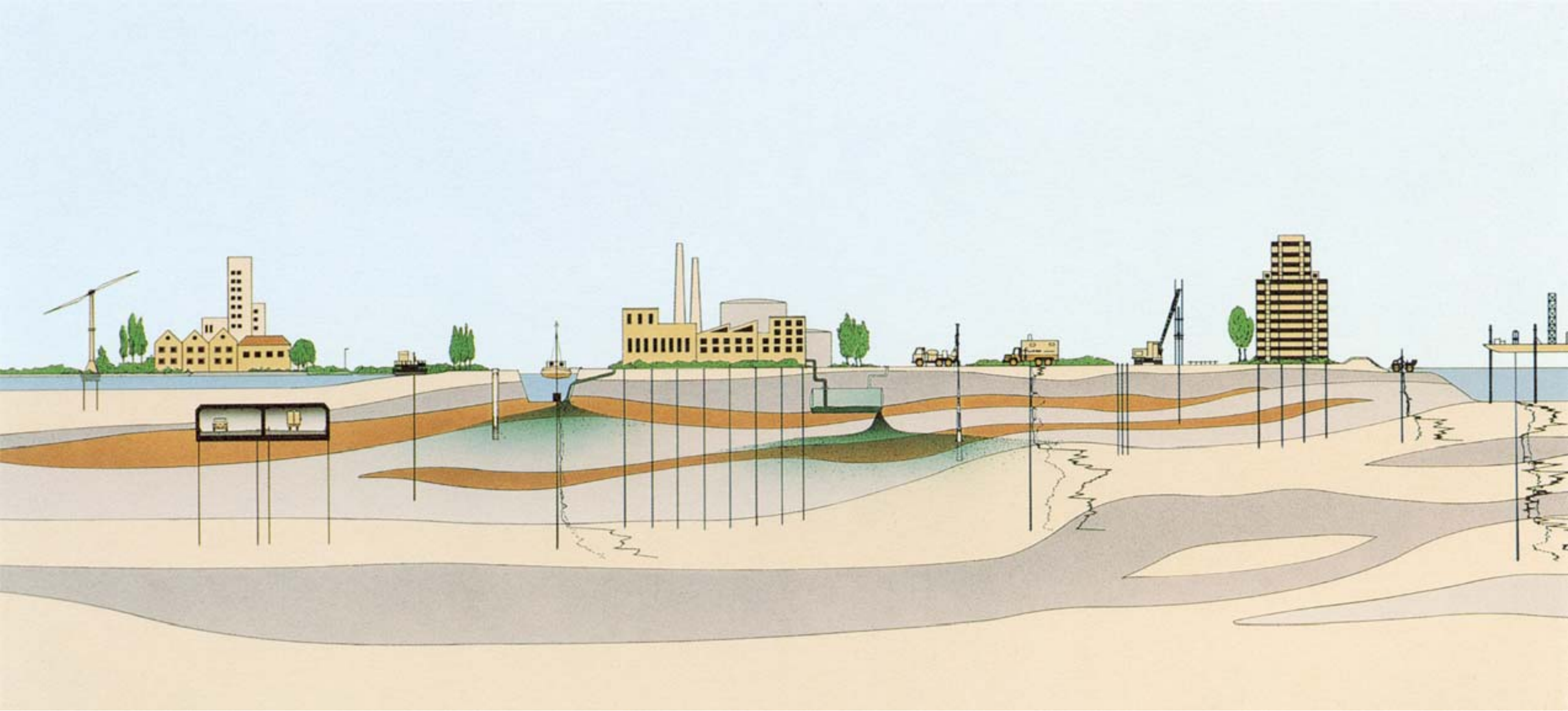
FUGRO CONSULTANTS, INC.

GEOTECHNICAL STUDY
BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS

LOCKWOOD, ANDREWS & NEWNAM, INC.
HOUSTON, TEXAS



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Report No. 04.10120193-2
November 5, 2013

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Attention: Mr. Jon Jelinek, P.E.
Associate, Facilities Team Leader

Geotechnical Study
Berth 6 and Bulkhead Wall Expansion
Port of Port Arthur
Port Arthur, Texas

Fugro Consultants, Inc. (Fugro) is pleased to present this report of our geotechnical study for the proposed Berth 6 and Bulkhead Wall Expansion at the Port of Port Arthur Facility along the Sabine-Neches Ship Channel in Port Arthur, Texas. Mr. Jon Jelinek, P.E. with Lockwood, Andrews & Newnam, Inc. (LAN) requested our additional services during a meeting with Mr. Nathan Daniels, P.E. with Fugro on March 12, 2012. This study was performed in general accordance Fugro Proposal Nos. 04.10120193-2p – Rev. 1 dated June 4, 2013 and 04.10120193-3p – Rev. 3 dated October 2, 2013.

This report contains the results of our field and laboratory testing and our geotechnical recommendations for the above referenced project. This report also incorporates comments received from the Project Team on Fugro Report No. 04.10120193 dated April 11, 2013. We appreciate the opportunity to be of continued service to LAN. Please call us if you have any questions with this report or when we may be of further service.

Sincerely,
FUGRO CONSULTANTS, INC.
TBPE Firm Registration No. F-299

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Senior Project Professional

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1.0 INTRODUCTION

1.1 Project Description

We understand that the Port of Port Arthur is planning to expand their existing wharf to include a new berth, designated Berth 6, at their facility along the Sabine-Neches Ship Channel in Port Arthur, Texas. A *Vicinity Map* of the project site is presented on Plate 1. The proposed Berth 6 will include construction of a 61.5-foot wide, 600-foot long extension of the existing pile supported wharf and extension of the existing bulkhead wall and accompanying anchor wall. The new berth will be dredged to a design dredge depth of El. -50 feet MSL[1], which includes a 2-foot over dredge allowance. Fugro performed a previous geotechnical investigation at the project site and provided recommendations for the proposed Berth 6, and associated bulkhead anchor walls in Fugro Report No. 04.10120193 dated April 11, 2013.

Based on the information provided to us by LAN, we understand that the current plans include development of the area behind the proposed Berth 6. The development will include grade raise activities and construction of a laydown area or storage yard. We understand the laydown area will extend approximately 200 feet beyond the bulkhead wall. The design live load for the laydown area is 1,000 psf. Anchor rods for the proposed bulkhead wall will be installed behind the proposed berth connecting to the anchor wall to be constructed within the footprint of the laydown area approximately 100 feet behind the proposed bulkhead. The project also includes modifications to approximately 200 lineal feet of existing bulkhead and anchor wall system that falls within the footprint of the Berth 6 expansion.

1.2 Purposes and Scope

The purpose of our geotechnical study was to provide geotechnical recommendations to assist the Project Team in their design and construction of the proposed Berth 6 expansion. Our recommendations in this report supplement our original geotechnical report for the proposed Berth 6 expansion and were limited to the evaluation of the following items.

- Impact of extending the dredge depth from El. -45 feet to El. -50 feet.
- Impact of site grade raise activities in laydown area from the current grade of approximately El. +8 feet to a finished design grade of El. +15 feet.
- Impact of using light weight aggregate versus structural sand fill for backfilling and site grade raise activities in the laydown area.
- Impact of extending the dredge depth to El. -50 feet on the existing 200 lineal-feet of bulkhead wall within the footprint of the Berth 6 expansion.

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[1] All the elevations presented herein are based on Mean Sea Level (MSL).

We accomplished this purpose by performing the following scope of services.

- Reviewing existing data from geotechnical reports provided to us by LAN and previous studies performed by Fugro in the area.
- Drilling 3 additional geotechnical soil borings, each to a depth of 60 feet below existing grade, to explore subsurface conditions and obtain samples for geotechnical laboratory testing.
- Performing field and laboratory tests on selected soil samples to evaluate the engineering properties of the subsurface soils.
- Analyzing the field and laboratory data to develop geotechnical engineering recommendations for the proposed structures.
- Preparing this engineering report summarizing our findings and recommendations.

Environmental assessments, compliance with state and federal regulatory requirements, and environmental analyses, were beyond the scope of our services. A geologic fault study was also beyond the scope of our services.

1.3 Applicability of Report

The explorations and analyses, as well as the conclusions and recommendations in this report, were selected or developed based on our understanding of the project as described herein. If there are differences in location or design features as we understand them, or if the locations or design features change, we should be authorized to review the changes and, if necessary, to modify our conclusions and recommendations.

We have prepared this report exclusively for LAN to assist them in their design and construction of the proposed Berth 6 expansion as described in this report. We have conducted this study using the standard level of care and diligence normally practiced by recognized engineering firms now performing similar services under similar circumstances. We intend for this report, including all illustrations, to be used in its entirety. This report should be made available to prospective contractors for information purposes only. It should not be construed to represent a warranty of subsurface conditions nor should this report be used as a stand-alone construction specification document.

2.0 FIELD INVESTIGATION

Our field activities related to geotechnical soil borings are discussed in this section. We have included discussions relating to drilling and sampling methods, depth-to-water measurements, and borehole completion.

2.1 General

We explored the subsurface soil conditions by drilling 3 soil borings, designated Borings B-6 through B-8, each to a depth of 60 feet below grade. The approximate boring locations are shown on the *Plan of Borings* presented on Plate 2. We selected the boring locations and they were staked onsite by Port of Port Arthur personnel. The boring coordinates presented on the boring logs were obtained in the field using our hand held GPS device.

2.2 Drilling and Sampling Methods

We completed our borings using an all-terrain vehicle (ATV) rig and a combination of both dry-auger and wet rotary drilling techniques. Each of the borings was initially drilled using dry-auger techniques to depths of 10 to 17 feet below existing grade. The borings were then completed using wet rotary techniques. Detailed descriptions of the soils encountered in the borings drilled for this study are presented on the boring logs in Appendix A on Plates A-1 through A-3. A key identifying the terms and symbols used on the boring logs is presented on Plates A-4a and A-4b.

Soil samples were generally taken at about 2-foot intervals to the completion depth of the borings or to a depth of 16 feet, and at about 5-foot intervals thereafter to the termination depth of the borings as indicated on the boring logs. Undisturbed samples of cohesive soils were generally obtained by hydraulically pushing a 3-inch diameter, thin-walled tube a distance of about 24 inches. Our field procedure for cohesive soil sampling was conducted in general accordance with ASTM D1587 (Standard Practice for Thin-Walled Tube Sampling of Soils). The samples were extruded in the field and visually classified by our field technician. We obtained field estimates of the undrained shear strength of the recovered samples using a hand penetrometer or Torvane. The field estimates were modified for stiff to hard, over-consolidated natural cohesive soils, as described on Plate A-4b. Portions of each recovered soil sample were placed into appropriate containers for transportation to our laboratory.

Granular soil samples were generally obtained using the Standard Penetration Test (SPT) as described on Plate A-4b. Our field procedure for granular soil sampling was conducted in general accordance with the ASTM D1586 (Standard Method for Penetration Test and Split-Barrel Sampling of Soils). Our field technician recorded the hammer blows for each sampling interval. The SPT N-values, as described on Plate A-4b, are recorded on the boring logs. Soil samples obtained from the split-barrel sampler were visually classified, packaged by the technician, and transported to our laboratory for testing.

2.3 Depth-to-Water Measurements

Depth-to-water observations were performed in each boring in an effort to identify the depth-to-water at the site. Discussion of our interpretation of the depth-to-water conditions at the site is presented later in the *General Site Conditions* section of this report.

2.4 Borehole Completion

After the completion of drilling and sampling activities, we backfilled the borings with cement-bentonite grout. The grout was placed in each borehole from the bottom up using a tremie pipe. When grout returned to the surface, we removed the tremie pipe and topped off each borehole by pouring grout from the surface.

3.0 LABORATORY TESTING

The laboratory testing program for this geotechnical study was directed toward evaluating the classification properties, undrained shear strength and compressibility characteristics of the subsurface cohesive soils. Our laboratory tests were performed in general accordance with the appropriate ASTM standards as tabulated at the end of this section.

3.1 Classification Tests

The classification tests included tests for natural water content, liquid and plastic limits (collectively termed Atterberg limits), and material finer than the No. 200 sieve (percent fines). These tests aid in classifying the soils and are used to correlate the results of other tests performed on samples taken from different borings and/or different depths. The results of the classification tests are provided in the boring logs in Appendix A.

3.2 Shear Strength Tests

We measured the undrained shear strength from selected undisturbed samples of cohesive soils by performing miniature vane shear tests, unconfined compression, and unconsolidated-undrained triaxial compression tests. The natural water content and dry unit weights were determined as routine parts of the shear strength tests. The results of the laboratory shear strength tests, along with the field estimates of shear strength, are presented on the boring logs in Appendix A.

3.3 Soil Compressibility

The compressibility characteristics of select undisturbed samples of cohesive soils were determined by completing 6 one-dimensional incremental consolidation tests. Natural moisture content, Atterberg limits, percent fines, and dry unit weight of the soil samples were also determined as part of our incremental consolidation testing. The results of the incremental consolidation tests are provided in Appendix B on Plates B-1 through B-6.

3.4 Summary

A summary of the laboratory testing performed for this study is presented in Table 3-1. The table includes the test description, quantity of tests performed, and the testing method generally followed.

Table 3-1. Laboratory Test Summary

Laboratory Test	Quantity	Testing Standard
Water Content	24	ASTM D2216
Atterberg Limits	10	ASTM D4318
Percent Passing the No. 200 Sieve	19	ASTM D1140
Unit Dry Weight	21	ASTM D7263
Miniature Vane Shear	6	ASTM D4648
One-Dimensional Incremental Consolidation	6	ASTM D2435
Unconfined Compression	5	ASTM D2166
Unconsolidated-Undrained Triaxial Compression	10	ASTM D2850

4.0 GENERAL SITE CONDITIONS

The interpreted site and subsurface conditions based on our field exploration and laboratory testing are discussed in this section.

4.1 Site Location and Description

The project site is located at the Port of Port Arthur Facility along the western bank of the Sabine-Neches Ship Channel in Port Arthur, Texas. *A Vicinity Map* showing the project site is presented on Plate 1. The proposed expansion will be on the west side of the existing wharf and will include the new Berth 6. The laydown area is behind the proposed Berth 6 and will extend approximately 200 feet. The borings for this study were drilled within the footprint of the proposed laydown area. Based on our review of publically available historical aerial imagery, the site has experienced multiple phases of excavation and dredge placement activities. Recent site activities include backfilling of a drainage ditch in the area. We drilled boring B-7 within the footprint of the backfilled drainage ditch. The subsurface conditions described in our report generally include the results of our review of existing data for the project site and the subsurface conditions encountered during our current geotechnical study.

4.2 Subsurface Conditions

The subsurface conditions within the depths explored at the project site consist primarily of natural cohesive soils with intermittent layers of cohesionless soils. Detailed descriptions of the soils encountered in the borings performed for this project are presented on the boring logs in Appendix A. The observed subsurface stratigraphy at the project site is generalized in the following sections.

4.2.1 Stratum I. Stratum I soils are comprised of cohesive fill soils extending from the existing ground surface to El. -10 feet to El. -24 feet. The Stratum I fill soils observed at the site consisted of clay and sandy clay. Measured moisture content in the Stratum I cohesive soils ranged from 16 to 33 percent. Results from liquid limit tests performed on soil samples obtained from Stratum I cohesive soils ranged from 31 to 72, plastic limits ranged from 10 to 14, and plasticity indices ranged from 18 to 58, indicative of moderately to very highly plastic cohesive soils. Field estimates and laboratory tests indicate that the undrained shear strength of the Stratum I cohesive soils generally range from soft (400 psf) to very stiff (greater than 3,500 psf). The percentage of material passing the No. 200 sieve measured in tests performed on samples of the Stratum I granular soils was 71 to 96 percent. We observed sand pockets, crushed stone, concrete fragments, metal debris, calcareous nodules, ferrous nodules, organics and shell fragments in the Stratum I fill soils.

4.2.2 Stratum II. Stratum II soils are comprised of very soft to very stiff natural cohesive soils and were observed beneath the Stratum I soils to a depth of approximately El. -58 feet, the maximum depth explored in this study. The Stratum II natural cohesive soils observed at the site consisted of clay, silty clay, and sandy clay. Measured moisture content in the Stratum II cohesive soils ranged from 21 to 50 percent. Results from liquid limit tests performed on soil samples obtained from Stratum II ranged from 37 to 88, plastic limits ranged from 11 to 19, and plasticity indices ranged from 22 to 69, indicative of moderately to very highly plastic cohesive soils. Field estimates and laboratory tests indicate that the undrained shear strength of the Stratum II soils generally range from very soft (200 psf) to very stiff (2,400 psf). We observed sand pockets, calcareous nodules, and ferrous nodules in the Stratum II cohesive soils.

4.2.3 Stratum III. Stratum III soils consist of intermittent layers of granular soil encountered within the cohesive soils of Stratum II. The Stratum III granular soils observed at the site consisted of silt and silty sand. Isolated layers of Stratum III were observed from approximately El. -10 feet to El. -20 feet in Boring B-6, from El. -15 feet to El. -20 feet in Boring B-7, and from El. -15 feet to El. -25 feet in Boring B-8. The percentage of material passing the No. 200 sieve measured in tests performed on samples of the Stratum III granular soils varied from approximately 24 to 98 percent. SPT blow counts indicate that the natural granular soils are generally very loose to dense, with blow counts ranging from 2 to 38 blows per foot.

Additional information about the soils encountered in the borings drilled for our study can be found on the boring logs presented in Appendix A.

4.3 Depth-to-Water Conditions

Depth-to-water observations were performed in each boring in an effort to identify the depth-to-water at the site. Free water was initially encountered at a depth of about 15.8 feet below existing grade and at a depth of about 14.5 feet after 15 minutes of observation in Boring B-6. Borings B-7 and B-8 were drilled using wet rotary techniques before free water was encountered. Hence, depth-to-water was not measured in these borings.

Please note that short-term depth-to-water observations recorded in open boreholes should ***not*** be considered to represent a long-term condition. The time associated with short-term observations may not be sufficient for the conditions in the open borehole to reach equilibrium especially in highly plastic soils. More accurate determinations of groundwater levels are usually made using long-term standpipe piezometer readings. It should be noted that groundwater levels will fluctuate due to seasonal variations in rainfall and surface runoff, and from water levels in the Sabine-Neches Channel. Perched water may be encountered in the fill soils. For foundation design purposes, the groundwater level should be considered at the ground surface.

4.4 Variations in Subsurface Conditions

Our interpretations of soil conditions, as described in this report, are based on data obtained from our visual observations, sample borings, laboratory tests, and our experience. Although we have allowed for minor variations in the subsurface conditions, our recommendations may ***not*** be appropriate for subsurface conditions other than those reported herein. It is possible that some undisclosed variations in soil conditions might occur outside the boring locations, especially along the mudline due to depositional channel action of the Sabine-Neches Channel as well as dredging and other channel maintenance activities. We also expect that variations are present between borings as result of discontinuous zones of granular soils that are the result of buried or abandoned drainage features and previous dredge fill placement activities. As such, we recommend careful observations during construction to verify our interpretations. Should variations from our interpretations be found, we recommend that we be notified and authorized to evaluate what, if any, revisions should be made to our recommendations.

5.0 BULKHEAD WALL RECOMMENDATIONS

The proposed Berth 6 expansion includes extension of the existing bulkhead wall and accompanying anchor wall. This section provides the results of our global stability analysis performed for the dredge slope underneath the deck and our recommendations for lateral earth pressures to be used in the design of the proposed bulkhead wall. We understand that the proposed dredge depth will be at El. -50 feet. This includes a 2-foot of over-dredge allowance. The results of our analysis and our recommendations for the proposed bulkhead wall presented in this section should supersede our previous bulkhead wall recommendations presented in Section 6 of Fugro Report No. 04.10120193.

We were also requested to evaluate 200 lineal-feet of existing bulkhead and anchor wall system that is within the footprint of the proposed Berth 6 expansion. We understand that the sheets of the existing bulkhead wall terminate at alternating elevations of El. -60 feet and El. -70 feet. The 200 lineal-feet of existing bulkhead also includes a pile-supported relieving platform immediately behind the bulkhead. The platform is located at approximately El. +3.5 feet and extends approximately 25 feet behind the back of the wall.

5.1 Introduction

Our scope of services included evaluation of the global stability of the proposed bulkhead wall expansion and the slope stability of the dredge slope in front of the bulkhead wall, and global stability of the existing bulkhead wall and anchor system. We have provided geotechnical soil parameters to assist the Project Team in their design of the proposed bulkhead wall in Fugro Report No. 04.10120193. The ultimate design of the bulkhead wall and dredge slope should satisfy requirements for global and slope stability and be able to resist the anticipated lateral forces. We performed the global stability analysis for the proposed bulkhead wall and anchor system by deepening the dredge depth from El. -45 feet as evaluated in our original study to El. -50 feet. We also evaluated the existing bulkhead wall and anchorage system using a proposed dredge depth of El. -50 feet. The results of our global stability analysis are provided in the following sections.

5.2 Loading Conditions

The selection of geotechnical parameters and our method of analyses are in general accordance with the guidelines outlined in the United States Army Corps of Engineers (USACE) EM 1110-2-2504[2], Naval Facilities Engineering Command (NAVFAC) DM 7.2[3], and our experience with similar structures and subsurface conditions. The proposed bulkhead wall should be evaluated for short-term, long-term, and rapid drawdown conditions. Our experience has shown that long-term conditions are often the most critical. For satisfactory performance, the proposed dredge slope

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[2] Design of Sheet Pile Walls, EM 1110-2-2504, 31 March 1994, United States Army Corps of Engineers.

[3] Foundations and Earth Structures, DM 7.2, 1 September 1986, Naval Facilities Engineering Command.

underneath the deck and shoreline slope should have an acceptable factor of safety during their entire projected time of service. Factors of safety for all potential loading conditions and modes of failure should be considered. The following paragraphs discuss each stability condition that should be analyzed.

5.2.1 Short-Term (Undrained). Short-term (undrained) loading conditions models the soil condition during and immediately following construction. EM 1110-2-2504 indicates that the end of construction usually represents the critical short-term (undrained) loading condition for bulkhead walls. For this loading condition, any excess pore pressures developed during construction activities have not had the opportunity to dissipate. A factor of safety of at least 2 should be applied to the passive soil pressures for this loading condition according to EM 1110-2-2504. In general accordance with USACE EM 1110-2-1913[4], we recommend a minimum factor of safety of 1.3 for global stability in short-term conditions. We performed our analysis with an assumed water surface elevation at El. -0.61 feet at the bulkhead wall sloping to the ground surface at El. +15 feet behind the face of the wall.

5.2.2 Long-Term (Drained). The long-term (drained) loading condition models the soils after excess pore water pressures have dissipated to post-construction equilibrium and post-construction consolidation of the cohesive soils has taken place. EM 1110-2-2504 indicates that a factor of safety of 1.5 should be applied to the passive soils pressures for long-term conditions. In general accordance with USACE EM 1110-2-1913, we recommend a minimum factor of safety of 1.5 for global stability in long-term conditions. Our long-term analysis modeled the depth-of-water using the same assumptions as used in our short-term analyses. It should be noted that relatively minor differences in the selected soil parameters for long-term analysis can have a significant impact on the results of our analyses. Discussion relating to soil parameters is presented later in this section.

5.2.3 Rapid Drawdown. Under certain circumstances, many slopes along rivers, creeks, bayous, channels, and basins are subject to rapid drops in the water level. This condition is known as rapid drawdown and causes seepage stresses in the slope that require special attention. Long-term (drained) soil parameters are used in evaluating this loading condition. In general accordance with USACE EM 1110-2-1913, we recommend a minimum factor of safety of 1.0 for global stability in rapid drawdown conditions. In rapid drawdown analysis, it is assumed that the water surface elevation is at El. +15 feet behind the face of the bulkhead wall and suddenly drops down to El. -0.61 feet at the bulkhead wall.

5.3 Soil Parameters

Undrained soil parameters (undrained cohesion and undrained friction angle) and drained soil parameters (drained cohesion and drained friction angle) were selected for each soil stratum

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[4] Design and Construction of Levees, EM 1110-2-1902, 30 April 2000, United States Army Corps of Engineers, Washington, D.C.

based on the results of our laboratory and field testing performed as part of this study, correlations with published papers, and our experience with similar projects and subsurface conditions. Short-term soil parameters were selected based on the pocket penetrometer readings and SPT blow counts obtained from the field testing and soil strength readings and grain size analysis readings obtained from the laboratory testing. The long term soil parameters were selected based on the SPT blow counts obtained from the field testing and soil strength readings obtained from consolidated-undrained (CU) triaxial tests and grain size analysis readings obtained from the laboratory testing. The soil parameters in each boring were evaluated across the site and an idealized subsurface profile was developed based on the observed stratigraphy across the site.

