

PART SIX – ATTACHMENTS

Attachment 1 – Site Plan Sketch

**Attachment 2 – Geotechnical Subsurface Investigation
Report – Sept 9 2009**

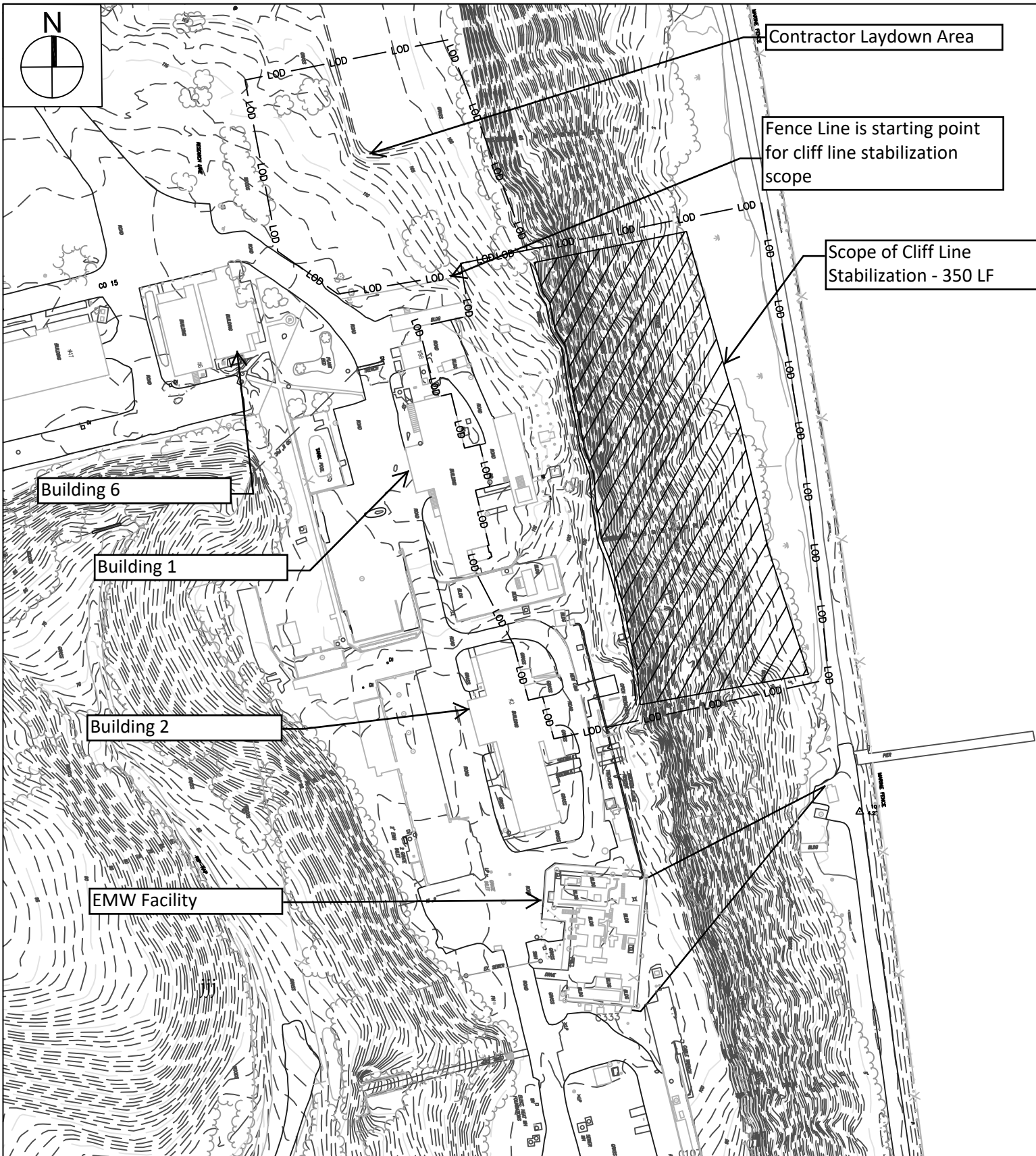
**Attachment 3 – Hydrologic and Hydraulic Report – Dec 7
2009**

Attachment 4 – Cliff Stabilization Options Report

PART SIX - ATTACHMENTS

Attachment 1

Site Plan Sketches



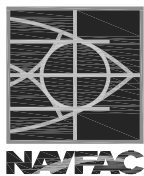
NAVAL FACILITIES ENGINEERING COMMAND WASHINGTON
 DEPARTMENT OF THE NAVY
 PUBLIC WORKS DEPARTMENT

THE UNITED STATES NAVAL ACADEMY
 ANNAPOLIS, MD

SKETCH - 01

CLIFF LINE STABILIZATION

SITE PLAN



DM: JOHN C JONES

DATE: 10/01/2020

PM: NATE JOHNSON

EPROJECT NO.: 1648257

SCALE: 1" = 100'

SHEET

1 OF 2

Hazardous Radiation Area



PART SIX - ATTACHMENTS

Attachment 2 Geotechnical Subsurface Investigation Report – Sept 9 2009

GEOTECHNICAL SUBSURFACE INVESTIGATION REPORT

Slope Stabilization Study Naval Research Laboratory at Chesapeake Bay Calvert County, Maryland



PREPARED FOR:

**US Army Corps of Engineers
10 South Howard Street
Baltimore, MD 21201**

PREPARED BY:



**AB CONSULTANTS, INC.
9450 ANNAPOLIS ROAD
LANHAM, MARYLAND 20706**

September 9, 2009

September 9, 2009 (Revision1)

July 31, 2009

US Army Corps of Engineers
10 South Howard Street
Baltimore, MD 21201

**REF: Report of Subsurface Investigation and Studies
Naval Research Laboratory at Chesapeake Bay, Phase II
Calvert County, Maryland
USACE Contract No. W912DR-07-D-0008, Task 18
AB Job No. 08-324**

Dear Sir or Madam:

AB Consultants, Inc. (ABC) is pleased to submit this soil report containing the results of our geotechnical investigation for the above referenced site. To obtain information of the subsurface conditions, five (5) 150-ft deep soil borings were drilled at the site. The purpose of this study was to explore the subsurface conditions for slope stabilization recommendations being prepared under the above referenced project. The following report sections discuss the results of field and laboratory studies, design recommendations and construction methods to stabilize portions of the slopes for this project.

All jar samples obtained from soil test borings were transported to the material testing laboratory of the US Army Corps Engineers.

It has been a pleasure serving you on this project. If you have any questions regarding this report, or if we can be of further service in any way, please contact us.

Very truly yours,
AB Consultants, Inc.

Kim-Hou Chan, P.E.
Director, Geotechnical & Field Services



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1.0 INTRODUCTION

1.1 General

This report presents the results of the subsurface exploration and laboratory test results performed for the slope stabilization of the Naval Research Laboratory at Chesapeake Beach, Calvert County of Maryland. Per our understanding, the earth slopes in question extend to a length of approximately 4,200 ft and heights up to 95 ft. The slopes are subjected to progressive erosion due to northeastern winds of the Chesapeake Bay, rain and the surface runoff from areas above the slope. This study was conducted for the US Army Corps of Engineers and has been performed in general accordance with the Scope of Architect-Engineer Services package dated on January 21, 2009.

1.2 Scope of Work

The investigation of existing subsurface soil conditions at the site consisted of the following:

- Planning and executing subsurface exploration programs to evaluate soil and ground conditions for slope stabilization analysis.
- Performing soil laboratory tests on soil samples that were obtained from the five (5) borings performed onsite.
- Providing a geotechnical report that includes results of our field and laboratory studies, and our design and recommendation.

1.3 Site Location

The site is located within the Naval Research Laboratory, located along MD Route 261 and is approximately 1.5 miles south of Chesapeake Beach, Maryland. The eroded cliffs are facing east and are located along the westerly side of the Chesapeake Bay.

2.0 FIELD ACTIVITIES AND SUBSURFACE EXPLORATION

2.1 Soil Borings

A total of five (5) soil borings were drilled for subsurface study in the project sites. Due to site accessibility and underground utilities, two boring locations had to be offset from the proposed location. Borings were drilled at the referenced sites to a depth of 150-ft below the existing ground surface between March 30 through April 17, 2009.

Soil borings were staked out in the field by ABC. A vicinity map indicating the approximate locations of the borings is included in the Appendix.

2.2 Subsurface Investigation

Borings were drilled using a truck-mounted drill rig, B-61. Test borings were advanced by using hollow-stem augers to 30 ft below the existing ground and then changed to the mud drilling method. Soil samples were obtained using the Standard Penetration Tests (SPT) in accordance with ASTM D1586. SPT samples were obtained for each boring at depth intervals of every 2.5 feet in the upper 10 feet and at every 5 feet thereafter. A representative portion of each split spoon sample was placed in a glass jar and was transported to our laboratory.

In the split-barrel sampling procedure, a 2-inch O.D. split-barrel sampling spoon is driven into the ground with a 140-pound hammer, free falling a distance of 30 inches. The blows required to advance the sampling spoon to a specified distance are reported as the penetration resistance values. The values are shown on boring logs at the depths of their occurrence. The N-value is the sum of standard penetration resistance values that advanced through the last 12-inches of sampling. The N-value is an indication of the relative density of in-place granular soils and, to a lesser degree of accuracy, the consistency of cohesive soils.

Groundwater level was monitored in the borings. Samples obtained from the borings were inspected by a geotechnical engineer and the field logs were edited accordingly. The final logs that indicated the subsurface conditions encountered is included in the Appendix.

2.3 In-Situ Soil Test

Dilatometer tests in accordance with ASTM D6635 were performed in boring B-2 and B-4. Stainless steel Dilatometer blade under a direct push rig was pushed into the soil at a constant rate. Generally the operator stopped penetration at different depth intervals, recorded the thrust at the test depth using a load cell, and then inflated the membrane. Electrical conductivity between the center of the membrane and the underlying body of the blade, then pressure readings from gauges were recorded and used to determine the soil properties. Due to the cementation of encountered soils, the depths

of the Dilatometer tests were penetrated to approximately 65 ft and 35 ft below the existing ground elevation in boring B-2 and B-4 respectively.

3.0 LABORATORY TESTING PROGRAM

3.1 Laboratory Testing Program

All jar samples obtained from soil test borings were transferred to and tested by the US Army Corps Engineers. Laboratory tests were performed on selected representative samples. Natural moisture contents were performed on all soil samples, and results are included in boring logs. Atterberg limits and sieve analysis were conducted on selected samples. Atterberg limits results are shown in boring logs in correspondence with the sample depths and results of sieve analyses are presented in the Appendix.

3.2 Laboratory Results

Results of laboratory tests performed by the US Army Corps Engineers are included in the Appendix.

4.0 GENERAL SITE AND SUBSURFACE CONDITIONS

4.1 Site Conditions

The project site has an exposed cliff running approximately 4200 lineal feet which is the easterly limits of the Naval Research Laboratory at Chesapeake Beach, Calvert County, Maryland. The ground is predominately covered by grass and trees with areas of paved surfaces and research and administrative buildings scattered throughout. The slopes vary with steeper slopes occurring at the higher elevations. A wooden seawall running from north to south along the Chesapeake Bay is located about 180 feet to the east of the top of the slope. The seawall system consists of timber piles with timber lagging.

4.2 Site Geology

Geologically, the project site is in the Calvert Formation of the Coastal Plain Province. It is underlain by a wedge of unconsolidated sediments including gravel, sand, silt and clay, which overlaps the rocks of the eastern Piedmont. The major soils found in this area were carried down and deposited from larger rivers during the Pleistocene time. Soils found in the project area are interbedded dark green to dark bluish-gray fine-grained

argillaceous sand and sandy clay, and contains prominent shell beds and locally silica-cemented sandstones.

4.3 Subsurface Soil Condition

Various soil types were grouped into the major zones noted on the boring logs. A brief explanation of the terms and notes used in the logs is included with this report. The stratification lines designating the interfaces between earth materials on the boring logs are approximate; in situ, the transitions may be gradual. Detailed soil description and depth of various soil strata are given in boring logs, together with the SPT blow counts with the depths. In general, the encountered soils are grouped into four (4) major types and summarized as follows:

- Stratum I: *Clayey Fine Sand*: Reddish brown to brown and tan sandy soil was found underlying the topsoil and extended to 23- to 27-ft below the existing ground. N-values of encountered soils were ranging from 2 to 24 blows per foot.
- Stratum II: *Fine Sandy Clay*: Underneath Stratum I, dark greenish gray clayey soil with shell fragments was found and extended to 53- to 67.5-ft. N-values of encountered soils were ranging from 2 to 25 blows per foot. This clayey soil exhibits low to moderate plasticity.
- Stratum III: *Silty Fine Sand*: Dark greenish gray silty fine sand with shell fragments was found underneath Stratum II and extended to 68- to 82-ft. N-values of encountered soils were ranging from 14 to 42 blows per foot.
- Stratum IV: *Silty Clay*: Underneath Stratum III, dark greenish gray silty clay with shall fragments and traces of sand was encountered and extended to the completion depths of the borings. N-values of encountered soils were ranging from 19 to 35 blows per foot. This clayey soil exhibits moderate to high plasticity.

4.4 Groundwater Observations

Groundwater observations were made in every borehole during drilling, and after completion of the drilling operations. As noted on boring logs, groundwater was **encountered** during and after drilling in some of the borings. Due to the mud drilling method, water readings obtained after the set up of this operation are not accurate. Water

level observations are presented at the lower left hand corner of the boring logs. The variations between the recorded water readings might be a result of saturated ground and surface runoff from rain. Fluctuations in the level and quantity of ground water will occur due to variations in rainfall, temperature, soil permeability and other factors not evident at the time of the water level measurements recorded on the boring logs.

5.0 ANALYSIS AND RECOMMENDATIONS

5.1 Slope Stability Analysis

A slope stability analysis was performed using the computer program STED, which includes STABLE5M. The program allows the generation of circular failure surfaces and calculation of the factor of safety against instability of the slopes. Idealized geometry and a graphic presentation were developed based on the available information and factors of safety which calculated for several typical sections representing a range of conditions. The factor of safety is defined as the ratio of the forces resisting to the force driving failure. In general, a minimum safety factor of 1.5 is typically required for slope stability. The soil parameters utilized for the slope stability analysis were based on field test data, laboratory results, empirical correlation from the SPT, laboratory data, and published information.

SUMMARY OF ENCOUNTERED SOIL PROPERTIES						
Sample Description	USCS	Average Sample Depth Below Existing Ground (ft)	Average N-Values	Range of Effective Unit Weight, γ (pcf)	Range of Friction Angle, ϕ (deg.)	Undrained Shear Strength, c_u (psf)
Clayey fine sand	SC	1 to 25	5 to 10	110 to 115	28 to 32	-
Fine sandy clay	CL	25 to 60	10 to 15	110 to 115	-	2000
Silty fine sand	SM	60 to 75	20 to 25	110 to 115	32 to 36	-
Silty clay	CL/CH	Below 75	20 to 25	110 to 115	-	4000

Slope stability analyses were performed for four (4) cross sections in the areas of boring B-1, B-2, B-4 and B-5 to evaluate the existing slope conditions. These sections represent the general subsurface conditions and areas of interest. The analysis models are based on encountered subsoils information that revealed from borings and few assumptions of general soil behaviors. The factors of safety obtained from these sections

were summarized in the following table and outputs from the analyses are included in the Appendix.

FACTOR OF SAFETY OF EXISTING SITE CONDITIONS		
Location	Cross Section Based on Civil Plan	Factor of Safety
B-1, close to Building #75	CS-01 Section A-1	1.35
B-1a, close to Building #75	CS-01 Section A-2	1.65*
B-2, close to Building #250	CS-02 Section B-1	1.11
B-2a, close to Building #5	CS-02 Section B-2	1.08
B-4, close to Building #2	CS-04 Section C-2	1.30
B-4a, close to Building #2	CS-04 Section C-3	1.36
B-5, close to Antenna Tower	CS-04 Section C-4	1.34

*Area with existing pile retaining system

Based upon our analyses, the global slope stability of this site is considered unstable. Considering the soil information revealed from borings and the site grading conditions, slope stabilization system, such as soil nails or different types of earth retaining system are believed to be appropriate in this case. With the exiting environment and minimal of earthwork, it is our opinion that a earth retaining system, such as pre-bored piles and lagging, and metal sheet piles are appropriate for these conditions.

Preliminary slope stability analyses were performed by STED program for the above cross sections by limiting the failure slopes with piles that are driven into the ground at the lower section of the deep slope. Driven metal sheet piles should be founded in the medium dense silty fine sand (Stratum III) or stiff silty clay (Stratum IV). The pile lengths are estimated to be ranging from 40 to 50 ft and they should be secured by anchors to eliminate any movement. Summary of our analyses are presented in the following table and results from the analyses are included in the Appendix. Other design alternatives can be provided if desired. Detail slope stabilization design by bored piles with a lagging system is not available at this time, as all geotechnical data has to be evaluated by other structural and civil engineers.

FACTOR OF SAFETY WITH INSTALLATION OF PILES				
Location	Estimated Pile Length (ft)	Approx. Pile Bottom Elevation	Approx. Distance from Seawall (ft)	Factor of Safety
B-1, close to Building #75	50	10	110	1.91
B-2, close to Building #250	40	10	105	1.88
B-2a, close to Building #5	50	0	120	1.68
B-4, close to Building #2	40	0	130	1.92
B-4a, close to Building #2	40	10	100	1.54
B-5, close to Antenna Tower	50	10	90	1.75

5.2 Earth Retaining System

Pre-bored piles and lagging or metal sheet piles retaining soils and fills will be subjected to lateral earth pressures. The magnitude of lateral earth pressure will depend upon the type and density of the backfill and/or natural soil adjacent to the wall, the rigidity of the wall and the drainage conditions behind the wall.

The design lateral earth pressure should be 50 lbs per sq. ft and 40 lbs per sq. ft equivalent fluid pressures for cohesive and granular backfill, respectively per vertical foot of wall. These values assume a fixed wall (at-rest earth pressure condition) and both drained and full hydrostatic pressure conditions. The wall design should also account for any surcharge loads within a 45 degree slope from the base of the wall. Wall surcharge loads must also be considered in design. Lateral earth pressure coefficient values of 0.7 and 0.5 are considered suitable for the sand and clean stone backfill, respectively, in consideration of surcharge loads.

The design lateral earth pressures provided above do not include a factor of safety. Surcharge due to sloping ground surface above the wall and other loads located adjacent to and above the base of the wall can have a significant influence in lateral earth pressure and should be considered during design. Also, there is no provision in the above pressures for hydrostatic loading on the wall.

5.3 Erosion Control

During our site visit, soil erosion was noticed in different areas. It is our opinion that some sort of erosion control system should be considered for better slope protection. Erosion control with a combination of geosynthetic erosion control materials and re-

vegetation systems should be considered. Geosynthetic materials, such as geogrids or geomats, are plastics formed into a very open, gridlike configuration, or even 3-dimensional matrices which function as reinforcement materials. The open space in these geomatrix designs allow vegetation to grow and provide soil retention. Examples of some geosynthetic erosion control materials for slope reinforcement and erosion control are included in the following table for reference.

Product Name	Company Name
Pyramat	Contech Construction Products
Enkamat	Colbond Geosynthetics
Tensor biaxial (BX) geogrids w/ erosion mat	Tensor Earth Technologies

5.4 Seismic Considerations

Moderate amount of low-level earthquake activities have been recorded in the mid-Atlantic Region and in the State of Maryland, where numerous faults exists. Faults have various patterns and they may be sub-parallel and braided but may diverge or branch. Earthquakes are often caused by energized-movements within faults and the ground shaking is caused by waves that accompany the movements. There are numerous faults in the State of Maryland but is known or considered to be **inactive**. It is noteworthy that despite the fact that these low-level seismic activities usually do not cause significant structural damage or injuries, all engineers must be cognizant of the International Building Code Seismic Design Requirements cited in the Building Code of the State of Maryland. Based on subsurface conditions encountered in the sample borings and Building Code criteria, a seismic site classification of Class D is determined. For further structural design parameters, refer to International Building Code 2006, Section 1613.

5.6 Construction Considerations

During construction and following completion of the project, positive surface drainage should be established and, be maintained to prevent surface water ponding and subsequent saturation of subgrade soils. Prolonged exposure or saturation of subgrade soils may result in significant changes in strength and compressibility characteristics. Groundwater may be encountered in the excavation areas. Any seepage into the

construction excavation could be controlled by pumping from sump pits. During site preparation, surface runoff should be directed away from the construction areas.

6.0 GENERAL COMMENTS

The soil classifications presented in this report are based upon the data obtained from the soil borings performed at indicated locations and from any other information discussed in this report. This report does not reflect any variations that may occur across the site. The nature and extent of such variations may not become evident until construction. If variations appear evident, the conclusion and recommendations of this report should then be reviewed by the ABC geotechnical engineer in light of the new information.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranties, either expressed or implied, are intended or made. In the event that any changes in the nature, design or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions of this report modified or verified in writing by ABC geotechnical engineer of record.

APPENDIX

A. General Notes

B. Vicinity Map

C. Boring Location Layout

D. Boring Logs and Subsurface Diagram

E. Dilatometer Test Results

F. Laboratory Test Results

G. Slope Stability Analysis Results

GENERAL NOTES

Drilling and Sampling Symbols



N = Standard penetration, blows per foot of a 140 lbs hammer for 30" drop

RQD = Rock Quality Designation

LL = Liquid Limit

PL = Plastic Limit

PI = Plasticity Index

Cohesionless Soils

If the sand or silt content of a soil is great enough, the soil becomes non-cohesive or semi-cohesive. The soil classification becomes SAND or SILT with the other soil constituents being modifying.

Based on N-Value

0 to 4 Blows.....Very Loose

5 to 9 Blows.....Loose

10 to 29 Blows.....Medium Dense

30 to 59 Blows.....Dense

Over 60 Blows.....Very Dense

Cohesive Soils

If clay content is sufficient so that clay dominates soil properties, then CLAY becomes the major soil constituent as modifier. Other minor soil constituents may be added according to classification breakdown for cohesion less soils: i.e. silty clay, trace of some sand, trace of gravel.

Based on N-Value

0 to 3 Blows.....Very Soft

4 to 5 Blows.....Soft

6 to 16 Blows.....Firm

16 to 30 Blows.....Stiff

30 to 60 Blows.....Very Stiff

Over 61 Blows.....Hard

Based on Penetrometer Value

Below 0.25.....Very Soft

0.25 to 0.49.....Soft

0.50 to 0.99.....Firm

1.00 to 1.99.....Stiff

2.00 to 3.99.....Very Stiff

Over 4.00.....Hard

Quantity Modifiers

<u>Term</u>	<u>% of Dry Weight</u>
trace	0 to 10
little	11 to 20
some	21 to 35
and/with	36 to 50

Particle Size Identifications

Boulder Over 8 inch diameter

Cobbles.....3 inch to 8 inch

Gravel.....Coarse.....1 inch to 3 inch

Medium.....1/2 inch to 1 inch

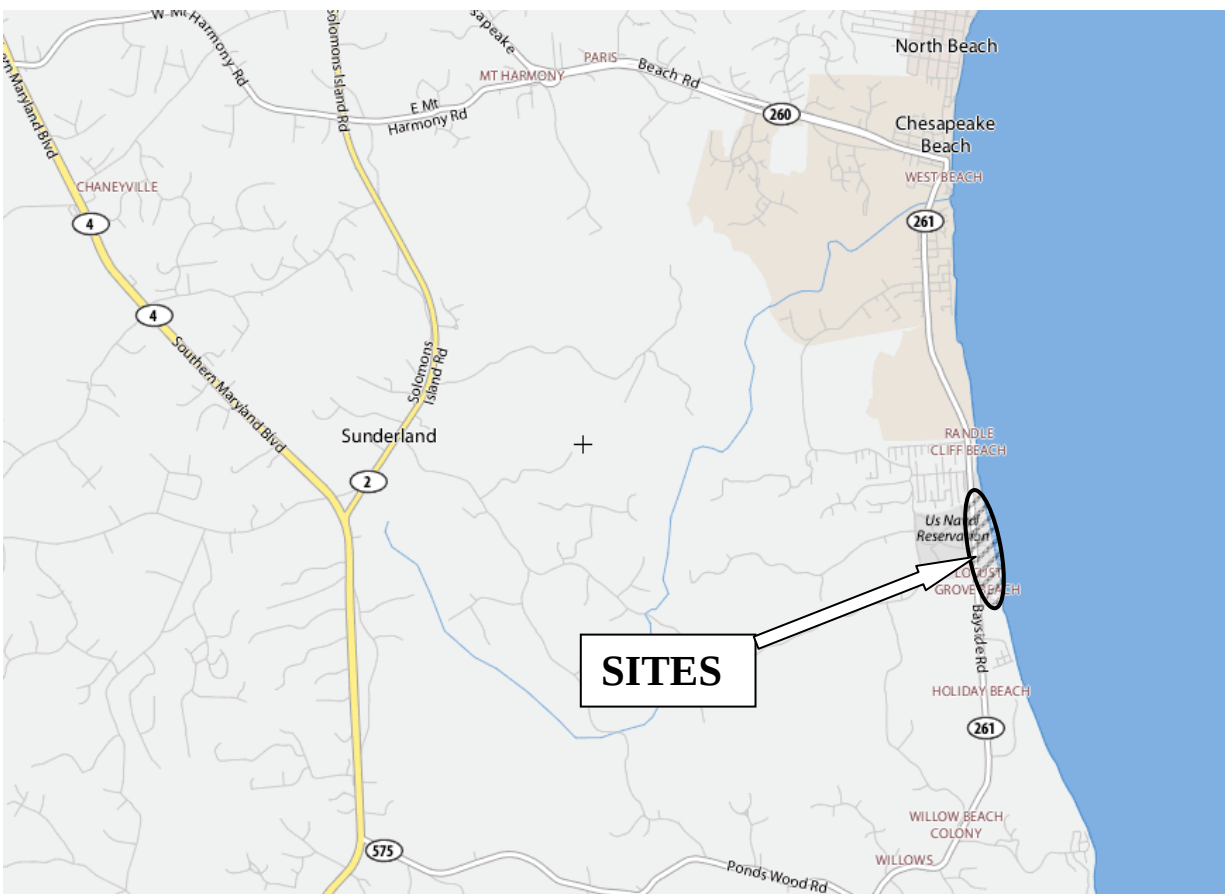
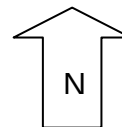
Fine.....4.75 mm to 1/2 inch

Sand.....Coarse.....2 mm to 4.75 mm

Medium.....0.425 mm to 2 mm

Fine.....0.075 mm to 0.425 mm

Silt/Clay.....Below 0.075 mm



VICINITY MAP

Naval Research Laboratory at Chesapeake Beach
Calvert County, Maryland

JOB NO.: 08-324

SCALE: N.T.S.

DATE: 7/17/09



PHASE II BORING LAYOUT PLAN
AT THE
NAVAL RESEARCH LAB
CALVERT COUNTY, MARYLAND

ABC
AB CONSULTANTS, INC.
9450 ANNAPOLIS ROAD
LANHAM, MARYLAND 20706
PHONE: (301) 306-3091
FAX: (301) 306-3092



BORING LOGS and SUBSURFACE DIAGRAM

Project No. 08-324

LOG OF BOREHOLE B-1

Sheet 1 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

		GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS									
				BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA					
SURFACE ELEV.: 90.6 ft.																	
0.5	5" Topsoil		90.1														
	Loose to very loose brown to tan CLAYEY FINE SAND (SC)			2-2 6 N=8	1	SS	15/18 83%	27									
			5	1-2 2 N=4	2	SS	14/18 78%	38									
				2-3 3 N=6	3	SS	14/18 78%	24									
			10	2-2 2 N=4	4	SS	16/18 89%	33								LL = 46 PL = 26 PI = 20	
			15		5	ST	24/24 100%	29									
				2-2 4 N=6	6	SS	18/18 100%	30									
			20	2-3 4 N=7	7	SS	18/18 100%	23									
23.0		Firm to stiff dark greenish gray FINE SANDY CLAY (CL) with shell fragments		25	1-1 1 N=2	8	SS	18/18 100%	56								
				30	1-1 1 N=2	9	SS	18/18 100%	62								
				35	3-6 11 N=17	10	SS	18/18 100%	51								
			40		11	ST	12/24 50%	59									

Continued Next Page

Continued Next Page

WATER LEVEL OBSERVATIONS

WL	▽	31	@ Drilling
WL		Dry, cave in 20 ft	@ 0 hr
WL		Dry, cave in 20 ft	@ 72 hr



AB Consultants, Inc.

9450 Annapolis Road
Lanham, MD 20706
Phone: 301-306-3091
Fax: 301-306-3092

STARTED:	4/8/09	FINISHED:	4/10/09
DRILL CO.:	ABC	DRILL RIG:	B-61
DRILLER:	SP	ASST DRILLER:	
LOGGED BY:		APPROVED:	

Project No. 08-324

LOG OF BOREHOLE B-1

Sheet 2 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

	GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS				
			BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA
(continued)											
Firm to stiff dark greenish gray FINE SANDY CLAY (CL) with shell fragments (continued)			4-8 9 N=17	12	SS	18/18 100%	63				
		45	5-7 11 N=18	13	SS	18/18 100%	80				
		50	3-5 13 N=18	14	SS	18/18 100%	58				
53.0	37.6										
Medium dense dark greenish gray SILTY FINE SAND (SM)			7-9 11 N=20	15	SS	18/18 100%	35				
		55									
		60	11-12 12 N=24	16	SS	18/18 100%	28				
		65	3-6 14 N=20	17	SS	18/18 100%	44				
68.0	22.6										
Firm to stiff dark greenish gray SILTY CLAY (CL) with shell fragments and trace of sand			4-9 15 N=24	18	SS	18/18 100%	60				
		70									
		75	5-8 15 N=23	19	SS	18/18 100%	67				
		80	4-7 14	20	SS	18/18 100%	51				

Continued Next Page

WATER LEVEL OBSERVATIONS

WL	▽	31	@ Drilling
WL		Dry, cave in 20 ft	@ 0 hr
WL		Dry, cave in 20 ft	@ 72 hr



AB Consultants, Inc.
 9450 Annapolis Road
 Lanham, MD 20706
 Phone: 301-306-3091
 Fax: 301-306-3092

STARTED:	4/8/09	FINISHED:	4/10/09
DRILL CO.:	ABC	DRILL RIG:	B-61
DRILLER:	SP	ASS'T DRILLER:	
LOGGED BY:		APPROVED:	

BORING LOG AB08 08-324.GPJ AB CONS.GDT 7/28/09

Project No. 08-324

LOG OF BOREHOLE B-1

Sheet 3 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

	GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS				
			BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA
(continued)			N=21								
Firm to stiff dark greenish gray SILTY CLAY (CL) with shell fragments and trace of sand (continued)		85	4-8 14 N=22	21	SS	18/18 100%	49				
		90	5-10 14 N=24	22	SS	18/18 100%	50				
		95	6-8 13 N=21	23	SS	18/18 100%	64				
		100	6-10 11 N=21	24	SS	18/18 100%	74				
		105	5-8 11 N=19	25	SS	18/18 100%	57				
		110	6-9 12 N=21	26	SS	18/18 100%	56				
		115	5-9 10 N=19	27	SS	18/18 100%	58				
117.0		-26.4									
Stiff to hard greenish gray SILTY CLAY (CH) with trace of fine sand		120	7-11 15	28	SS	18/18 100%	68				
Continued Next Page											

WATER LEVEL OBSERVATIONS

WL	▽	31	@ Drilling
WL		Dry, cave in 20 ft	@ 0 hr
WL		Dry, cave in 20 ft	@ 72 hr



AB Consultants, Inc.

9450 Annapolis Road
Lanham, MD 20706
Phone: 301-306-3091
Fax: 301-306-3092

STARTED:	4/8/09	FINISHED:	4/10/09
DRILL CO.:	ABC	DRILL RIG:	B-61
DRILLER:	SP	ASST DRILLER:	
LOGGED BY:		APPROVED:	

Project No. 08-324

LOG OF BOREHOLE B-1

Sheet 4 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Stiff to hard greenish gray SILTY CLAY (CH)
with trace of fine sand (continued)

GRAPHIC LOG

DEPTH (FT)

SAMPLES

TESTS

BLOWS/6"
N - VALUE
RQD

NUMBER

TYPE

IN. RECOVERED
IN. DRIVEN

MOISTURE (%)

DRY DENSITY
(PCF)Qu
(TSF)% PASSING
#200 SIEVEREMARKS/
ADDITIONAL
DATA

125

8-10
14
N=24

29

SS

18/18
100%

77

130

6-8
13
N=21

30

SS

18/18
100%

65

135

7-9
13
N=22

31

SS

18/18
100%

68

140

11-16
19
N=35

32

SS

18/18
100%

45

145

7-11
14
N=25

33

SS

18/18
100%

48

150.0

-59.4

150

8-12
16
N=28

34

SS

18/18
100%

80

End of Boring @ 150 ft

Mud drilling method started at 30 ft

WATER LEVEL OBSERVATIONS

WL	▽	31	@ Drilling
WL		Dry, cave in 20 ft	@ 0 hr
WL		Dry, cave in 20 ft	@ 72 hr



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DRILLER: SP ASS'T DRILLER:

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BORING LOG AB08 08-324.GPJ AB CONS.GDT 7/28/09

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Firm to stiff dark greenish gray FINE SANDY CLAY (CL) with shell fragments (continued)

GRAPHIC LOG

DEPTH (FT)

SAMPLES

TESTS

BLOWS/6"
N - VALUE
RQD

NUMBER

TYPE

IN. RECOVERED
IN. DRIVEN

MOISTURE (%)

DRY DENSITY
(PCF)Qu
(TSF)% PASSING
#200 SIEVEREMARKS/
ADDITIONAL
DATA

45

N=15

11

SS

18/18

52

LL = 74
PL = 26
PI = 48

46

4-6

9

18/18

100%

47

N=15

48

5-8

12

SS

18/18

57

49

N=20

50

6-8

12

SS

18/18

100%

51

N=20

52

6-8

12

SS

18/18

67

53

N=20

54

6-8

11

SS

18/18

84

55

N=19

56

7-8

10

SS

18/18

81

57

N=18

58

11-11

12

SS

18/18

24

59

N=23

60

5-7

13

SS

12/18

33

61

N=20

62

5-7

14

SS

18/18

39

63

N=14

64

100%

67.5

Medium dense dark greenish gray SILTY FINE SAND (SM) with shell fragments

36.0

70

11-11

12

SS

18/18

24

71

N=23

72

5-7

13

SS

12/18

67%

73

N=20

74

5-7

14

SS

18/18

39

75

N=20

76

5-7

14

SS

18/18

39

77

N=20

78

5-7

14

SS

18/18

39

79

N=20

80

5-7

14

SS

18/18

39

Continued Next Page

WATER LEVEL OBSERVATIONS

@ Drilling

WL Dry, cave in 6.5 ft @ 0 hr

WL Dry, cave in 6.5 ft @ 24 hr



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DRILLER: SP

ASS'T DRILLER:

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Project No. 08-324

LOG OF BOREHOLE B-2

Sheet 3 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Stiff dark greenish gray SILTY CLAY (CL) with
trace of shell fragments with trace of sand
(continued)

GRAPHIC LOG

DEPTH (FT)

SAMPLES

TESTS

BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA
N=21								
4-8 12 N=20	19	SS	18/18 100%	64				
5-9 12 N=21	20	SS	18/18 100%	70				
4-8 13 N=21	21	SS	18/18 100%	51				
5-10 19 N=29	22	SS	18/18 100%	42				
5-8 12 N=20	23	SS	18/18 100%	60				
5-8 11 N=19	24	SS	18/18 100%	82				
6-9 12 N=21	25	SS	18/18 100%	90				
5-8 14	26	SS	18/18 100%	50				

117.0

-13.5

Stiff dense dark greenish gray SILTY CLAY
(CH) with trace of fine sand

Continued Next Page

WATER LEVEL OBSERVATIONS

	@ Drilling
WL	Dry, cave in 6.5 ft @ 0 hr
WL	Dry, cave in 6.5 ft @ 24 hr



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Project No. 08-324

LOG OF BOREHOLE B-2

Sheet 4 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

	GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS				
			BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA
(continued)											
Stiff dense dark greenish gray SILTY CLAY (CH) with trace of fine sand (continued)			N=22								
		125	6-9 13 N=22	27	SS	18/18 100%	51				
		130	10-14 20 N=34	28	SS	18/18 100%	62				
		135	8-12 15 N=27	29	SS	18/18 100%	61				
		140	8-11 14 N=25	30	SS	18/18 100%	72				
		145	7-11 13 N=24	31	SS	18/18 100%	72				
150.0	-46.5	150	6-9 14 N=23	32	SS	12/18 67%	72				
End of boring @ 150 ft											
Mud drilling method started at 30 ft											

WATER LEVEL OBSERVATIONS

	@ Drilling
WL	Dry, cave in 6.5 ft @ 0 hr
WL	Dry, cave in 6.5 ft @ 24 hr



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Project No. 08-324

LOG OF BOREHOLE B-3

Sheet 1 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

			GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS						
					BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA		
SURFACE ELEV.: 101.0 ft.															
0.9	11" Top soil		100.1												
	Medium dense reddish brown to brown CLAYEY FINE SAND (SC)				2-4 6 N=10	1	SS	12/18 67%	29						
					2-3 4 N=7	2	SS	14/18 78%	30						
7.5			93.5		3-4 8 N=12	3	SS	15/18 83%	33						
	Medium dense brwon, tan and ligh gray CLAYEY FINE SAND (SC)				2-4 4 N=8	4	SS	15/18 83%	38						
															
					4-5 9 N=14	5	SS	15/18 83%	29						
															
					3-5 5 N=10	6	SS	18/18 100%	36						
22.0			79.0												
	Firm to stiff dark greenish gray FINE SAND CLAY (CL) with trace of shell fragments				2-4 4 N=8	7	SS	18/18 100%	55						
															
					2-2 3 N=5	8	SS	16/18 89%	33						
															
					4-6 10 N=16	9	SS	18/18 100%	40						
															
					3-6 10	10	SS	18/18 100%	44						
															

Continued Next Page

Continued Next Page

WATER LEVEL OBSERVATIONS

		@ Drilling
WL	▼ 29.5	@ 0 hr
WL	Dry, cave in 29 ft	@ 24 hr



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LOG OF BOREHOLE B-3

Sheet 2 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Firm to stiff dark greenish gray FINE SAND
CLAY (CL) with trace of shell fragments
(continued)

GRAPHIC LOG

DEPTH (FT)	SAMPLES				TESTS				
	BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Q _u (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA
	N=16								
45	4-8 12 N=20	11	SS	18/18 100%	49				
50	6-10 13 N=23	12	SS	18/18 100%	58				
55	7-10 14 N=24	13	SS	18/18 100%	78				
60	2-7 11 N=18	14	SS	18/18 100%	41				
65	6-10 15 N=25	15	SS	18/18 100%	51				
70	7-9 9 N=18	16	SS	18/18 100%	36				
75	3-5 9 N=14	17	SS	18/18 100%	38				
80	4-7 11	18	SS	18/18 100%	57				

66.0

35.0

Medium dense dark greenish gray SILTY FINE
SAND (SM) with trace of shell fragments

77.0

24.0

Medium dense dark greenish gray SILTY
CLAY (CH) with trace of fine sand

Continued Next Page

WATER LEVEL OBSERVATIONS

		@ Drilling
WL	▼ 29.5	@ 0 hr
WL	Dry, cave in 29 ft	@ 24 hr



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LOG OF BOREHOLE B-3

Sheet 3 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Medium dense dark greenish gray SILTY
CLAY (CH) with trace of fine sand (continued)

GRAPHIC LOG

DEPTH (FT)

SAMPLES

TESTS

BLOWS/6"
N - VALUE
RQD

NUMBER

TYPE

IN. RECOVERED
IN. DRIVEN

MOISTURE (%)

DRY DENSITY
(PCF)Qu
(TSF)% PASSING
#200 SIEVEREMARKS/
ADDITIONAL
DATA85
90
95
100
105
110
115
120N=18
6-12
16
N=28
5-9
14
N=23
5-9
19
N=28
6-13
21
N=34
6-10
12
N=22
7-9
12
N=21
5-7
10
N=17
6-8
1219
20
21
22
23
24
25
26SS
SS
SS
SS
SS
SS
SS
SS18/18
100%
18/18
100%
18/18
100%
18/18
100%
15/18
83%
18/18
100%64
53
44
47
73
69
56
62

Continued Next Page

WATER LEVEL OBSERVATIONS

		@ Drilling
WL	▼ 29.5	@ 0 hr
WL	Dry, cave in 29 ft	@ 24 hr



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Project No. 08-324

LOG OF BOREHOLE B-3

Sheet 4 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Medium dense dark greenish gray SILTY
CLAY (CH) with trace of fine sand (continued)

GRAPHIC LOG

DEPTH (FT)

SAMPLES

TESTS

BLOWS/6"
N - VALUE
RQD

NUMBER

TYPE

IN. RECOVERED
IN. DRIVEN

MOISTURE (%)

