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CROSS GENERATING STATION

Bottom Ash Pond Initial Safety Factor Assessment

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WorleyParsons

2675 Morgantown Rd.

Reading, PA 19607

USA

Telephone: +1 610 855 2000

Facsimile: +1 610 855 2001

www.worleyparsons.com

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**CROSS GENERATING STATION
BOTTOM ASH POND INITIAL SAFETY FACTOR ASSESSMENT**

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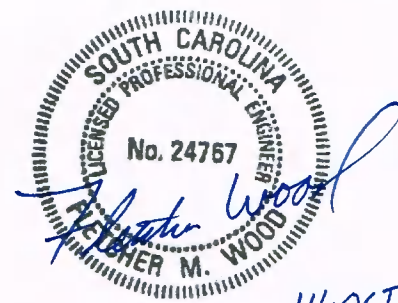


**CROSS GENERATING STATION
BOTTOM ASH POND INITIAL SAFETY FACTOR ASSESSMENT**

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**CROSS GENERATING STATION****BOTTOM ASH POND INITIAL SAFETY FACTOR ASSESSMENT**

1. INTRODUCTION

The United States Environmental Protection Agency (EPA) promulgated new regulations regarding Coal Combustion Residuals (CCRs). These regulations (40 CFR Part 257) were published in the Federal Register on April 17, 2015. One of the requirements (§257.73(e)(1)) of the new regulations includes conducting initial and periodic safety factor assessments on existing CCR surface impoundments and obtaining a certification from a qualified professional engineer. Required factors of safety are (i) 1.50 for long-term, maximum storage pool; (ii) 1.40 for maximum surcharge pool loading; (iii) 1.00 for seismic; (iv) 1.20 for dikes constructed of soils susceptible to liquefaction.

This report presents the results of the initial safety factor assessment for the Bottom Ash Pond at Cross Generating Station and provides the required certification by a qualified professional engineer. Subsequent periodic safety factor assessments are to be completed every five years.

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2. DISCUSSION

General Information

Cross Generating Station consists of four generating units and is located between Lakes Marion and Moultrie, in Pineville, South Carolina. Bottom ash from all four units is currently sluiced into the Bottom Ash Pond, which also receives several other wastewater streams. The plant is currently undergoing various equipment upgrades that will allow all inflows to be redirected away from the Bottom Ash Pond to an alternate wastewater treatment system, and to eliminate the sluicing of bottom ash, after which time the Bottom Ash Pond will be closed.

The pond was constructed in two phases. The first basin was constructed in 1984. Coal combustion residuals (CCR) have been removed from this pond, it has been repurposed for wastewater management, and it is not subject to the CCR Rule. This pond is now referred to as the Wastewater Decant Pond. In 1993, a much larger basin was constructed to the north and west of the Wastewater Decant Pond. This larger basin, now referred to as the Bottom Ash Pond, is the subject of this study. The basins are interconnected via a trapezoidal weir constructed through the north berm of the Wastewater Decant Pond. An emergency overflow serving both ponds is located near the south berm of the Wastewater Decant Pond.

Engineering calculation CROSS-0-DC-044-CE-0003, included as Appendix A, includes a detailed discussion of the site geometry, embankment and foundation soil conditions, soil parameter development, liquefaction potential assessment results, and stability results.

Embankment Soils and Geometry

The top of the Bottom Ash Pond embankment is approximately 11 feet higher than surrounding natural grade, and is comprised of compacted sandy lean clay and clayey sand soils. The embankment slopes are 3 horizontal to 1 vertical (3:1). The embankment soils have similar properties to the top several feet of existing site soils, which is consistent with the understanding that on-site borrow areas were used to obtain the fill materials used in embankment construction. Terracon performed field and laboratory testing in October 2015 to characterize the nature and strength of the embankment soils. This is presented in greater detail in Appendix A. Based on the liquefaction potential evaluation included in Appendix A, none of the embankment soils are considered susceptible to liquefaction.

Foundation Soils

The site subsurface exploration performed by Terracon in October 2015 indicated predominately sandy lean clay and clayey sand overlying weathered Santee Limestone. Depths to the weathered limestone

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layer ranged from approximately 29 to 47 feet below the top of the Bottom Ash Pond dike. Below a depth of approximately 17 feet below the top of the dike, there was a decrease in both SPT N-value and peak undrained shear strength. This lower layer of soil typically had higher fines content and moisture contents closer to the liquid limit than the plastic limit. Soil classifications were predominately sandy lean clay and fat clay with sand.

Method of Analysis and Results

Stability analyses were performed using limit equilibrium methods with the computer program STABL6H. The Modified Bishop Method was used to evaluate factors of safety for circular arc failures. Block (translational) failure modes were evaluated using the Modified Janbu Method. The calculated factors of safety are summarized in the following table.

Table 1: Calculated Factors of Safety

CCR Rule Reference	Analysis Condition	File Name	Circular Factor of Safety	Block Factor of Safety	Required Factor of Safety
257.73(e)(1)(i)	Maximum Storage	Cross734normalconditions	1.78	1.72	1.50
257.73(e)(1)(ii)	Maximum Surcharge	Cross734floodconditions	1.75	1.60	1.40
257.73(e)(1)(iii)	Seismic	Cross734seismicconditions	1.66	2.64	1.00
257.73(e)(1)(iii)	Seismic	Cross734seismicconditions_lower bound2	1.22	1.78	1.00
257.73(e)(1)(iv)	Liquefaction	Not Applicable (embankment soils not liquefiable)			1.20



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3. CONCLUSIONS

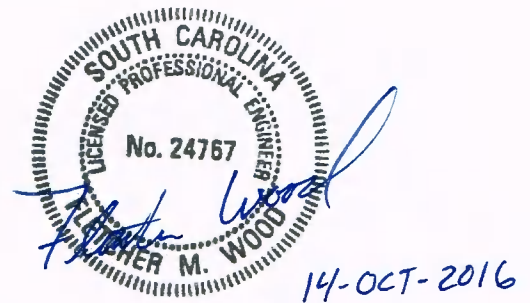
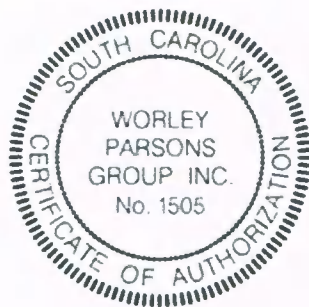
The results of the stability analyses indicate the perimeter embankment of the Bottom Ash Pond at Cross Generating Station has factors of safety that exceed the requirements of the CCR rule (§257.73(e)) for the current site and operational conditions. Embankment soils are not considered to be liquefiable.



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BOTTOM ASH POND INITIAL SAFETY FACTOR ASSESSMENT**

4. CERTIFICATION

I, the undersigned Professional Engineer registered in good standing in the State of South Carolina, do hereby certify under penalty of law that I have personally examined and am familiar with the information submitted in this demonstration, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. I certify, for the above-referenced CCR impoundment, that the initial safety factor assessment as specified in Section 40 CFR 257.73(e)(1) was conducted in accordance with the requirements of this section.



Fletcher Wood

Printed Name of Professional Engineer

Fletcher Wood

Signature of Professional Engineer

24767

South Carolina License #



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Appendix A - Calculation CROSS-0-DC-044-CE-0003



Calculation Cover Sheet

Customer	Santee Cooper	Project No.	108008-01330
Project Title	Cross Generating Station	Calc No.	CROSS-0-DC-044-CE-0003
Calculation Title	Bottom Ash Pond Initial Safety Factor Assessment	Phase/CTR	LBRCR
Elec File Location	\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm		
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Calculation Objective

The purpose of this calculation is to perform an initial safety factor assessment of the Bottom Ash Pond at the Cross Generating Station with respect to EPA's CCR rule (40 CFR Part 257.73(e)(1)).

Calculation Method

Contained in the body of the calculation

Assumptions

Presented in the body of the calculation
None that require further verification

Software Used

Title STEDWin/STABL6H	Version 6H	Validation (Y / N / N/A) 6/12/2006
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References

Conclusions

The embankment soils are not liquefiable. Using conservative interpretations of soil properties, the factors of safety calculated for the various loading conditions meet or exceed the requirements of the CCR rule.

Related to a Safety Critical System?	No	Status of Supplier Data used	N/A
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HOLDS

None

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Calculation Checklist

Customer	Santee Cooper	Project No.	108008-01330
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Elec File Location	\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm		
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Please check boxes for all applicable items checked or mark as "N/A" if not appropriate:

Calculations:

Originator Checker

- | | | |
|-------------------------------------|--------------------------|--|
| ☒ | ☐ | Calculation number assigned and registered (refer to project numbering system or Document Number Standard (DPP-031-COR-EN for format). |
| ☒ | ☐ | All required information on Cover Sheet provided |
| ☒ | ☐ | Revision history box complete and signed. (Typed names (minimum of first initial and surname e.g. A. Wood) of Originator, Checker, Approver to be initialed beside at sign-off) (Dates in standard format (DD-MMM-YY)) |
| ☒ | ☐ | Table of Contents. |
| ☒ | ☐ | Appropriate stamp for preliminary issues. |
| ☒ | ☐ | Source of input data stated (with revision number and date if relevant). |
| ☒ | ☐ | Customer's requirements included/addressed. |
| ☒ | ☐ | Approach used is appropriate for problem being solved. |
| ☒ | ☐ | Method clear and easy to follow. |
| ☒ | ☐ | Input data correct. |
| ☒ | ☐ | Calculation is arithmetically correct OR software previously verified and reference to verification checked. |
| ☒ | ☐ | Calculation result within expected limits. |
| ☒ | ☐ | Calculation tolerances stated if significant. |
| ☒ | ☐ | Units used as required by customer. Unit conversions correctly performed. |
| ☒ | ☐ | Appropriate cross-references. |
| ☐ | ☐ | Sketches included and clearly labeled, where required. (N/A) |
| ☒ | ☐ | Appendices included and referenced, as required. |
| ☐ | ☐ | Considered design reviews, Hazop actions, Customer input, safety and environmental issues, etc. (N/A) |
| ☐ | ☐ | Safety in Design (SID) and Sustainable Design are addressed. Refer relevant SID Discipline Standard. (N/A) |
| ☒ | ☐ | Conclusions and recommendations are appropriate. |

Checking records:

- | | | |
|--------------------------|--------------------------|--|
| ☐ | ☐ | Checked and annotated copy of calculation filed (use "Doc Check Print" stamp). |
| ☐ | ☐ | Corrections made as required and calculation dated and signed on cover sheet by checker. |
| ☐ | ☐ | Alternative method calculation and/or representative check performed and filed, as required. |

Revisions:

- | | | |
|--------------------------|--------------------------|--|
| ☐ | ☐ | Changes clouded, tracked or highlighted. |
| ☐ | ☐ | Revision history block updated. |
| ☐ | ☐ | Calculation re-checked if required. |

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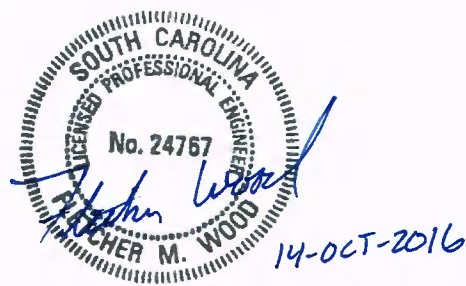
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1 PURPOSE

The purpose of this calculation is to perform safety factor assessments of the Bottom Ash Pond at Cross Generating Station in accordance with 40 CFR 257.73(e) (CCR Rule). These analyses are based on current site conditions and operational procedures. Required factors of safety are (i) 1.50 for long-term, maximum storage pool; (ii) 1.40 for maximum surcharge pool loading; (iii) 1.00 for seismic; (iv) 1.20 for dikes constructed of soils susceptible to liquefaction.

2 REFERENCES

1. BA-117-S0004, Rev. 1, Bottom Ash Pond Expansion Monitoring Well Location Plan, Gilbert/Commonwealth, Inc., November 21, 1995.
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11. WPC, Geotechnical Data Report Cross Generating Station Solid Waste Landfill (SWLF) Expansion Berkeley County, South Carolina, April 12, 2011.
12. Youd, T.L., et al., "Liquefaction Resistance of Soil: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soil," Journal of Geotechnical Engineering, ASCE, Vol. 127, No. 10, Pages 817-833, 2001.

3 CURRENT SITE CONDITIONS AND OPERATIONAL PROCEDURES

The bottom ash pond configuration at Cross Generating Station and its relationship to other site features is shown on the plan in Appendix A. The bottom ash basin was constructed in two phases. The first basin, currently referred to as the Wastewater Decant Pond, was approximately rectangular in shape and the top of the embankment extended to elevation 95 feet. In 1993, a much larger basin was constructed to the north and west of the initial basin. This larger basin is now known as the Bottom Ash Pond. Recent aerial images of the site show numerous berms within the Bottom Ash Pond which separate the basin into several cells. These berms appear to have been constructed of bottom ash. As they are interior to the basin perimeter, their presence does not affect the stability analyses.

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As shown in Section 1-1 in Appendix A [Ref. 2], embankment slopes on the inside of the Bottom Ash Pond extend from elevation 76 to elevation 91 feet. The basin has a bentonite geocomposite liner covered by a foot of bottom ash or structural fill, with the side slopes protected by a 3-inch thick concrete revetment. The basin was constructed with 3 horizontal to 1 vertical (3:1) side slopes and a 15- to 24-foot wide crest.

The Wastewater Decant Pond and the Bottom Ash Pond are connected via a spillway constructed through the north berm of the Wastewater Decant Pond. The invert elevation of the spillway between the two basins is approximately 85 feet. An emergency overflow at elevation 89.5 feet is located on the south berm of the Wastewater Decant Pond.

Coal combustion residuals (CCR) have been removed from the Wastewater Decant Pond and the pond repurposed for wastewater management. As such, the Wastewater Decant Pond is not subject to the CCR rule and does not require further evaluation under §257.73(e).

4 SITE SUBSURFACE CONDITIONS

A site subsurface exploration was performed by Terracon in October 2015. Two geotechnical borings with Standard Penetration Testing (SPT) were performed along with four cone penetrometer tests (CPTs). The approximate boring and CPT locations are shown on the plan included in Appendix B. Boring logs and CPT soundings are also provided in Appendix B.

Boring B-734 was drilled near the northeast corner of the Bottom Ash Pond, while Boring B-735 was located along the north berm of the Wastewater Decant Pond. CPT soundings C-835 and C-837 were advanced adjacent to Borings B-734 and B-735, respectively. C-834 was advanced in the northwest corner of the Bottom Ash Pond and C-836 was advanced along the southern berm of the pond.

The boring logs indicate predominately sandy lean clay and clayey sand overlying silty sand. The silty sand represents Santee Limestone that has been highly weathered. SPT N-values in the weathered limestone were greater than 40. The depths to the weathered limestone layer ranged from approximately 33 feet in Boring B-735 to 47 feet in Boring B-734. The depths to CPT tip refusal ranged from approximately 28 feet at sounding C-834 to 44 feet in sounding C-837. These depths are in general agreement with the boring data and consistent with the understanding that the surface elevation of the limestone varies due to relic solution weathering.

The subsurface conditions reported from the 2015 exploration are also consistent with historical exploration data. CPT soundings C823 and C824 [Ref. 11], logs for Borings 244, 245, and 442 [Ref. 5], and the logs for Borings 632 and 633 [Ref. 10] are provided in Appendix C. These logs were referenced because they were located near the ash pond, and in many instances are proximate to the test locations of the 2015 subsurface exploration. The approximate ground surface elevation at these historic exploration locations was 80 feet, which is approximately the current ground surface elevation beyond the toe of the ash pond slopes. A summary of layer thicknesses, average SPT N-values, and material types from both the current and historical subsurface explorations at elevations below the original ground surface elevation is presented in Table 1.

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Table 1: Summary of Exploration Data below Elevation 80 Feet

Boring or CPT	Layer 1			Layer 2			Layer 3			Elev. of Rock (ft)
	Elev. (ft)	Soil Type	N-Value	Elev. (ft)	Soil Type	N-Value	Elev. (ft)	Soil Type	N-Value	
244	79 – 67	Sand	10	67 – 55	Clay	2	--	--	--	54.8
245	80 – 73	Sand	17	73 – 67	Sand	6	--	--	--	67.4
442	80 – 71	Sand	10	71 – 68	Clay	9	68 – 62	Sand	2	62.2
B-632	77 – 67	Sand	7	67 – 52	Clay	3	52 – 38	Sand	6	38.1
B-633	77 – 63	Clay	4	63 – 54	Clay	2	54 – 47	Sand	9	47.4
B-734	79 – 70	Clay	9	70 – 59	Clay	5	59 – 47	Clay	1	43.9
B-735	80 – 73	Clay	5	73 – 67	Clay	2	67 – 62	Clay	9	62.2
C823	80 – 70	Clay	10	70 – 64	Clay	5	64 – 53	Sand	15	53.1
C824	80 – 63	Clay	10	63 – 47	Sand	15	47 – 34	Sand	25	33.6
C-834	80 – 69	Clay	7	69 – 66	Clay	10	66 – 63	Sand	40	62.9
C-835	80 – 74	Clay	5	74 – 55	Clay	3	--	--	--	54.1
C-836	80 – 78	Clay	7	78 – 76	Sand	20	76 – 61	Clay	7	60.4
C-837	80 – 75	Clay	10	75 – 60	Clay	7	60 – 51	Clay	5	51.0

The data shows no apparent trend in material type as a function of depth. This is misleading, however, as most of the layer descriptions contained both sand and clay constituents. Also, as will be shown from the laboratory test results, in many cases particularly in the upper soil layers, the difference in percentages between the coarse and fine fractions is only a couple of points. In general, softer material was encountered below a depth of approximately 10 feet. It is also evident that the depth to the Santee Limestone varies.

A plot of N_{60} values as a function of elevation is provided as Figure 1. A review of this figure yields the following conclusions:

- N-values in soil materials located above the Santee Limestone are generally less than 15.
- Above Elevation 74 feet, there is general agreement among C-834, C-835, C-836 and B-735. N-values from B-734 and C-837 tend to be 5 to 7 blows per foot higher.
- Below Elevation 74 feet, there is general agreement among C-834, C-836, and C-837. C-835 indicates N-values approximately 4 blows per foot lower.
- CPT soundings C-835 and C-837 show a general trend of decreasing N-value with depth, while soundings C-834 and C-836 are relatively constant. B-734 also shows a general decrease in N-value as a function of depth.
- CPT sounding C-835, which is co-located with Boring B-734, generally has the lowest N-values.

From a review of Figure 1, it is reasonable to conclude that subsurface conditions in the location of B-734/C-835 are not as good as those encountered in the other CPT soundings. This conclusion is further supported by a review of the plot of peak shear strength as a function of elevation, provided as Figure 2. This figure also demonstrates the shear strength profile in CPT sounding C-835 at elevations below 74 feet is lower than the other soundings.

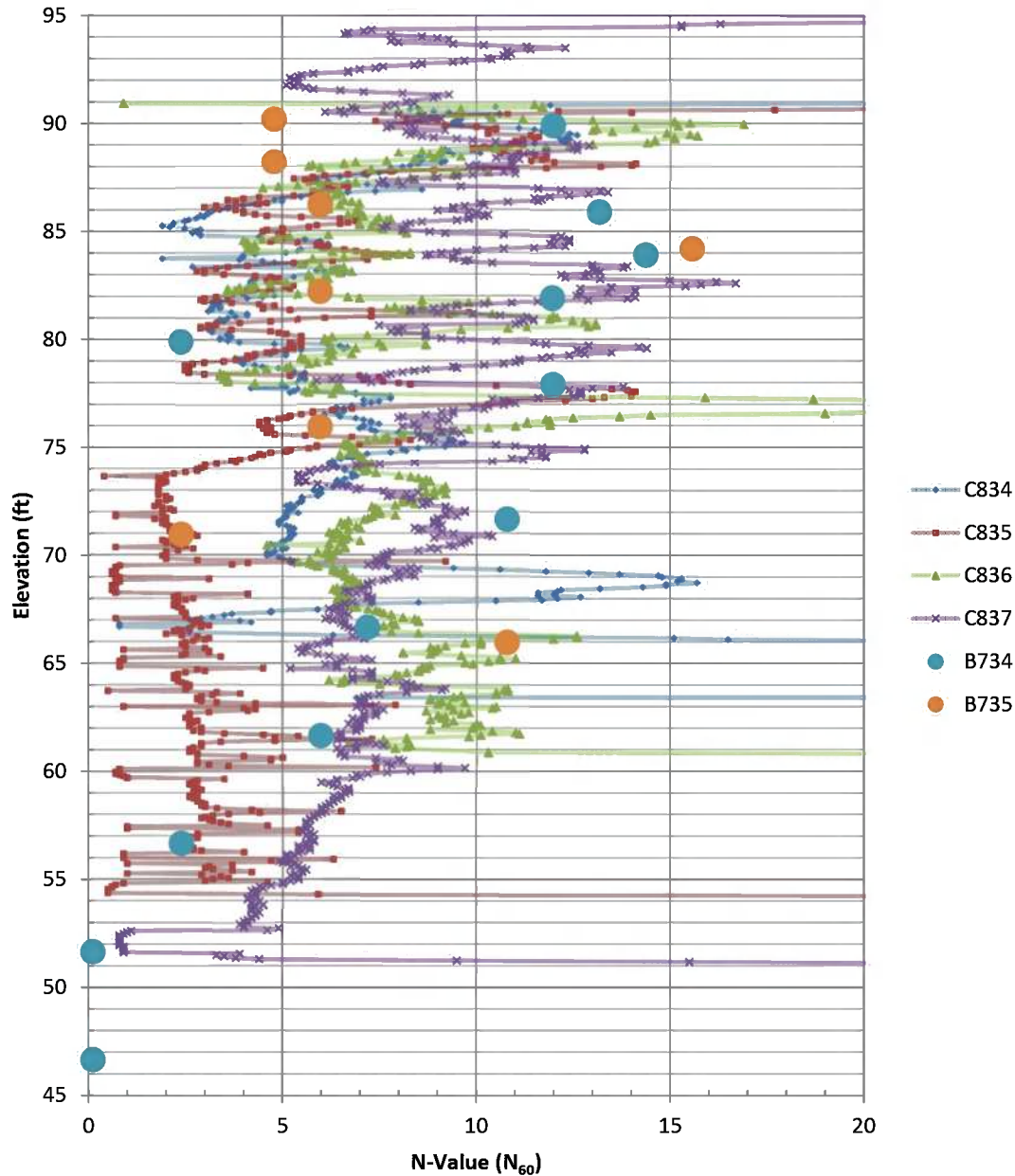
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Figure 1

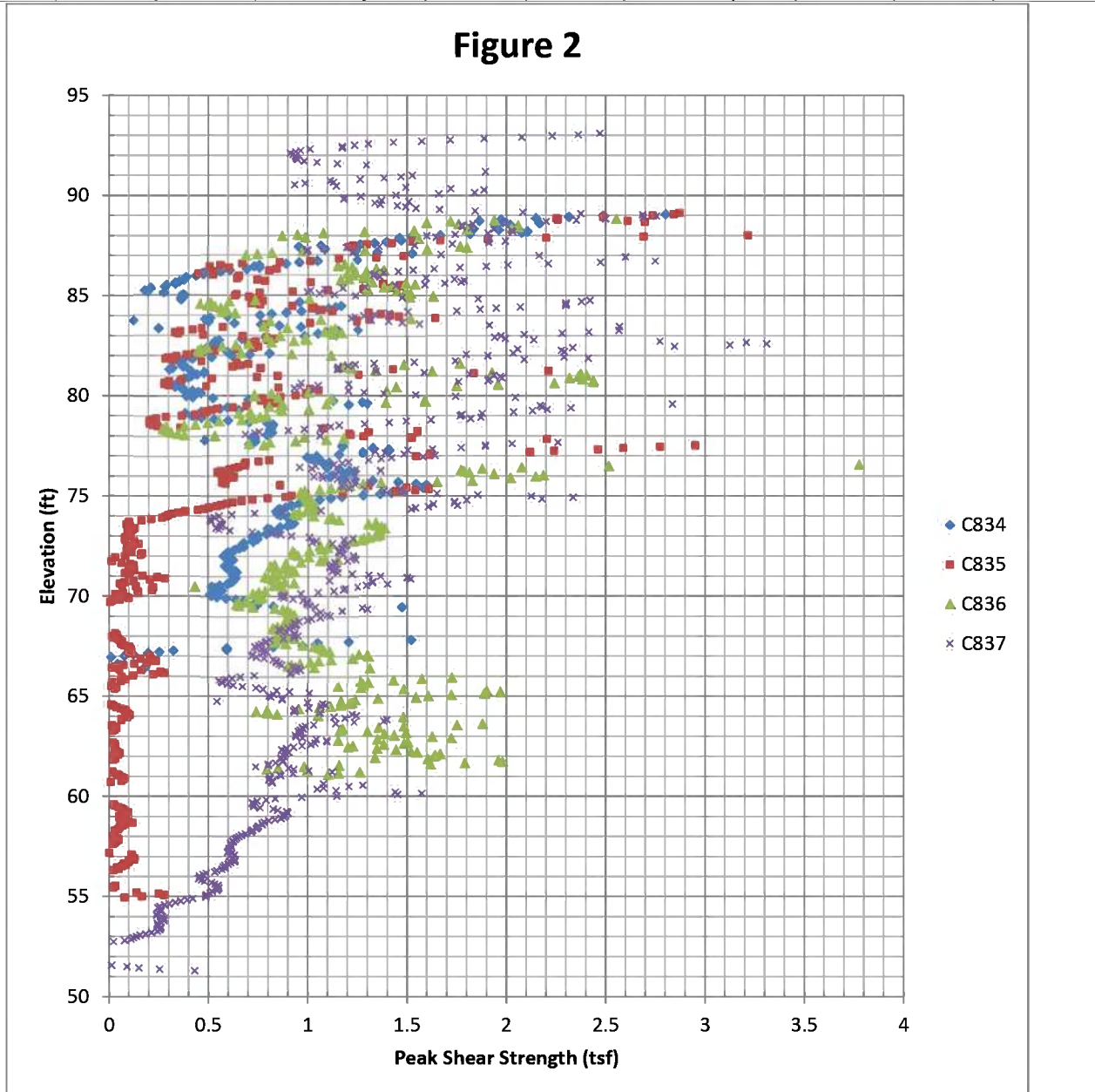


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Based on the boring and CPT data, the location of Boring B-734 / CPT sounding C-835 was determined to be the critical cross section. This location was selected for the following reasons:

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1. Based on review of the ash basin plan [Ref. 1] and site topographic mapping [Ref. 9], this location has the largest change in elevation from the toe to the crest of the embankment (highest slope).
2. The depth to the limestone bedrock layer was generally greater than at the other sounding locations (deepest soils).
3. As shown in Figure 2, the CPT-derived undrained shear strength below an elevation of approximately 74 feet is lower than the shear strengths recorded at the other sounding locations (softest soils).

5 SURFACE WATER AND GROUNDWATER CONDITIONS

Groundwater levels at the site vary seasonally from approximately Elevation 73 to Elevation 78 feet. The groundwater level in Boring B-734 after drilling was 18 feet, or Elevation 73. This elevation corresponds reasonably well to the data for well CAP-8, closest to the critical section, from the July 2014 Potentiometric Map (Appendix D). This map also shows that there is minimal seepage through the lined impoundment, as water levels at the piezometers are closer in elevation to groundwater than the water level in the pond. Since the groundwater fluctuates seasonally, a groundwater elevation of 78 feet was used for the analyses.

The normal pool elevation within the bottom ash pond is Elevation 88 feet [Ref. 2]. For the maximum surcharge pool elevation, the water level in the basin was taken as Elevation 91 feet, which corresponds to the top of the embankment. The water in the basin will flow out of the emergency overflow before overtopping the embankment, so it is conservative to assume the water level is at the top of the embankment.

6 EVALUATION OF SOIL PROPERTIES

6.1 Embankment and Near Surface Soils

Selected laboratory classification test results from the 2015 Terracon borings are summarized in Table 2. Laboratory test data is included as Appendix E.

Table 2: Summary of Soil Classification Data

Boring	Depth (ft)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Fines Content (%)	USCS Classification
B-734	2 - 4	17	44	32	62	CL
	6 - 8	23	42	24	49	SC
	10 - 12	39	40	26	41	SC
	12 - 14	15	36	23	--	CL
	18.5 - 20	17	29	15	--	CL
	23.5 - 25	31	57	40	--	CH
	28.5 - 30	44	74	52	81	CH
	33.5 - 35	50	44	26	69	CL
	38.5 - 40	64	84	64	67	CH
B-735	2 - 4	17	44	29	--	CL
	4 - 6	27	50	31	45	SC
	8 - 10	18	37	22	46	SC
	12 - 14	22	30	19	55	CL

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As shown in Table 2, the upper 14 feet of soils in both borings have similar characteristics. This range of soil depths generally encompasses the constructed embankment of the ash basin and the top several feet of the anticipated natural site soils. Since the embankments were reportedly constructed of materials excavated from on-site soil borrow areas, the similarity in soil properties is not unexpected. Within this upper zone, soil moisture contents are generally closer to the plastic limit of the soil than to its liquid limit. The fines percentages also vary between approximately 40 and 60, resulting in typical soil classifications of clayey sand (SC) and sandy lean clay (CL).

The similarity in these soils is also evident from the soil strength and density tests, which are summarized in Table 3. From the four test results, the effective friction angle varied from approximately 29 to 33 degrees (a difference of 4 degrees), and the apparent cohesion varied from 2.9 to 4.0 psi. Average moist soil densities ranged from approximately 122 pounds per cubic foot (pcf) to 130 pcf.

Table 3: Embankment Soil Strength Summary

Boring	Depth (ft)	Average Dry Sample Unit Wt. (pcf @ % moisture)	Test Type	Effective Stress		Undrained Shear Strength (psi)
				Friction Angle	Cohesion (psi)	
B-734	2 - 4	110 @ 16.4	Direct Shear	31.6	2.9	--
	6 - 8	111.3 @ 15.7	Cons. Undrained Triaxial	29.9	3.5	8.5, 11.5
B-735	4 - 6	97.8 @ 25.1	Direct Shear	33.3	3.0	--
	8 - 10	107.7 @ 20.8	Cons. Undrained Triaxial	29.2	4.0	9.0, 12.1

Undrained shear strength was evaluated in accordance with Section 5.6.4.2 of GEC 5 [Ref. 3], which states "The recommended approach for evaluating undrained shear strengths from CU tests for saturated soils for use in short-term total stress analyses includes developing a relationship between undrained shear strength S_u (which assumes $\phi = 0$) and vertical effective stress. ... An important issue relative to the interpretation of CU tests for total stress undrained analyses, is that a total stress friction angle and cohesion intercept, i.e. ϕT and cT that may be calculated from a Mohr circle representation of the total stresses at failure from CU tests, should not be used for analyses that assume undrained conditions."

Therefore, as shown on the laboratory test data in Appendix E, the results were re-interpreted using the $\phi = 0$ concept. The resulting shear strengths at failure were 8.5 and 11.5 psi for the sample from Boring B-734 and 9.0 and 12.1 psi for the sample from Boring B-735. The consolidation stresses used in both cases were 5.2 and 10.4 psi, respectively.

Based on the understanding that the embankments for the ash basin were constructed of soils obtained from on-site borrow areas, it is reasonable to assume the soils at different locations along the embankments, as well as the near-surface soils away from the embankments, have similar characteristics, and as such, could be modeled as a single layer. Figures 1 and 2 demonstrate the similarity in SPT N-value and peak shear strength above elevation 74 feet. Laboratory test results show similar moisture contents, Atterberg Limits, and fines contents for the soils encountered in Borings B-734 and B-735. The soil strength tests also confirm that the upper soil layers in these two borings have similar properties. Therefore, for the purposes of these stability analyses, it is reasonable to model the ash basin embankment and upper site soil as a single layer.

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For modelling purposes, a moist unit weight of 130 pcf was used. For analyses using drained strength parameters, an effective friction angle of 30 degrees was used, along with 50 psf of apparent cohesion. The cohesion value was less than 10 percent of the cohesion reported in the laboratory test results, and was used primarily to prevent the model from predicting unrealistically shallow surface sloughing type failures.

For analyses using undrained shear strengths, the friction angle was taken as zero and the cohesion was linearly interpolated from the triaxial test results. For a layer thickness of 17 feet (Elevation 91 to Elevation 74), the midheight of the layer was 8.5 feet. Using an assumed 130 pcf soil moist unit weight results in an overburden pressure of 1105 psf, or 7.7 psi, at a depth of 8.5 feet. This result is approximately half of the difference between the confining pressures of 5.2 psi and 10.4 psi used in the triaxial tests. Therefore, the peak undrained shear strength is approximately 50 percent of the difference of 3.0 psi between the test results. Fifty percent of 3.0 psi is approximately 1.5 psi, resulting in peak shear strengths at the midheight of the layer between $8.5 + 1.5 = 10.0$ and $9.0 + 1.5 = 10.5$ psi. Therefore, 10 psi, or 1440 psf, was used.

6.2 Underlying Soils

As shown in Figures 1 and 2, there is a marked decrease in both SPT N-value and peak shear strength below Elevation 74 feet in Boring B-734/ CPT sounding C-835. It seems reasonable to use this elevation as the demarcation between the upper site and embankment soils and the lower site soils. Table 1 also shows soils with lower N-values were more commonly encountered below an elevation of approximately 70 feet. The soil classification results in Table 2 for Boring B-734 below a depth of 14 feet indicate predominately sandy lean clay (CL) and fat clay with sand (CH). Compared to the embankment soils, the fines contents are generally higher (above 67 percent), and the moisture contents are closer to the liquid limit than the plastic limit. For the sample from 33.5 to 35 feet, the moisture content was higher than the liquid limit.

The soil properties of these materials were based on empirical correlations with CPT and SPT data as well as laboratory test results on undisturbed samples from previous geotechnical explorations. The plot of unit weight versus elevation in Figure 3 indicates most of the data below Elevation 74 falls in a range between 98 and 108 pcf, with a significant amount of scatter, particularly between 110 and 120 pcf. A moist unit weight of 102 pcf was used for the analyses; however, the results from the slope stability program are not particularly sensitive to soil unit weight. The unit weight plotted from the CPT data for the upper soil layer is considerably lower (approximately 115 pcf) than the 130 pcf obtained from the laboratory test data. However, the value of 102 pcf is in general agreement with the test results on samples of assumed cl type material obtained from the B-600 series borings (94 to 108 pcf) [Ref. 9] at depths of approximately 13 to 24 feet.

The effective stress friction angle was interpreted from the friction angles for triaxial tests performed on CH and CL samples from the 200- series borings [Ref. 5], as shown in Table 4, and included in Appendix E. Since cohesion is typically assumed to be negligible for the long term drained strength of assumed normally consolidated materials, the test results were re-interpreted to develop the same shear stress with no effective cohesion.

Table 4: 200- Series Borings Effective Stress Shear Strength

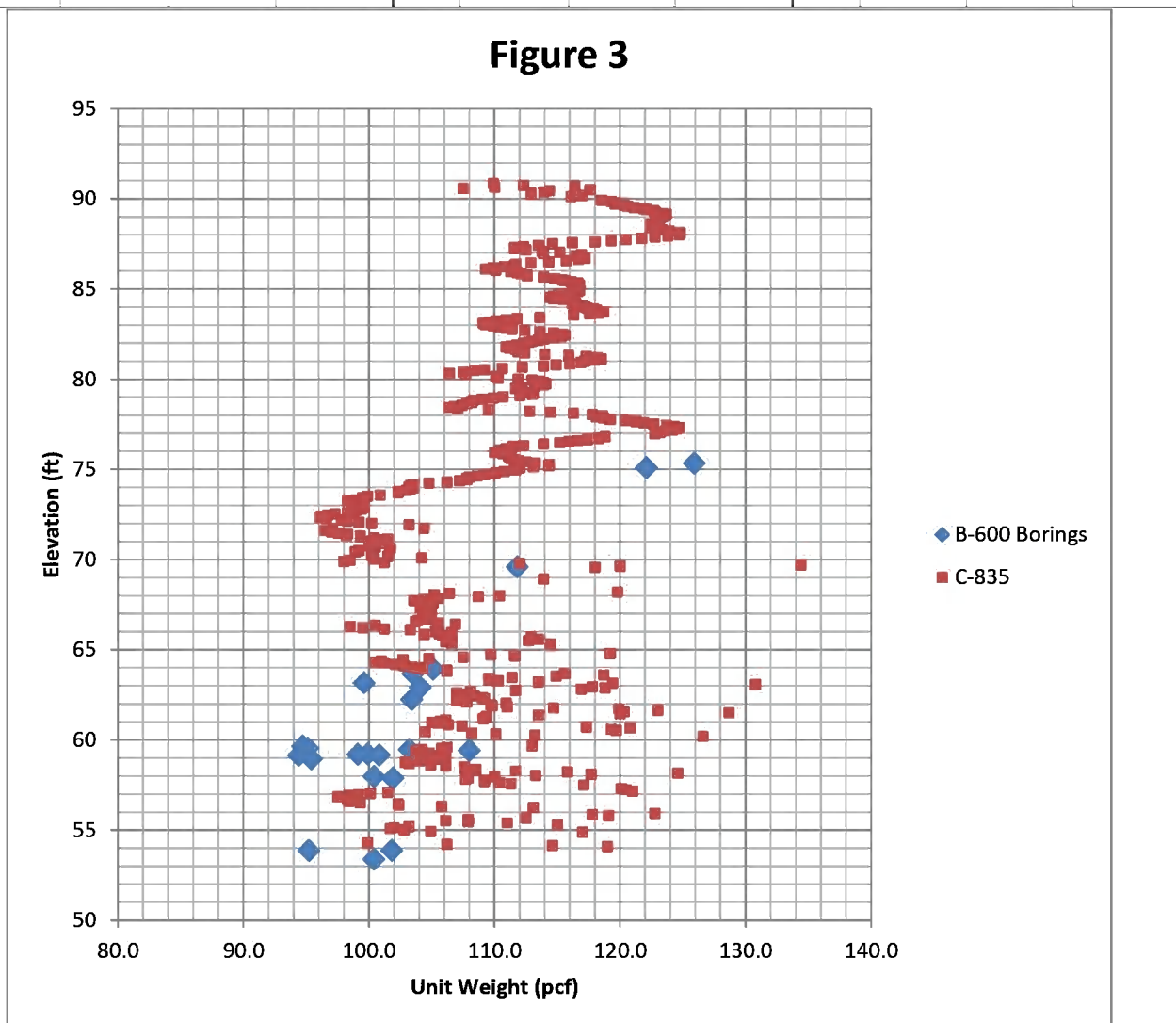
Boring	Depth (ft)	Effective Cohesion (psf)	Friction Angle (degrees)	Shear Stress at 44 feet (psf)	Equivalent Friction Angle (degrees)
221A	5.5 - 7.5	190	19	1233	22.1
224	5 - 7	260	16.1	1135	20.5
244	15.5 - 17.5	630	12	1274	22.8

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This evaluation was performed using the equation $\tau = c + \sigma \tan \phi$, where τ is shear stress, c is cohesion, σ is normal stress (overburden pressure), and ϕ is the friction angle. Although conservative, the normal stress at the bottom of the lower layer (i.e. the top of rock, approximately 44 feet from Boring B-734) was used in the calculation as for a given shear stress, the larger the normal stress the lower the friction angle.

Using the data from Boring 221A as an example, the normal stress (σ) is taken as 13 feet at 130 pcf (the upper soil layer above the water table) plus 4 feet at $130 - 62.4 = 67.6$ pcf (the upper soil layer below the water table) plus 27 feet at $102 - 62.4 = 39.6$ pcf. The resultant σ is $130(13) + 4(67.6) + 27(39.6) = 3030$ psf at 44 feet. The shear stress $\tau = 190 + 3030 \tan 19 = 1233$ psf. The equivalent friction angle is given by $\phi = \tan^{-1}(\tau / \sigma)$ or $\tan^{-1}$

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(1233/3030) = 22.1 degrees. The average of the three re-interpreted test results was approximately 22 degrees, which was used in the analyses.