The soil parameters used in our evaluation of the proposed bulkhead wall are presented in Fugro Report 04.10120193, and are reproduced here again for clarity in Table 5-1 and Table 5-2. The soil parameters used in the evaluation of the existing bulkhead wall for short-term and long-term conditions are presented in Table 5-3 and Table 5-4. The soil parameters used for long-term loading conditions are also used for rapid drawdown loading conditions. A discussion of our methodology in selecting geotechnical parameters is presented in the following sections.

5.3.1 Undrained Soil Parameters. We selected our undrained soil parameters by reviewing the results of our field exploration and laboratory testing. Granular soil conditions were based on the results of SPT blow counts and laboratory grain size analyses. The SPT and laboratory grain size data were obtained from the boring logs for each location. For stability purposes, the undrained angle of internal friction, ϕ, was based primarily on relative density correlations with SPT blow counts as developed by Terzaghi and Peck[5] as well as Lambe and Whitman[6]. Unit weight values for granular soils were also based on published relative density correlations with SPT blow counts recorded during our field exploration activities.

Undrained soil parameters for cohesive soils were similarly developed using a combination of unconfined compressive strength measurements taken during field exploration activities with a hand penetrometer and shear strength measurements with a Torvane. We also used the results of laboratory unconfined compressive strength, unconsolidated-undrained triaxial compression, and miniature vane tests. Unit weight values were determined based on measured unit weight values in the laboratory. To develop our design soil parameters, we reviewed the boring logs for soil strength, unit weight, and plasticity information at each boring location. The undrained shear strength parameters used for the evaluation of proposed bulkhead wall are presented in Table 5-1, and the undrained shear strength parameters used in the evaluation of existing bulkhead wall are presented in Table 5-3.

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[5] Terzaghi, K. and Peck, R.B., Soil Mechanism in Engineering Practice, 2nd Ed., John Wiley and Sons, New York, 1967, pp. 22-42, 341.

[6] Lambe, T.W. and Whitman, R.V., Soil Mechanics, John Wiley and Sons, New York, 1969, pp. 148-149, 352-373, 423-486.

5.3.1 Drained Soil Parameters. Drained soil parameters were also selected based on our review of the results of field exploration and laboratory testing. Granular soil conditions were based on the results of SPT blow counts and laboratory grain size analyses similar to the undrained condition described above. We developed our drained shear strength parameters of cohesive soils by evaluating the results of various shear strength tests performed on the recovered soils from the site. Particularly, we considered the results of consolidated-undrained shear strength tests presented in Appendix C of Fugro Report No. 04.10120193. The drained shear strength parameters used for the evaluation of proposed bulkhead wall are presented in Table 5-2, and the drained shear strength parameters used in the evaluation of existing bulkhead wall are presented in Table 5-4.

The soil parameters for the existing bulkhead wall were chosen based on information available from our exploration activities, including borings and CPT soundings performed as part of our original study. We also reviewed the results of existing geotechnical studies as listed in Fugro Report No. 04.10120193. It should be noted that the soil profile used in the evaluation of the existing bulkhead wall was heavily influenced by the subsurface conditions observed in the nearest exploration locations, including Boring B-3 and CPT-9. As such, there is some variability between the soil parameters used in our analysis for the existing 200 lineal feet of bulkhead wall and the proposed bulkhead wall to be constructed as part of the Berth 6 expansion.

Table 5-1. Undrained Soil Parameters – Proposed Bulkhead Wall – Short-Term Conditions

Soil Type	**Soil Stratum***	**Elevation (feet)**		**Effective Unit Weight, γ'**	**Cohesion, c**	**Friction Angle, ϕ**
		Top	**Bottom**	**(pcf)**	**(psf)**	**(deg)**
Sand (LWA**)	-	15	-1	8	-	35
Firm Clay***	I	15	-1	58	800	-
Stiff Clay	I,II	-1	-28	58	1,000	-
Sand	III	-28	-43	53	-	25
Firm Clay	II	-43	-60	58	800	-
Stiff Clay	II	-60	-100	58	1,700	-
Firm Clay	II	-100	-110	58	700	-
Stiff Clay	II	-110	-170	58	2,000	-

* Soil Stratum are summarized in Section 4 of this report.

** Light Weight Aggregate (LWA) will be placed 100 feet behind the bulkhead wall where anchor rods will be installed.

*** The area behind the LWA will be backfilled with select fill material to raise the existing grade.

Table 5-2. Drained Soil Parameters – Proposed Bulkhead Wall – Long-Term Conditions

Soil Type	Soil Stratum*	Elevation (feet)		Effective Unit Weight, γ'	Cohesion, c	Friction Angle, ϕ
		Top	Bottom	(pcf)	(psf)	(deg)
Sand (LWA**)	-	15	-1	8	-	35
Firm Clay***	I	15	-1	58	90	18
Stiff Clay	I,II	-1	-28	58	100	22
Sand	III	-28	-43	53	-	25
Firm Clay	II	-43	-60	58	90	18
Stiff Clay	II	-60	-100	58	200	22
Firm Clay	II	-100	-110	58	90	18
Stiff Clay	II	-110	-170	58	200	22

* Soil Stratum are summarized in Section 4 of this report.

** Light Weight Aggregate (LWA) will be placed 100 feet behind the bulkhead wall where anchor rods will be installed.

*** The area behind the LWA will be backfilled with select fill material to raise the existing grade.

Table 5-3. Undrained Soil Parameters – Existing Bulkhead Wall – Short-Term Conditions

Soil Type	Soil Stratum*	Elevation (feet)		Effective Unit Weight, γ'	Cohesion, c	Friction Angle, ϕ
		Top	Bottom	(pcf)	(psf)	(deg)
Sand (LWA**)	-	15	-1	8	-	35
Firm Clay***	I	15	-1	58	800	-
Sand	I, III	-1	-33	58	-	30
Stiff Clay	II	-33	-83	58	1,500	-
Silty Sand	III	-83	-108	53	-	28
Stiff Clay	II	-108	-138	58	2,000	-
Sandy Silt	III	-138	-153	58	-	30
Very Stiff Clay	II	-153	-165	58	2,500	-

* Soil Stratum are summarized in Section 4 of this report.

** Light Weight Aggregate (LWA) will be placed 100 feet behind the bulkhead wall where anchor rods will be installed.

*** The area behind the LWA will be backfilled with select fill material to raise the existing grade.

Table 5-4. Drained Soil Parameters – Existing Bulkhead Wall – Long-Term Conditions

Soil Type	Soil Stratum*	Elevation (feet)		Effective Unit Weight, γ'	Cohesion, c	Friction Angle, ϕ
		Top	Bottom	(pcf)	(psf)	(deg)
Sand (LWA**)	-	15	-1	8	-	35
Firm Clay***	I	15	-1	58	90	18
Sand	I, III	-1	-33	58	-	30
Stiff Clay	II	-33	-83	58	150	20
Silty Sand	III	-83	-108	53	-	28
Stiff Clay	II	-108	-138	58	200	22
Sandy Silt	III	-138	-153	58	-	30
Very Stiff Clay	II	-153	-165	58	250	22

* Soil Stratum are summarized in Section 4 of this report.
** Light Weight Aggregate (LWA) will be placed 100 feet behind the bulkhead wall where anchor rods will be installed.
*** The area behind the LWA will be backfilled with select fill material to raise the existing grade.

5.4 Slope and Global Stability

To evaluate the stability of the proposed bulkhead wall and the existing bulkhead wall for the dredge slopes as presented herein, we performed analyses on global stability considering short-term, long-term, and rapid drawdown conditions. We performed our stability analysis using the computer program *Slide*[7]. *Slide* randomly generates trial failure surfaces through a designed slope and evaluates the factor of safety for each trial failure surface. The program allows a large number of potential shear surfaces to be investigated to determine the critical failure surface for each of the analyzed slope configurations. We used the Simplified Bishop method in *Slide* to evaluate the global stability of the sheet pile wall. This method uses two-dimensional limit equilibrium analysis to determine the factor of safety for the slope. The computed factor of safety is the ratio of the forces resisting movement to the forces driving movement.

Global stability analyses should consider, at a minimum, static forces including soil, water, and surcharge loads. The analyses should also address the effects of dynamic forces, *e.g*. wind, waves, and vessel traffic, on the global stability. The effects of “extreme” events such as tropical storm or hurricane events may also be considered. The final design should be such that global stability is provided.

---

[7] *Slide 6.008* – 2D limit equilibrium slope stability analysis. Roc Science Slide

Based on information provided by LAN, we understand that the existing and proposed bulkhead wall have a top elevation at approximately El. +15 feet and a mudline at approximately El. -20 to -25 feet. The dredge slope in front of the wall slopes downward to an ultimate dredge elevation at approximately El. -50 feet. The dredge slope will include slope protection to protect against possible scour and erosion. Our analysis included a surcharge load of 1,000 psf behind the proposed and existing bulkhead walls, extending approximately 200 lineal feet. Site grade behind the bulkhead was evaluated with a finished grade elevation of El. +15 feet. Light weight aggregate was placed from El. +15 to -1 feet. We also understand that there is a 25 feet wide relieving platform behind the existing bulkhead wall founded at El. +3.5 feet. We have considered the relieving wall in the analysis of existing bulkhead wall section.

Soil parameters were selected based on the soil conditions encountered in our soil borings as summarized in Table 5-1 and Table 5-2 for the proposed bulkhead wall and in Table 5-3 and Table 5-4 for the existing bulkhead wall. The results of our analysis for the proposed bulkhead wall and existing bulkhead wall are summarized below in Table 5-5 and Table 5-6. Graphical representations of our stability analyses output are included in Appendix C. We recommend a minimum factor of safety of 1.3 for the global stability of the sheet pile wall for short-term loading conditions, 1.5 for long-term loading conditions, and 1.0 for rapid drawdown loading conditions. Based on our results, we recommend the design dredge slope be sloped 2.5-horizontal to 1-vertical from the top of the slope at El. -25 feet to the bottom of the slope El. -50 feet.

Table 5-5. Summary of Global Stability Analysis – Proposed Bulkhead Wall

Bulkhead Wall Length (feet)	Bulkhead Wall Tip Elevation (feet)	Surcharge (psf)	Loading Condition	Computed Factor of Safety
108	-93	1,000	Short-Term	1.4
			Long-Term	1.5
			Rapid Drawdown	1.4

Table 5-6. Summary of Global Stability Analysis – Existing Bulkhead Wall

Bulkhead Wall Length (feet)	Bulkhead Wall Tip Elevation (feet)	Surcharge (psf)	Loading Condition	Computed Factor of Safety
75	-60	1,000	Short-Term	1.4
			Long-Term	0.9
			Rapid Drawdown	0.8
85	-70	1,000	Short-Term	1.4
			Long-Term	1.0
			Rapid Drawdown	0.9
105	-91	1,000	Short-Term	1.7
			Long-Term	1.5
			Rapid Drawdown	1.3

We recommend constructing the proposal bulkhead wall and extending the existing bulkhead wall to El. -93 feet to meet the required factors of safety for short-term, long-term and rapid drawdown loading conditions. We understand that the final design of the proposed bulkhead wall has not been completed by the Project Team at the time of this report. We recommend performing global stability analyses once the final size and depth of the sheet pile wall and the location of the anchor system have been determined. The final design should be evaluated for short-term, long-term and rapid drawdown conditions. Recommendations for bulkhead wall analysis are provided in Fugro Report No. 04.10120193.

It should be noted that we observed isolated clay soils in Borings B-6 and B-8 that exhibited undrained shear strengths on the order of 600 to 800 psf at a depth of El. -100 to -108 feet. The factor of safety for short-term loading conditions is slightly less than the required factor of safety if this stratum is included in our analysis. Based on our experience, we believe that the bulkhead wall design is mainly governed by long-term stability and this stratum will not impact the stability of the wall at the time of construction.

6.0 SHORELINE PROTECTION RECOMMENDATIONS

The proposed Berth 6 expansion project also includes construction of approximately 1,200 lineal-feet of new shoreline protection between the end of the new dock and the State Highway 82 Bridge using articulated block mats anchored to the existing shoreline. Global stability analysis was performed for the new shoreline and the results are presented in Fugro Report No. 04.10120193. LAN requested Fugro to revise our analysis of the proposed shoreline protection presented in Section 4 of our original report based on a proposed dredge depth of El. -50 feet and a water elevation of El. -0.61 feet. Based on the information provided to us by LAN, we understand that the top of the slope will be at El. +6.0 feet. A surcharge load of 250 psf is used in our analysis. This section provides the results of our revised global stability analyses for the proposed shoreline protection and supersedes the analysis presented in Section 4 of our original report.

6.1 Soil Parameters

We developed soil parameters for our analysis based on the results of our geotechnical field exploration activities and laboratory testing program. The soil parameters used in our slope stability analysis are presented in Fugro Report 04.10120193, and are reproduced here again for clarity in Table 6-1.

Table 6-1. Soil Parameters – Shoreline Protection

Generalized Soil Type	Stratum	Elevation (feet)	Total Unit Weight (pcf)	Undrained (Short-Term)		Drained (Long-Term)	
				Cohesion, c (psf)	Friction Angle, ϕ (°)	Cohesion, c' (psf)	Friction Angle, ϕ' (°)
Stiff Clay	I, II	+6 to -28	120	1,000	-	100	22
Sand	III	-28 to -43	115	-	25	-	25
Firm Clay	II	-43 to -60	120	800	-	90	18
Stiff Clay	II	-60 to -100	120	1,700	-	200	22

6.2 Stability Analysis Results and Recommendations

The results of our global slope stability analyses for undrained (short-term), and drained (long-term) loading conditions for the proposed shore line protection are summarized in Table 6-2. The graphical results of our stability analyses are presented in Appendix C. For short-term, long-term and rapid drawdown conditions, the USACE EM 1110-2-1913 requires a minimum factor of safety (F.O.S.) of 1.3, 1.4 and 1.0, respectively. Our analyses were based on preliminary design drawings provided by LAN. We recommend that cross-section and survey data be provided during the final design to confirm the results of our global stability analyses.

It should be noted that our analyses assume slopes maintain their geometries as analyzed. This assumes no scour, erosion, or dispersion occurs. It is possible that slope geometries can change over time due to seepage, flood, and runoff events. We recommend a monitoring and maintenance program be established to repair and distress to the slopes. Considerations for scour and erosion protection are provided in Fugro Report No. 04.10120193.

Table 6-2. Global Stability Analyses Results – Section 4

Side Slope	**Short-Term Condition (Undrained)**		**Long-Term Condition (Drained)**		**Rapid Drawdown Condition**	
	Required Factor of Safety	**Calculated Factor of Safety**	**Required Factor of Safety**	**Calculated Factor of Safety**	**Required Factor of Safety**	**Calculated Factor of Safety**
2H:1V	1.3	1.2*	1.4	1.3*	1.0	1.3
2.5H:1V	1.3	1.3	1.4	1.5	1.0	1.4

* Does not meet the required minimum factors of safety

6.2.1 Slope Recommendation. Based on our analysis, a slope of 2.5-horizontal to 1-vertical meets the minimum required factors of safety for short-term, long-term, and rapid drawdown conditions with a top of slope elevation of El. +6 feet and an ultimate design dredge depth of El. -50 feet.

7.0 SITE GRADE RAISE

We understand that the current plans include development of the area behind the proposed Berth 6. The development behind the proposed Berth 6 will include grade raise activities to approximately El. +15 feet to facilitate the construction of a laydown area or storage yard. We understand that the grade raise will extend approximately 200 lineal-feet behind the bulkhead wall. The design live load for the laydown area is 1,000 psf. Anchor rods for the proposed bulkhead wall will be installed behind the proposed berth and connect to the anchor wall to be constructed within the footprint of the laydown area approximately 100 feet behind the proposed bulkhead. We understand that the tie-rods are currently proposed to be constructed at El. +3 feet. LAN requested that we perform settlement analysis for the proposed laydown area or storage yard behind the proposed Berth 6 to evaluate the impact of the site grade raise and design live load on the laydown area and the anchor rods.

7.1 Settlement Analysis

LAN is considering using light weight aggregate or granular fill material to raise the existing grade and to replace the existing surficial soils. Properly placed and compacted light weight aggregate is a granular material with a unit weight of approximately 70 pcf, roughly half that of traditional fill soils. The reduction in unit weight results in lower loads being imposed on the existing soil within the footprint of the laydown area. The reduced loads result in less settlement. We estimated settlement of laydown area by considering the placement of light weight aggregate and granular fill material. Of particular concern was the settlement observed at the depth of the anchor rods. We have provided the results of our settlement estimates at the depth of anchor rods and the ground surface within the laydown area in Table 7-1. Our analysis also included an evaluation of the impact of the live load of 1,000 psf across the laydown area.

Table 7-1. Settlement Analysis – Laydown Area

Site Grade Material	Unit Weight, γ (pcf)	Surcharge (psf)	Settlement at El. +3 feet (inches)	Settlement at El. +15 feet (inches)
Light Weight Aggregate	70	0	3	4
		1,000	10	12
Granular Fill	115	0	10	12
		1,000	18	22

7.2 Site Preparation

Site preparation prior to raising the grade within the proposed footprint of the laydown area should include clearing of debris, organics, pavements, crushed stone, and deleterious materials from the area to be raised. Following the removal of surficial soils to the required elevation, the exposed subgrade should be proofrolled and observed by the Geotechnical Engineer-of-Record or their qualified representative to evaluate the condition of the subgrade. We recommend that proofrolling be performed using a fully loaded dump truck or water truck with a weight of at least 20 tons and a tire pressure of at least 70 psi. We do not recommend that off road earth moving equipment (*i.e*. loaders or scrapers), compactors or track-mounted vehicles (i.e. bull dozers and front end loaders) for proofrolling. Proofrolling specifications should provide for rut depths less than 1 inch and no visual evidence of pumping. Areas of subgrade where rutting in excess of 1 inch or pumping are observed should also be removed. The site can then be brought to final grade using properly placed and compacted light weight aggregate or granular fill. We recommend scheduling subgrade preparation activities during a relatively dry period. We do not recommend that the subgrade preparation activities begin immediately after or during a significant rain event. Additional recommendations for site preparation are included in Fugro Report No. 04.10120193.

7.3 Light Weight Aggregate

Expanded Shale, Clay, and Slate (ESCS) light weight aggregates are approximately half the weight of fills that are commonly used. We understand that light weight aggregate will be placed next to the sheet pile wall from El. +15 to El. -1 feet. The light weight aggregate will have a bulk density less than 70 pounds per cubic feet with a friction angle ranging from 35^o to 45^o. Light weight aggregate shall meet the requirements of ASTM C 330.

7.4 Granular Fill

Granular fill can consist of crushed stone or sand with a maximum particle size of 4 inches and no more than 12 percent passing the No. 200 sieve. The material shall consist of sound particles, which are angular and not rounded. Numerous gradations will be applicable, however the material should be well graded and have sufficient fines to fill voids between larger particles. The gradation of the selected granular fill should be approved by the Geotechnical Engineer. Granular fill should be placed in lifts no greater than 8-inches, and at a moisture content within 2 percent of optimum moisture content, as determined by ASTM D698. Granular fill should be compacted to at least 98 percent of the maximum dry density, as determined by ASTM D698 using a vibratory roller.

8.0 BELOW GRADE STRUCTURES

We have provided our recommendations on allowable net bearing pressure and lateral earth pressures for walls for the proposed stormwater collection box to be constructed approximately 12 feet below grade in Fugro Report No. 04.10120193. We understand the footprint of the collection box is approximately 12 feet wide and 60 feet long and generally located between CPT-7 and Boring B-4. LAN requested that Fugro revise our calculations to evaluate the impact of the proposed grade raise to a final site grade of El. +15 feet.

8.1 Allowable Net Bearing Pressure

From a geotechnical perspective, the performance of a foundation system for the stormwater collection box should provide an adequate factor of safety against shear failure of the foundation soils and reduce the potential for excessive settlements due to overstressing of the underlying foundation soils. The collection box foundation should be designed such that the applied bearing pressures do **not** exceed the allowable net bearing pressure of the underlying soils.

The allowable net bearing pressure for the proposed collection box is a function of, among other items, the bearing surface, the strength of the foundation soils, the location of the foundation, the shape of the foundation, and the recommended factor of safety. The collection box foundation should be proportioned so the maximum contact pressure under dead, live, and transient loads, does **not** exceed the allowable net bearing pressure of the foundations soils. Total loading conditions as described in this report refers to the combination of properly factored dead and live loads. Transient loading conditions refer to the combination of dead, live, and infrequent transient loads.

For total loading conditions we recommend the net bearing pressure be limited to 2,000 psf. For transient loading conditions we recommend the net bearing pressure be limited to 2,600 psf. Allowable net bearing pressure, as used in this report, is defined on Plate 9. To calculate values of W_e, W_s, and W_f from Plate 9, use effective unit weights of 60 pcf for soil and 90 pcf for concrete.

The presented allowable net bearing pressures are for the collection box supported on undisturbed, competent firm to stiff cohesive soils. If wet, weak, or disturbed soils are encountered at the foundation depth then we recommend that the Geotechnical Engineer be consulted. The allowable net bearing pressures presented in this report include a factor of safety ranging between 1.5 to 3 with respect to shear failure of the foundation soils. The recommended net bearing pressures do not limit settlement. We anticipate that the proposed stormwater collection box may experience total consolidation settlements on the order of approximately 1 to 3 inches. A detailed settlement analysis for the collection box was beyond the scope of this study.

8.2 Lateral Earth Pressure on Below Grade Structures

Below grade walls should be designed to withstand permanent lateral earth pressures resulting from a combination of soil pressure, hydrostatic pressure, and surcharge loads. The distribution of lateral earth pressures on permanent non-yielding below grade walls is presented on Plate 3.

We understand that the design surcharge load for the laydown area is 1,000 psf. Surcharge loads should be evaluated if additional heavy loads are going to be present in the vicinity of the proposed below grade walls. We recommend that the allowable net passive pressure be taken as 800 psf for properly placed and compacted structural clay fill and as 600 psf for natural cohesive soils. We recommend that passive pressure be neglected to a depth of 5 feet unless area paving or other similar surface cover is provided.

It is possible a sloped excavation may be used to construct the proposed below grade structures. If this is the case, care should be taken during backfill operations not to over compact the backfill soils. Over compaction may induce significant stresses on walls. We recommend that compaction of the backfill soils not exceed 98 percent of the maximum dry unit weight of the placed soils. Hand held compaction equipment should be used to compact backfill within 4 to 8 feet of below grade walls. Settlement due to self-weight should be expected if compressive fill soils are used as backfill. Our experience indicates that properly placed and compacted fill soils may settle on the order of 1 to 2 percent of the fill height under self-weight.

If the wall is to be maintained in a relatively dry condition, backfill behind the walls should include at least 18 inches of free draining granular soils, or other engineered drainage system, along the wall extending from the base of the wall up to within about 3 feet of the surface. The granular soils or drainage system should collect the water and remove it from behind the walls with a discharge location or sumps and pumps. A 3-foot thick clay cover should be placed over the free draining granular soils or drainage system to reduce the potential for surface water entering the drainage soils or system behind the wall. Surface drainage should be provided away from all below grade structure walls.