DRY DENSITY
(PCF)Qu
(TSF)% PASSING
#200 SIEVEREMARKS/
ADDITIONAL
DATA

125

130

135

140

145

150

N=20

7-11
14
N=257-12
14
N=267-10
15
N=257-9
13
N=228-11
13
N=2417-26
27
N=53

27

28

29

30

31

32

SS

SS

SS

SS

SS

SS

18/18
100%18/18
100%18/18
100%18/18
100%18/18
100%18/18
100%

65

79

53

70

72

36

LL = 120
PL = 39
PI = 81

150.0

-49.0

End of Boring @ 150 ft

Mud drilling method started at 50 ft

WATER LEVEL OBSERVATIONS

@ Drilling

WL 29.5 @ 0 hr

WL Dry, cave in 29 ft @ 24 hr



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Project No. 08-324

LOG OF BOREHOLE B-4

Sheet 1 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

SURFACE ELEV.: 101.4 ft.	GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS				
			BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA
0.5 6" Top soil											
2.5 Medium dense brown SILTY FINE SAND (SM)		100.9	4-8 9 N=17	1	SS	14/18 78%	12				
		98.9	2-2 4 N=6	2	SS	14/18 78%	26				
			1-2 2 N=4	3	SS	15/18 83%	32				
			1-2 2 N=4	4	SS	18/18 100%	45				
				5	ST	24/24 100%	56				
			1-1 1 N=2	6	SS	18/18 100%					
			3-5 5 N=10	7	SS	18/18 100%	49				LL = 46 PL = 25 PI = 21
			2-2 5 N=7	8	SS	18/18 100%	35				
27.0 Firm to stiff dark greenish gray FINE SANDY CLAY (CL) with shell fragments		74.4	3-3 6 N=9	9	SS	18/18 100%	56				
			2-51/5 "	10	SS	10/11 91%	33				
			2-4 8	11	SS	18/18 100%	32				

Continued Next Page

WATER LEVEL OBSERVATIONS

		@ Drilling
WL	69	@ 100 hr
WL	Dry, cave in 15.5 ft @ 144 hr	



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DRILL CO.: ABC

DRILL RIG: B-61

DRILLER: SP

ASST DRILLER:

LOGGED BY:

APPROVED:

CLIENT:

US Army Corps Engineers

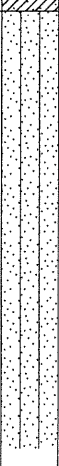
PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

	GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS				
			BLOWS/6" N-VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA
(continued)											
Firm to stiff dark greenish gray FINE SANDY CLAY (CL) with shell fragments (continued)			N=12	12	ST	0/24 0%	49				
		45	3-4 7 N=11	13	SS	18/18 100%	43				
		50		14	ST	0/24 0%					
			4-7 9 N=16	15	SS	18/18 100%	58				
		55	5-8 10 N=18	16	SS	18/18 100%	69				
		60	6-7 10 N=17	17	SS	18/18 100%	72				
66.0 Loose to medium dense dark greenish gray SILTY FINE SAND (SM) with shell fragments		65	6-8 9 N=17	18	SS	18/18 100%	80				
		70	7-7 9 N=16	18	SS	18/18 100%	31				
		75	5-6 10 N=16	20	SS	18/18 100%	32				
		80	9-16 26	21	SS	18/18 100%	34				

Continued Next Page

WATER LEVEL OBSERVATIONS

		@ Drilling
WL		69 @ 100 hr
WL		Dry, cave in 15.5 ft @ 144 hr



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CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

	GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS				REMARKS/ ADDITIONAL DATA
			BLOWS/6" N - VALUE ROD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	
(continued)			N=42								
82.0											
Loose to medium dense dark greenish gray SILTY FINE SAND (SM) with shell fragments (continued)											
		19.4									
Stiff dark greenish gray SILTY CLAY (CH) with shell fragments and trace of fine sand											
		85	5-9 15 N=24	22	SS	18/18 100%	64				
		90	7-12 20 N=32	23	SS	18/18 100%	67				
		95	4-7 15 N=22	24	SS	18/18 100%	42				
		100	5-10 18 N=28	25	SS	18/18 100%	45				
		105	5-7 15 N=22	26	SS	18/18 100%	52				
		110	6-9 11 N=20	27	SS	18/18 100%	70				
		115	6-7 11 N=18	28	SS	18/18 100%	54				
		120	6-11 18	29	SS	18/18 100%	44				

Continued Next Page

WATER LEVEL OBSERVATIONS

		@ Drilling
WL	▼ 69	@ 100 hr
WL	Dry, cave in 15.5 ft @ 144 hr	



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LOGGED BY:		APPROVED:	

Project No. 08-324

LOG OF BOREHOLE B-4

Sheet 4 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)	GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS			
			BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE
Stiff dark greenish gray SILTY CLAY (CH) with shell fragments and trace of fine sand (continued)			N=29							
		125	7-10 17 N=27	30	SS	18/18 100%	63			
		130	7-10 13 N=23	31	SS	18/18 100%	59			
		135	6-8 11 N=19	32	SS	18/18 100%	79			
		140	6-11 13 N=24	33	SS	18/18 100%	80			
		145	7-10 14 N=24	34	SS	18/18 100%	86			
150.0		-48.6	150	6-10 14 N=24	35	SS	18/18 100%	90		
End of Boring @ 150 ft										
Mud drilling method started at 30 ft										

WATER LEVEL OBSERVATIONS

		@ Drilling
WL	69	@ 100 hr
WL	Dry, cave in 15.5 ft @ 144 hr	



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DRILL CO.:	ABC	DRILL RIG:	B-61
DRILLER:	SP	ASST DRILLER:	
LOGGED BY:		APPROVED:	

Project No. 08-324

LOG OF BOREHOLE B-5

Sheet 1 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

		GRAPHIC LOG	DEPTH (FT)	SAMPLES				TESTS						
				BLOWS/6" N - VALUE RQD	NUMBER	TYPE	IN. RECOVERED IN. DRIVEN	MOISTURE (%)	DRY DENSITY (PCF)	Qu (TSF)	% PASSING #200 SIEVE	REMARKS/ ADDITIONAL DATA		
SURFACE ELEV.: 93.4 ft.														
0.5	5" Topsoil	92.9												
	Loose to medium dense brown and gray CLAYEY FINE SAND (SC) with some rock fragments, roots and woods													
5.0		88.4												
	Loose brown, tan and light gray CLAYEY FINE SAND (SC)													

Continued Next Page

WATER LEVEL OBSERVATIONS

WL	▽	23	@ Drilling
WL		Dry, cave in 15 ft	@ 0 hr
WL		Dry, cave in 15 ft	@ 24 hr



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9450 Annapolis Road
Lanham, MD 20706
Phone: 301-306-3091
Fax: 301-306-3092

STARTED:	4/16/09	FINISHED:	4/17/09
DRILL CO.:	ABC	DRILL RIG:	B-61
DRILLER:	SP	ASS'T DRILLER:	
LOGGED BY:		APPROVED:	

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Firm to stiff dark greenish gray FINE SANDY CLAY (CL) with trace of shell fragments
(continued)

GRAPHIC LOG

DEPTH (FT)

SAMPLES

TESTS

BLOWS/6"
N - VALUE
RQD

NUMBER

TYPE

IN. RECOVERED
IN. DRIVEN

MOISTURE (%)

DRY DENSITY
(PCF)Qu
(TSF)% PASSING
#200 SIEVEREMARKS/
ADDITIONAL
DATA

45
50
55
60
65
70
75
80

N=20
4-8
12
N=20
5-8
10
N=18
5-7
11
N=18
6-9
12
N=21
6-10
11
N=21
5-5
9
N=14
5-7
9
N=16
5-11
15

11
12
13
14
15
16
17
18

SS
SS
SS
SS
SS
SS
SS
SS

18/18
100%
18/18
100%
18/18
100%
18/18
100%
18/18
100%
18/18
100%
18/18
100%

60
87
86
74
52
41
36
61

67.0

26.4

Loose to medium dense dark greenish gray SILTY FINE SAND (SM) with shell fragments

77.0

16.4

Stiff dark greenish gray SILTY CLAY (CH) with trace of shell fragments and fine sand

Continued Next Page

WATER LEVEL OBSERVATIONS

WL	▽	23	@ Drilling
WL		Dry, cave in 15 ft	@ 0 hr
WL		Dry, cave in 15 ft	@ 24 hr



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STARTED: 4/16/09

FINISHED: 4/17/09

DRILL CO.: ABC

DRILL RIG: B-61

DRILLER: SP

ASST DRILLER:

LOGGED BY:

APPROVED:

Project No. 08-324

LOG OF BOREHOLE B-5

Sheet 3 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Stiff dark greenish gray SILTY CLAY (CH) with
trace of shell fragments and fine sand
(continued)

GRAPHIC LOG

DEPTH (FT)

SAMPLES

TESTS

BLOWS/6"
N - VALUE
RQD

NUMBER

TYPE

IN. RECOVERED
IN. DRIVEN

MOISTURE (%)

DRY DENSITY
(PCF)Qu
(TSF)% PASSING
#200 SIEVEREMARKS/
ADDITIONAL
DATA

N=26

6-9
12
N=21

19

SS

18/18
100%

66

85

5-7
14
N=21

20

SS

18/18
100%

47

90

6-8
13
N=21

21

SS

18/18
100%

52

95

6-8
13
N=21

22

SS

18/18
100%

64

100

5-9
14
N=23

23

SS

18/18
100%

61

105

5-10
12
N=22

24

SS

12/18
67%

55

110

6-10
13
N=23

25

SS

18/18
100%

70

115

7-11
15

26

SS

18/18
100%

71

120

Continued Next Page

WATER LEVEL OBSERVATIONS

WL	▽ 23	@ Drilling
WL	Dry, cave in 15 ft	@ 0 hr
WL	Dry, cave in 15 ft	@ 24 hr



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STARTED: 4/16/09

FINISHED: 4/17/09

DRILL CO.: ABC

DRILL RIG: B-61

DRILLER: SP

ASS'T DRILLER:

LOGGED BY:

APPROVED:

BORING LOG AB08 08-324.GPJ AB CONS.GDT 7/28/09

Project No. 08-324

LOG OF BOREHOLE B-5

Sheet 4 of 4

CLIENT:

US Army Corps Engineers

PROJECT:

NRL Slope Stabilization

ARCHITECT/ENGINEER:

SITE:

Calvert County, Maryland

(continued)

Stiff dark greenish gray SILTY CLAY (CH) with
trace of shell fragments and fine sand
(continued)

GRAPHIC LOG

DEPTH (FT)

SAMPLES

TESTS

BLOWS/6"
N - VALUE
RQD

NUMBER

TYPE

IN. RECOVERED
IN. DRIVEN

MOISTURE (%)

DRY DENSITY
(PCF)Qu
(TSF)% PASSING
#200 SIEVEREMARKS/
ADDITIONAL
DATA

125

130

135

140

145

150

N=26

8-10
14
N=24

27

SS

18/18
100%

71

7-9
13
N=22

28

SS

14/18
78%

97

6-10
12
N=22

29

SS

18/18
100%

78

7-11
13
N=24

30

SS

18/18
100%

92

7-9
13
N=22

31

SS

18/18
100%

82

8-10
10
N=20

32

SS

18/18
100%

65

150.0

-56.6

End of Boring @ 150 ft

Mud drilling method started at 30 ft

WATER LEVEL OBSERVATIONS

WL	▽ 23	@ Drilling
WL	Dry, cave in 15 ft	@ 0 hr
WL	Dry, cave in 15 ft	@ 24 hr



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STARTED: 4/16/09

FINISHED: 4/17/09

DRILL CO.: ABC

DRILL RIG: B-61

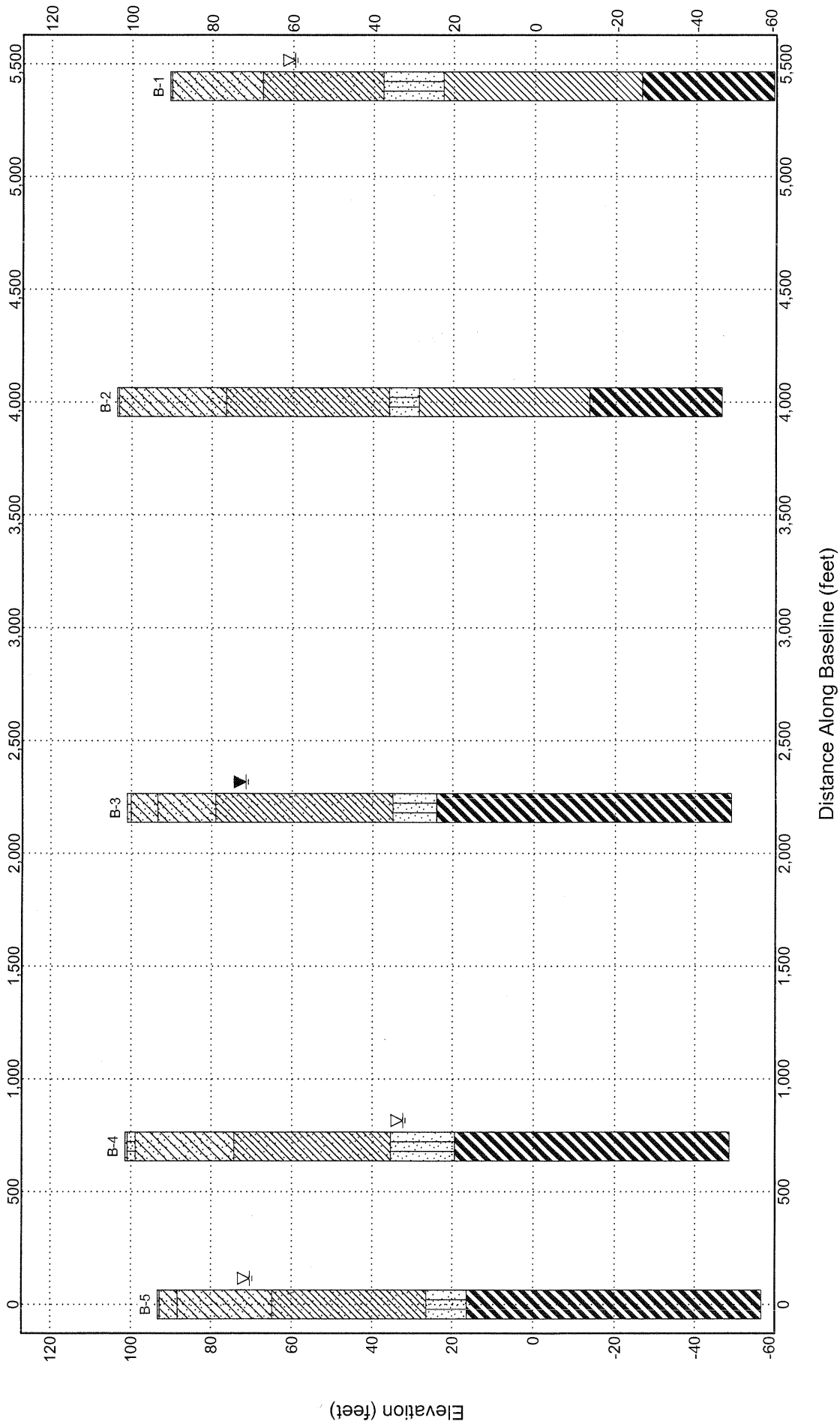
DRILLER: SP

ASS'T DRILLER:

LOGGED BY:

APPROVED:

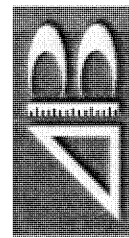
BORING LOG AB08 08-324.GPJ AB CONS.GDT 7/28/09



SUBSURFACE DIAGRAM

CLIENT: US Army Corps Engineers
PROJECT NO.: 08-324
PROJECT: NRL Slope Stabilization
SITE: Calvert County, Maryland

AB Consultants, Inc.
9450 Annapolis Road
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DILATOMETER TEST RESULTS

DILATOMETER DATA LISTING & INTERPRETATION (BASED ON THE 1988 DILATOMETER MANUAL)
 In-Situ Soil Testing, L.C.
 JOB FILE: Naval Research Laboratory--Phase II Slope Stability
 LOCATION: Calvert Cliffs, Maryland
 SNDG.BY : R. Failmezger
 ANAL.BY : Roger Failmezger, P.E.

SNDG. NO. :D-2
 Page 1a
 FILE NO. : 2009-13
 SNDG. DATE: 4/1/09
 ANAL. DATE: 4/15/09

ANALYSIS PARAMETERS: LO RANGE = 9.50 BARS ROD DIAM. = 3.6 CM BL.THICK. = 15.0 MM SU FACTOR = 1
 SURF.ELEV. = 31.5 M LO GAGE 0 = 0.00 BARS FR.RED.DIA. = 4.4 CM BL.WIDTH = 96.0 MM PHI FACTOR = 1
 WATER DEPTH = 30.0 M HI GAGE 0 = 0.40 BARS LIN.ROD WT. = 6.5 KGF/M DELTA-A = 0.21 BARS OCR FACTOR = 1
 SP.GR.WATER = 1.000 CAL GAGE 0 = 0.00 BARS DELTA/PHI = 0.5 DELTA-B = 0.14 BARS M FACTOR = 1
 MAX SU ID = 0.9 SU OPTION = 0 MIN PHI ID = 0.9 OCR OPTION = 0 K0 FACTOR = 1
 UNIT CONVERSIONS: 1 BAR = 1.019 KGF/CM2 = 100 KPA = 1.044 TSF = 14.51 PSI 1 M = 3.2808 FT

Z (M)	ELEV (M)	THRUST (KGF)	A (BAR)	B (BAR)	C (BAR)	DA (BAR)	DB (BAR)	ZMRNG (BAR)	ZMLO (BAR)	ZMHI (BAR)	ZMCAL (BAR)	P0 (BAR)	P1 (BAR)	P2 (BAR)	U0 (BAR)	GAMMA (T/M3)	SVP (BAR)
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
0.20	31.30	720	1.24	5.38		0.21	0.14	9.50	0.00	0.40	0.00	1.26	5.24		0.000	1.80	0.035
0.40	31.10	930	2.00	5.81		0.21	0.14	9.50	0.00	0.40	0.00	2.04	5.67		0.000	1.70	0.069
0.60	30.90	660	1.69	4.39		0.21	0.14	9.50	0.00	0.40	0.00	1.78	4.25		0.000	1.70	0.103
0.80	30.70	600	1.78	4.39		0.21	0.14	9.50	0.00	0.40	0.00	1.88	4.25		0.000	1.70	0.136
1.00	30.50	530	1.43	4.11		0.21	0.14	9.50	0.00	0.40	0.00	1.52	3.97		0.000	1.70	0.169
1.20	30.30	460	1.58	3.72		0.21	0.14	9.50	0.00	0.40	0.00	1.70	3.58		0.000	1.70	0.203
1.40	30.10	460	1.33	4.21		0.21	0.14	9.50	0.00	0.40	0.00	1.41	4.07		0.000	1.80	0.237
1.60	29.90	480	1.35	4.03		0.21	0.14	9.50	0.00	0.40	0.00	1.44	3.89		0.000	1.70	0.272
1.80	29.70	480	1.66	4.80		0.21	0.14	9.50	0.00	0.40	0.00	1.73	4.66		0.000	1.70	0.305
2.00	29.50	500	2.23	5.56		0.21	0.14	9.50	0.00	0.40	0.00	2.29	5.42		0.000	1.70	0.338
2.20	29.30	500	2.30	5.43		0.21	0.14	9.50	0.00	0.40	0.00	2.37	5.29		0.000	1.70	0.372
2.40	29.10	510	3.05	6.28		0.21	0.14	9.50	0.00	0.40	0.00	3.12	6.14		0.000	1.80	0.406
2.60	28.90	510	2.90	6.22		0.21	0.14	9.50	0.00	0.40	0.00	2.96	6.08		0.000	1.80	0.441
2.80	28.70	450	3.15	6.30		0.21	0.14	9.50	0.00	0.40	0.00	3.22	6.16		0.000	1.80	0.477
3.00	28.50	410	2.56	5.38		0.21	0.14	9.50	0.00	0.40	0.00	2.65	5.24		0.000	1.70	0.511
3.20	28.30	430	2.12	4.68		0.21	0.14	9.50	0.00	0.40	0.00	2.22	4.54		0.000	1.70	0.544
3.40	28.10	410	1.88	4.78		0.21	0.14	9.50	0.00	0.40	0.00	1.96	4.64		0.000	1.70	0.578
3.60	27.90	400	1.81	4.54		0.21	0.14	9.50	0.00	0.40	0.00	1.90	4.40		0.000	1.70	0.611
3.80	27.70	440	1.72	4.69		0.21	0.14	9.50	0.00	0.40	0.00	1.80	4.55		0.000	1.70	0.644
4.00	27.50	610	2.89	7.47		0.21	0.14	9.50	0.00	0.40	0.00	2.89	7.33		0.000	1.80	0.679
4.20	27.30	860	7.08	14.50		0.21	0.14	9.50	0.00	0.40	0.00	6.96	13.96		0.000	1.95	0.716
4.40	27.10	620	4.38	7.00		0.21	0.14	9.50	0.00	0.40	0.00	4.48	6.86		0.000	1.80	0.752
4.60	26.90	690	4.64	8.98		0.21	0.14	9.50	0.00	0.40	0.00	4.65	8.84		0.000	1.80	0.788
4.80	26.70	1020	5.24	11.45		0.21	0.14	9.50	0.00	0.40	0.00	5.18	10.91		0.000	1.80	0.823
5.00	26.50	1540	4.72	10.45		0.21	0.14	9.50	0.00	0.40	0.00	4.68	9.91		0.000	1.80	0.858
5.20	26.30	1660	5.71	11.55		0.21	0.14	9.50	0.00	0.40	0.00	5.67	11.01		0.000	1.80	0.894
5.40	26.10	1210	6.88	14.05		0.21	0.14	9.50	0.00	0.40	0.00	6.77	13.51		0.000	1.95	0.930
5.60	25.90	1310	12.30	22.00		0.21	0.14	9.50	0.00	0.40	0.00	11.64	21.46		0.000	2.10	0.970
5.80	25.70	1580	16.95	29.25		0.21	0.14	9.50	0.00	0.40	0.00	16.16	28.71		0.000	2.10	1.011
6.00	25.50	1740	14.20	27.35		0.21	0.14	9.50	0.00	0.40	0.00	13.37	26.81		0.000	2.10	1.053
6.20	25.30	3020	14.40	31.10		0.21	0.14	9.50	0.00	0.40	0.00	13.39	30.56		0.000	2.10	1.094
6.40	25.10	3500	13.55	29.65		0.21	0.14	9.50	0.00	0.40	0.00	12.57	29.11		0.000	2.10	1.135
6.60	24.90	3710	24.00	41.55		0.21	0.14	9.50	0.00	0.40	0.00	22.95	41.01		0.000	2.10	1.176
6.80	24.70	2710	15.30	26.05		0.21	0.14	9.50	0.00	0.40	0.00	14.59	25.51		0.000	2.10	1.218
7.00	24.50	2040	14.30	23.10		0.21	0.14	9.50	0.00	0.40	0.00	13.69	22.56		0.000	2.10	1.259
7.20	24.30	1330	13.60	20.60		0.21	0.14	9.50	0.00	0.40	0.00	13.08	20.06		0.000	2.05	1.299
7.40	24.10	1460	13.35	20.55		0.21	0.14	9.50	0.00	0.40	0.00	12.82	20.01		0.000	2.05	1.340
7.60	23.90	1560	15.25	22.30		0.21	0.14	9.50	0.00	0.40	0.00	14.73	21.76		0.000	2.05	1.380
7.80	23.70	1620	16.70	23.75		0.21	0.14	9.50	0.00	0.40	0.00	16.18	23.21		0.000	2.05	1.420
8.00	23.50	1740	18.45	26.10		0.21	0.14	9.50	0.00	0.40	0.00	17.90	25.56		0.000	2.05	1.460
8.20	23.30	1750	18.75	26.55		0.21	0.14	9.50	0.00	0.40	0.00	18.19	26.01		0.000	2.05	1.501
8.40	23.10	1790	20.50	29.20		0.21	0.14	9.50	0.00	0.40	0.00	19.89	28.66		0.000	2.05	1.541
8.60	22.90	1890	17.40	25.80		0.21	0.14	9.50	0.00	0.40	0.00	16.81	25.26		0.000	2.05	1.581
8.80	22.70	1940	13.70	21.30		0.21	0.14	9.50	0.00	0.40	0.00	13.15	20.76		0.000	2.05	1.621
9.00	22.50	2130	10.45	20.25		0.21	0.14	9.50	0.00	0.40	0.00	9.79	19.71		0.000	1.95	1.661
9.20	22.30	3040	8.60	24.60		0.21	0.14	9.50	0.00	0.40	0.00	8.05	24.06		0.000	2.00	1.699
9.40	22.10	3590	7.60	23.15		0.21	0.14	9.50	0.00	0.40	0.00	7.07	22.61		0.000	2.00	1.739
9.60	21.90	3350	6.38	19.75		0.21	0.14	9.50	0.00	0.40	0.00	5.96	19.21		0.000	2.00	1.778
9.80	21.70	3870	9.50	23.80		0.21	0.14	9.50	0.00	0.40	0.00	9.03	23.26		0.000	1.95	1.817
10.00	21.50	4070	10.45	23.40		0.21	0.14	9.50	0.00	0.40	0.00	9.63	22.86		0.000	2.10	1.856
10.20	21.30	4100	11.80	28.30		0.21	0.14	9.50	0.00	0.40	0.00	10.80	27.76		0.000	2.10	1.898
10.40	21.10	4550	10.90	28.75		0.21	0.14	9.50	0.00	0.40	0.00	9.84	28.21		0.000	2.15	1.939
10.60	20.90	4930	12.40	24.65		0.21	0.14	9.50	0.00	0.40	0.00	11.62	24.11		0.000	2.10	1.981
10.80	20.70	7160	29.70	59.70		0.21	0.14	9.50	0.00	0.40	0.00	28.03	59.16		0.000	2.10	2.022
11.00	20.50	7860	32.50	63.00		0.21	0.14	9.50	0.00	0.40	0.00	30.80	62.46		0.000	2.10	2.063
12.20	19.30	3400	18.80	30.50		0.19	0.16	9.50	0.00	0.40	0.00	18.02	29.94		0.000	2.10	2.311
12.40	19.10	3710	21.30	32.00		0.19	0.16	9.50	0.00	0.40	0.00	20.57	31.44		0.000	2.05	2.351
12.60	18.90	3750	23.55	34.95		0.19	0.16	9.50	0.00	0.40	0.00	22.79	34.39		0.000	2.05	2.392
12.80	18.70	3760	27.70	38.80		0.19	0.16	9.50	0.00	0.40	0.00	26.95	38.24		0.000	2.05	2.432
13.00	18.50	3770	21.45	33.30		0.19	0.16	9.50	0.00	0.40	0.00	20.67	32.74		0.000	2.05	2.472
13.20	18.30	3930	20.05	29.85		0.19	0.16	9.50	0.00	0.40	0.00	19.37	29.29		0.000	2.05	2.512
13.40	18.10	4300	21.50	31.55		0.19	0.16	9.50	0.00	0.40	0.00	20.81	30.99		0.000	2.05	2.553
13.60	17.90	4010	22.60	32.20		0.19	0.16	9.50	0.00	0.40	0.00	21.93	31.64		0.000	2.05	2.593
13.80	17.70	4000	24.45	33.75		0.19	0.16	9.50	0.00	0.40	0.00	23.79	33.19		0.000	2.05	2.633
14.00	17.50	4160	20.90	30.95		0.19	0.16	9.50	0.00	0.40	0.00	20.21	30.39		0.000	2.05	2.673

DILATOMETER DATA LISTING & INTERPRETATION (BASED ON THE 1988 DILATOMETER MANUAL)

In-Situ Soil Testing, L.C.

JOB FILE: Naval Research Laboratory--Phase II Slope Stability

LOCATION: Calvert Cliffs, Maryland

SNDG.BY : R. Failmezger

ANAL.BY : Roger Failmezger, P.E.

SNDG. NO. : D-2

Page 1b

FILE NO. :2009-13

SNDG. DATE: 4/1/09

ANAL. DATE: 4/15/09

ANALYSIS PARAMETERS: LO RANGE = 9.50 BARS ROD DIAM. = 3.6 CM BL.THICK. = 15.0 MM SU FACTOR = 1
 SURF.ELEV. = 31.5 M LO GAGE 0 = 0.00 BARS FR.RED.DIA. = 4.4 CM BL.WIDTH = 96.0 MM PHI FACTOR = 1
 WATER DEPTH = 30.0 M HI GAGE 0 = 0.40 BARS LIN.ROD WT. = 6.5 KGF/M DELTA-A = 0.21 BARS OCR FACTOR = 1
 SP.GR.WATER = 1.000 CAL GAGE 0 = 0.00 BARS DELTA / PHI = 0.5 DELTA-B = 0.14 BARS M FACTOR = 1
 MAX SU ID = 0.9 SU OPTION = 0 MIN PHI ID = 0.9 OCR OPTION = 0 K0 FACTOR = 1
 UNIT CONVERSIONS: 1 BAR = 1.019 KGF/CM2 = 100 KPA = 1.044 TSF = 14.51 PSI 1 M = 3.2808 FT

Z (M)	ELEV (M)	KD	ID	UD	ED (BAR)	K0	SU (BAR)	QD (BAR)	PHI (DEG)	SIGFF (BAR)	PHIO (DEG)	PC (BAR)	OCR	M (BAR)	SOIL TYPE
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
0.20	31.30	36.01	3.16		138									513	SILTY SAND
0.40	31.10	29.37	1.78		126	3.41		27.2	45.4	0.12	41.1	5.49	79.1	444	SANDY SILT
0.60	30.90	17.35	1.38		86	2.17		18.6	41.1	0.17	36.7	3.46	33.7	259	SANDY SILT
0.80	30.70	13.79	1.26		82	1.82		16.1	39.0	0.22	34.8	3.18	23.4	231	SANDY SILT
1.00	30.50	8.99	1.61		85	1.26		15.3	38.3	0.27	34.4	1.82	10.8	204	SANDY SILT
1.20	30.30	8.38	1.11		65	1.25		12.1	35.6	0.32	31.8	2.11	10.4	152	SILT
1.40	30.10	5.96	1.88		92	0.96		13.5	35.9	0.38	32.4	1.36	5.7	186	SILTY SAND
1.60	29.90	5.32	1.69		85	0.89		14.3	35.6	0.43	32.2	1.31	4.8	161	SANDY SILT
1.80	29.70	5.68	1.69		102	0.96		13.3	34.1	0.48	30.9	1.72	5.6	199	SANDY SILT
2.00	29.50	6.77	1.37		109	1.13		12.1	32.5	0.52	29.3	2.68	7.9	230	SANDY SILT
2.20	29.30	6.38	1.23		101	1.10		12.1	31.8	0.57	28.8	2.73	7.3	208	SANDY SILT
2.40	29.10	7.68	0.97		105	1.31		10.2	29.7	0.61	26.6	4.51	11.1	235	SILT
2.60	28.90	6.71	1.05		108	1.19		10.9	29.7	0.66	26.8	3.87	8.8	228	SILT
2.80	28.70	6.76	0.91		102	1.26		8.5	27.2	0.69	24.3	4.78	10.0	215	SILT
3.00	28.50	5.18	0.98		90	1.07		8.9	27.4	0.75	24.6	3.26	6.4	166	SILT
3.20	28.30	4.08	1.05		81	0.90		11.0	28.7	0.81	26.2	2.29	4.2	129	SILT
3.40	28.10	3.40	1.36		93	0.82		11.3	28.6	0.85	26.2	1.91	3.3	134	SANDY SILT
3.60	27.90	3.11	1.31		87	0.80		11.2	28.2	0.90	25.9	1.84	3.0	118	SANDY SILT
3.80	27.70	2.79	1.53		95	0.74		13.2	29.1	0.96	27.0	1.64	2.5	121	SANDY SILT
4.00	27.50	4.26	1.54		154	0.90		15.8	29.8	1.02	27.8	2.90	4.3	258	SANDY SILT
4.20	27.30	9.72	1.01		243	1.63		12.9	26.8	1.04	24.7	14.56	20.3	601	SILT
4.40	27.10	5.95	0.53		83	1.31	0.65					4.12	5.5	163	SILTY CLAY
4.60	26.90	5.90	0.90		145	1.16		13.8	27.3	1.15	25.4	6.25	7.9	286	SILT
4.80	26.70	6.29	1.11		199	1.11		23.3	30.8	1.24	29.3	6.16	7.5	406	SILT
5.00	26.50	5.45	1.12		181	0.91		44.6	35.4	1.36	34.1	4.35	5.1	345	SILT
5.20	26.30	6.34	0.94		185	1.02		45.3	35.0	1.41	33.8	5.87	6.6	379	SILT
5.40	26.10	7.27	1.00		234	1.25		25.3	30.3	1.40	29.0	9.13	9.8	510	SILT
5.60	25.90	12.00	0.84		341	2.06	2.00					15.88	16.4	910	CLAYEY SILT
5.80	25.70	15.98	0.78		435	2.44	2.99					25.88	25.6	1282	CLAYEY SILT
6.00	25.50	12.70	1.01		466	1.95		24.6	28.2	1.55	27.1	33.46	31.8	1271	SILT
6.20	25.30	12.24	1.28		596	1.74		66.4	34.8	1.72	33.9	23.47	21.5	1603	SANDY SILT
6.40	25.10	11.08	1.32		574	1.56		87.5	36.5	1.81	35.8	19.04	16.8	1490	SANDY SILT
6.60	24.90	19.51	0.79		627	2.74	4.46					41.09	34.9	1963	CLAYEY SILT
6.80	24.70	11.98	0.75		379	2.06	2.51					19.88	16.3	1012	CLAYEY SILT
7.00	24.50	10.87	0.65		308	1.94	2.30					17.66	14.0	794	CLAYEY SILT
7.20	24.30	10.06	0.53		242	1.85	2.15					16.16	12.4	607	SILTY CLAY
7.40	24.10	9.57	0.56		250	1.79	2.09					15.40	11.5	613	SILTY CLAY
7.60	23.90	10.67	0.48		244	1.91	2.46					18.80	13.6	625	SILTY CLAY
7.80	23.70	11.39	0.43		244	1.99	2.75					21.42	15.1	640	SILTY CLAY
8.00	23.50	12.25	0.43		266	2.08	3.10					24.69	16.9	716	SILTY CLAY
8.20	23.30	12.12	0.43		271	2.07	3.14					24.94	16.6	728	SILTY CLAY
8.40	23.10	12.91	0.44		304	2.15	3.49					28.26	18.3	834	SILTY CLAY
8.60	22.90	10.63	0.50		293	1.91	2.81					21.42	13.5	750	SILTY CLAY
8.80	22.70	8.11	0.58		264	1.61	2.05					14.40	8.9	604	SILTY CLAY
9.00	22.50	5.89	1.01		344	1.05		51.2	31.5	2.53	31.4	10.83	6.5	679	SILT
9.20	22.30	4.74	1.99		556	0.81		92.6	35.9	2.70	35.9	6.75	4.0	1001	SILTY SAND
9.40	22.10	4.07	2.20		539	0.68		119.1	37.7	2.80	37.7	5.04	2.9	901	SILTY SAND
9.60	21.90	3.35	2.22		460	0.60		114.9	37.5	2.86	37.6	3.90	2.2	688	SILTY SAND
9.80	21.70	4.97	1.58		494	0.80		121.4	37.2	2.91	37.3	7.38	4.1	903	SANDY SILT
10.00	21.50	5.19	1.37		459	0.83		126.8	37.3	2.98	37.4	8.05	4.3	854	SANDY SILT
10.20	21.30	5.69	1.57		588	0.90		122.8	36.8	3.03	36.9	9.78	5.2	1152	SANDY SILT
10.40	21.10	5.07	1.87		638	0.80		145.4	37.9	3.13	38.1	7.86	4.1	1186	SILTY SAND
10.60	20.90	5.86	1.08		434	0.89		152.4	37.8	3.20	38.1	10.25	5.2	854	SILT
10.80	20.70	13.86	1.11		1080	1.89		167.0	36.4	3.22	36.6	52.17	25.8	3035	SILT
11.00	20.50	14.93	1.03		1099	2.02		182.1	36.6	3.29	36.9	61.02	29.6	3163	SILT
12.20	19.30	7.80	0.66		414	1.57	2.79					19.31	8.4	929	CLAYEY SILT
12.40	19.10	8.75	0.53		377	1.69	3.27					23.51	10.0	891	SILTY CLAY
12.60	18.90	9.53	0.51		403	1.78	3.70					27.31	11.4	987	SILTY CLAY
12.80	18.70	11.08	0.42		392	1.96	4.55					35.16	14.5	1017	SILTY CLAY
13.00	18.50	8.36	0.58		419	1.64	3.25					23.02	9.3	971	SILTY CLAY
13.20	18.30	7.71	0.51		344	1.56	2.99					20.61	8.2	769	SILTY CLAY
13.40	18.10	8.15	0.49		353	1.62	3.25					22.85	9.0	809	SILTY CLAY
13.60	17.90	8.46	0.44		337	1.65	3.46					24.58	9.5	785	SILTY CLAY
13.80	17.70	9.04	0.39		326	1.73	3.82					27.68	10.5	781	SILTY CLAY
14.00	17.50	7.56	0.50		353	1.54	3.10					21.27	8.0	782	SILTY CLAY

DILATOMETER DATA LISTING & INTERPRETATION (BASED ON THE 1988 DILATOMETER MANUAL)

In-Situ Soil Testing, L.C.

JOB FILE: Naval Research Laboratory--Phase II Slope Stability

LOCATION: Calvert Cliffs, Maryland

SNDG.BY : R. Failmezger

ANAL.BY : Roger Failmezger, P.E.

