$

(4) The required configuration of the disposal area must correspond to a retention time that will allow the necessary sedimentation. Using Figure C-6, 50 milligrams per litre corresponds to a field mean retention time of 10 hours. To determine the required disposal site geometry, the theoretical retention time should be used. The hydraulic efficiency correction factor was calculated from Equation 4-14 to be 1.87 for an L/W of 3. The theoretical retention time was calculated using Equation 4-8 as follows:

$$T = T_d \text{ (HECF)} = 10 \text{ (1.87)} = 18.7 \text{ hours}$$

(5) The disposal area configuration can now be determined using data on the anticipated flow rate and the theoretical retention time. Since the dredging equipment available in the project area is capable of flow rates up to 47 cubic feet per second, the high value should be assumed. The ponded area required is calculated using Equation 4-13 as follows:

$$A_{df} = \frac{T\ Q_i}{H_{pd}\ (12.1)}$$

$$= \frac{18.7\ (47)}{2\ (12.1)}$$

$$= 36 \text{ acres}$$

The disposal site should therefore encompass approximately 36 acres of ponded surface area if the dredge selected for the project has an effective flow rate not greater than 47 cubic feet per second. In this case, the surface area of 36 acres required to meet the water quality standard is greater than the minimum surface area of 30 acres required for effective zone settling. However, the area required for storage, 59 acres, is the controlling surface area. The design surface area A_d is therefore 59 acres.

h. Determination of Disposal Area Geometry. From previous calculation, the minimum design area is 59 acres as required for initial storage. This corresponds to the following values as previously calculated:

$$H_{dm} = 11 \text{ feet}$$

H_{pd} = 2 feet

H_{fb} = 2 feet

A_d = 59 acres

i. Design for Weir.

(1) The design parameters are:

Q_i = 47 cubic feet per second

H_{pd} = 2 feet

(2) Using Figure 4-7, approximately 55 feet of effective weir length is required.

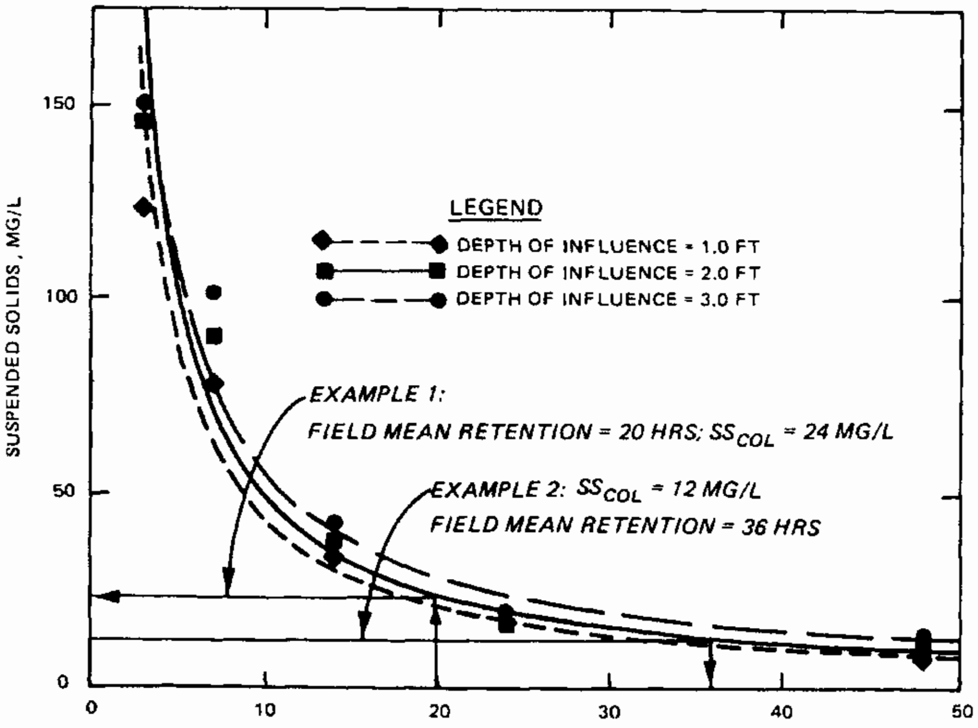

Figure C-6. Plot of supernatant suspended solids concentration versus time from column settling tests