ILLUSTRATIONS

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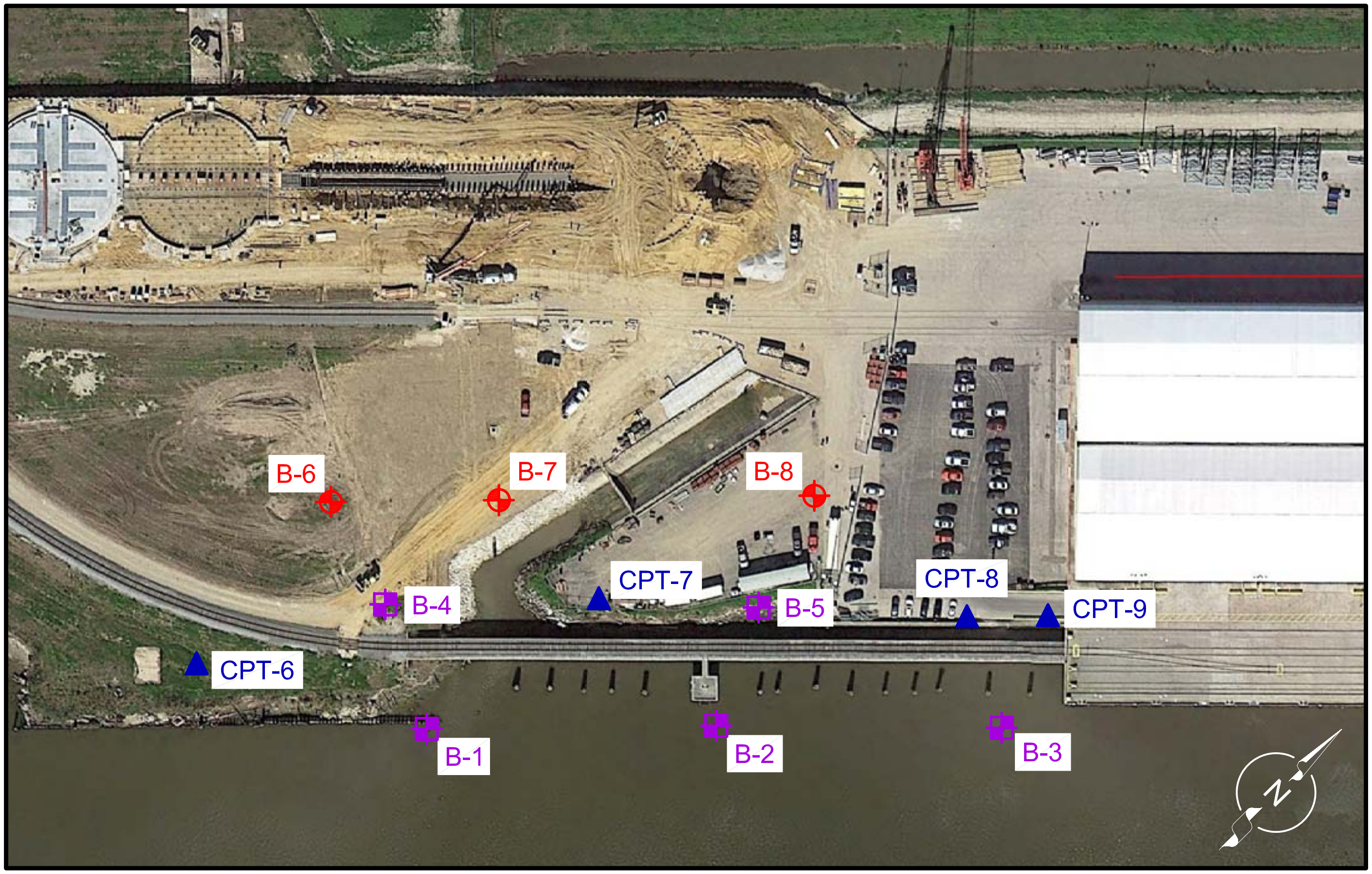
www.delorme.com

VICINITY MAP

BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS



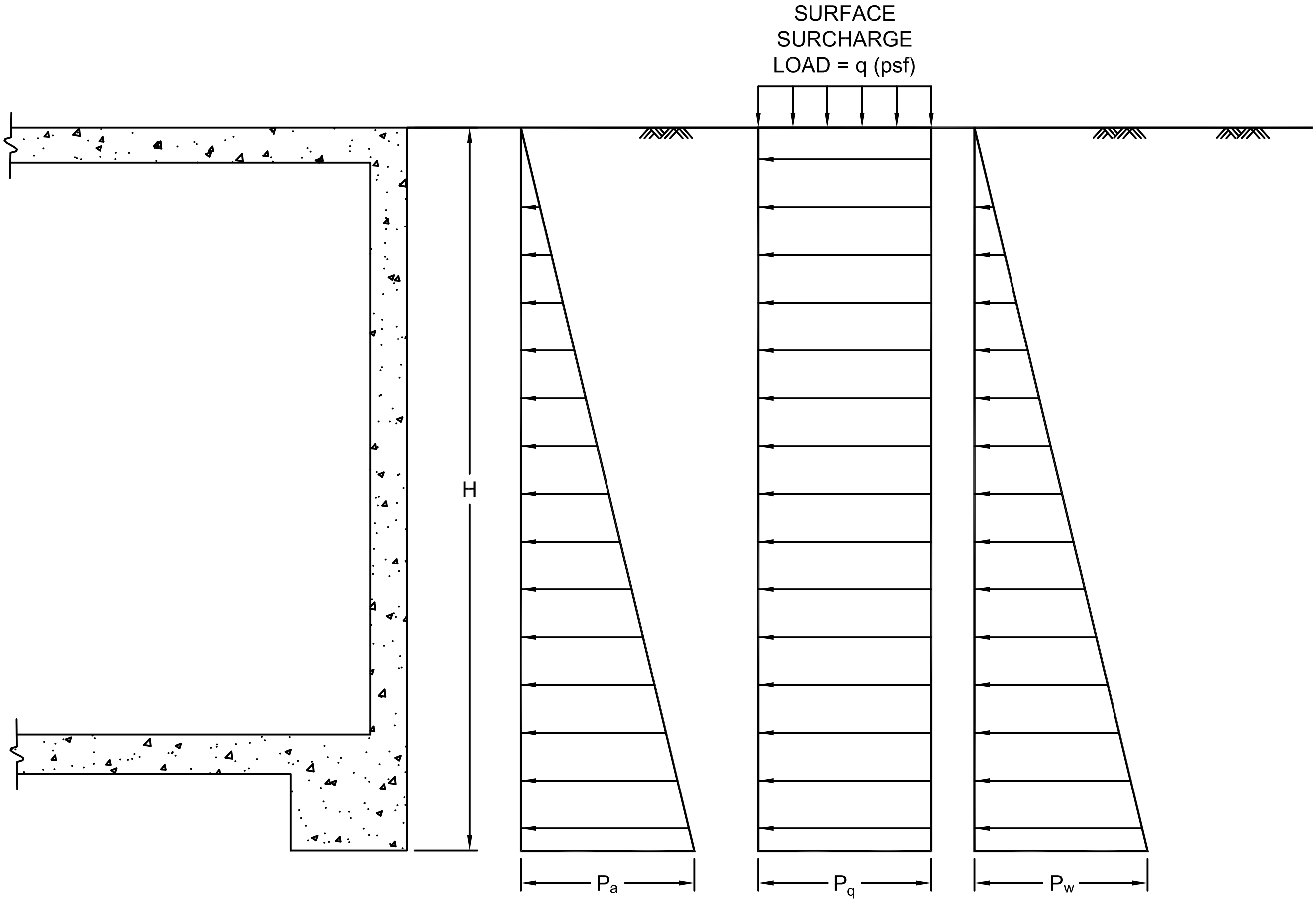
LEGEND

● B-6	GEOTECHNICAL BORING
▣ B-1	GEOTECHNICAL BORING FROM PREVIOUS FUGRO REPORT NO. 04.10120193 JULY 2012
▲ CPT-6	CONE PENETRATION TEST

NOTE:
1. BORING AND CPT LOCATIONS ARE APPROXIMATE.

0 150 300 FEET

PLAN OF BORINGS
BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS



NON-YIELDING WALLS

Soil: $P_a = 40\ (H)$, psf

Surcharge: $P_q = 0.5\ (q)$, psf

Water: $P_w = 63\ (H)$, psf

H = Excavation Depth, ft

q = Surcharge Load, psf

NOTES:

1. The lateral earth pressures shown above are for soils in contact with permanent below grade walls.
2. Lateral earth pressures assume hydrostatic pressures that develop behind the wall are short term.
3. These represent ultimate values. Structural Engineer should apply approximate safety or design factors. See report text for additional details.

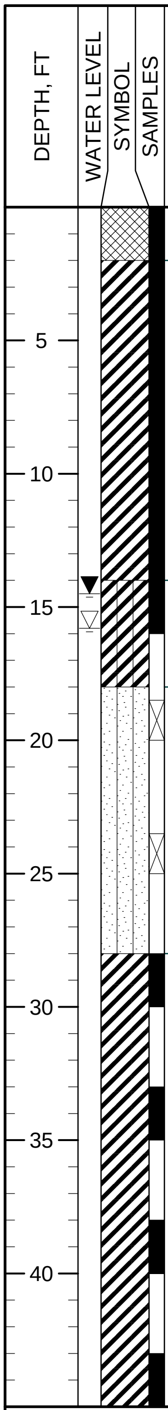
LATERAL EARTH PRESSURES FOR BELOW GRADE WALLS

BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS
(NOT TO SCALE)

APPENDIX A

GEOTECHNICAL SOIL BORING LOGS

LOCATION: See Plate 2
COORDINATES: 29°51'25.09"N
93°56'36.51"W
SURFACE EL.: 8' Approximately +8'

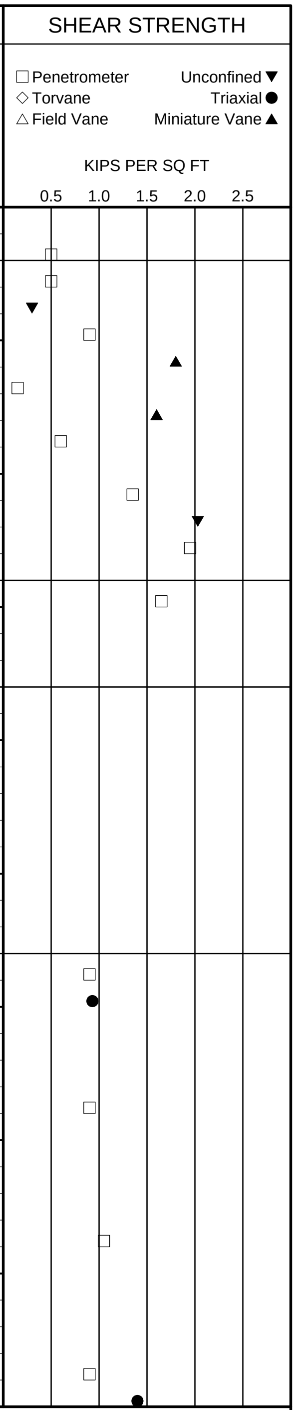


BLOWS PER FOOT	STRATUM DESCRIPTION	STRATUM DEPTH, FT
	FILL: CLAY, firm, tan, with sand pockets and crushed stone	2.0
	CLAY, soft to firm, dark gray, with organic materials - firm to stiff, dark gray, 4' to 6' - very soft to stiff, 6' to 8' - gray and tan, 6' to 10' - firm, 8' to 10' - stiff to very stiff, light gray and tan, with calcareous nodules and ferrous nodules below 10'	14.0
	SILTY CLAY, stiff, light gray and tan	18.0
2	SILTY SAND, very loose, red	
27	- medium dense, tan below 23'	28.0
	CLAY, firm, light gray and tan - stiff, below 38' - firm to stiff, below 43'	

CLASSIFICATION

UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	96				
90		32			
		25			
	90	24	44	11	33
	99	24	37	15	22
108		21			
	48				
	44				
94		30			
	80		66	14	52
77		44			

SHEAR STRENGTH

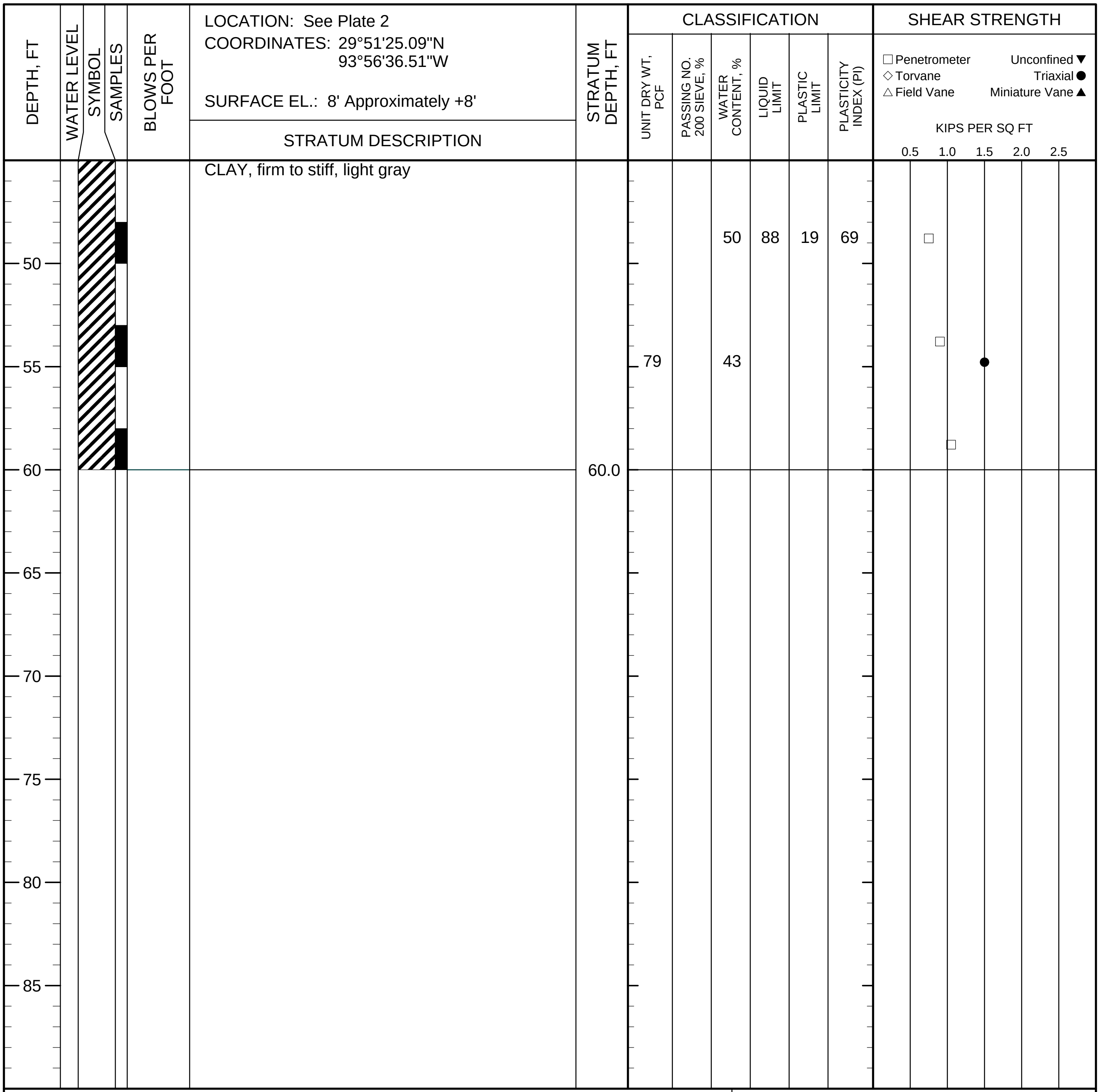


NOTES:
1. ▽: Water First Noticed. ▼: Depth To Water after 10 minutes.
2. Terms and symbols defined on Plates A-9a and A-9b.
3. Boring coordinates obtained using a hand-held GPS device.

DATE: June 26, 2013
TOTAL DEPTH: 60'
CAVED DEPTH: 18'
DRY AUGER: Surface to 17'
WET ROTARY: 17' to 60'
BACKFILL: Cement-Bentonite Grout
LOGGER: F. Lillie

LOG OF BORING NO. B-6
BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS

LOCATION: See Plate 2
COORDINATES: 29°51'25.09"N
93°56'36.51"W
SURFACE EL.: 8' Approximately +8'



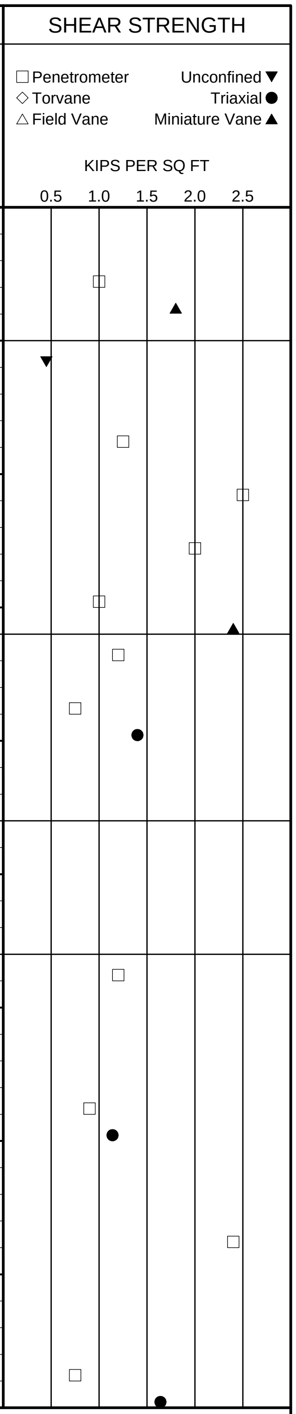
NOTES:
1. ▽: Water First Noticed.   ▼: Depth To Water after 10 minutes.
2. Terms and symbols defined on Plates A-9a and A-9b.
3. Boring coordinates obtained using a hand-held GPS device.

DATE: June 26, 2013
TOTAL DEPTH: 60'
CAVED DEPTH: 18'
DRY AUGER: Surface to 17'
WET ROTARY: 17' to 60'
BACKFILL: Cement-Bentonite Grout
LOGGER: F. Lillie

LOG OF BORING NO. B-6
BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS

LOCATION: See Plate 2
COORDINATES: 29°51'26.12"N
93°56'35.53"W
SURFACE EL.: 8' Approximately +8'

Blows per foot	Stratum description	Stratum depth, ft	Unit dry wt, pcf	Passing No. 200 sieve, %	Water content, %	Liquid limit	Plastic limit	Plasticity index (PI)
	FILL: SANDY CLAY, firm to stiff, brown and tan, with concrete fragments and organic material			71		31	13	18
					16			
	FILL: CLAY, soft, light gray and brown, with metal debris	5.0	90	93	33			
	- stiff to very stiff, below 8'							
				96		72	14	58
	- light tan and brown, with calcareous nodules and ferrous nodules below 13'							
	- with calcareous nodules 15' to 19'				20			
	SANDY CLAY, firm to stiff, light tan and brown - with calcareous nodules to 19'	16.0						
	- with ferrous nodules below 19'		104		23			
38	SILTY SAND, dense, tan	23.0		24				
	CLAY, stiff, tan	28.0		98	31			
	- firm to stiff, 33' to 38' - light gray and brown, 33' to 43'		91		35			
	- very stiff, 38' to 43'			99				
	- firm to stiff, gray, below 43'		81		38			



NOTES:
1. Free water not observed during drilling activities to a depth of 16'.
2. Terms and symbols defined on Plates A-9a and A-9b.
3. Boring coordinates obtained using a hand-held GPS device.

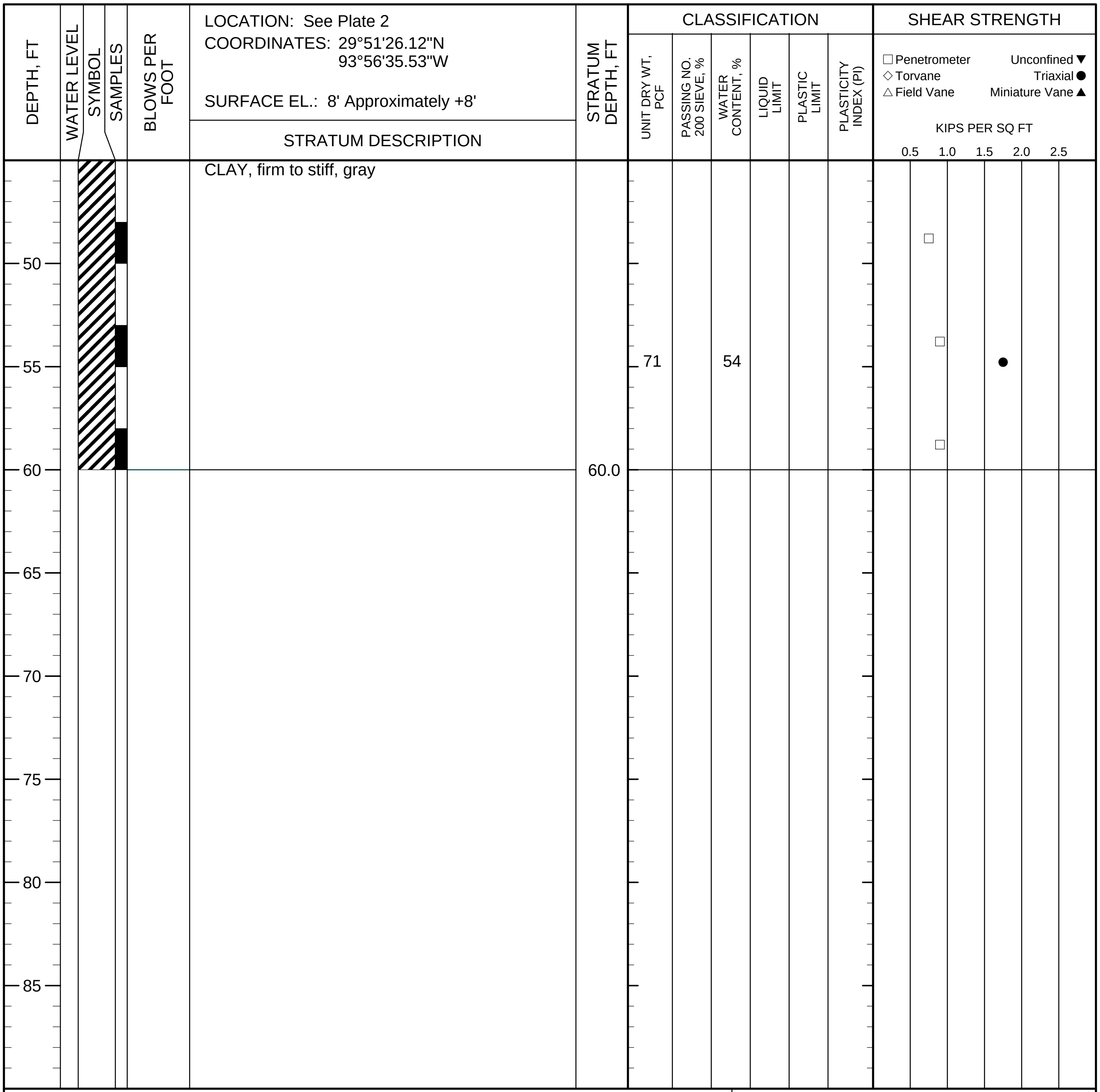
DATE: July 10, 2013
TOTAL DEPTH: 60'
CAVED DEPTH: Not Applicable
DRY AUGER: Surface to 16'
WET ROTARY: 16' to 60'
BACKFILL: Cement-Bentonite Grout
LOGGER: F. Lillie

LOG OF BORING NO. B-7
BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS

LOCATION: See Plate 2

COORDINATES: 29°51'26.12"N
93°56'35.53"W

SURFACE EL.: 8' Approximately +8'



NOTES:
1. Free water not observed during drilling activities to a depth of 16'.
2. Terms and symbols defined on Plates A-9a and A-9b.
3. Boring coordinates obtained using a hand-held GPS device.