As evident from Figure 4 [Ref. 8], the friction angle of 22 degrees is less than the friction angle that would be predicted by the correlation with plasticity index. Plasticity indices ranged from 15 to 64 for the soil samples below a depth of 14 feet in Boring B-734. The friction angles corresponding to these plasticity indices would range from approximately 32 degrees to 25 degrees. Therefore, it would appear the effective stress friction angle of 22 degrees used for the analyses is conservative.

Figure 4

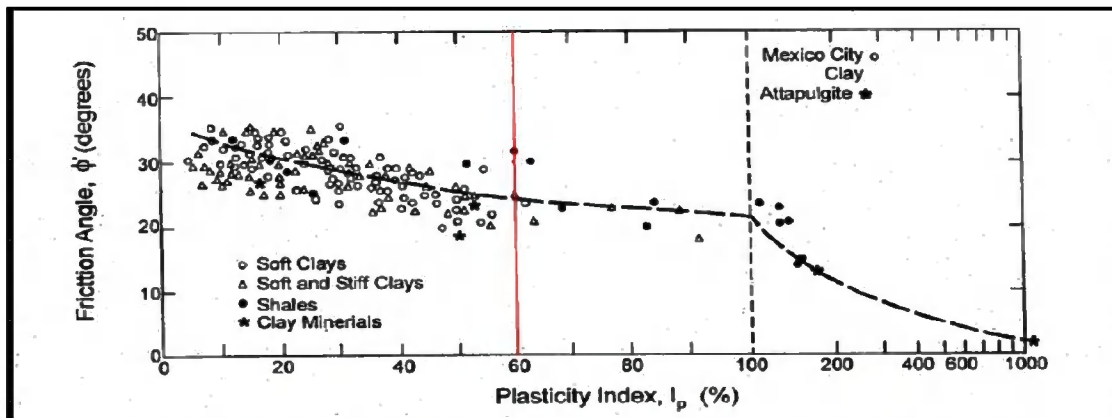


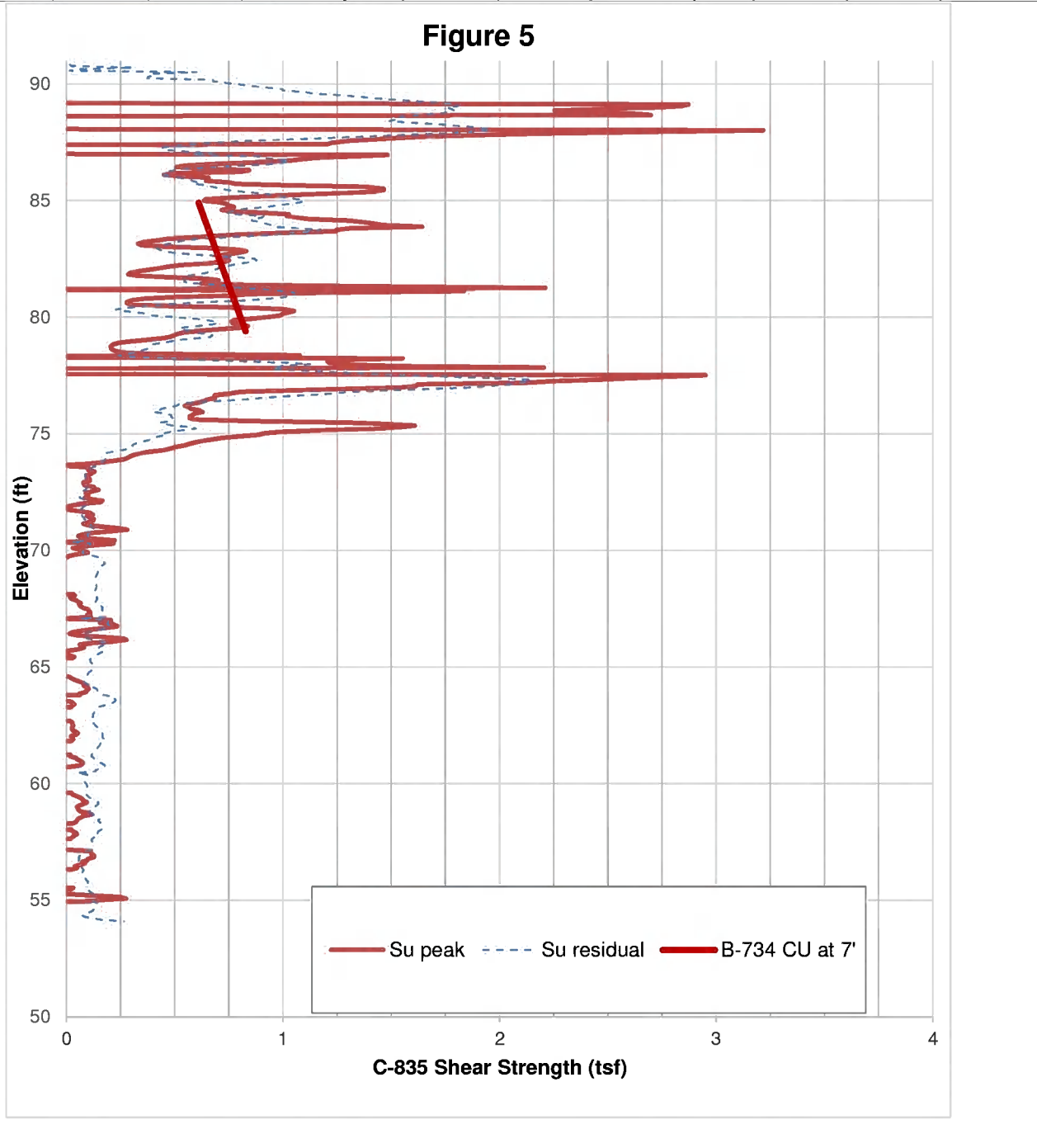
Figure 7-24. Plasticity Index versus Drained Friction Angle For NC Clays (Terzaghi, Peck, and Mesri, 1996)

Figure 5 is a plot prepared by Terracon of peak and residual undrained shear strength for CPT sounding C-835. The plot shows the peak undrained shear strength is generally less than the residual undrained shear strength below Elevation 74 feet. Physically that is not possible. Since the peak shear strength is a CPT-derived correlation, it is believed that the compressible nature of the material resulted in an underestimation of the peak shear strength. The residual shear strength is more of a direct measurement from the CPT sleeve, and is considered more reliable for this purpose. For analysis purposes, the peak undrained shear strength was conservatively assumed equal to the residual undrained shear strength, even though in reality the peak would be greater. A slightly conservative estimate of undrained shear strength of 0.1 tsf (200 psf) was used for the analyses.



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6.3 Bottom Ash

The bottom ash at Cross Generating Station is a coarse granular material. Testing performed by S&ME [Ref. 7] in 2006 on bulk samples from the ash ponds indicated maximum dry densities of 94 to 100 pcf on samples compacted to standard Proctor. A friction angle of approximately 35 degrees was also reported. The tested values were within the range of values reported in the literature referenced by S&ME. However, these values are representative of bottom ash in a compacted state. The bottom ash in the impoundment is sluiced, and therefore is expected to be loose, although the material in the impoundment is sufficiently dense to support vehicular traffic. Rather than characterize the strength of all the retained ash, the shear strength was assumed to be negligible. While this is a conservative assumption, the critical section for analysis is not influenced significantly by the strength of the retained ash. To account for the potential driving force of the bottom ash, a saturated unit weight of 95 pcf was assumed.

7 LIQUEFACTION EVALUATION

Based on a site specific seismic evaluation performed by Garrett & Moore in 2011 [Ref. 4] for the proposed Class III landfill, a peak ground acceleration (PGA) of 0.55g was recommended.

7.1 Methodology

The liquefaction potential of the granular subsoil was evaluated using the procedures in Reference 12 for the SPT and CPT data. The evaluation procedure is summarized as follows:

Factor of Safety Against Liquefaction

$$FOS = (CRR_{7.5}/CSR) * MSF * K\sigma * K\alpha$$

Where $CRR_{7.5}$ = Cyclic Resistance Ratio (CRR) for a 7.5-magnitude earthquake

CSR = Cyclic Stress Ratio

MSF = Magnitude Scaling Factor

$K\sigma$ = Correction Factor for Overburden Stress

$K\alpha$ = Correction Factor for Sloping Ground

If $FOS < 1.1$ and the soil layer is below the groundwater table, the soil is considered liquefiable.

Magnitude Scaling Factor (MSF)

$$MSF = 10^{2.24/M_w^{2.56}} \quad \text{For magnitudes} < 7.5$$

$$MSF = (M_w/7.5)^{-2.56} \quad \text{For magnitudes} > 7.5$$

Correction Factor for Overburden Stress $K\sigma$

$$K\sigma = 1.0 \quad \text{For } \sigma'_{vo} \leq P_a$$

$$K\sigma = (\sigma'_{vo}/P_a)^{(f-1)} \quad \text{For } \sigma'_{vo} > P_a$$

where σ'_{vo} is effective overburden pressure;

P_a is atmospheric pressure

f is an exponent that is a function of site conditions, including relative density, stress history, aging, and overconsolidation ratio.

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Correction Factor for Sloping Ground K_α

K_α is a correction factor to account for sloping ground. However, its use is currently not well defined, with a wide range of values proposed. For the purpose of this calculation, $K_\alpha=1.00$.

Evaluation of CSR

$$CSR=0.65(a_{max}/g)(\sigma_{vo}/\sigma'_{vo}) r_d$$

where a_{max} = peak horizontal acceleration at the ground surface generated by the earthquake;

g = acceleration of gravity;

$\sigma_{vo}, \sigma'_{vo}$ = total and effective vertical overburden stresses, respectively;

r_d = stress reduction coefficient.

$$r_d = \frac{1.0000 - 0.4113z^{0.5} + 0.04052z + 0.001753z^{1.5}}{1.000 - 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.001210z^2}$$

where z = depth beneath ground surface in meters. The r_d is conservatively limited on the lower bound to the value corresponding to a depth of 20 meters.

Evaluation of Liquefaction Resistance (CRR) Based on SPT

Correction of SPT Blow Count Data

$$(N_1)_{60} = N_m C_N C_E C_B C_R C_S$$

where N_m = measured standard penetration resistance;

C_N = factor to normalize N_m to a common reference effective overburden stress;

C_E = correction for hammer energy ratio (ER), $C_E = ER/60\%$, ER used in this calculation is based on actual equipment calibrations performed by Terracon;

C_B = correction factor for borehole diameter;

C_R = correction factor for rod length; and

C_S = correction for samplers with or without liners.

Correction of Fines Content

$$(N_1)_{60cs} = \alpha + \beta(N_1)_{60}$$

Where $\alpha=0$; $\beta=1.0$

$$\alpha = \exp[1.76 - (190/FC^2)]; \beta = 0.99 + FC^{1.5}/1000$$

$\alpha=5.0$; $\beta=1.2$

For $FC \leq 5\%$

For $5\% \leq FC \leq 35\%$

For $FC \geq 35\%$

Calculation of $CRR_{7.5}$

$$CRR_{7.5} = \frac{1}{34 - (N_1)_{60cs}} + \frac{(N_1)_{60cs}}{135} + \frac{50}{[10 \cdot (N_1)_{60cs} + 45]^2} - \frac{1}{200}$$

Evaluation of Liquefaction Resistance (CRR) Based on CPT

Soil Behavior Type Index I_c

$$I_c = [(3.47 - \log Q)^2 + (1.22 + \log F)^2]^{0.5}$$

Where $Q = [(q_c - \sigma_{vo})/P_a] [(P_a/\sigma'_{vo})^\eta]$

$$F = [f_s/(q_c - \sigma_{vo})] \times 100\%$$

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First Trial: Assuming $n=1.0$, if $I_c > 2.6$, the soil is classified as clayey and is considered too clay-rich to liquefy, and the analysis is complete. If $I_c \leq 2.6$, a second trial is made.

Second Trial: Assuming $n=0.5$, if $I_c < 2.6$, the soil is classified as nonplastic and granular, and the value of I_c is used for the later calculations. If $I_c \geq 2.6$, a third trial is made.

Third Trial: Assuming $n=0.7$, the value of I_c is used for the later calculations and the soil is classified as very silty and possibly plastic.

Normalization of Cone Penetration Resistance

$$q_{c1N} = C_Q(q_c/p_a)$$

Where $C_Q = (P_g/\sigma'_{vo})^n \leq 1.7$, and n is the value from the previous step.

Clean-Sand Equivalent Normalized Cone Penetration Resistance

$$(q_{c1N})_{cs} = K_c q_{c1N}$$

Use the value of I_c from the previous step.

$$K_c = 1.0$$

For $I_c \leq 1.64$

$$K_c = -0.403I_c^4 + 5.581I_c^3 - 21.63I_c^2 + 33.75I_c - 17.88$$

For $I_c > 1.64$

Calculation of $CRR_{7.5}$

$$CRR_{7.5} = 0.833[(q_{c1N})_{cs}/1000] + 0.05$$

For $(q_{c1N})_{cs} < 50$

$$CRR_{7.5} = 93[(q_{c1N})_{cs}/1000]^3 + 0.08$$

For $50 \leq (q_{c1N})_{cs} < 160$

For each test method, SPT and CPT, a spreadsheet was created to evaluate the liquefaction potential at each SPT and CPT location. Since the CCR rule specifically focused on the potential for liquefaction in the embankment soils, the soil unit weight for the embankment was used in these analyses. The printouts of the spreadsheets are included in Appendix F.

7.2 SPT Analysis

For the SPT based analysis, the logs for Borings B-734 and B-735 indicate granular soils at depths below 44 and 33 feet, respectively, so only those layers were evaluated. This evaluation is provided as Page 1 of Appendix F. The analysis indicates the interval from 44 to 47 feet in Boring B-734 is likely to be liquefiable. However, this layer does not comprise part of the embankment soils, and therefore is not subject to the liquefaction analysis required by the CCR rule. Also, as demonstrated in the stability analyses, this layer is too deep to affect the factor of safety, as the critical failure planes pass above it.

7.3 CPT Analysis

The liquefaction evaluations for the four CPT soundings (C-834, C-835, C-836, and C-837) are provided as pages 2 through 6 in Appendix F. Due to the volume of data from the CPT soundings (readings were obtained on approximately 3/4 - inch intervals), liquefaction was evaluated on both a per foot and a per interval basis. The per foot basis used tip resistance and sleeve friction averaged over each foot. Intervals were based on determinations of similar soil properties using professional judgement. In this manner, zones of soil with similar tip resistances and/or sleeve frictions were lumped together and the values averaged. These methods reduced the scatter in the data, making it easier to discern trends. Soil layers that were deemed potentially liquefiable are summarized in Table 5.

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resources & energy

Customer	Santee Cooper							Project No.	108008-01330			
Project Title	Cross Generating Station							Calc No.	CROSS-0-DC-044-CE-0003			
Calculation Title	Bottom Ash Pond Initial Safety Factor Assessment							Phase/CTR	LBRCRR			
Elec File Location	\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm											
								Page	18	of	128	
Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked	
0	14-OCT-16	B. Gordon	Y. Xu									

Table 5: Potentially Liquefiable Soil Zones on the Basis of CPT Testing

Sounding	Depths (per foot basis)	Depths (per interval basis)	Remarks
C-834	22 - 23	21.5 - 23.3	NA - Below natural ground
C-835	1 - 4	0 - 3.3	NA - Above the water table
		12.5 - 13.9	NA - Below natural ground
	36 - 36.8		NA - Just above CPT refusal
C-836	13 - 15	13.5 - 14.4	NA - Below natural ground
C-837	44 - 44.2	43.8 - 44.2	NA - Just above CPT refusal

On the basis of the CPT data, within the four soundings there were six zones identified that are potentially liquefiable. Two zones (one in C-835 and the other in C-837), less than one foot thick, are located just above the Santee Limestone layer, as indicated by the depths where CPT refusal occurred. These zones are too deep and too thin to affect the stability of the embankments.

The zone identified in sounding C-835, which was co-located with Boring B-734, from approximately 1 to 4 feet is in the embankment. Although the CPT sounding log assumed the water level at this location was at one foot, this zone is well above the recorded groundwater table of 13 feet, and even above the normal operating level of the basin. The adjacent boring log confirmed the greater depth to water, and also indicates sandy lean clay with uncorrected SPT N-values of 10 and 19. Therefore, this zone is not considered liquefiable.

A potentially liquefiable zone was also identified from approximately 12.5 to 13.9 feet in sounding C-835. This depth is similar to the zone identified in sounding C-836 (approximately 13 to 15 feet). These zones are below the existing ground surface elevation of approximately 80 feet, which corresponds to an approximate depth of 11 feet. Therefore, these areas also are not part of the dike. The other potentially liquefiable zone extended from approximately 21.5 to 23.3 feet in sounding C-834. This area is also below the embankment.

7.4 Liquefaction Summary

As stated in §257.73(e)(1)(iv) and further explained in the preamble to the CCR rule, liquefaction analysis applies only to CCR surface impoundments with dikes constructed of soils that have susceptibility to liquefaction. The bottom ash pond dike soils are not susceptible to liquefaction and, as such, §257.73(e)(1)(iv) does not apply.

The seismic analyses performed pursuant to §257.73(e)(1)(iii) account for any seismically-induced strength loss within the foundations soils, when applicable.

8 STABILITY ANALYSES

Evaluation of the various stability cases was performed using limit equilibrium methods. The computer program STABL6H, developed at Perdue University in cooperation with the Federal Highway Administration, was used. Safety factors for circular arc failures were calculated using the Modified Bishop Method. Block failure modes were also analyzed using the Modified Janbu Method. Analyses were performed for the following conditions: (i) long-term, maximum storage pool; (ii) maximum surcharge pool; (iii) seismic. As demonstrated in Section 7, embankment soils are not subject to liquefaction, so no further analysis was required.

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resources & energy

Customer	Santee Cooper							Project No.	108008-01330			
Project Title	Cross Generating Station							Calc No.	CROSS-0-DC-044-CE-0003			
Calculation Title	Bottom Ash Pond Initial Safety Factor Assessment							Phase/CTR	LBRCCR			
Elec File Location	\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm											
								Page	19	of	128	
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0	14-OCT-16	B. Gordon	Y. Xu									

The long-term, maximum storage pool condition models the stability of the downstream slope of the embankment under steady-state seepage with the reservoir at the normal operating pool elevation. The factor of safety was calculated using effective stress shear strengths and pore water pressures corresponding to long-term conditions.

The maximum surcharge pool elevation models the effect of a flood surcharge within the pond on the stability of the downstream slope of the embankment. As indicated in the preamble to the CCR rule, this evaluation is based on the assumption that the maximum surcharge pool loading condition exists for a length of time sufficient for steady-state seepage conditions to develop. As such, effective shear strength parameters are used for this analysis also.

Also as indicated in the preamble to the CCR rule, the seismic loading condition is based on a seismic event with a two percent probability of exceedance in 50 years, which is equivalent to a return period of 2500 years. For the analysis of the ash pond embankment at Cross, this evaluation was based on Chapter 7 of MSHA [Ref. 6]. Seismic stability was analyzed as a static (i.e. no seismic coefficient) limit-equilibrium slope stability problem, using post-earthquake shear strengths.

Susceptibility to strength loss was evaluated by first determining if the soil behavior was more like a sand or like a clay. As shown on Page 7 of Appendix F, most of the soils encountered were clay, consistent with the descriptions on the boring logs. The criteria for clay-like behavior includes having more than 35 percent of soil particles passing the No. 40 sieve, having more than 20 percent of the soil particles passing the No. 200 sieve, and having a Plasticity Index (PI) greater than 10. Based on MSHA methodology, soils potentially susceptible to strength loss have SPT N-values (N_{60}) of less than 6 for clay-like material. These soil layers are summarized in Table 6.

Table 6: Soils with Strength Loss Susceptibility

Boring	Depth (ft)	Soil Type	N-value	Remarks
B-734	10 - 12	Clay	2	At existing ground elevation
	33.5 - 35	Clay	2	
	38.5 - 40	Clay	0	
	43.5 - 45	Clay	0	
B-735	4 - 6	Clay	5	Above the water table
	23.5 - 25	Clay	2	

Only two zones identified as potentially susceptible to strength loss were within the upper soil layer. The layer from 10 to 12 feet in Boring B-734 is located at the approximate elevation of the natural ground surface. The zone from 4 to 6 feet in Boring B-735 is located above the water table, and therefore would not experience strength loss. A review of the liquefaction evaluation summary in Table 5 also shows that the layer from approximately 12.5 to 13.9 feet in sounding C-835 is potentially liquefiable. This layer is slightly deeper than the layer identified in Boring B-734, located just a few feet away. Another layer from approximately 13 to 15 feet in sounding C-836 is also potentially liquefiable.

Based on these results, portions of the lower soil layer are potentially susceptible to strength loss. In lieu of performing a formal triggering analysis, it was assumed that the earthquake would trigger strength loss. For stiff clay-like materials (the embankment and upper soil layer), the peak undrained strength was used for analysis. For soft clay-like materials (the lower soil zone), a lower bound value of the residual undrained shear

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Customer	Santee Cooper	Project No.	108008-01330
Project Title	Cross Generating Station	Calc No.	CROSS-0-DC-044-CE-0003
Calculation Title	Bottom Ash Pond Initial Safety Factor Assessment	Phase/CTR	LBRCR
Elec File Location	\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm		

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strength was used. Reference 6 indicates that this assumption is probably overly conservative. Also, the entire lower soil layer was modelled using residual undrained shear strength.

Since there were a couple of locations where localized zones of softer soils were observed within the upper soil layer, a second seismic analysis was performed, wherein the soils between Elevations 80 and 74 feet were assigned different soil properties. Based on Figure 5, a residual shear strength of 0.25 tsf (500 psf) was assigned to this layer.

The soil properties used in the various stability analyses are summarized in Table 7. As indicated previously, the normal and flood conditions were modelled using effective stress peak shear strength parameters. For the seismic condition, the peak undrained shear strength was used for the embankment soil. The value of 1440 psf obtained from interpolating the laboratory triaxial data corresponds well to the peak undrained shear strength shown in Figure 5. The lower portion of the embankment layer (corresponding to the original ground surface) was modelled conservatively as the residual undrained shear strength (500 psf). The lower soil layer also was modelled using residual undrained shear strength. As indicated in Reference 6, these values are probably overly conservative.

Table 7: Soil Properties

Layer	Normal Condition	Flood Condition	Seismic Condition	Lower Bound Seismic
Embankment Soil				
Moist Unit Weight (pcf)	130	130	130	130
Friction Angle (deg)	30	30	0	0
Cohesion (psf)	50	50	1440	1440
Soft Embankment Soil	Not Used	Not Used	Not Used	
Moist Unit Weight (pcf)				130
Friction Angle (deg)				0
Cohesion (psf)				500
Lower Soil (Clay)				
Moist Unit Weight (pcf)	102	102	102	102
Friction Angle (deg)	22	22	0	0
Cohesion (psf)	0	0	200	200
Bottom Ash				
Moist Unit Weight (pcf)	90	90	90	90
Friction Angle (deg)	0	0	0	0
Cohesion (psf)	0	0	0	0

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9 CONCLUSIONS

The output files and plots from the slope stability analyses are provided in Appendix G. The factors of safety are summarized in Table 8. The calculated factors of safety exceed the requirements of the CCR rule. Also, there are no soils within the embankment that are considered liquefiable.

Table 8: Calculated Factors of Safety

CCR Rule Reference	Analysis Condition	File Name	Circular Factor of Safety	Block Factor of Safety	Required Factor of Safety
257.73(e)(1)(i)	Maximum Storage	Cross734normalconditions	1.78	1.72	1.50
257.73(e)(1)(ii)	Maximum Surcharge	Cross734floodconditions	1.75	1.60	1.40
257.73(e)(1)(iii)	Seismic	Cross734seismicconditions	1.66	2.64	1.00
257.73(e)(1)(iii)	Seismic	Cross734seismicconditions_lower bound2	1.22	1.78	1.00
257.73(e)(1)(iv)	Liquefaction	Not Applicable			1.20

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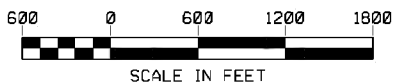
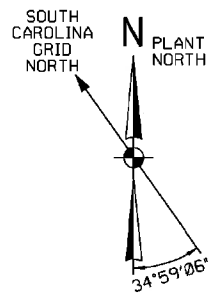


Customer				Santee Cooper				Project No.		108008-01330		
Project Title				Cross Generating Station				Calc No.		CROSS-0-DC-044-CE-0003		
Calculation Title				Bottom Ash Pond Initial Safety Factor Assessment				Phase/CTR		LBRCR		
Elec File Location				\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm								
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Appendix A – Site Location and Cross Section Plans

(3 total pages)

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DRAWN BY	KPF	ENGINEER	F.M. WOOD
CHECKED BY	J.A. WEIST	PROJECT ENGINEERING MANAGER	
LEAD DESIGNER	K.P. FEEG	PROJECT MANAGER	
DATE	01/19/16	REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.	
DATE		REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED 'HOLD' RETAINS PRELIMINARY STATUS.	



OneWay

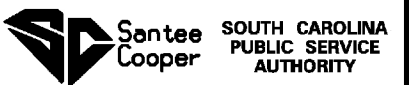
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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF

PRO. NO. _____ STATE _____ DATE _____

LIC. NO. _____

CROSS GENERATING STATION



BOTTOM ASH POND
SITE LAYOUT PLAN

SCALE AS SHOWN DRAWING SIZE ARCH D (36" x 24") JOB NO. 105008-01338

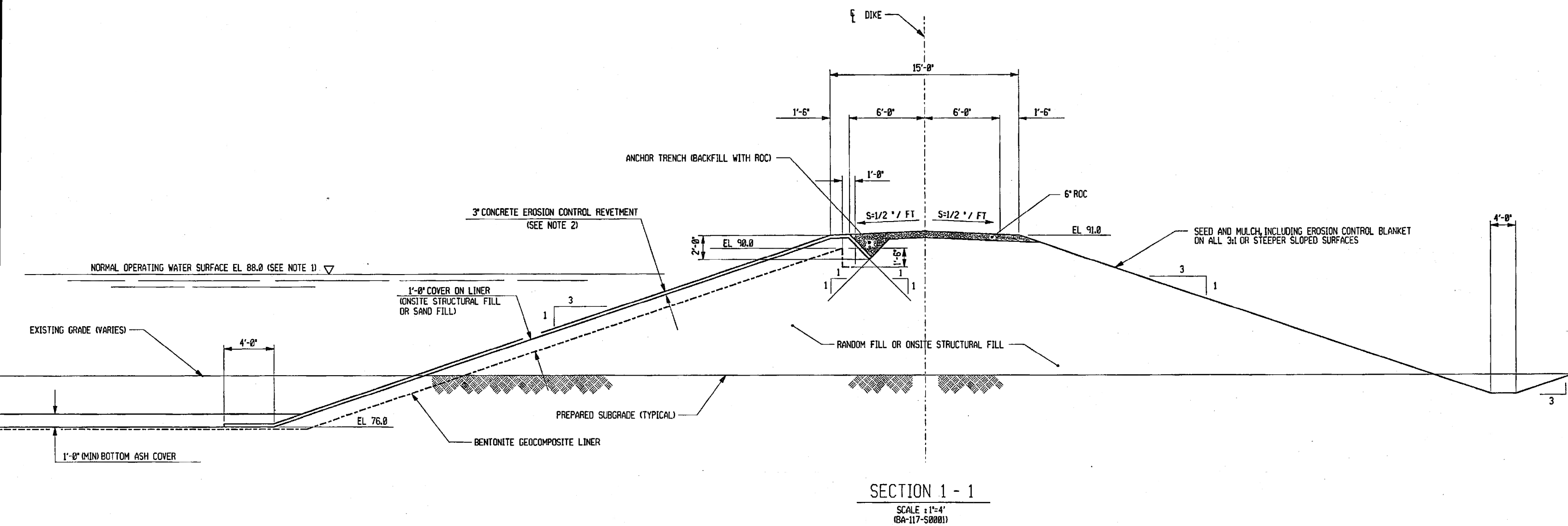
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PLAN

ISSUED FOR INFORMATION	B	01/19/16	KPF	FPM	KPF	FPM	FPM
ISSUED FOR INFORMATION	A	11/20/15	KPF	FPM	KPF	FPM	FPM
DATE	REV						

LEAD DISC ENGINEER	FPM	FPM	FPM
ENGINEER/TECH. SPEC.	KPF	FPM	FPM
LEAD DESIGNER	KPF	FPM	FPM
CHECKED	KPF	FPM	FPM
DRAWN	KPF	FPM	FPM

DESIGNER: F.M. WOOD
CHECKER: J.A. WEIST
DATE: 01/19/16



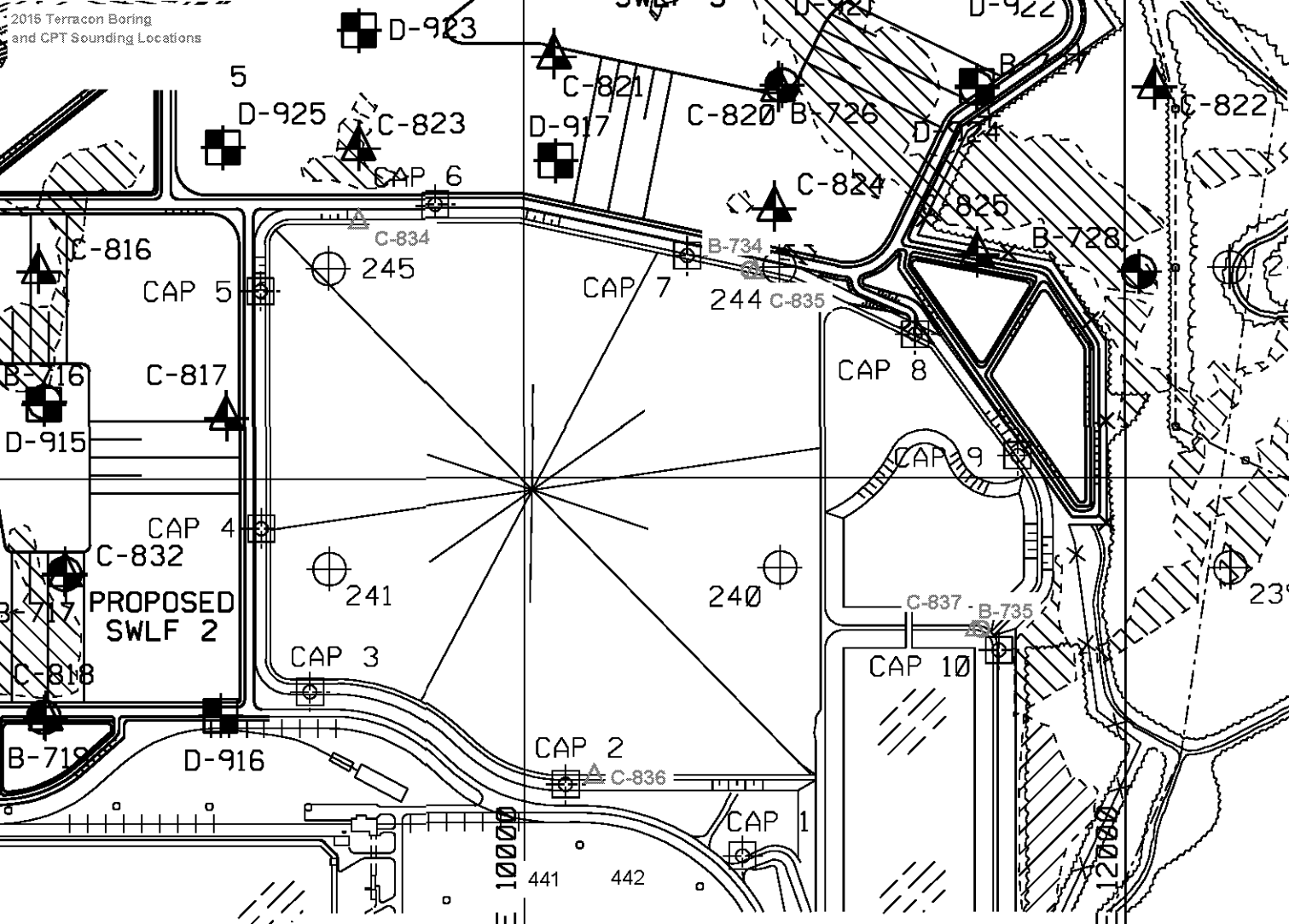


Customer				Santee Cooper					Project No.		108008-01330		
Project Title				Cross Generating Station					Calc No.		CROSS-0-DC-044-CE-0003		
Calculation Title				Bottom Ash Pond Initial Safety Factor Assessment					Phase/CTR		LBRCCR		
Elec File Location				\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm									
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Appendix B – 2015 Terracon Subsurface Exploration and Laboratory Test Results

(8 total pages)

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BORING LOG NO. B-734

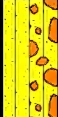
Page 1 of 1

PROJECT: Cross Generating Station- Ash Pond Dikes

CLIENT: Santee Cooper
Moncks Corner

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 33.377012° Longitude: -80.10171° Northing: 14692 Easting: 10701 Surface Elev.: 90.9 (Ft.)	DEPTH (FL.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
						TEST TYPE	COMPRESSIVE STRENGTH (tsf)	STRAIN (%)				
	DEPTH ELEVATION (FL.)											
	SANDY LEAN CLAY (CL) , tan to brown, stiff to very stiff -Shelby tube taken in offset boring between 2 to 4 feet	6.0	85	5	X	3-4-6-8 N=10						
					X	8-9-10-10 N=19			17		44-12-32	62
	CLAYEY SAND (SC) , tan, soft -Shelby tube taken in offset boring between 6 to 8 feet	12.0	79	10	X	2-2-9-10 N=11			20			
					X	4-6-6-7 N=12			23		42-18-24	49
	SANDY LEAN CLAY (CL) , reddish brown to gray, stiff			15	X	2-4-6-7 N=10			22		40-14-26	41
					X	1-1-1-1 N=2			39		40-14-26	41
	SANDY LEAN CLAY (CL) , reddish brown to gray, stiff			15	X	3-4-6-8 N=10			15		36-13-23	
					X	3-3-6 N=9			17		29-14-15	
	FAT CLAY WITH SAND (CH) , gray, medium stiff	21.0	70	20	X	2-2-4 N=6			31		57-17-40	
					X	1-2-3 N=5			44		74-22-52	81
	SANDY LEAN CLAY (CL) , gray to tan, soft to medium-stiff	32.0	59	30	X	1-1-1 N=2			50		44-18-26	69
					X	WOH-WOH-WOH N=0			64		84-20-64	67
	SANDY FAT CLAY (CH) , gray, soft	38.0	53	40	X	WOH-WOH-WOH N=0			42		43-32-11	35
					X	13-28-15 N=43						
	SILTY SAND (SM) , trace gravel, gray	44.0	47	45	X	26-50/2" N=100						
	SILTY SAND (SM) , gray, dense to very dense, strong cementation, (Weathered Santee Limestone)	47.0	44	50	X							
	Boring Terminated at 55 Feet	55.0	36	55	X							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
SPT energy 71.9%

Advancement Method:
mud rotary

See Exhibit A-3 for description of field procedures.

Notes:

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

WATER LEVEL OBSERVATIONS

13.4 ft after casing removed
18 ft at end of day

after boring completion

Terracon
1450 5th Street West
North Charleston, South Carolina

Boring Started: 10/8/2015

Boring Completed: 10/8/2015

Drill Rig: CME-45

Driller: J. Pawless

Project No.: EN131025

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL EN131025 CGS ASH POND.GPJ TERRACON2015.GDT 11/9/15

BORING LOG NO. B-735

Page 1 of 1

PROJECT: Cross Generating Station- Ash Pond Dikes

CLIENT: Santee Cooper
Moncks Corner

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

GRAPHIC LOG	LOCATION See Exhibit A-2		DEPTH (FL)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS		PERCENT FINES
	Latitude: 33.373027° Longitude: -80.101761° Northing: 13447 Easting: 11565	Surface Elev.: 95.2 (Ft.)					DEPTH	ELEVATION (FL)	TEST TYPE			COMPRESSIVE STRENGTH (tsf)	STRAIN (%)	
	<u>SANDY LEAN CLAY (CL)</u> , reddish brown, very stiff					9-8-12-9 N=20								
	4.0	91				7-9-11-12 N=20			17		44-15-29			
	<u>CLAYEY SAND (SC)</u> , with silt, brown, soft to medium-stiff -Shelby tube taken in offset boring between 4 to 6 feet -Shelby tube taken in offset boring between 8 to 10 feet		5			3-2-2-2 N=4			27		50-19-31	45		
						2-2-2-2 N=4			32					
	<u>SANDY LEAN CLAY (CL)</u> , gray to brown, medium stiff		10			3-3-2-2 N=5			18		37-15-22	46		
	12.0	83				4-4-9-10 N=13			12					
	<u>SANDY LEAN CLAY (CL)</u> , gray to brown, medium stiff		15			2-2-3-3 N=5			22		30-11-19	55		
	<u>FAT CLAY (CH)</u> , gray, whit to tan, loose		20			2-2-3-3 N=5			22		47-16-31			
	22.0	73												
	<u>SANDY LEAN CLAY (CL)</u> , gray, whit to tan		25			1-1-1-1 N=2			37		56-20-36	91		
	28.0	67												
	<u>SANDY LEAN CLAY (CL)</u> , gray, whit to tan		30			3-4-5 N=9			25		39-15-24			
	33.0	62												
	<u>SILTY SAND (SM)</u> , gray, dense to very dense, strong cementation, (Weathered Santee Limestone)		35			5-19-27 N=46								
	<u>SILTY SAND (SM)</u> , gray, dense to very dense, strong cementation, (Weathered Santee Limestone)		40			16-20-26 N=46								
	<u>SILTY SAND (SM)</u> , gray, dense to very dense, strong cementation, (Weathered Santee Limestone)		45			8-15-26 N=41								
	<u>SILTY SAND (SM)</u> , gray, dense to very dense, strong cementation, (Weathered Santee Limestone)		50			28-32-50/2" N=100					NP			
	50.0	45												
Boring Terminated at 50 Feet														

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
SPT energy 71.9%

Advancement Method:
mud rotary

See Exhibit A-3 for description of field procedures.