SNDG. NO. :D-2

Page 2a

FILE NO. : 2009-13

SNDG. DATE: 4/1/09

ANAL. DATE: 4/15/09

ANALYSIS PARAMETERS: LO RANGE = 9.50 BARS ROD DIAM. = 3.6 CM BL.THICK. = 15.0 MM SU FACTOR = 1
 SURF.ELEV. = 31.5 M LO GAGE 0 = 0.00 BARS FR.RED.DIA. = 4.4 CM BL.WIDTH = 96.0 MM PHI FACTOR = 1
 WATER DEPTH = 30.0 M HI GAGE 0 = 0.40 BARS LIN.ROD WT. = 6.5 KGF/M DELTA-A = 0.21 BARS OCR FACTOR = 1
 SP.GR.WATER = 1.000 CAL GAGE 0 = 0.00 BARS DELTA/PHI = 0.5 DELTA-B = 0.14 BARS M FACTOR = 1
 MAX SU ID = 0.9 SU OPTION = 0 MIN PHI ID = 0.9 OCR OPTION = 0 K0 FACTOR = 1
 UNIT CONVERSIONS: 1 BAR = 1.019 KGF/CM2 = 100 KPA = 1.044 TSF = 14.51 PSI 1 M = 3.2808 FT

Z (M)	ELEV (M)	THRUST (KGF)	A (BAR)	B (BAR)	C (BAR)	DA (BAR)	DB (BAR)	ZMRNG (BAR)	ZMLO (BAR)	ZMHI (BAR)	ZMCAL (BAR)	P0 (BAR)	P1 (BAR)	P2 (BAR)	U0 (BAR)	GAMMA (T/M3)	SVP (BAR)
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
14.20	17.30	4570	20.50	31.20		0.19	0.16	9.50	0.00	0.40	0.00	19.77	30.64		0.000	2.05	2.714
14.40	17.10	4710	24.35	35.40		0.19	0.16	9.50	0.00	0.40	0.00	23.61	34.84		0.000	2.05	2.754
14.60	16.90	4660	24.70	36.10		0.19	0.16	9.50	0.00	0.40	0.00	23.94	35.54		0.000	2.05	2.794
14.80	16.70	4590	21.80	32.90		0.19	0.16	9.50	0.00	0.40	0.00	21.05	32.34		0.000	2.05	2.834
15.00	16.50	4630	22.40	34.00		0.19	0.16	9.50	0.00	0.40	0.00	21.63	33.44		0.000	2.05	2.875
15.20	16.30	4620	20.95	31.40		0.19	0.16	9.50	0.00	0.40	0.00	20.24	30.84		0.000	2.05	2.915
15.40	16.10	4910	26.05	37.40		0.19	0.16	9.50	0.00	0.40	0.00	25.29	36.84		0.000	2.05	2.955
15.60	15.90	4950	27.80	39.55		0.19	0.16	9.50	0.00	0.40	0.00	27.02	38.99		0.000	2.05	2.995
15.80	15.70	5080	29.05	40.55		0.19	0.16	9.50	0.00	0.40	0.00	28.28	39.99		0.000	2.05	3.035
16.00	15.50	5070	25.35	37.20		0.19	0.16	9.50	0.00	0.40	0.00	24.57	36.64		0.000	2.05	3.076
16.20	15.30	5290	25.75	37.70		0.19	0.16	9.50	0.00	0.40	0.00	24.96	37.14		0.000	2.05	3.116
16.40	15.10	5580	29.85	44.20		0.19	0.16	9.50	0.00	0.40	0.00	28.94	43.64		0.000	2.05	3.156
16.60	14.90	5660	33.30	47.95		0.19	0.16	9.50	0.00	0.40	0.00	32.38	47.39		0.000	2.05	3.196
16.80	14.70	5640	30.90	45.15		0.19	0.16	9.50	0.00	0.40	0.00	30.00	44.59		0.000	2.05	3.237
17.00	14.50	5590	30.55	44.70		0.19	0.16	9.50	0.00	0.40	0.00	29.65	44.14		0.000	2.05	3.277
17.20	14.30	5340	26.60	39.65		0.19	0.16	9.50	0.00	0.40	0.00	25.76	39.09		0.000	2.05	3.317
17.40	14.10	5430	25.75	39.00		0.19	0.16	9.50	0.00	0.40	0.00	24.90	38.44		0.000	2.05	3.357
17.60	13.90	5500	33.10	44.80		0.19	0.16	9.50	0.00	0.40	0.00	32.32	44.24		0.000	2.05	3.398
17.80	13.70	5470	30.80	43.20		0.19	0.16	9.50	0.00	0.40	0.00	29.99	42.64		0.000	2.05	3.438
18.00	13.50	5450	28.65	41.70		0.19	0.16	9.50	0.00	0.40	0.00	27.81	41.14		0.000	2.05	3.478
18.20	13.30	5380	30.30	43.25		0.19	0.16	9.50	0.00	0.40	0.00	29.46	42.69		0.000	2.05	3.518
18.40	13.10	5630	28.70	41.10		0.19	0.16	9.50	0.00	0.40	0.00	27.89	40.54		0.000	2.05	3.559
18.60	12.90	5590	22.80	32.60		0.19	0.16	9.50	0.00	0.40	0.00	22.12	32.04		0.000	2.05	3.599
18.80	12.70	5650	17.20	25.20		0.19	0.16	9.50	0.00	0.40	0.00	16.61	24.64		0.000	2.05	3.639
19.00	12.50	5630	15.50	25.40		0.19	0.16	9.50	0.00	0.40	0.00	14.81	24.84		0.000	2.10	3.680
19.20	12.30	5810	21.40	34.20		0.19	0.16	9.50	0.00	0.40	0.00	20.57	33.64		0.000	2.10	3.721
19.40	12.10	6090	27.90	41.00		0.19	0.16	9.50	0.00	0.40	0.00	27.05	40.44		0.000	2.05	3.762
19.60	11.90	6070	29.50	44.00		0.19	0.16	9.50	0.00	0.40	0.00	28.58	43.44		0.000	2.05	3.802
19.80	11.70	6100	33.20	46.40		0.19	0.16	9.50	0.00	0.40	0.00	32.35	45.84		0.000	2.05	3.842
20.00	11.50	5980	33.45	44.90		0.19	0.16	9.50	0.00	0.40	0.00	32.69	44.34		0.000	2.05	3.882
20.20	11.30	6110	32.60	45.00		0.19	0.16	9.50	0.00	0.40	0.00	31.79	44.44		0.000	2.05	3.923
20.40	11.10	6300	30.60	43.60		0.19	0.16	9.50	0.00	0.40	0.00	29.76	43.04		0.000	2.05	3.963
20.60	10.90	6100	26.10	37.30		0.19	0.16	9.50	0.00	0.40	0.00	25.35	36.74		0.000	2.05	4.003
20.80	10.70	7950	10.70	28.30		0.19	0.16	9.50	0.00	0.40	0.00	9.63	27.74		0.000	2.15	4.044
21.00	10.50	9030	11.10	30.55		0.19	0.16	9.50	0.00	0.40	0.00	9.94	29.99		0.000	2.15	4.087
21.20	10.30	9040	11.00	30.95		0.19	0.16	9.50	0.00	0.40	0.00	9.81	30.39		0.000	2.15	4.129
21.40	10.10	8950	12.60	36.65		0.19	0.16	9.50	0.00	0.40	0.00	11.21	36.09		0.000	2.15	4.171
21.60	9.90	8890	9.30	25.60		0.19	0.16	9.50	0.00	0.40	0.00	8.71	25.04		0.000	2.00	4.212
21.80	9.70	9600	13.75	38.95		0.19	0.16	9.50	0.00	0.40	0.00	12.30	38.39		0.000	2.15	4.252
22.00	9.50	11890	21.25	52.60		0.19	0.16	9.50	0.00	0.40	0.00	19.49	52.04		0.000	2.10	4.294

DILATOMETER DATA LISTING & INTERPRETATION (BASED ON THE 1988 DILATOMETER MANUAL)
In-Situ Soil Testing, L.C.
JOB FILE: Naval Research Laboratory--Phase II Slope Stability
LOCATION: Calvert Cliffs, Maryland
SNDG.BY : R. Failmezger
ANAL.BY : Roger Failmezger, P.E.

SNDG. NO. : D-2
Page 2b
FILE NO. :2009-13

SNDG. DATE: 4/1/09
ANAL. DATE: 4/15/09

ANALYSIS PARAMETERS: LO RANGE = 9.50 BARS ROD DIAM. = 3.6 CM BL.THICK. = 15.0 MM SU FACTOR = 1
SURF.ELEV. = 31.5 M LO GAGE 0 = 0.00 BARS FR.RED.DIA. = 4.4 CM BL.WIDTH = 96.0 MM PHI FACTOR = 1
WATER DEPTH = 30.0 M HI GAGE 0 = 0.40 BARS LIN.ROD WT. = 6.5 KGF/M DELTA-A = 0.21 BARS OCR FACTOR = 1
SP.GR.WATER = 1.000 CAL GAGE 0 = 0.00 BARS DELTA / PHI = 0.5 DELTA-B = 0.14 BARS M FACTOR = 1
MAX SU ID = 0.9 SU OPTION = 0 MIN PHI ID = 0.9 OCR OPTION = 0 K0 FACTOR = 1
UNIT CONVERSIONS: 1 BAR = 1.019 KGF/CM2 = 100 KPA = 1.044 TSF = 14.51 PSI 1 M = 3.2808 FT

Z (M)	ELEV (M)	KD	ID	UD	ED (BAR)	K0	SU (BAR)	QD (BAR)	PHI (DEG)	SIGFF (BAR)	PHIO (DEG)	PC (BAR)	OCR	M (BAR)	SOIL TYPE
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
14.20	17.30	7.29	0.55		377	1.50	3.00					20.39	7.5	820	SILTY CLAY
14.40	17.10	8.57	0.48		390	1.67	3.74					26.66	9.7	913	SILTY CLAY
14.60	16.90	8.57	0.48		403	1.67	3.79					27.03	9.7	943	SILTY CLAY
14.80	16.70	7.43	0.54		392	1.52	3.21					21.95	7.7	860	SILTY CLAY
15.00	16.50	7.52	0.55		410	1.53	3.31					22.71	7.9	905	SILTY CLAY
15.20	16.30	6.94	0.52		368	1.45	3.04					20.31	7.0	782	SILTY CLAY
15.40	16.10	8.56	0.46		401	1.67	4.00					28.54	9.7	938	SILTY CLAY
15.60	15.90	9.02	0.44		415	1.72	4.33					31.41	10.5	995	SILTY CLAY
15.80	15.70	9.32	0.41		406	1.76	4.57					33.47	11.0	986	SILTY CLAY
16.00	15.50	7.99	0.49		419	1.59	3.82					26.67	8.7	951	SILTY CLAY
16.20	15.30	8.01	0.49		423	1.60	3.88					27.14	8.7	961	SILTY CLAY
16.40	15.10	9.17	0.51		510	1.74	4.66					33.95	10.8	1230	SILTY CLAY
16.60	14.90	10.13	0.46		521	1.85	5.34					40.15	12.6	1309	SILTY CLAY
16.80	14.70	9.27	0.49		506	1.75	4.84					35.39	10.9	1227	SILTY CLAY
17.00	14.50	9.05	0.49		503	1.73	4.76					34.52	10.5	1205	SILTY CLAY
17.20	14.30	7.76	0.52		463	1.57	3.98					27.52	8.3	1037	SILTY CLAY
17.40	14.10	7.42	0.54		470	1.52	3.80					25.93	7.7	1031	SILTY CLAY
17.60	13.90	9.51	0.37		414	1.78	5.25					38.70	11.4	1013	SILTY CLAY
17.80	13.70	8.72	0.42		439	1.69	4.77					34.21	9.9	1036	SILTY CLAY
18.00	13.50	7.99	0.48		463	1.60	4.32					30.20	8.7	1051	SILTY CLAY
18.20	13.30	8.37	0.45		459	1.64	4.64					32.84	9.3	1064	SILTY CLAY
18.40	13.10	7.84	0.45		439	1.58	4.32					29.96	8.4	988	SILTY CLAY
18.60	12.90	6.15	0.45		344	1.34	3.22					20.74	5.8	689	SILTY CLAY
18.80	12.70	4.56	0.48		279	1.09	2.25					13.18	3.6	473	SILTY CLAY
19.00	12.50	4.03	0.68		348	0.99	1.94					10.96	3.0	547	CLAYEY SILT
19.20	12.30	5.53	0.64		454	1.25	2.92					18.17	4.9	859	CLAYEY SILT
19.40	12.10	7.19	0.49		465	1.49	4.10					27.70	7.4	1004	SILTY CLAY
19.60	11.90	7.52	0.52		516	1.53	4.38					30.00	7.9	1138	SILTY CLAY
19.80	11.70	8.42	0.42		468	1.65	5.10					36.17	9.4	1088	SILTY CLAY
20.00	11.50	8.42	0.36		404	1.65	5.15					36.55	9.4	940	SILTY CLAY
20.20	11.30	8.10	0.40		439	1.61	4.96					34.79	8.9	1003	SILTY CLAY
20.40	11.10	7.51	0.45		461	1.53	4.56					31.21	7.9	1017	SILTY CLAY
20.60	10.90	6.33	0.45		395	1.37	3.72					24.17	6.0	803	SILTY CLAY
20.80	10.70	2.38	1.88		629	0.45		293.3	38.7	6.57	40.0	5.08	1.3	722	SILTY SAND
21.00	10.50	2.43	2.02		696	0.43		336.5	39.5	6.69	40.9	4.85	1.2	822	SILTY SAND
21.20	10.30	2.38	2.10		714	0.43		337.7	39.5	6.75	40.9	4.76	1.2	834	SILTY SAND
21.40	10.10	2.69	2.22		864	0.48		327.0	39.1	6.80	40.5	5.96	1.4	1115	SILTY SAND
21.60	9.90	2.07	1.87		567	0.39		337.5	39.5	6.89	40.9	4.03	1.0	576	SILTY SAND
21.80	9.70	2.89	2.12		905	0.49		348.3	39.3	6.95	40.7	6.62	1.6	1224	SILTY SAND
22.00	9.50	4.54	1.67		1129	0.68		405.5	39.6	7.03	41.0	13.23	3.1	1971	SANDY SILT

PROJECT: Naval Research Laboratory Phase II Slope Stability Investigation
LOCATION: Calvert Cliffs, Maryland

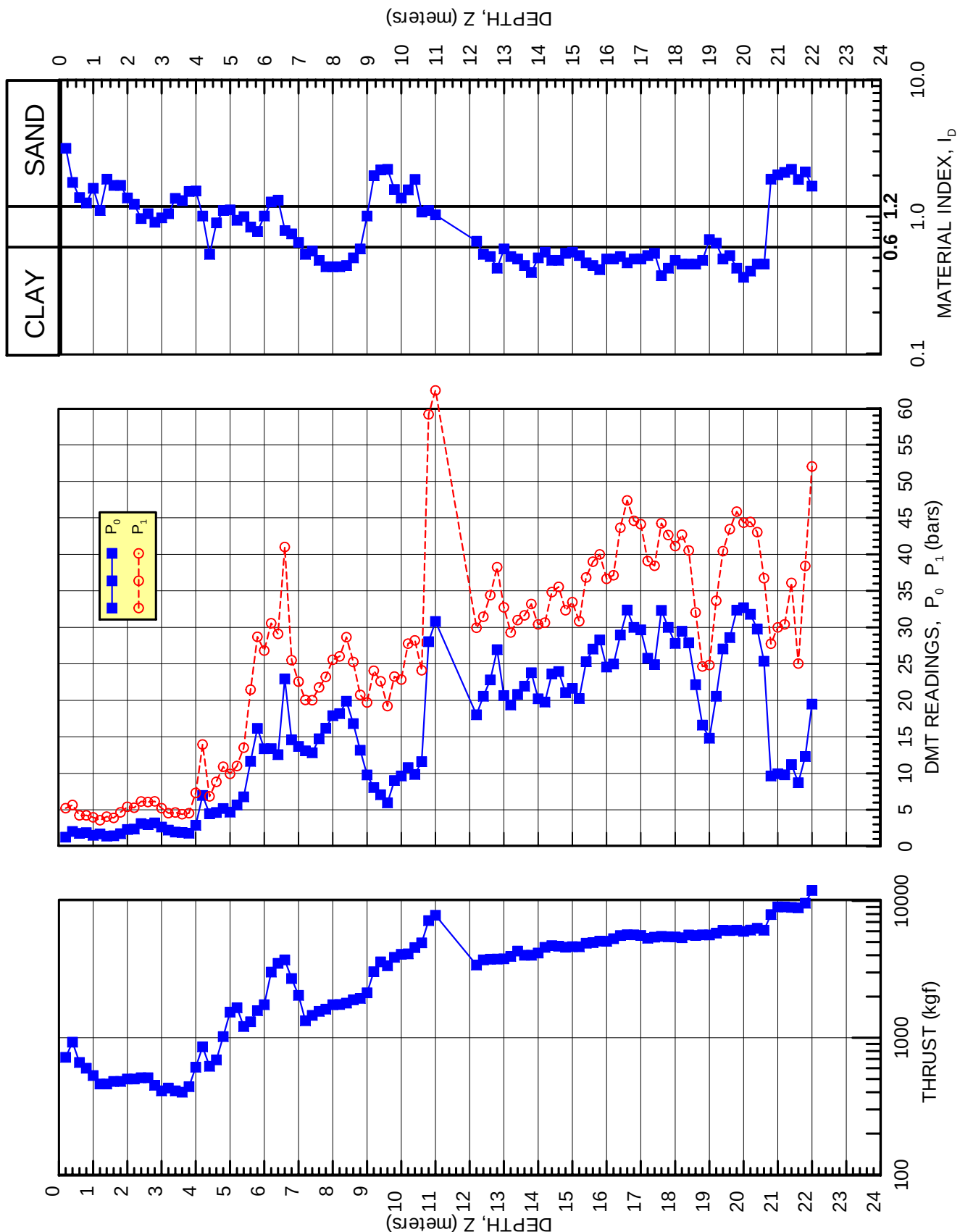
IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Failmezger
SOUNDING DATE: 4/1/09

SOUNDING

D-2

DILATOMETER RESULTS

Ground Surface Elev.: ~ 31.5 m
Water Depth: None Found



PROJECT: Naval Research Laboratory Phase II Slope Stability Investigation
LOCATION: Calvert Cliffs, Maryland

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Failmezger
SOUNDING DATE: 4/1/09

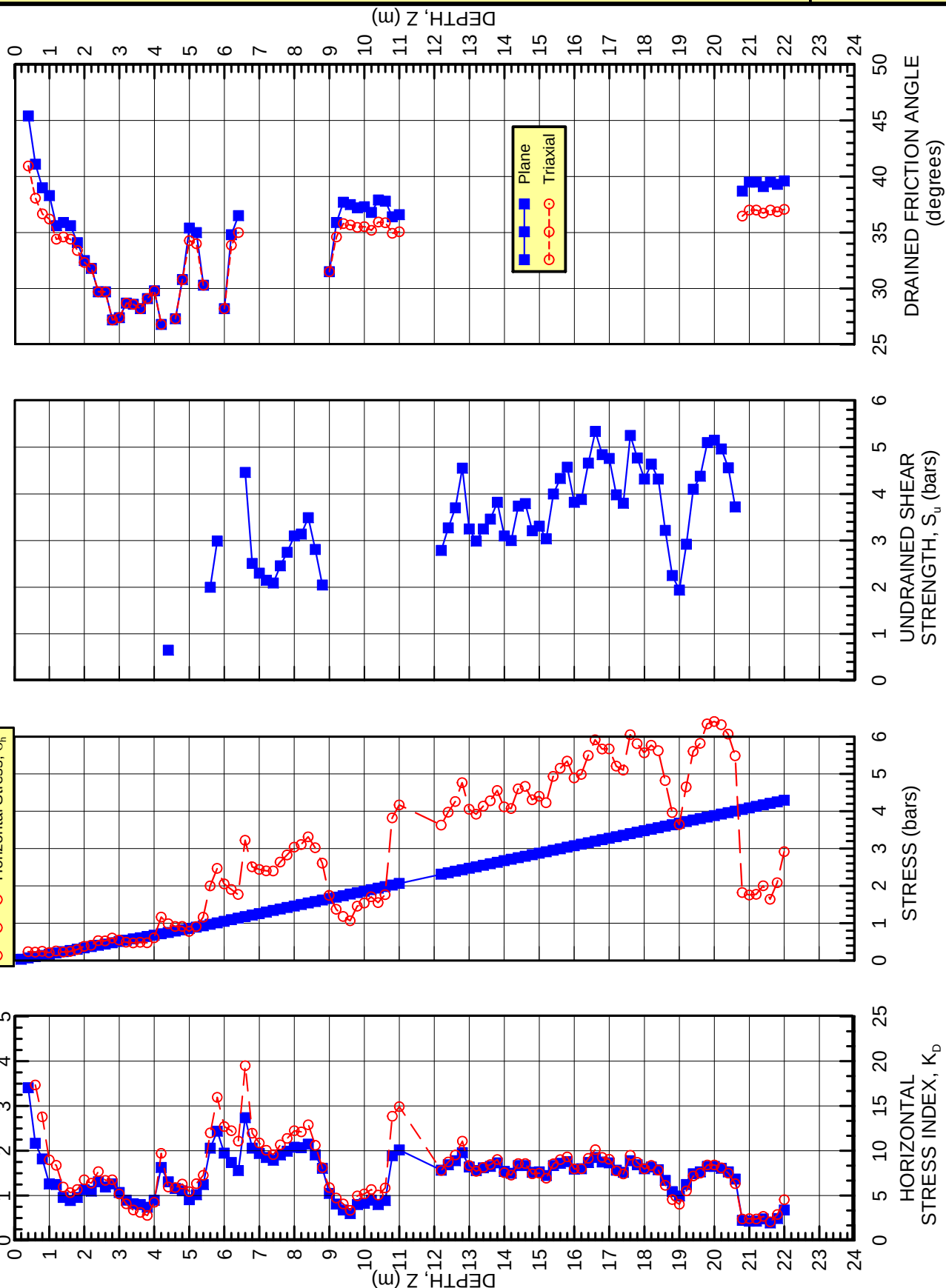
SOUNDING

D-2

INTERPRETED DMT STRENGTH PARAMETERS

Ground Surface Elev: ~ 31.5 m
Water Depth: None Found

Note: For angles <32°,
Triaxial ~ Plane.



PROJECT: Naval Research Laboratory Phase II Slope Stability Investigation
LOCATION: Calvert Cliffs, Maryland

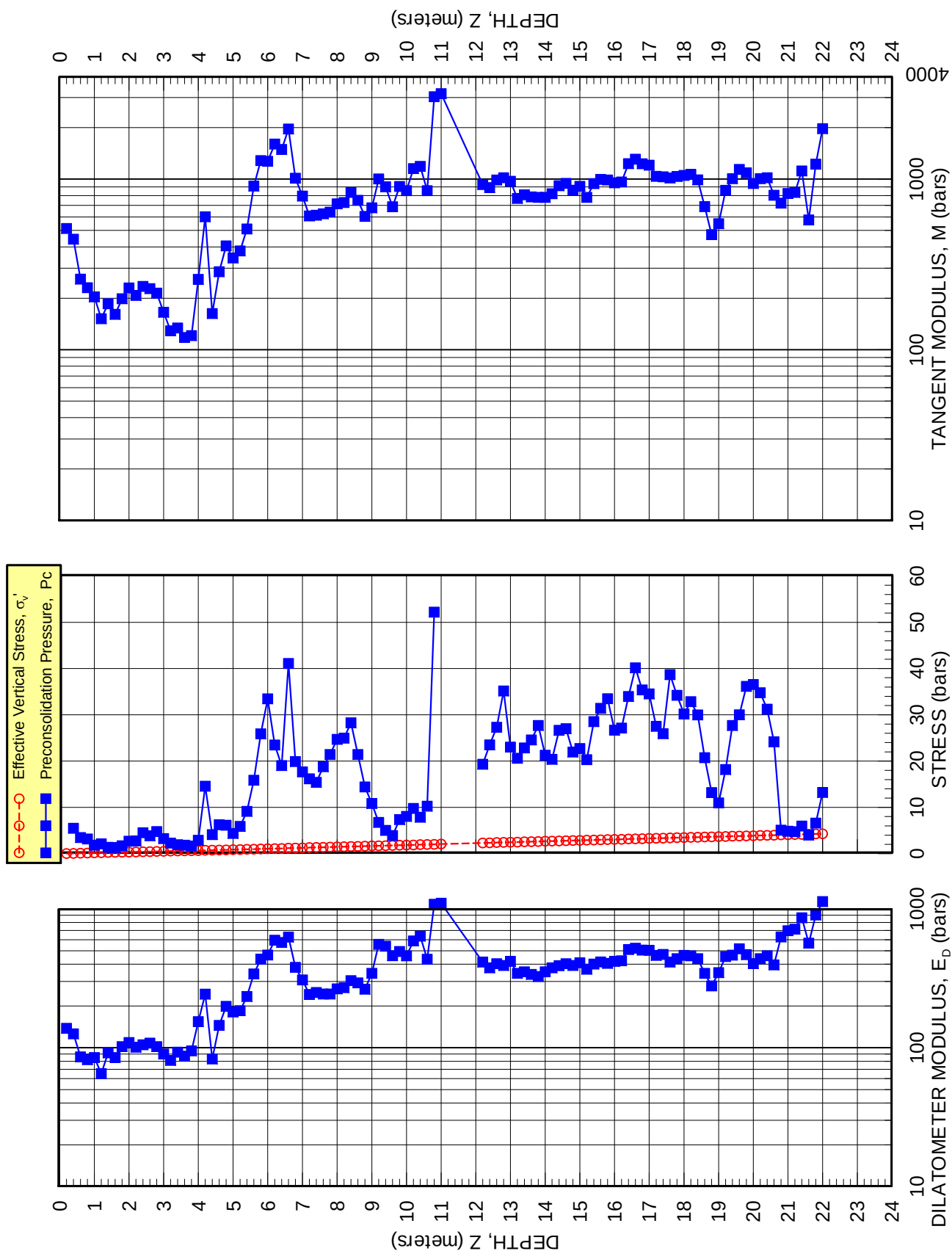
IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Failmezger
SOUNDING DATE: 4/1/09

SOUNDING

INTERPRETED DMT DEFORMATION PARAMETERS

D-2

Ground Surface Elev.: ~ 31.5 m
Water Depth: None Found



DILATOMETER DATA LISTING & INTERPRETATION (BASED ON THE 1988 DILATOMETER MANUAL)

In-Situ Soil Testing, L.C.

JOB FILE: Naval Research Laboratory--Phase II Slope Stability

LOCATION: Calvert Cliffs, Maryland

SNDG.BY : R. Failmezger

ANAL.BY : Roger Failmezger, P.E.

SNDG. NO. :D-4

Page 1a

FILE NO. : 2009-13

SNDG. DATE: 4/2/09

ANAL. DATE: 4/15/09

ANALYSIS PARAMETERS: LO RANGE = 9.50 BARS ROD DIAM. = 3.6 CM BL.THICK. = 15.0 MM SU FACTOR = 1
 SURF.ELEV. = 30.9 M LO GAGE 0 = 0.00 BARS FR.RED.DIA. = 4.4 CM BL.WIDTH = 96.0 MM PHI FACTOR = 1
 WATER DEPTH = 30.0 M HI GAGE 0 = 0.40 BARS LIN.ROD WT. = 6.5 KGF/M DELTA-A = 0.19 BARS OCR FACTOR = 1
 SP.GR.WATER = 1.000 CAL GAGE 0 = 0.00 BARS DELTA/PHI = 0.5 DELTA-B = 0.17 BARS M FACTOR = 1
 MAX SU ID = 0.9 SU OPTION = 0 MIN PHI ID = 0.9 OCR OPTION = 0 K0 FACTOR = 1
 UNIT CONVERSIONS: 1 BAR = 1.019 KGF/CM2 = 100 KPA = 1.044 TSF = 14.51 PSI 1 M = 3.2808 FT

Z (M)	ELEV (M)	THRUST (KGF)	A (BAR)	B (BAR)	C (BAR)	DA (BAR)	DB (BAR)	ZMRNG (BAR)	ZMLO (BAR)	ZMHI (BAR)	ZMCAL (BAR)	P0 (BAR)	P1 (BAR)	P2 (BAR)	U0 (BAR)	GAMMA (T/M3)	SVP (BAR)
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
0.20	30.70	1210	2.68	9.58		0.19	0.17	9.50	0.00	0.40	0.00	2.56	9.01		0.000	1.90	0.035
0.40	30.50	1190	1.80	5.70		0.19	0.17	9.50	0.00	0.40	0.00	1.81	5.53		0.000	1.80	0.071
0.60	30.30	710	0.98	3.41		0.19	0.17	9.50	0.00	0.40	0.00	1.07	3.24		0.000	1.70	0.106
0.80	30.10	1620	4.72	13.45		0.19	0.17	9.50	0.00	0.40	0.00	4.51	12.88		0.000	1.90	0.141
1.00	29.90	1450	4.08	10.10		0.19	0.17	9.50	0.00	0.40	0.00	4.01	9.53		0.000	1.80	0.177
1.20	29.70	1220	3.55	7.52		0.19	0.17	9.50	0.00	0.40	0.00	3.56	7.35		0.000	1.80	0.213
1.40	29.50	970	3.39	7.90		0.19	0.17	9.50	0.00	0.40	0.00	3.37	7.73		0.000	1.80	0.248
1.60	29.30	800	2.87	7.43		0.19	0.17	9.50	0.00	0.40	0.00	2.85	7.26		0.000	1.80	0.283
1.80	29.10	630	2.80	6.00		0.19	0.17	9.50	0.00	0.40	0.00	2.85	5.83		0.000	1.70	0.318
2.00	28.90	520	3.40	6.10		0.19	0.17	9.50	0.00	0.40	0.00	3.47	5.93		0.000	1.80	0.352
2.20	28.70	510	2.90	6.41		0.19	0.17	9.50	0.00	0.40	0.00	2.93	6.24		0.000	1.80	0.387
2.40	28.50	500	2.91	6.04		0.19	0.17	9.50	0.00	0.40	0.00	2.96	5.87		0.000	1.70	0.422
2.60	28.30	530	3.38	6.89		0.19	0.17	9.50	0.00	0.40	0.00	3.41	6.72		0.000	1.80	0.456
2.80	28.10	520	3.78	6.87		0.19	0.17	9.50	0.00	0.40	0.00	3.83	6.70		0.000	1.80	0.491
3.00	27.90	510	3.04	6.43		0.19	0.17	9.50	0.00	0.40	0.00	3.08	6.26		0.000	1.80	0.527
3.20	27.70	640	2.68	7.48		0.19	0.17	9.50	0.00	0.40	0.00	2.65	7.31		0.000	1.80	0.562
3.40	27.50	690	2.57	7.03		0.19	0.17	9.50	0.00	0.40	0.00	2.56	6.86		0.000	1.80	0.597
3.60	27.30	720	2.51	7.31		0.19	0.17	9.50	0.00	0.40	0.00	2.48	7.14		0.000	1.90	0.634
3.80	27.10	630	2.87	6.40		0.19	0.17	9.50	0.00	0.40	0.00	2.90	6.23		0.000	1.80	0.670
4.00	26.90	500	2.50	5.60		0.19	0.17	9.50	0.00	0.40	0.00	2.55	5.43		0.000	1.70	0.704
4.20	26.70	580	2.31	5.51		0.19	0.17	9.50	0.00	0.40	0.00	2.36	5.34		0.000	1.70	0.738
4.40	26.50	680	2.88	6.62		0.19	0.17	9.50	0.00	0.40	0.00	2.90	6.45		0.000	1.80	0.772
4.60	26.30	910	2.23	7.03		0.19	0.17	9.50	0.00	0.40	0.00	2.20	6.86		0.000	1.80	0.807
4.80	26.10	930	2.69	7.72		0.19	0.17	9.50	0.00	0.40	0.00	2.65	7.55		0.000	1.90	0.844
5.00	25.90	720	2.71	7.31		0.19	0.17	9.50	0.00	0.40	0.00	2.69	7.14		0.000	1.80	0.880
5.20	25.70	570	2.22	5.79		0.19	0.17	9.50	0.00	0.40	0.00	2.25	5.62		0.000	1.70	0.914
5.40	25.50	1040	5.69	13.00		0.19	0.17	9.50	0.00	0.40	0.00	5.55	12.43		0.000	1.95	0.950
5.60	25.30	1380	5.40	15.00		0.19	0.17	9.50	0.00	0.40	0.00	5.15	14.43		0.000	2.00	0.989
5.80	25.10	1360	4.20	12.30		0.19	0.17	9.50	0.00	0.40	0.00	4.02	11.73		0.000	1.90	1.027
6.00	24.90	770	2.28	4.40		0.19	0.17	9.50	0.00	0.40	0.00	2.38	4.23		0.000	1.70	1.062
6.20	24.70	1160	3.60	12.85		0.19	0.17	9.50	0.00	0.40	0.00	3.37	12.28		0.000	1.90	1.098
6.40	24.50	1700	8.03	20.90		0.19	0.17	9.50	0.00	0.40	0.00	7.61	20.33		0.000	1.95	1.136
6.60	24.30	1750	9.38	15.30		0.19	0.17	9.50	0.00	0.40	0.00	9.31	14.73		0.000	1.90	1.173
6.80	24.10	1190	10.25	15.25		0.19	0.17	9.50	0.00	0.40	0.00	9.81	14.68		0.000	1.90	1.211
7.00	23.90	1270	12.45	18.60		0.19	0.17	9.50	0.00	0.40	0.00	11.95	18.03		0.000	1.90	1.248
7.20	23.70	1340	12.40	17.15		0.19	0.17	9.50	0.00	0.40	0.00	11.97	16.58		0.000	1.90	1.285
7.40	23.50	1600	17.55	26.35		0.19	0.17	9.50	0.00	0.40	0.00	16.92	25.78		0.000	2.05	1.324
7.60	23.30	1620	16.85	23.60		0.19	0.17	9.50	0.00	0.40	0.00	16.32	23.03		0.000	2.05	1.364
7.80	23.10	1630	17.70	24.40		0.19	0.17	9.50	0.00	0.40	0.00	17.17	23.83		0.000	2.05	1.404
8.00	22.90	1780	18.40	25.45		0.19	0.17	9.50	0.00	0.40	0.00	17.86	24.88		0.000	2.05	1.445
8.20	22.70	1910	18.00	25.20		0.19	0.17	9.50	0.00	0.40	0.00	17.45	24.63		0.000	2.05	1.485
8.40	22.50	2730	22.60	38.20		0.19	0.17	9.50	0.00	0.40	0.00	21.63	37.63		0.000	2.10	1.526
8.60	22.30	2920	15.35	23.90		0.19	0.17	9.50	0.00	0.40	0.00	14.73	23.33		0.000	2.05	1.566
8.80	22.10	3100	10.50	21.60		0.19	0.17	9.50	0.00	0.40	0.00	9.75	21.03		0.000	1.95	1.606
9.00	21.90	3540	10.85	23.80		0.19	0.17	9.50	0.00	0.40	0.00	10.01	23.23		0.000	2.10	1.645
9.20	21.70	3390	8.19	23.40		0.19	0.17	9.50	0.00	0.40	0.00	7.66	22.83		0.000	2.00	1.686
9.40	21.50	2840	5.48	13.20		0.19	0.17	9.50	0.00	0.40	0.00	5.32	12.63		0.000	1.95	1.724
9.60	21.30	2510	5.72	15.15		0.19	0.17	9.50	0.00	0.40	0.00	5.48	14.58		0.000	1.95	1.763
9.80	21.10	2420	5.79	15.65		0.19	0.17	9.50	0.00	0.40	0.00	5.53	15.08		0.000	1.95	1.801
10.00	20.90	2520	5.73	13.80		0.19	0.17	9.50	0.00	0.40	0.00	5.55	13.23		0.000	1.95	1.839
10.20	20.70	3310	7.78	24.30		0.19	0.17	9.50	0.00	0.40	0.00	7.18	23.73		0.000	2.00	1.878
10.40	20.50	10280	13.70	27.35		0.19	0.17	9.50	0.00	0.40	0.00	12.83	26.78		0.000	2.10	1.918

DILATOMETER DATA LISTING & INTERPRETATION (BASED ON THE 1988 DILATOMETER MANUAL)

In-Situ Soil Testing, L.C.

JOB FILE: Naval Research Laboratory--Phase II Slope Stability

LOCATION: Calvert Cliffs, Maryland

SNDG.BY : R. Failmezger

ANAL.BY : Roger Failmezger, P.E.

SNDG. NO. : D-4

Page 1b

FILE NO. :2009-13

SNDG. DATE: 4/2/09

ANAL. DATE: 4/15/09

ANALYSIS PARAMETERS: LO RANGE = 9.50 BARS ROD DIAM. = 3.6 CM BL.THICK. = 15.0 MM SU FACTOR = 1
 SURF.ELEV. = 30.9 M LO GAGE 0 = 0.00 BARS FR.RED.DIA. = 4.4 CM BL.WIDTH = 96.0 MM PHI FACTOR = 1
 WATER DEPTH = 30.0 M HI GAGE 0 = 0.40 BARS LIN.ROD WT. = 6.5 KGF/M DELTA-A = 0.19 BARS OCR FACTOR = 1
 SP.GR.WATER = 1.000 CAL GAGE 0 = 0.00 BARS DELTA / PHI = 0.5 DELTA-B = 0.17 BARS M FACTOR = 1
 MAX SU ID = 0.9 SU OPTION = 0 MIN PHI ID = 0.9 OCR OPTION = 0 K0 FACTOR = 1
 UNIT CONVERSIONS: 1 BAR = 1.019 KGF/CM2 = 100 KPA = 1.044 TSF = 14.51 PSI 1 M = 3.2808 FT

Z (M)	ELEV (M)	KD	ID	UD	ED (BAR)	K0	SU (BAR)	QD (BAR)	PHI (DEG)	SIGFF (BAR)	PHIO (DEG)	PC (BAR)	OCR	M (BAR)	SOIL TYPE
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
0.20	30.70	73.23	2.52		224									981	SILTY SAND
0.40	30.50	25.42	2.05		129									436	SILTY SAND
0.60	30.30	10.09	2.04		75	1.15		24.3	44.4	0.18	40.6	1.03	9.7	189	SILTY SAND
0.80	30.10	32.00	1.85		290	3.91		43.4	41.7	0.23	37.9	15.46	109.7	1046	SILTY SAND
1.00	29.90	22.60	1.38		192	2.81		39.6	41.0	0.29	37.5	10.05	56.7	627	SANDY SILT
1.20	29.70	16.74	1.06		132	2.14		33.0	39.8	0.35	36.5	7.00	32.9	393	SILT
1.40	29.50	13.60	1.29		151	1.83		24.6	37.7	0.40	34.4	5.89	23.8	422	SANDY SILT
1.60	29.30	10.06	1.55		153	1.43		20.6	36.5	0.45	33.3	3.98	14.1	383	SANDY SILT
1.80	29.10	8.97	1.05		103	1.37		14.6	33.7	0.49	30.5	3.96	12.5	247	SILT
2.00	28.90	9.87	0.71		85	1.82	0.57					4.24	12.1	212	CLAYEY SILT
2.20	28.70	7.57	1.13		115	1.28		10.6	30.3	0.58	27.2	4.07	10.5	255	SILT
2.40	28.50	7.02	0.98		101	1.23		10.4	29.7	0.63	26.7	4.01	9.5	217	SILT
2.60	28.30	7.48	0.97		115	1.31		10.3	28.9	0.68	26.0	5.03	11.0	254	SILT
2.80	28.10	7.80	0.75		99	1.57	0.59					4.11	8.4	224	CLAYEY SILT
3.00	27.90	5.85	1.03		110	1.12		11.0	28.6	0.78	26.0	3.86	7.3	217	SILT
3.20	27.70	4.71	1.76		162	0.90		17.1	31.8	0.86	29.5	2.56	4.6	289	SANDY SILT
3.40	27.50	4.28	1.68		149	0.83		19.5	32.4	0.92	30.3	2.31	3.9	252	SANDY SILT
3.60	27.30	3.91	1.88		162	0.78		21.1	32.6	0.98	30.7	2.14	3.4	261	SILTY SAND
3.80	27.10	4.33	1.15		115	0.90		16.4	30.2	1.01	28.2	2.89	4.3	193	SILT
4.00	26.90	3.62	1.13		100	0.86		13.1	28.2	1.04	26.2	2.58	3.7	149	SILT
4.20	26.70	3.20	1.26		103	0.77		16.8	29.9	1.11	28.1	2.14	2.9	143	SANDY SILT
4.40	26.50	3.76	1.22		123	0.83		18.7	30.2	1.16	28.5	2.73	3.5	189	SANDY SILT
4.60	26.30	2.72	2.12		162	0.61		30.3	33.9	1.26	32.4	1.62	2.0	210	SILTY SAND
4.80	26.10	3.14	1.85		170	0.68		29.4	33.2	1.31	31.8	2.07	2.5	239	SILTY SAND
5.00	25.90	3.05	1.66		154	0.74		21.4	30.4	1.33	29.0	2.35	2.7	211	SANDY SILT
5.20	25.70	2.46	1.50		117	0.71		17.4	28.6	1.35	27.2	2.06	2.2	134	SANDY SILT
5.40	25.50	5.84	1.24		239	1.08		23.5	29.9	1.42	28.6	6.57	6.9	471	SANDY SILT
5.60	25.30	5.21	1.80		322	0.93		37.3	33.2	1.53	32.1	5.00	5.1	606	SILTY SAND
5.80	25.10	3.92	1.92		267	0.75		41.2	34.0	1.60	33.0	3.31	3.2	433	SILTY SAND
6.00	24.90	2.24	0.78		64	0.61	0.27					1.27	1.2	63	CLAYEY SILT
6.20	24.70	3.07	2.65		309	0.68		36.4	32.8	1.69	31.9	2.66	2.4	447	SILTY SAND
6.40	24.50	6.71	1.67		441	1.12		40.7	32.4	1.74	31.6	8.86	7.8	935	SANDY SILT
6.60	24.30	7.94	0.58		188	1.59	1.45					10.07	8.6	425	SILTY CLAY
6.80	24.10	8.10	0.50		169	1.61	1.53					10.73	8.9	386	SILTY CLAY
7.00	23.90	9.58	0.51		211	1.79	1.94					14.36	11.5	518	SILTY CLAY
7.20	23.70	9.31	0.39		160	1.76	1.93					14.16	11.0	388	SILTY CLAY
7.40	23.50	12.78	0.52		308	2.14	2.96					23.90	18.0	840	SILTY CLAY
7.60	23.30	11.96	0.41		233	2.05	2.81					22.22	16.3	622	SILTY CLAY
7.80	23.10	12.23	0.39		231	2.08	2.97					23.67	16.9	621	SILTY CLAY
8.00	22.90	12.36	0.39		244	2.09	3.10					24.76	17.1	658	SILTY CLAY
8.20	22.70	11.75	0.41		249	2.03	2.99					23.52	15.8	661	SILTY CLAY
8.40	22.50	14.18	0.74		555	2.27	3.88					32.38	21.2	1572	CLAYEY SILT
8.60	22.30	9.40	0.58		298	1.77	2.39					17.53	11.2	727	SILTY CLAY
8.80	22.10	6.07	1.16		391	0.98		87.1	35.5	2.54	35.3	9.65	6.0	785	SILT
9.00	21.90	6.08	1.32		459	0.96		103.2	36.4	2.62	36.4	9.58	5.8	924	SANDY SILT
9.20	21.70	4.54	1.98		526	0.76		108.1	37.1	2.70	37.0	5.97	3.5	928	SILTY SAND
9.40	21.50	3.09	1.37		254	0.59		97.1	36.6	2.75	36.7	3.54	2.1	343	SANDY SILT
9.60	21.30	3.11	1.66		316	0.62		83.3	35.4	2.78	35.4	3.90	2.2	437	SANDY SILT
9.80	21.10	3.07	1.73		332	0.63		79.6	34.9	2.83	35.0	4.00	2.2	456	SANDY SILT
10.00	20.90	3.02	1.38		266	0.62		83.6	35.1	2.90	35.2	3.96	2.2	355	SANDY SILT
10.20	20.70	3.82	2.30		574	0.68		108.0	36.5	3.00	36.7	5.26	2.8	931	SILTY SAND
10.40	20.50	6.69	1.09		484	0.80		363.6	43.2	3.23	43.4	9.07	4.7	1017	SILT