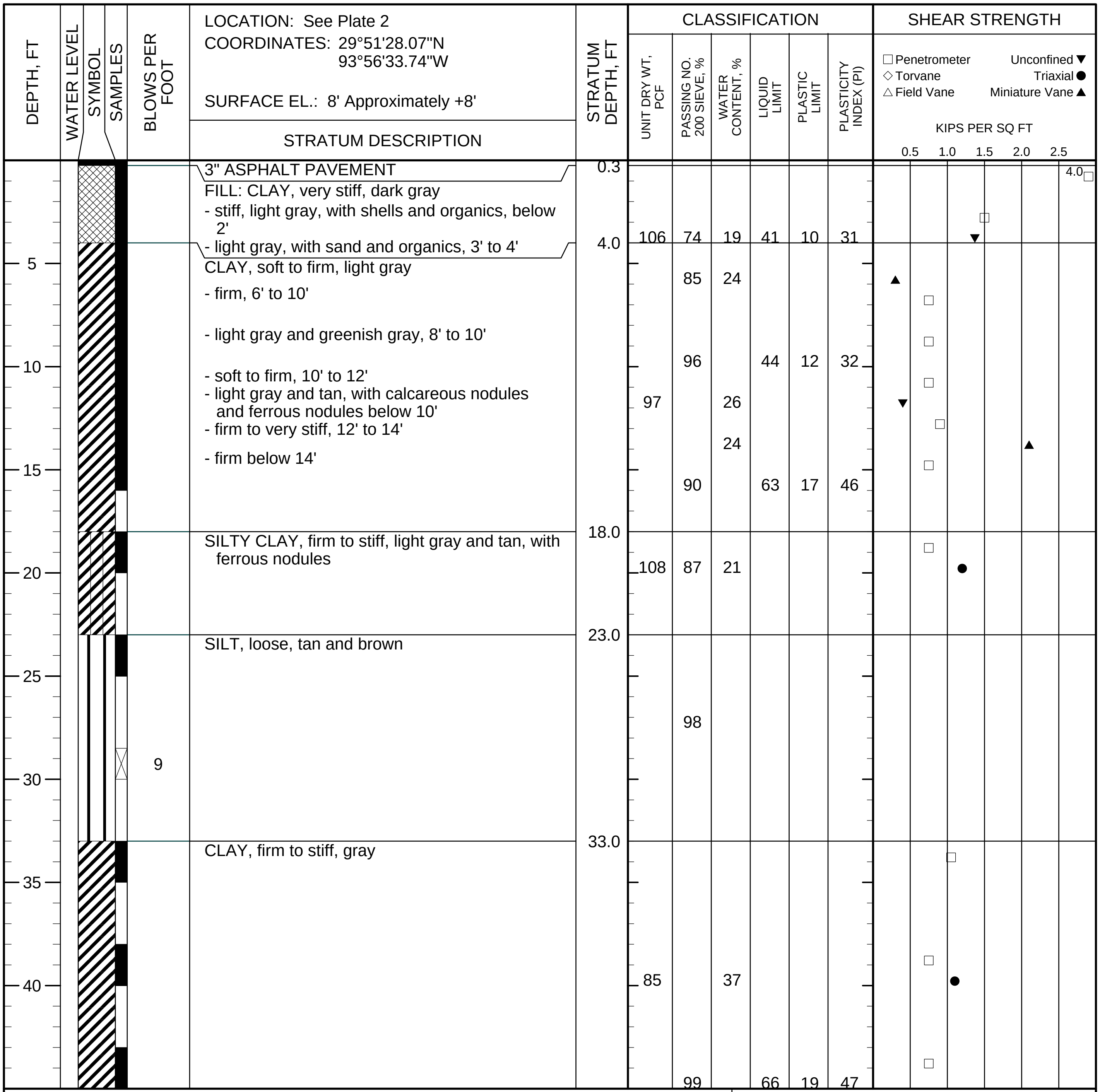
DATE: July 10, 2013
TOTAL DEPTH: 60'
CAVED DEPTH: Not Applicable
DRY AUGER: Surface to 16'
WET ROTARY: 16' to 60'
BACKFILL: Cement-Bentonite Grout
LOGGER: F. Lillie

LOG OF BORING NO. B-7

BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS

R:\04100\2012 PROJECTS\04.10120193\ADDITIONAL SERVICES - PHASE 2\DRAFTING\04.10120193.GPJ 0415-1415 10/23/2013

LOCATION: See Plate 2
COORDINATES: 29°51'28.07"N
93°56'33.74"W
SURFACE EL.: 8' Approximately +8'



STRATUM DESCRIPTION	STRATUM DEPTH, FT
3" ASPHALT PAVEMENT	0.3
FILL: CLAY, very stiff, dark gray - stiff, light gray, with shells and organics, below 2' - light gray, with sand and organics, 3' to 4'	4.0
CLAY, soft to firm, light gray - firm, 6' to 10' - light gray and greenish gray, 8' to 10' - soft to firm, 10' to 12' - light gray and tan, with calcareous nodules and ferrous nodules below 10' - firm to very stiff, 12' to 14' - firm below 14'	18.0
SILTY CLAY, firm to stiff, light gray and tan, with ferrous nodules	23.0
SILT, loose, tan and brown	33.0
CLAY, firm to stiff, gray	

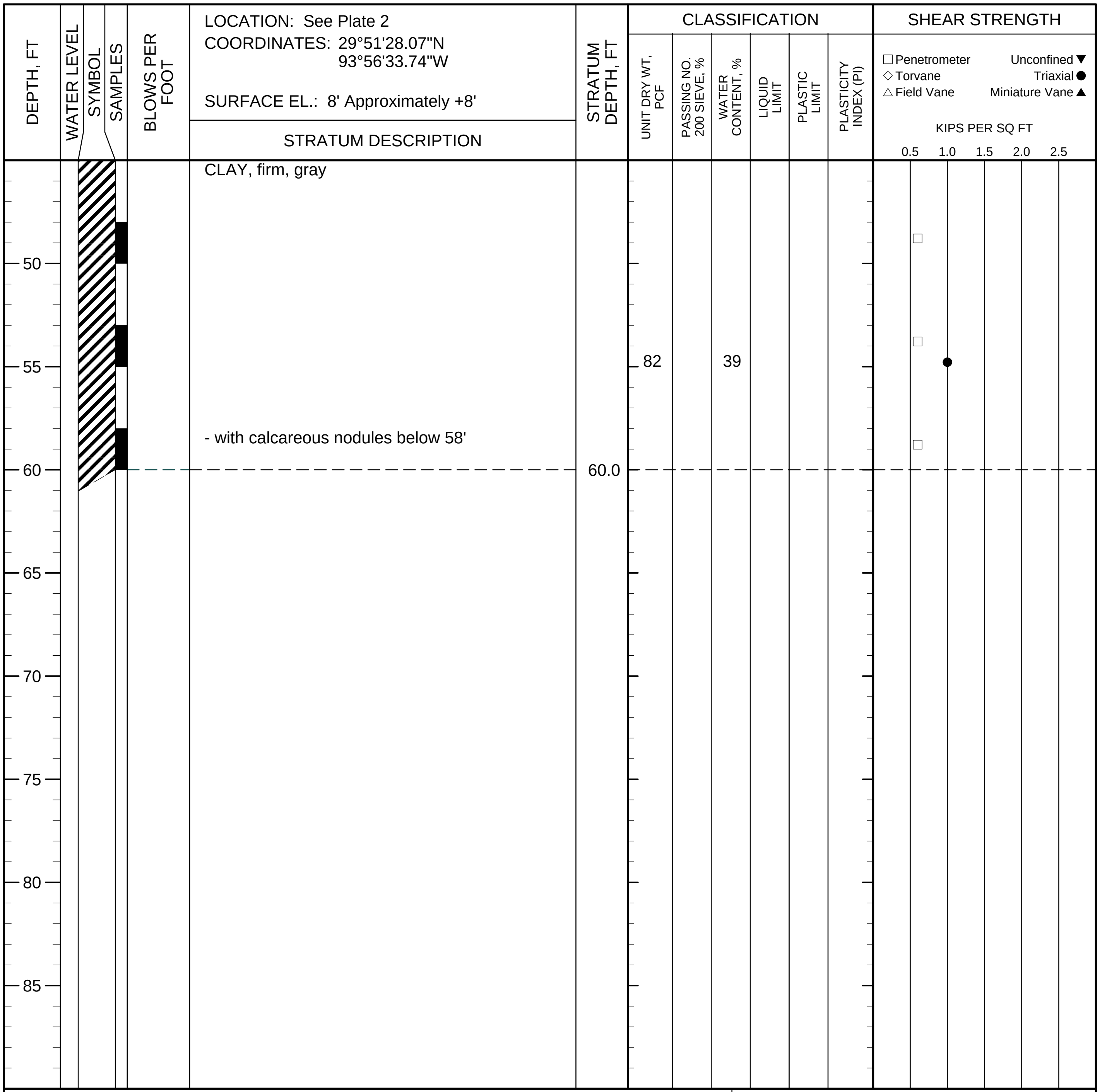
CLASSIFICATION					
UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
106	74	19	41	10	31
	85	24			
	96		44	12	32
97		26			
		24			
	90		63	17	46
108	87	21			
	98				
85		37			
	99		66	19	47

NOTES:
1. Free water not observed during drilling activities to a depth of 10'.
2. Terms and symbols defined on Plates A-9a and A-9b.
3. Boring coordinates obtained using a hand-held GPS device.

DATE: June 25, 2013
TOTAL DEPTH: 60'
CAVED DEPTH: Not Applicable
DRY AUGER: Surface to 10'
WET ROTARY: 10' to 60'
BACKFILL: Cement-Bentonite Grout
LOGGER: F. Lillie

LOG OF BORING NO. B-8
BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS

LOCATION: See Plate 2
COORDINATES: 29°51'28.07"N
93°56'33.74"W
SURFACE EL.: 8' Approximately +8'



STRATUM DESCRIPTION	STRATUM DEPTH, FT	UNIT DRY WT, PCF	WATER CONTENT, %
CLAY, firm, gray			
		82	39
- with calcareous nodules below 58'	60.0		

NOTES:
1. Free water not observed during drilling activities to a depth of 10'.
2. Terms and symbols defined on Plates A-9a and A-9b.
3. Boring coordinates obtained using a hand-held GPS device.

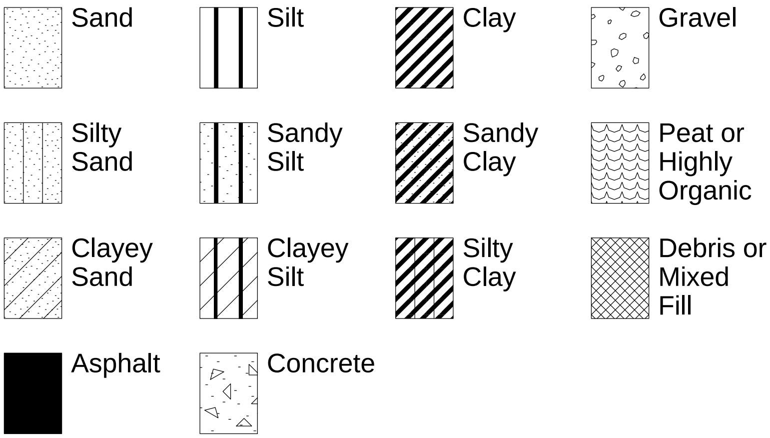
DATE: June 25, 2013
TOTAL DEPTH: 60'
CAVED DEPTH: Not Applicable
DRY AUGER: Surface to 10'
WET ROTARY: 10' to 60'
BACKFILL: Cement-Bentonite Grout
LOGGER: F. Lillie

LOG OF BORING NO. B-8

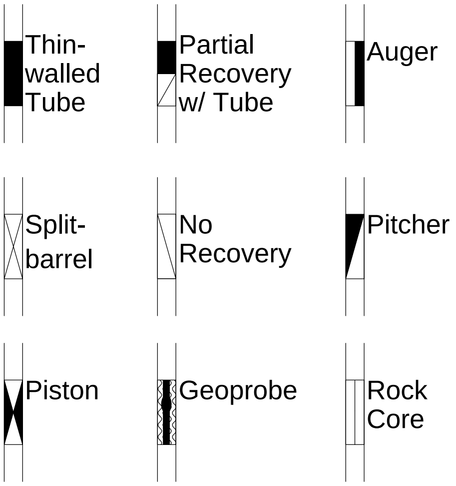
BERTH 6 AND BULKHEAD WALL EXPANSION
PORT OF PORT ARTHUR
PORT ARTHUR, TEXAS

R:\04100\2012 PROJECTS\04.10120193\ADDITIONAL SERVICES - PHASE 2\DRAFTING\04.10120193.GPJ 0415-1415 10/23/2013

SOIL TYPES



SAMPLER TYPES



SOIL GRAIN SIZE

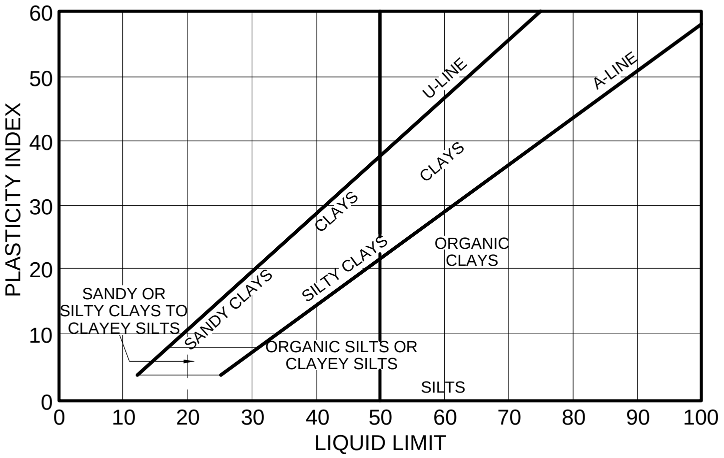
U.S. Standard Sieve

6" 3" 3/4" 4 10 40 200

Boulders	Cobbles	Gravel		Sand			Silt	Clay
		Coarse	Fine	Coarse	Medium	Fine		

152 76.2 19.1 4.76 2.00 0.420 0.074 0.002 (mm)

PLASTICITY CHART



SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil type.
Interlayered	Soil sample composed of alternating layers of different soil type.
Intermixed	Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.
Carbonate	Having more than 50% carbonate content.

TERMS AND SYMBOLS USED ON BORING LOGS

SOIL CLASSIFICATION (1 of 2)

STANDARD PENETRATION TEST (SPT)

A 2-in.-OD, 1-3/8-ID split spoon sampler is driven 1.5 ft into undisturbed soil with a 140-pound hammer free falling 30 in. After the sampler is seated 6 in. into undisturbed soil, the number of blows required to drive the sampler the last 12 in. is the Standard Penetration Resistance or "N" value, which is recorded as blows per foot as described below.

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows Per Foot	Description
25	25 blows drove sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows drove sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows drove sampler 3 inches during initial 6-inch seating interval.

NOTE: To avoid damage to sampling tools, driving is limited to 50 blows during or after seating interval.

DENSITY OF GRANULAR SOILS

Descriptive Term	*Relative Density, %	**Blows Per Foot (SPT)
Very Loose	< 15	0 to 4
Loose	15 to 35	5 to 10
Medium Dense	35 to 65	11 to 30
Dense	65 to 85	31 to 50
Very Dense	> 85	> 50

*Estimated from sampler driving record.
**Requires correction for depth, groundwater level, and grain size.

STRENGTH OF COHESIVE SOILS

Term	Undrained Shear Strength, ksf	Blows Per Foot (SPT) (approximate)
Very Soft	< 0.25	0 to 2
Soft	0.25 to 0.50	2 to 4
Firm	0.50 to 1.00	4 to 8
Stiff	1.00 to 2.00	8 to 16
Very Stiff	2.00 to 4.00	16 to 32
Hard	> 4.00	> 32

SHEAR STRENGTH TEST METHOD

U - Unconfined Q = Unconsolidated - Undrained Triaxial
P = Pocket Penetrometer T = Torvane V = Miniature Vane F = Field Vane

HAND PENETROMETER CORRECTION

Our experience has shown that the hand penetrometer generally overestimates the in-situ undrained shear strength of over consolidated Pleistocene Gulf Coast clays. These strengths are partially controlled by the presence of macroscopic soil defects such as slickensides, which generally do not influence smaller scale tests like the hand penetrometer. Based on our experience, we have adjusted these field estimates of the undrained shear strength of natural, overconsolidated Pleistocene Gulf Coast soils by multiplying the measured penetrometer reading by a factor of 0.6. These adjusted strength estimates are recorded in the "Shear Strength" column on the boring logs. Except as described in the text, we have not adjusted estimates of the undrained shear strength for projects located outside of the Pleistocene Gulf Coast formations.

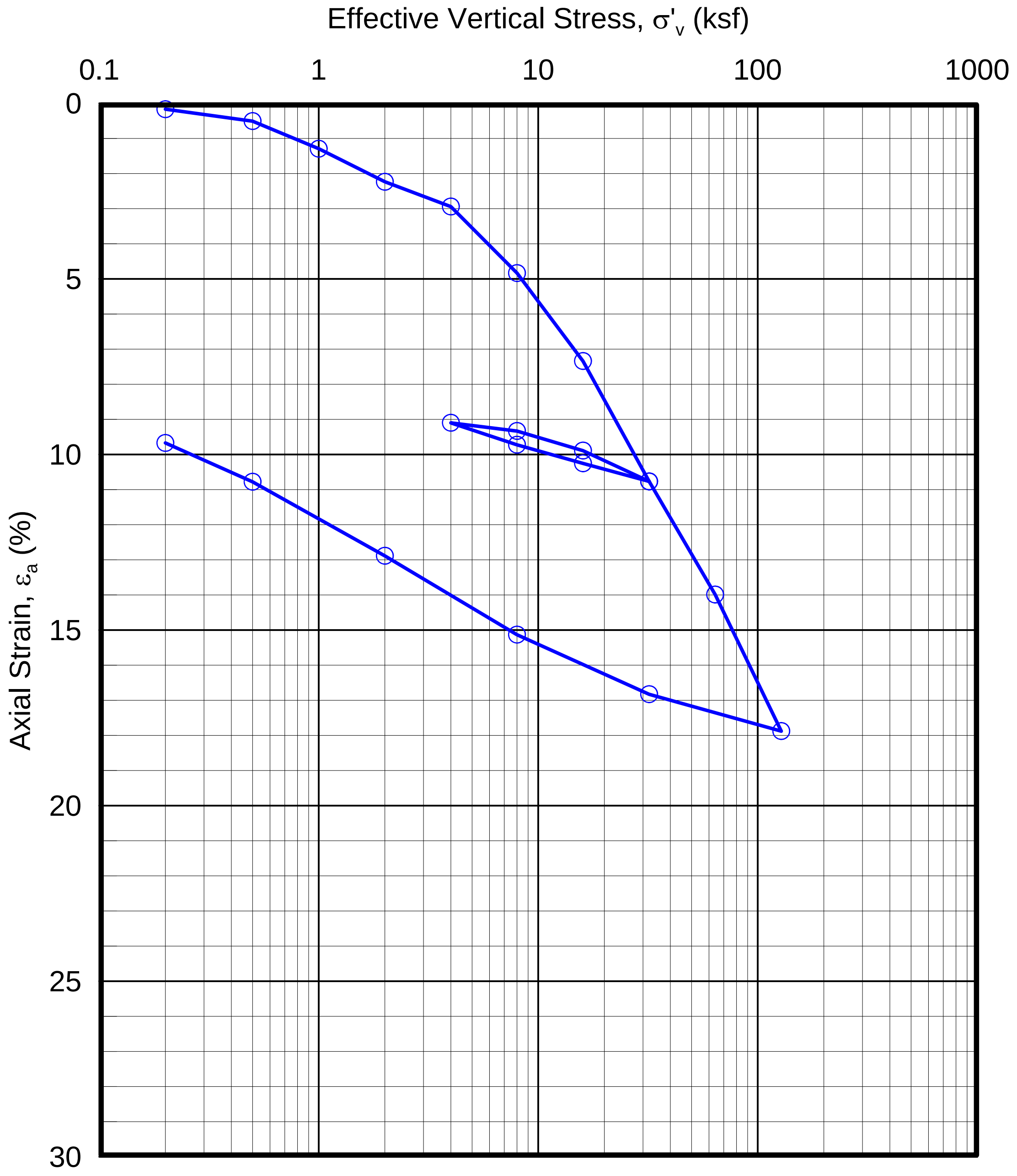
Information on each boring log is a compilation of subsurface conditions and soil or rock classifications obtained from the field as well as from laboratory testing of samples. Strata have been interpreted by commonly accepted procedures. The stratum lines on the logs may be transitional and approximate in nature. Water level measurements refer only to those observed at the time and places indicated, and can vary with time, geologic condition, or construction activity.

TERMS AND SYMBOLS USED ON BORING LOGS

SOIL CLASSIFICATION (2 of 2)

APPENDIX B

INCREMENTAL CONSOLIDATION TEST RESULTS



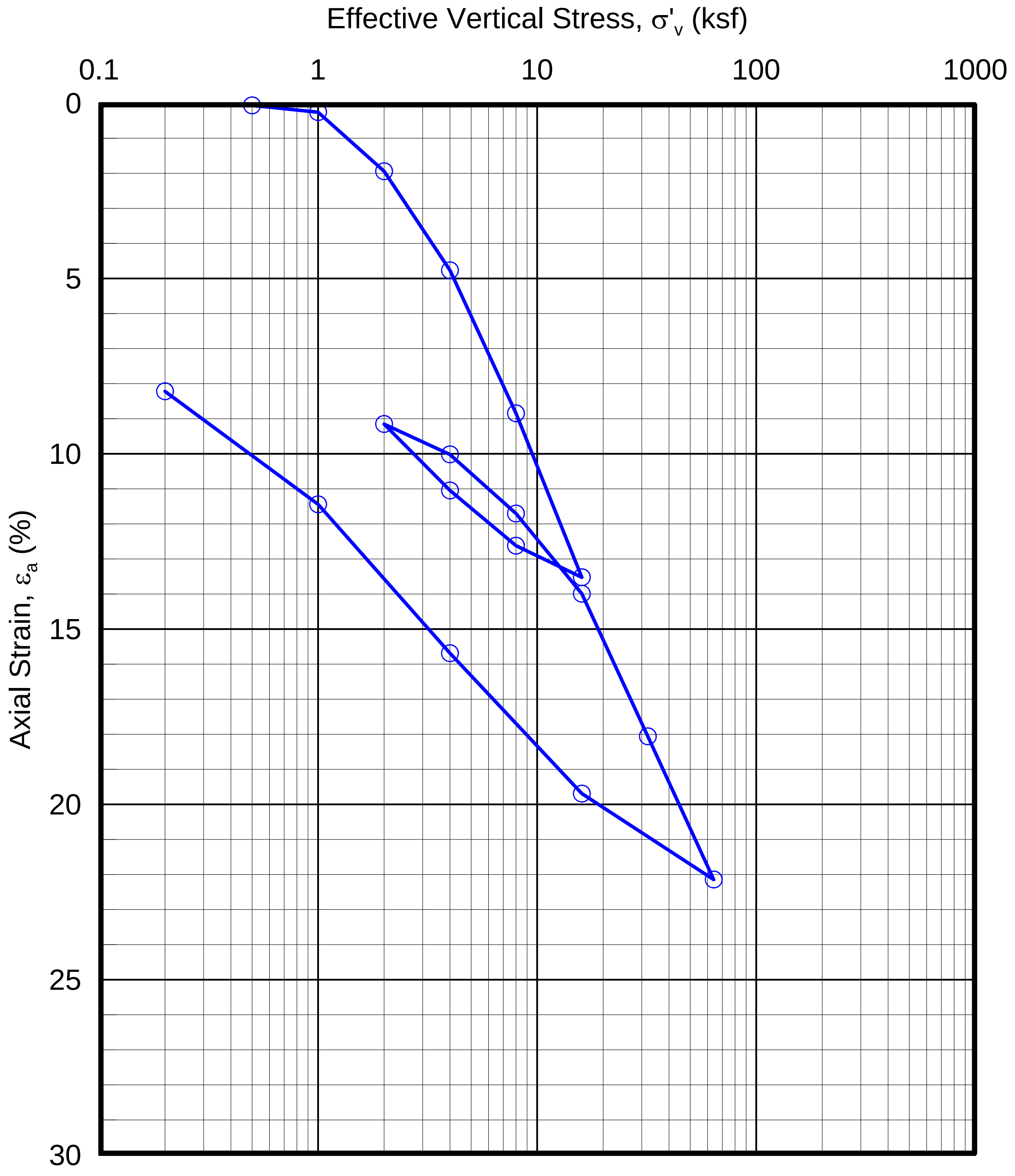
MATERIAL: Clay, Gray and Tan
INITIAL WATER CONTENT: 30.1 %
FINAL WATER CONTENT: 24.5 %
INITIAL VOID RATIO: 0.831
FINAL VOID RATIO: 0.663