Notes:

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

WATER LEVEL OBSERVATIONS

13 ft after casing removed
17.6 ft at end of day

after boring completion

Terracon
1450 5th Street West
North Charleston, South Carolina

Boring Started: 10/8/2015

Boring Completed: 10/8/2015

Drill Rig: CME-45

Driller: J. Pawless

Project No.: EN131025

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL EN131025 CGS ASH POND.GPJ TERRACON2015.GDT 11/16/15

CPT LOG NO. C-834

Page 1 of 1

PROJECT: Cross Generating Station- Ash Pond
Dikes

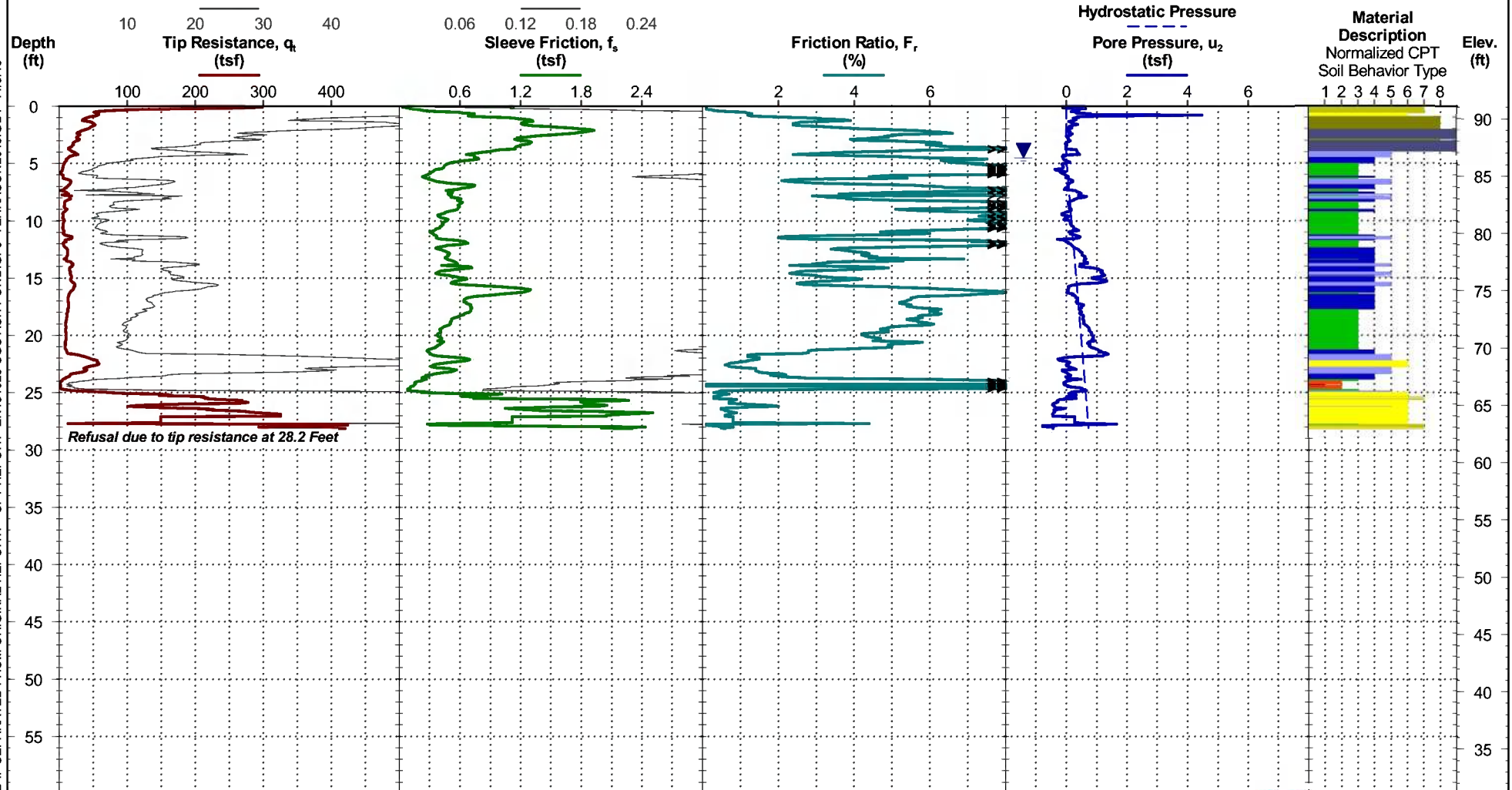
CLIENT: Santee Cooper
Moncks Corner

TEST LOCATION: See Exhibit A-2

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

Surface Elev.: 91.1 ft
LL: 33.3796°,-80.10488°
NE: 14899,9355



See Exhibit A-3 for description of field procedures.
See Appendix C for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 1 Sensitive, fine grained
- 2 Organic soils - clay
- 3 Clay - silty clay to clay
- 4 Silt mixtures - clayey silt to silty clay
- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravelly sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff fine grained

WATER LEVEL OBSERVATION

4.5 ft estimated water depth
(used in normalizations and correlations;
see Appendix C)

Probe no. 4675 with net area ratio of 0.84
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 10/22/2015
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 5th Street West
North Charleston, South Carolina

CPT Started: 10/9/2015

Rig: Pagani TG73-200

Project No.: EN131025

CPT Completed: 10/9/2015

Operator: J. Bandle

Exhibit: A-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT EN131025 CGS ASH POND.GPJ TERRACON2015.GDT 11/9/15

CPT LOG NO. C-835

Page 1 of 1

PROJECT: Cross Generating Station- Ash Pond
Dikes

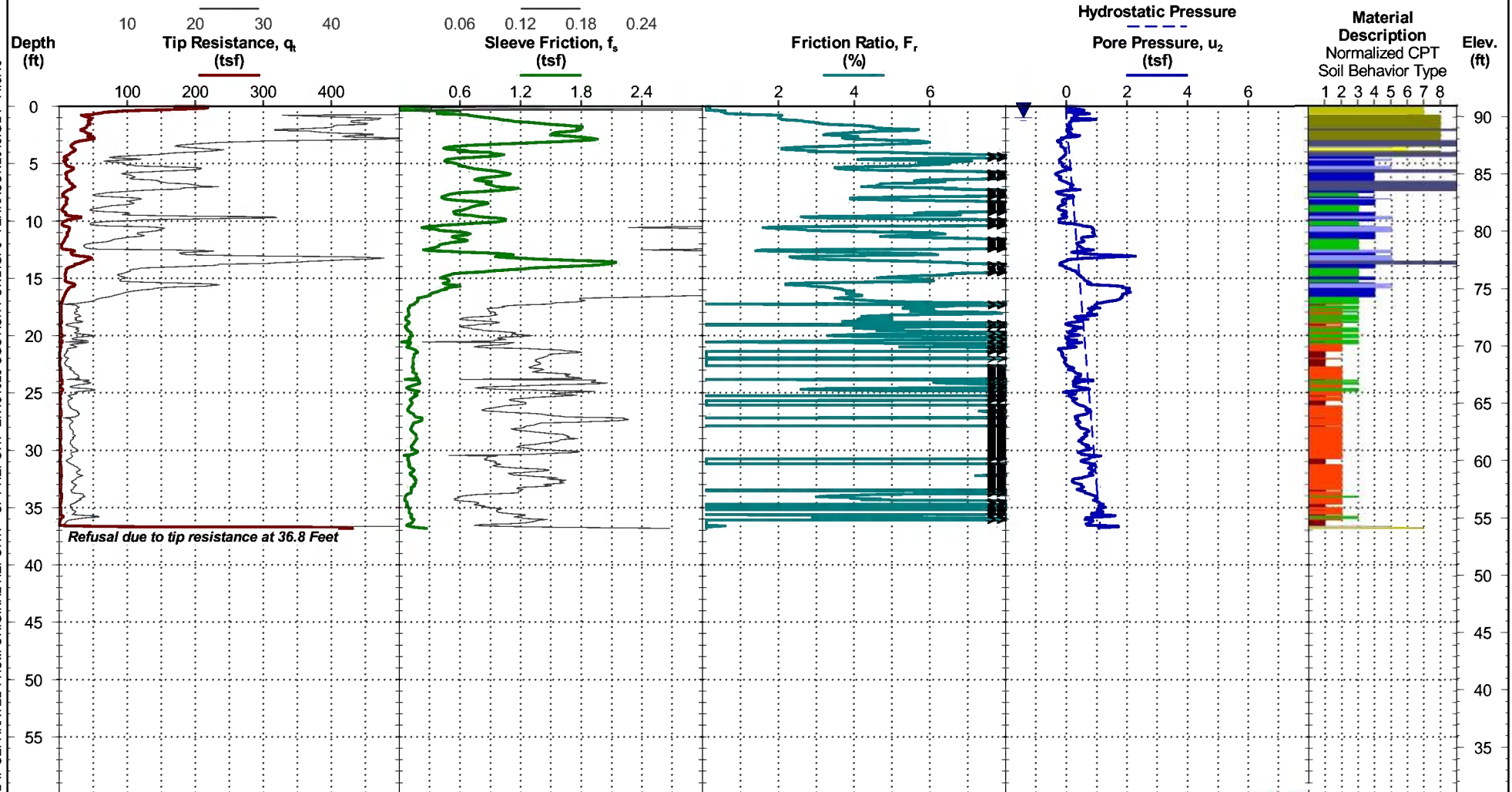
CLIENT: Santee Cooper
Moncks Corner

TEST LOCATION: See Exhibit A-2

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

Surface Elev.: 90.9 ft
LL: 33.37689°, -80.10157°
NE: 14692,10701



See Exhibit A-3 for description of field procedures.
See Appendix C for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

WATER LEVEL OBSERVATION

1 ft estimated water depth
(used in normalizations and correlations;
see Appendix C)

Probe no. 4675 with net area ratio of 0.84
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 10/22/2015
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 5th Street West
North Charleston, South Carolina

CPT Started: 10/9/2015

Rig: Pagani TG73-200

Project No.: EN131025

CPT Completed: 10/9/2015

Operator: J. Bandle

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT EN131025 CGS ASH POND.GPJ TERRACON2015.GDT 11/9/15

CPT LOG NO. C-836

Page 1 of 1

PROJECT: Cross Generating Station- Ash Pond
Dikes

CLIENT: Santee Cooper
Moncks Corner

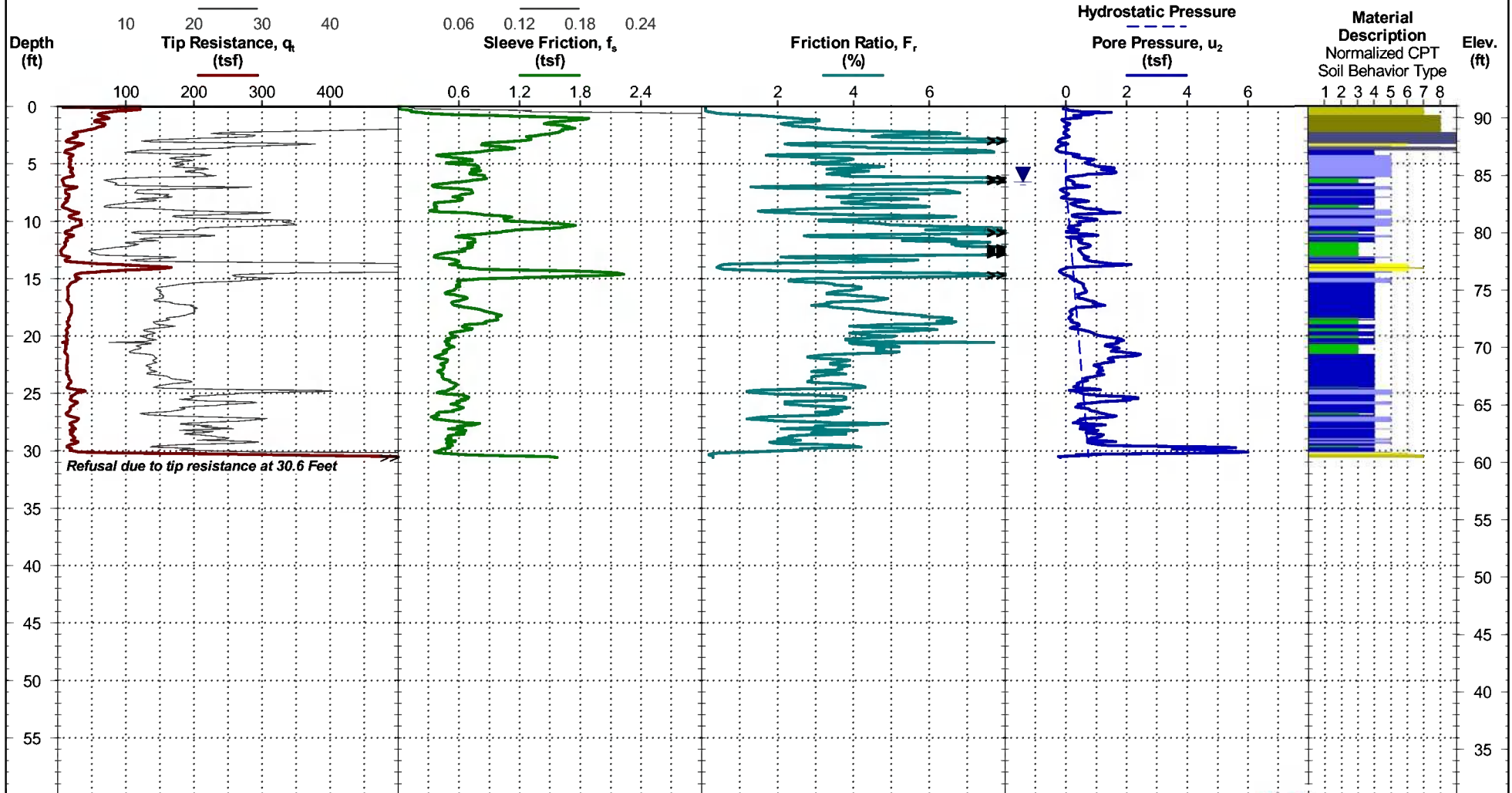
TEST LOCATION: See Exhibit A-2

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

Surface Elev.: 91.0 ft
LL: 33.374°,-80.10619°
NE: 12993,10212

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT EN131025 CGS ASH POND.GPJ TERRACON2015.GDT 11/9/15



See Exhibit A-3 for description of field procedures.
See Appendix C for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 1 Sensitive, fine grained
- 2 Organic soils - clay
- 3 Clay - silty clay to clay
- 4 Silt mixtures - clayey silt to silty clay
- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravely sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff fine grained

WATER LEVEL OBSERVATION

6.6 ft estimated water depth
(used in normalizations and correlations;
see Appendix C)

Probe no. 4675 with net area ratio of 0.84
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 10/22/2015
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 5th Street West
North Charleston, South Carolina

CPT Started: 10/9/2015

Rig: Pagani TG73-200

Project No.: EN131025

CPT Completed: 10/9/2015

Operator: J. Bandle

Exhibit: A-3

CPT LOG NO. C-837

Page 1 of 1

PROJECT: Cross Generating Station- Ash Pond
Dikes

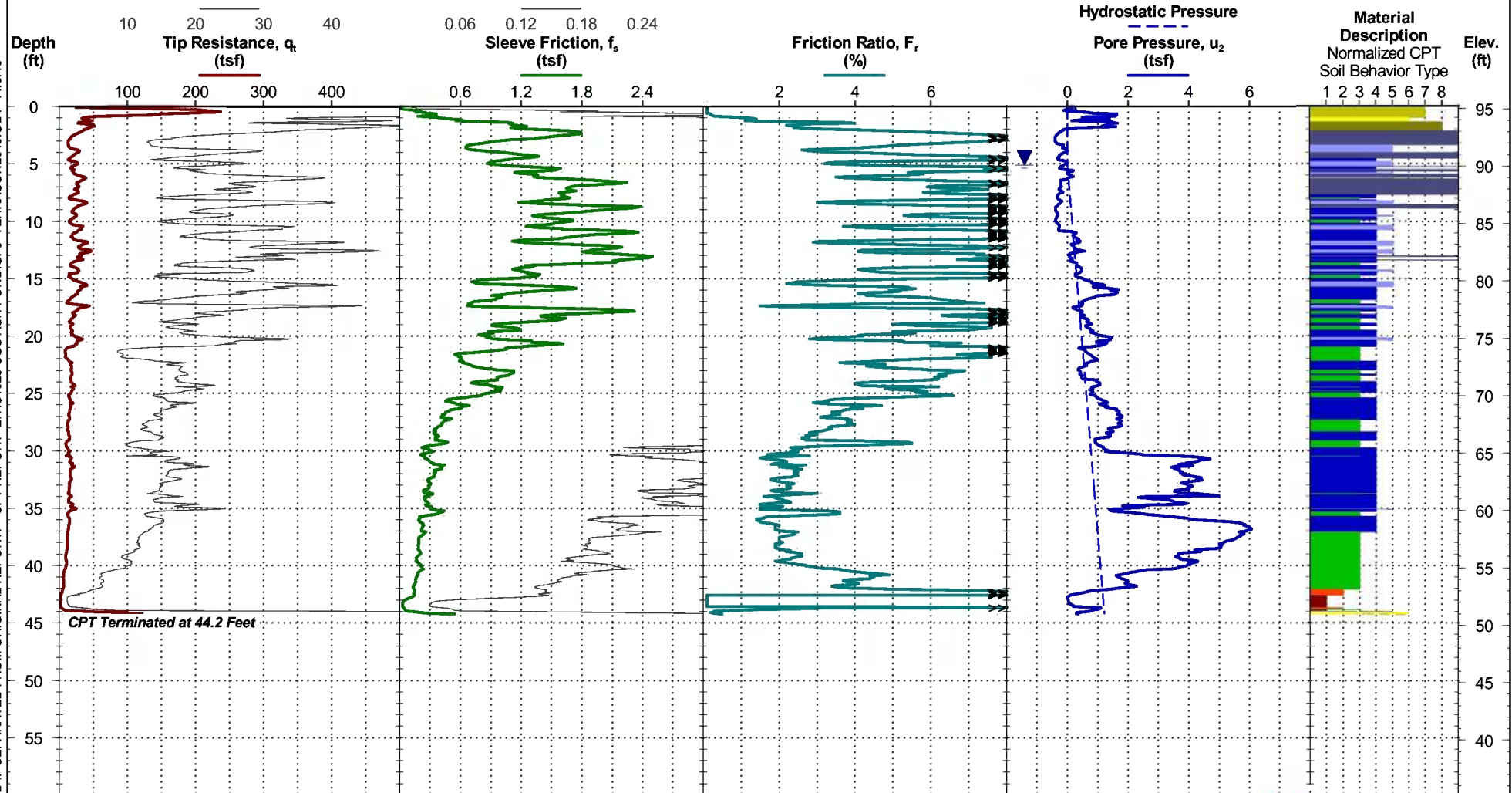
CLIENT: Santee Cooper
Moncks Corner

TEST LOCATION: See Exhibit A-2

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

Surface Elev.: 95.2 ft
LL: 33.37303°, -80.10186°
NE: 13447, 11565



See Exhibit A-3 for description of field procedures.

See Appendix C for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 1 Sensitive, fine grained
- 2 Organic soils - clay
- 3 Clay - silty clay to clay
- 4 Silt mixtures - clayey silt to silty clay
- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravely sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff fine grained

WATER LEVEL OBSERVATION

5.1 ft estimated water depth
(used in normalizations and correlations;
see Appendix C)

Probe no. 4675 with net area ratio of 0.84
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 10/22/2015
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 5th Street West
North Charleston, South Carolina

CPT Started: 10/9/2015

Rig: Pagani TG73-200

Project No.: EN131025

CPT Completed: 10/9/2015

Operator: J. Bandle

Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT EN131025 CGS ASH POND.GPJ TERRACON2015.GDT 11/9/15

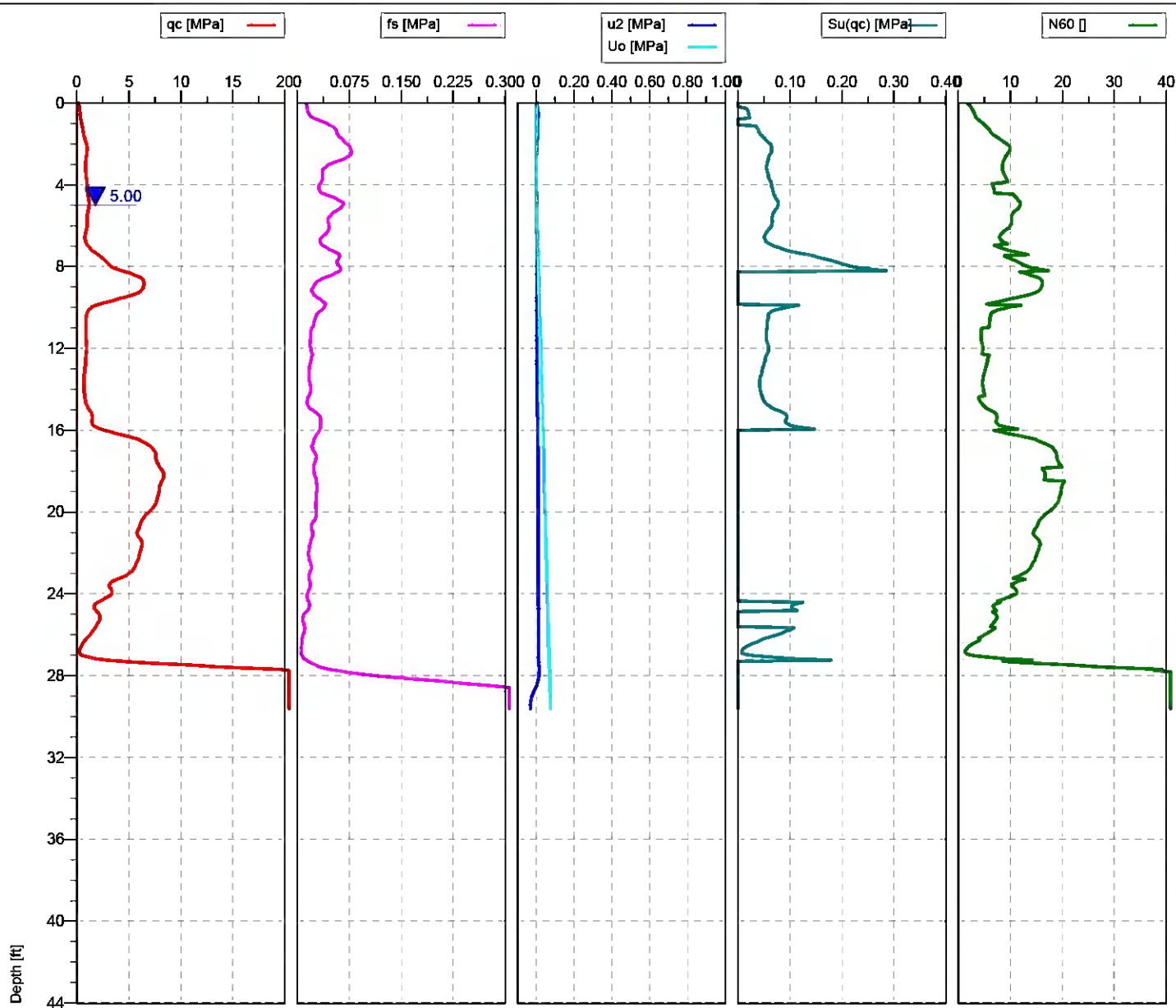
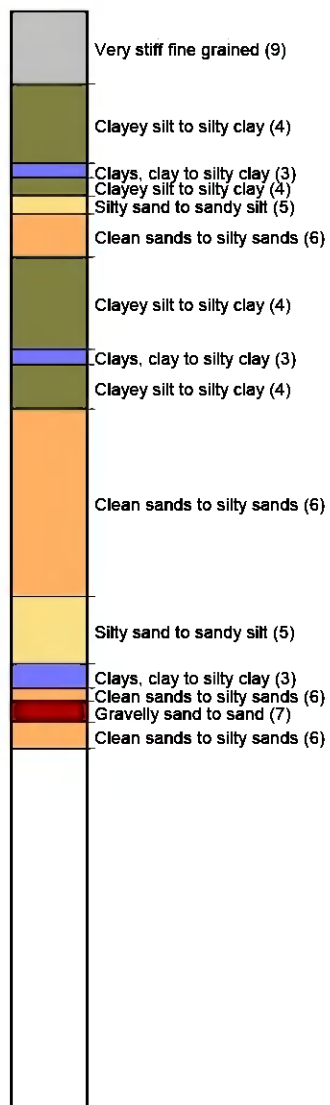


Customer				Santee Cooper				Project No.		108008-01330		
Project Title				Cross Generating Station				Calc No.		CROSS-0-DC-044-CE-0003		
Calculation Title				Bottom Ash Pond Initial Safety Factor Assessment				Phase/CTR		LBRCCR		
Elec File Location				\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm								
								Page		33	of	128
Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked	
0	14-OCT-16	B. Gordon	Y. Xu									

Appendix C – Historical Boring Logs

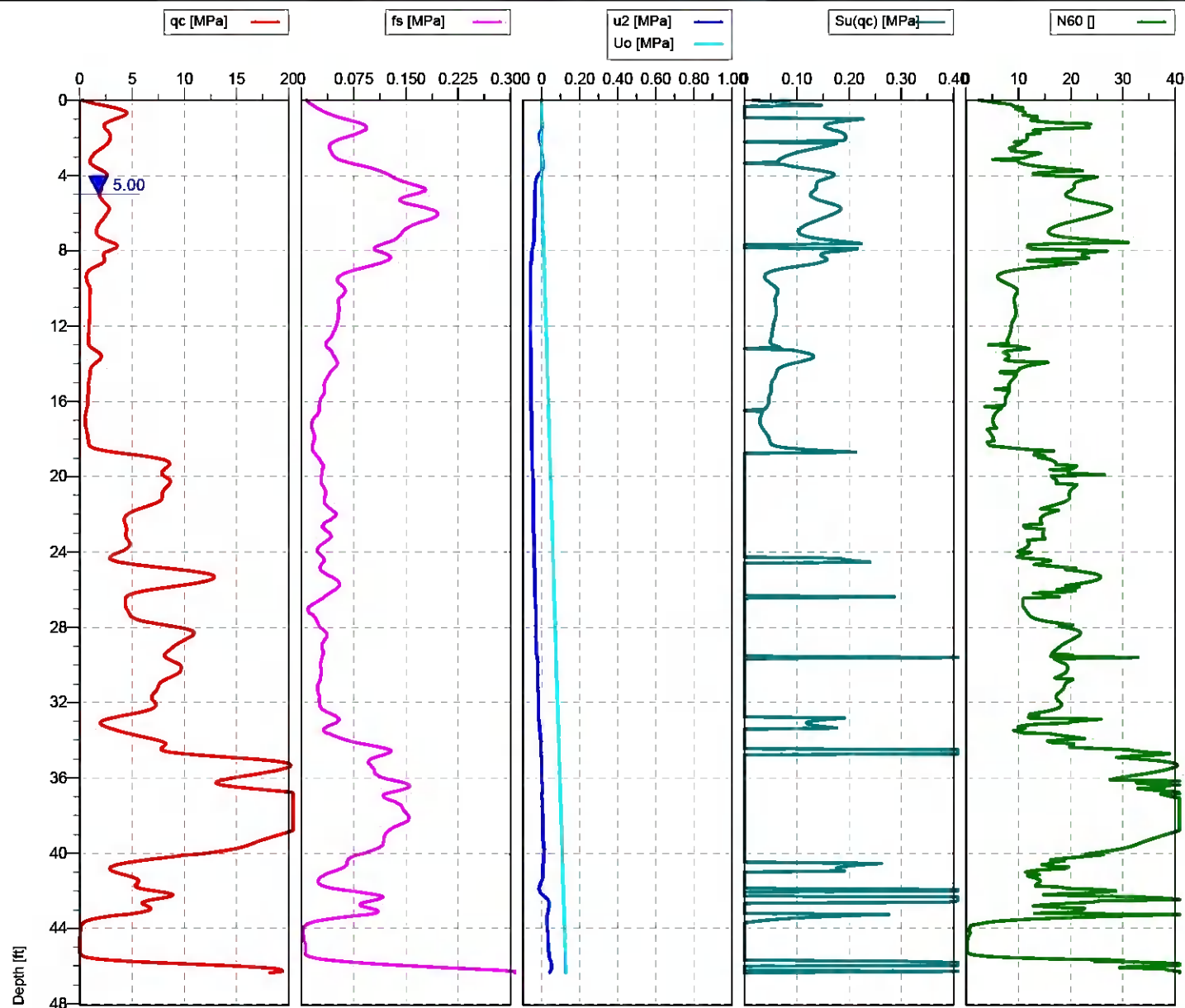
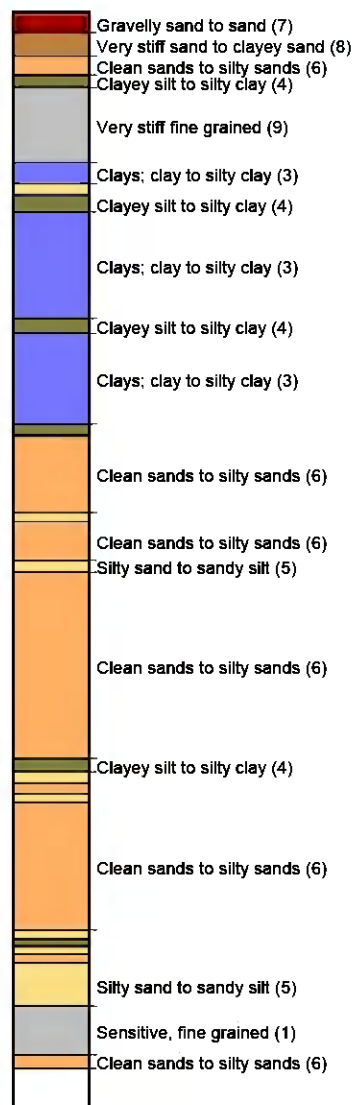
(13 total pages)

This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither WorleyParsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.



Cone No: 0
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location:	Cross Generating Station	Position:	X: 0.00 m, Y: 0.00 m	Ground level:	0.00	Test no:	C823
Project ID:	EN105045	Client:	Santee Cooper	Date:	5/19/2010	Scale:	
Project:	Cross Generating Station: SWLF Expansion			Page:	1/1	Fig:	
Northing: 15100	Easting: 9450	Elevation: 80.1;	Grouted Upon Completion	File:	C823.cpd		



Cone No: 0
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location:	Cross Generating Station	Position:	X: 0.00 m, Y: 0.00 m	Ground level:	0.00	Test no:	C824
Project ID:	EN105045	Client:	Santee Cooper	Date:	6/4/2010	Scale:	
Project:	Cross Generating Station: SWLF Expansion			Page:	1/1	Fig:	
Northing: 14893.83	Easting: 10834.1	Elevation: 79.63;	Grouted Upon Completion	File:	C824.cpd		

DEPTH FT.	DESCRIPTION	CORE % & TIME SIZE MIN.	38.8 ELEV.	REMARKS	% R Q D
40.0	Very Dense to Dense Gray Slightly Cemented Calcareous Silty Fine to Coarse Sand With Some Shell Fragments (Santee Limestone)				
		33.8	N=43		
		28.8	N=44		
			N=50/6"		
56.0	Firm Dark Green Slightly Clayey Silty Fine to Medium Sand (Black Mingo Formation)	23.8			
		18.8	N=25		
60.0	Boring Terminated at 60.0 Ft.				
	Groundwater Encountered At 6.8 Ft. 24 Hours After Boring				

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-8113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
FALLING 30 IN. REQUIRED TO DRIVE 1-4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE WATER TABLE, 24 HR

ROCK JOINT:

% ROCK CORE RECOVERY WATER TABLE, 1 HR.

L = LOW DIP 0°-30°

N STANDARD PENETRATION LOSS OF DRILLING WATER

M = MED DIP 30°-60°

S = STEEP DIP 60°-90°

Page 2 of 2 TEST BORING RECORD

BORING NO. 243
DATE DRILLED 12-18-78
JOB NO. CH 4193

LAW ENGINEERING TESTING CO

DEPTH FT.	DESCRIPTION	CORE % & TIME SIZE MIN.	79.3 ELEV.	REMARKS	% R Q D
0	Topsoil-Black Silty Fine to Medium*				
1.0	Gray Tan Very Clayey Fine to Medium Sand				
2.5	Loose Red Brown Gray Very Clayey Fine to Medium Sand		74.3	N=10	
7.0	Firm Gray Slightly Clayey Silty Fine to Medium Sand		69.3	N=11	
12.0	Very Soft Gray Tan Fine Sandy Silty Clay With Seams of Fine to Medium Sand		64.3	N=2	
			59.3	N=2	
24.5	Firm Gray Calcareous Slightly Clayey Silty Fine to Coarse Sand (Santee Limestone)		54.3	N=1 N=11/6"	
29.0	Very Soft Blue Green Silty Clay (Void Filling)		49.3		
			44.3	N=Weight of Rods (29.0 to 38.0 Ft.)	
38.0	Santee Limestone - No Recovery		39.3	N=45 No Recovery	

BORING AND SAMPLING MEETS ASTM D-1586 *Sand and Organic Material
CORE DRILLING MEETS ASTM D-8113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
FALLING 30 IN. REQUIRED TO DRIVE 1-4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE WATER TABLE, 24 HR

ROCK JOINT:

% ROCK CORE RECOVERY WATER TABLE, 1 HR.

L = LOW DIP 0°-30°

N STANDARD PENETRATION LOSS OF DRILLING WATER

M = MED DIP 30°-60°

S = STEEP DIP 60°-90°

Page 1 of 2 TEST BORING RECORD

BORING NO. 244
DATE DRILLED 12-18-78
JOB NO. CH 4193

LAW ENGINEERING TESTING CO

Pocket Penetrometer:
Qu = 1400 PSF
Torvane: S=500 PSF
Bottom of UD,
Pocket Penetrometer:
Qu = 1400 PSF
Torvane: S=640 PSF
Pocket Penetrometer:
Qu = 1400 PSF
Torvane: S=500 PSF

100%
N=1
N=11/6"

N=Weight of Rods (29.0 to 38.0 Ft.)

Field Permeability Test,
38.5 to 40.0 Ft.:
K=1.32 x 10⁻⁵ cm/sec

DEPTH FT.	DESCRIPTION	CORE % & TIME SIZE MIN. ELEV.	39.3	REMARKS	% R Q D
40.0	Santee Limestone - No Recovery			100%	
41.5	Medium and Hard Gray Cemented Calcareous Silt, Sand, and Shell Fragments (Santee Limestone)	NQ 100	34.3	N= 50/1/2" No Recovery Drag Bit Refusal at 41.5 Ft.	36
46.0	Very Soft and Soft Slightly Cemented Calcareous Silt, Sand and Shell Fragments (Santee Limestone)	8	29.3	Packer Test, 43.8 to 49.0 Ft.: K=7.62 x 10 ⁻⁴ cm/sec Crystalline Limestone (41.5 to 43.0 Ft.) Packer Test, 48.0 to 54.0 Ft.: K=2.94 x 10 ⁻⁴ cm/sec	0
54.0	Very Dense to Dense Slightly Cemented Calcareous Silty Fine to Coarse Sand With Some Shell Fragments (Santee Limestone)		24.3	N=53	
60.0	Boring Terminated at 60.0 Ft. Groundwater Encountered at 7.6 Ft. 24 Hours After Boring NW Casing Set to 38.5 Ft.		19.3	N=45	

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-4113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
FALLING 30 IN. REQUIRED TO DRIVE 1-4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE WATER TABLE, 24 HR

ROCK CORE RECOVERY WATER TABLE, 1 HR

N = STANDARD PENETRATION LOSS OF DRILLING WATER

R Q D: ROCK QUALITY DESIGNATION

ROCK JOINT:

L = LOW DIP 0°-30°

M = MED. DIP 30°-60°

S = STEEP DIP 60°-90°

Page 2 of 2 TEST BORING RECORD

BORING NO. 244
DATE DRILLED 12/18-19/78
JOB NO. CH 4193

LAW ENGINEERING TESTING CO

DEPTH FT.	DESCRIPTION	CORE % & TIME SIZE MIN. ELEV.	79.7	REMARKS	% R Q D
0	Topsoil-Black Silty Fine to Medium*				
1.0	Gray Tan Clayey Fine to Medium Sand				
3.0	Firm Gray Brown Very Clayey Fine to Medium Sand		74.7	N=17	
7.0	Firm Gray Slightly Micaceous Fine Sandy Clay With Thin Fine Sand Seams		69.7	N=6 Pocket Penetrometer: Qu = 1800 PSF Torvane: S=1000 PSF	
12.3	Very Dense to Dense Gray to Light Green Gray Slightly Cemented Calcareous Silty Fine to Coarse Sand With Some Shell Fragments (Santee Limestone)		64.7	N=62	
			59.7	N=50/4"	
			54.7	100% N=50/5" Void (23.2 to 23.5 Ft.)	
			49.7	N=55	
			44.7	N=50/5" No Recovery	
			39.7	N=50/3" No Recovery Hard Drilling (38.7 to 40.3 Ft.)	

*Sand and Organic Material

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-4113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
FALLING 30 IN. REQUIRED TO DRIVE 1-4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE WATER TABLE, 24 HR

ROCK CORE RECOVERY WATER TABLE, 1 HR

N = STANDARD PENETRATION LOSS OF DRILLING WATER

R Q D: ROCK QUALITY DESIGNATION

ROCK JOINT:

L = LOW DIP 0°-30°

M = MED. DIP 30°-60°

S = STEEP DIP 60°-90°

Page 1 of 2 TEST BORING RECORD

BORING NO. 245
DATE DRILLED 12/17-18/78
JOB NO. CH 4193

LAW ENGINEERING TESTING CO

DEPTH FT.	DESCRIPTION	CORE % & SIZE	TIME MIN.	80.2 ELEV.	REMARKS	% R.Q.D.
0	Loose Brown Silty Fine to Medium Sand With Organic Matter					
3.0				N=6		
	Firm Brown and Gray Silty Clayey Fine to Medium Sand and Slightly Silty Fine to Medium Sand With Some Organic Matter		75.2	N=11		
				N=13		
9.0	Stiff Multicolored Silty Clay		70.2	N=9		
12.5						
	Very Loose Multicolored Slightly Clayey Silty Fine to Medium Sand (Wet)		65.2	N=2		
18.0						
	Very Dense Tan Partially Cemented Calcareous Silty Fine to Coarse Sand With Shell Fragments (Santee Limestone)		60.2	N=91		
23.1						
	Void		55.2			
25.7						
	Very Dense Tan Partially Cemented Calcareous Silty Fine to Coarse Sand With Shell Fragments (Santee Limestone)		50.2	N=50/3"		
			45.2	N=50/4"		
				N=50/2"	No Recovery	
40.0			40.2			

BORING AND SAMPLING MEETS ASTM D-1586

CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER

FALLING 30 IN. REQUIRED TO DRIVE 1-4 IN. I.D. SAMPLER 1 FT.

 UNDISTURBED SAMPLE  WATER TABLE. 24 HR.

 50% ROCK CORE RECOVERY  WATER TABLE. 1 HR.

N - STANDARD PENETRATION  LOSS OF DRILLING WATER

R.Q.D. ROCK QUALITY DESIGNATION

 ROCK JOINT:

L = LOW DIP 0-30°

M = MED. DIP 30°-60°

S = STEEP DIP 60°-90°

Page 1 of 2

TEST BORING RECORD

BORING NO. 442

DATE DRILLED 7-14-80

JOB NO. CH 4193D

LAW ENGINEERING TESTING CO.