PROJECT: Naval Research Laboratory Phase II Slope Stability Investigation
LOCATION: Calvert Cliffs, Maryland

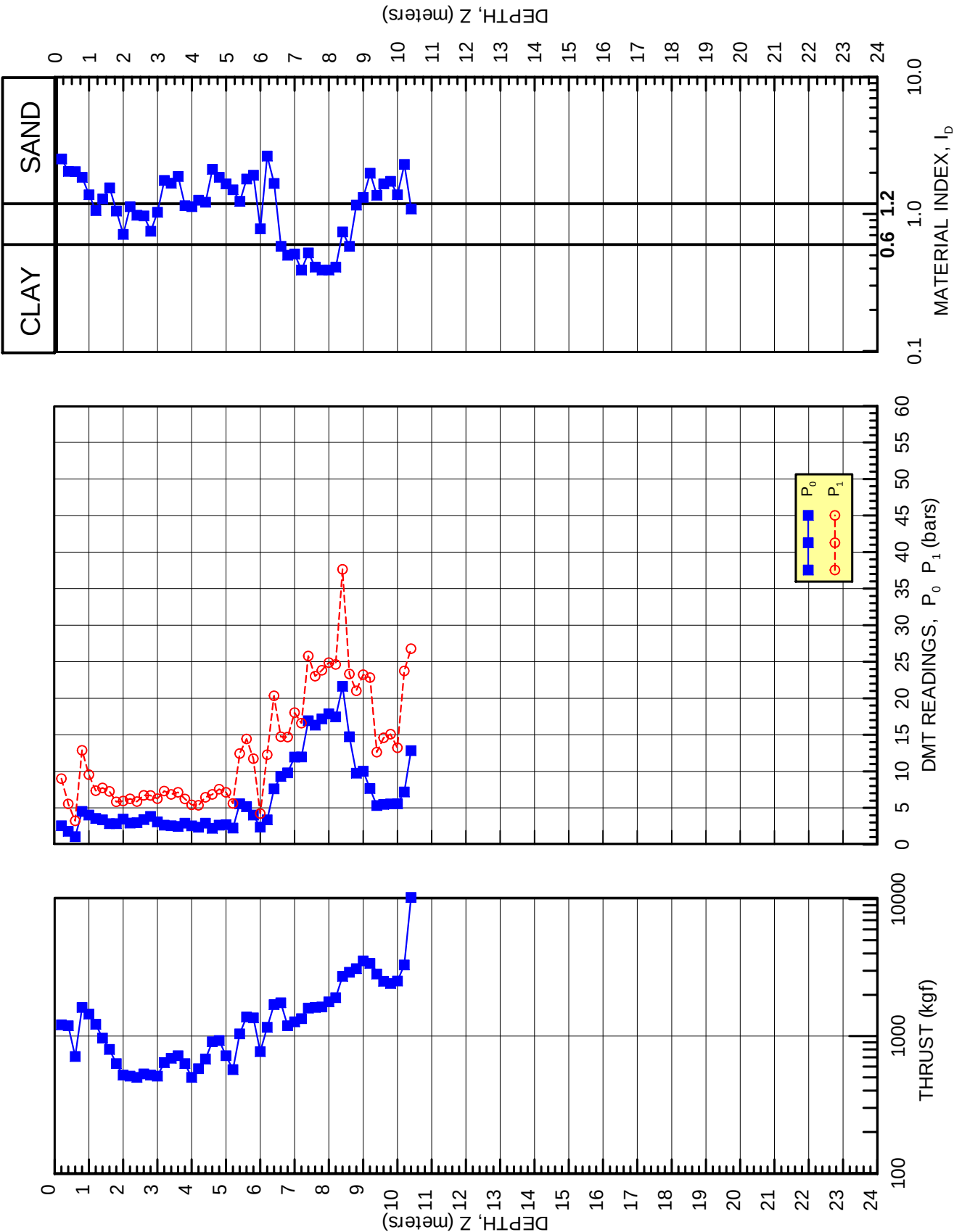
IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Failmezger
SOUNDING DATE: 4/1/09

SOUNDING

D-4

DILATOMETER RESULTS

Ground Surface Elev.: ~ 30.9 m
Water Depth: None Found



PROJECT: Naval Research Laboratory Phase II Slope Stability Investigation
LOCATION: Calvert Cliffs, Maryland

IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Failmezger
SOUNDING DATE: 4/1/09

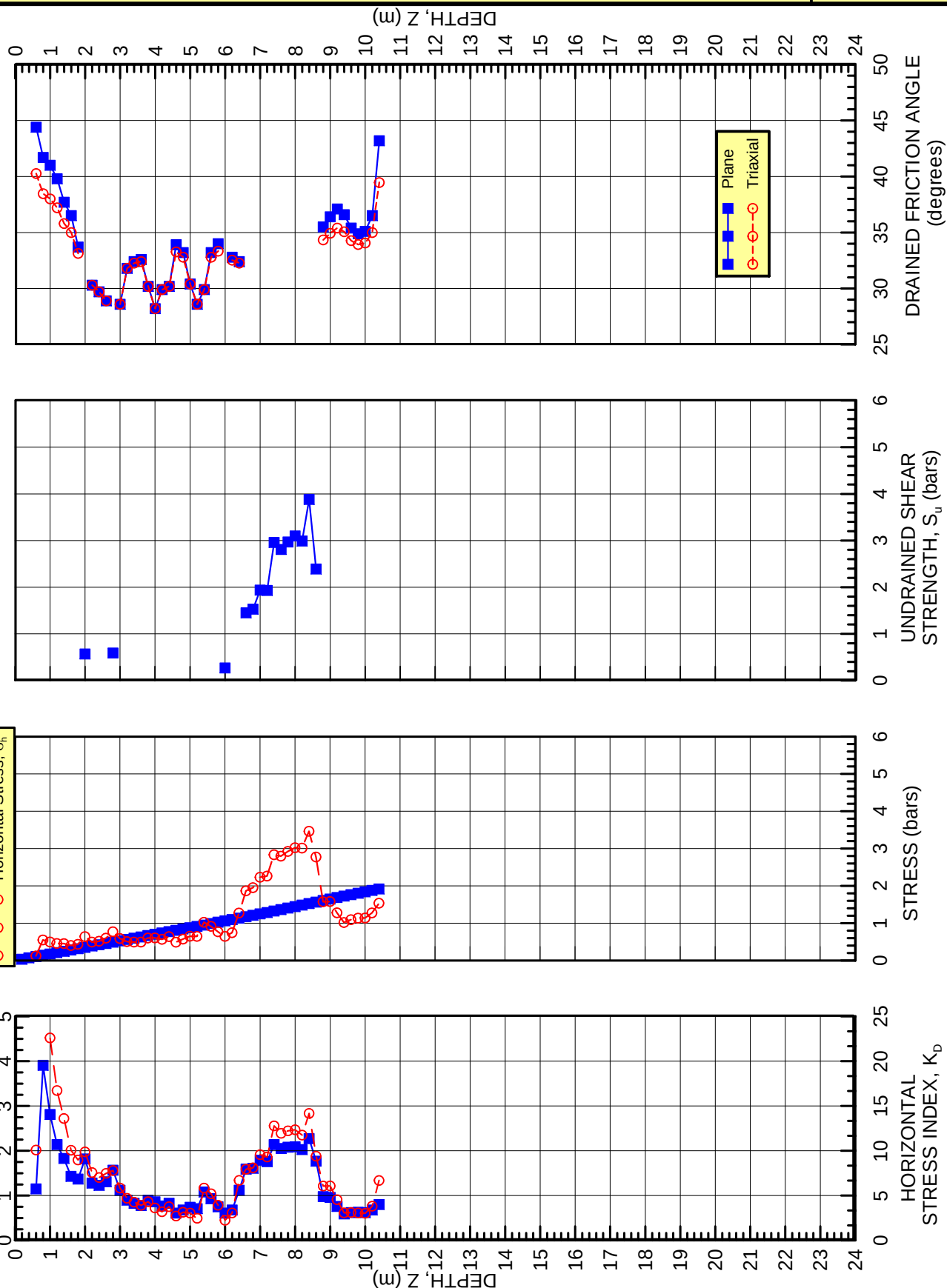
SOUNDING

D-4

INTERPRETED DMT STRENGTH PARAMETERS

Ground Surface Elev: ~ 30.9 m
Water Depth: None Found

Note: For angles <32°,
Triaxial ~ Plane.



PROJECT: Naval Research Laboratory Phase II Slope Stability Investigation
LOCATION: Calvert Cliffs, Maryland

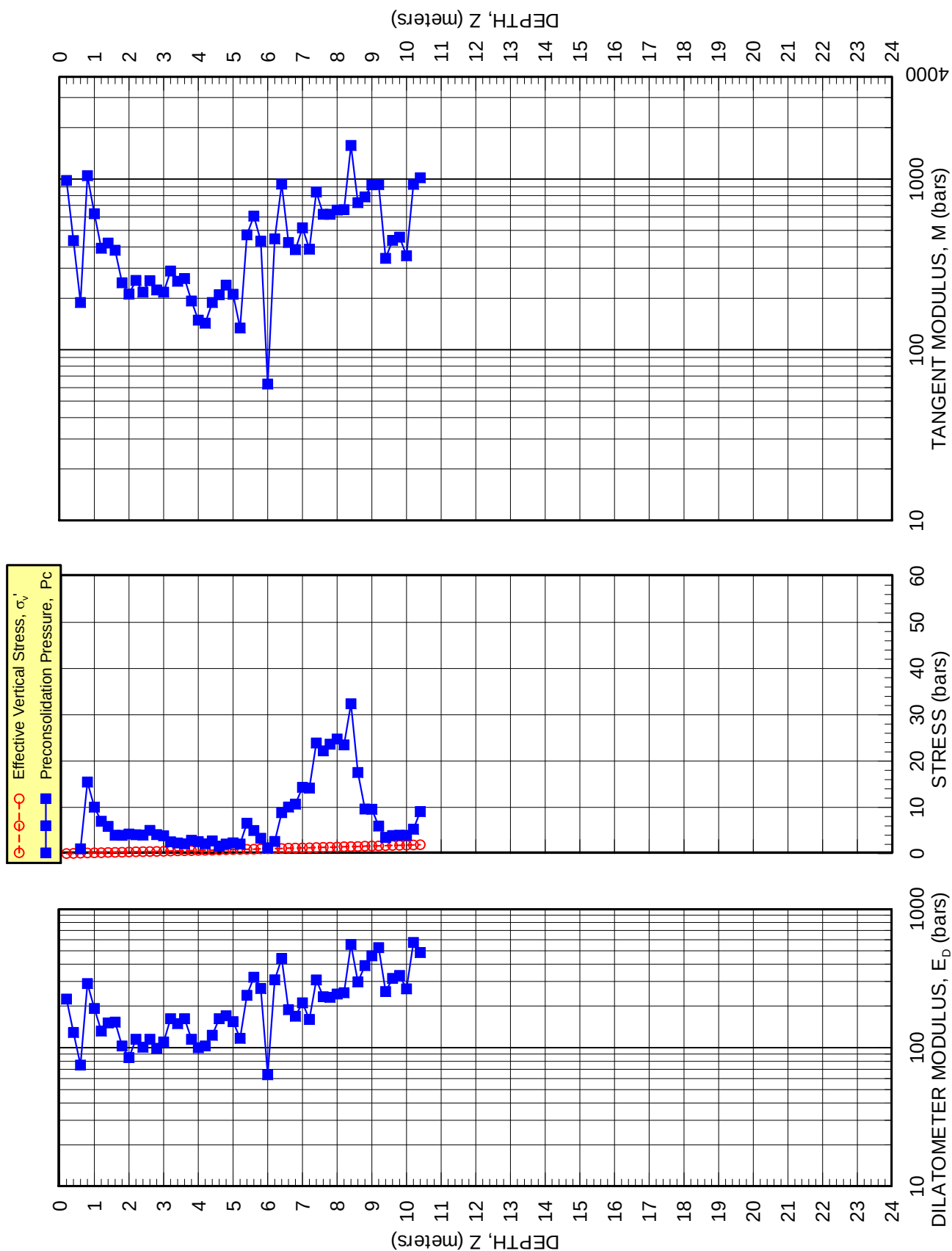
IN-SITU SOIL TESTING, L.C.
ENGINEER: R. Failmezger
SOUNDING DATE: 4/1/09

SOUNDING

INTERPRETED DMT DEFORMATION PARAMETERS

D-4

Ground Surface Elev.: ~ 30.9 m
Water Depth: None Found



LABORATORY TEST RESULTS
(From US Army Corps Engineers)

LABORATORY TEST RESULTS

PROJECT: Naval Research Lab – Slope Stabilization
AREA: Calvert County, MD

DATE: Jun 2009

TEST: Natural Moisture Contents (ASTM D 2216)

Page 1 of 5

<u>Hole No.</u>	<u>Sample No.</u>	<u>Depth (ft)</u>	<u>Moisture Content, %</u>	<u>Hole No.</u>	<u>Sample No.</u>	<u>Depth (ft)</u>	<u>Moisture Content, %</u>
B-1	Jar-1	1.0-2.5	27.1	B-2	Jar-1	1.0-2.5	15.9
B-1	Jar-2	3.5-5.0	37.8	B-2	Jar-2	3.5-5.0	35.7
B-1	Jar-3	6.0-7.5	23.6	B-2	Jar-3	6.0-7.5	45.1
B-1	Jar-4	8.5-10.0	33.0	B-2	Jar-4	8.5-10.0	49.3
B-1	Jar-5	13.5-15.5	28.7	B-2	Jar-5	13.5-15.0	65.7
B-1	Jar-6	15.5-17.0	30.3	B-2	Jar-6	18.5-20.0	32.4
B-1	Jar-7	18.5-20.0	22.7	B-2	Jar-7	23.5-25.0	43.6
B-1	Jar-8	23.5-25.0	55.6	B-2	Jar-8	28.5-30.0	38.4
B-1	Jar-9	28.5-30.0	62.0	B-2	Jar-9	33.5-35.0	37.7
B-1	Jar-10	33.5-35.0	50.5	B-2	Jar-10	38.5-40.0	48.9
B-1	Jar-11	38.5-39.5	59.0	B-2	Jar-11	43.5-45.0	51.7
B-1	Jar-12	39.5-41.0	62.7	B-2	Jar-12	48.5-50.0	56.5
B-1	Jar-13	43.5-45.0	79.6	B-2	Jar-13	53.5-55.0	66.6
B-1	Jar-14	48.5-50.0	58.3	B-2	Jar-14	58.5-60.0	84.4
B-1	Jar-15	53.5-55.0	35.0	B-2	Jar-15	63.5-65.0	81.2
B-1	Jar-16	58.5-60.0	27.6	B-2	Jar-16	68.5-70.0	23.6
B-1	Jar-17	63.5-65.0	44.3	B-2	Jar-17	73.5-75.0	32.7
B-1	Jar-18	68.5-70.0	59.5	B-2	Jar-18	78.5-80.0	39.3
B-1	Jar-19	73.5-75.0	66.6	B-2	Jar-19	83.5-85.0	64.3
B-1	Jar-20	78.5-80.0	51.4	B-2	Jar-20	88.5-90.0	69.5
B-1	Jar-21	83.5-85.0	49.3	B-2	Jar-21	93.5-95.0	50.5
B-1	Jar-22	88.5-90.0	49.8	B-2	Jar-22	98.5-100.0	41.9
B-1	Jar-23	93.5-95.0	63.8	B-2	Jar-23	103.5-105.0	59.7
B-1	Jar-24	98.5-100.0	73.8	B-2	Jar-24	108.5-110.0	82.2
B-1	Jar-25	103.5-105.0	56.5	B-2	Jar-25	113.5-115.0	90.0
B-1	Jar-26	108.5-110.0	55.6	B-2	Jar-26	118.5-120.0	50.2
B-1	Jar-27	113.5-115.0	57.8	B-2	Jar-27	123.5-125.0	51.3
B-1	Jar-28	118.5-120.0	68.4	B-2	Jar-28	128.5-130.0	61.7
B-1	Jar-29	123.5-125.0	76.8	B-2	Jar-29	133.5-135.0	61.0
B-1	Jar-30	128.5-130.0	64.8	B-2	Jar-30	138.5-140.0	72.4
B-1	Jar-31	133.5-135.0	67.7	B-2	Jar-31	143.5-145.0	72.1
B-1	Jar-32	138.5-140.0	44.7	B-2	Jar-32	148.5-150.0	71.6
B-1	Jar-33	143.5-145.0	48.0				
B-1	Jar-34	148.5-150.0	79.8				

LABORATORY TEST RESULTS

PROJECT: Naval Research Lab – Slope Stabilization
AREA: Calvert County, MD

DATE: Jun 2009

TEST: Natural Moisture Contents (ASTM D 2216)

Page 2 of 5

<u>Hole No.</u>	<u>Sample No.</u>	<u>Depth (ft)</u>	<u>Moisture Content, %</u>	<u>Hole No.</u>	<u>Sample No.</u>	<u>Depth (ft)</u>	<u>Moisture Content, %</u>
B-3	Jar-1	1.0-2.5	28.6	B-4	Jar-1	1.0-2.5	11.6
B-3	Jar-2	3.5-5.0	29.8	B-4	Jar-2	3.5-5.0	25.6
B-3	Jar-3	6.0-7.5	33.2	B-4	Jar-3	6.0-7.5	31.7
B-3	Jar-4	8.5-10.0	37.6	B-4	Jar-4	8.5-10.0	44.8
B-3	Jar-5	13.5-15.0	29.3	B-4	Jar-5	13.5-15.0	55.6
B-3	Jar-6	18.5-20.0	35.7	B-4	Jar-6	15.0-17.0	49.3
B-3	Jar-7	23.5-25.0	55.0	B-4	Jar-7	18.5-20.0	34.8
B-3	Jar-8	28.5-30.0	33.3	B-4	Jar-8	23.5-25.0	55.7
B-3	Jar-9	33.5-35.0	40.3	B-4	Jar-9	28.5-30.0	32.8
B-3	Jar-10	38.5-40.0	43.7	B-4	Jar-10	33.5-35.0	32.4
B-3	Jar-11	43.5-45.0	49.3	B-4	Jar-11	38.5-40.0	49.2
B-3	Jar-12	48.5-50.0	58.3	B-4	Jar-12	40.0-42.0	Shelby tube
B-3	Jar-13	53.5-55.0	78.4	B-4	Jar-13	43.5-45.0	43.3
B-3	Jar-14	58.5-60.0	41.3	B-4	Jar-14	48.5-50.0	Shelby tube
B-3	Jar-15	63.5-65.0	50.7	B-4	Jar-15	49.5-51.0	57.8
B-3	Jar-16	68.5-70.0	36.0	B-4	Jar-16	53.5-55.0	69.4
B-3	Jar-17	73.5-75.0	38.1	B-4	Jar-17	58.5-60.0	71.9
B-3	Jar-18	78.5-80.0	57.3	B-4	Jar-18	63.5-65.0	80.1
B-3	Jar-19	83.5-85.0	64.0	B-4	Jar-19	68.5-70.0	30.7
B-3	Jar-20	88.5-90.0	52.9	B-4	Jar-20	73.5-75.0	31.5
B-3	Jar-21	93.5-95.0	44.4	B-4	Jar-21	78.5-80.0	33.7
B-3	Jar-22	98.5-100.0	47.2	B-4	Jar-22	83.5-85.0	63.6
B-3	Jar-23	103.5-105.0	72.9	B-4	Jar-23	88.5-90.0	67.1
B-3	Jar-24	108.5-110.0	69.3	B-4	Jar-24	93.5-95.0	41.9
B-3	Jar-25	113.5-115.0	56.0	B-4	Jar-25	98.5-100.0	45.2
B-3	Jar-26	118.5-120.0	61.7	B-4	Jar-26	103.5-105.0	51.9
B-3	Jar-27	123.5-125.0	65.0	B-4	Jar-27	108.5-110.0	70.4
B-3	Jar-28	128.5-130.0	78.9	B-4	Jar-28	113.5-115.0	54.0
B-3	Jar-29	133.5-135.0	52.6	B-4	Jar-29	118.5-120.0	43.6
B-3	Jar-30	138.5-140.0	69.9	B-4	Jar-30	123.5-125.0	62.8
B-3	Jar-31	143.5-145.0	72.0	B-4	Jar-31	128.5-130.0	58.5
B-3	Jar-32	148.5-150.0	36.1	B-4	Jar-32	133.5-135.0	79.1
				B-4	Jar-33	138.5-140.0	79.8
				B-4	Jar-34	143.5-145.0	86.3
				B-4	Jar-35	148.5-150.0	90.0

LABORATORY TEST RESULTS

PROJECT: Naval Research Lab – Slope Stabilization
AREA: Calvert County, MD

DATE: Jun 2009

TEST: Natural Moisture Contents (ASTM D 2216)

Page 3 of 5

<u>Hole No.</u>	<u>Sample No.</u>	<u>Depth ft)</u>	<u>Moisture Content, %</u>
B-5	Jar-1	1.0-2.5	17.2
B-5	Jar-2	3.5-5.0	19.9
B-5	Jar-3	6.0-7.5	21.8
B-5	Jar-4	8.5-10.0	20.6
B-5	Jar-5	13.5-15.0	30.0
B-5	Jar-6	18.5-20.0	49.5
B-5	Jar-7	23.5-25.0	39.3
B-5	Jar-8	28.5-30.0	53.1
B-5	Jar-9	33.5-35.0	48.7
B-5	Jar-10	38.5-40.0	51.1
B-5	Jar-11	43.5-45.0	60.2
B-5	Jar-12	48.5-50.0	87.2
B-5	Jar-13	53.5-55.0	86.0
B-5	Jar-14	58.5-60.0	73.8
B-5	Jar-15	63.5-65.0	51.5
B-5	Jar-16	68.5-70.0	40.8
B-5	Jar-17	73.5-75.0	36.1
B-5	Jar-18	78.5-80.0	61.0
B-5	Jar-19	83.5-85.0	65.7
B-5	Jar-20	88.5-90.0	46.9
B-5	Jar-21	93.5-95.0	51.9
B-5	Jar-22	98.5-100.0	63.9
B-5	Jar-23	103.5-105.0	60.8
B-5	Jar-24	108.5-110.0	55.4
B-5	Jar-25	113.5-115.0	69.6
B-5	Jar-26	118.5-120.0	71.0
B-5	Jar-27	123.5-125.0	70.5
B-5	Jar-28	128.5-130.0	96.9
B-5	Jar-29	133.5-135.0	78.1
B-5	Jar-30	138.5-140.0	91.9
B-5	Jar-31	143.5-145.0	81.6
B-5	Jar-32	148.5-150.0	65.1

LABORATORY TEST RESULTS

PROJECT: Naval Research Lab – Slope Stabilization
AREA: Calvert County, MD

DATE: Jun 2009

TEST: Natural Moisture Contents (ASTM D 2216) & Atterberg Limits (ASTM D 4318)

Page 4 of 5

<u>Hole No.</u>	<u>Sample No.</u>	<u>Depth (ft)</u>	<u>Moisture Content, %</u>	<u>LL</u>	<u>PL</u>	<u>PI</u>	<u>Classification</u>	<u>Symbol</u>
B-1	Jar-4	8.5-10.0	33.0	46	26	20	Lean clay	CL
B-2	Jar-11	43.5-45.0	51.7	74	26	48	Fat clay	CH
B-3	Jar-27	123.5-125.0	65.0	120	39	81	Fat clay	CH
B-4	Jar-7	18.5-20.0	34.8	46	25	21	Lean clay	CL
B-5	Jar-20	88.5-90.0	46.9	70	41	29	Elastic silt	MH

Note: The Atterberg Limits test is only performed on minus No. 40 material portion of a sample and does not represent the entire sample. Refer to the Visual Classification or the Gradation Analysis for the complete classification.

LABORATORY TEST RESULTS

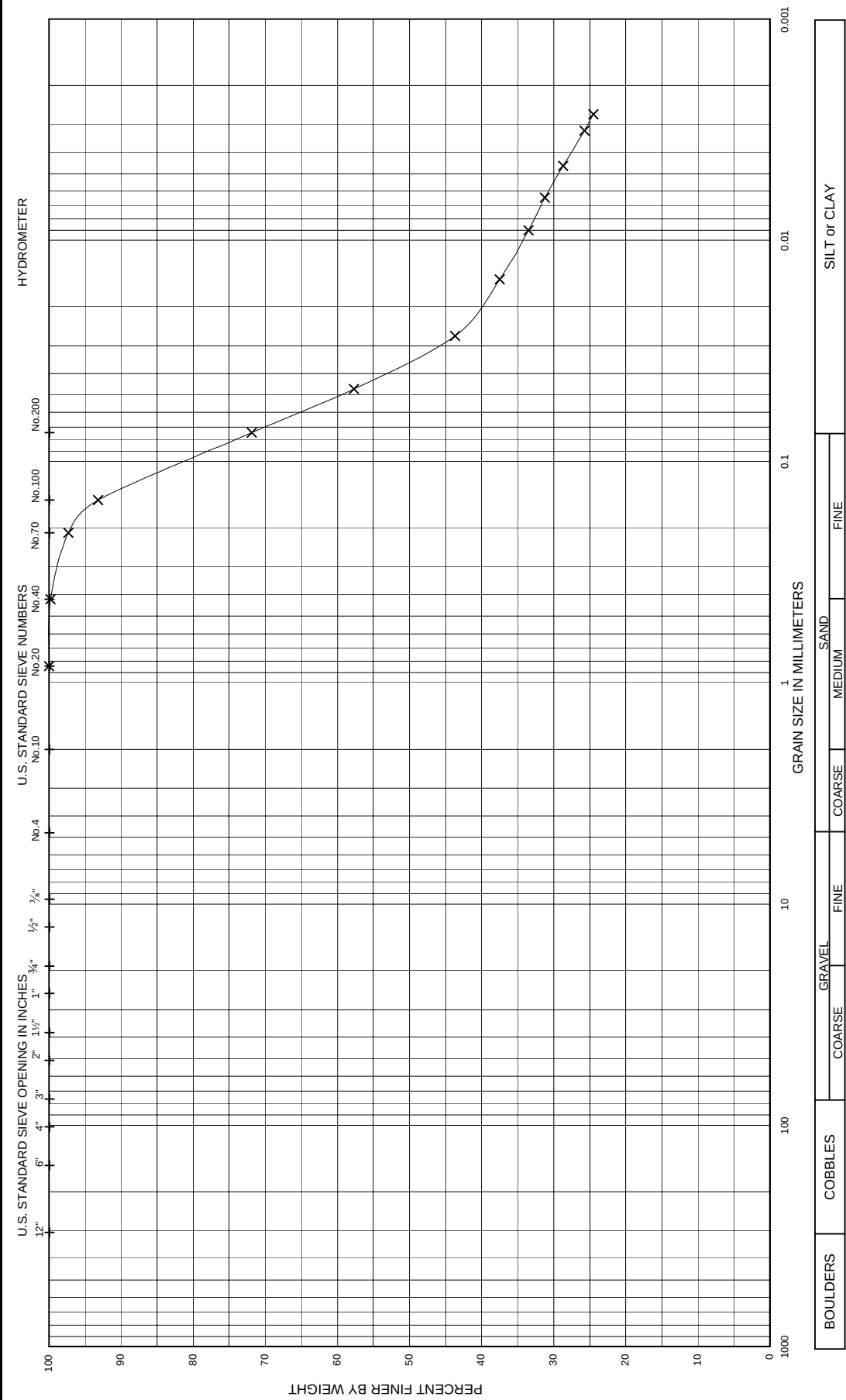
PROJECT: Naval Research Lab – Slope Stabilization
AREA: Calvert County, MD

DATE: Jun 2009

TEST: Specific Gravity (ASTM D 854)

Page 5 of 5

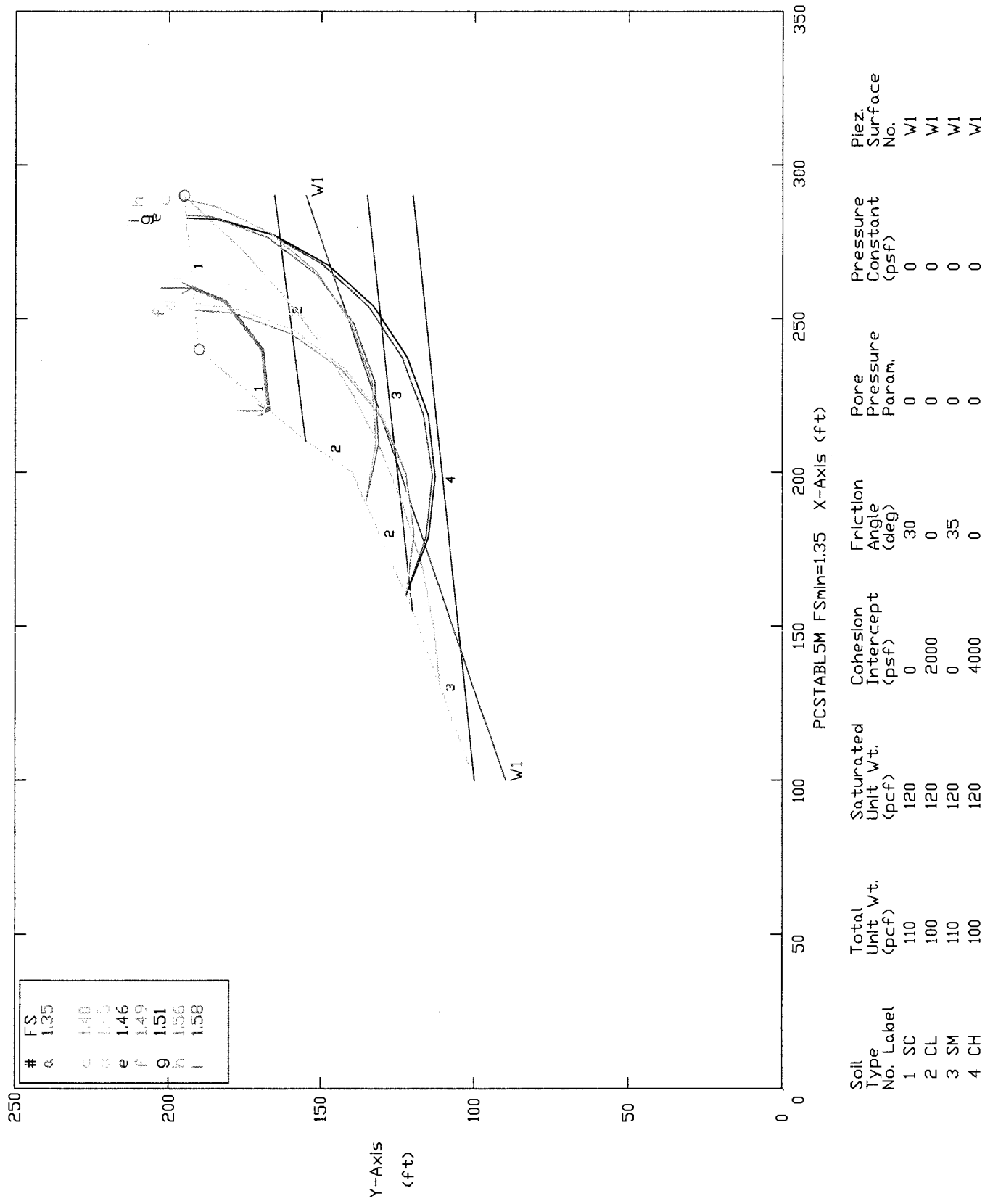
<u>Hole No.</u>	<u>Sample No.</u>	<u>Depth (ft)</u>	<u>Specific Gravity</u>
B-1	Jar-16	58.5-60.0	2.68
B-2	Jar-23	103.5-105.0	2.54
B-3	Jar-5	13.5-15.0	2.66
B-4	Jar-27	108.5-110.0	2.51
B-5	Jar-11	43.5-45.0	2.60



SLOPE STABILITY ANALYSIS RESULTS

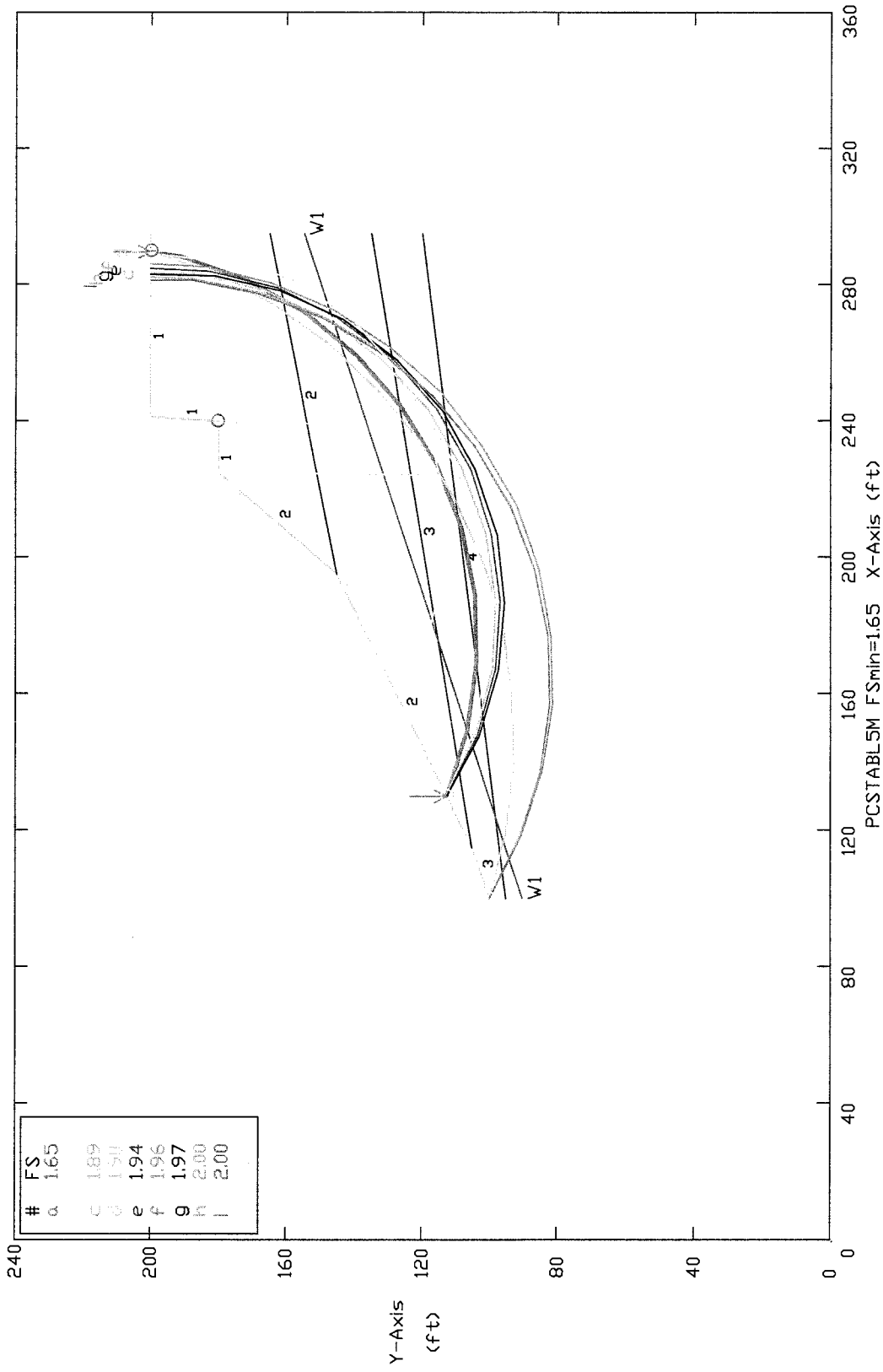
08324 NRL-B1

Ten Most Critical, C:NRL-B1.PLT By: AB Con 07-30-09 2:52pm



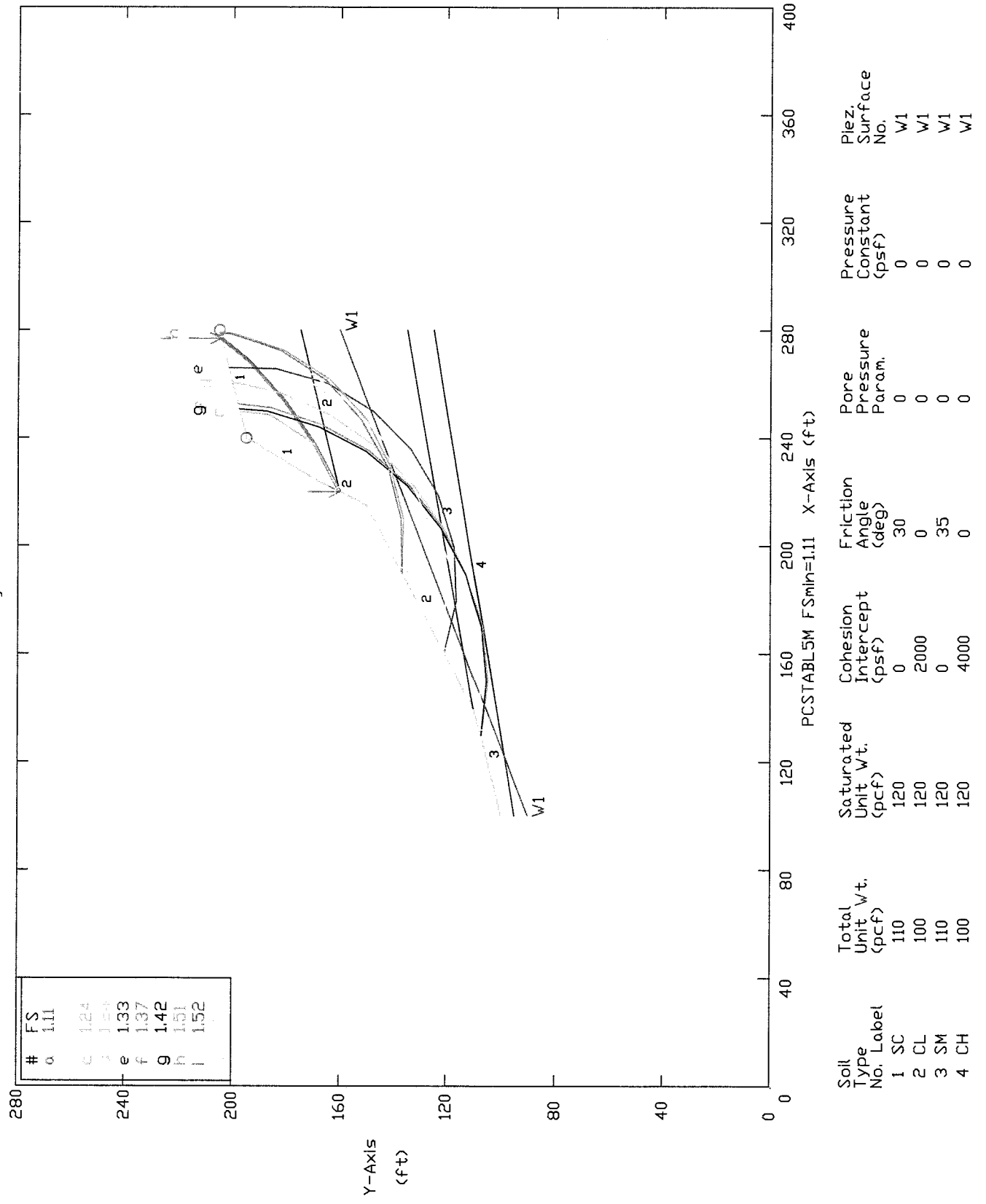
08324 NRL-B1a

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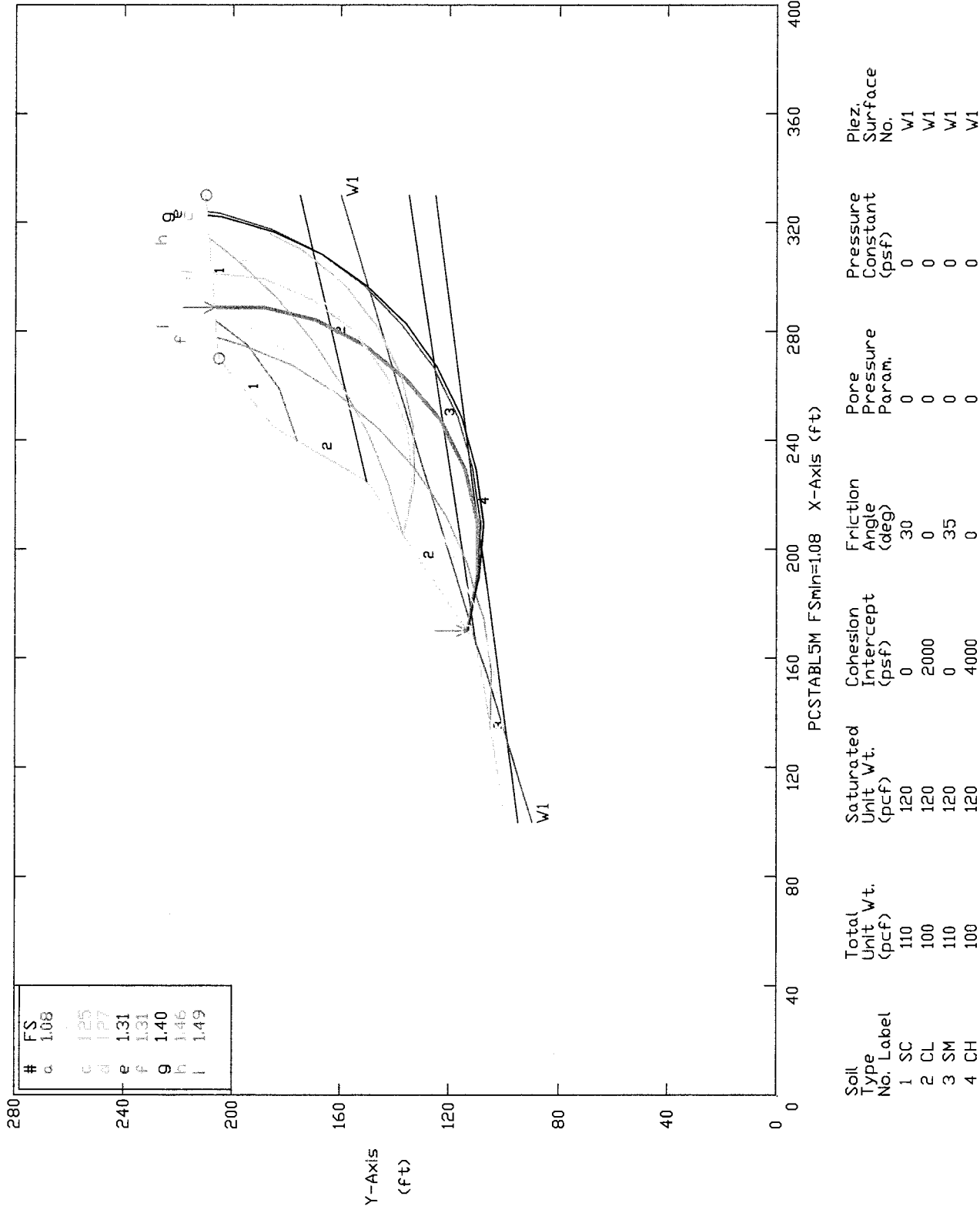
08324 NRL-B2