LIQUID LIMIT: 37
PLASTIC LIMIT: 15
PLASTICITY INDEX: 22
SPECIFIC GRAVITY: 2.7

INCREMENTAL CONSOLIDATION TEST RESULTS

BORING B-6, 10-FOOT DEPTH

PORT OF PORT ARTHUR WHARF 6 AND BULKHEAD WALL EXPANSION
LOCKWOOD, ANDREWS & NEWNAM, INC.
PORT ARTHUR, TEXAS

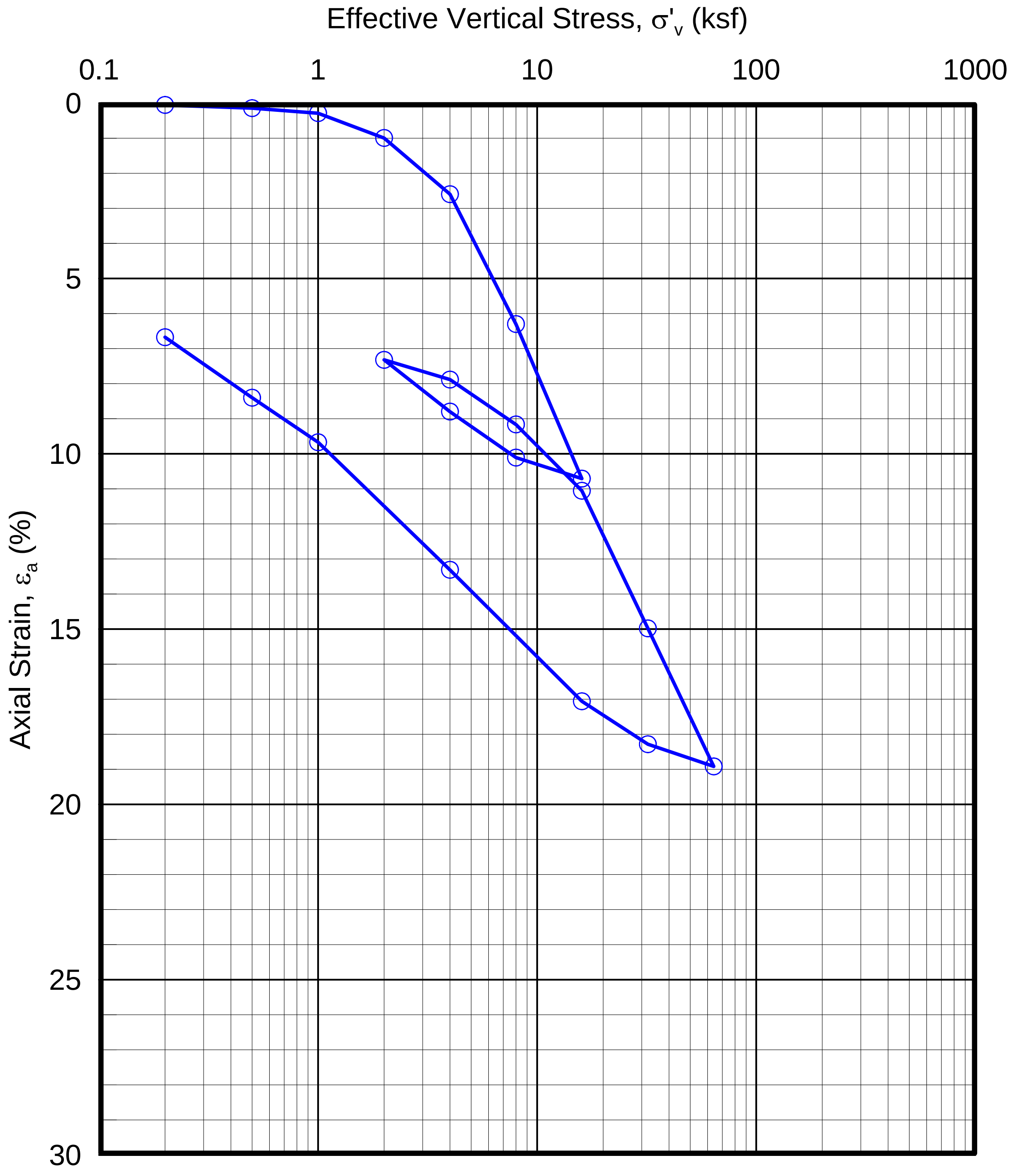


MATERIAL: Clay, Light gray and Tan
INITIAL WATER CONTENT: 27.8 %
FINAL WATER CONTENT: 25.6 %
INITIAL VOID RATIO: 0.814
FINAL VOID RATIO: 0.698

LIQUID LIMIT: 66
PLASTIC LIMIT: 14
PLASTICITY INDEX: 52
SPECIFIC GRAVITY: 2.701

INCREMENTAL CONSOLIDATION TEST RESULTS

BORING B-6, 35-FOOT DEPTH
PORT OF PORT ARTHUR WHARF 6 AND BULKHEAD WALL EXPANSION
LOCKWOOD, ANDREWS & NEWNAM, INC.
PORT ARTHUR, TEXAS



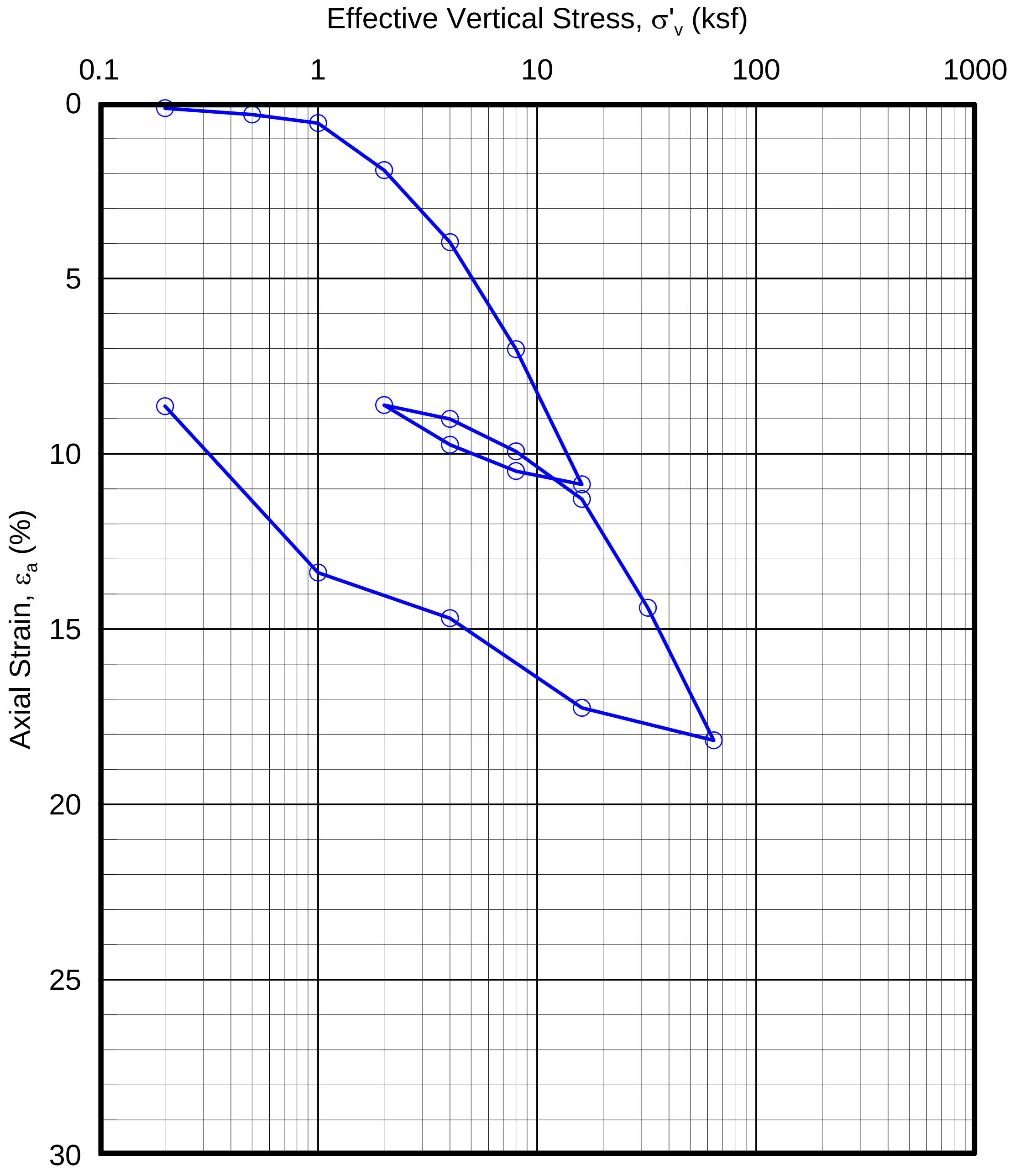
MATERIAL: Clay, Light gray and Brown
INITIAL WATER CONTENT: 19.6 %
FINAL WATER CONTENT: 18 %
INITIAL VOID RATIO: 0.686
FINAL VOID RATIO: 0.615

LIQUID LIMIT: 72
PLASTIC LIMIT: 14
PLASTICITY INDEX: 58
SPECIFIC GRAVITY: 2.565

INCREMENTAL CONSOLIDATION TEST RESULTS

BORING B-7, 10-FOOT DEPTH

PORT OF PORT ARTHUR WHARF 6 AND BULKHEAD WALL EXPANSION
LOCKWOOD, ANDREWS & NEWNAM, INC.
PORT ARTHUR, TEXAS

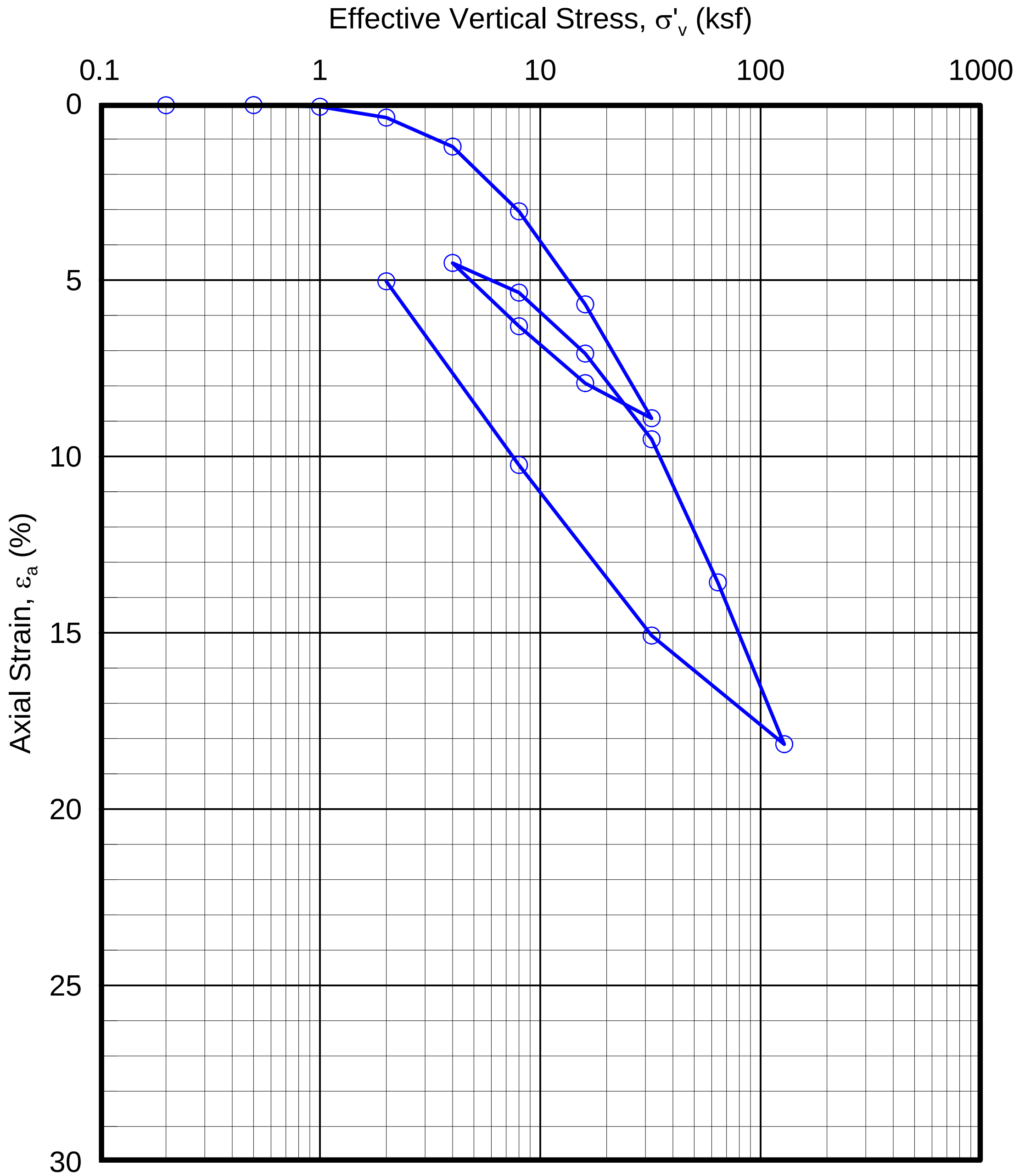


MATERIAL: Clay, Light gray and Greenish gray
INITIAL WATER CONTENT: 26.5 %
FINAL WATER CONTENT: 22.6 %
INITIAL VOID RATIO: 0.748
FINAL VOID RATIO: 0.610

LIQUID LIMIT: 44
PLASTIC LIMIT: 12
PLASTICITY INDEX: 32
SPECIFIC GRAVITY: 2.766

INCREMENTAL CONSOLIDATION TEST RESULTS

BORING B-8, 10-FOOT DEPTH
PORT OF PORT ARTHUR WHARF 6 AND BULKHEAD WALL EXPANSION
LOCKWOOD, ANDREWS & NEWNAM, INC.
PORT ARTHUR, TEXAS



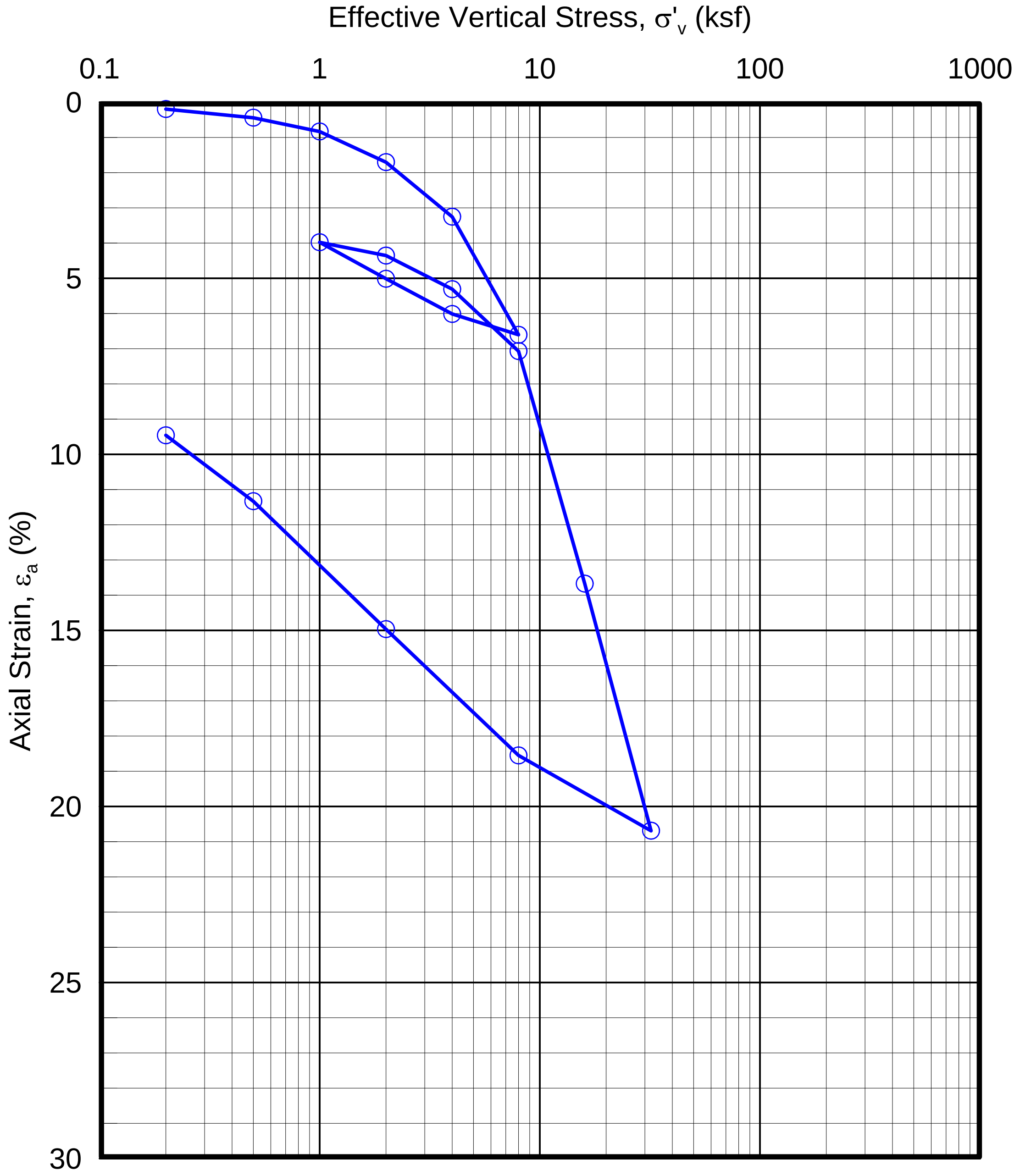
MATERIAL: Clay, Light gray and Tan, with Calcareous and Ferrous Nodules

INITIAL WATER CONTENT: 28.1 %	LIQUID LIMIT: 63
FINAL WATER CONTENT: 28.0 %	PLASTIC LIMIT: 17
INITIAL VOID RATIO: 0.793	PLASTICITY INDEX: 46
FINAL VOID RATIO: 0.767	SPECIFIC GRAVITY: 2.732

INCREMENTAL CONSOLIDATION TEST RESULTS

BORING B-8, 16-FOOT DEPTH

PORT OF PORT ARTHUR WHARF 6 AND BULKHEAD WALL EXPANSION
LOCKWOOD, ANDREWS & NEWNAM, INC.
PORT ARTHUR, TEXAS



MATERIAL: Clay, Gray
INITIAL WATER CONTENT: 41.4 %
FINAL WATER CONTENT: 36.3 %
INITIAL VOID RATIO: 1.133
FINAL VOID RATIO: 0.980

LIQUID LIMIT: 66
PLASTIC LIMIT: 19
PLASTICITY INDEX: 47
SPECIFIC GRAVITY: 2.728

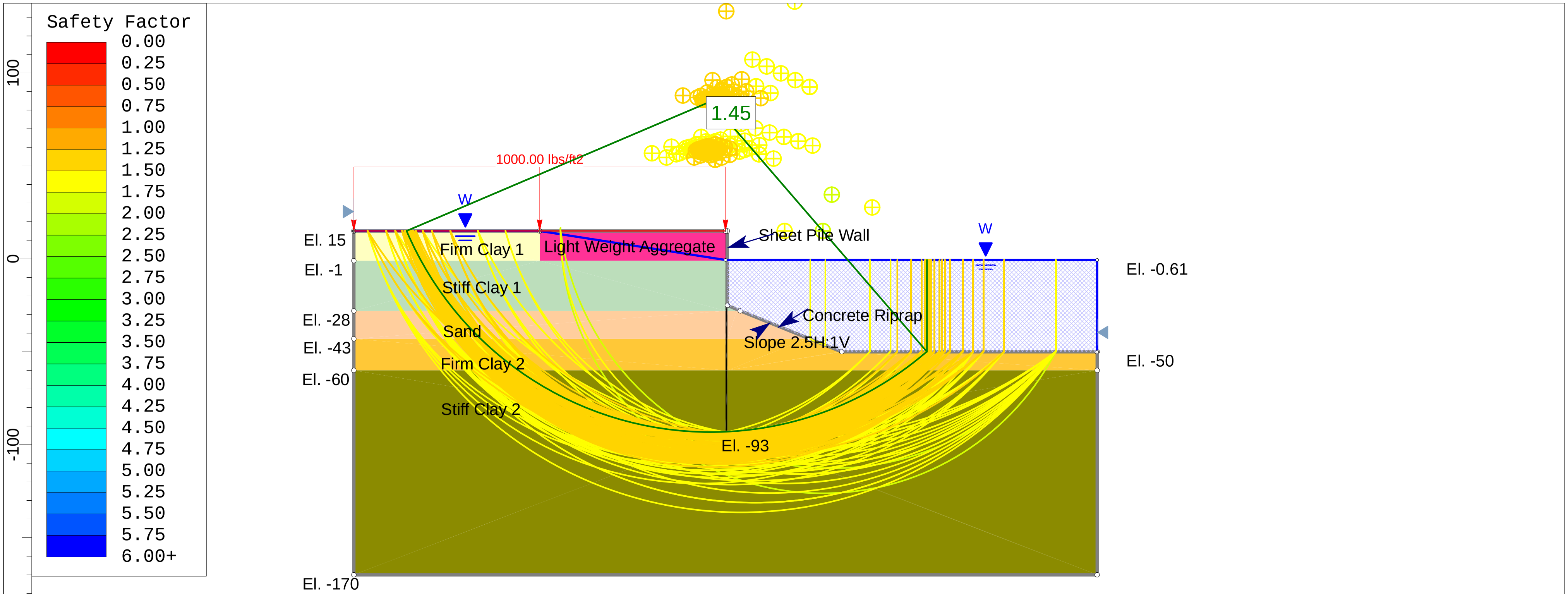
INCREMENTAL CONSOLIDATION TEST RESULTS

BORING B-8, 45-FOOT DEPTH

PORT OF PORT ARTHUR WHARF 6 AND BULKHEAD WALL EXPANSION
LOCKWOOD, ANDREWS & NEWNAM, INC.
PORT ARTHUR, TEXAS

APPENDIX C

GLOBAL SLOPE STABILITY ANALYSIS



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Firm Clay 1	🟨	120	Mohr-Coulomb	800	0	Water Surface	Constant
Stiff Clay 1	🟩	120	Mohr-Coulomb	1000	0	Water Surface	Constant
Sand	🟧	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay 2	🟧	120	Mohr-Coulomb	800	0	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Concrete Rip-rap	🟩	120	Mohr-Coulomb	0	35	Water Surface	Constant
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Stiff Clay 2	🟫	120	Mohr-Coulomb	1700	0	Water Surface	Constant

FUGRO

Project Wharf 6 and Bulkhead Wall Expansion

Analysis Description Global Stability - Short Term - Proposed Bulkhead (Dredge Depth El. -50 ft)

Drawn By S. Vedantam

Company Fugro Consultants, Inc.