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

LOG OF BORING B-632

SHEET 1 OF 3

PROJECT AND LOCATION Santee Cooper Generating Station, Unit 1				ELEVATION AND DATUM 77.11 ft MSL		PROJECT NO. 80C4090C01	
DRILLING AGENCY ARDAMAN AND ASSOCIATES			FOREMAN D. Gandy		DATE STARTED 23 July 1980		DATE FINISHED 23 July 1980
DRILLING EQUIPMENT CME-55 Hydro Rotary				COMPLETION DEPTH 66.5 ft		ROCK DEPTH 39.0 ft	
SIZE AND TYPE OF BIT 3-7/8 "Ticone"		SIZE AND TYPE CORE BARREL NX "Double Tube" CB		NO SAMPLES DIST 15		UNDIST -- CORE --	
CASING 3" "Flush Joint"				WATER LEVEL FIRST --		COMPL 4.5 24.5 ft	
CASING HAMMER		WEIGHT		DROP		BORING ANGLE AND DIRECTION VERTICAL	
SAMPLER 2-IN O.D. SPLIT SPOON				INSPECTOR M. Giordano			
SAMPLER HAMMER		WEIGHT 140 LBS		DROP 30-IN			

DESCRIPTION	ELEV. FT.	DEPTH, FT.	SAMPLES			ROCK CORE				REMARKS
			TYPE NO. LOC	RECOV. FT	PENETR RESIST BL/6IN.	CORE NO.	RECOV. %	RQD	CORE TIME MIN/FT.	
-Dk brn silty f-SAND, some veg., v. loose (dry) (1.5 ft)	75.6	1	S-1	1.4	1					23 July 1980
		2			2					
-Dk grayish & yellowish brn f-sandy CLAY, some silt m (dry) (5.0 ft)	72.1	3	S-2	1.3	3					No sample
		4			4					
No recovery		5								
		6	NR	0.0	6					
Gray & yellowish brn clayey, f-SAND (8.0 ft)	69.1	7								
Lt gray & yellowish brn f-sandy CLAY, freq. silty f. sand lenses, firm (moist)		8	S-3	1.5	2					
		9			3					
		10			4					
Lt yellowish brn f-sandy CLAY (10.8 ft)	66.3	11	S-4	1.5	2					
		12			1					
		13			2					
		14	S-5	1.1	1					
Lt tannish brn m-f SAND, some clay, tr. c. sand (moist) (12.5 ft)	64.6	15								
		16								
		17	S-6	1.5	1					
		18			WH					
Greenish gray silty CLAY frequent lenses of silty f-sand, v. soft (moist)		19								Vane shear test: 14.0 ft - 16.5 ft Undisturbed: 1.17 tsf Remolded: 1.09 tsf
		20	S-7	1.5	1					
Greenish gray silty CLAY w/frequent lenses of silty f-sand, v. soft (moist)										Vane shear test: 17.5 ft - 19.0 ft Undisturbed: 0.78 tsf Remolded: 0.78 tsf

SHEET 2 OF 3

[illegible]

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

LOG OF BORING B-633

SHEET 1 OF 3

PROJECT AND LOCATION SANTEE COOPER GENERATING STATION, UNIT 1		ELEVATION AND DATUM 77.39 ft MSL		PROJECT NO. 80C4090C01	
DRILLING AGENCY ARDAMAN AND ASSOCIATES		FOREMAN J. Jones		DATE STARTED 24 July 1980	
DRILLING EQUIPMENT CME-55 Hydro Rotary		COMPLETION DEPTH 59.0 ft		DATE FINISHED 25 July 1980	
SIZE AND TYPE OF BIT 3-7/8" "Falcon"		SIZE AND TYPE CORE BARREL NX "Double Tube" CB		ROCK DEPTH 30.0 ft	
CASING 3" "Flush Joint"		NO SAMPLES DIST 11		UNDIST 2	
CASING HAMMER		WEIGHT		DROP	
SAMPLER 2-IN O.D. SPLIT SPOON		WATER LEVEL		FIRST --	
SAMPLER HAMMER		WEIGHT 140 LBS		DROP 30-IN	
		BORING ANGLE AND DIRECTION VERTICAL		INSPECTOR M. Giordano	

DESCRIPTION	ELEV. FT.	DEPTH, FT	SAMPLES			ROCK CORE				REMARKS
			TYPE NO. LOC	RECOV. FT	PENETR RESIST BL/6IN.	CORE NO.	RECOV. %	RQD	CORE TIME MIN/FT.	
Top 12": Dk brn f-sandy CLAY, tr. veg., soft (dry)	76.4	1	S-1	1.5	2					
Gray & yellowish brn CLAY some f-sand, tr silt (dry to moist)		2			2					
Gray & yellowish brn CLAY some f-sand, tr. silt, firm (moist)		3	S-2	1.4	2					
		4			4					
Gray to lt gray CLAY, soft (moist)		5			1					
		6	S-3	1.0	1					
		7			3					
Lt gray CLAY w/frequent pockets of lt brownish gray f-sandy silty, firm (moist)		8	S-4	0.9	2					
		9			3					
	67.9	10								
Lt greenish gray silty CLAY w/frequent silty, f-sand seams, firm (moist)		11	S-5	1.5	1					
		12			2					
		13			3					
(14.0 ft)	63.4	14								
Lt gray clayey f. SAND w/ frequent thick lenses of grn clay, soft, firm (moist) (17.0 ft)		15	S-6	1.5	2					
		16			2					
	60.4	17			2					
Dk greenish gray CLAY, some silty f-sand seams, v. soft (moist)		18	S-7		1					
		19			1					
Dk greenish gray CLAY, highly plastic (moist)		20	UD-1	2.0	PUSH					

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

LOG OF BORING B-633

SHEET 2 OF 3

DESCRIPTION	ELEV. FT.	DEPTH, FT.	SAMPLES			ROCK CORE				REMARKS
			TYPE NO. LOC	RECOV. FT.	PENETR RESIST BL/6IN.	CORE NO.	RECOV. %	RQD	CORE TIME MIN/FT.	
Dk greenish gray CLAY w/ frequent fine sand seams v.soft, (moist)	53.9	21	UD	2.5	PUSH					Change of soil in tube
Dk greenish gray CLAY, highly plastic (23.5 ft)		22	S-8	1.5	WH WH 1					
		23	UD-2		PUSH					
Dk gray clayey silty f-m SAND, tr.c-sand, loose (moist-wet)	47.4	24		2.0						Losing water slowly at 31.5 ft
		25	S-9	1.5	2 1 8					
		26								
	38.4	27								Spoon dropped at 35.0 ft, about 2½", no recovery (probable void)
(30.0 ft)		28								
		29								
Lt gray, clayey, silty f-SAND some limestone rock frag- ments, v. loose (moist) (decomposed rock)	38.4	30	S-10		1 1 3					Change to coring at 39.0 ft
		31		1.5						
		32								
	38.4	33								Partial water loss Casing to 44.0 ft
		34								
		35								
Lt gray, clayey, silty, f-c SAND, some limestone rock fragments (moist), v.dense (decomposed rock) (39.0 ft)	38.4	36	S-11		11 23 37					24 July 1980 25 July 1980
		37		1.5						
		38								
Lt gray, mod.to slightly weathered fossiliferous LIMESTONE, hard, closely fractured, glauconite noted		39								
		40								
		41								
		42				Run-1	26%	22%	2.2	
		43								
		44								
		45								



Resources & Energy

Customer				Santee Cooper				Project No.		108008-01330		
Project Title				Cross Generating Station				Calc No.		CROSS-0-DC-044-CE-0003		
Calculation Title				Bottom Ash Pond Initial Safety Factor Assessment				Phase/CTR		LBRCRR		
Elec File Location				\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm								
								Page		46	of	128
Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked	
0	14-OCT-16	B. Gordon	Y. Xu									

Appendix D – July 2014 Potentiometric Map

(2 total pages)

This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither WorleyParsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.

Cross Generating Station NPDES Groundwater Monitoring July 14 Potentiometric Map

● CAP Well Location

● PM Well Location

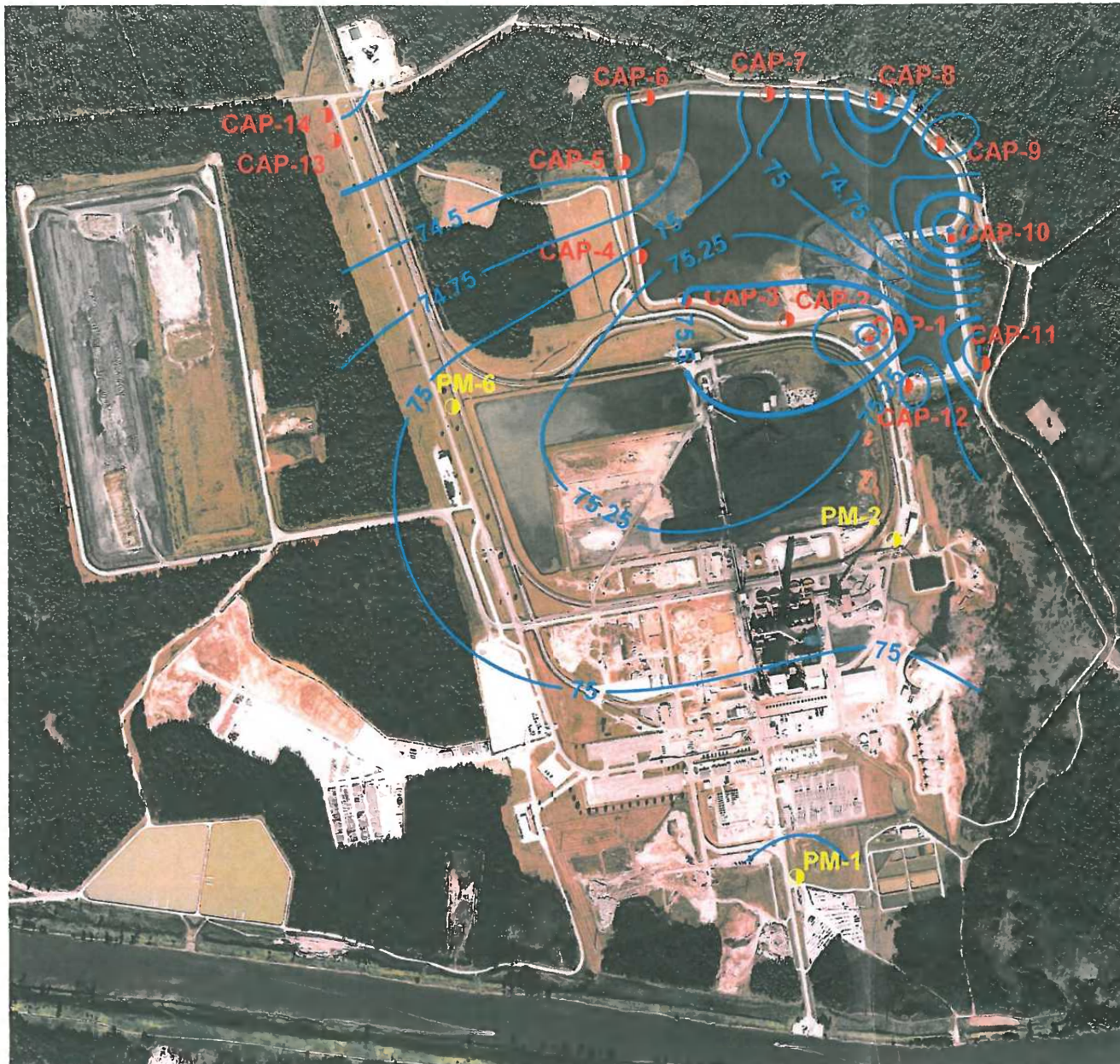
Groundwater Contour Interval
77.2 Groundwater Elevation (msl)

Well ID	TOC Elevation (feet)	GW Depth (feet)	GW Elevation (feet)
CAP-1*	82.70	6.54	76.16
CAP-2	91.85	16.20	75.65
CAP-3	91.49	15.97	75.52
CAP-4	91.77	16.72	75.05
CAP-5	91.78	17.36	74.42
CAP-6	91.82	17.21	74.61
CAP-7	91.64	16.50	75.14
CAP-8	91.61	17.80	73.81
CAP-9	91.59	16.55	75.04
CAP-10	95.68	22.00	73.68
CAP-11	95.55	19.46	76.09
CAP-12	98.33	23.56	74.77
CAP-13	80.77	6.71	74.06
CAP-14	80.77	6.82	73.95
PM-1	83.24	8.53	74.71
PM-2	82.05	6.99	75.06
PM-6	84.35	9.18	75.17

Water levels were collected on July 8, 2014



Date: 10/20/2014, MDH





Customer				Santee Cooper				Project No.		108008-01330					
Project Title				Cross Generating Station				Calc No.		CROSS-0-DC-044-CE-0003					
Calculation Title				Bottom Ash Pond Initial Safety Factor Assessment				Phase/CTR		LBRCCR					
Elec File Location				\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm											
								Page		48		of		128	
Rev		Date		By		Checked		Rev		Date		By		Checked	
0		14-OCT-16		B. Gordon		Y. Xu									

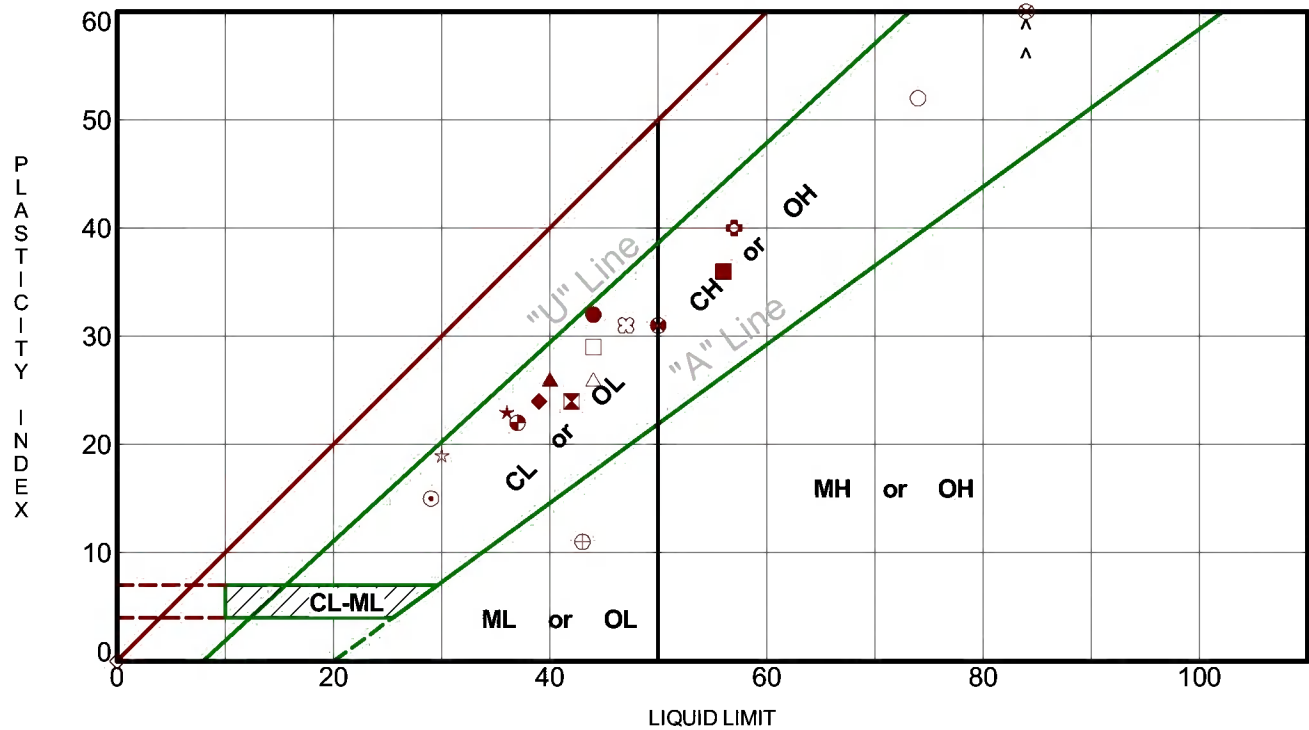
Appendix E – Laboratory Test Data

(21 total pages)

This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither WorleyParsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● B-734	2 - 4	44	12	32	62	CL	SANDY LEAN CLAY
⊠ B-734	6 - 8	42	18	24	49	SC	CLAYEY SAND
▲ B-734	10 - 12	40	14	26	41	SC	CLAYEY SAND
★ B-734	12 - 14	36	13	23		CL	SANDY LEAN CLAY
⊙ B-734	18.5 - 20	29	14	15		CL	SANDY LEAN CLAY
⊕ B-734	23.5 - 25	57	17	40		CH	FAT CLAY with SAND
○ B-734	28.5 - 30	74	22	52	81	CH	FAT CLAY with SAND
△ B-734	33.5 - 35	44	18	26	69	CL	SANDY LEAN CLAY
⊗ B-734	38.5 - 40	84	20	64	67	CH	SANDY FAT CLAY
⊕ B-734	43.5 - 45	43	32	11	35	SM	SILTY SAND
□ B-735	2 - 4	44	15	29		CL	SANDY LEAN CLAY
⊕ B-735	4 - 6	50	19	31	45	SC	CLAYEY SAND
⊕ B-735	8 - 10	37	15	22	46	SC	CLAYEY SAND
☆ B-735	12 - 14	30	11	19	55	CL	SANDY LEAN CLAY
⊗ B-735	18.5 - 20.5	47	16	31		CL	SANDY LEAN CLAY
■ B-735	23.5 - 25.5	56	20	36	91	CH	FAT CLAY
◆ B-735	28.5 - 30	39	15	24		CL	SANDY LEAN CLAY
◇ B-735	48.5 - 50	NP	NP	NP		SM	SILTY SAND

PROJECT: Cross Generating Station- Ash Pond
Dikes

SITE: Cross Generating Station
Pineville, South Carolina

Terracon
1450 5th Street West
North Charleston, South Carolina

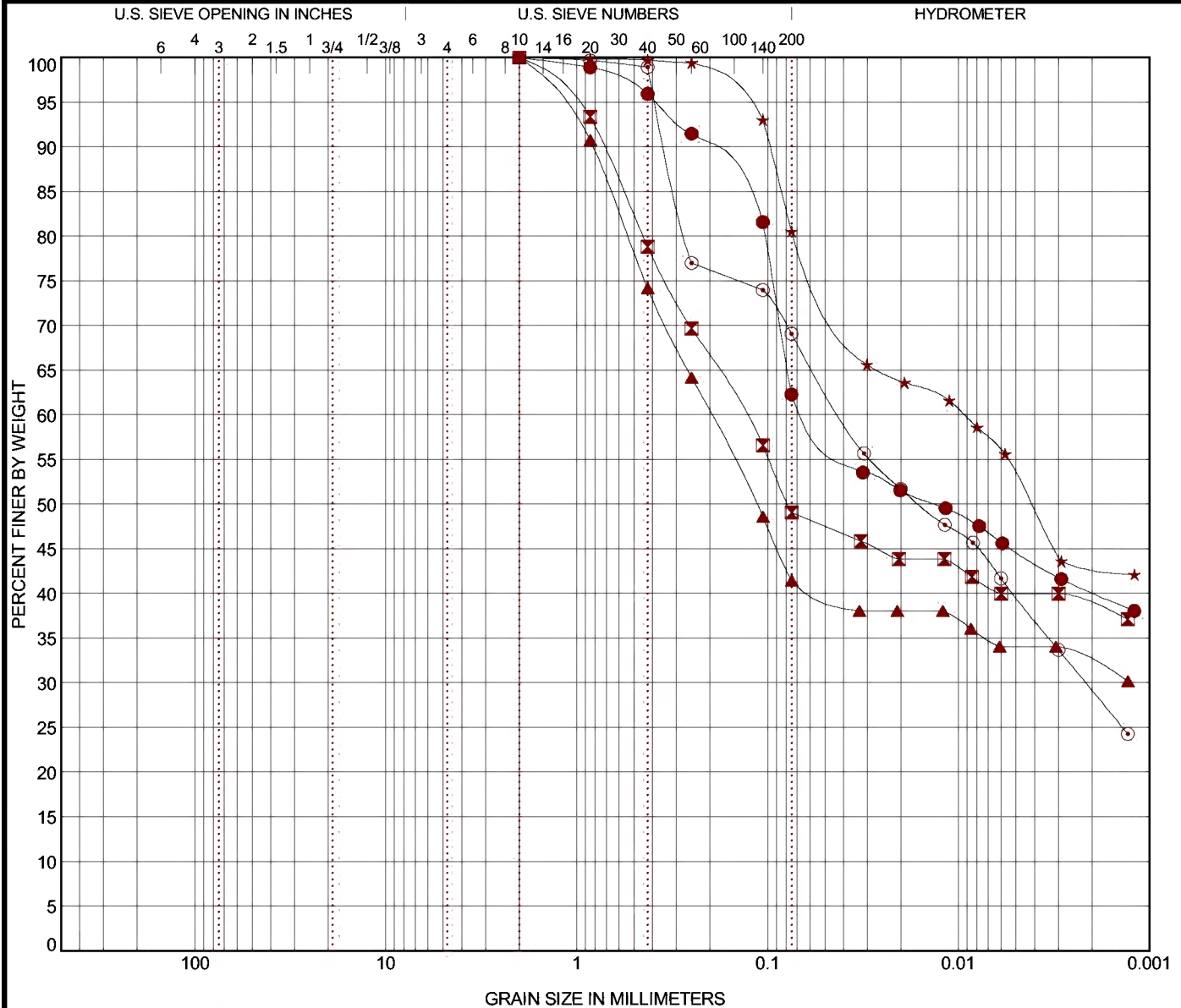
PROJECT NUMBER: EN131025

CLIENT: Santee Cooper
Moncks Corner

EXHIBIT: B-1

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification			LL	PL	PI	Cc	Cu
● B-734	2 - 4	SANDY LEAN CLAY(CL)			44	12	32		
⊠ B-734	6 - 8	CLAYEY SAND(SC)			42	18	24		
▲ B-734	10 - 12	CLAYEY SAND(SC)			40	14	26		
★ B-734	28.5 - 30	FAT CLAY with SAND(CH)			74	22	52		
⊙ B-734	33.5 - 35	SANDY LEAN CLAY(CL)			44	18	26		
Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Gravel	%Sand	%Fines	
● B-734	2 - 4	2	0.06			0.0	37.7	17.6	44.7
⊠ B-734	6 - 8	2	0.133			0.0	50.9	9.1	40.0
▲ B-734	10 - 12	2	0.199			0.0	58.5	7.4	34.0
★ B-734	28.5 - 30	2	0.009			0.0	19.5	27.3	53.3
⊙ B-734	33.5 - 35	2	0.041	0.002		0.0	30.9	29.5	39.6

PROJECT: Cross Generating Station- Ash Pond
Dikes

SITE: Cross Generating Station
Pineville, South Carolina

Terracon
1450 5th Street West
North Charleston, South Carolina

PROJECT NUMBER: EN131025

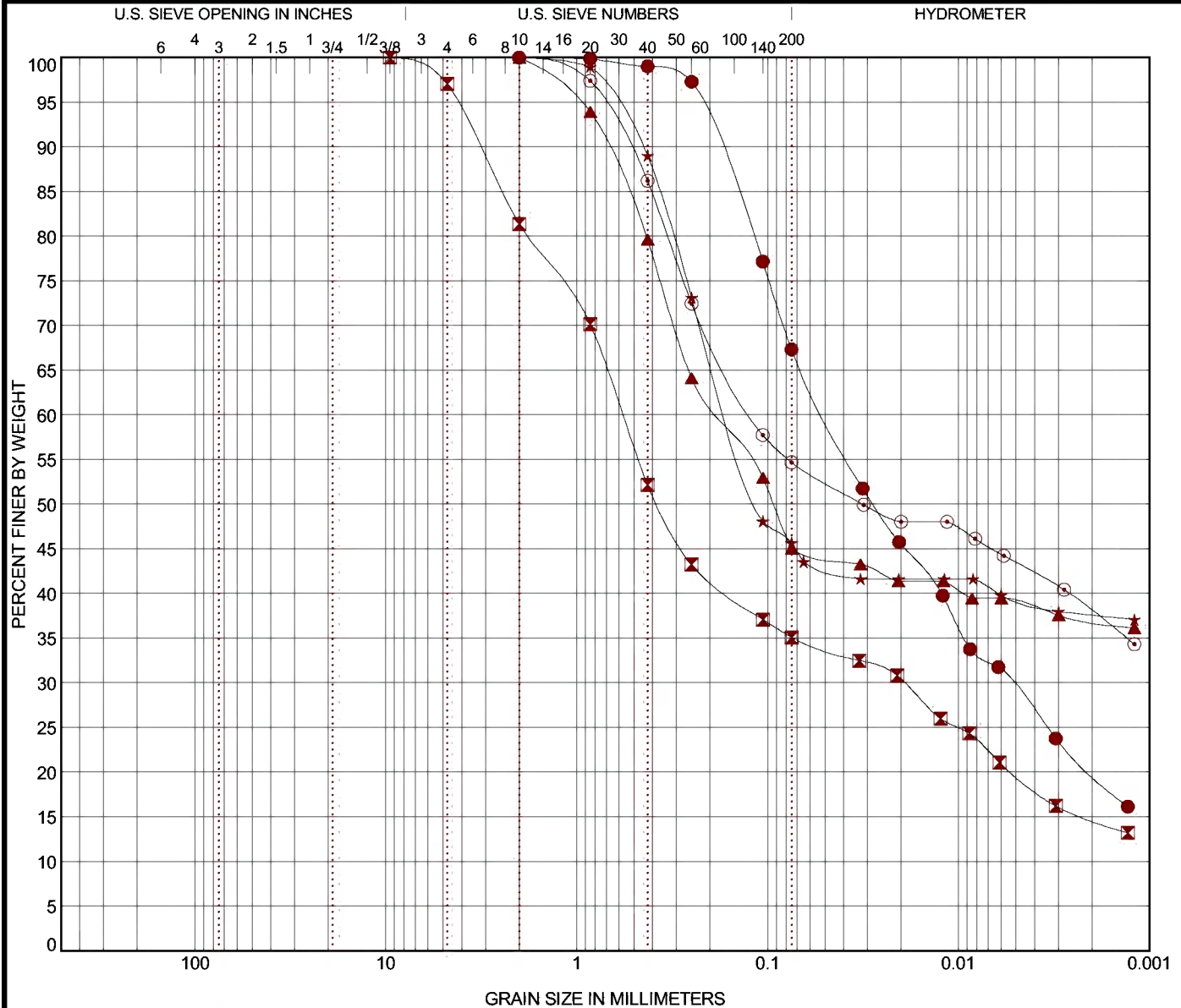
CLIENT: Santee Cooper
Moncks Corner

EXHIBIT: B-1

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 EN131025 CGS ASH POND.GPJ TERRACON2012.GDT 11/16/15

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification			LL	PL	PI	Cc	Cu
● B-734	38.5 - 40	SANDY FAT CLAY(CH)			84	20	64		
⊠ B-734	43.5 - 45	SILTY SAND(SM)			43	32	11		
▲ B-735	4 - 6	CLAYEY SAND(SC)			50	19	31		
★ B-735	8 - 10	CLAYEY SAND(SC)			37	15	22		
⊙ B-735	12 - 14	SANDY LEAN CLAY(CL)			30	11	19		
Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Gravel	%Sand	%Fines	
● B-734	38.5 - 40	2	0.05	0.005		0.0	32.7	38.0	29.3
⊠ B-734	43.5 - 45	9.5	0.575	0.019		3.0	62.0	15.4	19.6
▲ B-735	4 - 6	2	0.182			0.0	55.0	6.1	39.0
★ B-735	8 - 10	2	0.159			0.0	54.3	6.3	39.3
⊙ B-735	12 - 14	2	0.121			0.0	45.3	11.2	43.4

PROJECT: Cross Generating Station- Ash Pond
Dikes

SITE: Cross Generating Station
Pineville, South Carolina

Terracon
1450 5th Street West
North Charleston, South Carolina

PROJECT NUMBER: EN131025

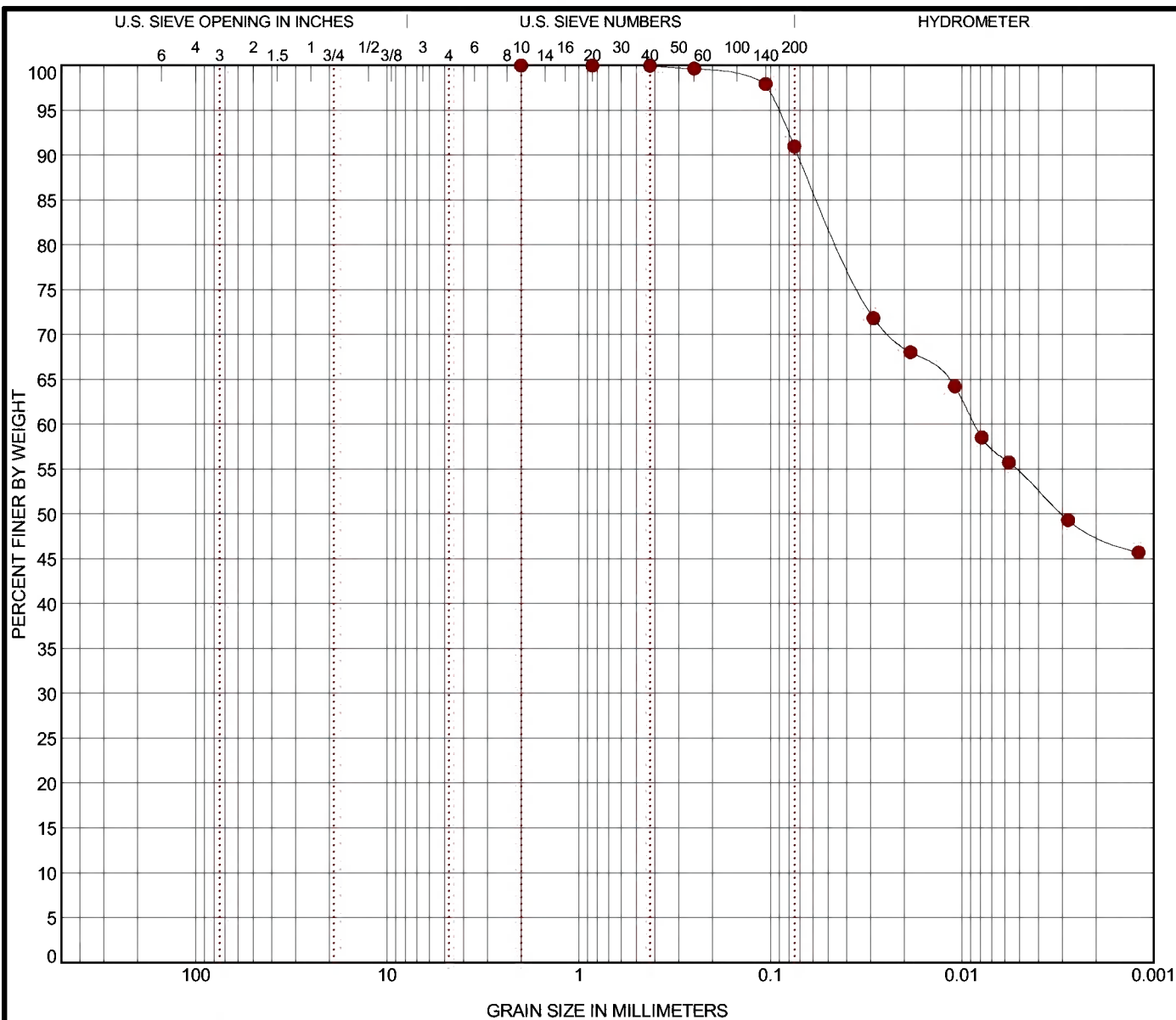
CLIENT: Santee Cooper
Moncks Corner

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 EN131025 CGS ASH POND.GPJ TERRACON2012.GDT 11/16/15

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification				LL	PL	PI	Cc	Cu
● B-735	23.5 - 25.5	FAT CLAY(CH)				56	20	36		
Boring ID	Depth	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Gravel	%Sand	%Fines		
● B-735	23.5 - 25.5	2	0.009			0.0	9.0	36.4		

PROJECT: Cross Generating Station- Ash Pond
Dikes

SITE: Cross Generating Station
Pineville, South Carolina

Terracon
1450 5th Street West
North Charleston, South Carolina

PROJECT NUMBER: EN131025

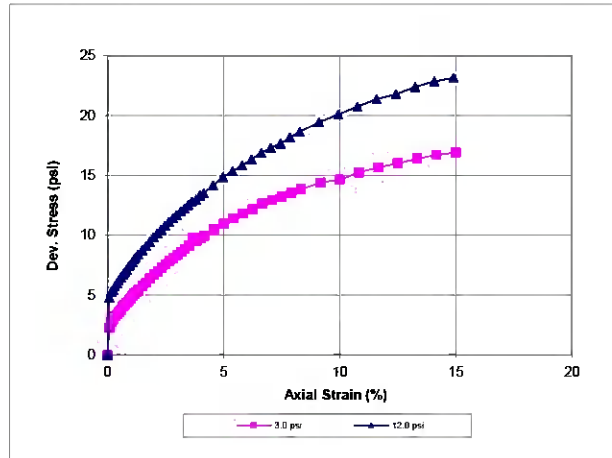
CLIENT: Santee Cooper
Moncks Corner

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 EN131025 CGS ASH POND.GPJ TERRACON2012.GDT 11/16/15

Consolidated - Undrained Triaxial Shear Test

ASTM D4767

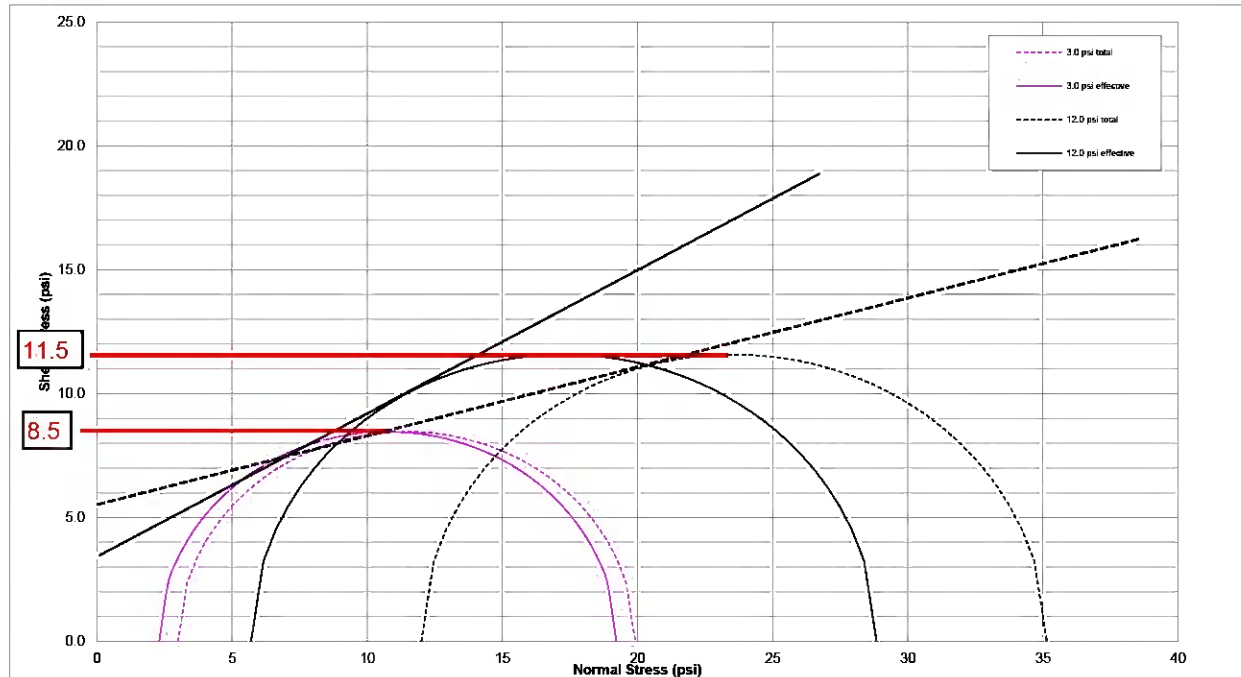
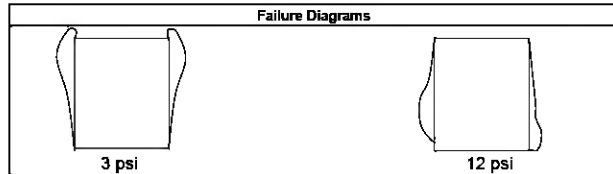


Project Name: CGS
Job Number: EN131025
Proj. Location: Ash Pond Dikes
Sample No.: B 734
Soil Description: Clayey Sand

Description	I	II	III
Initial wet density (pcf)	127.04	130.51	
Initial dry density (pcf)	109.70	112.92	
Initial water content (%)**	15.8%	15.6%	
Initial void ratio	0.536	0.492	
Initial Degree of Sat. (%)*	79.6	85.5	
Initial Height	6.00	6.04	
Initial Diameter	2.84	2.84	
Parameter B	0.98	0.98	
Final Degree of Sat. (%)*	98.0	98.0	
Liquid Limit	42		
Plastic Limit	18		
% finer than #200	49		

	I	II	III
Total Back Pressure (psi)		60.0	
Effective Consolidation Stress (psi)	5.2	10.4	
Axial Strain at failure (%)***	4.2	2.8	
Deviator Stress at failure (psi)	16.9	23.1	
Pore Pressure at failure (psi)	0.7	6.3	
Effective minor principal stress, σ'_3 (psi)	2.3	5.7	
Effective major principal stress, σ'_1 (psi)	19.2	28.8	
Φ	15.6°		
Φ'	29.9°		
Cohesion, c (psi)	5.5		
Effective Cohesion, c' (psi)	3.5		
Rate of Strain (% / minute)	0.2		

* Specific Gravity assumed 2.7; wet method of sat.
** obtained from cuttings
*** failure criterion - 5% stress after peak/15% strain
**** Time to 50% primary consolidation not measured



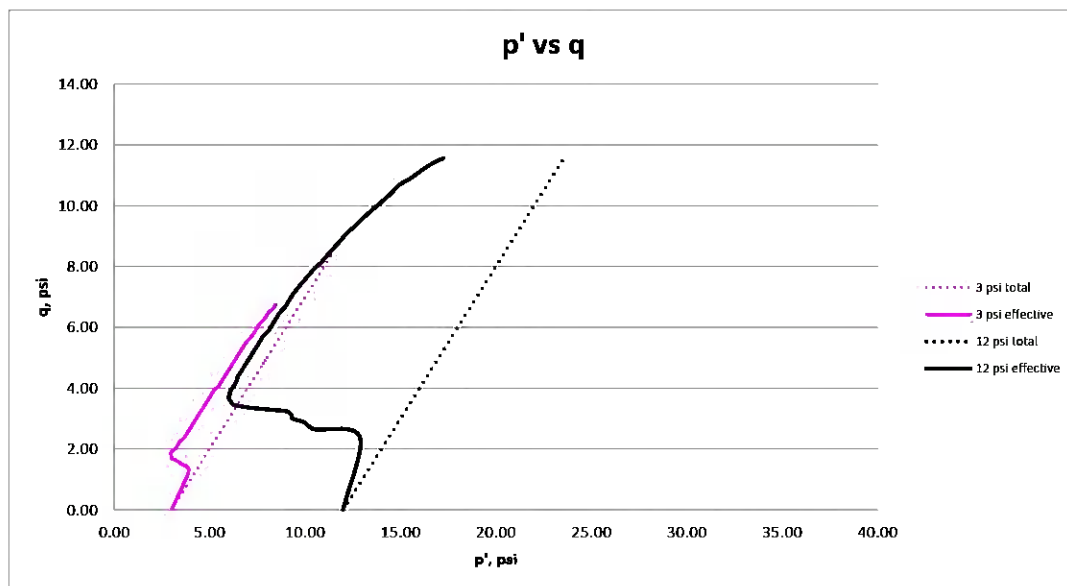
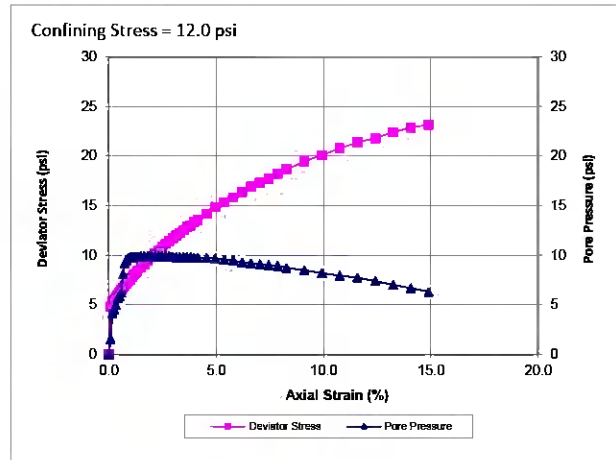
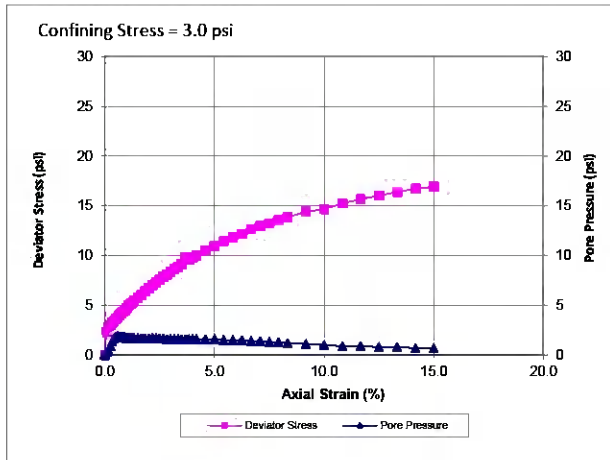
Terracon

CGS
Ash Pond Dikes
EN131025
10/25/2015
B 734 6-8'