Ten Most Critical, CNRL-B2.PLT By: AB Con 07-30-09 11:29am



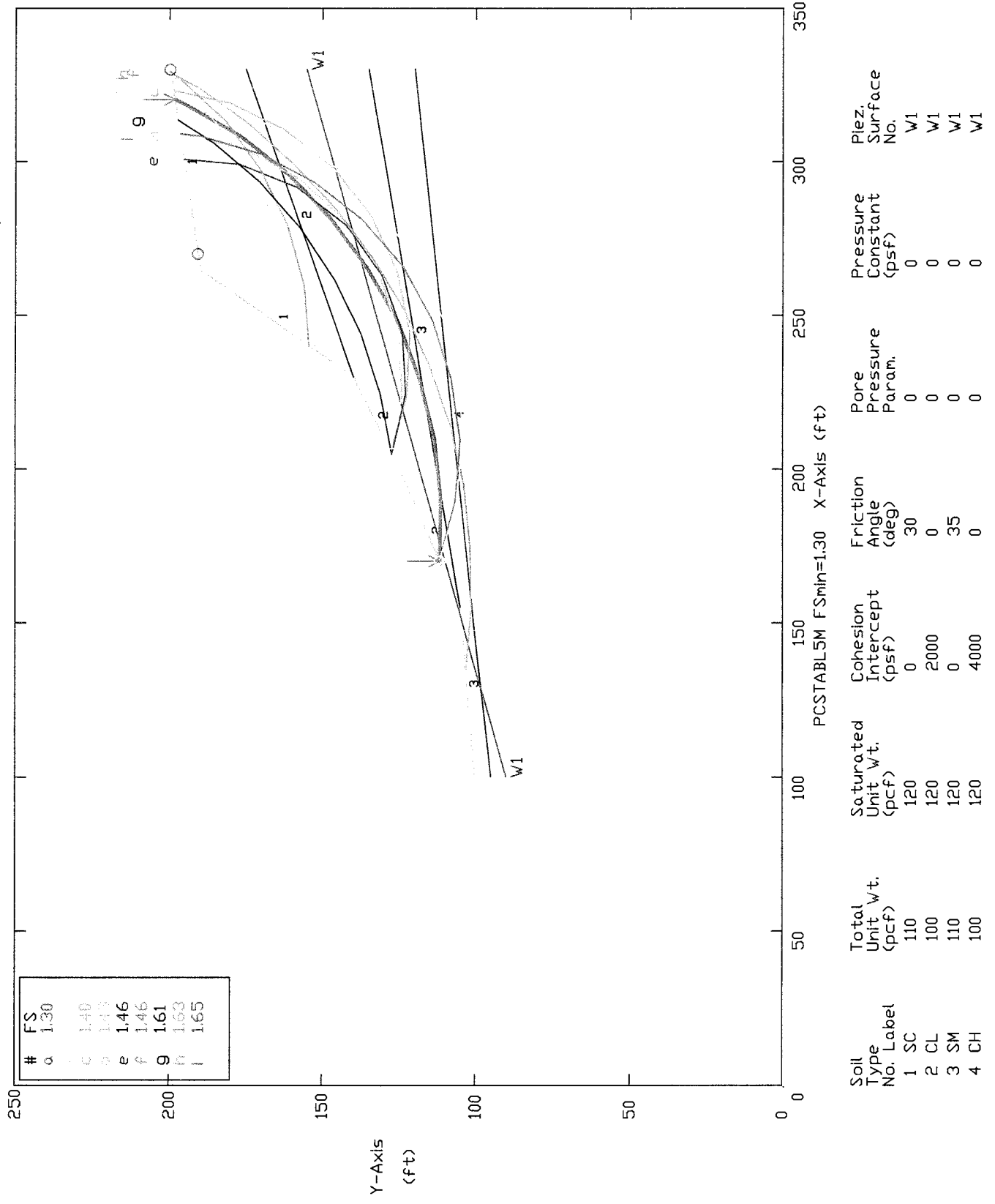
08324 NRL-B2a

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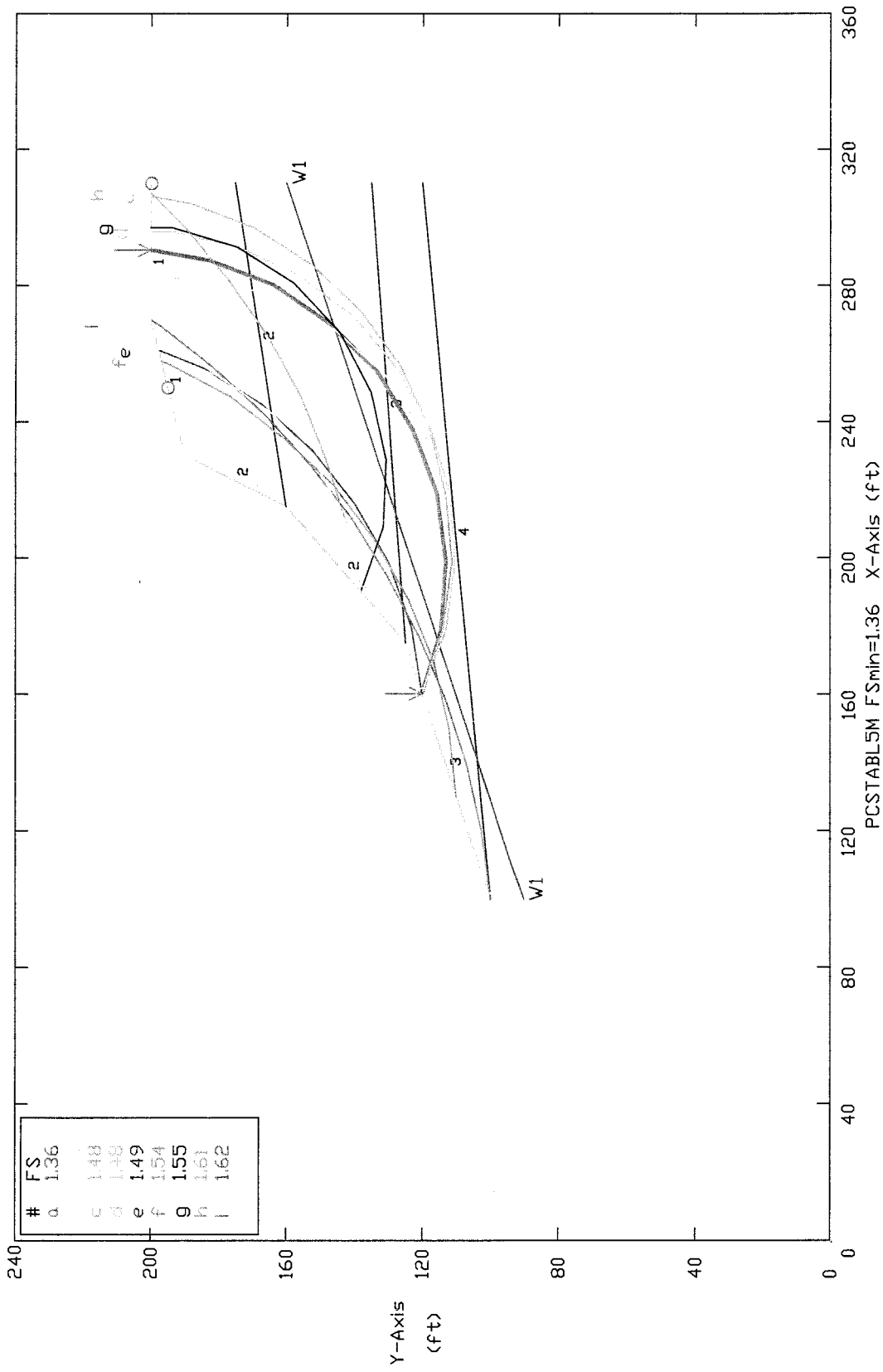
08324 NRL-B4

Ten Most Critical, C:\NRL-B4.PLT By: AB Con 07-30-09 2:38pm



08324 NRL-B4a

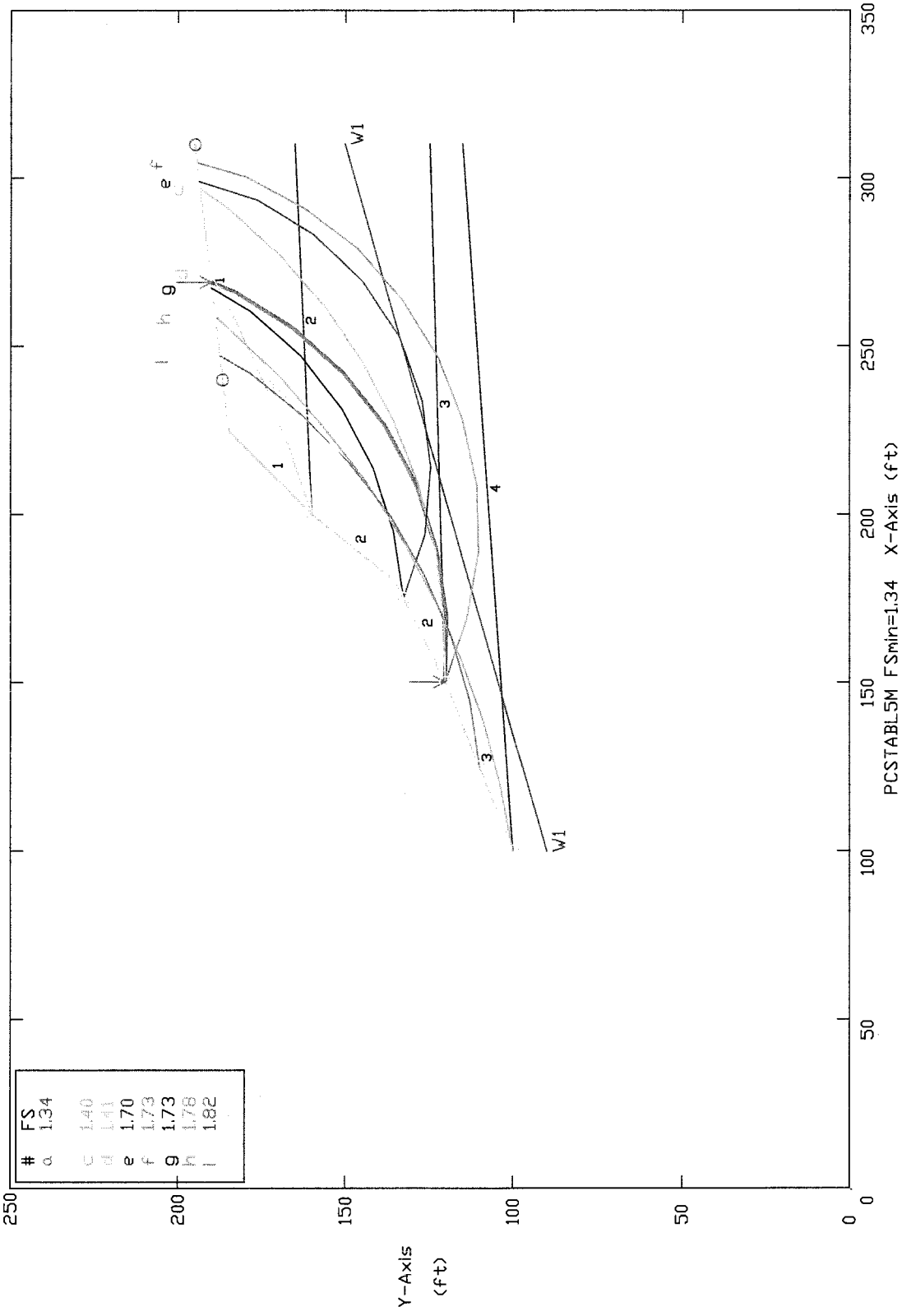
Ten Most Critical, C:NRL-B4A,PLT By: AB Con 07-30-09 2:39pm



Sail Type No. Label	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1 SC	110	120	0	30	0	0	W1
2 CL	100	120	2000	0	0	0	W1
3 SM	110	120	0	35	0	0	W1
4 CH	100	120	4000	0	0	0	W1

08324 NRL-B5

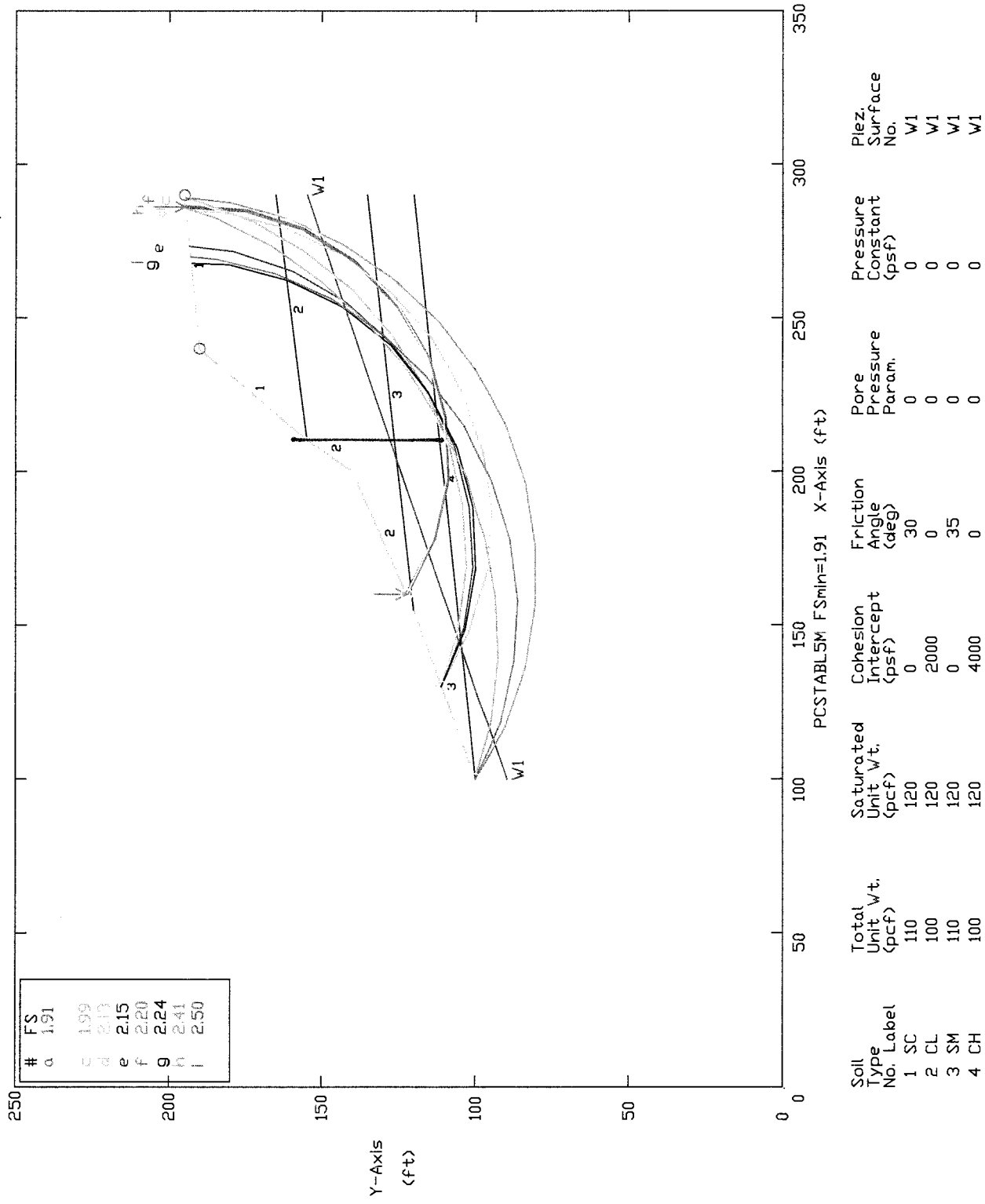
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Soll Type No. Label	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1 SC	110	120	0	30	0	0	W1
2 CL	100	120	2000	0	0	0	W1
3 SM	110	120	0	35	0	0	W1
4 CH	100	120	4000	0	0	0	W1

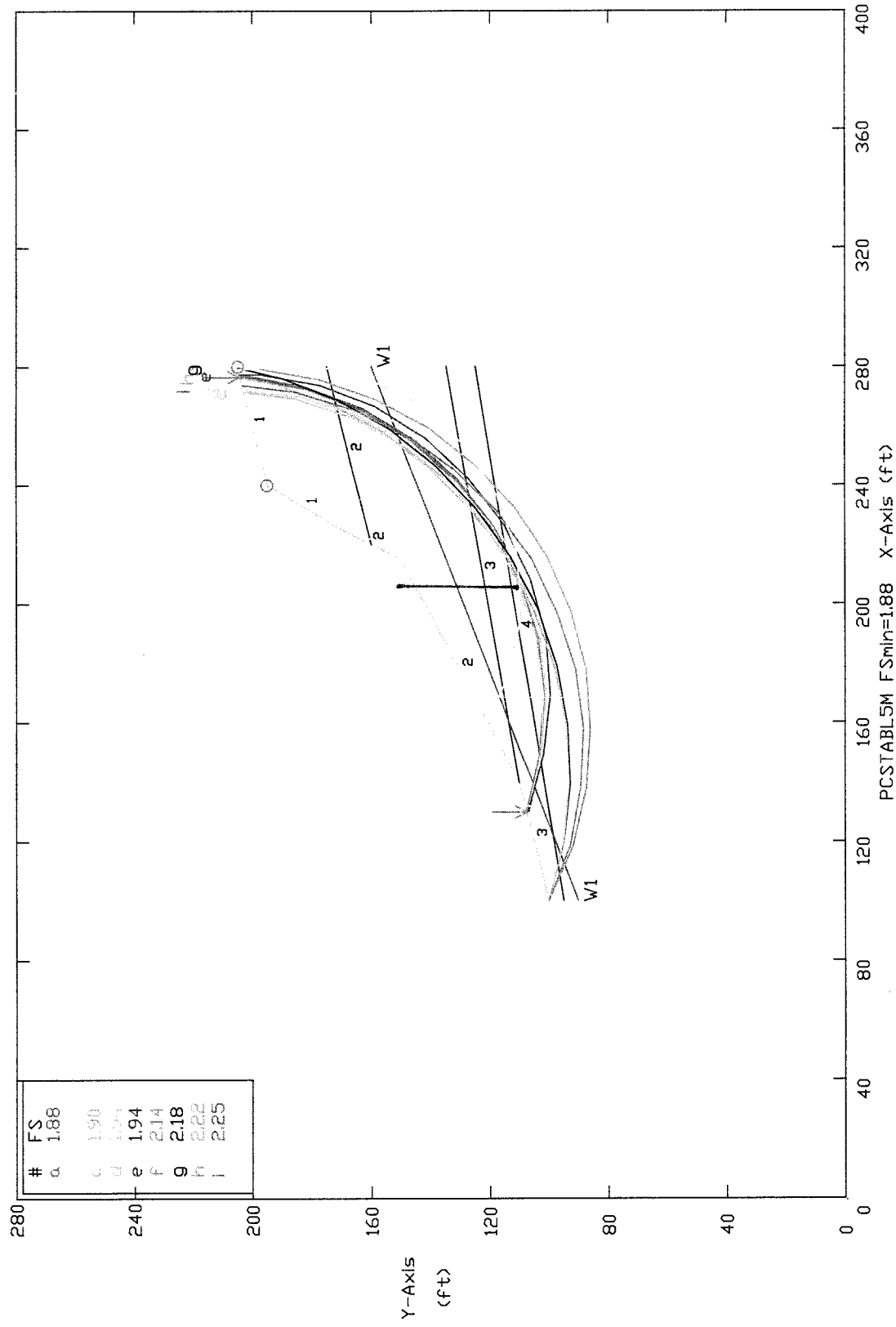
08324 NRL-B1L

Ten Most Critical, C:NRL-B1L,PLT By: AB Con 07-30-09 2:40pm



08324 NRL-B2L

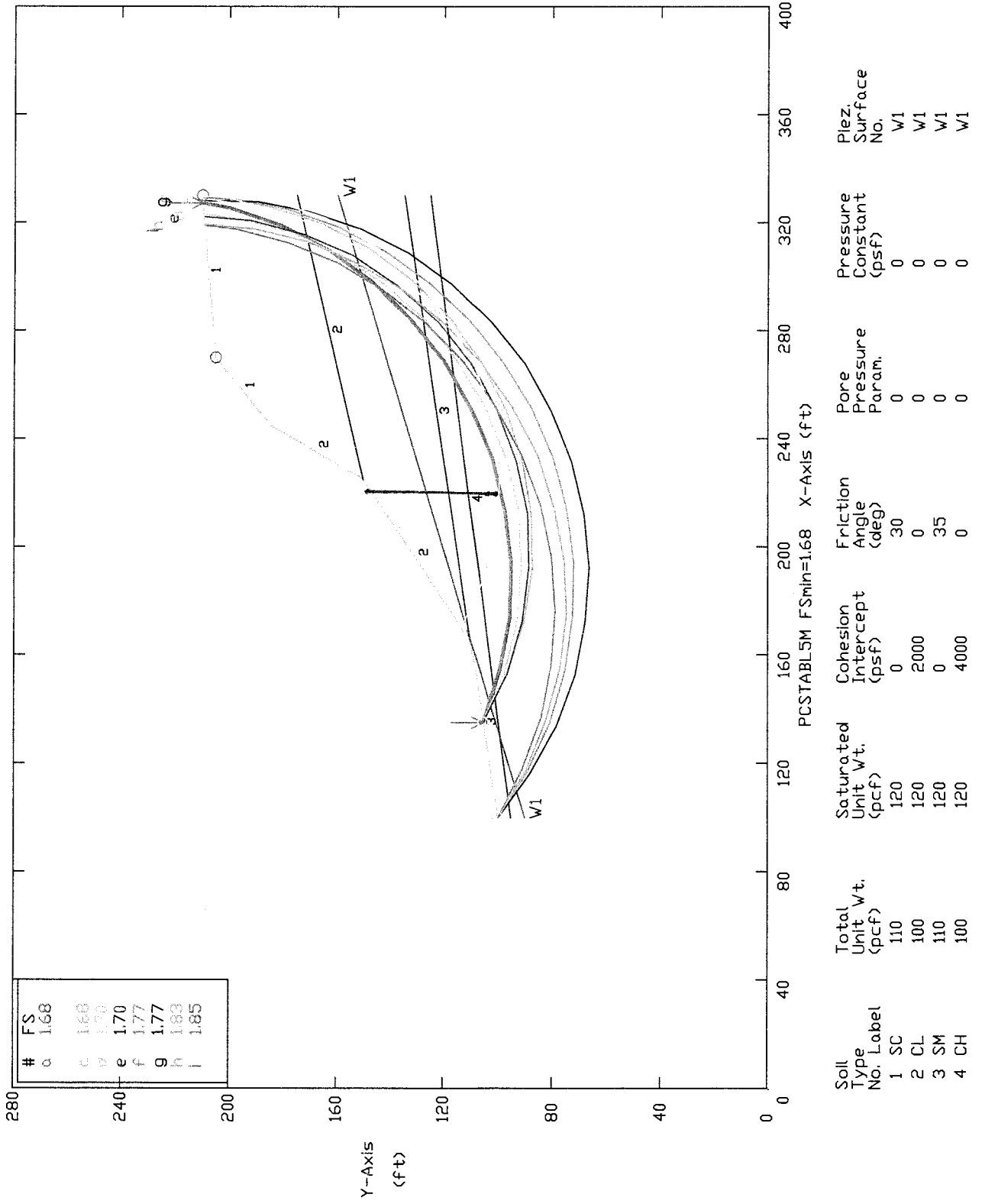
Ten Most Critical, C:NRL-B2L.PLT By: AB Con 07-30-09 2:41pm



Soil Type No. Label	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1 SC	110	120	0	30	0	0	W1
2 CL	100	120	2000	0	0	0	W1
3 SM	110	120	0	35	0	0	W1
4 CH	100	120	4000	0	0	0	W1

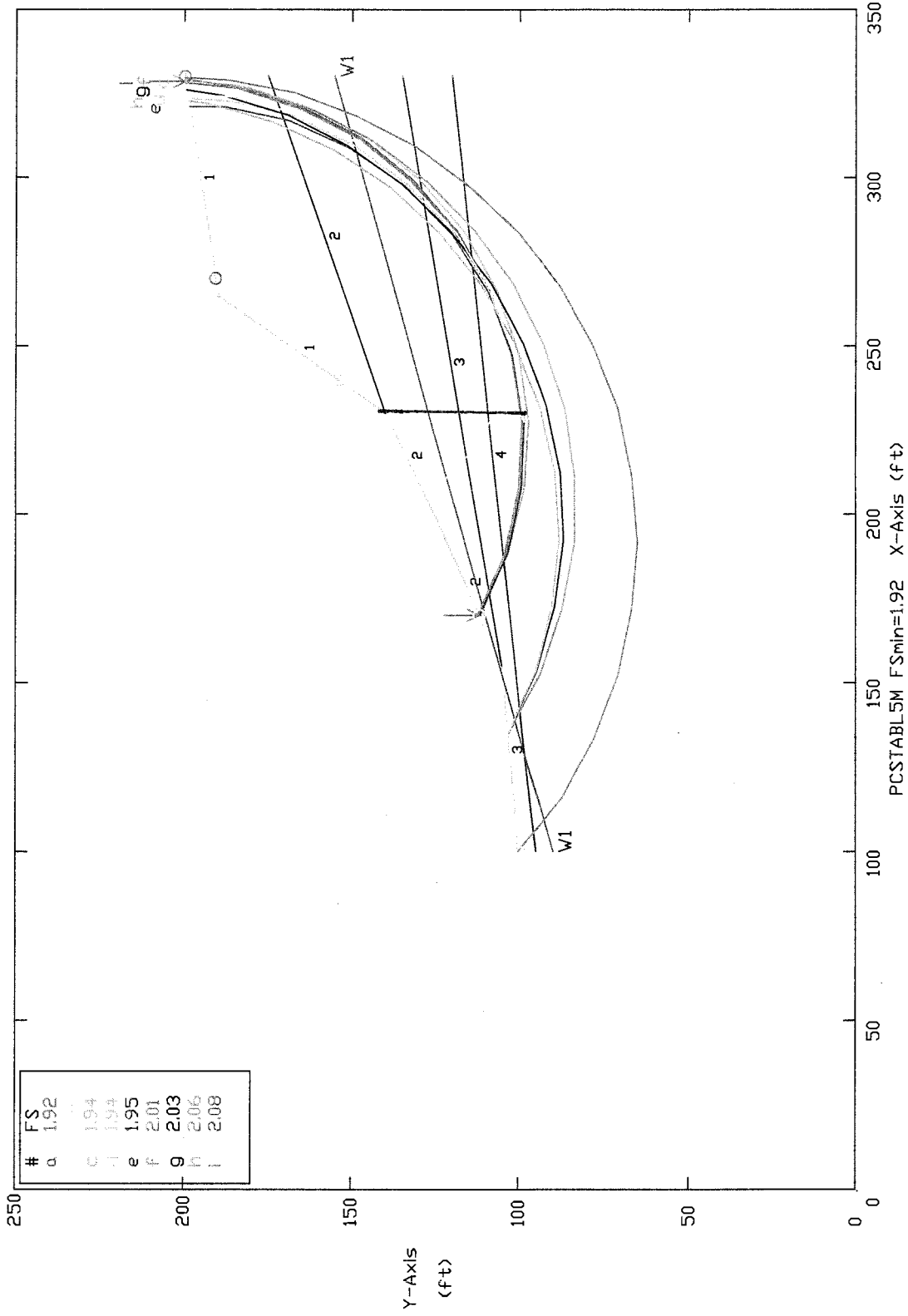
08324 NRL-B2aL

Ten Most Critical, C:\NRL-B2AL.PLT By: AB Con 07-30-09 11:43am



08324 NRL-B4L

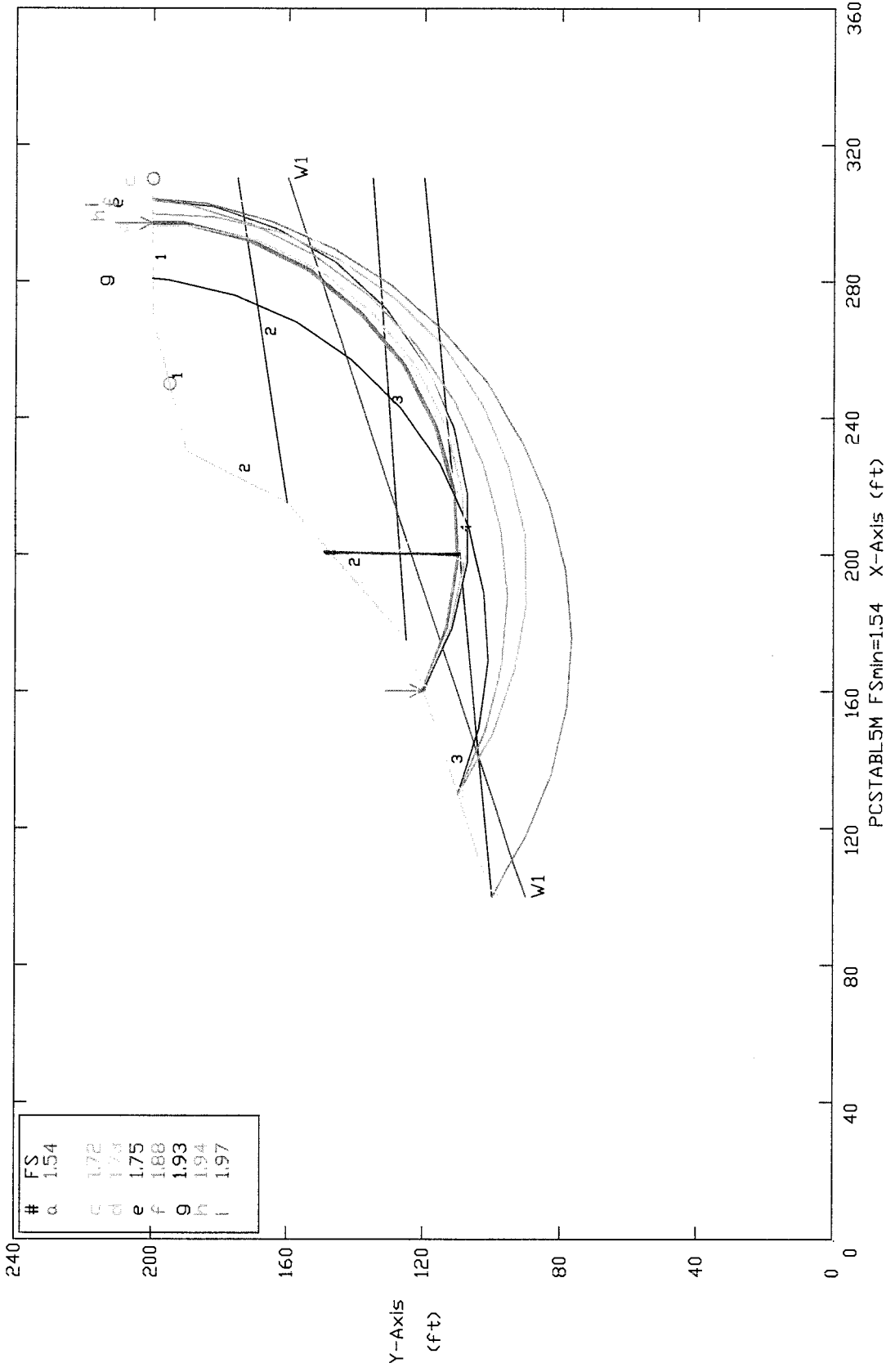
Ten Most Critical, C:NRL-B4L.PLT By: AB Con 07-30-09 2:38pm



Soil Type No. Label	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1 SC	110	120	0	30	0	0	W1
2 CL	100	120	2000	0	0	0	W1
3 SM	110	120	0	35	0	0	W1
4 CH	100	120	4000	0	0	0	W1

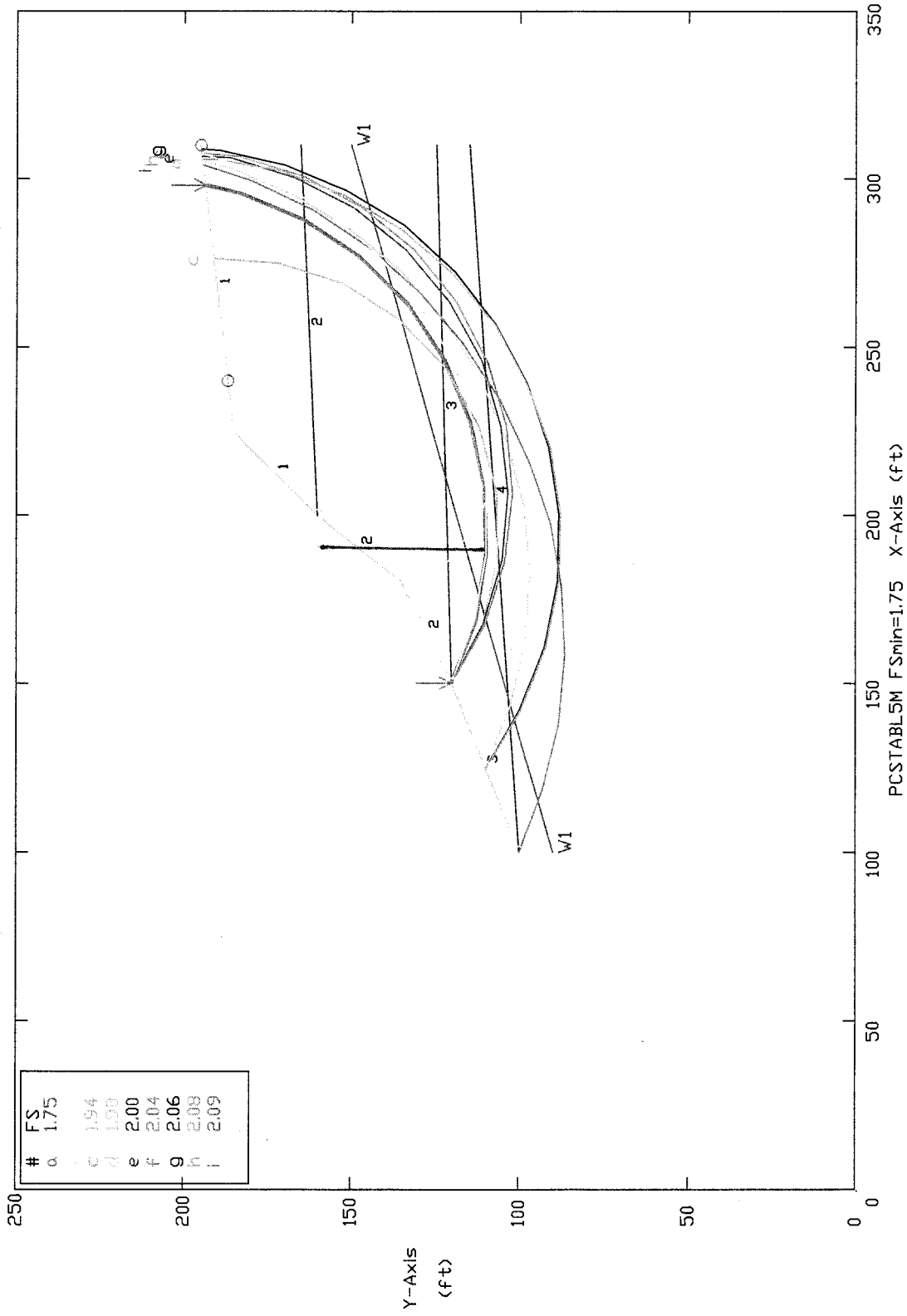
08324 NRL-B4aL

Ten Most Critical, C:NRL-B4AL.PLT By: AB Con 07-30-09 2:39pm



Soil Type No. Label	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1 SC	110	120	0	30	0	0	W1
2 CL	100	120	2000	0	0	0	W1
3 SM	110	120	0	35	0	0	W1
4 CH	100	120	4000	0	0	0	W1

Ten Most Critical, CINRL-B5L.PLT By: AB Con 07-30-09 2:42pm



Soil Type No. Label	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Plaz. Surface No.
1 SC	110	120	0	30	0	0	W1
2 CL	100	120	2000	0	0	0	W1
3 SM	110	120	0	35	0	0	W1
4 CH	100	120	4000	0	0	0	W1

PART SIX - ATTACHMENTS

Attachment 4

Hydrologic and Hydraulic Report – Dec 7 2009

**NAVAL RESEARCH LAB
AT CHESAPEAKE BAY
MARYLAND**

HYDROLOGIC & HYDRAULIC REPORT



SUBMITTED TO:

**U.S. Army Corps of Engineers
Baltimore District
10 South Howard Street
Baltimore, MD 21201**

PREPARED BY:



**AB CONSULTANTS, INC.
9450 ANNAPOLIS ROAD
LANHAM, MD 20706**

September, 2009
Revised December 7, 2009

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I. INTRODUCTION:

Naval Research Laboratory (NRL) facility is an Navy occupied property located at Calvert County, MD. The facility is located on the plateau of the Calvert Cliffs along Potomac River. In existing conditions, runoff from the existing improvements sheet flows to the cliff. A Preliminary Investigation (PI) of the existing cliff-slopes identified drainage related erosion patterns with a potential for slope failure.

The goals of this project are as under:

- Establish the existing drainage patterns
- Establish the sheet flow areas that can be picked up by linear devices to minimize sheet flow to the cliff.
- Provide a minimum intrusion storm drain conveyance to ensure it can be constructed without heavy equipment.

In accordance with the scope of work, AB Consultants, Inc. has evaluated the hydrologic conditions and completed this Hydrologic and Hydraulic Report for the project.

II. SCOPE OF REPORT

The scope of this report includes the following:

- Sources of Information
- Field Investigation
- Methodology
- Conclusion

III. METHODOLOGY

The methodology used to prepare this report includes the following:

- Establish a drainage area map utilizing aerial topography/field survey..
- Establishing hydrologic soils group based on USGS classification
- Utilizing TR-55 methodology to perform hydrologic and hydraulic computations.
- Utilize SCS methodologies for computation of outfall riprap.

VI. ANALYSIS OF PROPOSED WORK AREAS

In order to achieve the Two distinct Study Points (1 and 2) were established for the study purpose. The following describes the study points.

Study Point 1: In existing conditions, a total of 0.56 acres of drainage area of which 0.42 acres is impervious drains to this study point. In proposed conditions, a total of 1.35 acres of drainage area with 0.97 acres of impervious area drains to this study point. There is no new

impervious area being added to this study point. The proposed improvements comprise of underground storm drainage and a linear riprap outfall channel designed to convey the runoff to the bottom of the cliff to an existing stream.

Study Point 2: In existing conditions, a total of 0.54 acres of drainage area of which 0.14 acres is impervious drains to this study point. In proposed conditions, a total of 2.98 acres of drainage area with 1.10 acres of impervious area drains to this study point. There is no new impervious area being added to this study point. The proposed improvements comprise of underground storm drainage that conveys the runoff to an existing outfall. It should be noted that the last portion of the storm drain system being shown along the steep contours is to be constructed by directional drilling which ensures that the integrity of the existing slope is not damaged.