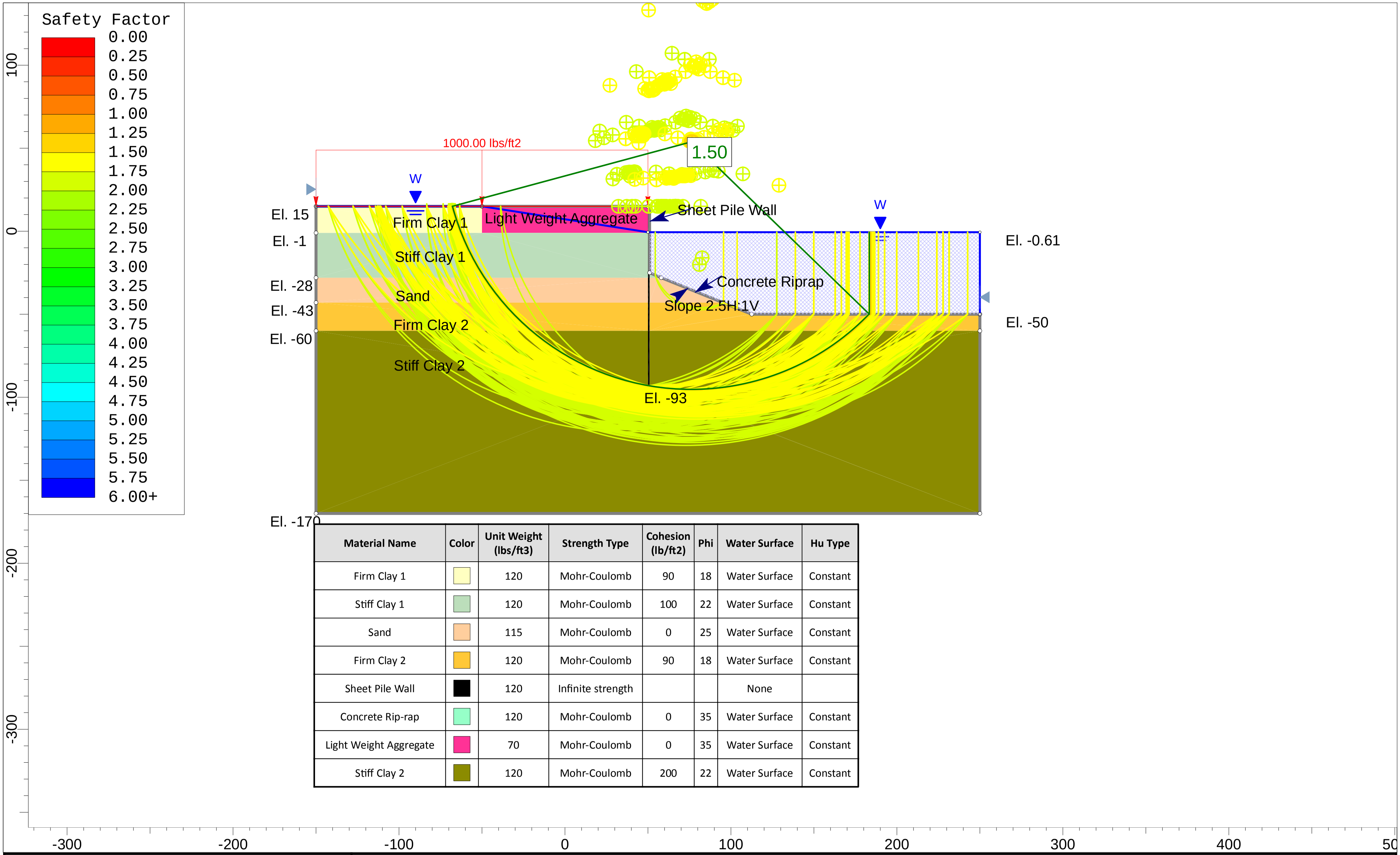
Date 10/22/13

Scale 1:960

File Name Short Term - 1000 psf Surcharge - No Platform (El. -93).slim

SLIDEINTERPRET 6.008

PLATE C-1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Firm Clay 1	🟨	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 1	🟩	120	Mohr-Coulomb	100	22	Water Surface	Constant
Sand	🟧	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay 2	🟧	120	Mohr-Coulomb	90	18	Water Surface	Constant
Sheet Pile Wall	■	120	Infinite strength			None	
Concrete Rip-rap	🟩	120	Mohr-Coulomb	0	35	Water Surface	Constant
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Stiff Clay 2	🟫	120	Mohr-Coulomb	200	22	Water Surface	Constant

SLIDEINTERPRET 6.008

Project
Wharf 6 and Bulkhead Wall Expansion

Analysis Description
Global Stability - Long Term - Proposed Bulkhead (Dredge Depth El. -50 ft)

Drawn By S. Vedantam

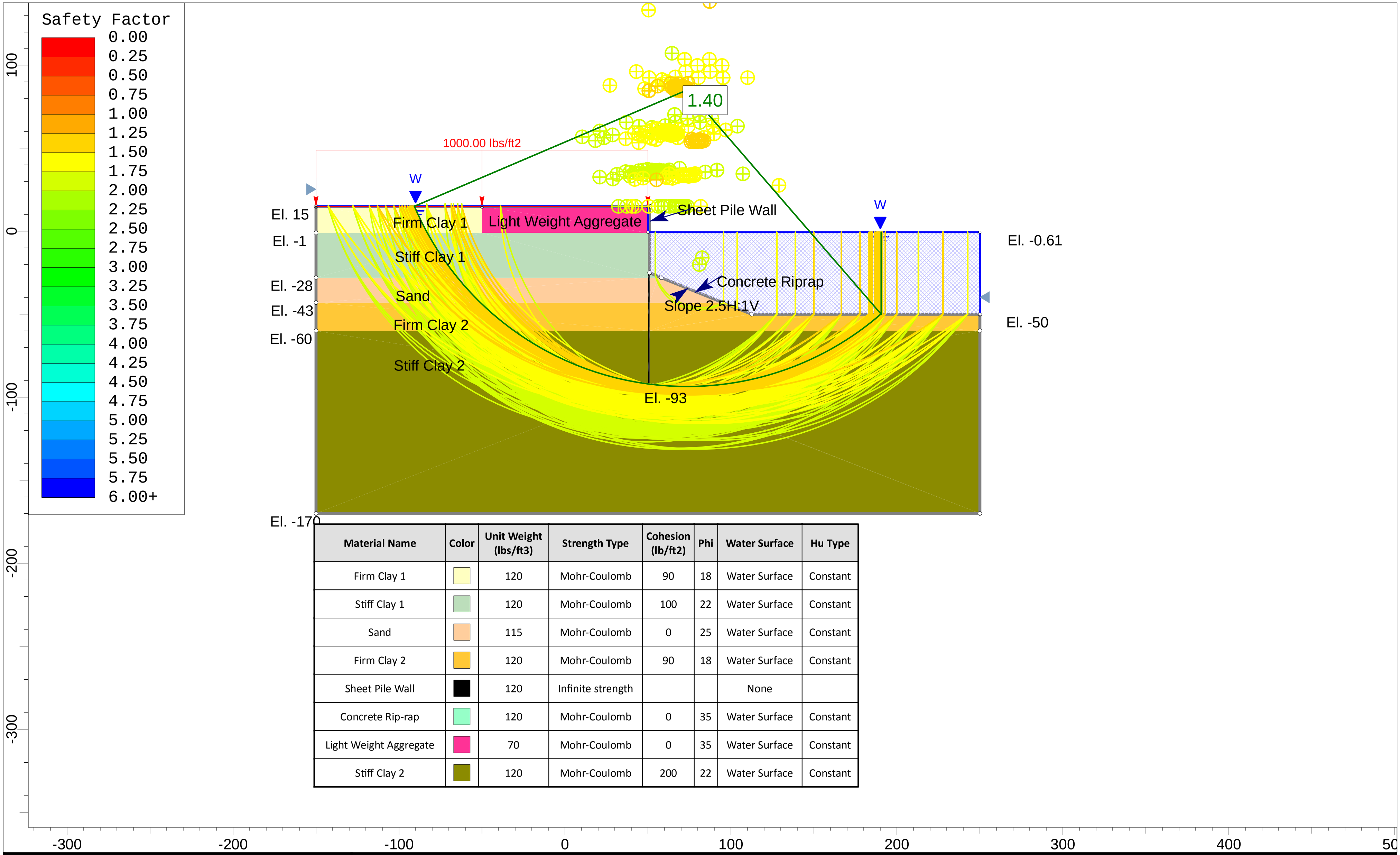
Company Fugro Consultants, Inc.

Date 10/22/13

Scale 1:960

File Name Long Term - 1000 psf Surcharge - No Platform (El. -93).slim

PLATE C-2

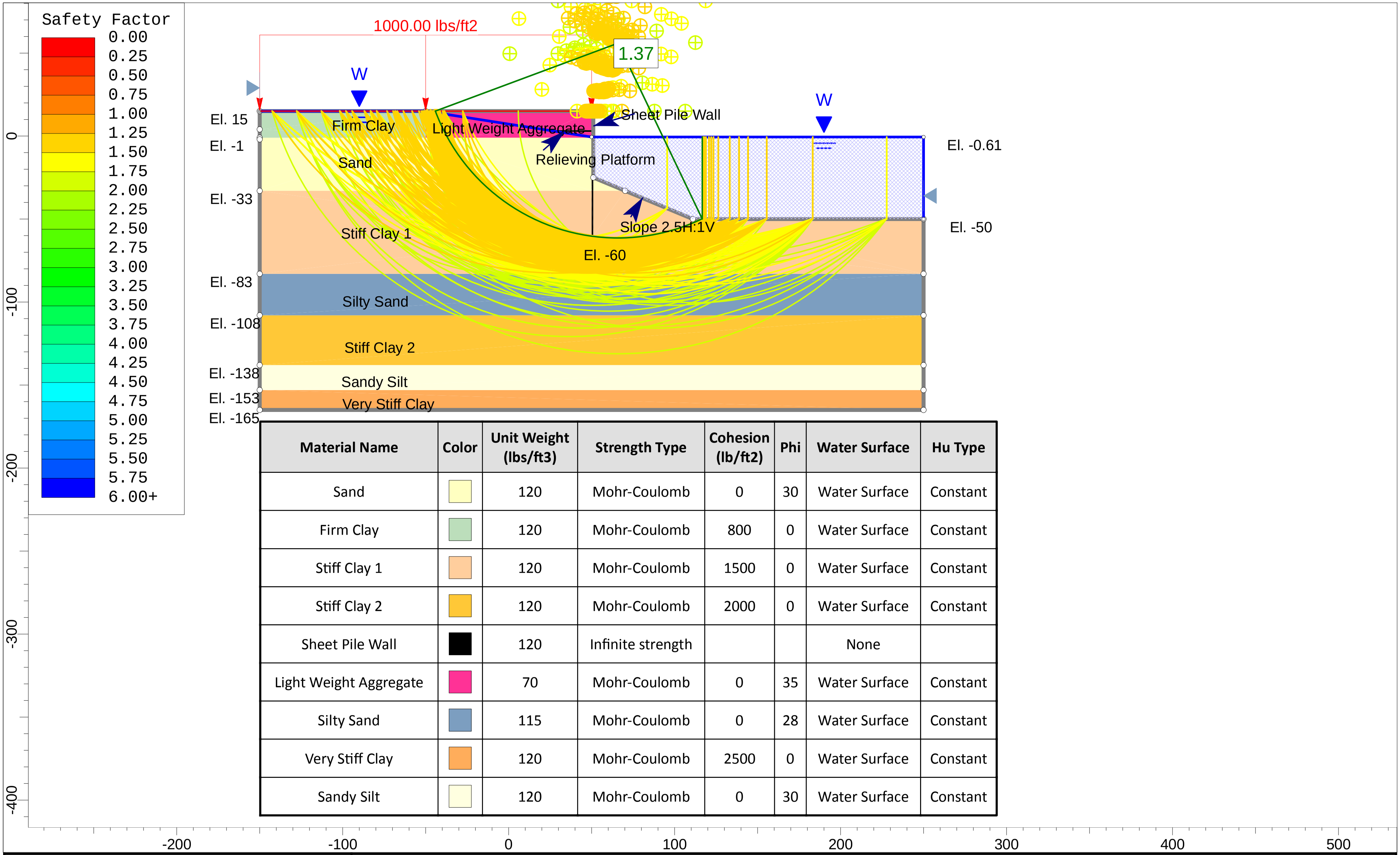


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Firm Clay 1	🟨	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 1	🟩	120	Mohr-Coulomb	100	22	Water Surface	Constant
Sand	🟧	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay 2	🟨	120	Mohr-Coulomb	90	18	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Concrete Rip-rap	🟩	120	Mohr-Coulomb	0	35	Water Surface	Constant
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Stiff Clay 2	🟫	120	Mohr-Coulomb	200	22	Water Surface	Constant

Project	Wharf 6 and Bulkhead Wall Expansion
Analysis Description	Global Stability - RDD - Proposed Bulkhead (Dredge Depth El. -50 ft)
Drawn By	S. Vedantam
Company	Fugro Consultants, Inc.
Date	10/22/13
Scale	1:960
File Name	RDD - 1000 psf Surcharge - No Platform (El. -93).slim

SLIDEINTERPRET 6.008

PLATE C-3



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	🟨	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	🟩	120	Mohr-Coulomb	800	0	Water Surface	Constant
Stiff Clay 1	🟧	120	Mohr-Coulomb	1500	0	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	2000	0	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	🟦	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	🟧	120	Mohr-Coulomb	2500	0	Water Surface	Constant
Sandy Silt	⬜	120	Mohr-Coulomb	0	30	Water Surface	Constant

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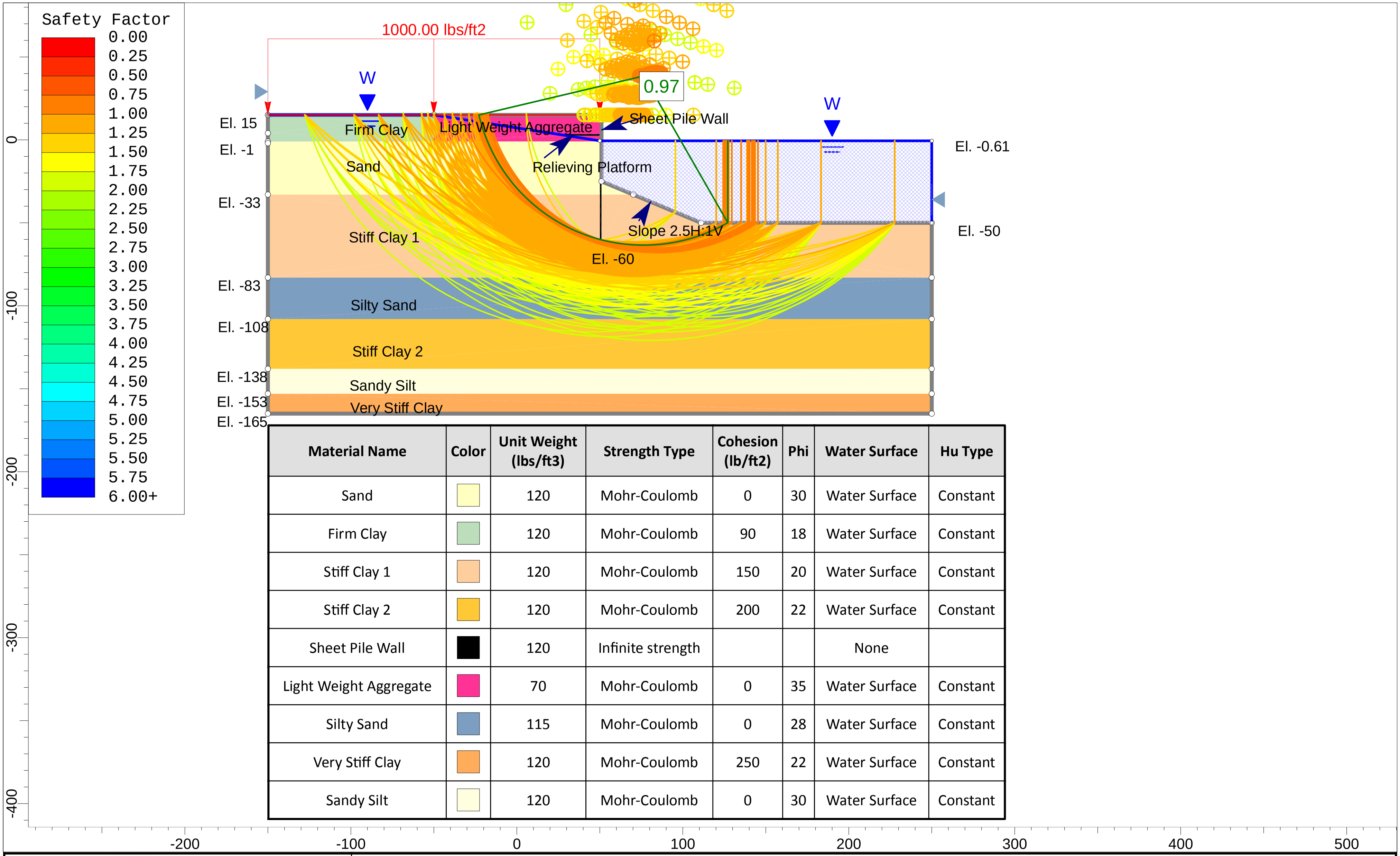
SLIDEINTERPRET 6.008

Project	Wharf 6 and Bulkhead Wall Expansion
Analysis Description	Global Stability - Short Term - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -60 ft
Drawn By	S. Vedantam
Company	Fugro Consultants, Inc.
Date	10/22/13
Scale	1:960
File Name	Short Term - 1000 psf Surcharge - With Platform (El. -60).slim

PLATE C-4

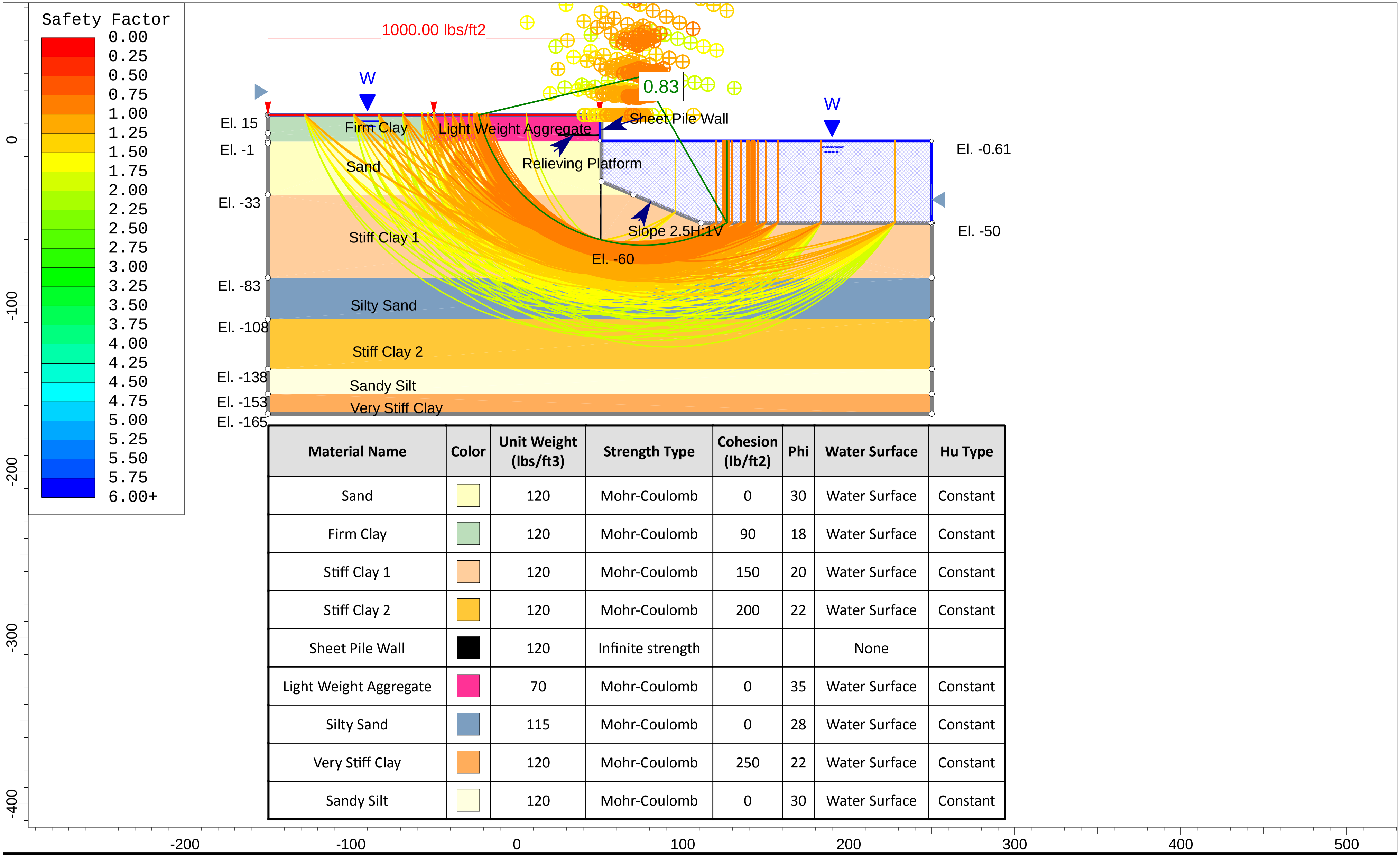


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	▨	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	▨	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 1	▨	120	Mohr-Coulomb	150	20	Water Surface	Constant
Stiff Clay 2	▨	120	Mohr-Coulomb	200	22	Water Surface	Constant
Sheet Pile Wall	■	120	Infinite strength			None	
Light Weight Aggregate	▨	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	▨	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	▨	120	Mohr-Coulomb	250	22	Water Surface	Constant
Sandy Silt	▨	120	Mohr-Coulomb	0	30	Water Surface	Constant

Project	Wharf 6 and Bulkhead Wall Expansion
Analysis Description	Global Stability - Long Term - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -60 ft
Drawn By	S. Vedantam
Company	Fugro Consultants, Inc.
Date	10/22/13
Scale	1:960
File Name	Long Term - 1000 psf Surcharge - With Platform (El. -60).slim

SLIDEINTERPRET 6.008

PLATE C-5



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	🟨	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	🟩	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 1	🟧	120	Mohr-Coulomb	150	20	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	200	22	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	🟦	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	🟧	120	Mohr-Coulomb	250	22	Water Surface	Constant
Sandy Silt	⬜	120	Mohr-Coulomb	0	30	Water Surface	Constant

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SLIDEINTERPRET 6.008

Project Wharf 6 and Bulkhead Wall Expansion

Analysis Description Global Stability - RDD - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -60 ft

Drawn By S. Vedantam

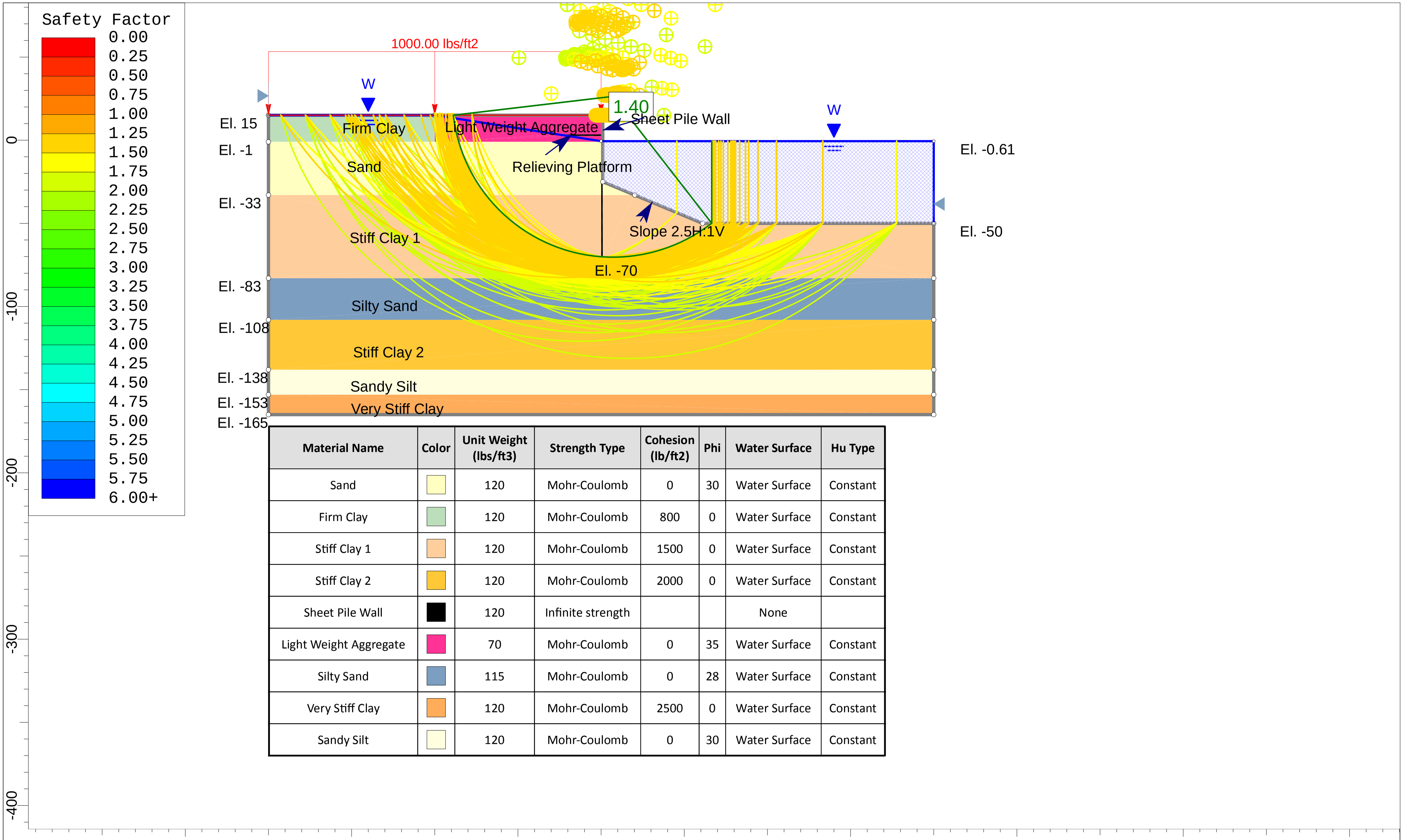
Company Fugro Consultants, Inc.