Tested By: DL
Approved By: JH

Consolidated - Undrained Triaxial Shear Test

ASTM D4767



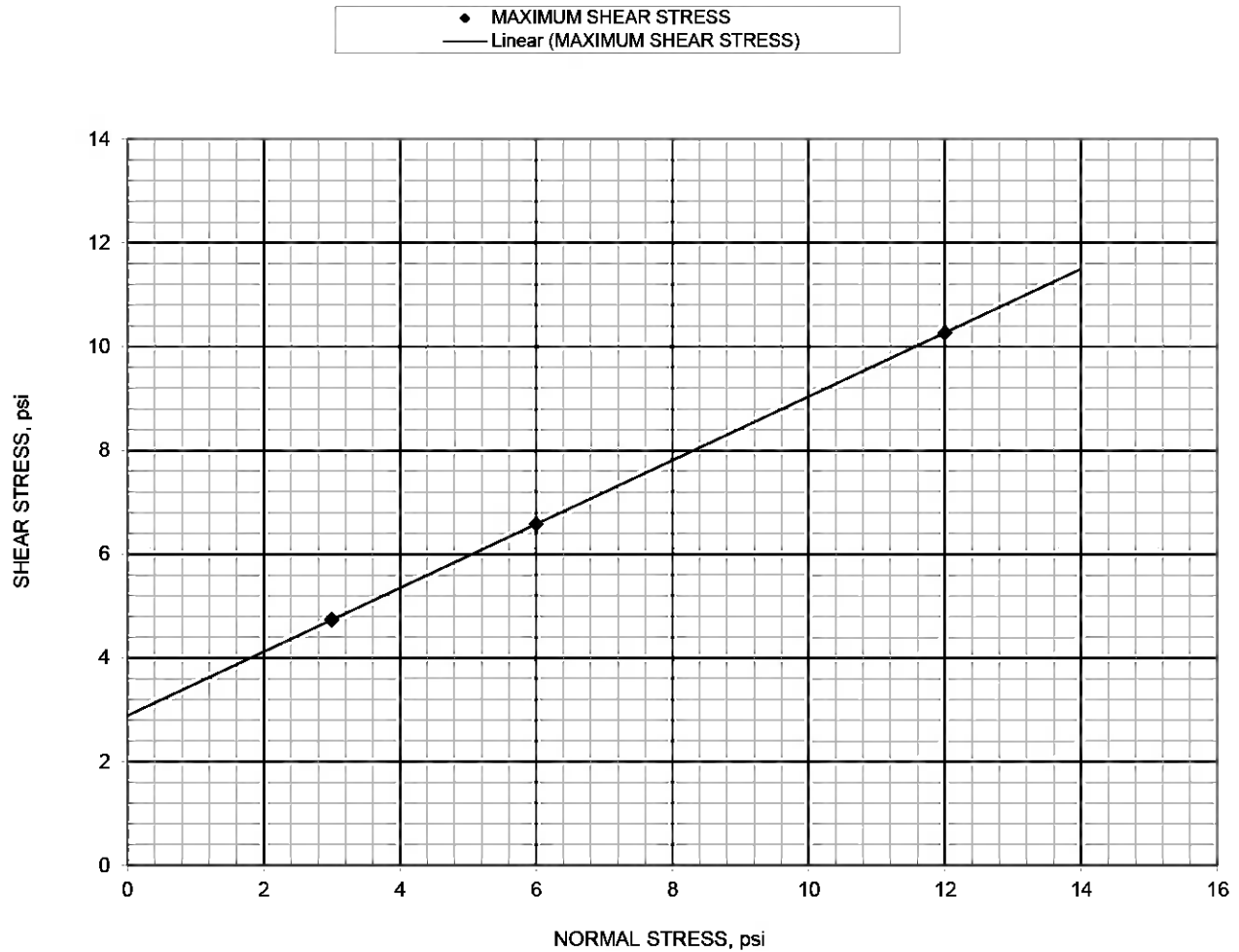
Terracon

CGS
Ash Pond Dikes
EN131025
10/25/2015
B 734

Tested By: DL
Approved By: JH

**DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS
AASHTO T236**

SHEAR STRENGTH



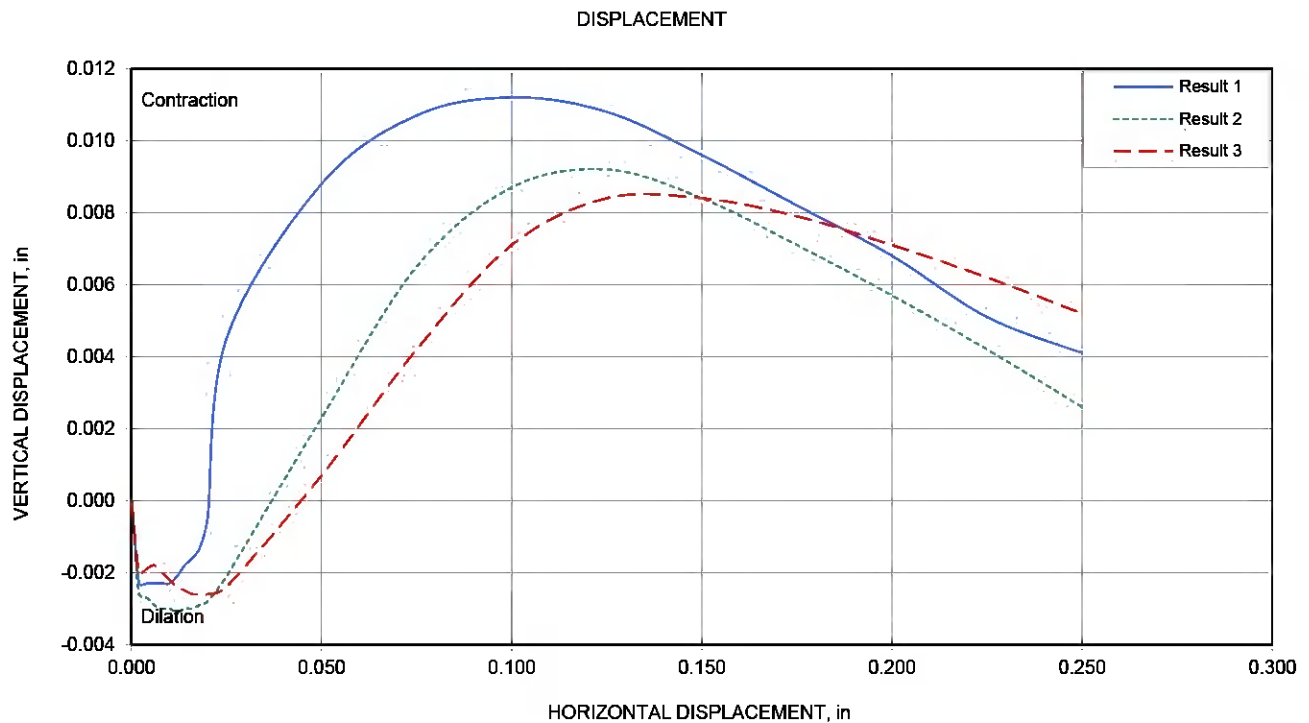
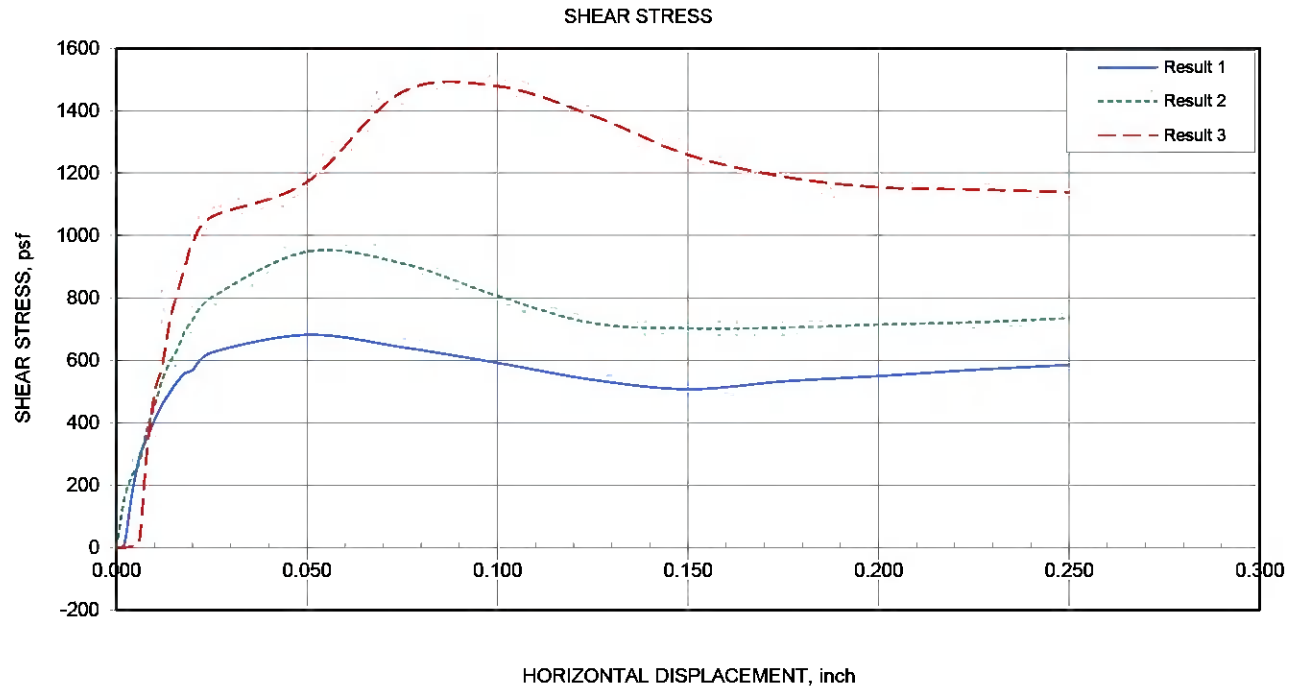
			FRICITION ANGLE	COHESION	NORMAL STRESS, ksf		
AT MAXIMUM SHEAR STRESS			31.6 deg	2.9 psi			
INITIAL AREA, in2		4.909	INITIAL MOISTURE, %		16.4	16.1	16.6
INITIAL LENGTH, in		1.000	INITIAL DRY DENSITY, pcf		109.4	110.5	110.2
SPECIFIC GRAVITY		2.70	INITIAL SATURATION, %		82.2	82.8	84.5
SG ASSUMED		X	INITIAL VOID RATIO		0.54	0.53	0.53
SG TESTED			FINAL MOISTURE, %		18.2	17.0	17.6
LIQUID LIMIT		-	FINAL SATURATION, %		91.2	87.4	92.3
PLASTIC LIMIT		-	FINAL VOID RATIO		0.54	0.53	0.51
PLASTICITY INDEX		-	MAXIMUM SHEAR STRESS, psf		4.73	6.58	10.27
SAMPLE TYPE		UNDISTURBED	RATE OF LOADING, in/min		0.0020	0.0020	0.0020
DESCRIPTION							
SOURCE	CGS	SAMPLE NO.	B734		DEPTH, Feet	2' - 4'	
PROJECT: Cross Ash Pond Dikes			Terracon 1450 Fifth Street West Charleston, SC			PROJECT NUMBER: EN131025	
SITE: CGS		CLIENT: Santee Cooper					
NOTES:		EXHIBIT:					

Terracon
 1450 Fifth Street West
 Charleston, SC

DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS

ASTM D3080

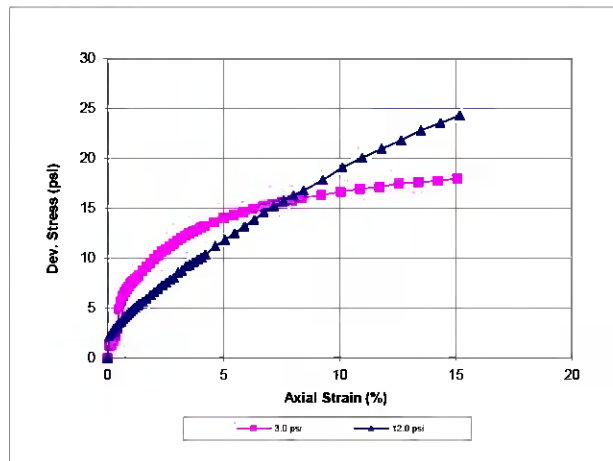
Page 2 of 2



DESCRIPTION					
SOURCE	CGS	SAMPLE NO.	B734	DEPTH, Feet	2' - 4'
PROJECT: Cross Ash Pond Dikes		 1450 Fifth Street West Charleston, SC		PROJECT NUMBER: EN131025	
SITE: CGS				CLIENT: Santee Cooper	
NOTES: 0				EXHIBIT:	

Consolidated - Undrained Triaxial Shear Test

ASTM D4767



Project Name: CGS
Job Number: EN131025
Proj. Location: Ash Pond Dikes
Sample No.: B 734
Soil Description: Clayey Sand

Description	I	II	III
Initial wet density (pcf)	130.16	129.82	
Initial dry density (pcf)	107.79	107.50	
Initial water content (%)**	20.8%	20.8%	
Initial void ratio	0.563	0.567	
Initial Degree of Sat. (%)*	99.5	98.8	
Initial Height	5.98	5.93	
Initial Diameter	2.84	2.86	
Parameter B	0.98	0.98	
Final Degree of Sat. (%)*	98.0	98.0	
Liquid Limit	37		
Plastic Limit	15		
% finer than #200	46		

	I	II	III
Total Back Pressure (psi)		60.0	
Effective Consolidation Stress (psi)	5.2	10.4	
Axial Strain at failure (%)***	4.2	2.8	
Deviator Stress at failure (psi)	18.0	24.3	
Pore Pressure at failure (psi)	0.9	6.3	
Effective minor principal stress, σ'_3 (psi)	2.1	5.7	
Effective major principal stress, σ'_1 (psi)	20.1	30.0	
Φ	14.8°		
Φ'	29.2°		
Cohesion, c (psi)	6.1		
Effective Cohesion, c' (psi)	4.0		
Rate of Strain (% / minute)	0.2		

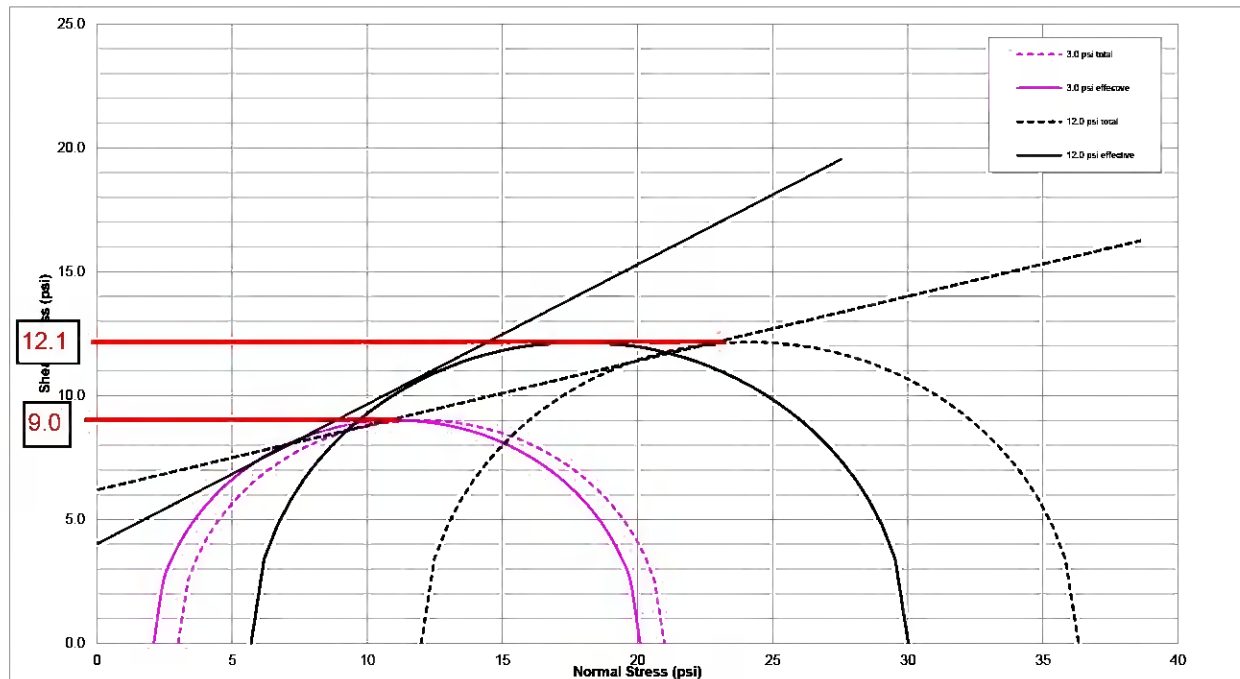
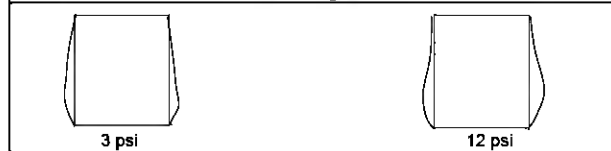
* Specific Gravity assumed 2.7; wet method of sat.

** obtained from cuttings

*** failure criterion - 5% stress after peak/15% strain

**** Time to 50% primary consolidation not measured

Failure Diagrams



Terracon

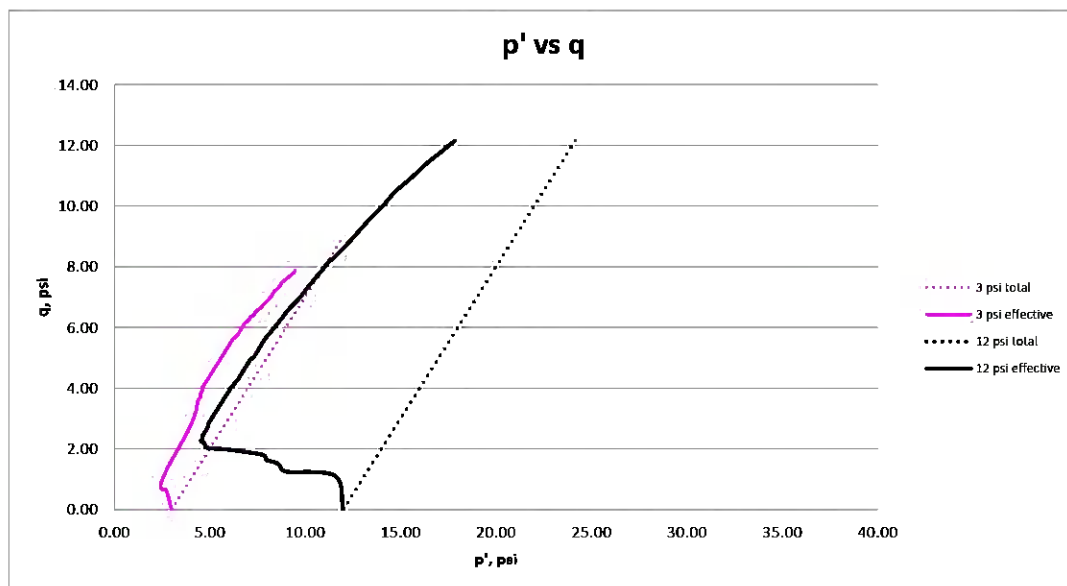
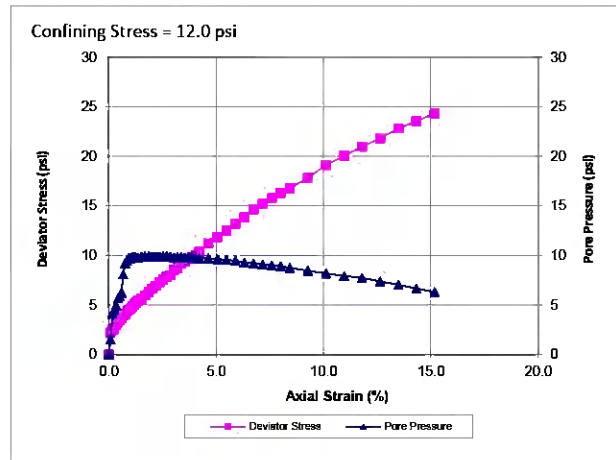
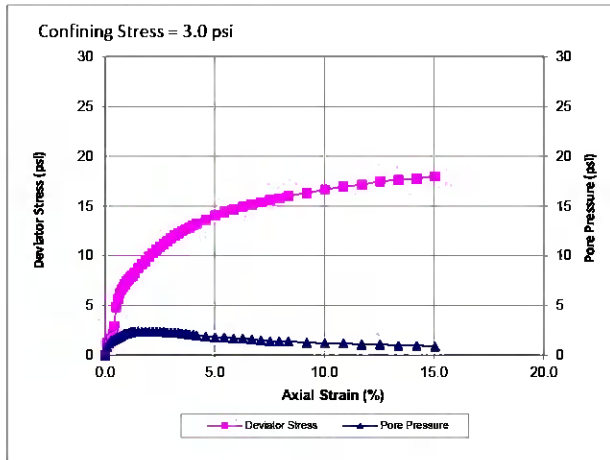
CGS
Ash Pond Dikes
EN131025
10/25/2015
B 735 8-10'

Tested By: DL

Approved By: JH

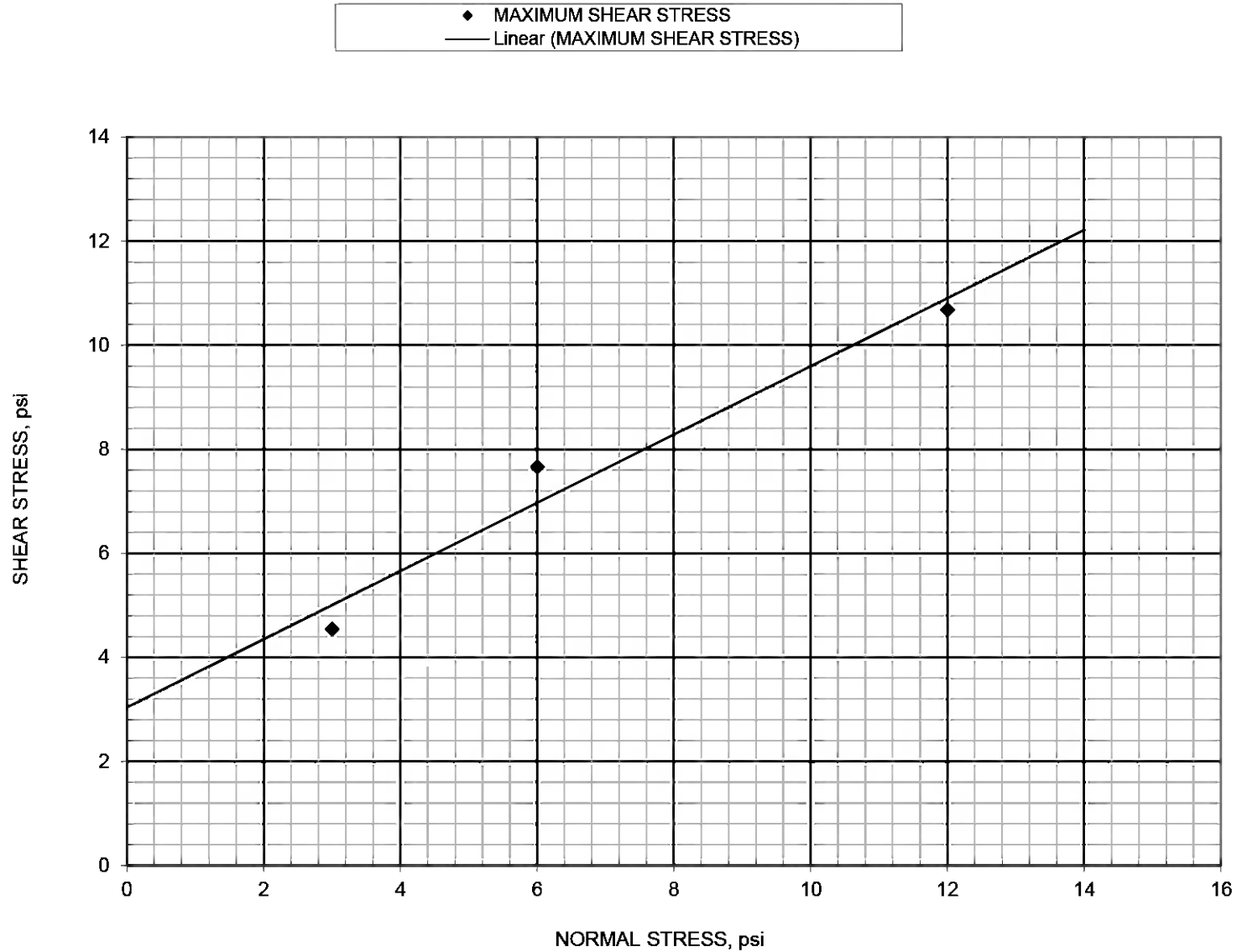
Consolidated - Undrained Triaxial Shear Test

ASTM D4767



**DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS
AASHTO T236**

SHEAR STRENGTH

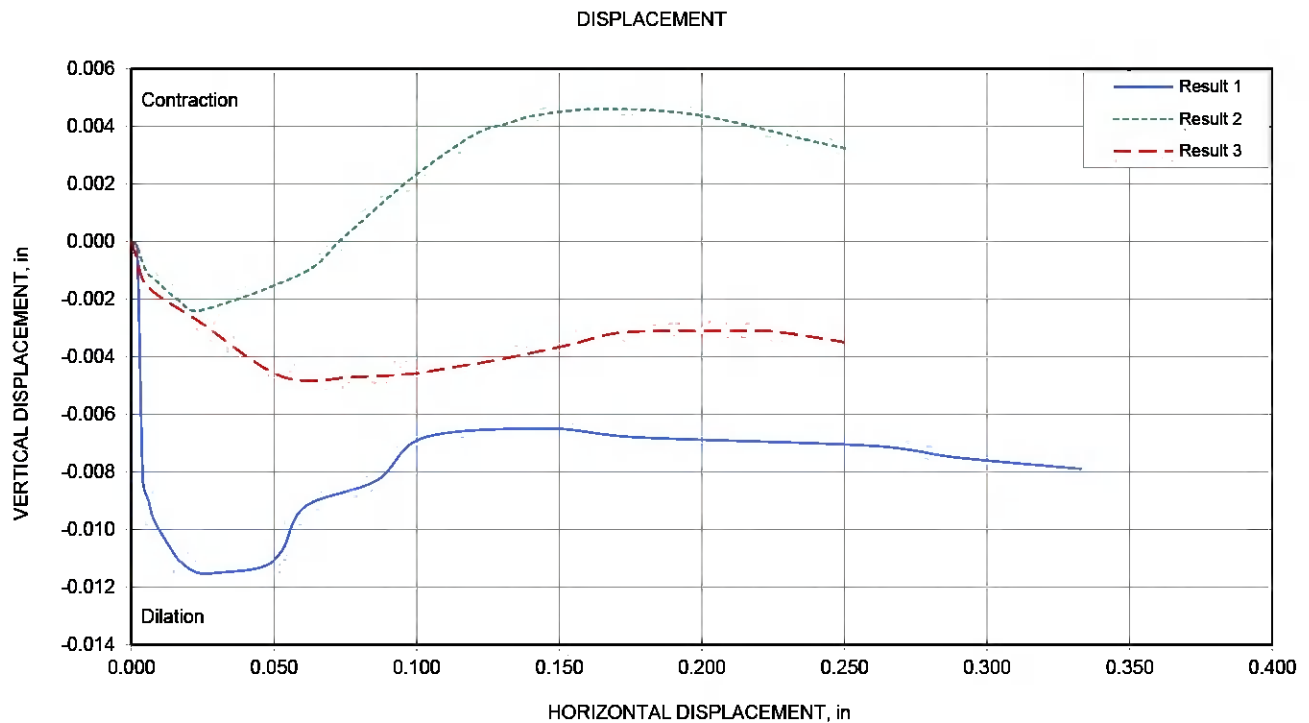
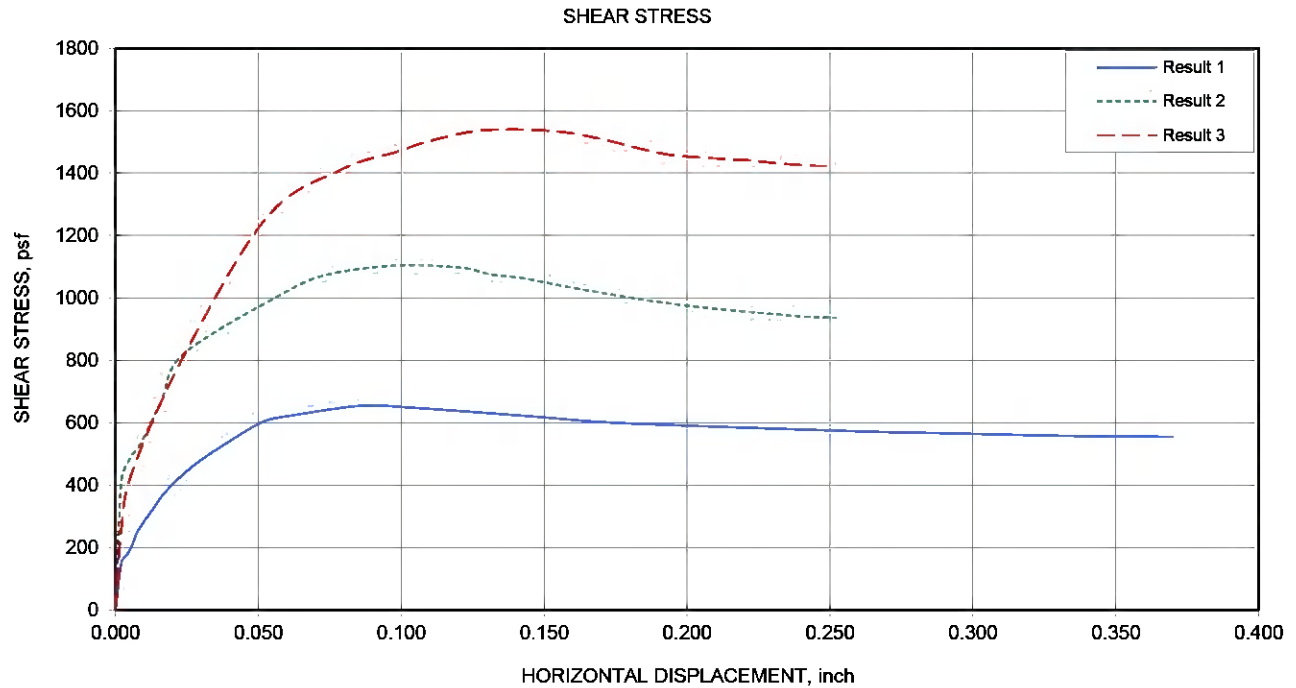


			FRICITION ANGLE	COHESION	NORMAL STRESS, ksf			
AT MAXIMUM SHEAR STRESS			33.3 deg	3.0 psi				
					3	6	12	
INITIAL AREA, in2	4.909		INITIAL MOISTURE, %			24.5	24.7	26.0
INITIAL LENGTH, in	1.000		INITIAL DRY DENSITY, pcf			97.9	98.4	97.0
SPECIFIC GRAVITY	2.70		INITIAL SATURATION, %			92	93	95
SG ASSUMED	X		INITIAL VOID RATIO			0.72	0.71	0.74
SG TESTED			FINAL MOISTURE, %			25.8	26.0	26.6
LIQUID LIMIT	-		FINAL SATURATION, %			96.2	98.5	99.5
PLASTIC LIMIT	-		FINAL VOID RATIO			0.72	0.71	0.72
PLASTICITY INDEX	-		MAXIMUM SHEAR STRESS, psf			4.54	7.66	10.67
SAMPLE TYPE	UNDISTURBED		RATE OF LOADING, in/min			0.0020	0.0020	0.0200
DESCRIPTION								
SOURCE	CGS	SAMPLE NO.	B735		DEPTH, Feet	4' - 6'		
PROJECT: Cross Ash Pond Dikes			Terracon 1450 Fifth Street West Charleston, SC			PROJECT NUMBER: EN131025		
SITE: CGS						CLIENT: Santee Cooper		
NOTES:						EXHIBIT:		

DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS

ASTM D3080

Page 2 of 2



DESCRIPTION					
SOURCE	CGS	SAMPLE NO.	B735	DEPTH, Feet	4' - 6'
PROJECT: Cross Ash Pond Dikes		 1450 Fifth Street West Charleston, SC		PROJECT NUMBER: EN131025	
SITE: CGS				CLIENT: Santee Cooper	
NOTES: 0				EXHIBIT:	

CPT CORRELATIVE PARAMETER LOG NO. C-834

Page 1 of 1

SEE CPT LOG NO. C-834 FOR DETAILED TEST RESULTS

PROJECT: Cross Generating Station- Ash Pond
Dikes

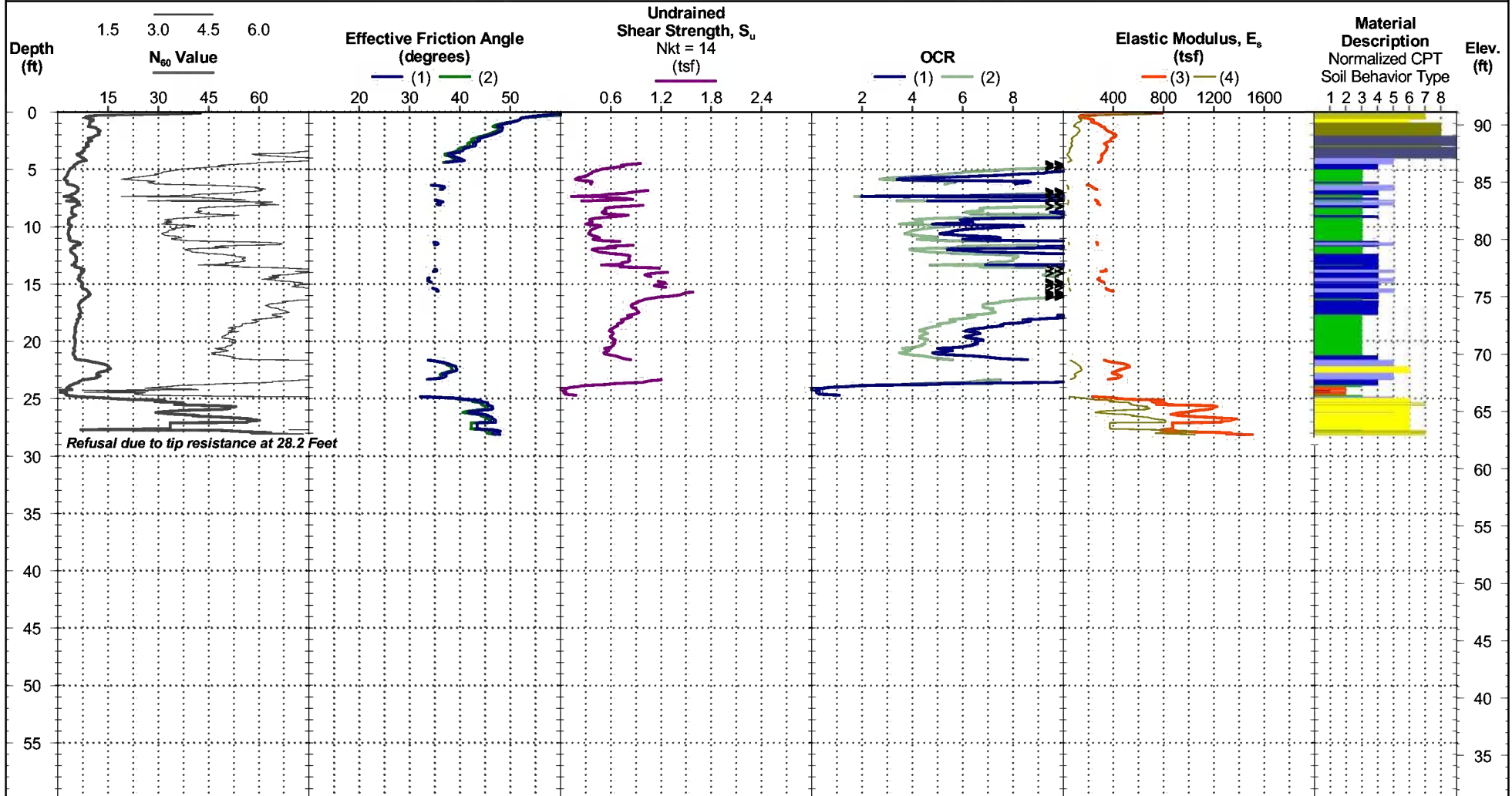
CLIENT: Santee Cooper
Moncks Corner

TEST LOCATION: See Exhibit A-2

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

Surface Elev.: 91.1 ft
LL: 33.3796°, -80.10488°
NE: 14899,9355



Tip resistance, sleeve resistance, porewater pressure, and tilt angle are measured. Other parameters presented are derived from interpretations of the measured data, based upon published correlations, but do not necessarily represent actual values that would be derived from direct testing. Appendix C provides the formulas used for these correlations and presents estimates of the relative reliability associated with the correlated parameters.

WATER LEVEL OBSERVATION

4.5 ft estimated water depth
(used in normalizations and correlations;
see Appendix C)

Notes:
Probe no. 4675 with net area ratio of 0.84
Manufactured by Geotech A.B.; calibrated 10/22/2015
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 5th Street West
North Charleston, South Carolina

CPT Started: 10/9/2015

Rig: Pagani TG73-200

Project No.: EN131025

CPT Completed: 10/9/2015

Operator: J. Bandle

Exhibit: A-1

CPT CORRELATIVE PARAMETER LOG NO. C-835

Page 1 of 1

SEE CPT LOG NO. C-835 FOR DETAILED TEST RESULTS

PROJECT: Cross Generating Station- Ash Pond
Dikes

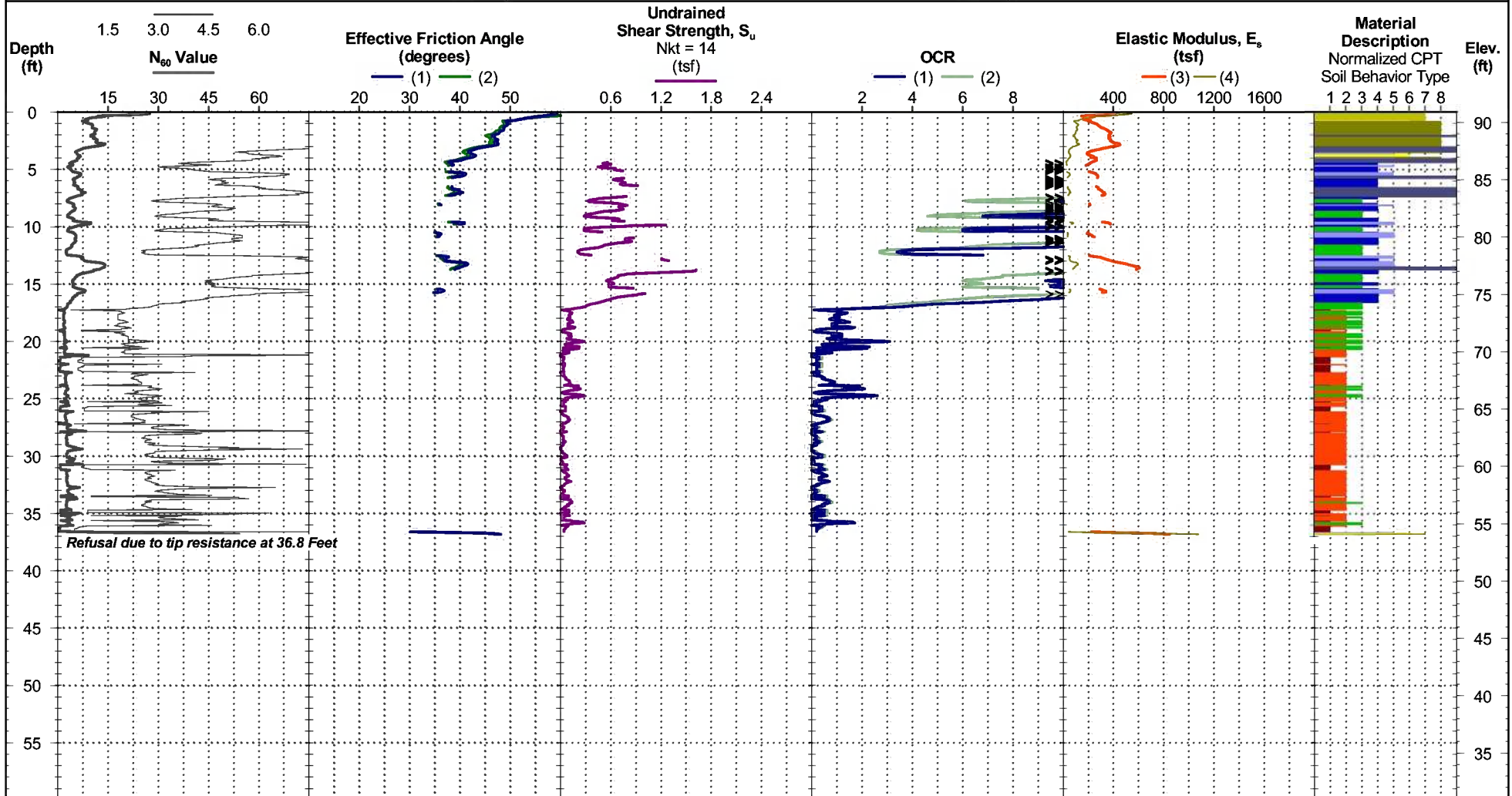
CLIENT: Santee Cooper
Moncks Corner

TEST LOCATION: See Exhibit A-2

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

Surface Elev.: 90.9 ft
LL: 33.37689°, -80.10157°
NE: 14692,10701



Tip resistance, sleeve resistance, porewater pressure, and tilt angle are measured. Other parameters presented are derived from interpretations of the measured data, based upon published correlations, but do not necessarily represent actual values that would be derived from direct testing. Appendix C provides the formulas used for these correlations and presents estimates of the relative reliability associated with the correlated parameters.