VII. CONCLUSION

The proposed improvements comprise utilizing trench drains to pick up sheet flow run off and conveying it through an underground shallow storm drain system to the bottom of the cliff, thereby reducing the amount of sheet flow over the cliff. There is no additional impervious area being added in the project.

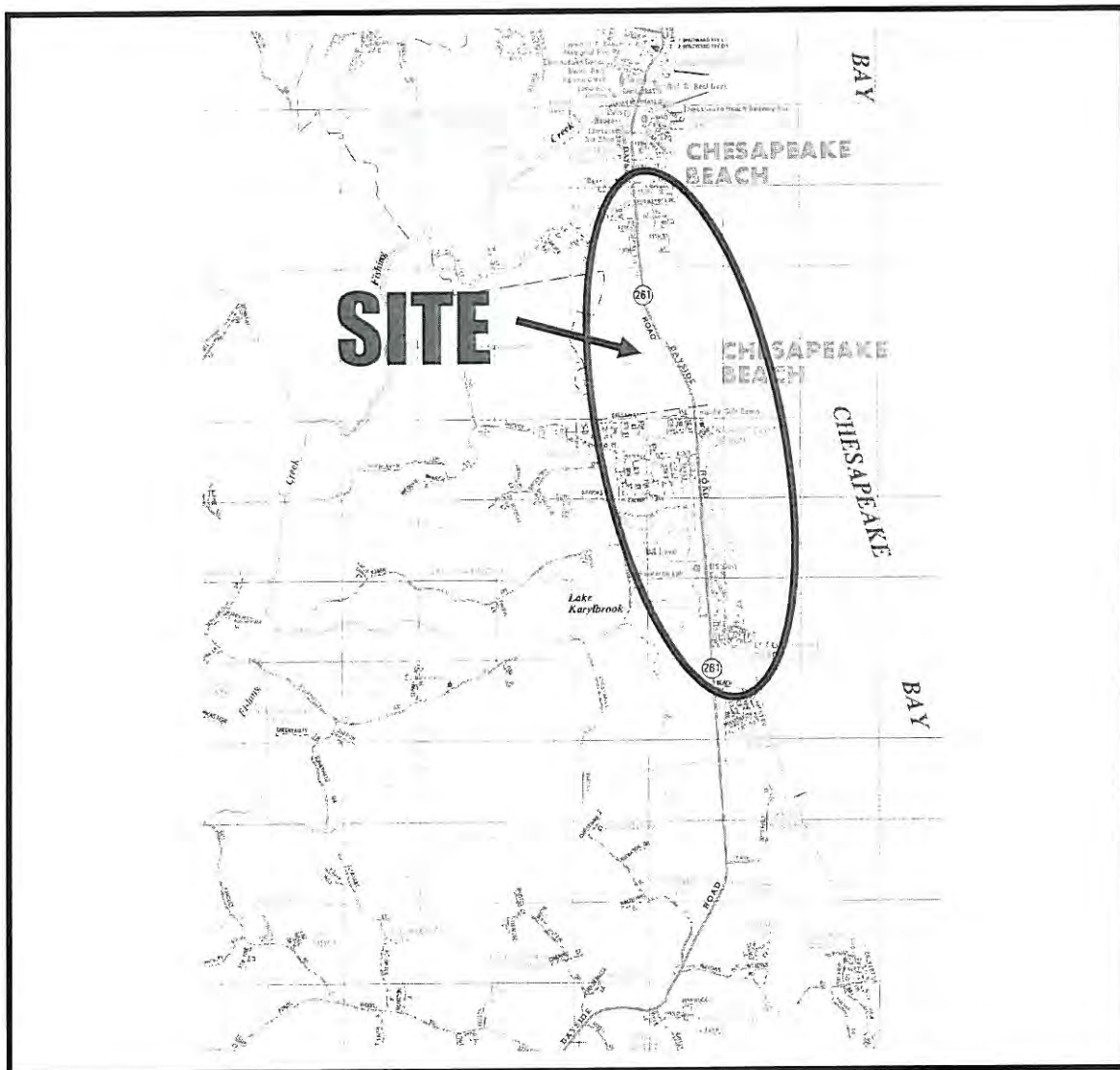
VICINITY MAP

**NAVAL RESEARCH LABORATORY
AT CHESAPEAKE BAY**

CHESAPEAKE BEACH, MARYLAND

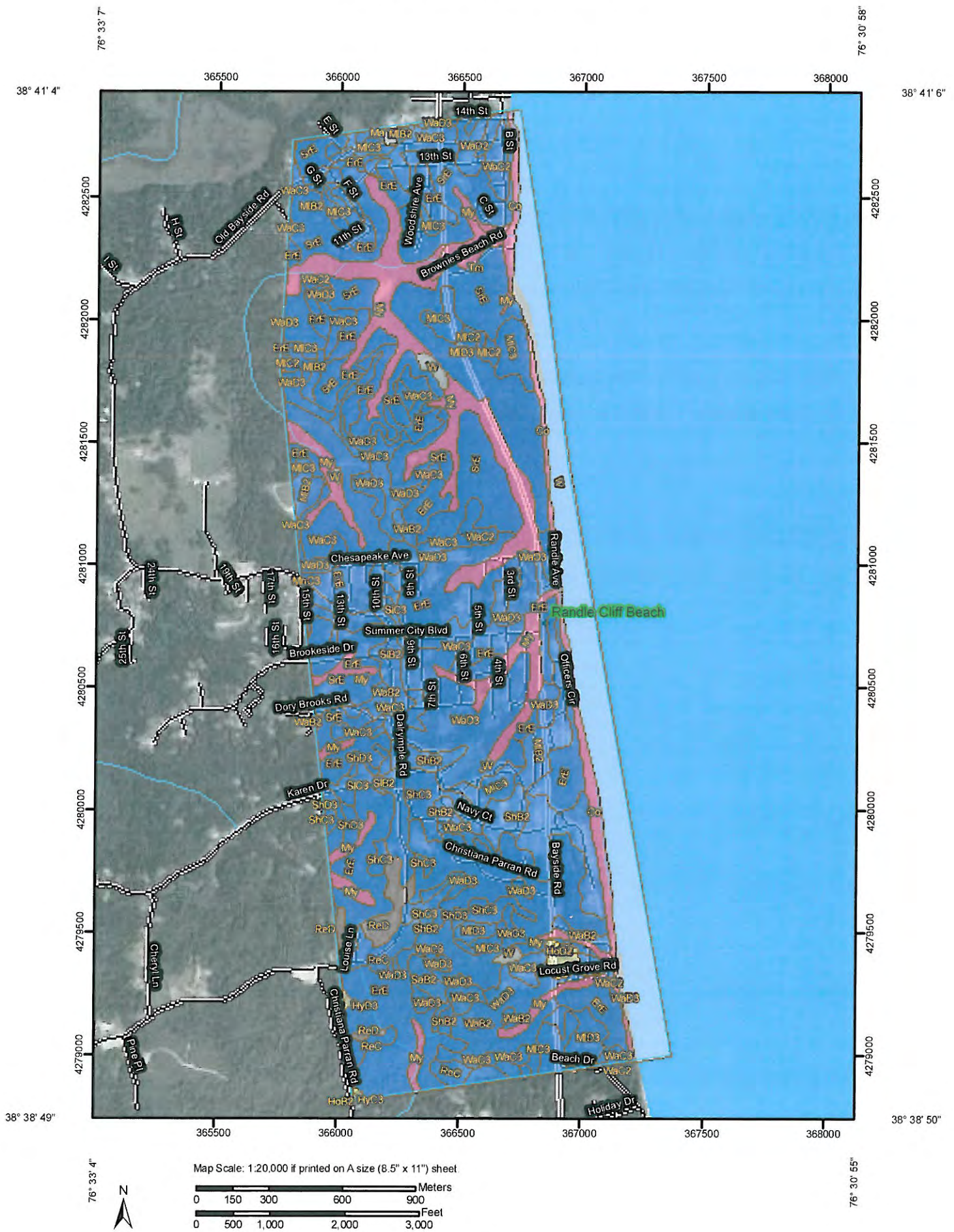
VICINITY MAP

**Calvert County, ADC MAP
Pg. #4 & 7, Grid F-H: 12-13, 1-5**



SOIL MAP

Hydrologic Soil Group—Calvert County, Maryland



MAP LEGEND

Area of Interest (AOI)
 Area of Interest (AOI)

Soils
 Soil Map Units

Soil Ratings

	A
	A/D
	B
	B/D
	C
	C/D
	D

Not rated or not available

Political Features

 Cities

Water Features

 Oceans

 Streams and Canals

Transportation

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

MAP INFORMATION

Map Scale: 1:20,000 if printed on A size (8.5" x 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:20,000. Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>
 Coordinate System: UTM Zone 18N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Calvert County, Maryland
 Survey Area Data: Version 7, Apr 2, 2008

Date(s) aerial images were photographed: 6/23/2005; 6/21/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Calvert County, Maryland				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Co	Coastal beaches	D	23.8	2.1%
ErE	Eroded land, steep	B	286.6	25.4%
HoB2	Howell fine sandy loam, 2 to 6 percent slopes, moderately eroded	C	0.2	0.0%
HoD2	Howell fine sandy loam, 12 to 20 percent slopes, moderately eroded	C	3.7	0.3%
HyC3	Howell clay loam, 6 to 12 percent slopes, severely eroded	C	0.4	0.0%
HyD3	Howell clay loam, 12 to 20 percent slopes, severely eroded	C	1.4	0.1%
Ma	Made land		0.7	0.1%
MIB2	Marr fine sandy loam, 2 to 6 percent slopes, moderately eroded	B	43.5	3.8%
MIC2	Marr fine sandy loam, 6 to 12 percent slopes, moderately eroded	B	4.8	0.4%
MIC3	Marr fine sandy loam, 6 to 12 percent slopes, severely eroded	B	36.8	3.3%
MID3	Marr fine sandy loam, 12 to 20 percent slopes, severely eroded	B	12.9	1.1%
MnB2	Matapeake silt loam, 2 to 5 percent slopes, moderately eroded	B	4.7	0.4%
MnC3	Matapeake silt loam, 5 to 10 percent slopes, severely eroded	B	2.6	0.2%
My	Mixed alluvial land	D	97.5	8.6%
ReB	Rumford-Evesboro gravelly loamy sands, 2 to 6 percent slopes	B	0.0	0.0%
ReC	Rumford-Evesboro gravelly loamy sands, 6 to 12 percent slopes	B	15.3	1.4%
ReD	Rumford-Evesboro gravelly loamy sands, 12 to 20 percent slopes	A	10.2	0.9%
SaB2	Sassafras loamy fine sand, 2 to 5 percent slopes, moderately eroded	B	4.1	0.4%
ShB2	Sassafras fine sandy loam, 2 to 5 percent slopes, moderately eroded	B	17.3	1.5%
ShC3	Sassafras fine sandy loam, 5 to 10 percent slopes, severely eroded	B	24.3	2.2%
ShD3	Sassafras fine sandy loam, 10 to 15 percent slopes severely eroded	B	4.9	0.4%

Hydrologic Soil Group— Summary by Map Unit — Calvert County, Maryland				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
SIB2	Sassafras loam, 2 to 5 percent slopes, moderately eroded	B	20.4	1.8%
SIC3	Sassafras loam, 5 to 10 percent slopes, severely eroded	B	2.3	0.2%
SrE	Sassafras and Westphalia soils, steep	B	183.6	16.2%
Tm	Tidal marsh	D	7.5	0.7%
W	Water		110.6	9.8%
WaB2	Westphalia fine sandy loam, 2 to 6 percent slopes, moderately eroded	B	16.1	1.4%
WaC2	Westphalia fine sandy loam, 6 to 12 percent slopes moderately eroded	B	13.3	1.2%
WaC3	Westphalia fine sandy loam, 6 to 12 percent slope severely eroded	B	54.7	4.8%
WaD2	Westphalia fine sandy loam, 12 to 20 percent slopes moderately eroded	B	6.2	0.5%
WaD3	Westphalia fine sandy loam, 12 to 20 percent slopes severely eroded	B	120.0	10.6%
Totals for Area of Interest			1,130.4	100.0%

DISCHARGE COMPUTATIONS

DISCHARGE COMPUTATION AT STUDY POINT # 2

EXISTING CONDITION

TOTAL IMPERVIOUS AREA	=	0.14 AC.	C = 0.90
GRASS AREA	=	0.40 AC.	C = 0.25
TOTAL DRAINAGE AREA (A)	=	0.54 AC.	
RUNOFF COEFFICIENT C	=	0.42 (Composite)	

STORMWATER RUNOFF (Q)

TIME OF CONCENTRATION (T _c)	=	5.00 MIN
RAINFALL INTENSITY (I ₂)	=	5.38 IPH
RAINFALL INTENSITY (I ₁₀)	=	7.00 IPH
RAINFALL INTENSITY (I ₁₀₀)	=	9.50 IPH
Q ₂ = C x I x A	=	1.22 CFS
Q ₁₀ = C x I x A	=	1.58 CFS
Q ₁₀₀ = C x I x A	=	2.15 CFS

PROPOSED CONDITION

TOTAL IMPERVIOUS AREA	=	1.10 AC.	C = 0.90
GRASS AREA	=	1.88 AC.	C = 0.25
TOTAL DRAINAGE AREA (A)	=	2.98 AC.	
RUNOFF COEFFICIENT C	=	0.49 (Composite)	

STORMWATER RUNOFF (Q)

TIME OF CONCENTRATION (T _c)	=	8.0 MIN (BASED ON STORM DRAIN TC)
RAINFALL INTENSITY (I ₂)	=	4.76 IPH
RAINFALL INTENSITY (I ₁₀)	=	6.33 IPH
RAINFALL INTENSITY (I ₁₀₀)	=	8.82 IPH
Q ₂ = C x I x A	=	6.95 CFS
Q ₁₀ = C x I x A	=	9.24 CFS
Q ₁₀₀ = C x I x A	=	12.88 CFS

DISCHARGE COMPUTATION AT STUDY POINT # 1

EXISTING CONDITION

TOTAL IMPERVIOUS AREA	=	0.42 AC.	C =	0.90
GRASS AREA	=	0.14 AC.	C =	0.25
TOTAL DRAINAGE AREA (A)	=	0.56 AC.		
RUNOFF COEFFICIENT C	=	0.74 (Composite)		

STORMWATER RUNOFF (Q)

TIME OF CONCENTRATION (T _c)	=	5.00 MIN
RAINFALL INTENSITY (I ₂)	=	5.38 IPH
RAINFALL INTENSITY (I ₁₀)	=	7.00 IPH
RAINFALL INTENSITY (I ₁₀₀)	=	9.50 IPH
Q ₂ = C x I x A	=	2.22 CFS
Q ₁₀ = C x I x A	=	2.89 CFS
Q ₁₀₀ = C x I x A	=	3.92 CFS

PROPOSED CONDITION

TOTAL IMPERVIOUS AREA	=	0.97 AC.	C =	0.90
GRASS AREA	=	0.38 AC.	C =	0.25
TOTAL DRAINAGE AREA (A)	=	1.35 AC.		
RUNOFF COEFFICIENT C	=	0.72 (Composite)		

STORMWATER RUNOFF (Q)

TIME OF CONCENTRATION (T _c)	=	9.2 MIN (BASED ON STORM DRAIN TC)
RAINFALL INTENSITY (I ₂)	=	4.48 IPH
RAINFALL INTENSITY (I ₁₀)	=	6.14 IPH
RAINFALL INTENSITY (I ₁₀₀)	=	8.57 IPH
Q ₂ = C x I x A	=	4.34 CFS
Q ₁₀ = C x I x A	=	5.94 CFS
Q ₁₀₀ = C x I x A	=	8.30 CFS

STORM DRAIN COMPUTATIONS

**SPREAD DESIGN
(2 YEAR STORM)**

$$Q = (0.56/N)^{(Sx^{(5/3)})^{(S^{(0.5)})^{(T^{(8/3)})}}$$

C = 0.90 for Impervious Area, C = 0.25 for Pervious Area

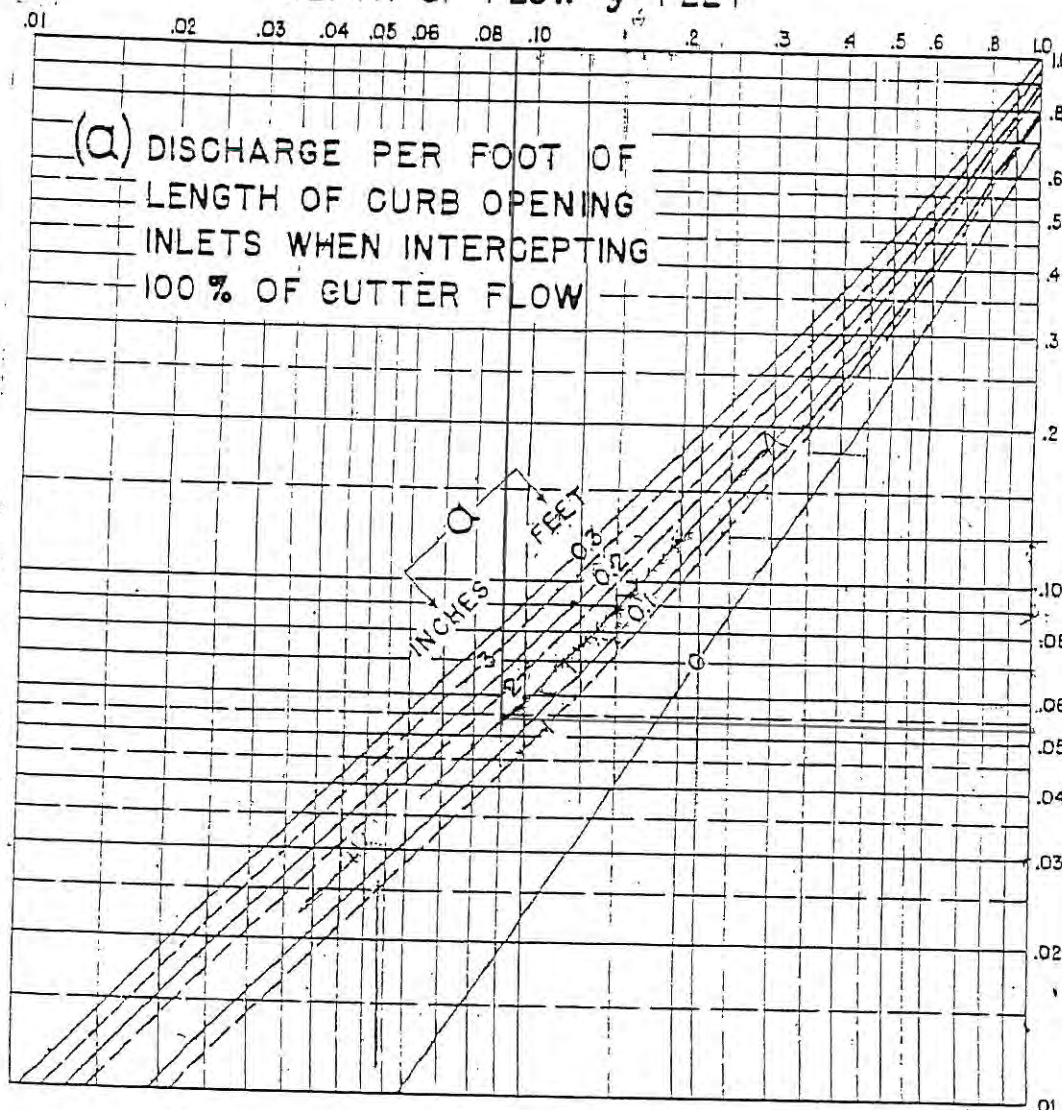
Sx = Street Cross Slope

C = ((0.90* Impervious Area)+(0.25*(Total Area-Impervious Area))/Total Area

S = Street Slope

INLET #	N	Total Area	Impervious Area	C	I	Q=(CIA)	Bypass Q (cfs)	Total Q (cfs)	Sx	S	T(Spread) (Ft.)	Depth(Ft.) y	Inlet Type	Inlet Capacity	Bypass Q (cfs)	To Inlet
TD/24	0.015	0.15	0.11	0.73	5.38	0.59	0.00	0.59						100%	0.00	
TD/22	0.015	0.11	0.09	0.78	5.38	0.46	0.00	0.46						100%	0.00	
TD/20	0.015	0.11	0.05	0.55	5.38	0.32	0.00	0.32						100%	0.00	
TD/18	0.015	0.02	0.02	0.90	5.38	0.10	0.00	0.10						100%	0.00	
I/12	0.015	0.13	0.07	0.60	5.38	0.42	0.00	0.42	0.020	0.0240	4.31	0.09	COG 10	100%	0.00	
I/10	0.015	0.20	0.16	0.77	5.38	0.83	0.00	0.83	0.020	0.0045	7.62	0.15	COG 20	100%	0.00	
I/8	0.015	0.07	0.05	0.71	5.38	0.27	0.00	0.27	0.020	0.0050	3.75	0.08	COS 5	100%	0.00	LP
I/6	0.015	0.24	0.21	0.82	5.38	1.06	0.00	1.06					YARD INLET	100%	0.00	
I/4	0.015	0.32	0.21	0.68	5.38	1.16	0.00	1.16					YARD INLET	100%	0.00	
TD/40	0.015	0.54	0.32	0.64	5.38	1.85	0.00	1.85						100%	0.00	
TD/39	0.015	0.41	0.17	0.52	5.38	1.15	0.00	1.15						100%	0.00	
TD/38	0.015	0.03	0.01	0.47	5.38	0.08	0.00	0.08						100%	0.00	
TD/37	0.015	0.24	0.07	0.44	5.38	0.57	0.00	0.57						100%	0.00	
TD/41	0.015	0.18	0.05	0.43	5.38	0.42	0.00	0.42						100%	0.00	
I/34	0.015	1.04	0.34	0.46	5.38	2.59	0.00	2.59					K-INLET	100%	0.00	
I/33	0.015	0.54	0.14	0.42	5.38	1.22	0.00	1.22					K-INLET	100%	0.00	

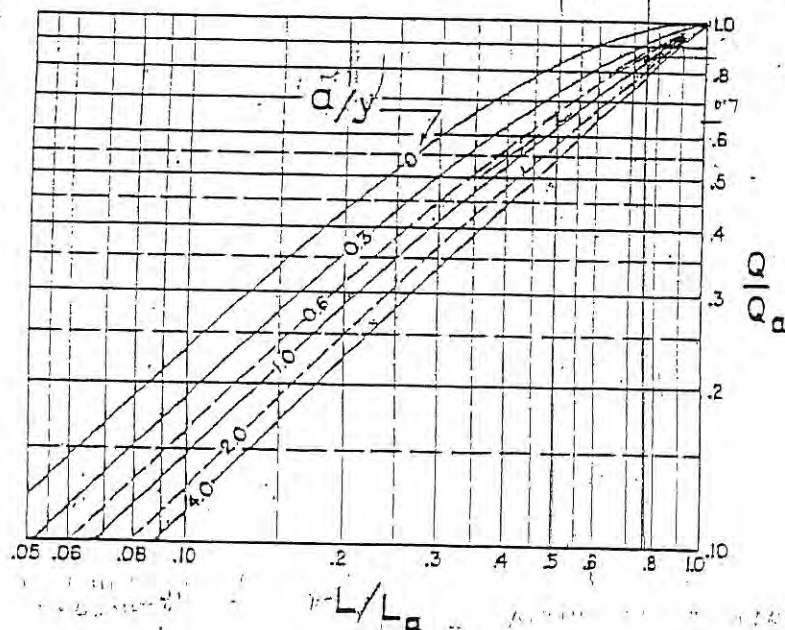
DEPTH OF FLOW - y - FEET



$I/12$
 $Q = 0.42$
 $y = 0.09$
 $Q_y = 0.054$
 L_y
 $L_a = 7.78$
 USE
 COU-10
 100%
 PICKUP

$Q = 0.125$

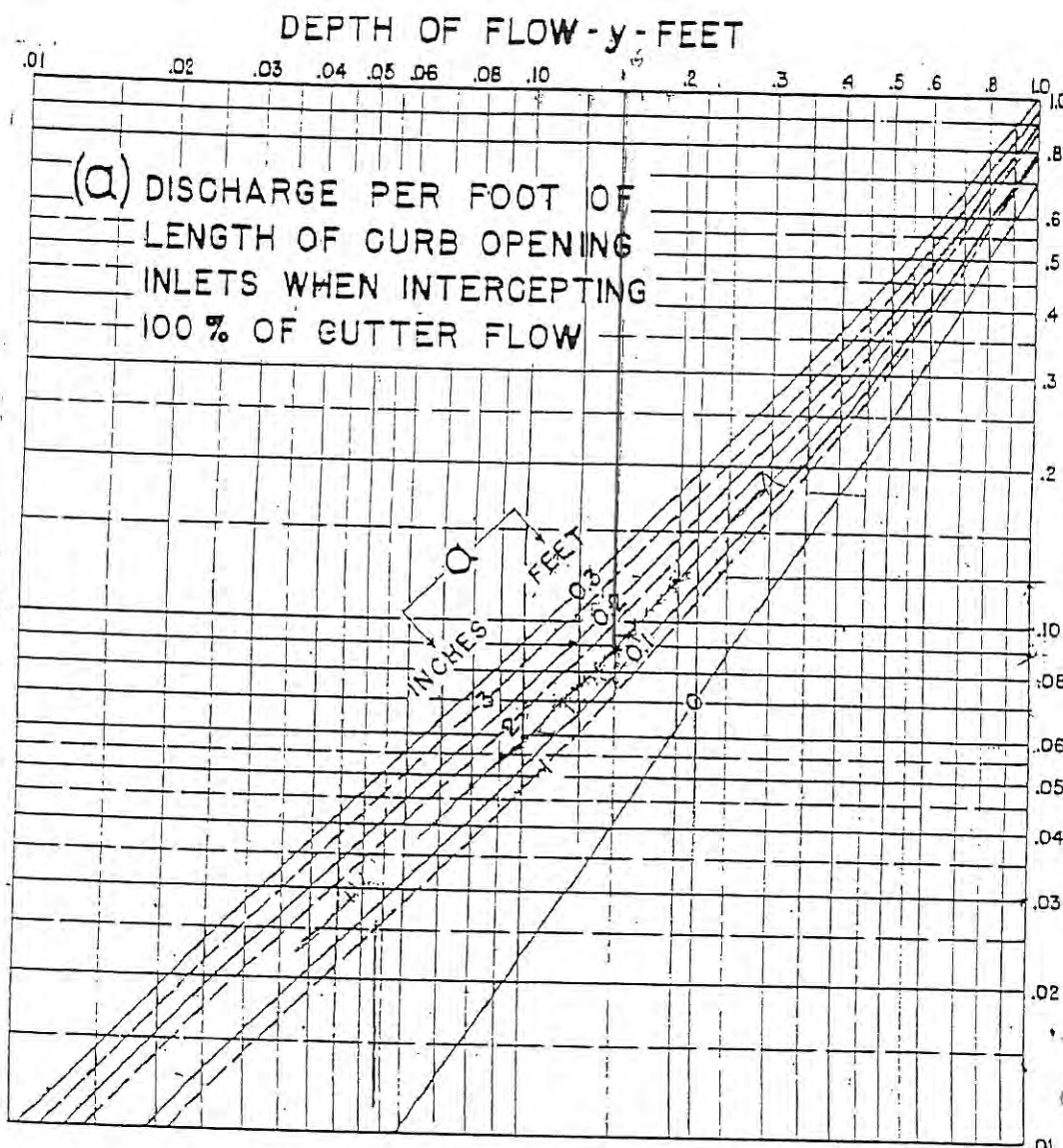
(b)
 PARTIAL INTER-
 CEPTION RATIO
 FOR INLETS OF
 LENGTH LESS
 THAN L_a



CAPACITY OF CURB OPENING INLETS
 ON CONTINUOUS GRADE

COG

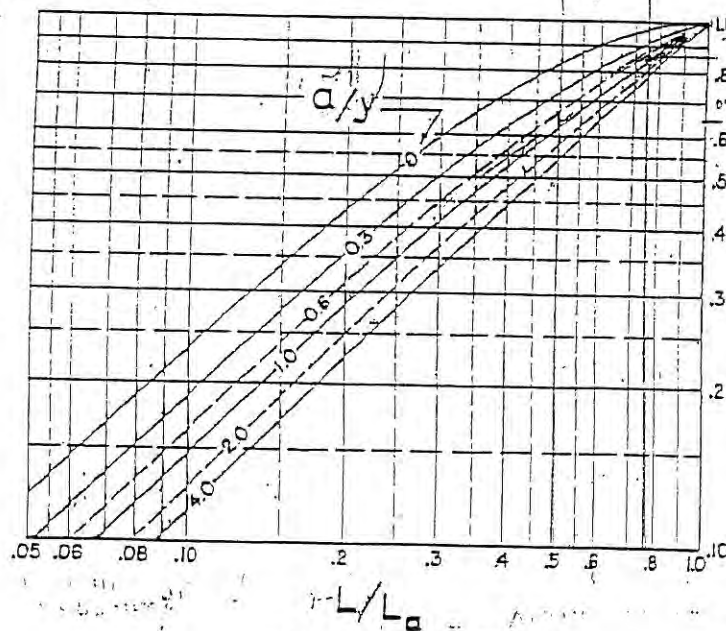
IV-3-7-1



$I/10$
 $Q = 0.83$
 $y = 0.15$
 $\frac{Qa}{La} = 0.09$
 $La = 9.22$

$\frac{Q}{Q_a}$
 VSG
 COU-1.0'
 COU-2.0'
 HAS BEEN
 VSGD TO
 COVER EX.
 CONCR. TRENCH

(b)
 PARTIAL INTER-
 CEPTION RATIO
 FOR INLETS OF
 LENGTH LESS
 THAN L_a

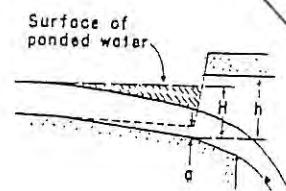
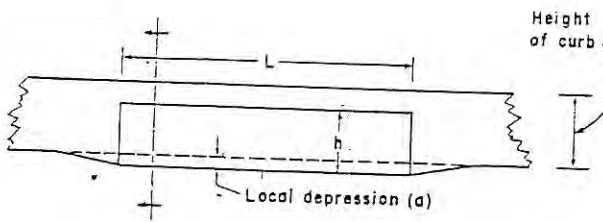
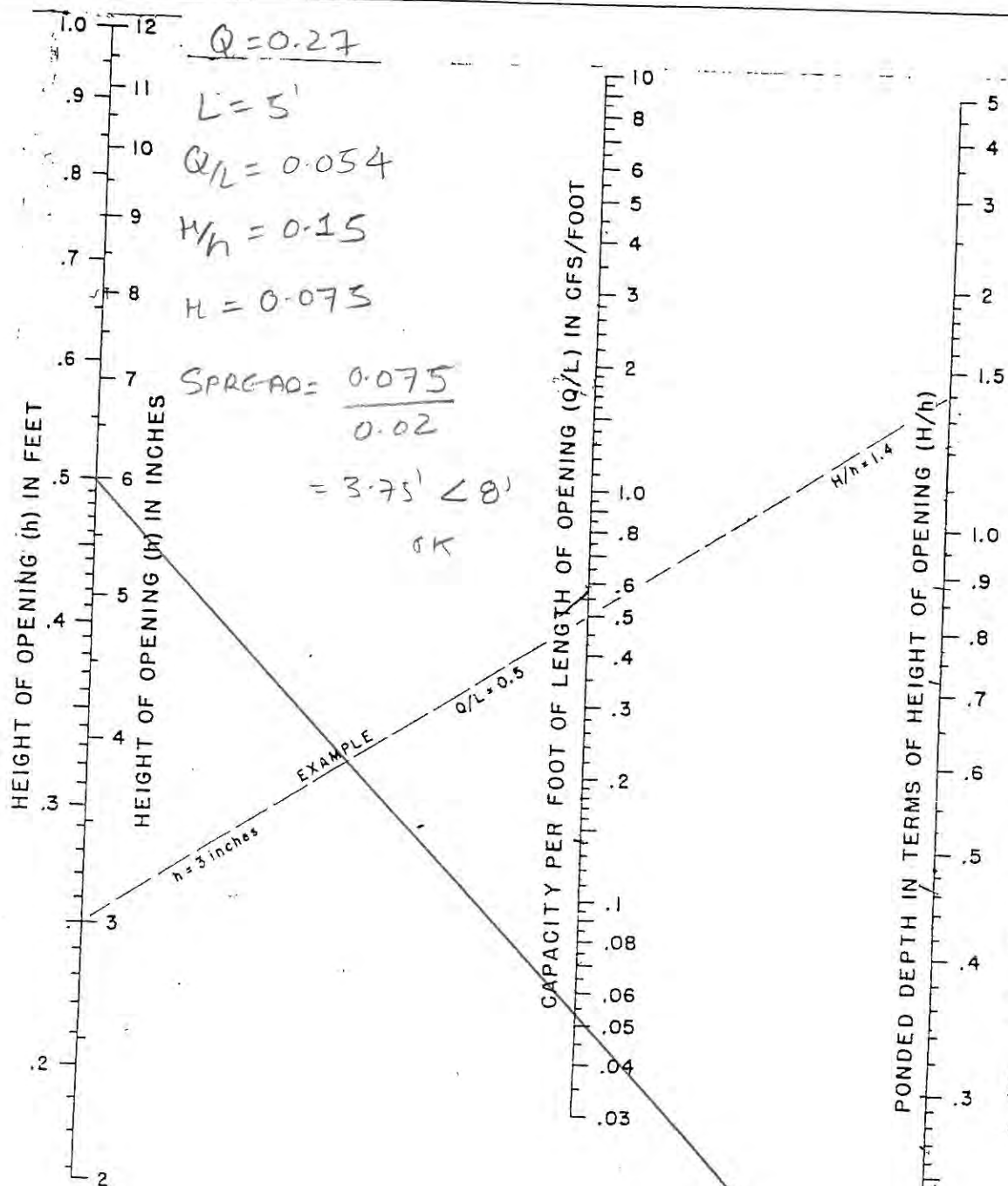


CAPACITY OF CURB OPENING INLETS
 ON CONTINUOUS GRADE

COG

IV-3-7-1

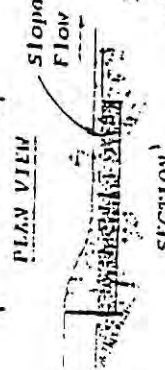
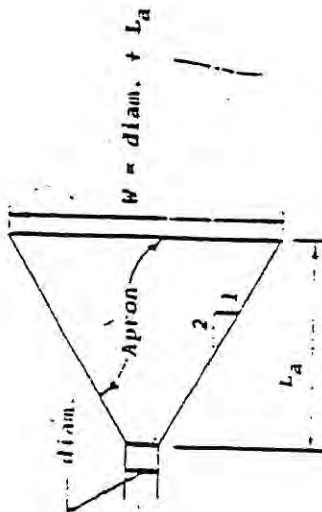
118



CAPACITY OF CURB OPENING INLET AT LOW POINT IN GRADE

STORM DRAIN DESIGN																				
DESIGNED: JRP				U.S. ARMY CORPS OF ENGINEERS, BALTIMORE															DATE : 11-Sep-09	
CHECKED: SBP				CONTRACT: NAVAL RESEARCH LAB - PHASE 2																
RAINFALL FACTOR: 10 YR.				TITLE:																
Structure		Contributing Area				10 Year Runoff					PIPE									
From	To	Area #	Area Ac.	Runoff Coefficient	CA	Total Area Ac.	Total CA	Tc min.	I, Rainfall Intensity in./hr.	Q cfs	Size in.	Manning's n	Sf %	So	Vf ft/sec	L Length ft	Time in pipe (Min.)	Capacity Full, cfs	Remarks	
TD/24	TD/22		0.15	0.73	0.11	0.15	0.11	5.0	7.00	0.76	10	0.012	0.10	0.50	1.40	80	0.95			
TD/22	TD/20		0.11	0.78	0.09	0.26	0.20	6.0	6.79	1.32	10	0.012	0.31	1.21	2.43	70	0.48			
TD/20	TD/18		0.11	0.55	0.06	0.37	0.26	6.4	6.68	1.70	12	0.012	0.19	12.70	2.17	41	0.32			
TD/18	CB/16		0.02	0.90	0.02	0.39	0.27	6.7	6.61	1.80	12	0.012	0.22	8.59	2.30	34	0.25			
CB/16	CB/14		0.00	0.00	0.00	0.39	0.27	7.0	6.56	1.79	12	0.012	0.21	1.33	2.28	19	0.14			
CB/14	I/12		0.00	0.00	0.00	0.39	0.27	7.1	6.52	1.78	12	0.012	0.21	0.98	2.27	10	0.07			
I/12	I/10		0.13	0.60	0.08	0.52	0.35	7.2	6.49	2.28	15	0.012	0.11	2.16	1.86	100	0.90			
I/10	I/8		0.20	0.77	0.15	0.72	0.51	8.1	6.30	3.18	15	0.012	0.21	0.57	2.59	61	0.39			
I/8	I/6		0.07	0.71	0.05	0.79	0.56	8.5	6.25	3.47	15	0.012	0.24	0.62	2.83	96	0.57			
I/6	I/4		0.24	0.82	0.20	1.03	0.75	9.1	6.17	4.64	15	0.012	0.44	0.93	3.78	22	0.10			
I/4	EW/2		0.32	0.68	0.22	1.35	0.97	9.2	6.14	5.94	15	0.012	0.72	0.80	4.84	38	0.13			
TD/40	TD/39		0.54	0.64	0.34	0.54	0.34	5.0	7.00	2.40	12	0.012	0.39	0.53	3.06	133	0.72			
TD/39	TD/38		0.41	0.52	0.21	0.95	0.56	5.7	6.84	3.80	12	0.012	0.97	6.75	4.84	126	0.43			
TD/38	TD/37		0.03	0.47	0.01	0.98	0.57	6.2	6.75	3.85	12	0.012	0.99	2.25	4.90	39	0.13			
TD/37	CB/36		0.24	0.44	0.11	1.22	0.68	6.3	6.72	4.54	15	0.012	0.42	0.97	3.70	103	0.46			
TD/41	CB/36		0.18	0.43	0.08	0.18	0.08	5.0	7.00	0.54	12	0.012	0.02	9.71	0.69	35	0.84			
CB/36	CB/35		0.00	0.00	0.00	1.40	0.75	6.8	6.61	4.98	18	0.012	0.19	1.67	2.82	3	0.02			
CB/35	I/34		0.00	0.00	0.00	1.40	0.75	6.8	6.61	4.98	18	0.012	0.19	0.57	2.82	35	0.21			
I/33	I/34		0.54	0.42	0.23	0.54	0.98	5.0	7.00	6.85	18	0.012	0.36	6.70	3.88	135	0.58			
I/34	MH/32		1.04	0.46	0.48	2.98	2.21	7.0	6.56	14.52	18	0.012	1.62	1.64	8.22	335	0.68			
MH/32	MH/30		0.00	0.00	0.00	2.98	2.21	7.7	6.40	14.52	12	0.012	14.08	19.93	18.49	285	0.26			
MH/30	MH/28		0.00	0.00	0.00	2.98	2.21	7.9	6.33	14.52	18	0.024	6.48	19.69	8.22	32	0.06			
MH/28	EW/26		0.00	0.00	0.00	2.98	2.21	8.0	6.33	14.52	24	0.013	0.41	0.97	4.62	36	0.13			

DESIGN OF OUTLET PROTECTION
MINIMUM TAILWATER CONDITION ($T_w < 0.5$ diam.)



Median stone diameter, d_{50} , is the stone size which 50% of the riprap mixture, by weight, is larger than.