Date 10/22/13

Scale 1:960

File Name RDD - 1000 psf Surcharge - With Platform (El. -60).slim

PLATE C-6

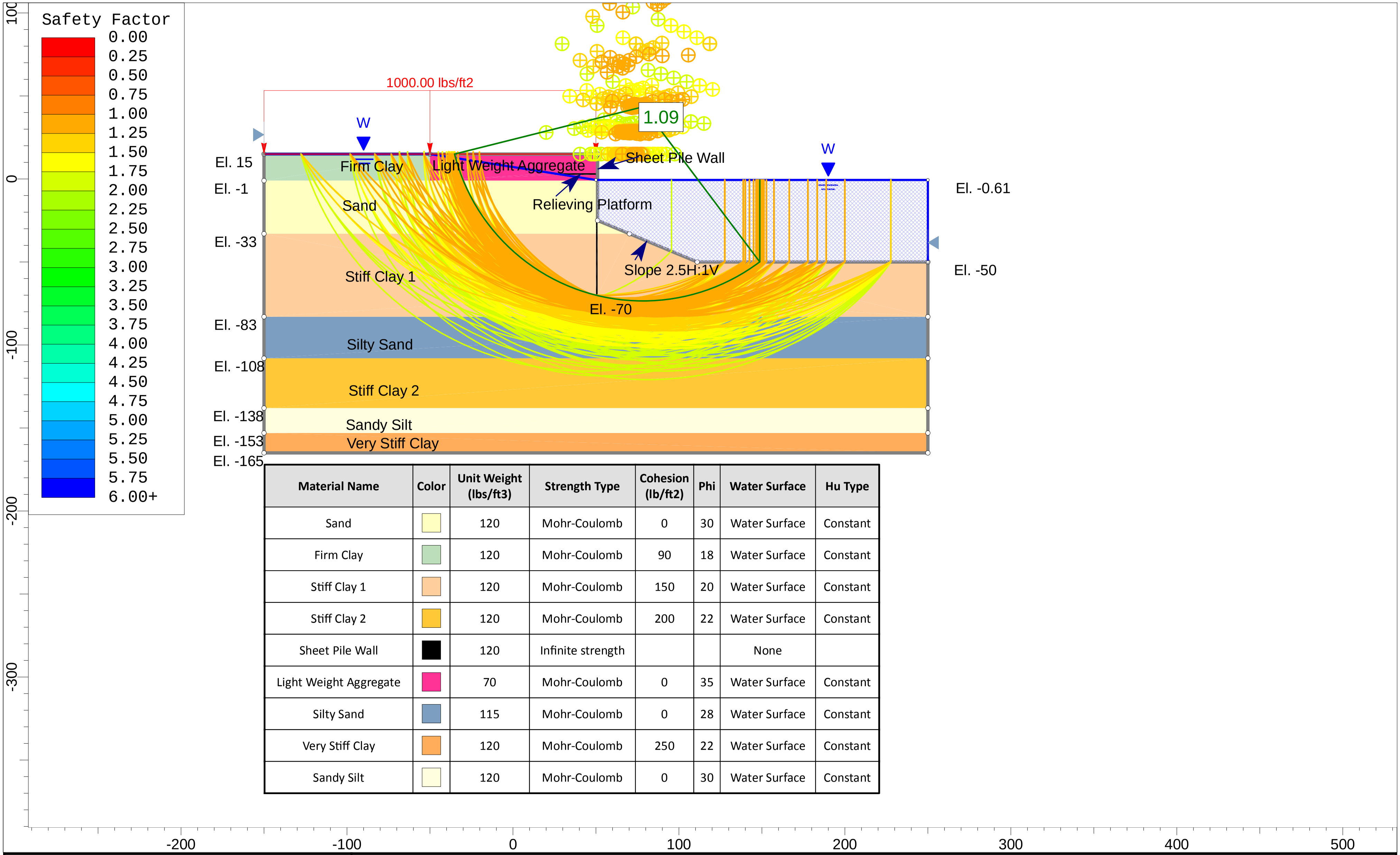


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	▢	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	🟩	120	Mohr-Coulomb	800	0	Water Surface	Constant
Stiff Clay 1	🟧	120	Mohr-Coulomb	1500	0	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	2000	0	Water Surface	Constant
Sheet Pile Wall	■	120	Infinite strength			None	
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	🟦	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	🟧	120	Mohr-Coulomb	2500	0	Water Surface	Constant
Sandy Silt	▢	120	Mohr-Coulomb	0	30	Water Surface	Constant

Project	Wharf 6 and Bulkhead Wall Expansion
Analysis Description	Global Stability - Short Term - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -70 ft
Drawn By	S. Vedantam
Company	Fugro Consultants, Inc.
Date	10/22/13
Scale	1:960
File Name	Short Term - 1000 psf Surcharge - With Platform (El. -70).slim

SLIDEINTERPRET 6.008

PLATE C-7



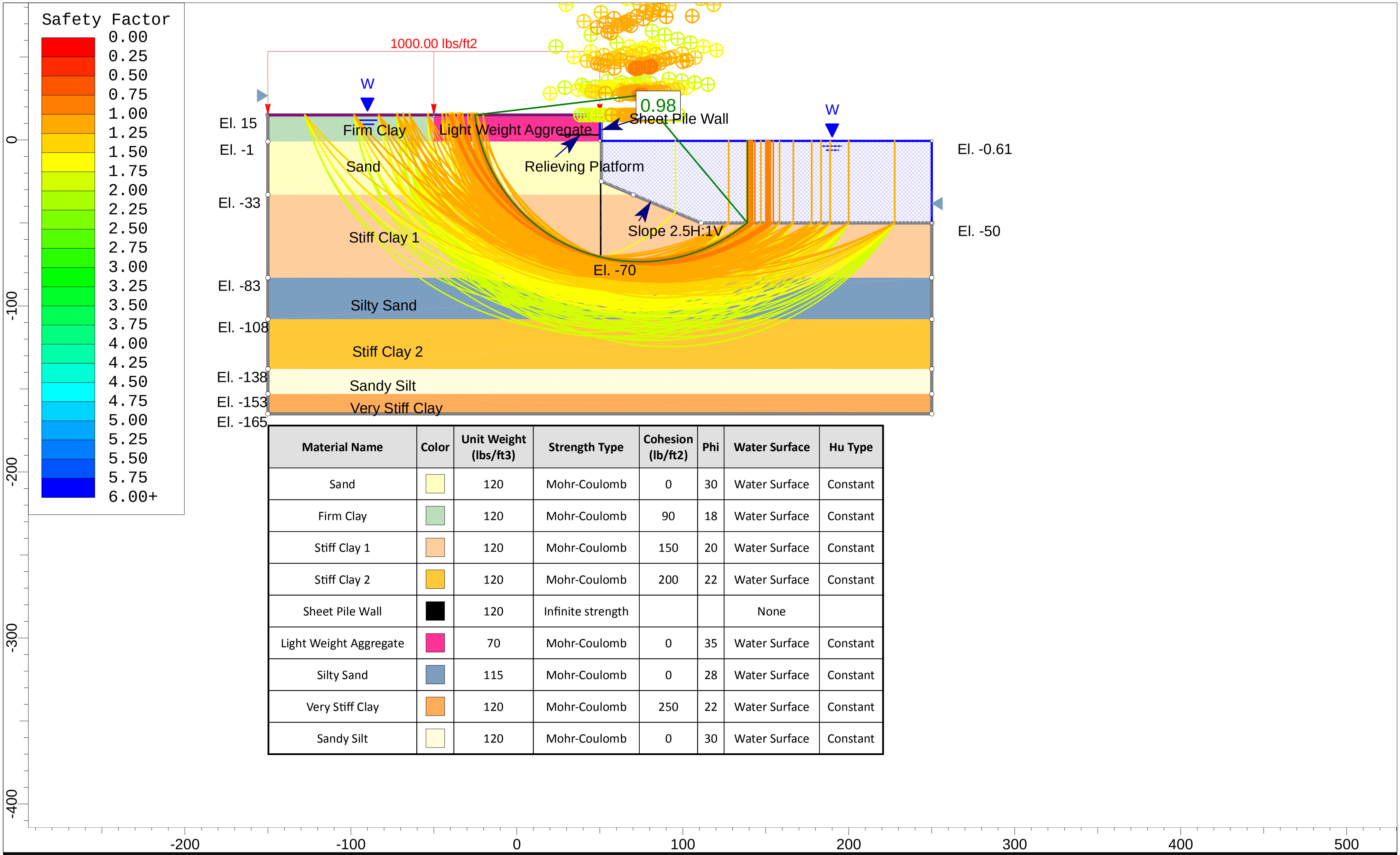
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	🟨	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	🟩	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 1	🟧	120	Mohr-Coulomb	150	20	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	200	22	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Light Weight Aggregate	🟥	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	🟦	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	🟧	120	Mohr-Coulomb	250	22	Water Surface	Constant
Sandy Silt	⬜	120	Mohr-Coulomb	0	30	Water Surface	Constant

FUGRO

SLIDEINTERPRET 6.008

Project	Wharf 6 and Bulkhead Wall Expansion
Analysis Description	Global Stability - Long Term - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -70 ft
Drawn By	S. Vedantam
Company	Fugro Consultants, Inc.
Date	10/22/13
Scale	1:960
File Name	Long Term - 1000 psf Surcharge - With Platform (El. -70).slim

PLATE C-8



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	🟨	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	🟩	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 1	🟧	120	Mohr-Coulomb	150	20	Water Surface	Constant
Stiff Clay 2	🟧	120	Mohr-Coulomb	200	22	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	🟦	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	🟧	120	Mohr-Coulomb	250	22	Water Surface	Constant
Sandy Silt	⬜	120	Mohr-Coulomb	0	30	Water Surface	Constant

SLIDEINTERPRET 6.008

Project
Wharf 6 and Bulkhead Wall Expansion

Analysis Description
Global Stability - RDD - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -70 ft

Drawn By S. Vedantam

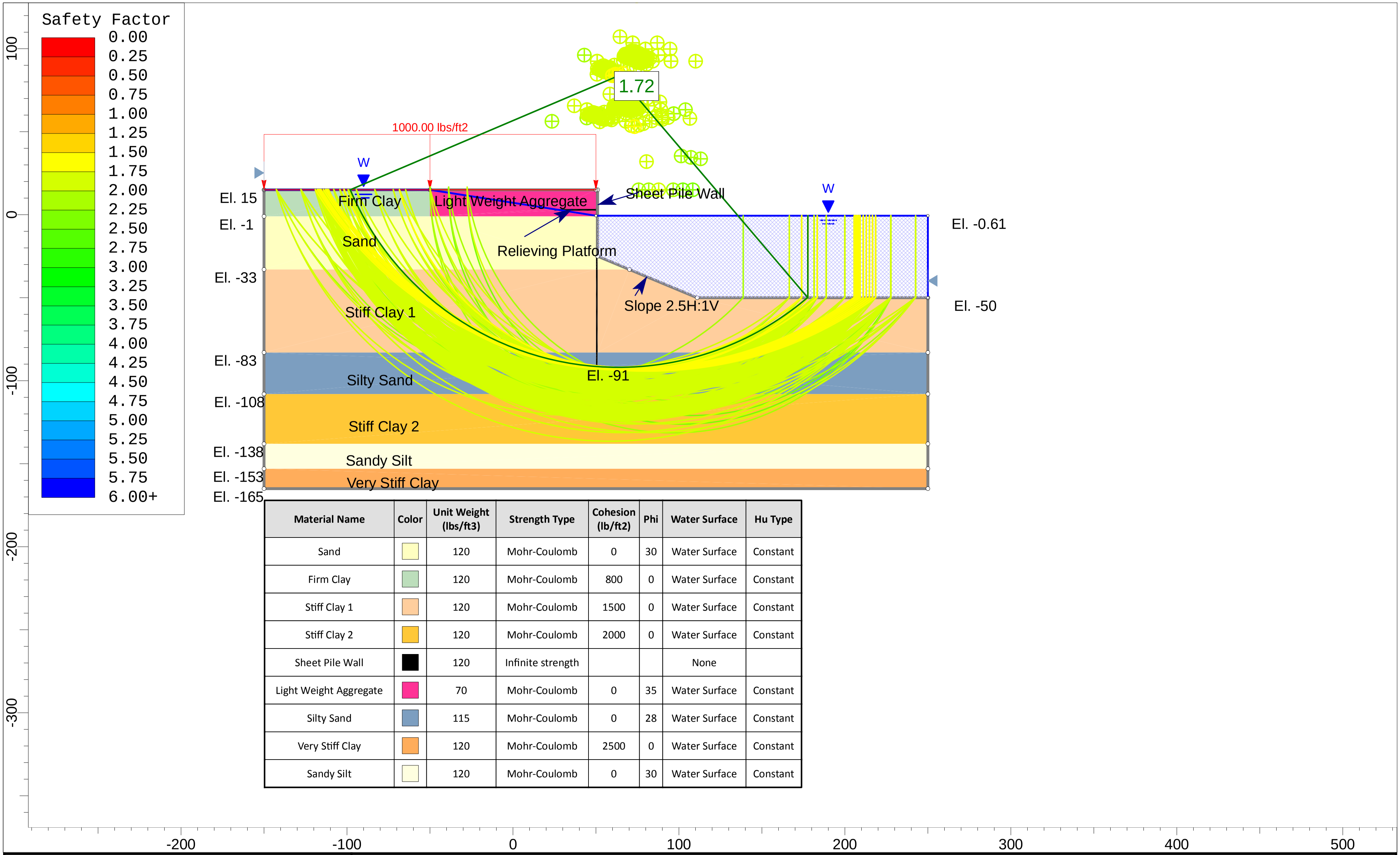
Company Fugro Consultants, Inc.

Date 10/22/13

Scale 1:960

File Name RDD - 1000 psf Surcharge - With Platform (El. -70).slim

PLATE C-9

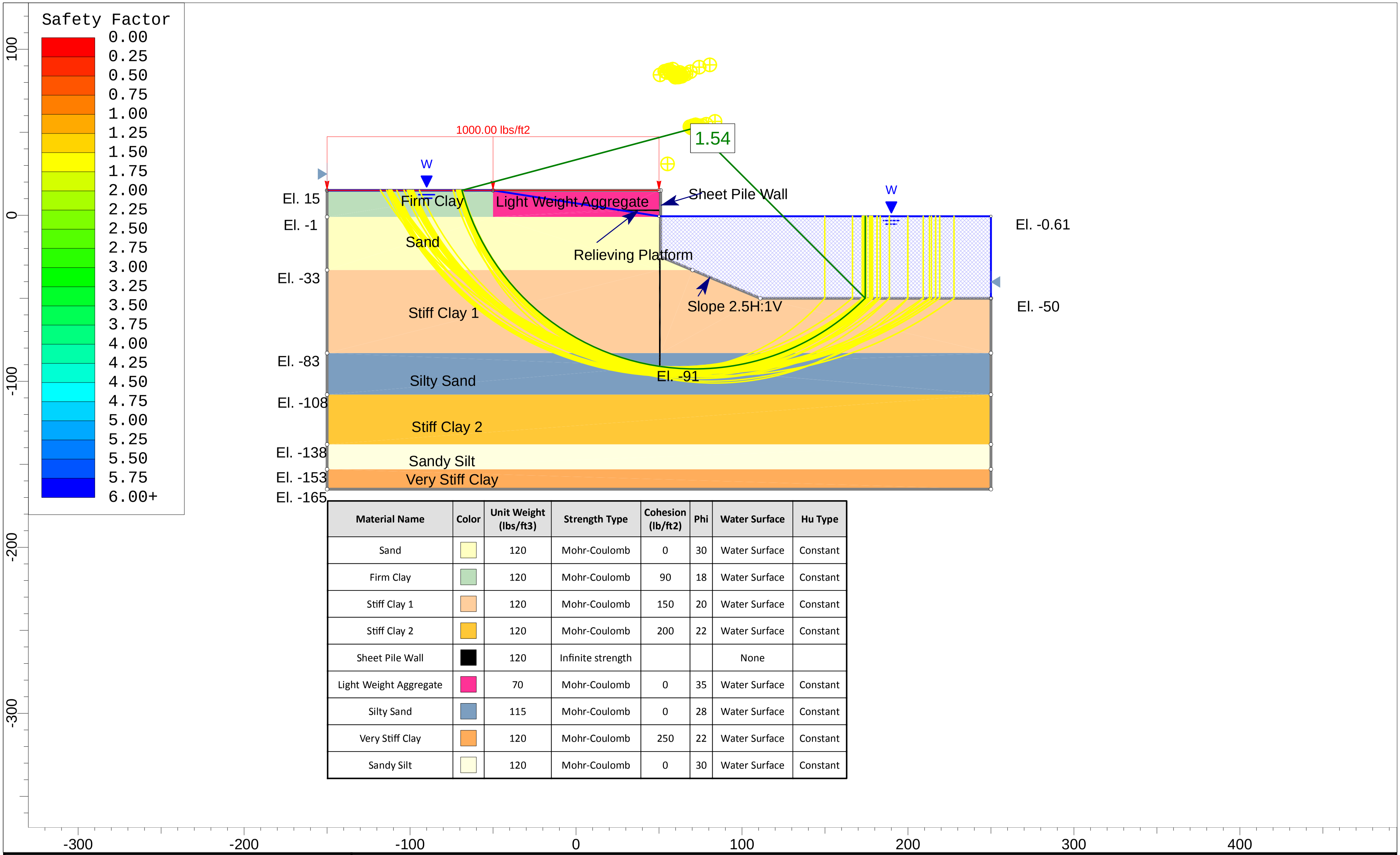


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	🟨	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	🟩	120	Mohr-Coulomb	800	0	Water Surface	Constant
Stiff Clay 1	🟧	120	Mohr-Coulomb	1500	0	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	2000	0	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	🟦	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	🟧	120	Mohr-Coulomb	2500	0	Water Surface	Constant
Sandy Silt	⬜	120	Mohr-Coulomb	0	30	Water Surface	Constant

Project	Wharf 6 and Bulkhead Wall Expansion		
Analysis Description	Global Stability - Short Term - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -91 ft		
Drawn By	S. Vedantam	*Company*	Fugro Consultants, Inc.
Date	10/22/13	*Scale*	1:960
File Name	Short Term - 1000 psf Surcharge - No Platform (El. -91).slim		

SLIDEINTERPRET 6.008

PLATE C-10

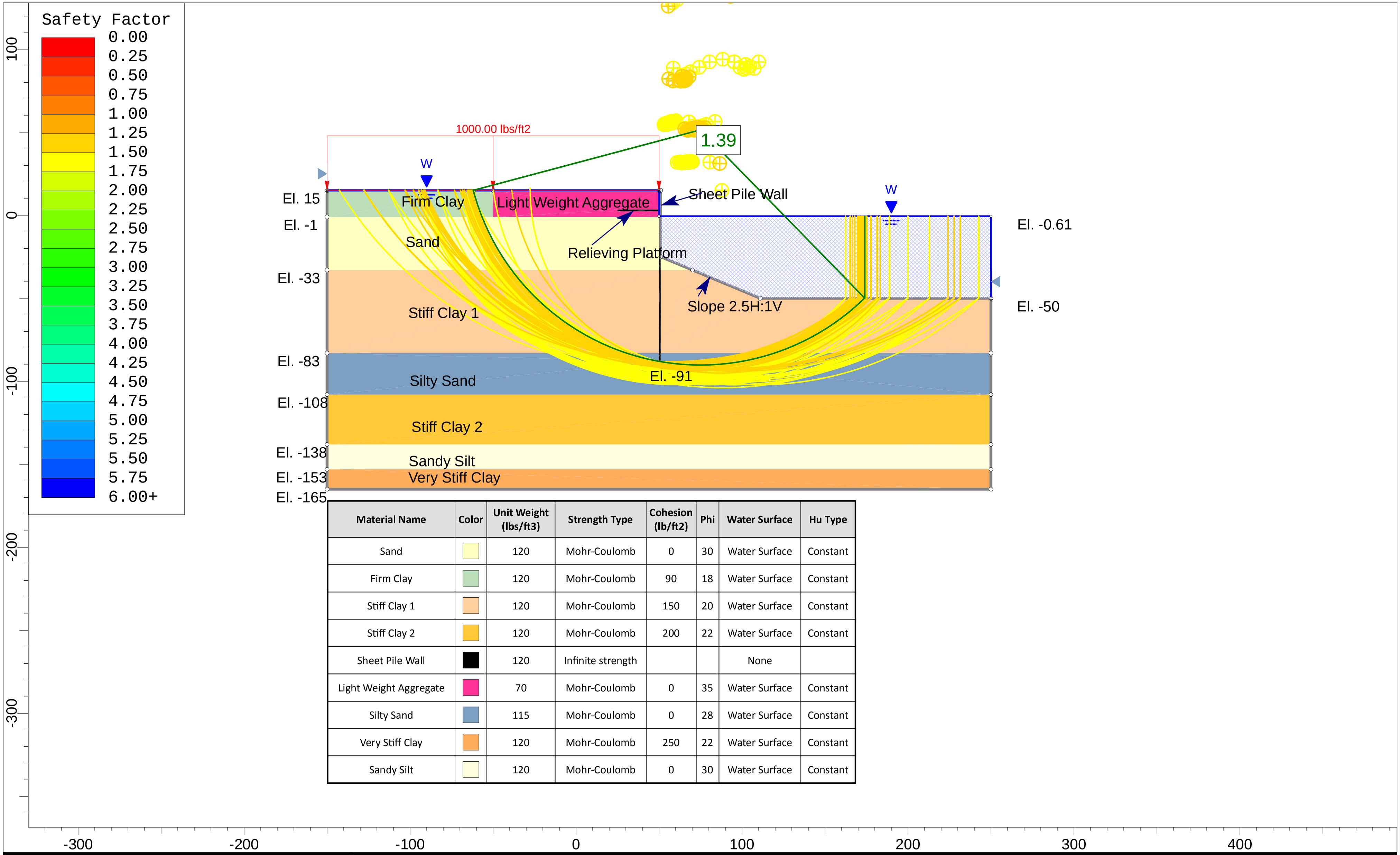


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	☐	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	🟩	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 1	🟧	120	Mohr-Coulomb	150	20	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	200	22	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	🟦	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	🟧	120	Mohr-Coulomb	250	22	Water Surface	Constant
Sandy Silt	☐	120	Mohr-Coulomb	0	30	Water Surface	Constant

Project	Wharf 6 and Bulkhead Wall Expansion
Analysis Description	Global Stability - Long Term - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -91 ft
Drawn By	S. Vedantam
Company	Fugro Consultants, Inc.
Date	10/22/13
Scale	1:960
File Name	Long Term - 1000 psf Surcharge - No Platform (El. -91).slim

SLIDEINTERPRET 6.008

PLATE C-11



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Sand	🟨	120	Mohr-Coulomb	0	30	Water Surface	Constant
Firm Clay	🟩	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 1	🟧	120	Mohr-Coulomb	150	20	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	200	22	Water Surface	Constant
Sheet Pile Wall	⬛	120	Infinite strength			None	
Light Weight Aggregate	🟪	70	Mohr-Coulomb	0	35	Water Surface	Constant
Silty Sand	🟦	115	Mohr-Coulomb	0	28	Water Surface	Constant
Very Stiff Clay	🟧	120	Mohr-Coulomb	250	22	Water Surface	Constant
Sandy Silt	🟨	120	Mohr-Coulomb	0	30	Water Surface	Constant

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SLIDEINTERPRET 6.008

Project Wharf 6 and Bulkhead Wall Expansion

Analysis Description Global Stability - RDD - Existing Bulkhead (Dredge Depth El. -50 ft) - Bulkhead El. -91 ft

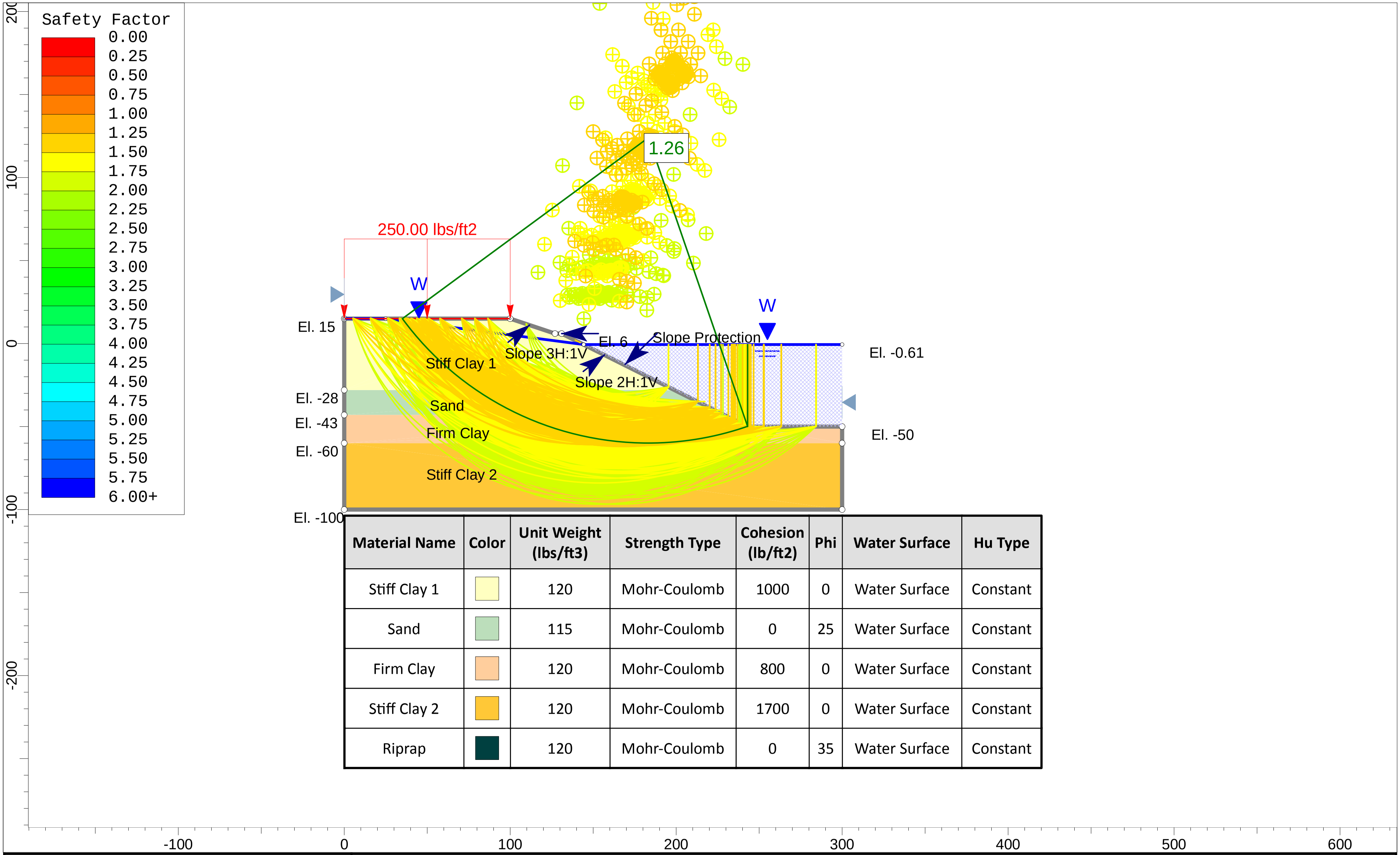
Drawn By S. Vedantam

Company Fugro Consultants, Inc.