WATER LEVEL OBSERVATION

1 ft estimated water depth
(used in normalizations and correlations;
see Appendix C)

Notes:
Probe no. 4675 with net area ratio of 0.84
Manufactured by Geotech A.B.; calibrated 10/22/2015
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 5th Street West
North Charleston, South Carolina

CPT Started: 10/9/2015

Rig: Pagani TG73-200

Project No.: EN131025

CPT Completed: 10/9/2015

Operator: J. Bandle

Exhibit: A-2

CPT CORRELATIVE PARAMETER LOG NO. C-836

Page 1 of 1

SEE CPT LOG NO. C-836 FOR DETAILED TEST RESULTS

PROJECT: Cross Generating Station- Ash Pond
Dikes

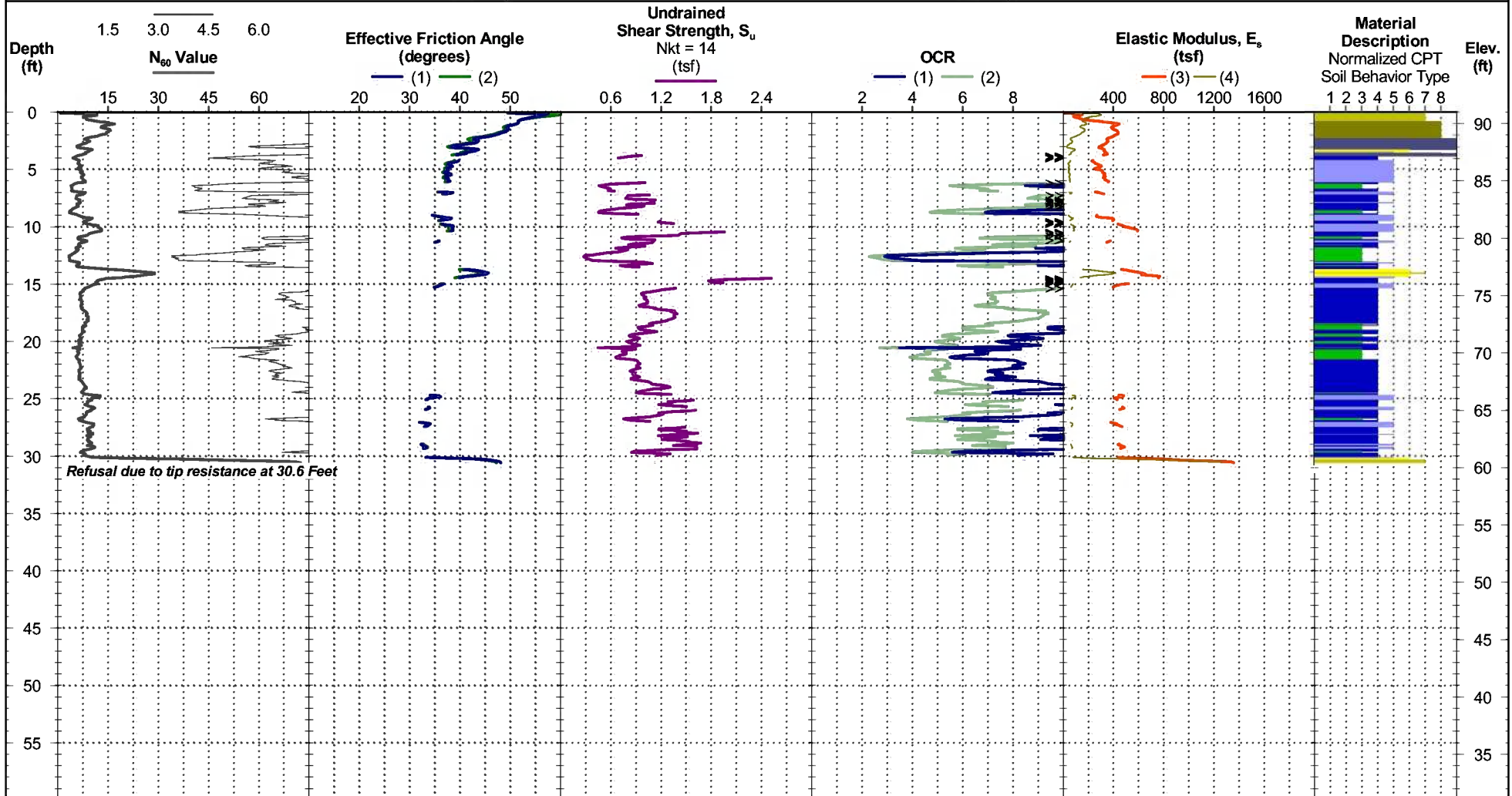
CLIENT: Santee Cooper
Moncks Corner

TEST LOCATION: See Exhibit A-2

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

Surface Elev.: 91.0 ft
LL: 33.374°, -80.10619°
NE: 12993,10212



Tip resistance, sleeve resistance, porewater pressure, and tilt angle are measured. Other parameters presented are derived from interpretations of the measured data, based upon published correlations, but do not necessarily represent actual values that would be derived from direct testing. Appendix C provides the formulas used for these correlations and presents estimates of the relative reliability associated with the correlated parameters.

WATER LEVEL OBSERVATION

6.6 ft estimated water depth
(used in normalizations and correlations;
see Appendix C)

Notes:
Probe no. 4675 with net area ratio of 0.84
Manufactured by Geotech A.B.; calibrated 10/22/2015
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 5th Street West
North Charleston, South Carolina

CPT Started: 10/9/2015

Rig: Pagani TG73-200

Project No.: EN131025

CPT Completed: 10/9/2015

Operator: J. Bandle

Exhibit: A-3

CPT CORRELATIVE PARAMETER LOG NO. C-837

Page 1 of 1

SEE CPT LOG NO. C-837 FOR DETAILED TEST RESULTS

PROJECT: Cross Generating Station- Ash Pond
Dikes

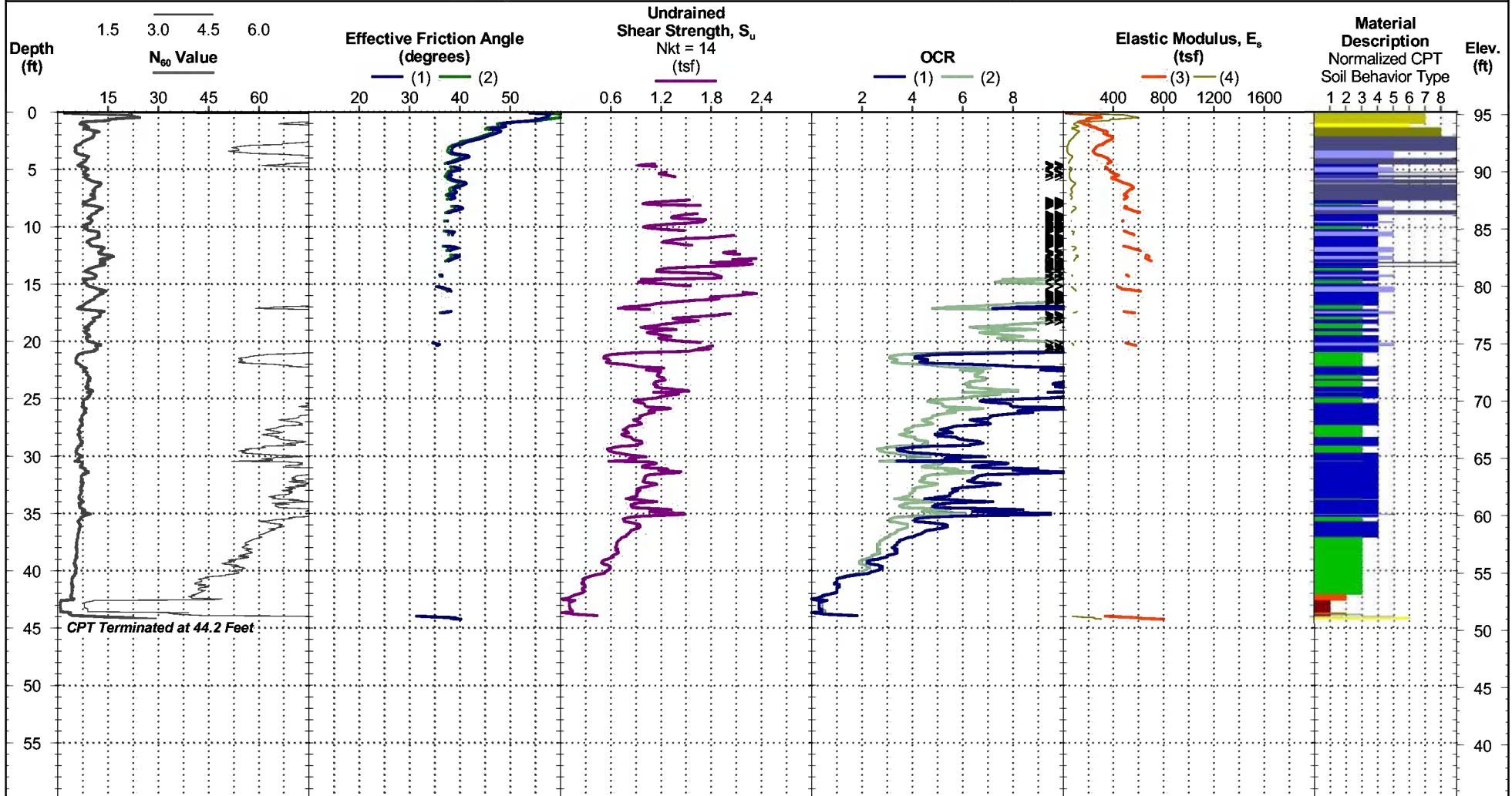
CLIENT: Santee Cooper
Moncks Corner

TEST LOCATION: See Exhibit A-2

SITE: Cross Generating Station
Pineville, South Carolina

WorleyParsons

Surface Elev.: 95.2 ft
LL: 33.37303°, -80.10186°
NE: 13447,11565



Tip resistance, sleeve resistance, porewater pressure, and tilt angle are measured. Other parameters presented are derived from interpretations of the measured data, based upon published correlations, but do not necessarily represent actual values that would be derived from direct testing. Appendix C provides the formulas used for these correlations and presents estimates of the relative reliability associated with the correlated parameters.

WATER LEVEL OBSERVATION

5.1 ft estimated water depth
(used in normalizations and correlations;
see Appendix C)

Notes:
Probe no. 4675 with net area ratio of 0.84
Manufactured by Geotech A.B.; calibrated 10/22/2015
Tip and sleeve areas of 10 cm² and 150 cm²
Ring friction reducer with O.D. of 1.875 in

Terracon
1450 5th Street West
North Charleston, South Carolina

CPT Started: 10/9/2015

Rig: Pagani TG73-200

Project No.: EN131025

CPT Completed: 10/9/2015

Operator: J. Bandle

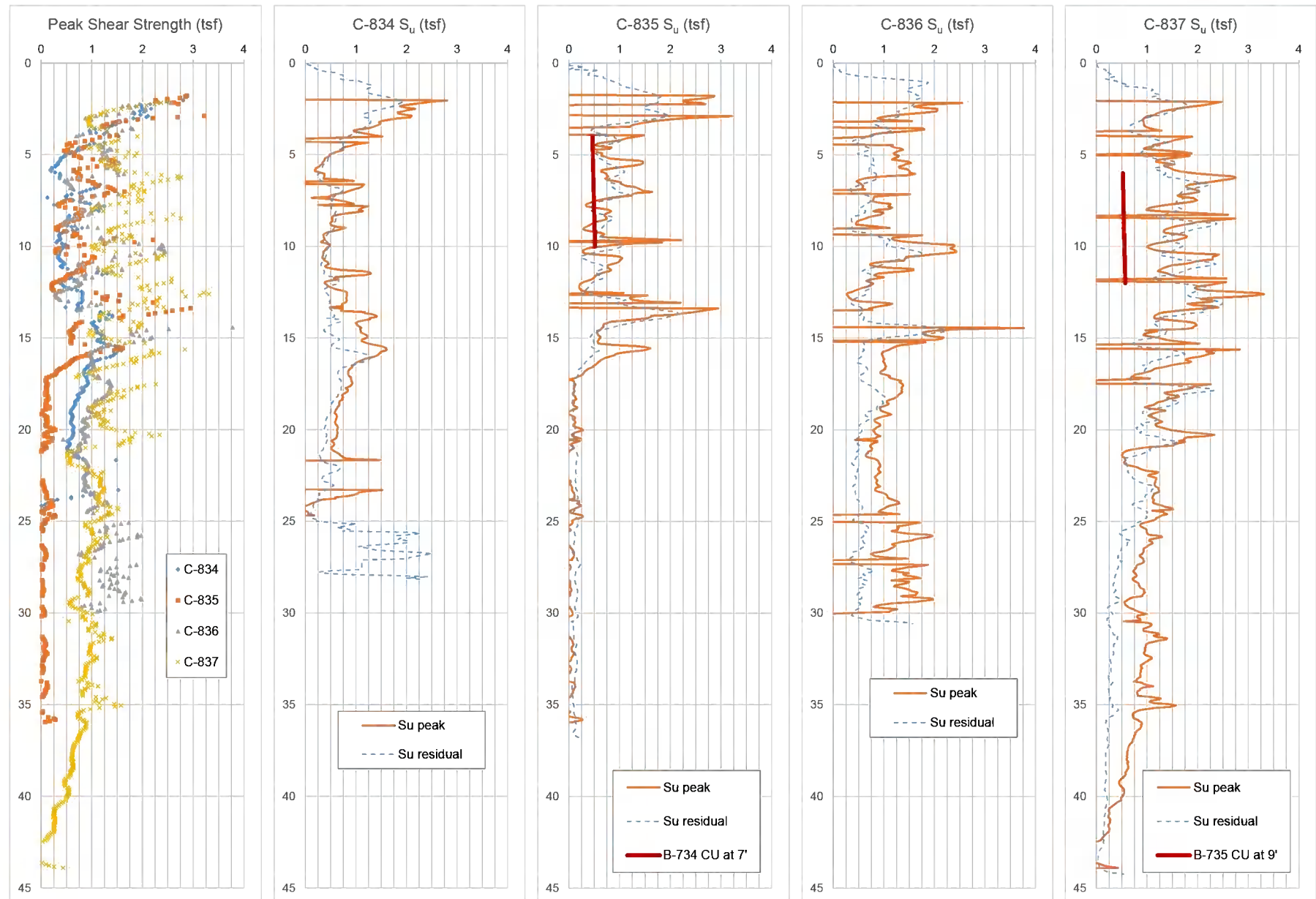
Exhibit: A-4

Summary of Shear Strength

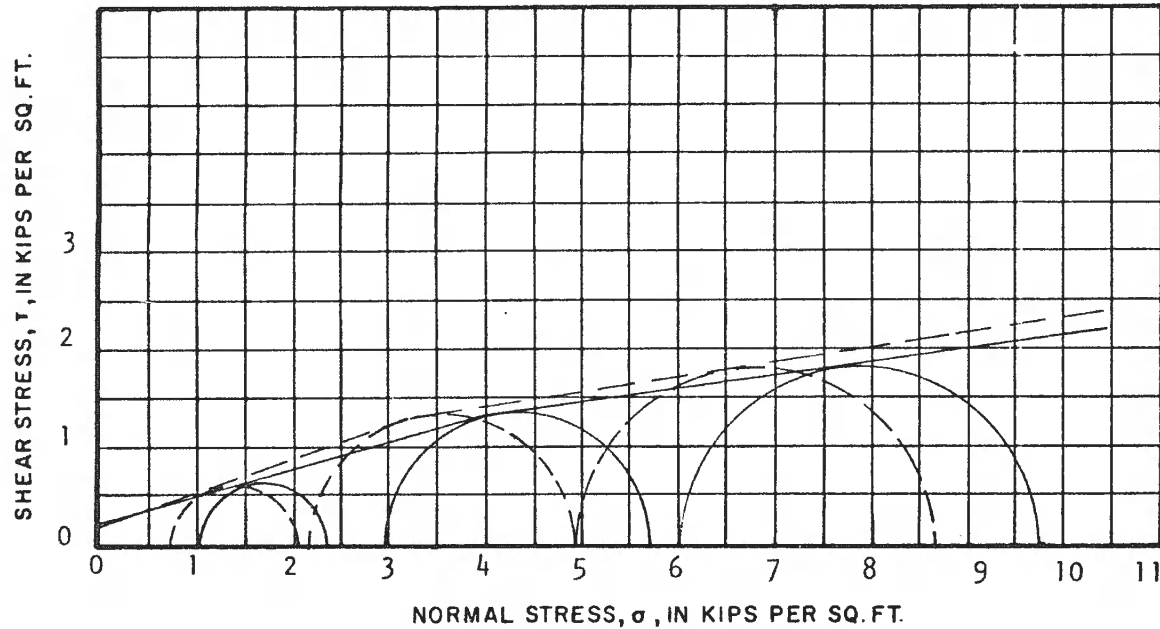
EN131025 - Cross Generating Station Ash Pond Dikes

December 30, 2015

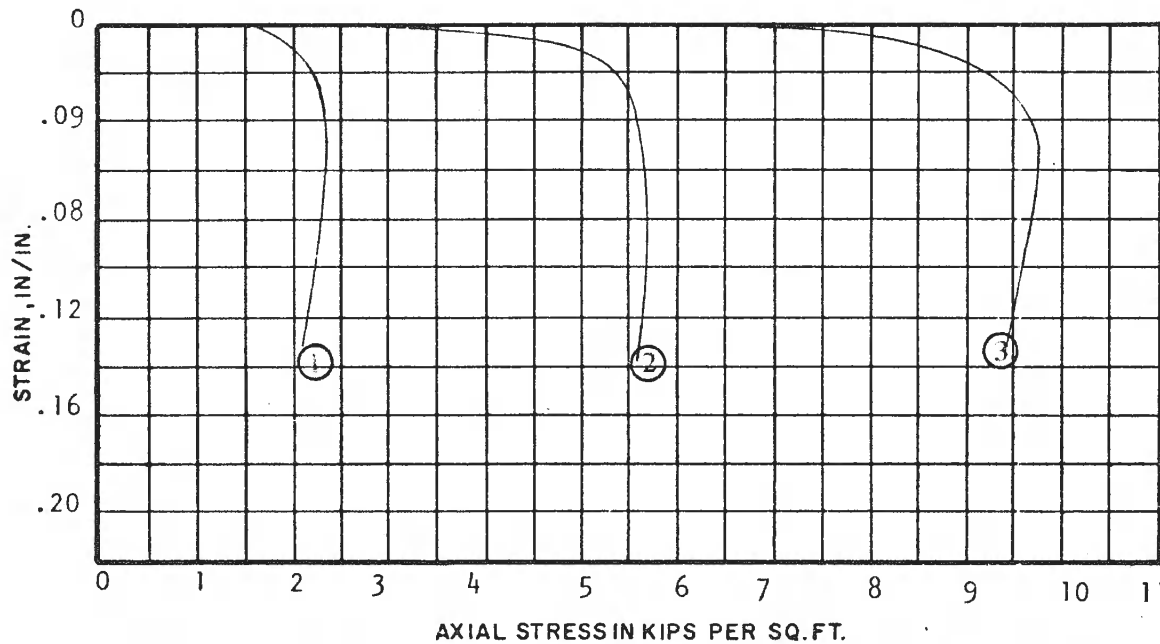
Terracon



LAW ENGINEERING TESTING COMPANY



MOHR DIAGRAMS



STRESS - STRAIN AND PORE PRESSURE-STRAIN CURVES

EFFECTIVE COHESION, c' 190 psf
 EFFECTIVE SHEAR ANGLE, ϕ' 19°; 8.5° above 3.3
 TOTAL COHESION, c 210 psf ksf
 TOTAL SHEAR ANGLE, ϕ 15.5°; 7.5° above 4.0 ksf

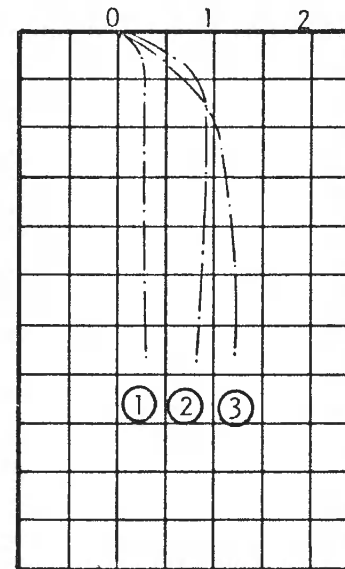
INITIAL PROPERTIES:

	①	②	③	AVG.
UNIT WEIGHT γ	116.8	115.1	110.3	114.1
WATER CONTENT, w	24.7	31.9	31.8	29.5
VOID RATIO, e	0.772	0.902	0.983	0.886
SATURATION, s	84.9	94.1	86.1	88.4

FINAL PROPERTIES:

	①	②	③	AVG.
UNIT WEIGHT, γ	122.0	119.2	120.4	120.5
WATER CONTENT, w	27.8	31.0	29.6	29.5
VOID RATIO, e	0.739	0.824	0.787	0.783
SATURATION, s	100	100	100	100

EXCESS PORE PRESSURE
IN KIPS PER SQ. FT.



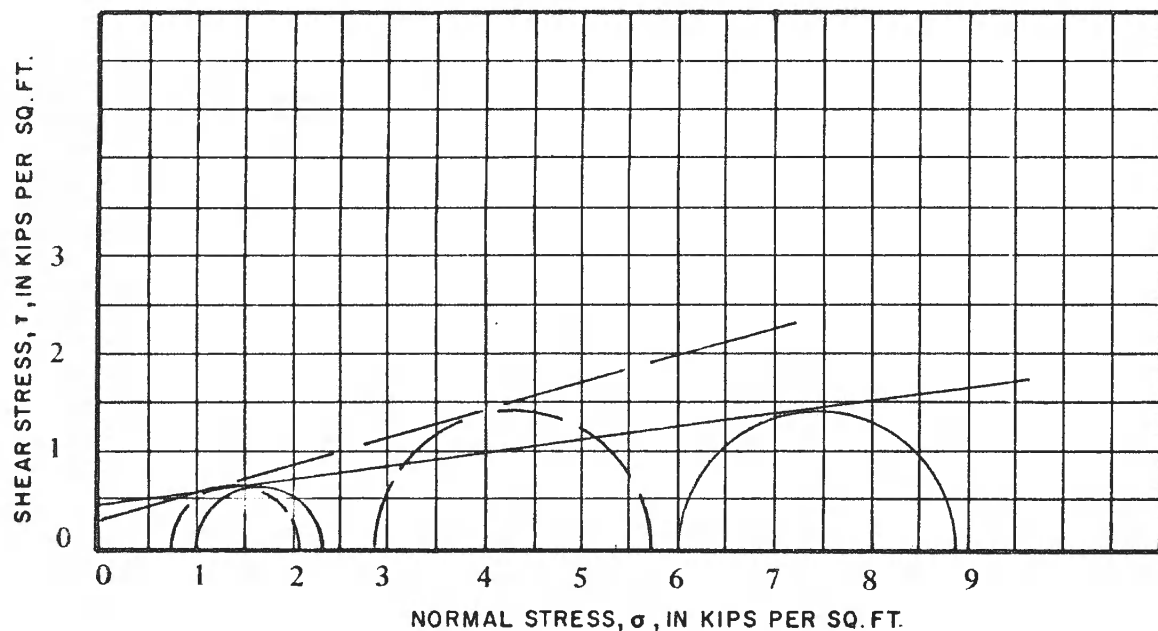
SAMPLE DESCRIPTION:
Firm Gray Silty Clay (CH)

TOTAL STRESSES _____
 EFFECTIVE STRESSES _____

SATURATED,
 CONSOLIDATED,
 UNDRAINED
 TRIAXIAL SHEAR
 TEST WITH
 PORE PRESSURE
 MEASUREMENTS

JOB NO. CH 4193 BORING NO. 221A
 DEPTH 5.5 - 7.5 SAMPLE TYPE UD

LAW ENGINEERING TESTING COMPANY



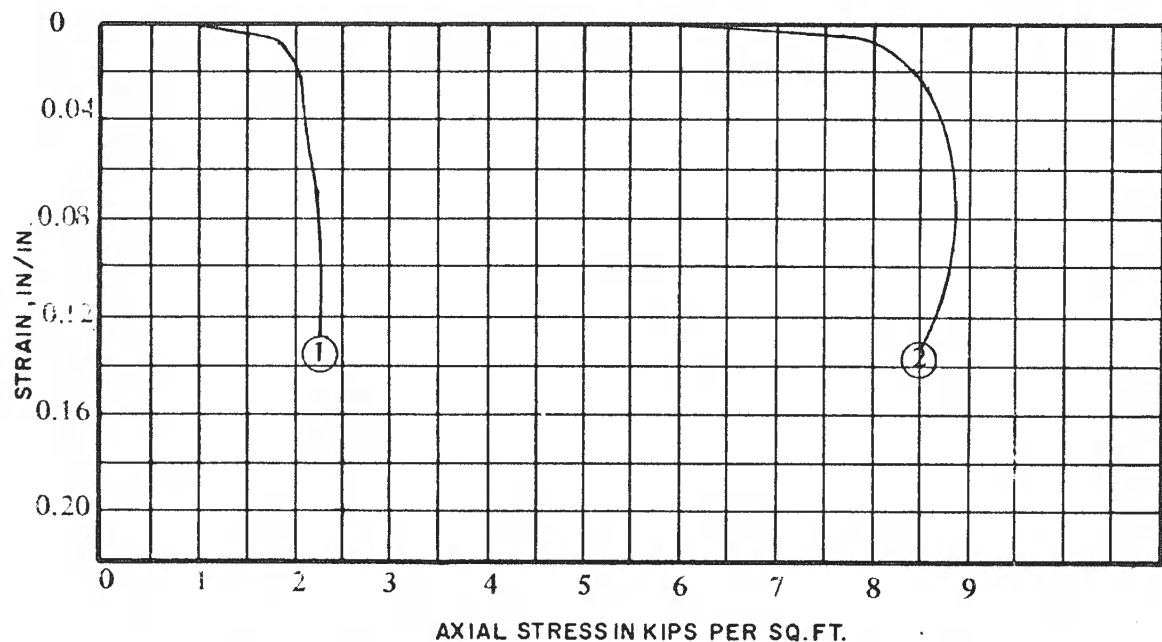
EFFECTIVE COHESION, c' 260 psf
 EFFECTIVE SHEAR ANGLE, ϕ' 16.1°
 TOTAL COHESION, c 440 psf
 TOTAL SHEAR ANGLE, ϕ 8.1°

INITIAL PROPERTIES:

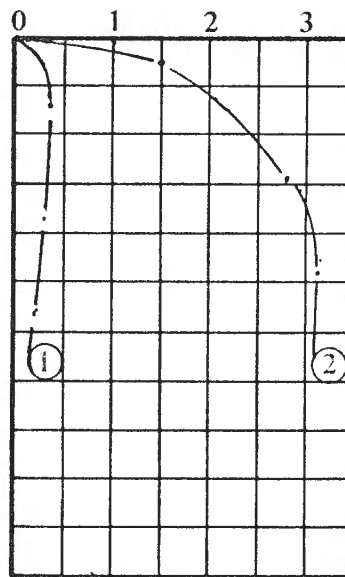
	①	②	③	AVG.	
UNIT WEIGHT, γ	111.4	109.5		110.5	pcf
WATER CONTENT, w	44.5	47.7		46.1	%
VOID RATIO, e	1.233	1.323		1.278	
SATURATION, s	99.5	99.6		99.6	%

FINAL PROPERTIES:

	①	②	③	AVG.	
UNIT WEIGHT, γ	112.2	114.1		113.2	pcf
WATER CONTENT, w	43.7	40.7		42.2	%
VOID RATIO, e	1.207	1.124		1.166	
SATURATION, s	100	100		100	%



EXCESS PORE PRESSURE
IN KIPS PER SQ. FT.



SAMPLE DESCRIPTION:

Soft Gray Brown Silty
Clay (CH)

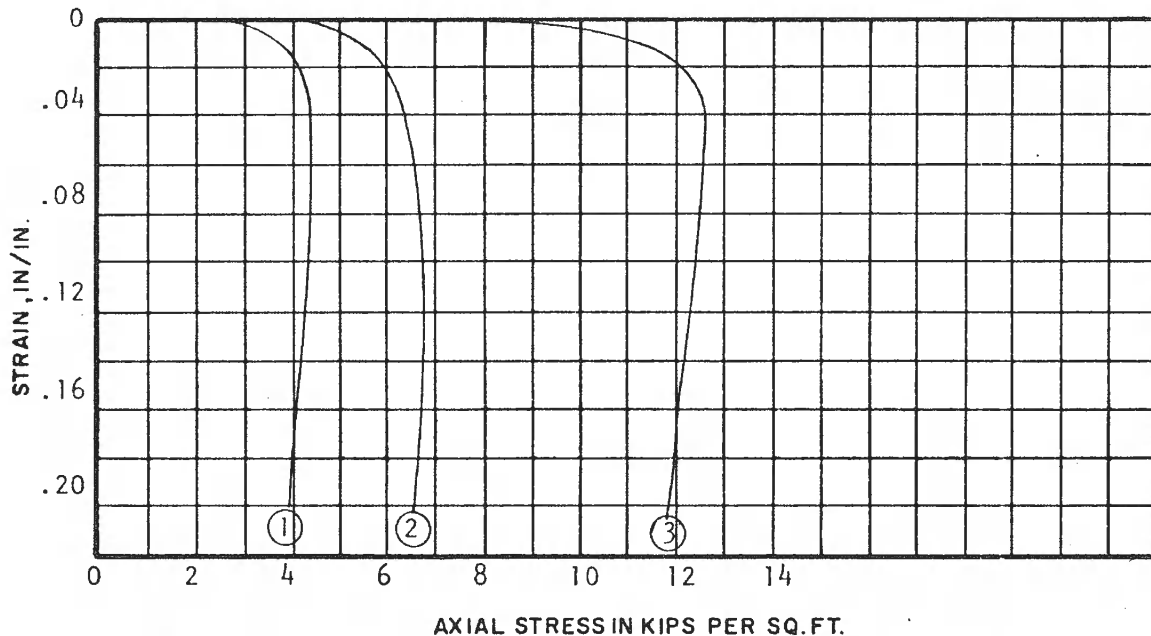
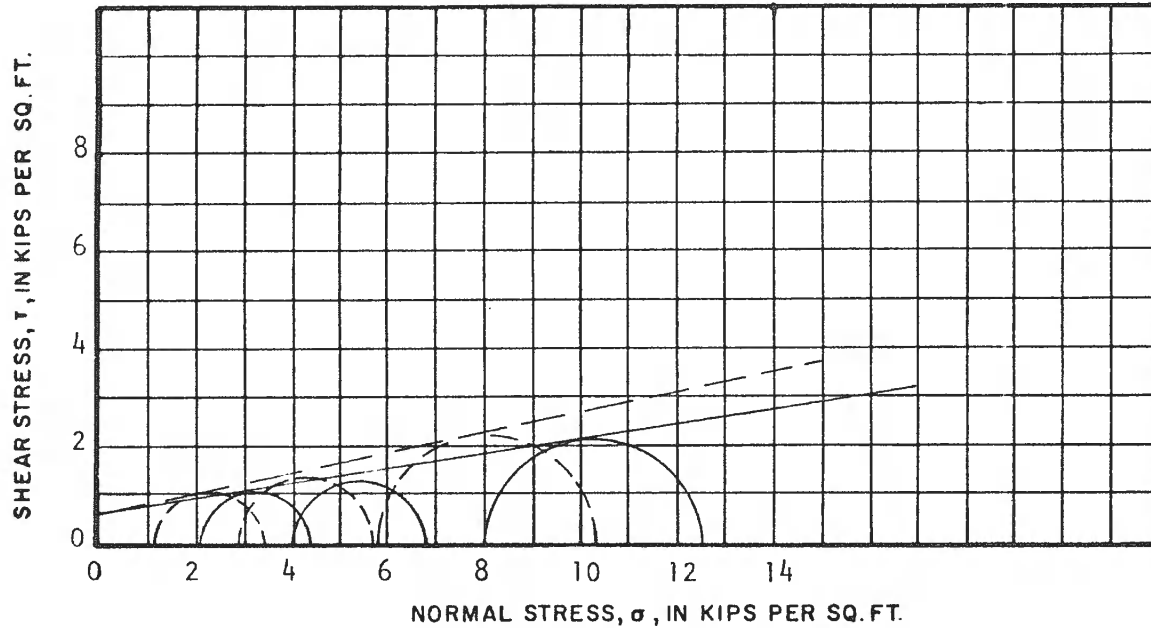
TOTAL STRESSES _____

EFFECTIVE STRESSES _____

**SATURATED,
 CONSOLIDATED,
 UNDRAINED
 TRIAXIAL SHEAR
 TEST WITH
 PORE PRESSURE
 MEASUREMENTS**

JOB NO. CH 4193 BORING NO. 224
 DEPTH 5'-7' SAMPLE TYPE UD

LAW ENGINEERING TESTING COMPANY



EFFECTIVE COHESION, c' 630 psf
 EFFECTIVE SHEAR ANGLE, ϕ' 12°
 TOTAL COHESION, c 630 psf
 TOTAL SHEAR ANGLE, ϕ 9.1°

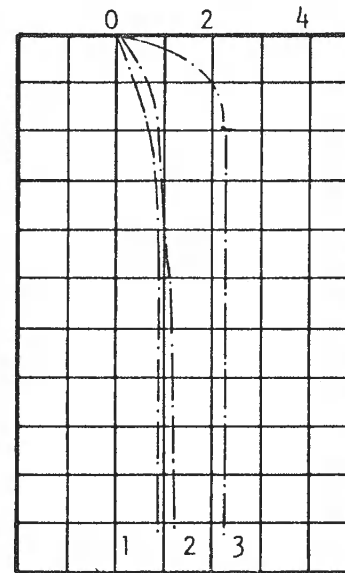
INITIAL PROPERTIES:

	①	②	③	AVG.	
UNIT WEIGHT γ	115.9	113.0	115.6	114.8	pcf
WATER CONTENT, w	33.0	42.2	32.1	35.8	%
VOID RATIO, e	0.905	1.088	0.897	0.963	
SATURATION, s	97.0	100	95.1	97.4	%

FINAL PROPERTIES:

	①	②	③	AVG.	
UNIT WEIGHT, γ	118.3	113.6	121.4	117.8	pcf
WATER CONTENT, w	32.1	38.4	28.5	33.0	%
VOID RATIO, e	0.853	1.022	0.757	.877	
SATURATION, s	100	100	100	100	%

EXCESS PORE PRESSURE
IN KIPS PER SQ. FT.



SAMPLE DESCRIPTION:

Very Soft Gray Tan Fine
Sandy Silty Clay (CL)

TOTAL STRESSES _____

EFFECTIVE STRESSES _____

SATURATED,
CONSOLIDATED,
UNDRAINED
TRIAXIAL SHEAR
TEST WITH
PORE PRESSURE
MEASUREMENTS

JOB NO. CH 4193 BORING NO. 244
 DEPTH 15.5'-17.5' SAMPLE TYPE UD



Customer				Santee Cooper					Project No.		108008-01330		
Project Title				Cross Generating Station					Calc No.		CROSS-0-DC-044-CE-0003		
Calculation Title				Bottom Ash Pond Initial Safety Factor Assessment					Phase/CTR		LBRCCR		
Elec File Location				\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm									
									Page		69	of	128
Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked		
0	14-OCT-16	B. Gordon	Y. Xu										

Appendix F – Liquefaction Evaluation Spreadsheets

(8 total pages)

This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither WorleyParsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.

Liquefaction Potential Assessment, Simplified Procedure Using SPT Data

General Parameters

γ_{soil}	130	lb/ft³
γ_{soil}	20.5	kN/m³
γ_{water}	62.4	lb/ft³
γ_{water}	9.8	kN/m³
Pa	101.3	kPa
ER	93	% MAD
	86	% WPC
	71.9	% Terracon

Earthquake Parameters

Mw	7.3	
MSF	1.07	Lower bound of
MSF	1.09	MSF is used
a_{max}	0.55	g

Boring No.	Groundwater		Cohesionless Soil		Depth (Layer Middle ft m	CSR=0.65(a _{max} /g)(σ _{vo} '/σ _{vo} ')r _d					(N1) ₆₀ =N _m C _N C _E C _B C _R C _S						Fines Content Correction		Kσ=(σ _{vo} '/P _a) ^(f-1)			FS=(CRR7.5/CSR))*MSF*Kσ			
	Depth ft m		Layer Top Bottom			σ _{vo} kPa	σ _{vo} ' kPa	r _d	CSR	N _m	C _N C _N =(P _a /σ _{vo} ') ^{0.5}	C _E	C _B	C _R	C _S	(N1) ₆₀	FC %	(N1) _{60cs} (N1) _{60cs} =α+β(N1) ₆₀	CRR _{7.5}	Dr	f	K _σ	FS	Liquefiable?	
B-734	13.4	4.1	44 47	47 55	45.5 51	13.87 15.55	283.76 318.06	187.67 205.50	0.80 0.74	0.43 0.41	1 43	0.73 0.70	1.20 1.20	1.0 1.0	1.00 1.00	1.2 1.2	1 43	35 na	6 43	0.08 Non-liquefiable	30.00 90.00	0.80 0.60	0.88 0.75	0.18 Non-liquefiable	Likely Not Likely
B-735	13.0	4.0	33	50	41.5	12.65	258.81	173.50	0.84	0.45	45	0.76	1.20	1.0	1.00	1.2	49	na	49	Non-liquefiable	90.00	0.60	0.81	Non-liquefiable	Not Likely

Liquefaction Potential Assessment, Simplified Procedure Using CPT Data

Indicates user input

General Parameters

γ_{soil}	130	lb/ft ³
γ_{soil}	20.5	kN/m ³
γ_{water}	62.4	lb/ft ³
γ_{water}	9.8	kN/m ³
Pa	101.33	kPa

Quake Parameters

Mw	7.3
MSF	1.07
MSF	1.09
a _{max}	0.55 %g

Note:

1. The soil is classified as clayey and is considered too clay-rich to liquefy. However, soil samples should be retrieved and tested to confirm the soil type and liquefaction resistance.