Velocities shown are for pipes flowing full.

feet 60

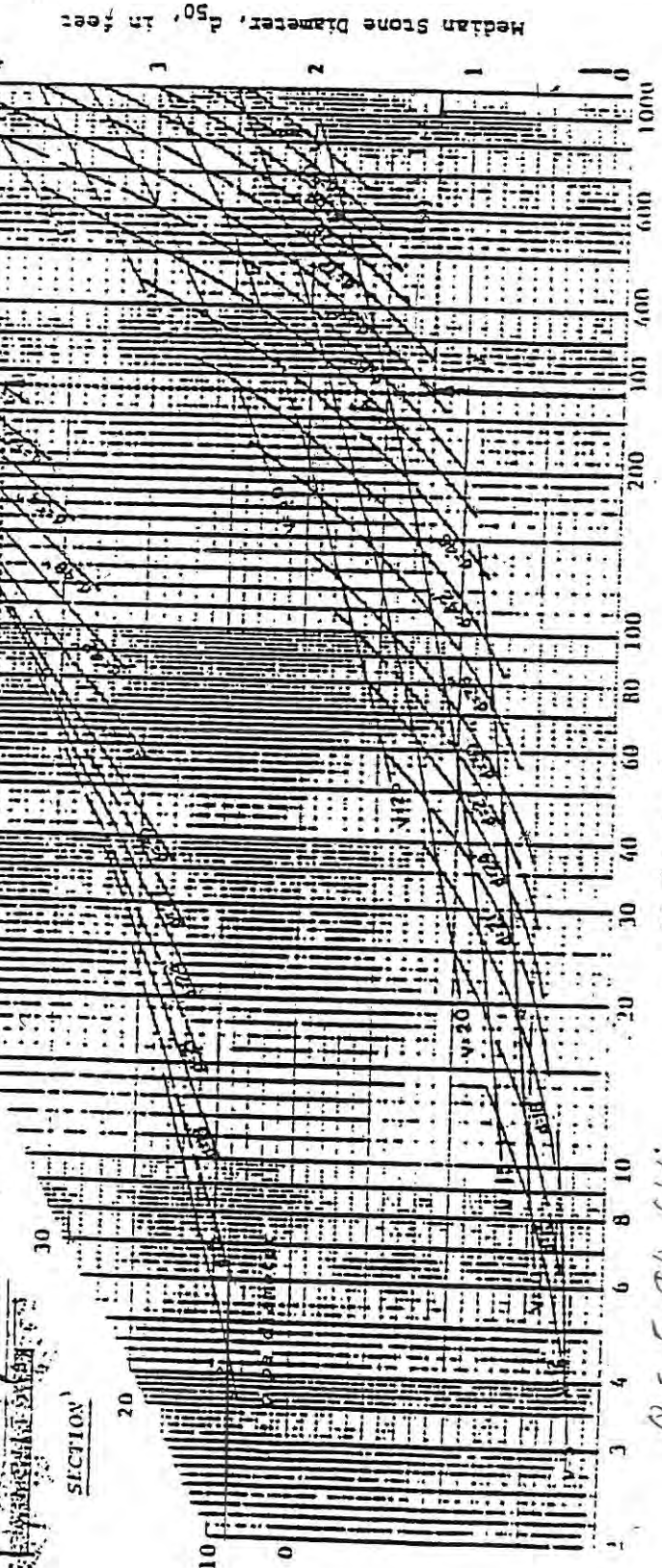
Minimum length of apron, L_a , feet 50

feet 40

feet 30

feet 20

feet 10



$Q_0 = 5.94$ cfs
 $h_s = 4.86$ fps

U.S. ARMY CORPS OF ENGINEERS, BALTIMORE
NAVAL RESEARCH LAB - PHASE 2
SUMP INLET COMPUTATION FOR 100 YEAR

$$Q = 3.0 \cdot P \cdot (H)^{3/2}$$

INLET #	Total Area (Ac.)	Length (Ft.)	C	I ₁₀₀	Composite C For Q	Q ₁₀₀ =(CIA)	H=(Q/0.75*CP) ^{2/3} (Ft.)	100 YR ELEV	Inlet Type
1/8	0.07	5.00	3.00	9.50	0.71	0.48	0.12	100.42	COS 5
INLET #	Total Area (Ac.)	Length (Ft.)	C	I ₁₀₀	Composite C For Q	Q ₁₀₀ =(CIA)	H=(Q/0.5*CP) ^{2/3}	100 YR ELEV	Inlet Type
1/33	0.54	9.66	3.00	9.50	0.42	2.15	0.28	95.84	K INLET
1/34	1.04	9.66	3.00	9.50	0.46	4.57	0.46	92.36	K INLET
1/4	0.32	9.66	3.00	9.50	0.68	2.06	0.27	101.57	YARD INLET
1/6	0.24	9.66	3.00	9.50	0.82	1.87	0.25	100.95	YARD INLET

DRAINAGE AREA MAP

PART SIX - ATTACHMENTS

Attachment 4

Cliff Stabilization Options Report

CBD AT NRL CLIFF STABILIZATION



Presented by
Steve W. Fung, PE
Qamar A.O. Kazmi, PE



Schnabel
ENGINEERING



Outline

- ▣ Project Background
- ▣ Subsurface Exploration
- ▣ Process of Cliff Retreat
- ▣ Cliff Retreat at CBD
- ▣ Building 75 Cliff Stabilization Effort
- ▣ Evaluation of Existing Cliff and Wall Stability
- ▣ Cliff Stabilization Concepts
- ▣ Conclusions
- ▣ Questions

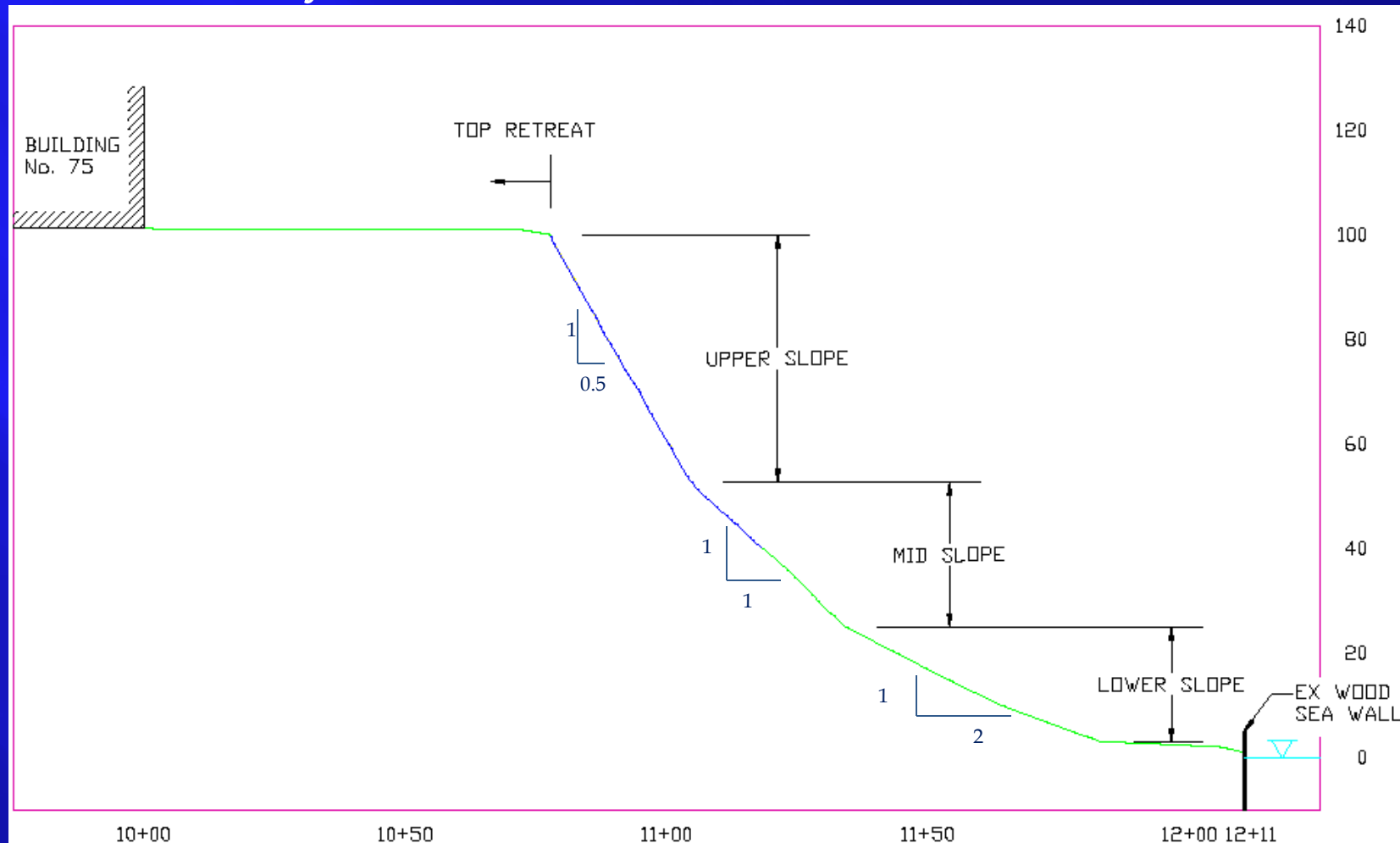
Project Background

- ❑ Study area is 700 feet of cliff near Building 75 at the Chesapeake Bay Detachment (CBD).
- ❑ Some of the structures are as close as 10 to 65 feet from the cliff edge.
- ❑ Cliff height at study area is about 100 feet
- ❑ Cliff top is progressively receding
- ❑ Major failure in 1996
- ❑ Recent failures in 2009 and 2012



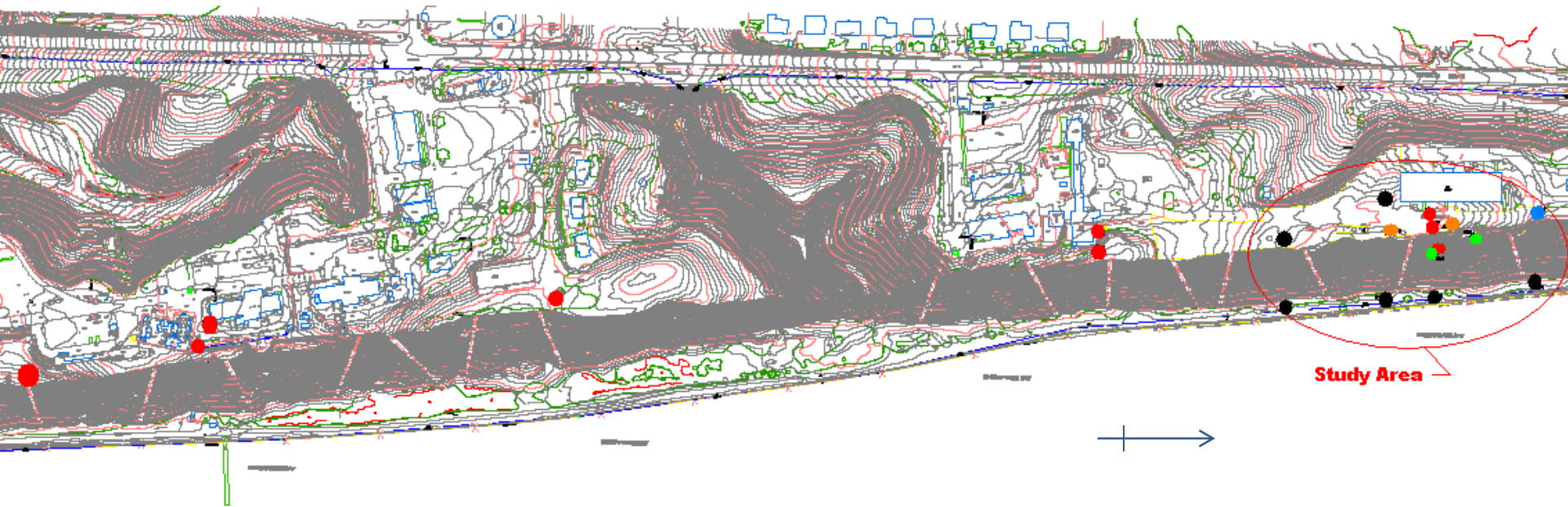
Project Background (Cont'd)

▣ Cliff Geometry



Subsurface Exploration

- ▣ 16 Borings
- ▣ 2 Hand Augers
- ▣ 2 Cone Penetration Tests
- ▣ 9 Inclinometers
- ▣ 1 Piezometer



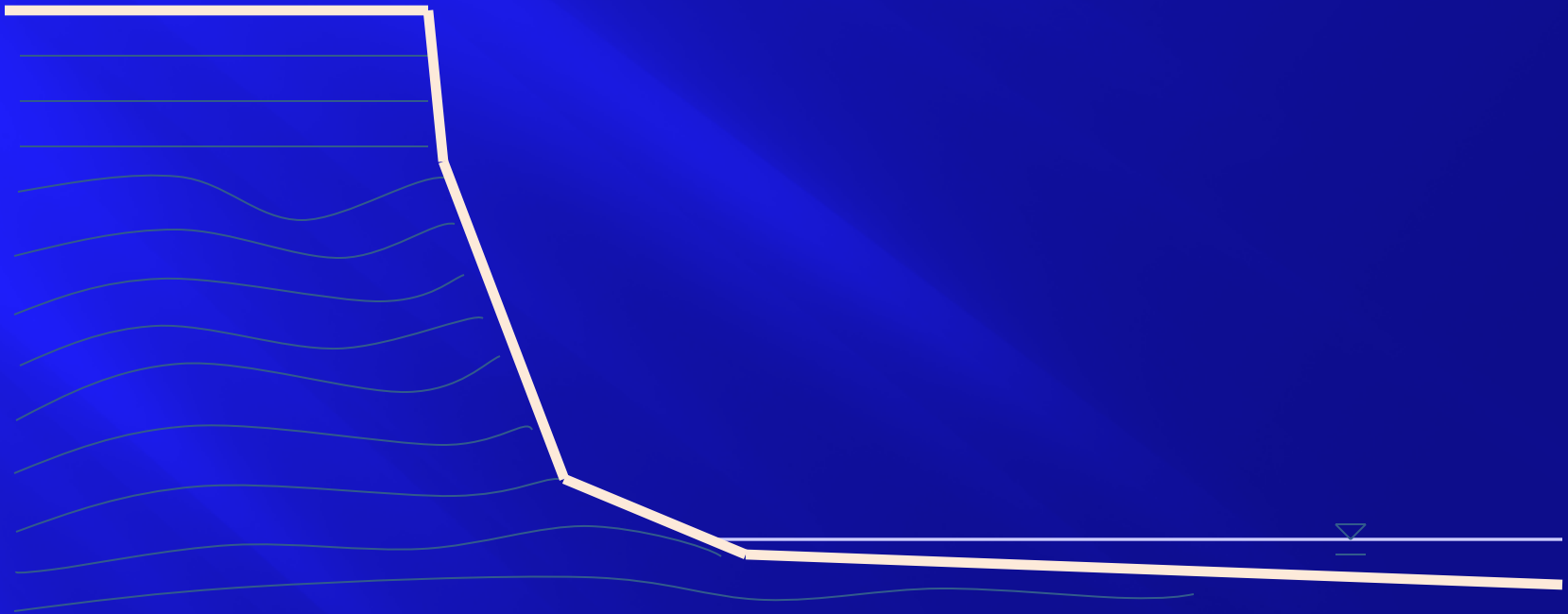
Process of Cliff Retreat

- ▣ The cliff has been retreating since it's formation about 10,000 to 20,000 years ago
 - Toe Erosion
 - Surface Erosion
 - Instability

Process of Cliff Retreat (Cont'd)

Toe Erosion – Stage 1

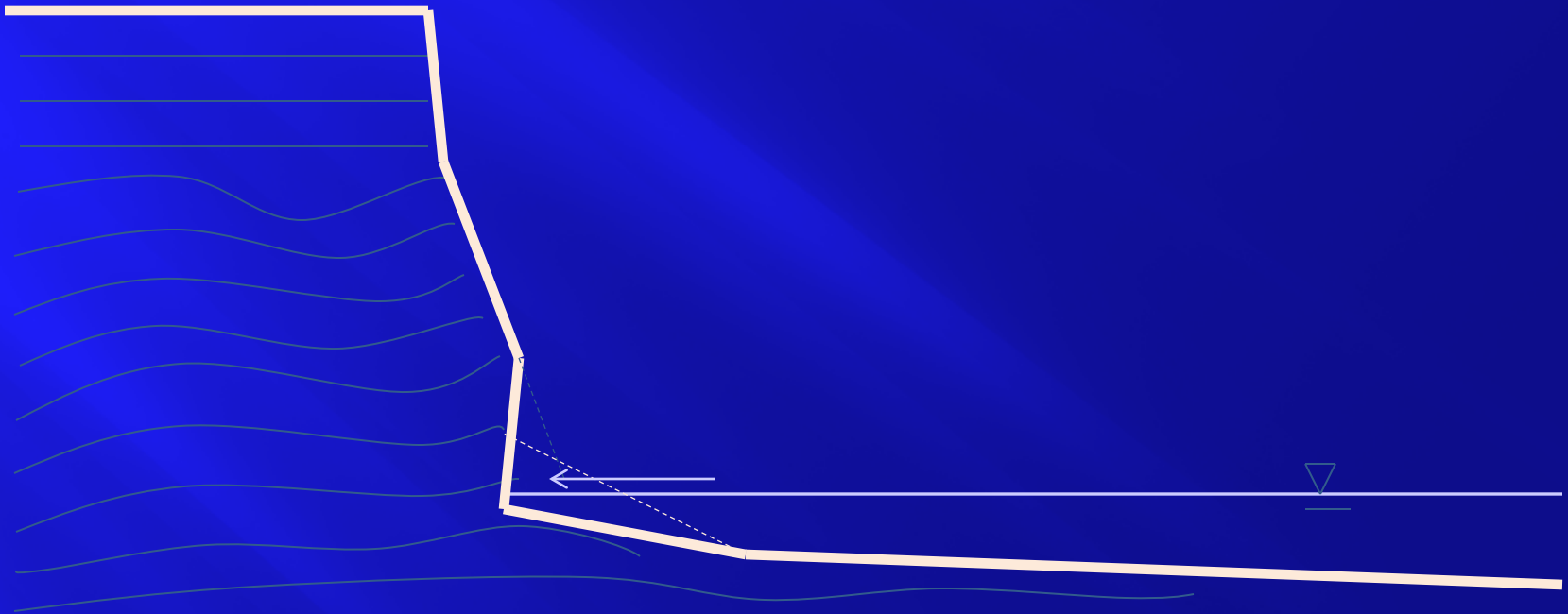
- ▣ Initial cliff configuration



Process of Cliff Retreat (Cont'd)

Toe Erosion – Stage 2

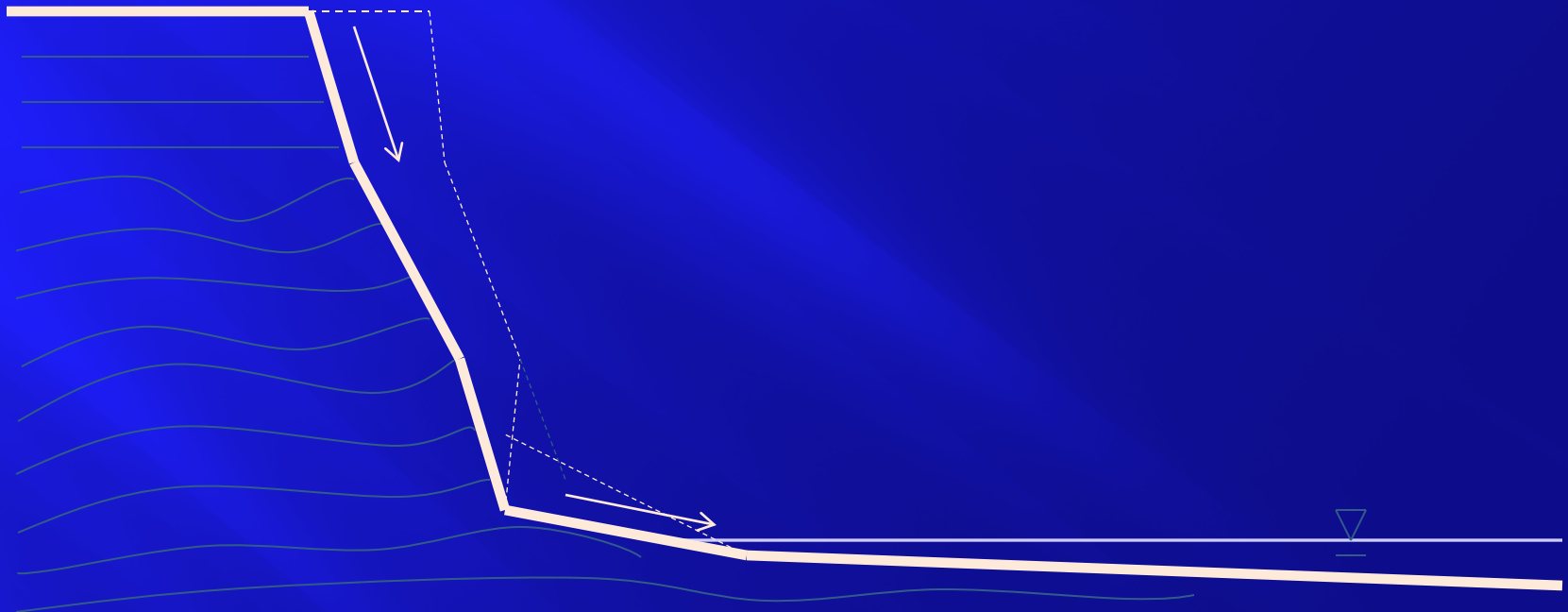
- ▣ Erosion at toe from wave action of the Bay



Process of Cliff Retreat (Cont'd)

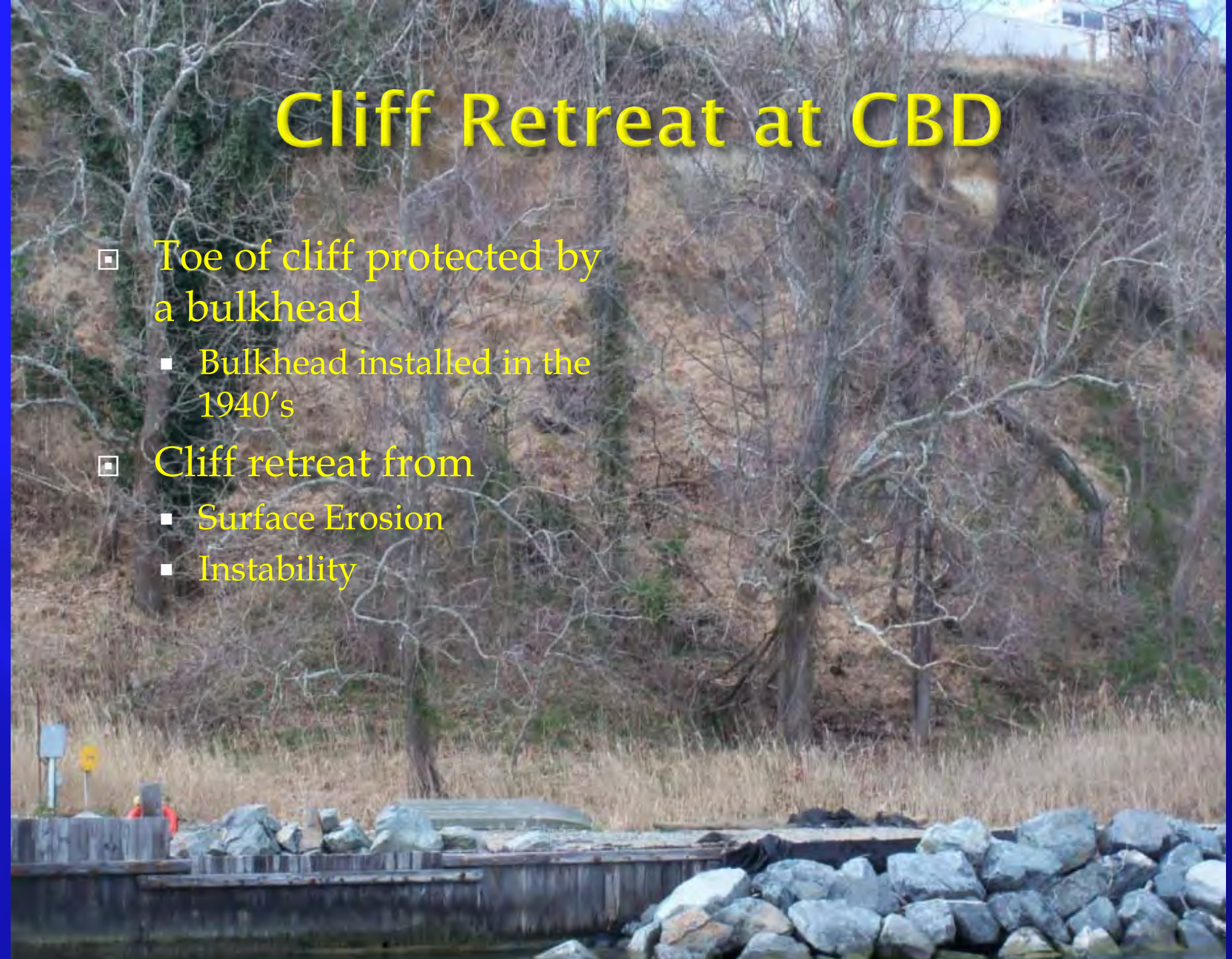
Toe Erosion – Stage 3

- Upper portion of cliff becomes unstable, fails, and the crest retreats



Cliff Retreat at CBD

- ▣ Toe of cliff protected by a bulkhead
 - Bulkhead installed in the 1940's
- ▣ Cliff retreat from
 - Surface Erosion
 - Instability





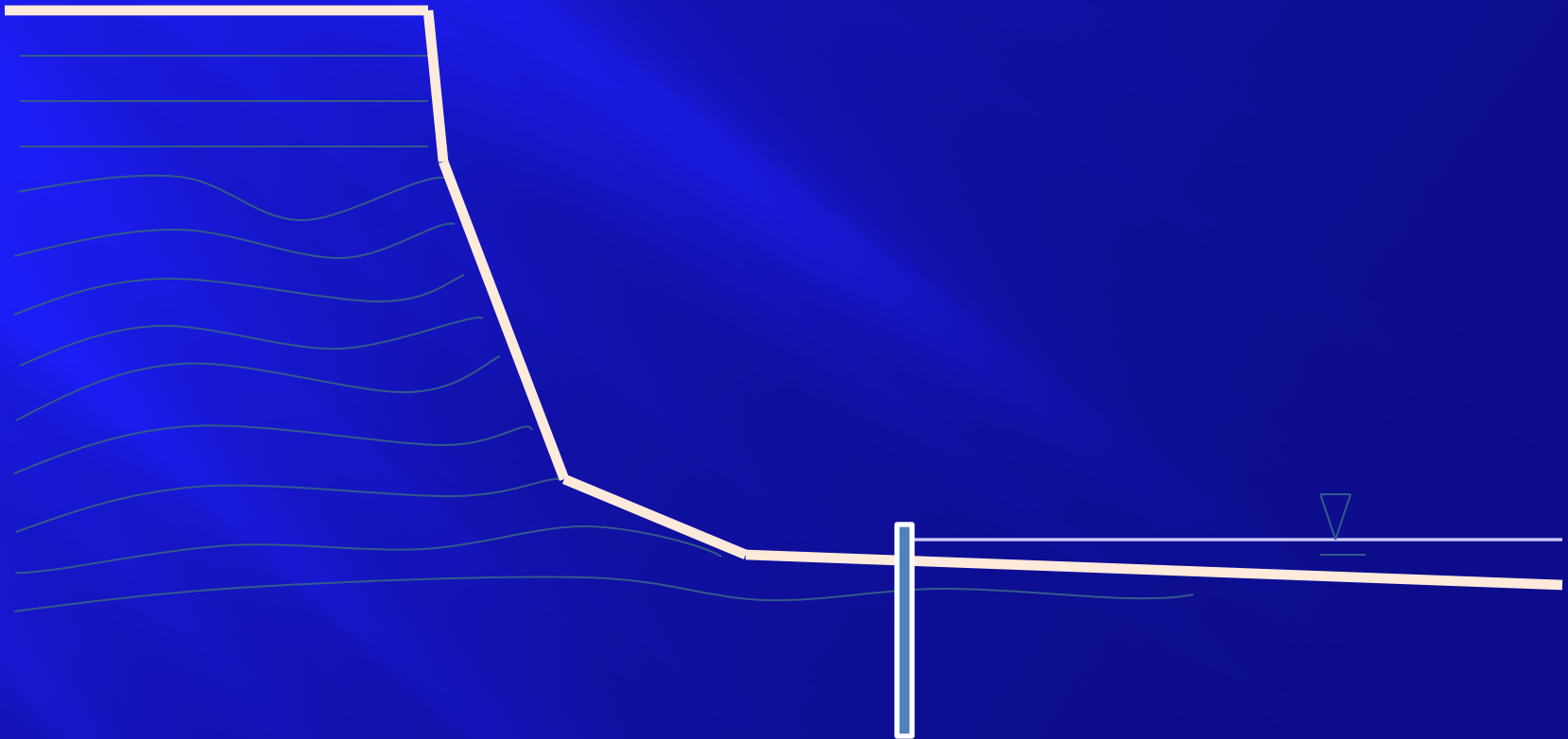
Cliff Retreat at CBD (Cont'd)

Surface Erosion

- ▣ Surface Erosion
 - Surface runoff from cliff top
 - ▣ Cliff Edge higher than plateau south of Bldg 75
 - ▣ Road higher than cliff edge in front of Bldg 75
 - Direct Rain Impact
 - ▣ Wind from across the Bay.
 - ▣ Sparse vegetation compounds effect

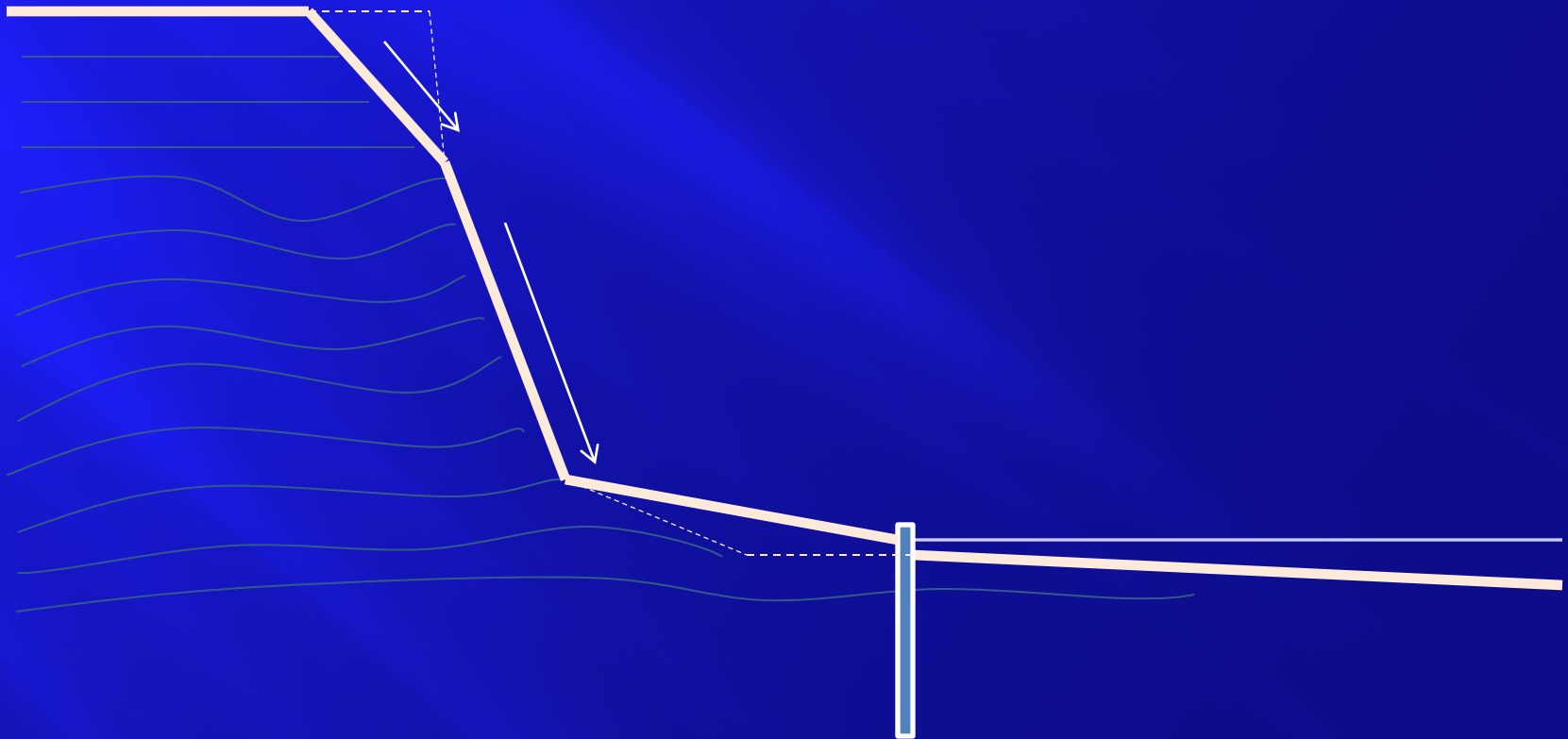
Cliff Retreat at CBD (Cont'd)

- ▣ Process of cliff retreat from top instability



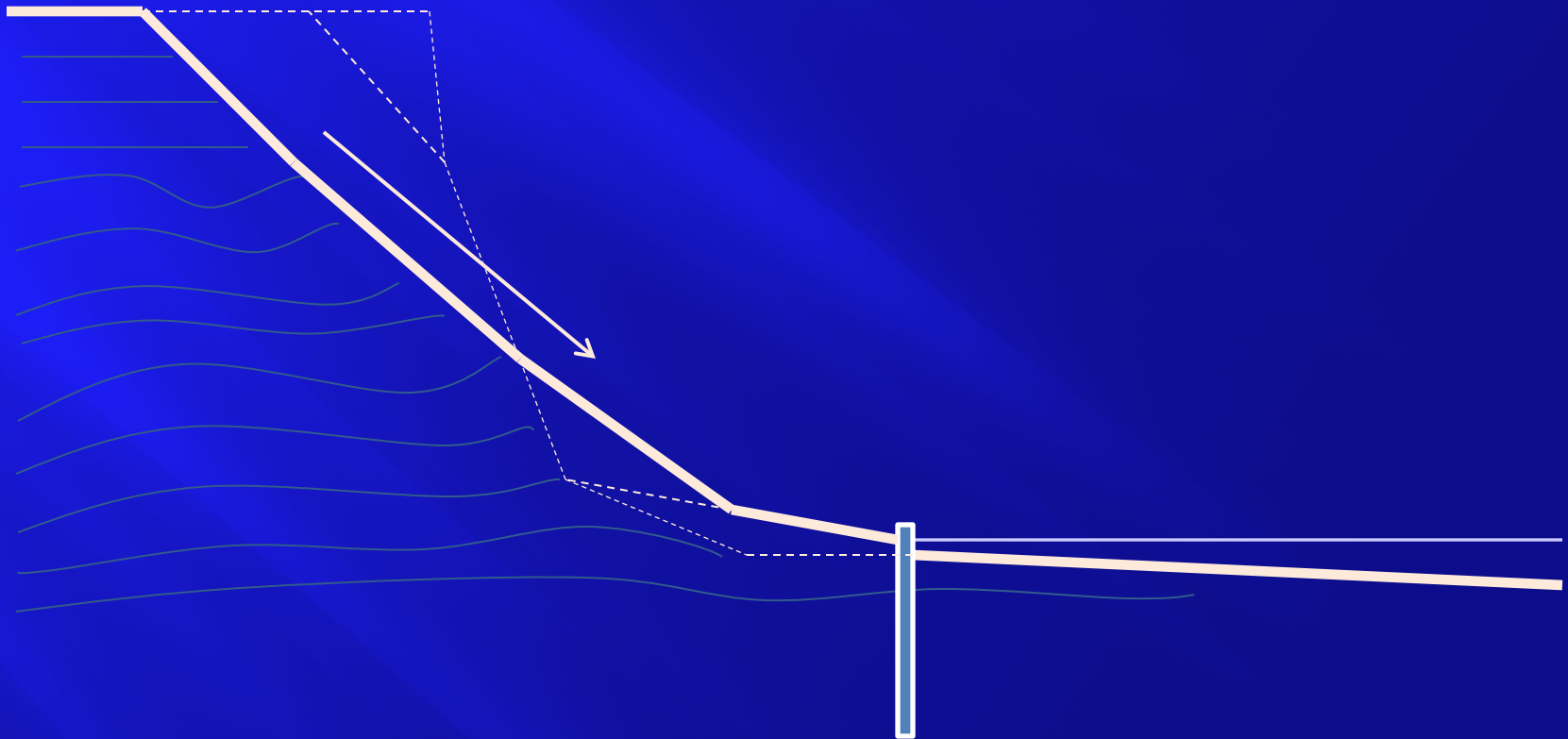
Cliff Retreat at CBD (Cont'd)

- ▣ Upper slope fails and material slides down to the toe



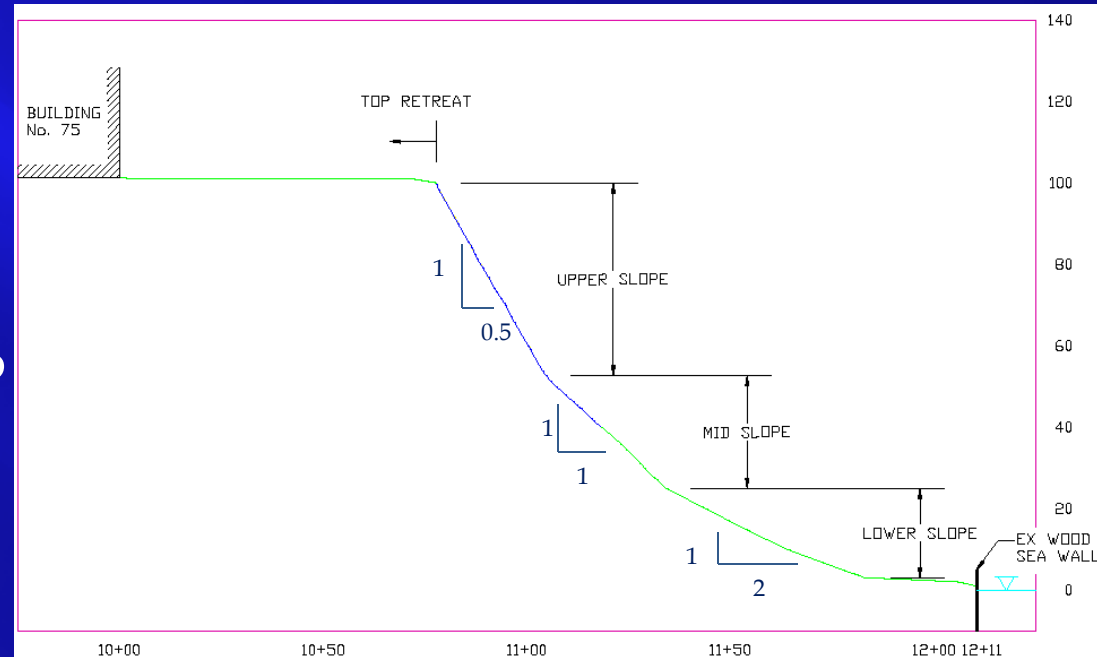
Cliff Retreat at CBD (Cont'd)

- ▣ Cliff continues to recede until stable angle is achieved



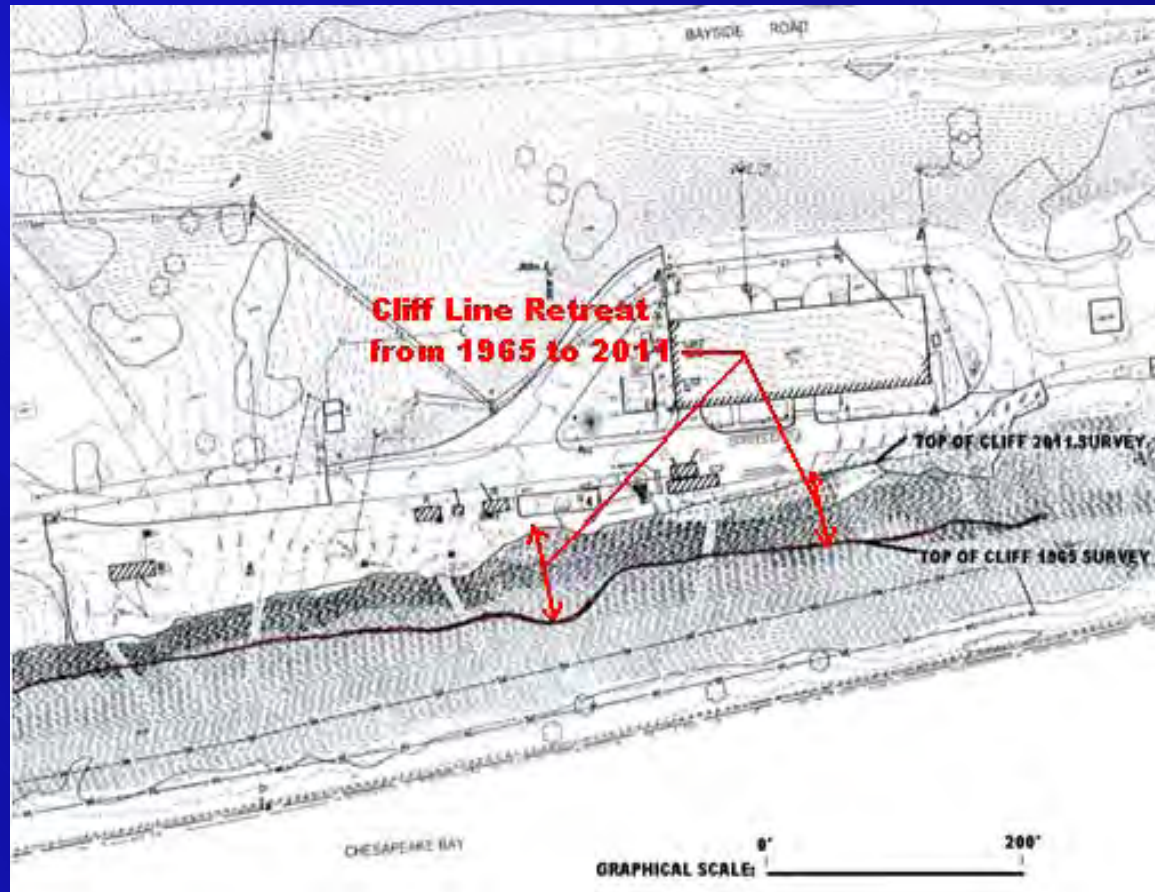
What is the Stable Cliff Angle at Calvert Cliffs?