Date 10/22/13

Scale 1:960

File Name RDD - 1000 psf Surcharge - No Platform (El. -91).slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Stiff Clay 1	🟨	120	Mohr-Coulomb	1000	0	Water Surface	Constant
Sand	🟩	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay	🟧	120	Mohr-Coulomb	800	0	Water Surface	Constant
Stiff Clay 2	🟧	120	Mohr-Coulomb	1700	0	Water Surface	Constant
Riprap	⬛	120	Mohr-Coulomb	0	35	Water Surface	Constant

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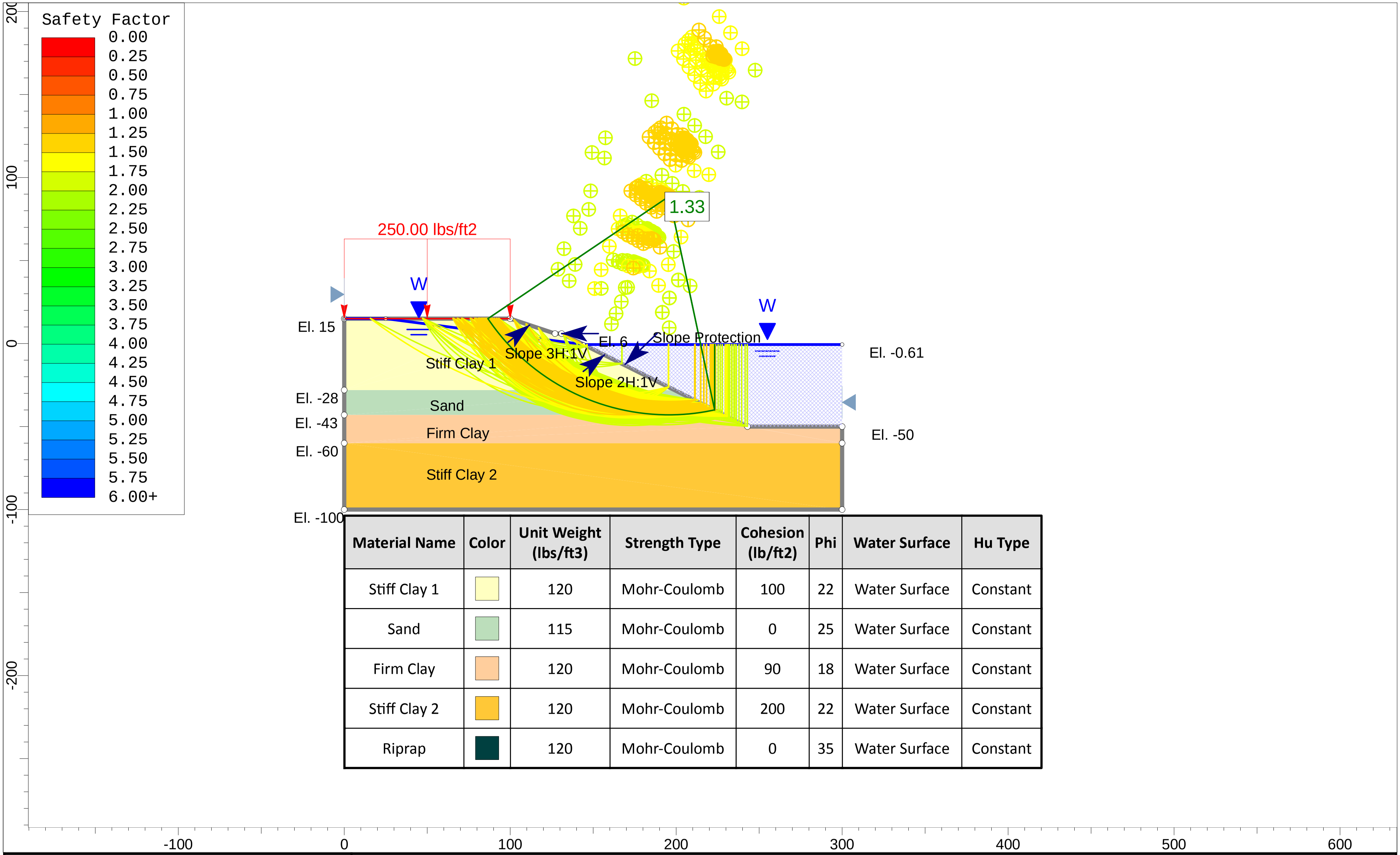
SLIDEINTERPRET 6.008

Project	Berth 6 and Bulkhead Wall Expansion		
Analysis Description	Global Stability - Short Term - Cross Section 4 - Slope 2H:1V		
Drawn By	S. Vedantam	*Company*	Fugro Consultants, Inc.
Date	11/1/13	*Scale*	1:960
File Name	Short Term - 250 psf Surcharge.slim		

PLATE C-13

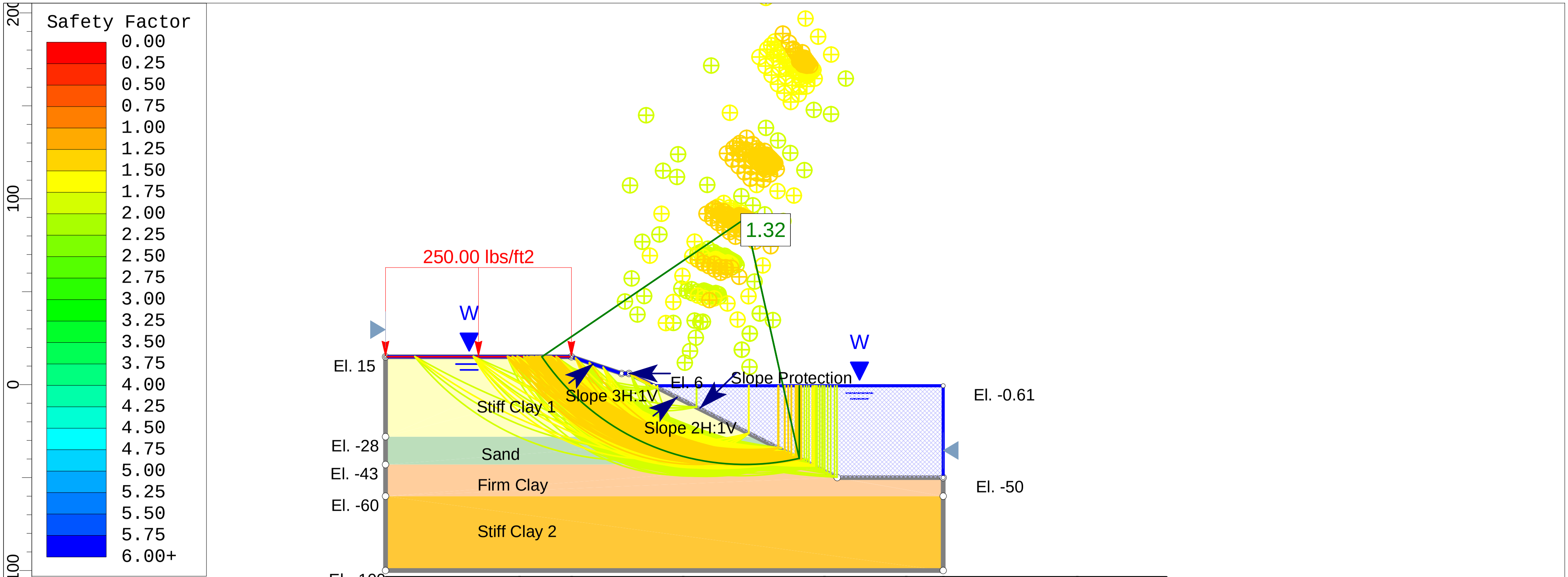


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Stiff Clay 1	🟨	120	Mohr-Coulomb	100	22	Water Surface	Constant
Sand	🟩	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay	🟧	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	200	22	Water Surface	Constant
Riprap	■	120	Mohr-Coulomb	0	35	Water Surface	Constant

SLIDEINTERPRET 6.008

Project	Berth 6 and Bulkhead Wall Expansion		
Analysis Description	Global Stability - Long Term - Cross Section 4 - Slope 2H:1V		
Drawn By	S. Vedantam	*Company*	Fugro Consultants, Inc.
Date 11/1/13	*Scale* 1:960	*File Name*	Long Term - 250 psf Surcharge.slim

PLATE C-14



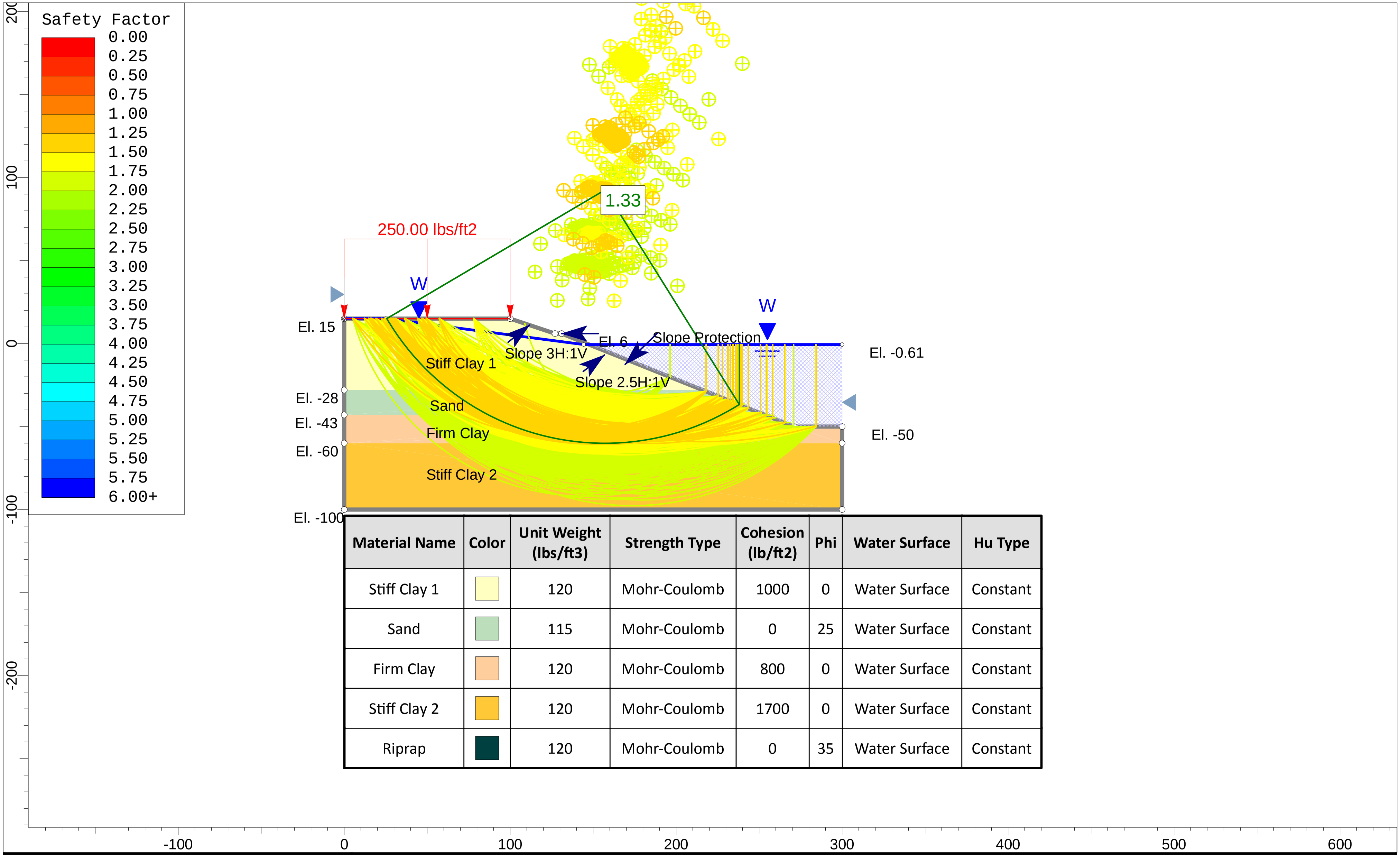
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Stiff Clay 1	🟨	120	Mohr-Coulomb	100	22	Water Surface	Constant
Sand	🟩	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay	🟧	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	200	22	Water Surface	Constant
Riprap	■	120	Mohr-Coulomb	0	35	Water Surface	Constant

FUGRO

SLIDEINTERPRET 6.008

Project	Berth 6 and Bulkhead Wall Expansion		
Analysis Description	Global Stability - Rapid Drawdown - Cross Section 4 - Slope 2H:1V		
Drawn By	S. Vedantam	*Company*	Fugro Consultants, Inc.
Date	11/1/13	*Scale*	1:960
File Name	Rapid Drawdown - 250 psf Surcharge.slim		

PLATE C-15



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Stiff Clay 1	🟨	120	Mohr-Coulomb	1000	0	Water Surface	Constant
Sand	🟩	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay	🟧	120	Mohr-Coulomb	800	0	Water Surface	Constant
Stiff Clay 2	🟧	120	Mohr-Coulomb	1700	0	Water Surface	Constant
Riprap	⬛	120	Mohr-Coulomb	0	35	Water Surface	Constant

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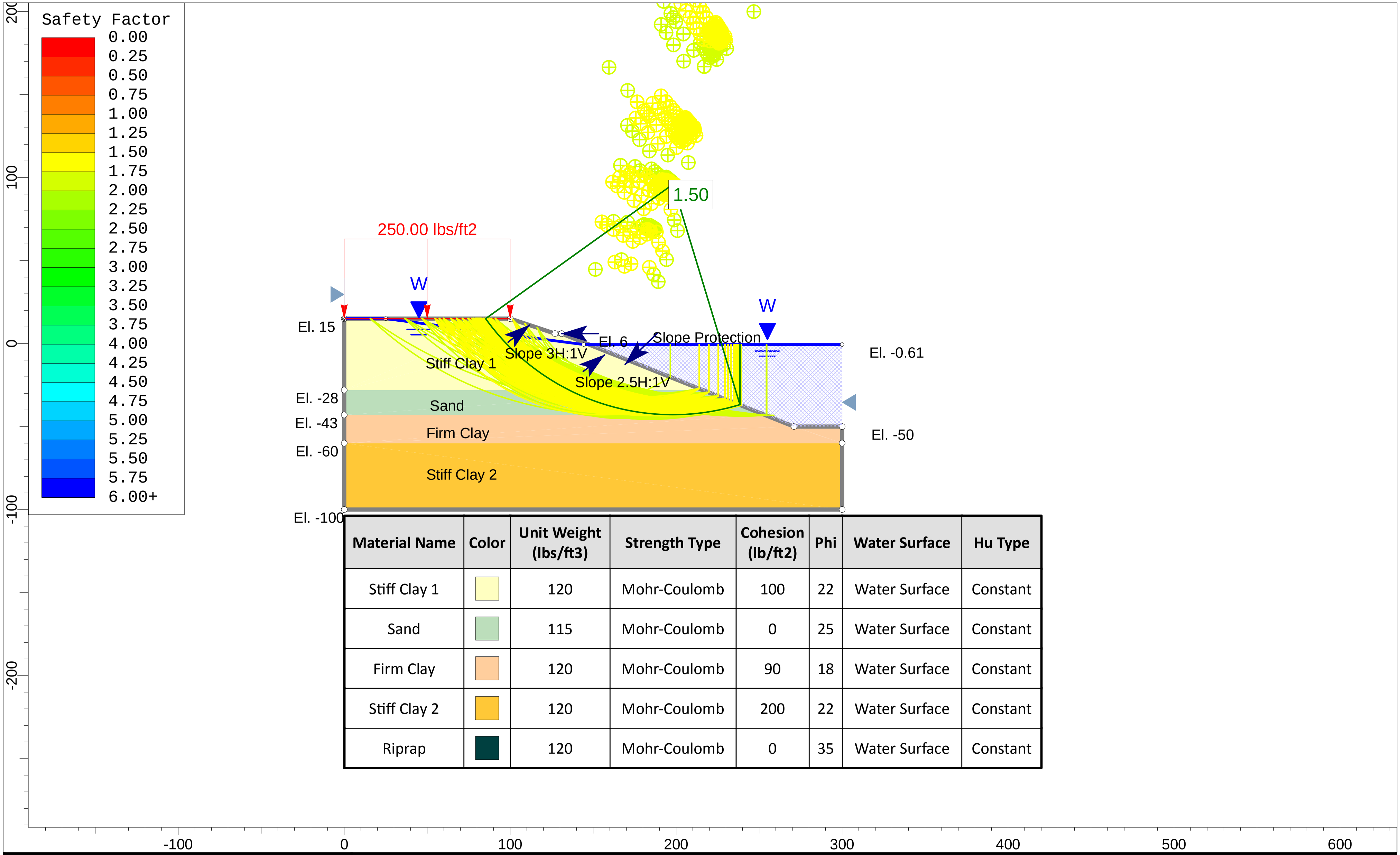
Project	Berth 6 and Bulkhead Wall Expansion
Analysis Description	Global Stability - Short Term - Cross Section 4 - Slope 2.5H:1V
Drawn By	S. Vedantam
Company	Fugro Consultants, Inc.
Date	11/1/13
Scale	1:960
File Name	Short Term - 250 psf Surcharge.slim

SLIDEINTERPRET 6.008

PLATE C-16



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Stiff Clay 1	🟨	120	Mohr-Coulomb	100	22	Water Surface	Constant
Sand	🟩	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay	🟧	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 2	🟧	120	Mohr-Coulomb	200	22	Water Surface	Constant
Riprap	⬛	120	Mohr-Coulomb	0	35	Water Surface	Constant

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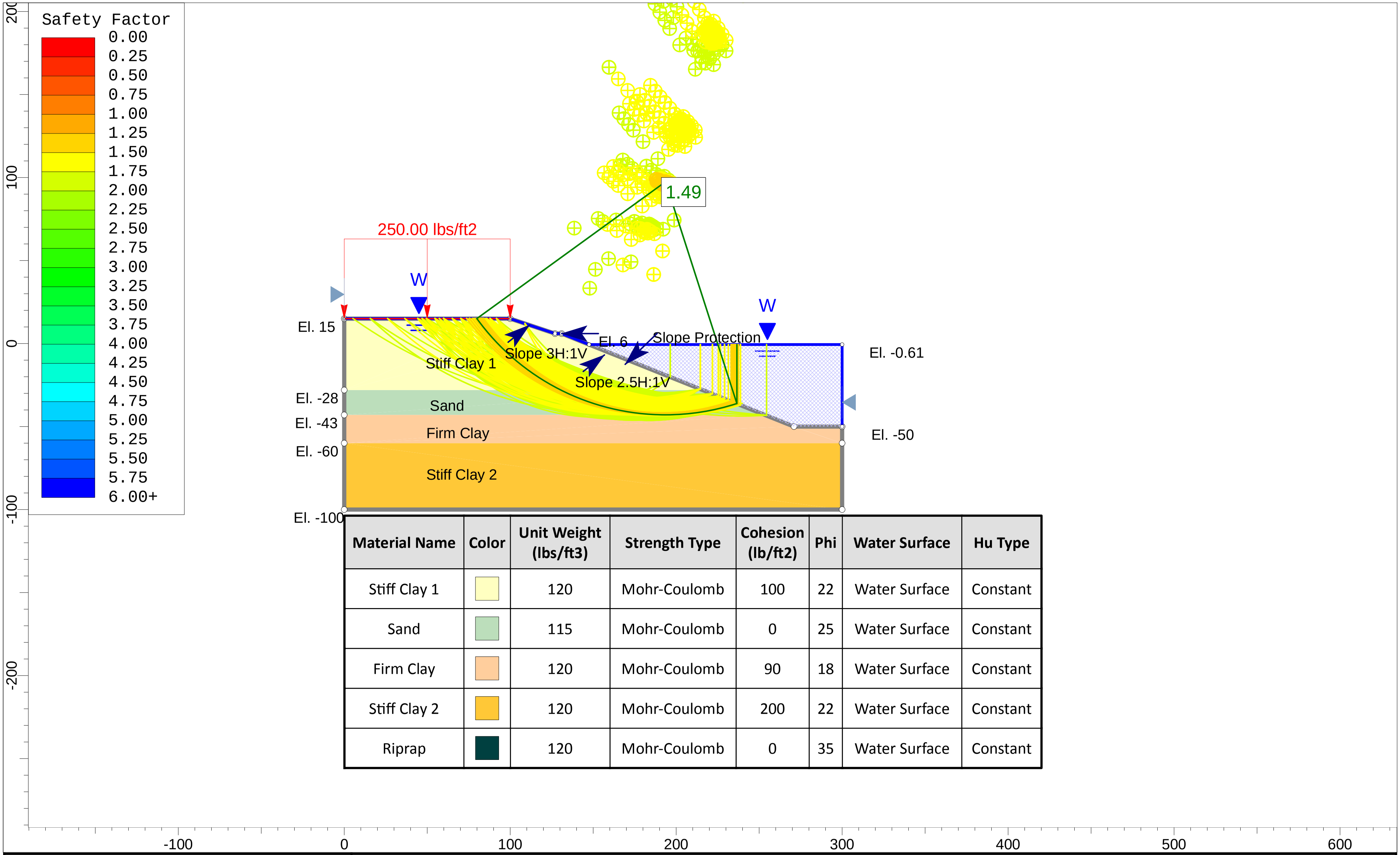
Project
Berth 6 and Bulkhead Wall Expansion

Analysis Description
Global Stability - Long Term - Cross Section 4 - Slope 2.5H:1V

Drawn By S. Vedantam
Company Fugro Consultants, Inc.
Date 11/1/13
Scale 1:960
File Name Long Term - 250 psf Surcharge.slim

SLIDEINTERPRET 6.008

PLATE C-17



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (lb/ft2)	Phi	Water Surface	Hu Type
Stiff Clay 1	🟨	120	Mohr-Coulomb	100	22	Water Surface	Constant
Sand	🟩	115	Mohr-Coulomb	0	25	Water Surface	Constant
Firm Clay	🟧	120	Mohr-Coulomb	90	18	Water Surface	Constant
Stiff Clay 2	🟨	120	Mohr-Coulomb	200	22	Water Surface	Constant
Riprap	⬛	120	Mohr-Coulomb	0	35	Water Surface	Constant

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SLIDEINTERPRET 6.008

Project	Berth 6 and Bulkhead Wall Expansion
Analysis Description	Global Stability - Rapid Drawdown - Cross Section 4 - Slope 2.5H:1V
Drawn By	S. Vedantam
Company	Fugro Consultants, Inc.
Date	11/1/13
Scale	1:960
File Name	Rapid Drawdown - 250 psf Surcharge.slim

PLATE C-18