CPT No. C-834

Groundwater depth 4.5 ft

Groundwater depth 1.4 m

Lower bound of
MSF is used

LAYER		z		q _c		f _e		σ _{vo}	σ' _{vo}	F	r _d	CSR	Q			I _c				C _Q		q _{c1N}		K _c	(q _{c1N}) _{cs}	CRR _{7.5}	q _{c1}	D _r	f	K _s	FOS	Liquefiable?	
Top	Bottom	ft	m	tsf	kPa	tsf	kPa	kPa	kPa	%			Q _{n1}	Q _{n.5}	Q _{n.7}	I _{c1}	I _{c.5}	I _{c.7}	I _c	C _{Q.5}	C _{Q.7}	q _{c1N.5}	q _{c1N.7}	q _{c1N}									
Ave. per Foot																																	
0	0.984	0.49213	0.2	100.7138	9663.0	0.47723	45.8	3.07	3.07	0.47	1.00	0.36	3147.47	547.77	1102.41	0.90	1.16	na	1.16	5.75	na	162.12	na	162.12	1.00	162.12	na	na	na	na	na	No	
0.984	1.968	1.47631	0.5	44.67334	4286.2	1.35101	129.6	9.21	9.21	3.03	1.00	0.36	464.54	140.03	226.22	1.88	2.16	na	2.16	3.32	na	71.91	na	71.91	1.57	112.56	0.21	140.33	67.83	0.66	1.00	0.64	No
1.968	2.953	2.46063	0.8	29.55638	2835.8	1.52415	146.2	15.35	15.35	5.18	1.00	0.36	183.80	71.53	104.33	2.28	2.52	na	2.52	2.57	na	47.58	na	47.58	2.87	136.76	0.32	71.91	48.56	0.76	1.00	0.96	No
2.953	3.937	3.44488	1.1	18.92973	1816.2	1.16387	111.7	21.48	21.48	6.22	0.99	0.36	83.54	38.47	52.46	2.54	2.76	2.67	2.67	2.17	2.96	30.47	30.47	30.47	na	na	na	na	na	na	na	No	
3.937	4.987	4.51007	1.4	14.05016	1348.0	0.68924	66.1	28.13	28.10	5.01	0.99	0.35	46.98	not liq	not liq	2.63	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
4.987	5.971	5.54457	1.7	4.72944	453.8	0.37977	36.4	34.58	31.45	8.69	0.99	0.39	13.33	not liq	not liq	3.19	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
5.971	6.955	6.46325	2.0	11.78905	1131.1	0.41313	39.6	40.31	34.43	3.63	0.99	0.41	31.68	not liq	not liq	2.65	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
6.955	7.94	7.4475	2.3	10.47125	1004.7	0.54817	52.6	46.45	37.62	5.49	0.98	0.43	25.47	not liq	not liq	2.85	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
7.94	8.989	8.46453	2.6	9.895219	949.4	0.59308	56.9	52.79	40.92	6.35	0.98	0.45	21.91	not liq	not liq	2.94	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
8.989	9.974	9.48156	2.9	6.568613	630.2	0.44717	42.9	59.13	44.22	7.51	0.98	0.47	12.92	not liq	not liq	3.16	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
9.974	10.958	10.4659	3.2	5.99744	575.4	0.39607	38.0	65.27	47.41	7.45	0.98	0.48	10.76	not liq	not liq	3.21	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
10.958	11.942	11.4501	3.5	10.80293	1036.5	0.45092	43.3	71.41	50.60	4.48	0.98	0.49	19.07	not liq	not liq	2.88	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
11.942	12.992	12.4671	3.8	10.20795	979.4	0.46385	44.5	77.75	53.90	4.94	0.97	0.50	16.73	not liq	not liq	2.95	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
12.992	13.976	13.4842	4.1	14.45057	1386.5	0.51816	49.7	84.09	57.20	3.82	0.97	0.51	22.77	not liq	not liq	2.78	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
13.976	14.961	14.4685	4.4	16.3061	1564.5	0.50605	48.6	90.23	60.39	3.29	0.97	0.52	24.41	not liq	not liq	2.71	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
14.961	15.945	15.4528	4.7	20.26501	1944.3	0.76301	73.2	96.37	63.58	3.96	0.97	0.52	29.06	not liq	not liq	2.71	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
15.945	16.995	16.4698	5.0	14.83739	1423.6	0.9283	89.1	102.71	66.88	6.74	0.97	0.53	19.75	not liq	not liq	2.99	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
16.995	17.979	17.5021	5.3	13.17034	1263.6	0.69519	66.7	109.15	70.23	5.78	0.96	0.54	16.44	not liq	not liq	3.00	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
17.979	18.963	18.4711	5.6	10.57061	1014.2	0.55945	53.7	115.19	73.37	5.97	0.96	0.54	12.25	not liq	not liq	3.11	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
18.963	19.947	19.4553	5.9	9.62632	923.6	0.42377	40.7	121.33	76.56	5.07	0.96	0.54	10.48	not liq	not liq	3.12	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
19.947	20.997	20.4724	6.2	9.306963	893.0	0.40074	38.4	127.67	79.86	5.02	0.96	0.55	9.58	not liq	not liq	3.14	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
20.997	21.982	21.4894	6.6	20.12611	1931.0	0.36208	34.7	134.02	83.16	1.93	0.95	0.55	21.61	not liq	not liq	2.61	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
21.982	22.966	22.4737	6.9	49.58327	4757.3	0.48021	46.1	140.16	86.35	1.00	0.95	0.55	53.47	49.36	50.96	2.13	2.15	na	2.15	1.08	na	50.86	na	50.86	1.56	79.48	0.13	50.86	40.83	0.80	1.00	0.25	Yes
22.966	23.95	23.4579	7.2	18.74252	1798.3	0.33966	32.6	146.29	89.54	1.97	0.95	0.55	18.45	not liq	not liq	2.67	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
23.95	24.934	24.3906	7.4	8.3752	803.6	0.14347	13.8	152.11	92.57	2.11	0.94	0.55	7.04	not liq	not liq	3.04	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
24.934	25.984	25.4592	7.8	203.3936	19514.7	1.26396	121.3	158.78	96.03	0.63	0.94	0.56	201.55	196.21	198.33	1.55	1.56	na	1.56	1.03	na	197.82	na	197.82	1.00	197.82	na	na	na	na	na	No	
25.984	26.968	26.4763	8.1	222.7602	21372.8	1.80967	173.6	165.12	99.33	0.82	0.94	0.56	213.50	211.39	212.23	1.61	1.61	na	1.61	1.01	na	213.03	na	213.03	1.00	213.03	na	na	na	na	na	No	
26.968	27.953	27.4606	8.4	215.8136	20706.3	1.05109	100.8	171.26	102.52	0.49	0.93	0.56	200.29	201.47	201.00	1.48	1.48	na	1.48	0.99	na	203.15	na	203.15	1.00	203.15	na	na	na	na	na	No	
Ave. per Interval																																	
0	4.396	2.14048	0.7	46.34169	4446.3	1.09943	105.5	13.35	13.35	2.38	1.00	0.36	332.08	120.53	180.78	1.86	2.12	na	2.12	2.76	na	74.59	na	74.59	1.48	110.75	0.21	120.89	62.96	0.69	1.00	0.62	No
4.396	6.299	5.34773	1.6	6.595803	632.8	0.44437	42.6	33.35	30.81	7.11	0.99	0.38	19.46	not liq	not liq	3.01	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
6.299	9.121	7.70995	2.4	11.25873	1080.2	0.55153	52.9	48.08	38.47	5.13	0.98	0.44	26.83	not liq	not liq	2.81	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
9.121	11.155	10.1378	3.1	6.061045	581.5	0.40502	38.9	63.22	46.35	7.50	0.98	0.48	11.18	not liq	not liq	3.20	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
11.155	13.517	12.3359	3.8	10.86214	1042.2	0.47425	45.5	76.93	53.48	4.71	0.97	0.50	18.05	not liq	not liq	2.91	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
13.517	16.273	14.895	4.5	18.30883	1756.6	0.69583	66.8	92.89	61.77	4.01	0.97	0.52																					

Liquefaction Potential Assessment, Simplified Procedure Using CPT Data

Indicates user input

General Parameters

γ_{soil}	130	lb/ft ³
γ_{soil}	20.5	kN/m ³
γ_{water}	62.4	lb/ft ³
γ_{water}	9.8	kN/m ³
Pa	101.33	kPa

Quake Parameters

Mw	7.3
MSF	1.07
MSF	1.09
a _{max}	0.55 %g

Note:

1. The soil is classified as clayey and is considered too clay-rich to liquefy. However, soil samples should be retrieved and tested to confirm the soil type and liquefaction resistance.

CPT No. C-835

Groundwater depth 1 ft

Groundwater depth 0.3 m

Lower bound of
MSF is used

LAYER		z		q _c		f _e		σ _{vo}	σ' _{vo}	F	r _d	CSR	Q			I _c			C _Q		q _{c1N}		K _c	(q _{c1N}) _{cs}	CRR _{7.5}	q _{c1}	D _r	f	K _s	FOS	Liquefiable?		
Top	Bottom	ft	m	tsf	kPa	tsf	kPa	kPa	kPa	%			Q _{n1}	Q _{n.5}	Q _{n.7}	I _{c1}	I _{c.5}	I _{c.7}	I _c	C _{Q.5}	C _{Q.7}	q _{c1N.5}	q _{c1N.7}	q _{c1N}									
Ave. per Foot																																	
0	0.984	0.43586	0.1	105.6393	10135.6	0.36927	35.4	2.72	2.72	0.35	1.00	0.36	3727.79	610.55	1258.97	0.77	1.03	na	1.03	6.11	na	170.04	na	170.04	1.00	170.04	na	na	na	na	na	No	
0.984	1.968	1.47631	0.5	42.61068	4088.3	1.41206	135.5	9.21	7.78	3.32	1.00	0.42	524.23	145.27	242.72	1.90	2.18	na	2.18	3.61	na	68.59	na	68.59	1.61	110.70	0.21	145.60	69.09	0.65	1.00	0.52	Yes
1.968	2.953	2.46063	0.8	41.69389	4000.3	1.71657	164.7	15.35	10.97	4.13	1.00	0.50	363.16	119.51	186.41	2.05	2.30	na	2.30	3.04	na	67.11	na	67.11	1.96	131.78	0.29	119.97	62.72	0.69	1.00	0.63	Yes
2.953	3.937	3.44488	1.1	21.65883	2078.1	0.85046	81.6	21.48	14.17	3.97	0.99	0.54	145.19	54.28	80.46	2.24	2.51	na	2.51	2.67	na	34.86	na	34.86	2.84	98.96	0.17	54.85	42.41	0.79	1.00	0.34	Yes
3.937	4.987	4.48244	1.4	10.69733	1026.4	0.68825	66.0	27.95	17.53	6.61	0.99	0.57	56.95	not liq	not liq	2.67	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
4.987	5.971	5.47894	1.7	14.29275	1371.3	0.82909	79.5	34.17	20.76	5.95	0.99	0.58	64.41	29.15	40.03	2.60	2.83	2.73	2.73	2.21	3.03	23.01	23.01	23.01	na	na	na	na	na	na	na	No	
5.971	6.955	6.46325	2.0	14.56417	1397.4	0.87865	84.3	40.31	23.95	6.21	0.99	0.59	56.65	not liq	not liq	2.65	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
6.955	7.94	7.44967	2.3	11.32894	1087.0	0.75076	72.0	46.46	27.15	6.92	0.98	0.60	38.32	not liq	not liq	2.79	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
7.94	8.989	8.46453	2.6	9.137444	876.7	0.69157	66.4	52.79	30.44	8.05	0.98	0.61	27.06	not liq	not liq	2.94	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
8.989	9.974	9.48156	2.9	14.58305	1399.2	0.75105	72.1	59.13	33.74	5.38	0.98	0.61	39.71	not liq	not liq	2.70	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
9.974	10.958	10.4505	3.2	9.842914	944.4	0.53222	51.1	65.17	36.88	5.81	0.98	0.62	23.84	not liq	not liq	2.88	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
10.958	11.942	11.4501	3.5	9.2315	885.7	0.60568	58.1	71.41	40.13	7.14	0.98	0.62	20.29	not liq	not liq	3.00	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
11.942	12.992	12.4671	3.8	11.76111	1128.4	0.53591	51.4	77.75	43.42	4.89	0.97	0.62	24.20	not liq	not liq	2.83	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
12.992	13.911	13.4514	4.1	34.72504	3331.7	1.60928	154.4	83.89	46.62	4.75	0.97	0.63	69.67	47.26	55.19	2.50	2.61	2.57	2.57	1.47	1.72	48.48	55.90	55.90	3.13	174.72	na	na	na	na	na	na	No
13.911	14.961	14.4926	4.4	9.842043	944.3	0.74233	71.2	90.38	49.99	8.34	0.97	0.63	17.08	not liq	not liq	3.10	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
14.961	15.945	15.4528	4.7	15.00827	1440.0	0.492	47.2	96.37	53.11	3.51	0.97	0.63	25.30	not liq	not liq	2.72	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
15.945	16.995	16.4698	5.0	7.804506	748.8	0.28169	27.0	102.71	56.40	4.18	0.97	0.63	11.45	not liq	not liq	3.03	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
16.995	17.979	17.4868	5.3	2.465647	236.6	0.11321	10.9	109.06	59.70	8.52	0.96	0.63	2.14	not liq	not liq	3.81	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
17.979	18.963	18.4711	5.6	2.543547	244.0	0.08319	8.0	115.19	62.89	6.19	0.96	0.63	2.05	not liq	not liq	3.74	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
18.963	19.947	19.4553	5.9	2.379938	228.3	0.08765	8.4	121.33	66.09	7.86	0.96	0.63	1.62	not liq	not liq	3.89	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
19.947	20.997	20.4724	6.2	2.758238	264.6	0.09548	9.2	127.67	69.38	6.69	0.96	0.63	1.97	not liq	not liq	3.78	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
20.997	21.982	21.4894	6.6	1.142213	109.6	0.14865	14.3	134.02	72.68	0.01	0.95	0.63	0.01	NOTE 1	NOTE 1	5.53	NOTE 1	na	NOTE 1	NOTE 1	na	NOTE 1	na	NOTE 1	na	na	na	na	na	na	na	No	
21.982	22.966	22.4737	6.9	1.173953	112.6	0.13589	13.0	140.16	75.87	0.01	0.95	0.63	0.01	NOTE 1	NOTE 1	5.53	NOTE 1	na	NOTE 1	NOTE 1	na	NOTE 1	na	NOTE 1	na	na	na	na	na	na	na	No	
22.966	23.95	23.4579	7.2	2.58302	247.8	0.15693	15.1	146.29	79.07	14.83	0.95	0.63	1.28	not liq	not liq	4.13	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
23.95	24.934	24.4422	7.5	3.382393	324.5	0.14559	14.0	152.43	82.26	8.12	0.94	0.63	2.09	not liq	not liq	3.80	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
24.934	25.984	25.4592	7.8	1.612338	154.7	0.13575	13.0	158.78	85.56	0.01	0.94	0.62	0.01	NOTE 1	NOTE 1	5.53	NOTE 1	na	NOTE 1	NOTE 1	na	NOTE 1	na	NOTE 1	na	na	na	na	na	na	na	No	
25.984	26.968	26.4763	8.1	2.1383	205.2	0.10729	10.3	165.12	88.85	25.71	0.94	0.62	0.45	not liq	not liq	4.63	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
26.968	27.953	27.4606	8.4	1.67994	161.2	0.17328	16.6	171.26	92.05	0.01	0.93	0.62	0.01	NOTE 1	NOTE 1	5.53	NOTE 1	na	NOTE 1	NOTE 1	na	NOTE 1	na	NOTE 1	na	na	na	na	na	na	na	No	
27.953	28.937	28.4448	8.7	1.891573	181.5	0.14264	13.7	177.39	95.24	334.36	0.93	0.62	0.04	not liq	not liq	6.12	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
28.937	29.987	29.4619	9.0	1.885219	180.9	0.14065	13.5	183.74	98.54	0.01	0.92	0.62	0.01	NOTE 1	NOTE 1	5.53	NOTE 1	na	NOTE 1	NOTE 1	na	NOTE 1	na	NOTE 1	na	na	na	na	na	na	na	No	
29.987	30.971	30.4789	9.3	1.648753	158.2	0.11439	11.0	190.08	101.84	0.01	0.92	0.61	0.01	NOTE 1	NOTE 1	5.53	NOTE 1	na	NOTE 1	NOTE 1	na	NOTE 1	na	NOTE 1	na	na	na	na	na	na	na	No	
30.971	31.955	31.4632	9.6	2.232087	214.2	0.11467	11.0	196.22	105.03	61.33	0.91	0.61	0.17	not liq	not liq	5.20	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
31.955	32.94	32.4474	9.9	2.407373	231.0	0.14348	13.8	202.36	108.22	48.10	0.91	0.61	0.26	not liq	not liq	4.98	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na							

Liquefaction Potential Assessment, Simplified Procedure Using CPT Data

Indicates user input

General Parameters

γ_{soil}	130	lb/ft ³
γ_{soil}	20.5	kN/m ³
γ_{water}	62.4	lb/ft ³
γ_{water}	9.8	kN/m ³
Pa	101.33	kPa

Quake Parameters

Mw	7.3
MSF	1.07
MSF	1.09
a _{max}	0.55 %g

Note:

1. The soil is classified as clayey and is considered too clay-rich to liquefy. However, soil samples should be retrieved and tested to confirm the soil type and liquefaction resistance.

CPT No. C-837

Groundwater depth 5.1 ft

Groundwater depth 1.6 m

Lower bound of
MSF is used

LAYER		z		q _c		f _s		σ _{vo}	σ' _{vo}	F	r _d	CSR	Q			I _c			C _q		q _{c1N}		K _c	(q _{c1N}) _{cs}	CRR _{7.5}	q _{c1}	D _r	f	K _s	FOS	Liquefiable?		
Top	Bottom	ft	m	tsf	kPa	tsf	kPa	kPa	kPa	%			Q _{n1}	Q _{n.5}	Q _{n.7}	I _{c1}	I _{c.5}	I _{c.7}	I _c	C _{q.5}	C _{q.7}	q _{c1N.5}	q _{c1N.7}	q _{c1N}									
Ave. per Foot																																	
0	0.984	0.47247	0.1	140.4791	13478.3	0.19686	18.9	2.95	2.95	0.14	1.00	0.36	4573.33	779.86	1582.35	0.41	0.68	na	0.68	5.86	na	226.12	na	226.12	1.00	226.12	na	na	na	na	na	No	
0.984	1.968	1.47631	0.5	41.05068	3938.6	0.96302	92.4	9.21	9.21	2.35	1.00	0.36	426.79	128.65	207.84	1.80	2.09	na	2.09	3.32	na	66.08	na	66.08	1.44	95.38	0.16	128.95	65.02	0.67	1.00	0.48	No
1.968	2.953	2.46063	0.8	23.68102	2272.1	1.52505	146.3	15.35	15.35	6.48	1.00	0.36	147.06	57.23	83.48	2.41	2.66	2.55	2.55	2.57	3.75	38.12	38.12	38.12	3.06	116.64	0.23	57.62	43.46	0.78	1.00	0.68	No
2.953	3.937	3.44488	1.1	17.73674	1701.8	0.76434	73.3	21.48	21.48	4.36	0.99	0.36	78.21	36.01	49.11	2.44	2.67	2.57	2.57	2.17	2.96	28.55	28.55	28.55	3.17	90.48	0.15	36.47	34.58	0.80	1.00	0.45	No
3.937	4.987	4.51007	1.4	20.15728	1934.0	1.10185	105.7	28.13	28.13	5.55	0.99	0.35	67.76	35.70	46.13	2.56	2.74	2.67	2.67	1.90	2.45	32.45	32.45	32.45	na	na	na	na	na	na	na	No	
4.987	5.971	5.47894	1.7	20.99935	2014.8	1.29971	124.7	34.17	33.03	6.30	0.99	0.37	59.96	not liq	not liq	2.63	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
5.971	6.955	6.46325	2.0	30.99857	2974.2	1.78842	171.6	40.31	36.23	5.85	0.99	0.39	80.99	48.42	59.48	2.53	2.67	2.61	2.61	1.67	2.05	49.09	49.90	49.90	na	na	na	na	na	na	na	No	
6.955	7.94	7.44967	2.3	23.0881	2215.2	1.64509	157.8	46.46	39.43	7.28	0.98	0.41	55.01	not liq	not liq	2.71	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
7.94	8.989	8.46453	2.6	28.54054	2738.3	1.7455	167.5	52.79	42.72	6.24	0.98	0.43	62.87	not liq	not liq	2.62	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
8.989	9.974	9.48156	2.9	20.71279	1987.3	1.58785	152.3	59.13	46.02	7.90	0.98	0.45	41.90	not liq	not liq	2.81	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
9.974	10.958	10.4659	3.2	25.90923	2485.9	1.65922	159.2	65.27	49.21	6.58	0.98	0.46	49.19	not liq	not liq	2.70	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
10.958	11.942	11.4501	3.5	25.58021	2454.3	1.59195	152.7	71.41	52.40	6.41	0.98	0.48	45.48	not liq	not liq	2.72	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
11.942	12.992	12.4671	3.8	34.92405	3350.8	2.01766	193.6	77.75	55.70	5.91	0.97	0.49	58.77	not liq	not liq	2.62	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
12.992	13.976	13.4842	4.1	23.55989	2260.5	1.97097	189.1	84.09	59.00	8.69	0.97	0.50	36.89	not liq	not liq	2.88	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
13.976	14.961	14.4685	4.4	21.58879	2071.3	1.25119	120.0	90.23	62.19	6.06	0.97	0.50	31.86	not liq	not liq	2.81	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
14.961	15.945	15.4528	4.7	30.87468	2962.3	1.162	111.5	96.37	65.38	3.89	0.97	0.51	43.84	35.21	38.44	2.57	2.64	2.61	2.61	1.24	1.36	36.39	39.73	39.73	na	na	na	na	na	na	na	No	
15.945	16.995	16.4698	5.0	21.05161	2019.8	1.04173	99.9	102.71	68.68	5.21	0.97	0.52	27.91	not liq	not liq	2.80	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
16.995	17.979	17.5149	5.3	25.39959	2437.0	1.46792	140.8	109.23	72.07	6.05	0.96	0.52	32.30	not liq	not liq	2.80	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
17.979	18.963	18.4711	5.6	19.13706	1836.1	1.41987	136.2	115.19	75.17	7.92	0.96	0.53	22.89	not liq	not liq	2.99	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
18.963	19.947	19.4553	5.9	17.87489	1715.0	0.99137	95.1	121.33	78.36	5.97	0.96	0.53	20.34	not liq	not liq	2.94	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
19.947	20.997	20.4724	6.2	24.76653	2376.2	1.19713	114.9	127.67	81.66	5.11	0.96	0.53	27.54	not liq	not liq	2.80	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
20.997	21.982	21.4894	6.6	9.370967	899.1	0.74192	71.2	134.02	84.96	9.30	0.95	0.54	9.01	not liq	not liq	3.33	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
21.982	22.966	22.4737	6.9	16.47473	1580.7	0.72055	69.1	140.16	88.15	4.80	0.95	0.54	16.34	not liq	not liq	2.95	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
22.966	23.95	23.4579	7.2	17.70195	1698.4	1.01767	97.6	146.29	91.34	6.29	0.95	0.54	16.99	not liq	not liq	3.02	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
23.95	24.934	24.4422	7.5	19.42923	1864.1	0.89737	86.1	152.43	94.53	5.03	0.94	0.54	18.11	not liq	not liq	2.93	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
24.934	25.984	25.4592	7.8	15.83906	1519.7	0.62423	59.9	158.78	97.83	4.40	0.94	0.55	13.91	not liq	not liq	2.98	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
25.984	26.968	26.4763	8.1	15.11751	1450.5	0.52276	50.2	165.12	101.13	3.90	0.94	0.55	12.71	not liq	not liq	2.98	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
26.968	27.953	27.4606	8.4	13.15029	1261.7	0.43043	41.3	171.26	104.32	3.79	0.93	0.55	10.45	not liq	not liq	3.04	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
27.953	28.937	28.4448	8.7	13.51753	1296.9	0.35295	33.9	177.39	107.51	3.02	0.93	0.55	10.41	not liq	not liq	2.98	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
28.937	29.987	29.4619	9.0	11.59253	1112.2	0.3416	32.8	183.74	110.81	3.53	0.92	0.55	8.38	not liq	not liq	3.10	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
29.987	30.971	30.4789	9.3	14.64481	1405.1	0.26433	25.4	190.08	114.11	2.09	0.92	0.55	10.65	not liq	not liq	2.89	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
30.971	31.955	31.4632	9.6	17.60573	1689.2	0.37421	35.9	196.22	117.30	2.40	0.91	0.55	12.73	not liq	not liq	2.86	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
31.955	32.94	32.4474	9.9	15.53479	1490.5	0.30681	29.																										

Liquefaction Potential Assessment, Simplified Procedure Using CPT Data

Indicates user input

General Parameters

γ_{soil}	130	lb/ft ³
γ_{soil}	20.5	kN/m ³
γ_{water}	62.4	lb/ft ³
γ_{water}	9.8	kN/m ³
Pa	101.33	kPa

Quake Parameters

Mw	7.3
MSF	1.07
MSF	1.09
a _{max}	0.55 %g

Note:

1. The soil is classified as clayey and is considered too clay-rich to liquefy. However, soil samples should be retrieved and tested to confirm the soil type and liquefaction resistance.

CPT No. C-837

Groundwater depth 5.1 ft

Groundwater depth 1.6 m

Lower bound of
MSF is used

LAYER		z		q _c		f _s		σ _{vo}	σ' _{vo}	F	r _d	CSR	Q			I _c			C _q		q _{c1N}		K _c	(q _{c1N}) _{cs}	CRR _{7.5}	q _{c1}	D _r	f	K _a	FOS	Liquefiable?		
Top	Bottom	ft	m	tsf	kPa	tsf	kPa	kPa	kPa	%			Q _{n1}	Q _{n.5}	Q _{n.7}	I _{c1}	I _{c.5}	I _{c.7}	I _c	C _{q.5}	C _{q.7}	q _{c1N.5}	q _{c1N.7}	q _{c1N}									
Ave. per Interval																																	
0	1.312	0.6496	0.2	114.2405	10960.8	0.30142	28.9	4.05	4.05	0.26	1.00	0.36	2704.58	540.78	1029.56	0.64	0.98	na	0.98	5.00	na	183.89	na	183.89	1.00	183.89	na	na	na	na	na	No	
1.312	2.493	1.90284	0.6	36.10373	3464.0	1.38986	133.4	11.87	11.87	3.86	1.00	0.36	290.90	99.55	152.87	2.07	2.33	na	2.33	2.92	na	58.11	na	58.11	2.05	119.18	0.24	99.89	57.23	0.71	1.00	0.71	No
2.493	5.84	4.16928	1.3	18.99388	1822.4	1.08167	103.8	26.00	26.00	5.78	0.99	0.35	69.09	35.00	45.94	2.57	2.76	2.68	2.68	1.97	2.59	30.57	30.57	30.57	na	na	na	na	na	na	na	No	
5.84	10.302	8.08049	2.5	25.23798	2421.5	1.67273	160.5	50.39	41.47	6.77	0.98	0.43	57.17	not liq	not liq	2.67	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
10.302	16.273	13.2874	4.1	27.70694	2658.4	1.59772	153.3	82.87	58.36	5.95	0.97	0.49	44.13	not liq	not liq	2.70	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
16.273	17.192	16.7323	5.1	17.08146	1638.9	0.88814	85.2	104.35	69.53	5.55	0.96	0.52	22.07	not liq	not liq	2.89	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
17.192	18.241	17.7733	5.4	27.2916	2618.5	1.65182	158.5	110.84	72.90	6.32	0.96	0.52	34.40	not liq	not liq	2.80	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
18.241	20.013	19.1272	5.8	18.2383	1749.9	1.15366	110.7	119.29	77.30	6.79	0.96	0.53	21.10	not liq	not liq	2.97	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
20.013	20.932	20.4724	6.2	25.77463	2473.0	1.22635	117.7	127.68	81.66	5.02	0.96	0.53	28.72	not liq	not liq	2.78	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
20.932	21.982	21.4566	6.5	9.627813	923.7	0.76448	73.3	133.81	84.85	9.29	0.95	0.54	9.31	not liq	not liq	3.32	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
21.982	26.247	24.1141	7.4	17.29267	1659.2	0.80099	76.9	150.39	93.47	5.09	0.94	0.54	16.14	not liq	not liq	2.97	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
26.247	29.068	27.6574	8.4	13.70273	1314.7	0.41287	39.6	172.48	104.96	3.47	0.93	0.55	10.88	not liq	not liq	3.00	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
29.068	29.921	29.4946	9.0	10.92838	1048.5	0.34244	32.9	183.94	110.92	3.80	0.92	0.55	7.79	not liq	not liq	3.14	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
29.921	33.005	31.4632	9.6	15.86891	1522.5	0.31453	30.2	196.22	117.30	2.28	0.91	0.55	11.31	not liq	not liq	2.89	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
33.005	35.236	34.1206	10.4	15.73336	1509.5	0.28311	27.2	212.79	125.92	2.09	0.90	0.54	10.30	not liq	not liq	2.90	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
35.236	37.27	36.2532	11.1	12.94498	1242.0	0.24699	23.7	226.09	132.83	2.33	0.88	0.54	7.65	not liq	not liq	3.03	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
37.27	40.42	38.845	11.8	9.939885	953.7	0.19251	18.5	242.25	141.24	2.60	0.86	0.53	5.04	not liq	not liq	3.21	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
40.42	42.06	41.24	12.6	5.955116	571.4	0.1589	15.2	257.19	149.01	4.85	0.84	0.52	2.11	not liq	not liq	3.68	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
42.06	42.52	42.2899	12.9	3.740414	358.9	0.14321	13.7	263.74	152.41	14.44	0.83	0.51	0.62	not liq	not liq	4.38	not liq	na	not liq	not liq	na	not liq	na	not liq	na	na	na	na	na	na	na	No	
42.52	43.832	43.1757	13.2	1.910425	183.3	0.06124	5.9	269.26	155.28	0.01	0.82	0.51	0.01	NOTE 1	NOTE 1	5.53	NOTE 1	na	VOTE 1	NOTE 1	na	NOTE 1	na	NOTE 1	na	na	na	na	na	na	na	No	
43.832	44.226	44.0289	13.4	69.93018	6709.5	0.22245	21.3	274.58	158.05	0.33	0.81	0.51	40.71	50.85	46.52	2.00	1.91	na	1.91	0.80	na	53.02	na	53.02	1.20	63.69	0.10	53.02	41.69	0.79	0.91	0.20	Yes

MSHA CH. 7 Soil Type Evaluation

Appendix E
Calculation
Page 7 of 7

General Parameters

γ_{soil}	130	lb/ft ³
γ_{soil}	20.5	kN/m ³
γ_{water}	62.4	lb/ft ³
γ_{water}	9.8	kN/m ³
Pa	101.3	kPa
ER	93	% MAD
	86	% WPC
	71.9	% Terracon

Boring No.	Groundwater Depth		Soil Layer		Z Depth (Layer)		(N1) ₆₀ =N _m C _N C _E C _B C _R C _S											Soil Type	Strength Loss			
							σ _{vo} kPa	σ' _{vo} kPa	N _m	C _N C _N =(P _a /σ' _{vo}) ^{0.5}	C _E	C _B	C _R	C _S	(N1) ₆₀	(N) ₆₀	FC %			(N1) _{60cs} (N1) _{60cs} =α+β(N1)	PI %	
	Top	Bottom	ft	m																		
B-734	13.4	4.1	0	2	1	0.30	6.24	6.24	10	1.70	1.20	1.0	0.75	1.2	18	12		18			Clay	No
			2	4	3	0.91	18.71	18.71	19	1.70	1.20	1.0	0.75	1.2	35	23	62	47	32		Clay	No
			4	6	5	1.52	31.18	31.18	11	1.70	1.20	1.0	0.80	1.2	22	13		22			Clay	No
			6	8	7	2.13	43.66	43.66	12	1.52	1.20	1.0	0.80	1.2	21	14	49	30	24		Clay	No
			8	10	9	2.74	56.13	56.13	10	1.34	1.20	1.0	0.85	1.2	16	12		16			Clay	No
			10	12	11	3.35	68.60	68.60	2	1.22	1.20	1.0	0.85	1.2	3	2	41	9	26		Clay	Yes
			12	14	13	3.96	81.07	81.07	10	1.12	1.20	1.0	0.85	1.2	14	12		14	23		Clay	No
			18.5	20	19.25	5.87	120.05	102.54	9	0.99	1.20	1.0	0.95	1.2	12	11		12	15		Clay	No
			23.5	25	24.25	7.39	151.23	118.75	6	0.92	1.20	1.0	0.95	1.2	8	7		8	40		Clay	No
			28.5	30	29.25	8.92	182.42	134.97	5	0.87	1.20	1.0	1.00	1.2	6	6	81	12	52		Clay	No
			33.5	35	34.25	10.44	213.60	151.18	2	0.82	1.20	1.0	1.00	1.2	2	2	69	7	26		Clay	Yes
			38.5	40	39.25	11.97	244.78	167.40	0.1	0.78	1.20	1.0	1.00	1.2	0	0	67	5	64		Clay	Yes
			43.5	45	44.25	13.49	275.96	183.61	0.1	0.74	1.20	1.0	1.00	1.2	0	0	35	5	11		Clay	Yes
			48.5	50	49.25	15.02	307.15	199.83	43	0.71	1.20	1.0	1.00	1.2	44	52		44				No
			53.5	55	54.25	16.54	338.33	216.04	100	0.68	1.20	1.0	1.00	1.2	98	120		98				No
B-735	13.0	4.0	0	2	1	0.30	6.24	6.24	20	1.70	1.20	1.0	0.75	1.2	37	24		37			Clay	No
			2	4	3	0.91	18.71	18.71	20	1.70	1.20	1.0	0.75	1.2	37	24		37	29		Clay	No
			4	6	5	1.52	31.18	31.18	4	1.70	1.20	1.0	0.80	1.2	8	5	45	15	31		Clay	Yes
			6	8	7	2.13	43.66	43.66	4	1.52	1.20	1.0	0.80	1.2	7	5		7			Clay	No
			8	10	9	2.74	56.13	56.13	5	1.34	1.20	1.0	0.85	1.2	8	6	46	15	22		Clay	No
			10	12	11	3.35	68.60	68.60	13	1.22	1.20	1.0	0.85	1.2	19	16		19			Clay	No
			12	14	13	3.96	81.07	81.07	5	1.12	1.20	1.0	0.85	1.2	7	6	55	13	19		Clay	No
			18.5	20	19.25	5.87	120.05	101.34	5	1.00	1.20	1.0	0.95	1.2	7	6		7	31		Clay	No
			23.5	25	24.25	7.39	151.23	117.56	2	0.93	1.20	1.0	0.95	1.2	3	2	91	9	36		Clay	Yes
			28.5	30	29.25	8.92	182.42	133.77	9	0.87	1.20	1.0	1.00	1.2	11	11		11	24		Clay	No
			33.5	35	34.25	10.44	213.60	149.99	46	0.82	1.20	1.0	1.00	1.2	54	55		54				No
			38.5	40	39.25	11.97	244.78	166.20	46	0.78	1.20	1.0	1.00	1.2	52	55		52				No
			43.5	45	44.25	13.49	275.96	182.42	41	0.75	1.20	1.0	1.00	1.2	44	49		44				No
			48.5	50	49.25	15.02	307.15	198.63	100	0.71	1.20	1.0	1.00	1.2	103	120		103				No



Customer				Santee Cooper				Project No.		108008-01330					
Project Title				Cross Generating Station				Calc No.		CROSS-0-DC-044-CE-0003					
Calculation Title				Bottom Ash Pond Initial Safety Factor Assessment				Phase/CTR		LBRCCR					
Elec File Location				\\usreawpfil01\civileng\01 PROJECTS\Santee Cooper\Cross\Ash Pond Stability\Safety Factor Assessment\Ash basin stability calc_R0.docm											
								Page		77		of		128	
Rev		Date		By		Checked		Rev		Date		By		Checked	
0		14-OCT-16		B. Gordon		Y. Xu									

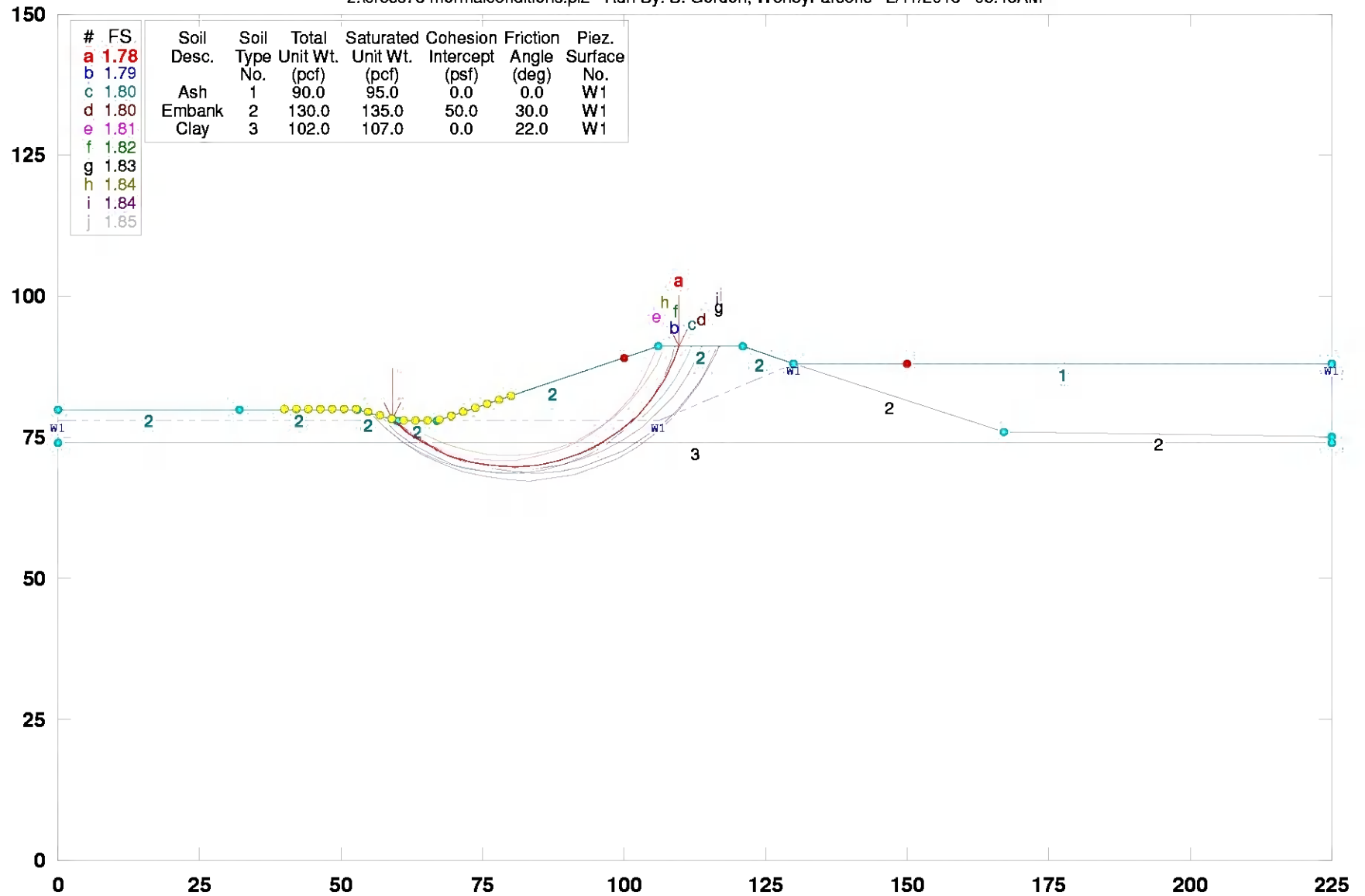
Appendix G – Slope Stability Output

(52 total pages)

This Calculation represents the work of WorleyParsons performed to recognized engineering principles and practices appropriate for the terms of reference provided by WorleyParsons contractual Customer. This Calculation is confidential and prepared solely for the use of the Customer. The contents of this Calculation may not be disclosed to or relied upon by any party other than the Customer, and neither WorleyParsons, its subconsultants nor their respective employees assume any liability for any reason, including, but not limited to, negligence, to any other party for any information or representation herein.