- Angle of Repose reported to be 30 to 45 degrees for the Calvert Cliffs
- Slope angle at CBD:
 - Upper slope 0.5H:1V to near vertical.
 - Mid-slope at 1H:1V
 - Lower slope at 2H:1V



So what is the rate of Cliff Top Retreat?

- ▣ Estimating Rate of Retreat
 - Compared survey of cliff top in 2011 to survey of cliff top in 1965
 - 30 to 65 feet of cliff top lost in 46 years
 - Average recession rate: 8 to 17 inches/year



Cliff Retreat at CBD (Cont'd)

Rate of Cliff Top Retreat

- ▣ Rate of recession is NOT uniform on an annual basis.
 - Major failures can and do occur.
 - A major failure occurred circa 1996 near Building 75.



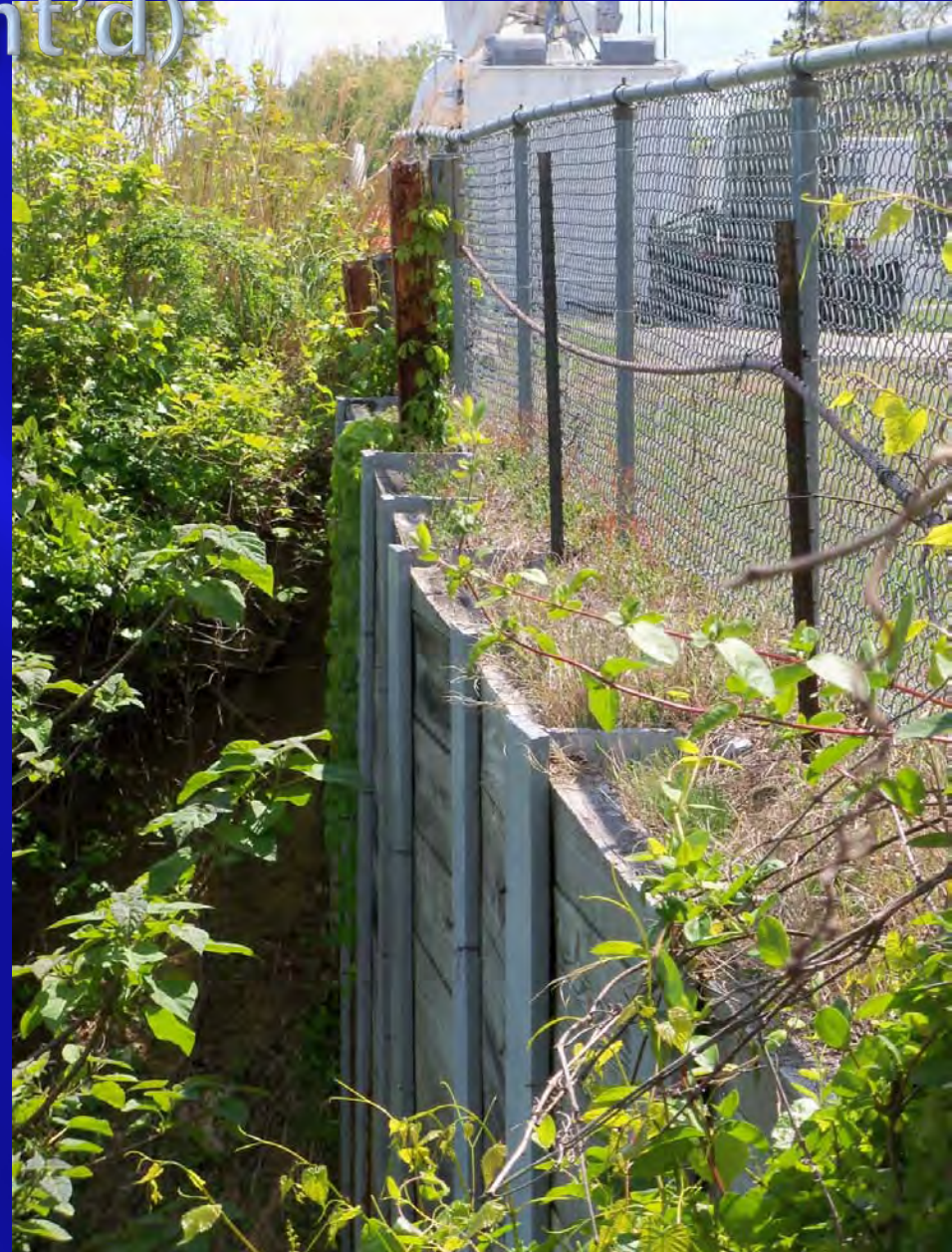
Bldg 75 Cliff Stabilization Effort

- ▣ A two-tiered retaining wall was installed to stabilize the cliff at the failed section.
 - Cantilevered Wall
 - 43 foot long
 - W14x176 and W14x211 driven steel soldier piles
 - Pile lengths vary from 39 to 65 feet
 - Piles spaced at 5 feet o.c.
 - Wood lagging



Bldg 75 Cliff Stabilization Effort (Cont'd)

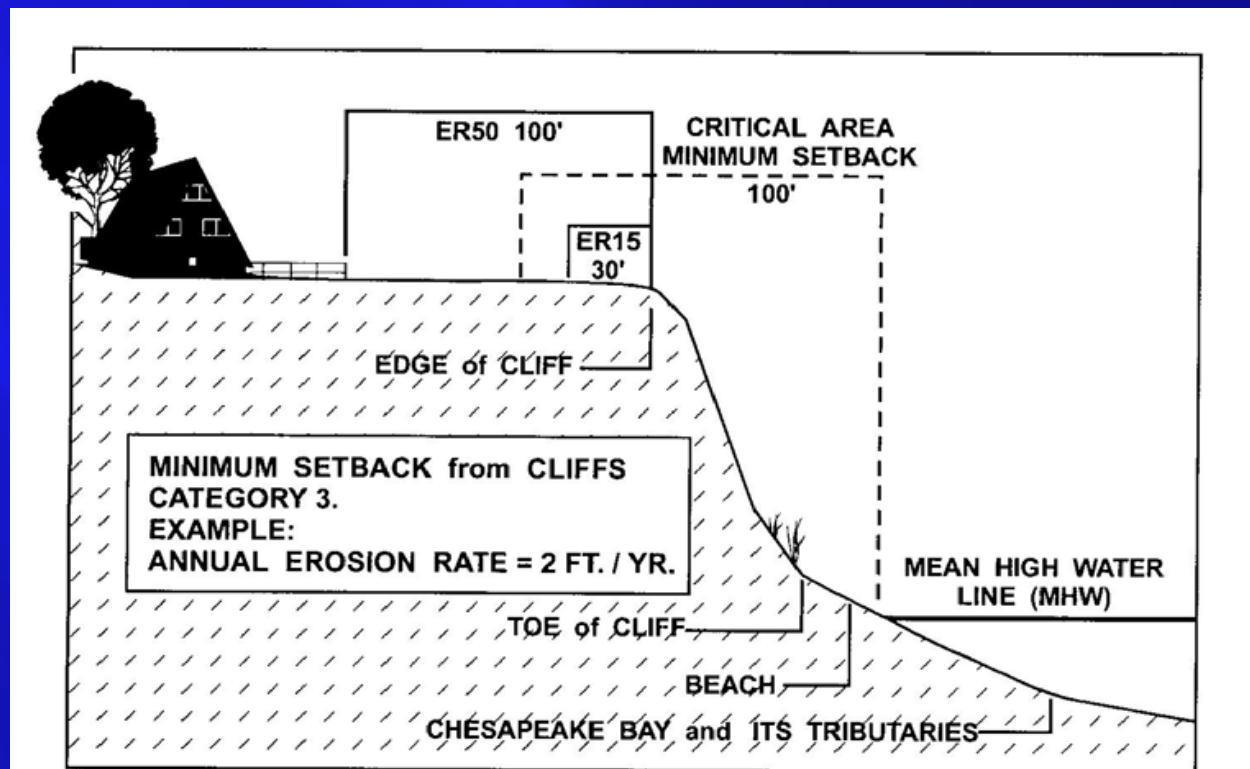
- ▣ Two -tiered wall is performing very well
 - No obvious evidence of tilt
 - No obvious evidence of instability
- ▣ Erosion around ends of wall



Bldg 75 Cliff Stabilization Effort (Cont'd)

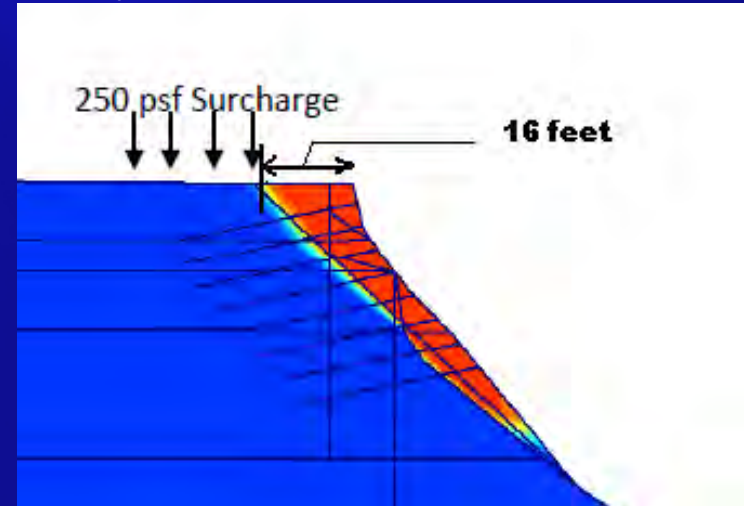
Calvert County Regulations

- ▣ Calvert County Zoning Regulation
 - 100 feet setback of primary structures to edge of cliff



Evaluation of Existing Cliff Stability

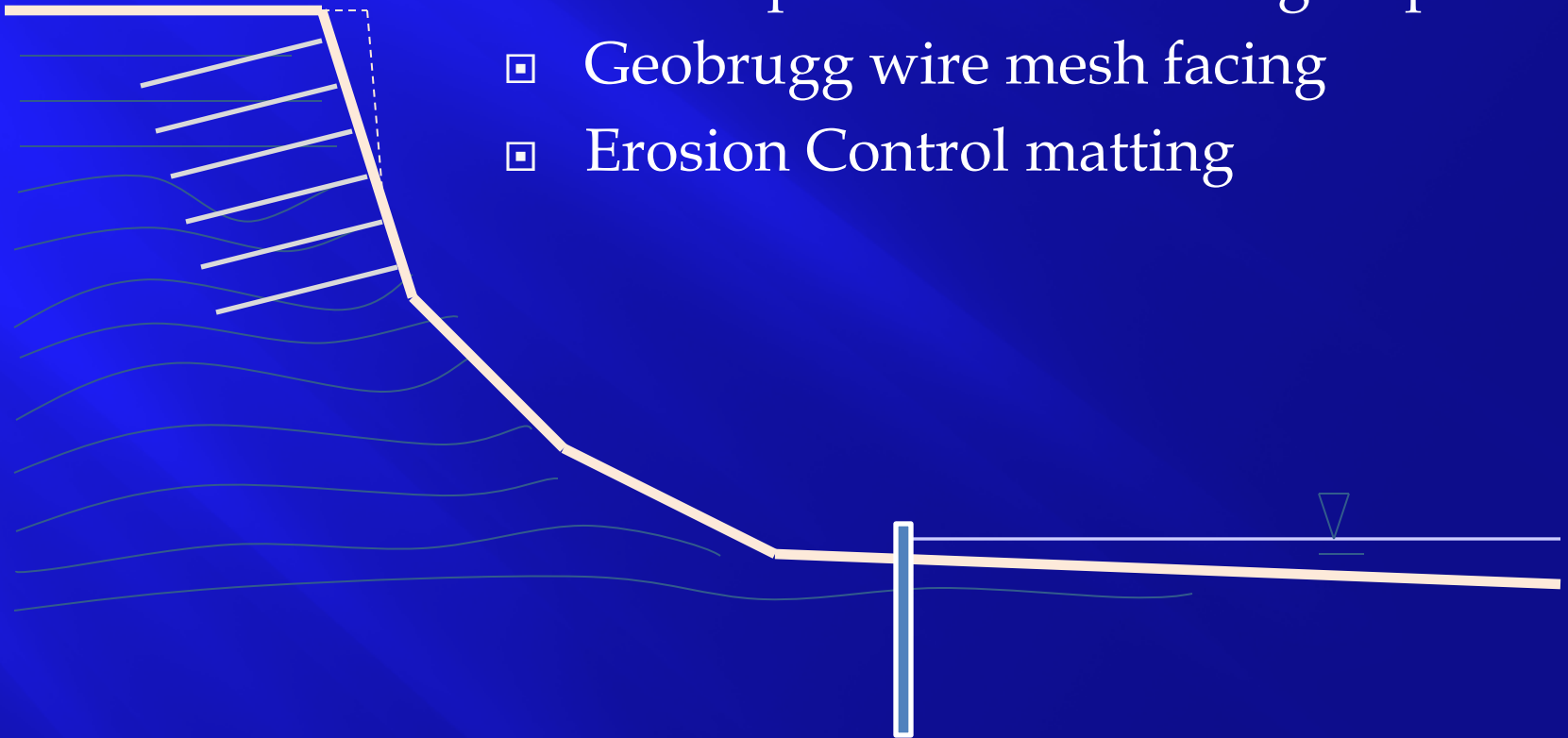
- ▣ Cliff is marginally stable
 - Failures can occur without prior warning
 - Large failures can and do occur
 - Due to height of cliff, failures could be catastrophic
 - The ex. wall is performing well
 - Failures can theoretically extend 12 to 16 feet behind the cliff edge
 - ▣ Can impact portions of the road, the parking pad, and the WARLOC facility



CBD Cliff Stabilization Concepts (Cont'd)

Concept B – Soil Nail Reinforcement

- ▣ 28 foot long grouted soil nails
- ▣ Nails spaced at 5 feet in a grid pattern
- ▣ Geobrugg wire mesh facing
- ▣ Erosion Control matting



Concept B – Soil Nail Reinforcement

▣ Advantages:

- ▣ Current geometry of cliff can generally be maintained
- ▣ Aesthetics not adversely affected.
- ▣ Limited excavation
- ▣ Can be constructed from top of cliff

▣ Disadvantages:

- ▣ Construction challenging
- ▣ Larger area of disturbance
- ▣ Only grass and small shrubs will be allowed to grow on treated area.
- ▣ To promote vegetation growth cliff will need to be flattened to 1H:2V



Concept B – Soil Nail Reinforcement

- ▣ Installing the Geobrigg wire mesh



CBD Cliff Stabilization Concepts (Cont'd)

Concept B – Soil Nail Reinforcement

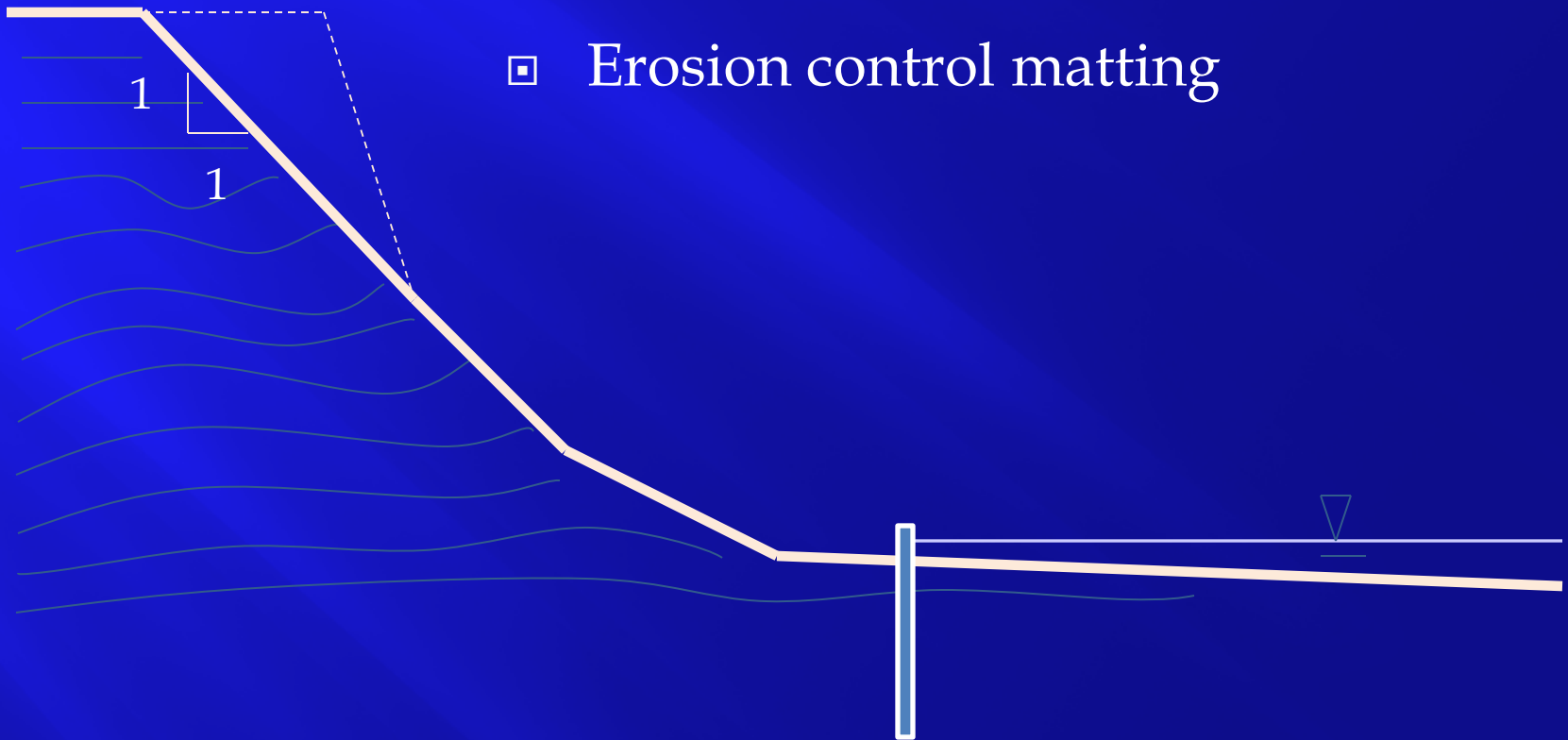
- ▣ Completed system after Vegetation growth



CBD Cliff Stabilization Concepts (Cont'd)

Concept C – Cutback Cliff Top

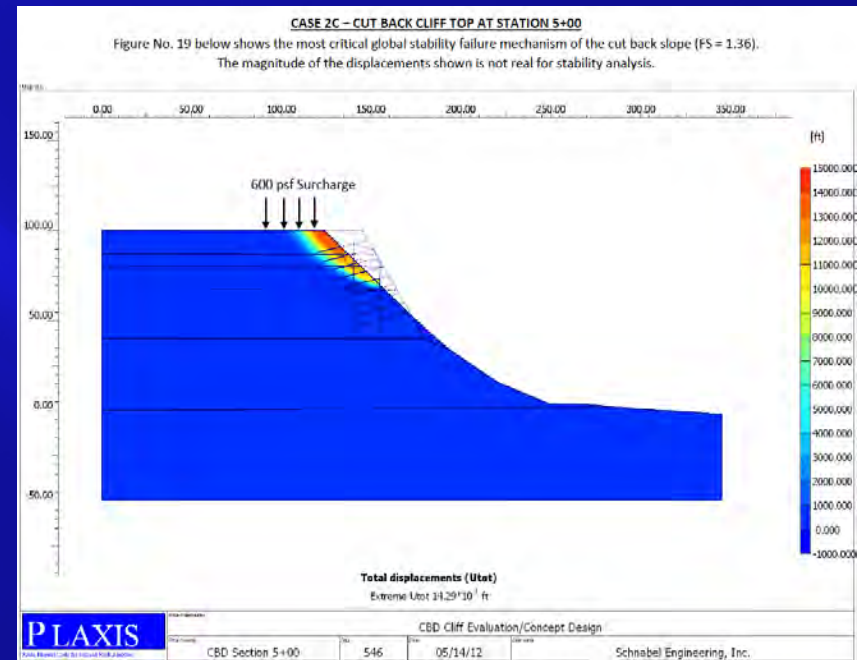
- ▣ Flatten slope to 1H:1V
- ▣ Geoweb cellular confinement
- ▣ Erosion control matting



CBD Cliff Stabilization Concepts (Cont'd)

Concept C – Cutback Cliff Top

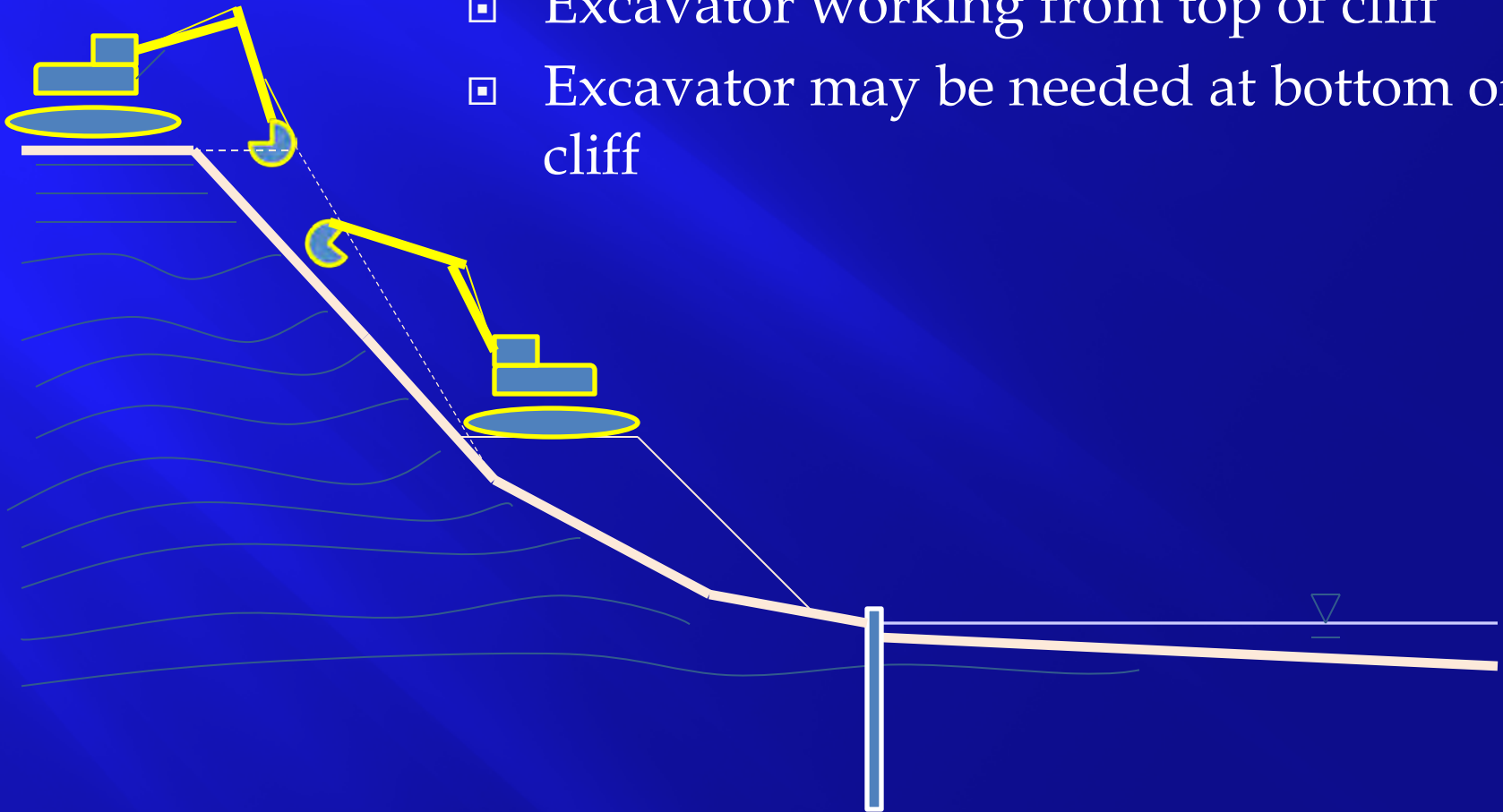
- ▣ Advantages:
 - Simple construction technique
 - Can be vegetated with small vegetation and tree plantings at selected locations.
- ▣ Disadvantages:
 - Large area of disturbance
 - Large volumes of excavated materials.
 - Cliff aesthetics altered
 - Loss of about 20 feet of cliff top
 - Access road may be needed from the base of cliff



CBD Cliff Stabilization Concepts (Cont'd)

Concept C – Cutback Cliff Top

- ▣ Flatten slope to 1H:1V
- ▣ Excavator working from top of cliff
- ▣ Excavator may be needed at bottom of cliff



Concept C – Cutback Cliff Top

- ▣ Cellular confinement to reduce risk of erosion and shallow failures



CBD Cliff Stabilization Concepts (Cont'd)

Concept C – Cutback Cliff Top

- ▣ Example of partially completed slope



CBD Cliff Stabilization Concepts (Cont'd)

Concept C – Cutback Cliff Top

- ▣ Completed slope at Fort Washington



CBD Cliff Stabilization Concepts (Cont'd)

Concept X – Do Nothing

- ❑ Not a feasible option near Building 75 or at locations where failures would impact structures or personnel safety
- ❑ May be evaluated on a case-by-case basis at other locations at the facility.
- ❑ Safe distances must be maintained

Conclusions

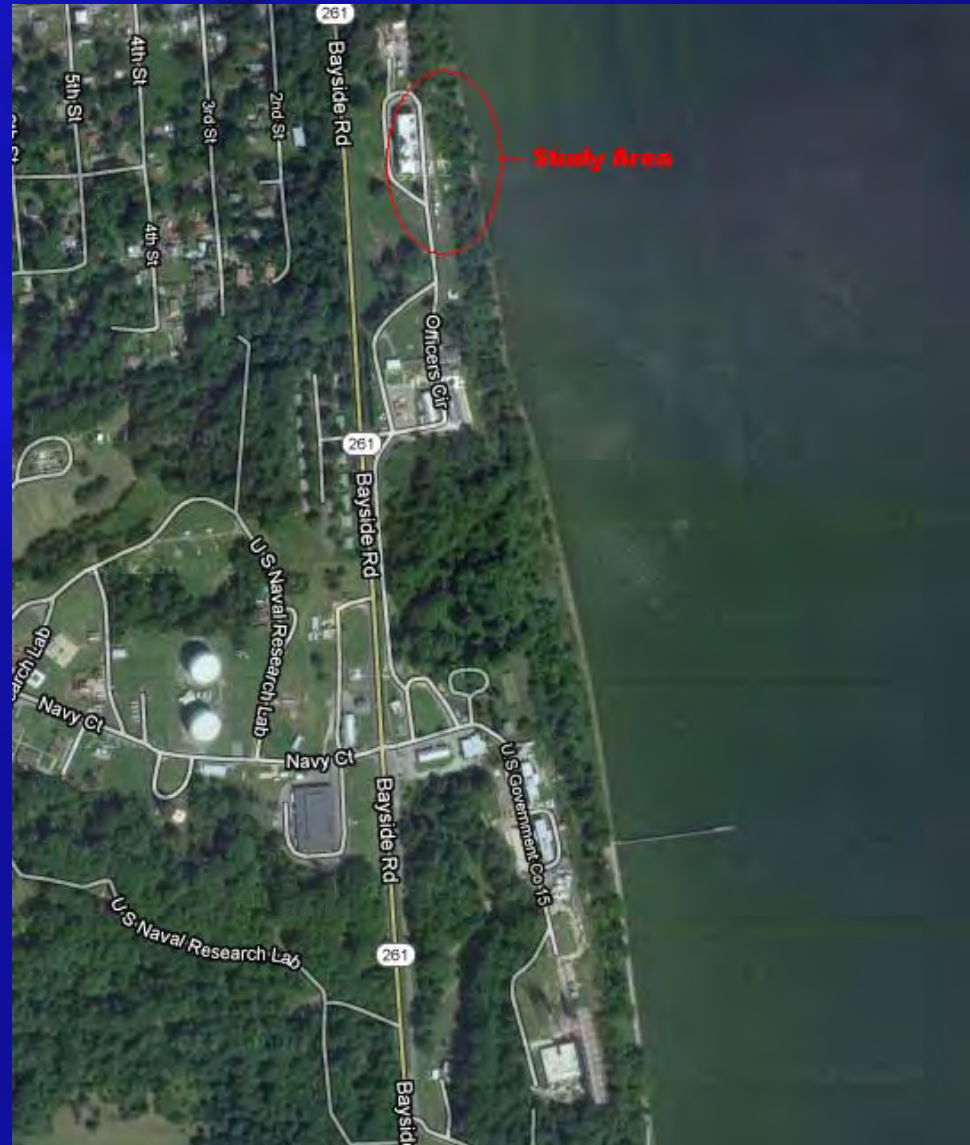
- ▣ Concepts A, B and C are all viable options with their respective advantages and disadvantages.
- ▣ All 3 concepts will alter the cliff aesthetics
- ▣ Concept A (Tiered Wall) is the most costly, but is proven
 - Least amount of disturbance
- ▣ Concept B (Soil Nail Reinforcement) retains the general shape of the cliff, but is difficult to construct and not proven at the site
- ▣ Concept C (Cliff Cutback) is the least costly, but would result in a significant loss of real estate
 - Significant disturbed area
 - Would look like a tall slope

What's next?

- ▣ Immediate enforcement of safe distances from cliff edge
 - 25 feet restriction near cliff edge
 - Relocation of structures that are within 25 feet of the cliff edge
- ▣ Continue monitoring
 - Quarterly monitoring
 - ▣ Instrumentation
 - ▣ Visual
- ▣ Selection of Cliff Stabilization option
- ▣ Final design and construction of selected option(s)

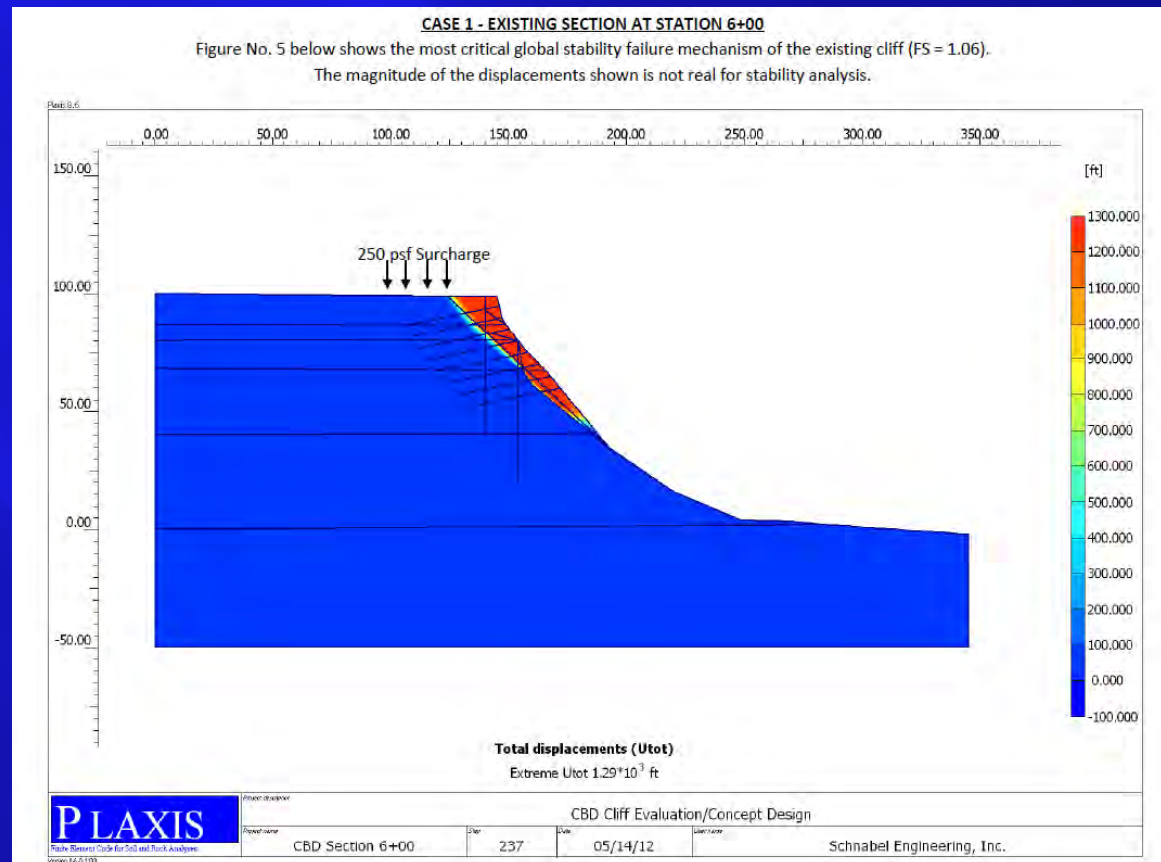
Project Background

- ❑ Cliff at Chesapeake Beach Detachment (CBD) is about $\frac{3}{4}$ mile long
- ❑ Part of 30 mile Calvert Cliff line
- ❑ Study area is 700 feet of cliff near Building 75
- ❑ The cliff height varies from 85 to 110 feet above the Bay



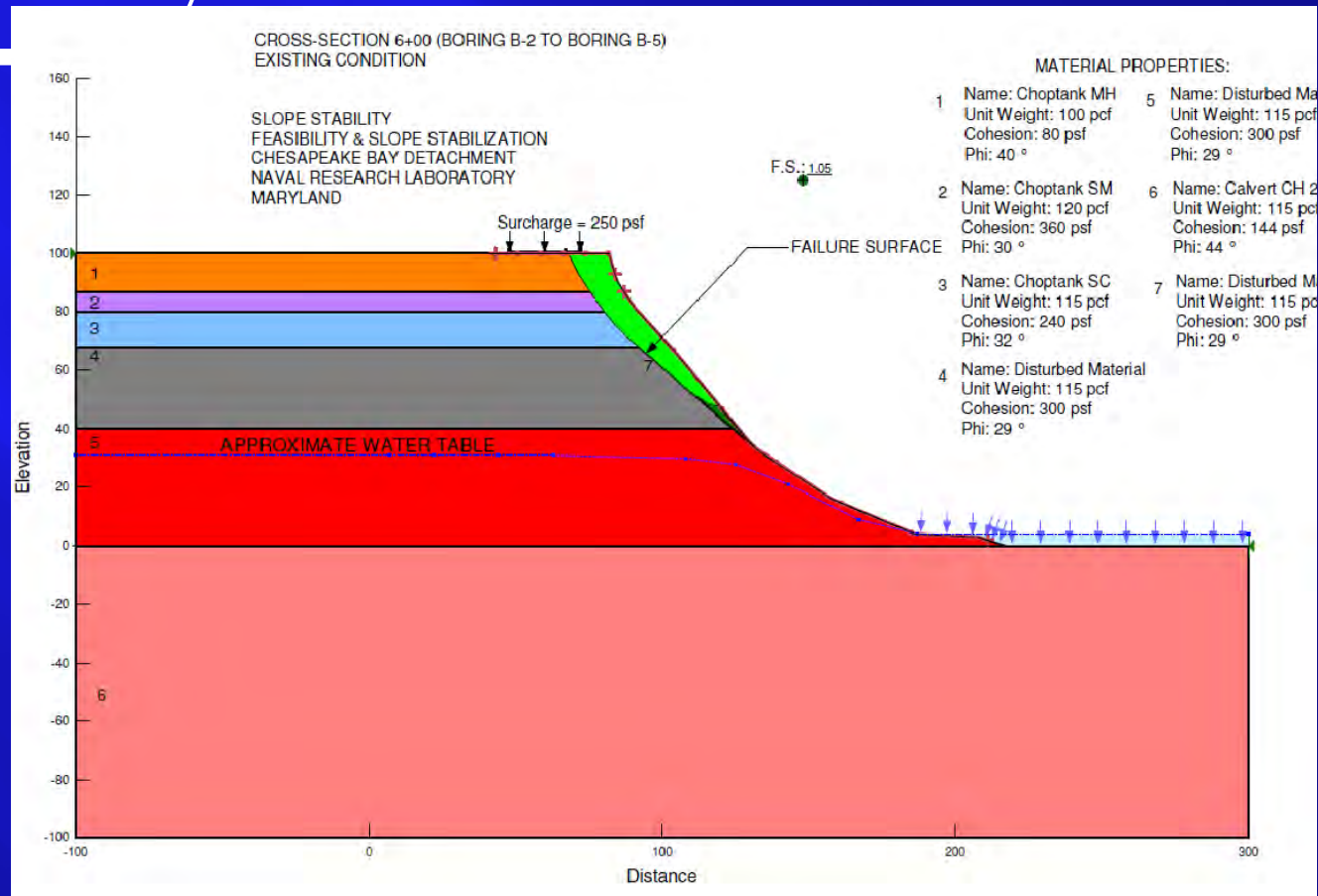
Evaluation of Existing Cliff Stability

- Finite Element Modeling using Plaxis
 - FOS = 1.06



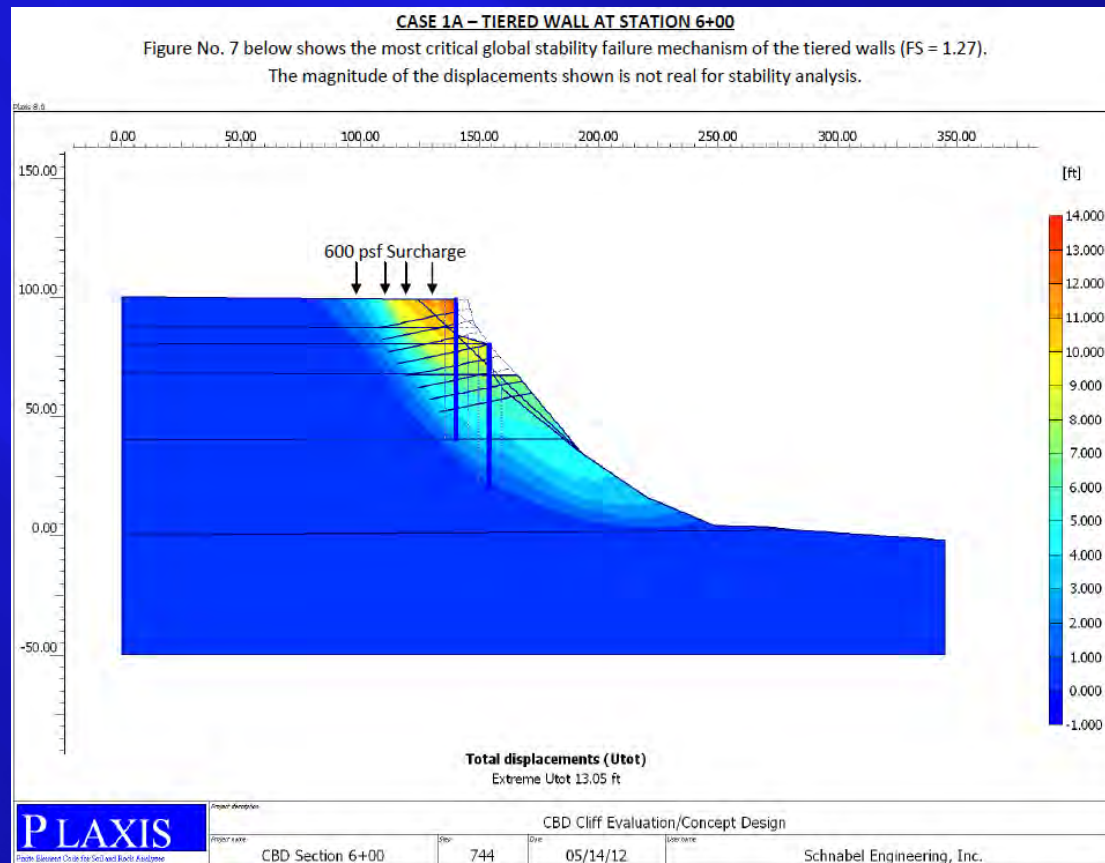
Evaluation of Existing Cliff Stability (Cont'd)

▣ Limit Equilibrium Modeling using GeoSlope SLOPE/W



Evaluation of Existing Wall Stability

- ▣ Finite Element Modeling using Plaxis
 - FOS = 1.27



CBD Cliff Stabilization Concepts (Cont'd)

Concept B – Soil Nail Reinforcement

CASE 2B – SOIL NAIL REINFORCEMENT AT STATION 5+00

Figure No. 18 below shows the most critical global stability failure mechanism of the soil nail reinforced slope (FS = 1.32).
The magnitude of the displacements shown is not real for stability analysis.