Cross BA Pond Section 734, Normal Conditions

z:\cross734normalconditions.pl2 Run By: B. Gordon, WorleyParsons 2/11/2016 06:48AM



STABL6H FSmin=1.78

Safety Factors Are Calculated By The Modified Bishop Method

**** STABL6H ****

by

Purdue University

--Slope Stability Analysis--

Simplified Janbu, Simplified Bishop

or Spencer's Method of Slices

Run Date: 2/11/2016
 Time of Run: 06:48AM
 Run By: B. Gordon, WorleyParsons
 Input Data Filename: Z:\cross734normalconditions.in
 Output Filename: Z:\cross734normalconditions.OUT
 Plotted Output Filename: Z:\cross734normalconditions.PLT
 PROBLEM DESCRIPTION Cross BA Pond
 Section 734, Normal Conditions

BOUNDARY COORDINATES

8 Top Boundaries

11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	80.00	32.00	80.00	2
2	32.00	80.00	53.00	80.00	2
3	53.00	80.00	60.00	78.00	2
4	60.00	78.00	67.00	78.00	2
5	67.00	78.00	106.00	91.00	2
6	106.00	91.00	121.00	91.00	2
7	121.00	91.00	130.00	88.00	2
8	130.00	88.00	225.00	88.00	1
9	130.00	88.00	167.00	76.00	2
10	167.00	76.00	225.00	75.00	2
11	0.00	74.00	225.00	74.00	3

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param. (psf)	Pressure Constant (psf)	Piez. Surface No.
1	90.0	95.0	0.0	0.0	0.00	0.0	1
2	130.0	135.0	50.0	30.0	0.00	0.0	1
3	102.0	107.0	0.0	22.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	78.00
2	106.00	78.00
3	130.00	88.00
4	225.00	88.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.
 400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced
 Along The Ground Surface Between X = 40.00 ft.
 and X = 80.00 ft.
 Each Surface Terminates Between X = 100.00 ft.
 and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
 At Which A Surface Extends Is Y = 0.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial

Failure Surfaces Examined. They Are Ordered - Most Critical
 First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *
 Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	58.95	78.30
2	62.01	75.72
3	65.37	73.56
4	68.99	71.85

5	72.80	70.63
6	76.73	69.90
7	80.73	69.69
8	84.71	70.00
9	88.63	70.82
10	92.40	72.14
11	95.98	73.94
12	99.29	76.18
13	102.28	78.84
14	104.91	81.85
15	107.12	85.18
16	108.89	88.77
17	109.65	91.00

Circle Center At X = 80.3 ; Y = 100.6 and Radius, 30.9
 *** 1.779 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.84	78.90
2	59.67	76.07
3	62.85	73.64
4	66.32	71.65
5	70.02	70.13
6	73.88	69.11
7	77.85	68.60
8	81.85	68.62
9	85.81	69.17
10	89.67	70.23
11	93.35	71.79
12	96.80	73.82
13	99.95	76.28
14	102.75	79.14
15	105.15	82.33
16	107.12	85.82
17	108.60	89.53
18	108.97	91.00

Circle Center At X = 79.7 ; Y = 98.9 and Radius, 30.4
 *** 1.793 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.84	78.90
2	59.93	76.36
3	63.29	74.19
4	66.89	72.43
5	70.66	71.10
6	74.56	70.22
7	78.54	69.79
8	82.54	69.83
9	86.50	70.34
10	90.39	71.30
11	94.13	72.71
12	97.69	74.54
13	101.01	76.77
14	104.04	79.38
15	106.76	82.32
16	109.11	85.55
17	111.07	89.04
18	111.89	91.00

Circle Center At X = 80.2 ; Y = 104.1 and Radius, 34.4
 *** 1.795 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	58.95	78.30
2	62.07	75.80
3	65.46	73.68
4	69.07	71.96
5	72.86	70.69
6	76.78	69.86

7	80.76	69.49
8	84.76	69.60
9	88.72	70.17
10	92.58	71.19
11	96.30	72.67
12	99.83	74.56
13	103.10	76.86
14	106.09	79.52
15	108.74	82.51
16	111.03	85.79
17	112.92	89.31
18	113.59	91.00

Circle Center At X = 81.9 ; Y = 103.7 and Radius, 34.2

*** 1.801 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	58.95	78.30
2	62.09	75.82
3	65.54	73.80
4	69.24	72.28
5	73.11	71.28
6	77.08	70.83
7	81.08	70.93
8	85.03	71.59
9	88.85	72.79
10	92.46	74.50
11	95.80	76.70
12	98.81	79.34
13	101.42	82.37
14	103.58	85.73
15	105.26	89.36
16	105.73	90.91

Circle Center At X = 78.3 ; Y = 99.6 and Radius, 28.8

*** 1.810 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	54.74	79.50
2	57.57	76.68
3	60.73	74.22
4	64.17	72.19
5	67.84	70.59
6	71.68	69.47
7	75.63	68.84
8	79.63	68.71
9	83.61	69.08
10	87.51	69.94
11	91.28	71.29
12	94.85	73.09
13	98.17	75.33
14	101.17	77.97
15	103.83	80.96
16	106.09	84.26
17	107.92	87.81
18	109.09	91.00

Circle Center At X = 78.7 ; Y = 100.6 and Radius, 31.9

*** 1.823 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	58.95	78.30
2	62.03	75.75
3	65.37	73.55
4	68.93	71.74
5	72.68	70.33
6	76.56	69.35
7	80.52	68.80
8	84.52	68.70
9	88.50	69.04

10	92.43	69.82
11	96.24	71.04
12	99.89	72.66
13	103.34	74.69
14	106.55	77.08
15	109.47	79.81
16	112.07	82.86
17	114.31	86.17
18	116.17	89.71
19	116.68	91.00

Circle Center At X = 83.4 ; Y = 104.7 and Radius, 36.0
 *** 1.831 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.05	78.00
2	64.37	75.76
3	67.95	73.99
4	71.74	72.71
5	75.67	71.96
6	79.67	71.73
7	83.65	72.05
8	87.56	72.90
9	91.32	74.26
10	94.86	76.12
11	98.13	78.44
12	101.05	81.17
13	103.57	84.27
14	105.66	87.68
15	107.12	91.00

Circle Center At X = 79.3 ; Y = 101.5 and Radius, 29.7
 *** 1.840 ***

Failure Surface Specified By 20 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	54.74	79.50
2	57.57	76.68
3	60.69	74.18
4	64.06	72.03
5	67.65	70.26
6	71.41	68.90
7	75.30	67.94
8	79.26	67.42
9	83.26	67.33
10	87.25	67.68
11	91.17	68.46
12	94.99	69.66
13	98.65	71.27
14	102.12	73.26
15	105.34	75.62
16	108.30	78.32
17	110.94	81.33
18	113.24	84.60
19	115.17	88.10
20	116.38	91.00

Circle Center At X = 82.1 ; Y = 104.1 and Radius, 36.7
 *** 1.842 ***

Failure Surface Specified By 20 Coordinate Points

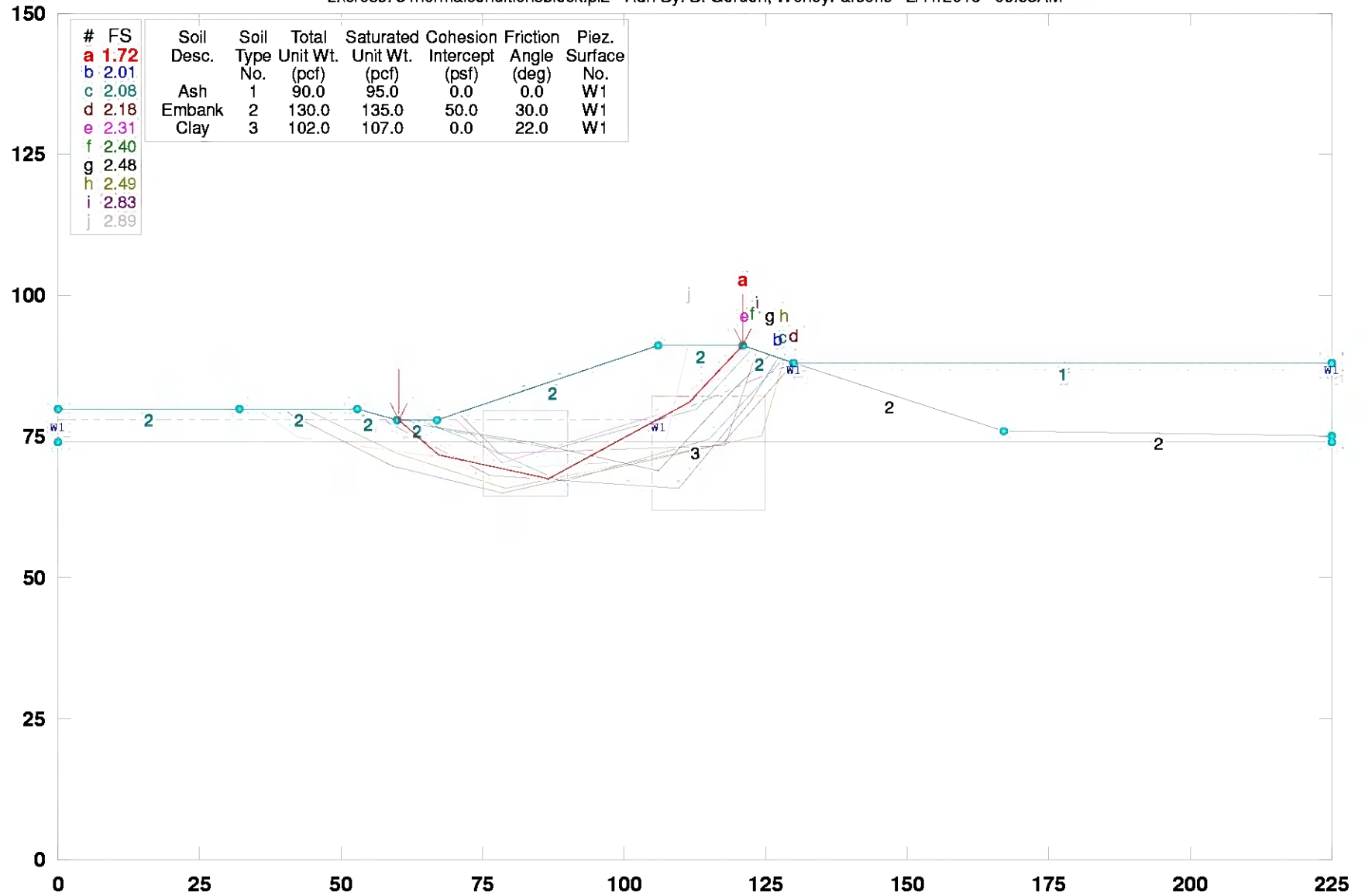
Point No.	X-Surf (ft)	Y-Surf (ft)
1	54.74	79.50
2	57.58	76.69
3	60.70	74.19
4	64.08	72.05
5	67.67	70.28
6	71.42	68.90
7	75.30	67.94
8	79.27	67.40
9	83.27	67.28
10	87.25	67.60

11	91.18	68.35
12	95.01	69.51
13	98.69	71.08
14	102.18	73.03
15	105.44	75.35
16	108.43	78.00
17	111.12	80.96
18	113.48	84.20
19	115.48	87.66
20	116.95	91.00

Circle Center At X = 82.3 ; Y = 104.5 and Radius, 37.2
*** 1.845 ***

Cross BA Pond Section 734, Normal Conditions, Block

z:\cross734normalconditionsblock.pl2 Run By: B. Gordon, WorleyParsons 2/11/2016 06:53AM



STABL6H FSmin=1.72
Safety Factors Are Calculated By The Modified Janbu Method

**** STABL6H ****

by

Purdue University

--Slope Stability Analysis--

Simplified Janbu, Simplified Bishop

or Spencer's Method of Slices

Run Date: 2/11/2016

Time of Run: 06:53AM

Run By: B. Gordon, WorleyParsons

Input Data Filename: Z:\cross734normalconditionsblock.in

Output Filename: Z:\cross734normalconditionsblock.OUT

Plotted Output Filename: Z:\cross734normalconditionsblock.PLT

PROBLEM DESCRIPTION Cross BA Pond

Section 734, Normal Conditions, Block

BOUNDARY COORDINATES

8 Top Boundaries

11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	80.00	32.00	80.00	2
2	32.00	80.00	53.00	80.00	2
3	53.00	80.00	60.00	78.00	2
4	60.00	78.00	67.00	78.00	2
5	67.00	78.00	106.00	91.00	2
6	106.00	91.00	121.00	91.00	2
7	121.00	91.00	130.00	88.00	2
8	130.00	88.00	225.00	88.00	1
9	130.00	88.00	167.00	76.00	2
10	167.00	76.00	225.00	75.00	2
11	0.00	74.00	225.00	74.00	3

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param. (psf)	Pressure Constant (psf)	Piez. Surface No.
1	90.0	95.0	0.0	0.0	0.00	0.0	1
2	130.0	135.0	50.0	30.0	0.00	0.0	1
3	102.0	107.0	0.0	22.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	78.00
2	106.00	78.00
3	130.00	88.00
4	225.00	88.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

20 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 20.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	75.00	72.00	90.00	72.00	15.00
2	105.00	72.00	125.00	72.00	20.00

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	60.15	78.00
2	67.19	71.58
3	86.76	67.44
4	111.29	81.11
5	120.92	91.00

```

***      1.718      ***
Failure Surface Specified By 6 Coordinate Points
Point      X-Surf      Y-Surf
No.      (ft)      (ft)
1          56.99      78.86
2          58.55      77.41
3          76.30      68.19
4         109.65      65.81
5         122.31      81.29
6         127.22      88.93
***      2.009      ***
Failure Surface Specified By 5 Coordinate Points
Point      X-Surf      Y-Surf
No.      (ft)      (ft)
1          63.39      78.00
2          71.01      75.21
3          89.25      67.00
4         114.93      74.59
5         127.99      88.67
***      2.076      ***
Failure Surface Specified By 6 Coordinate Points
Point      X-Surf      Y-Surf
No.      (ft)      (ft)
1          39.81      80.00
2          41.36      78.78
3          59.14      69.62
4          78.58      64.92
5         117.18      73.60
6         130.06      88.00
***      2.182      ***
Failure Surface Specified By 4 Coordinate Points
Point      X-Surf      Y-Surf
No.      (ft)      (ft)
1          69.40      78.80
2          78.45      70.23
3         111.22      80.53
4         121.23      90.92
***      2.307      ***
Failure Surface Specified By 5 Coordinate Points
Point      X-Surf      Y-Surf
No.      (ft)      (ft)
1          64.36      78.00
2          68.08      76.26
3          87.77      72.78
4         112.68      79.98
5         122.60      90.47
***      2.404      ***
Failure Surface Specified By 6 Coordinate Points
Point      X-Surf      Y-Surf
No.      (ft)      (ft)
1          61.48      78.00
2          63.85      77.15
3          83.59      73.96
4         105.94      68.82
5         119.62      83.41
6         125.61      89.46
***      2.477      ***
Failure Surface Specified By 5 Coordinate Points
Point      X-Surf      Y-Surf
No.      (ft)      (ft)
1          43.52      80.00
2          60.03      72.01
3          79.08      65.93
4         124.30      74.99
5         128.12      88.63
***      2.490      ***
Failure Surface Specified By 4 Coordinate Points
Point      X-Surf      Y-Surf
No.      (ft)      (ft)
1          70.70      79.23

```

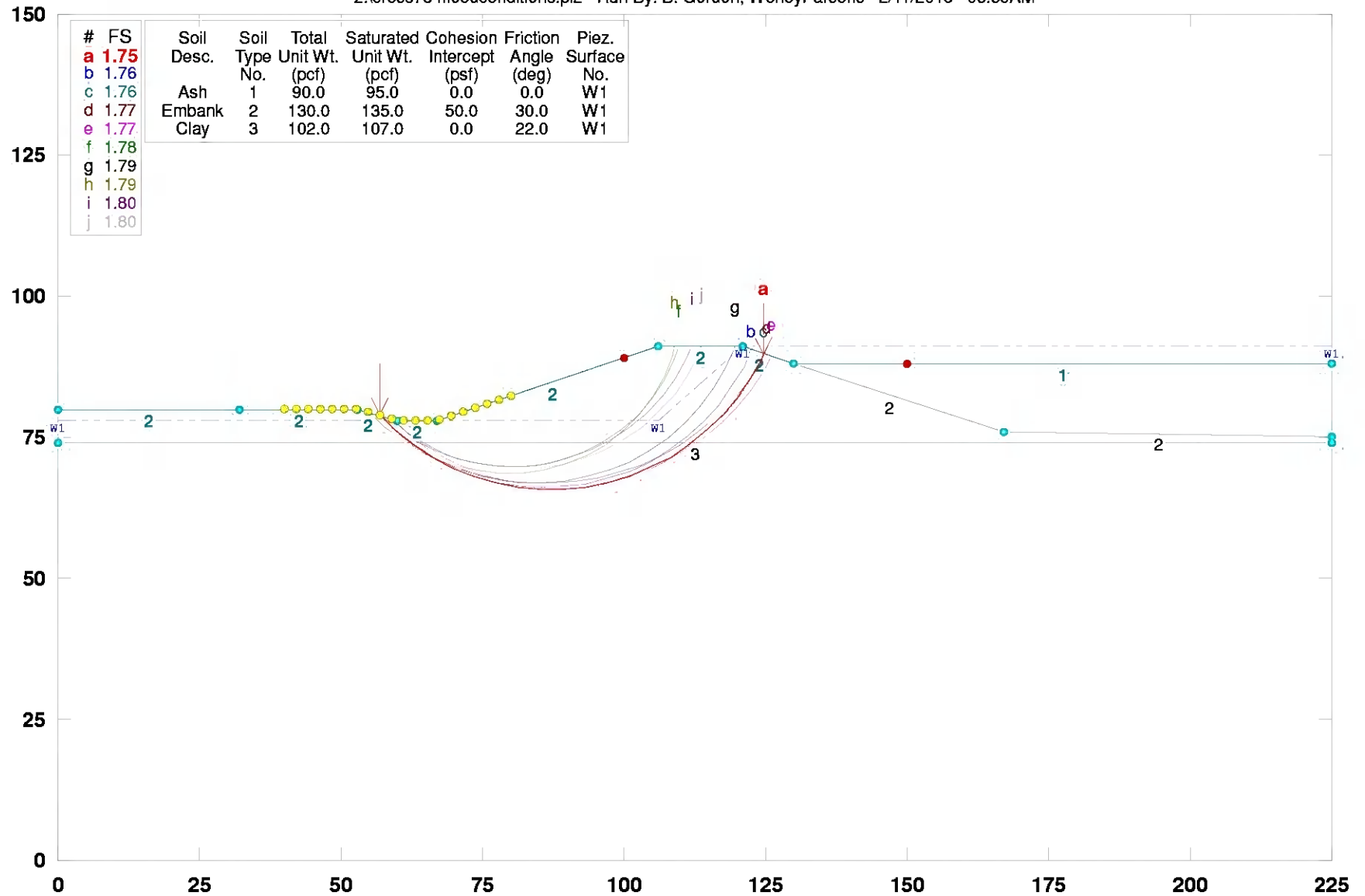
2	77.90	72.09
3	117.85	73.48
4	123.52	90.16
***	2.833	***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	35.24	80.00
2	42.52	74.77
3	62.33	72.01
4	82.18	69.57
5	106.67	70.75
6	111.19	90.23
7	111.30	91.00
***	2.888	***

Cross BA Pond Section 734, Flood Conditions

z:\cross734floodconditions.pl2 Run By: B. Gordon, WorleyParsons 2/11/2016 06:59AM



STABL6H FSmin=1.75

Safety Factors Are Calculated By The Modified Bishop Method

**** STABL6H ****

by

Purdue University

--Slope Stability Analysis--

Simplified Janbu, Simplified Bishop

or Spencer's Method of Slices

Run Date: 2/11/2016
 Time of Run: 06:59AM
 Run By: B. Gordon, WorleyParsons
 Input Data Filename: Z:\cross734floodconditions.in
 Output Filename: Z:\cross734floodconditions.OUT
 Plotted Output Filename: Z:\cross734floodconditions.PLT
 PROBLEM DESCRIPTION Cross BA Pond
 Section 734, Flood Conditions

BOUNDARY COORDINATES

8 Top Boundaries

11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	80.00	32.00	80.00	2
2	32.00	80.00	53.00	80.00	2
3	53.00	80.00	60.00	78.00	2
4	60.00	78.00	67.00	78.00	2
5	67.00	78.00	106.00	91.00	2
6	106.00	91.00	121.00	91.00	2
7	121.00	91.00	130.00	88.00	2
8	130.00	88.00	225.00	88.00	1
9	130.00	88.00	167.00	76.00	2
10	167.00	76.00	225.00	75.00	2
11	0.00	74.00	225.00	74.00	3

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param. (psf)	Pressure Constant (psf)	Piez. Surface No.
1	90.0	95.0	0.0	0.0	0.00	0.0	1
2	130.0	135.0	50.0	30.0	0.00	0.0	1
3	102.0	107.0	0.0	22.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	78.00
2	106.00	78.00
3	121.00	91.00
4	225.00	91.00

A Critical Failure Surface Searching Method, Using A Random
 Technique For Generating Circular Surfaces, Has Been Specified.
 400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced
 Along The Ground Surface Between X = 40.00 ft.

and X = 80.00 ft.

Each Surface Terminates Between X = 100.00 ft.

and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
 At Which A Surface Extends Is Y = 0.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial

Failure Surfaces Examined. They Are Ordered - Most Critical
 First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.84	78.90
2	59.71	76.11
3	62.83	73.62
4	66.19	71.43
5	69.73	69.58

6	73.44	68.08
7	77.28	66.95
8	81.20	66.19
9	85.19	65.81
10	89.19	65.82
11	93.17	66.22
12	97.09	67.00
13	100.92	68.16
14	104.62	69.68
15	108.15	71.55
16	111.49	73.75
17	114.60	76.27
18	117.46	79.07
19	120.03	82.14
20	122.29	85.44
21	124.22	88.94
22	124.59	89.80

Circle Center At X = 87.1 ; Y = 107.1 and Radius, 41.4
 *** 1.753 ***

Failure Surface Specified By 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.84	78.90
2	59.69	76.10
3	62.81	73.59
4	66.17	71.42
5	69.73	69.59
6	73.45	68.14
7	77.31	67.06
8	81.25	66.39
9	85.24	66.11
10	89.24	66.24
11	93.20	66.77
12	97.09	67.70
13	100.87	69.02
14	104.49	70.72
15	107.93	72.77
16	111.14	75.16
17	114.09	77.86
18	116.75	80.84
19	119.10	84.08
20	121.11	87.54
21	122.45	90.52

Circle Center At X = 86.0 ; Y = 105.6 and Radius, 39.5
 *** 1.758 ***

Failure Surface Specified By 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	58.95	78.30
2	61.83	75.53
3	64.98	73.06
4	68.36	70.92
5	71.93	69.12
6	75.67	67.70
7	79.53	66.65
8	83.48	66.00
9	87.47	65.74
10	91.46	65.88
11	95.43	66.43
12	99.32	67.37
13	103.09	68.69
14	106.72	70.38
15	110.15	72.43
16	113.37	74.81
17	116.33	77.50
18	119.00	80.47
19	121.37	83.70
20	123.40	87.14
21	124.62	89.79

Circle Center At X = 88.0 ; Y = 105.7 and Radius, 39.9

```

***      1.764      ***
Failure Surface Specified By 22 Coordinate Points
Point      X-Surf      Y-Surf
No.        (ft)        (ft)
  1         54.74         79.50
  2         57.72         76.84
  3         60.93         74.46
  4         64.35         72.37
  5         67.93         70.59
  6         71.66         69.14
  7         75.50         68.03
  8         79.43         67.27
  9         83.41         66.86
 10         87.41         66.81
 11         91.40         67.11
 12         95.34         67.77
 13         99.21         68.77
 14        102.98         70.12
 15        106.61         71.80
 16        110.07         73.80
 17        113.35         76.10
 18        116.41         78.68
 19        119.22         81.52
 20        121.77         84.60
 21        124.03         87.90
 22        125.02         89.66
Circle Center At X =   86.0 ; Y = 111.6 and Radius,   44.8
***      1.765      ***

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Failure Surface Specified By 21 Coordinate Points
Point      X-Surf      Y-Surf
No.        (ft)        (ft)
  1         58.95         78.30
  2         61.93         75.64
  3         65.15         73.27
  4         68.59         71.21
  5         72.20         69.49
  6         75.96         68.12
  7         79.83         67.12
  8         83.78         66.48
  9         87.77         66.22
 10         91.77         66.34
 11         95.73         66.84
 12         99.64         67.71
 13        103.44         68.95
 14        107.11         70.54
 15        110.61         72.47
 16        113.92         74.73
 17        116.99         77.29
 18        119.81         80.13
 19        122.34         83.22
 20        124.58         86.54
 21        126.08         89.31
Circle Center At X =   88.5 ; Y = 108.4 and Radius,   42.2
***      1.768      ***

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Failure Surface Specified By 17 Coordinate Points
Point      X-Surf      Y-Surf
No.        (ft)        (ft)
  1         58.95         78.30
  2         62.01         75.72
  3         65.37         73.56
  4         68.99         71.85
  5         72.80         70.63
  6         76.73         69.90
  7         80.73         69.69
  8         84.71         70.00
  9         88.63         70.82
 10         92.40         72.14
 11         95.98         73.94
 12         99.29         76.18
 13        102.28         78.84

```

14	104.91	81.85
15	107.12	85.18
16	108.89	88.77
17	109.65	91.00

Circle Center At X = 80.3 ; Y = 100.6 and Radius, 30.9
 *** 1.779 ***

Failure Surface Specified By 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.84	78.90
2	59.72	76.12
3	62.87	73.66
4	66.26	71.54
5	69.86	69.80
6	73.63	68.45
7	77.52	67.51
8	81.48	66.99
9	85.48	66.89
10	89.47	67.21
11	93.40	67.96
12	97.23	69.12
13	100.91	70.68
14	104.41	72.62
15	107.68	74.92
16	110.69	77.56
17	113.40	80.50
18	115.78	83.71
19	117.81	87.16
20	119.46	90.80
21	119.53	91.00

Circle Center At X = 84.4 ; Y = 104.5 and Radius, 37.6
 *** 1.787 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.84	78.90
2	59.67	76.07
3	62.85	73.64
4	66.32	71.65
5	70.02	70.13
6	73.88	69.11
7	77.85	68.60
8	81.85	68.62
9	85.81	69.17
10	89.67	70.23
11	93.35	71.79
12	96.80	73.82
13	99.95	76.28
14	102.75	79.14
15	105.15	82.33
16	107.12	85.82
17	108.60	89.53
18	108.97	91.00

Circle Center At X = 79.7 ; Y = 98.9 and Radius, 30.4
 *** 1.793 ***

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.84	78.90
2	59.93	76.36
3	63.29	74.19
4	66.89	72.43
5	70.66	71.10
6	74.56	70.22
7	78.54	69.79
8	82.54	69.83
9	86.50	70.34
10	90.39	71.30
11	94.13	72.71
12	97.69	74.54

13	101.01	76.77
14	104.04	79.38
15	106.76	82.32
16	109.11	85.55
17	111.07	89.04
18	111.89	91.00

Circle Center At X = 80.2 ; Y = 104.1 and Radius, 34.4
 *** 1.795 ***

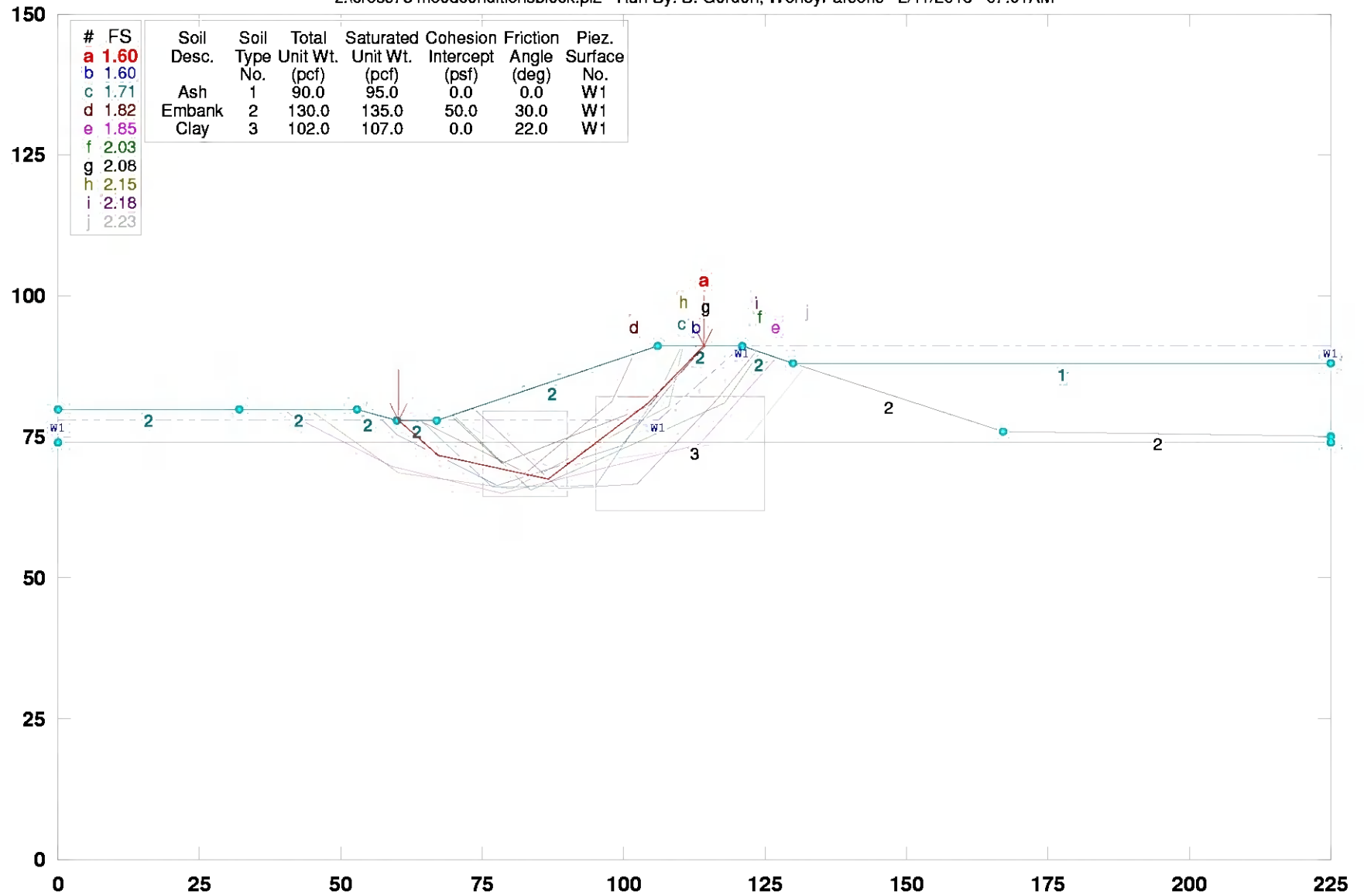
Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	58.95	78.30
2	62.07	75.80
3	65.46	73.68
4	69.07	71.96
5	72.86	70.69
6	76.78	69.86
7	80.76	69.49
8	84.76	69.60
9	88.72	70.17
10	92.58	71.19
11	96.30	72.67
12	99.83	74.56
13	103.10	76.86
14	106.09	79.52
15	108.74	82.51
16	111.03	85.79
17	112.92	89.31
18	113.59	91.00

Circle Center At X = 81.9 ; Y = 103.7 and Radius, 34.2
 *** 1.801 ***

Cross BA Pond Section 734, Flood Conditions, Block

z:\cross734floodconditionsblock.pl2 Run By: B. Gordon, WorleyParsons 2/11/2016 07:01AM



STABL6H FSmin=1.60

Safety Factors Are Calculated By The Modified Janbu Method

**** STABL6H ****

by

Purdue University

--Slope Stability Analysis--

Simplified Janbu, Simplified Bishop

or Spencer's Method of Slices

Run Date: 2/11/2016

Time of Run: 07:01AM

Run By: B. Gordon, WorleyParsons

Input Data Filename: Z:\cross734floodconditionsblock.in

Output Filename: Z:\cross734floodconditionsblock.OUT

Plotted Output Filename: Z:\cross734floodconditionsblock.PLT

PROBLEM DESCRIPTION Cross BA Pond

Section 734, Flood Conditions, Block

BOUNDARY COORDINATES

8 Top Boundaries

11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	80.00	32.00	80.00	2
2	32.00	80.00	53.00	80.00	2
3	53.00	80.00	60.00	78.00	2
4	60.00	78.00	67.00	78.00	2
5	67.00	78.00	106.00	91.00	2
6	106.00	91.00	121.00	91.00	2
7	121.00	91.00	130.00	88.00	2
8	130.00	88.00	225.00	88.00	1
9	130.00	88.00	167.00	76.00	2
10	167.00	76.00	225.00	75.00	2
11	0.00	74.00	225.00	74.00	3

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param. (psf)	Pressure Constant (psf)	Piez. Surface No.
1	90.0	95.0	0.0	0.0	0.00	0.0	1
2	130.0	135.0	50.0	30.0	0.00	0.0	1
3	102.0	107.0	0.0	22.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	78.00
2	106.00	78.00
3	121.00	91.00
4	225.00	91.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

20 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 20.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	75.00	72.00	90.00	72.00	15.00
2	95.00	72.00	125.00	72.00	20.00

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	60.15	78.00
2	67.19	71.58
3	86.76	67.44
4	104.44	81.11
5	114.07	91.00

*** 1.599 ***
 Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.39	79.03
2	59.93	75.50
3	77.73	66.39
4	99.52	73.45
5	112.31	88.83
6	112.66	91.00

*** 1.602 ***
 Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	64.10	78.00
2	76.69	66.13
3	95.20	66.32
4	106.22	83.00
5	110.20	91.00

*** 1.706 ***
 Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	62.81	78.00
2	64.85	77.35
3	82.83	68.58
4	97.86	81.30
5	101.89	89.63

*** 1.823 ***
 Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	39.81	80.00
2	41.36	78.78
3	59.14	69.62
4	78.58	64.92
5	113.27	73.60
6	126.60	88.51
7	126.95	89.02

*** 1.849 ***
 Failure Surface Specified By 4 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.69	78.90
2	83.61	65.57
3	117.89	81.00
4	123.96	90.01

*** 2.034 ***
 Failure Surface Specified By 4 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.40	78.80
2	78.45	70.23
3	104.34	80.53
4	114.42	91.00

*** 2.080 ***
 Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	44.30	80.00
2	60.27	68.51
3	80.07	65.76
4	108.12	80.38
5	110.58	91.00

*** 2.145 ***
 Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.09	80.03
2	74.06	79.53

3	88.60	65.80
4	102.37	66.65
5	116.02	81.27
6	123.34	90.22

*** 2.177 ***

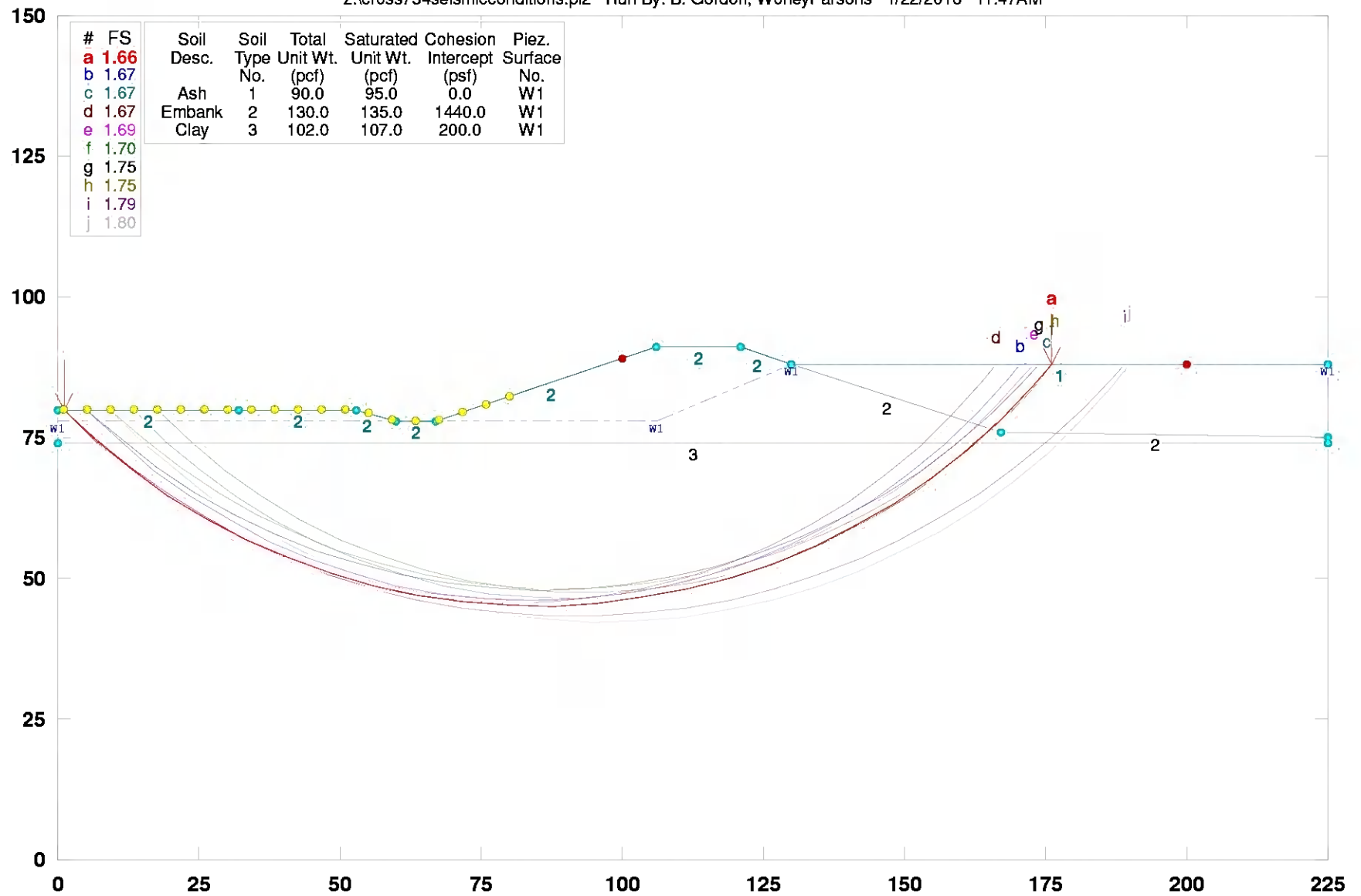
Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	68.98	78.66
2	69.27	78.41
3	87.11	69.37
4	121.85	74.65
5	132.59	88.00

*** 2.229 ***

Cross BA Pond Section 734, Seismic Conditions

z:\cross734seismicconditions.pl2 Run By: B. Gordon, WorleyParsons 1/22/2016 11:47AM



STABL6H FSmin=1.66

Safety Factors Are Calculated By The Modified Bishop Method

cross734seismicconditions.OUT
** STABL6H **
by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer's Method of Slices

Run Date: 1/22/2016
Time of Run: 11:47AM
Run By: B. Gordon, WorleyParsons
Input Data Filename: Z:cross734seismicconditions.in

Output Filename: Z:cross734seismicconditions.OUT

Plotted Output Filename: Z:cross734seismicconditions.PLT

PROBLEM DESCRIPTION Cross BA Pond
Section 734, Seismic Conditions

BOUNDARY COORDINATES

8 Top Boundaries
11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	80.00	32.00	80.00	2
2	32.00	80.00	53.00	80.00	2
3	53.00	80.00	60.00	78.00	2
4	60.00	78.00	67.00	78.00	2
5	67.00	78.00	106.00	91.00	2
6	106.00	91.00	121.00	91.00	2
7	121.00	91.00	130.00	88.00	2
8	130.00	88.00	225.00	88.00	1
9	130.00	88.00	167.00	76.00	2
10	167.00	76.00	225.00	75.00	2
11	0.00	74.00	225.00	74.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

cross734seismicconditions.OUT

Soil Type No.	Total Unit wt. (pcf)	Saturated Unit wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	95.0	0.0	0.0	0.00	0.0	1
2	130.0	135.0	1440.0	0.0	0.00	0.0	1
3	102.0	107.0	200.0	0.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	78.00
2	106.00	78.00
3	130.00	88.00
4	225.00	88.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 1.00 ft.
and X = 80.00 ft.

Each Surface Terminates Between X = 100.00 ft.
and X = 200.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

8.00 ft. Line Segments Define Each Trial Failure Surface.

The Factor Of Safety For The Trial Failure Surface Defined
By The Coordinates Listed Below Is Misleading.

Failure Surface Defined By 16 Coordinate Points

cross734seismicconditions.OUT		
Point No.	X-Surf (ft)	Y-Surf (ft)
1	80.00	82.33
2	85.70	76.72
3	92.05	71.86
4	98.96	67.82
5	106.32	64.68
6	114.01	62.48
7	121.91	61.25
8	129.91	61.01
9	137.87	61.78
10	145.68	63.52
11	153.21	66.23
12	160.34	69.85
13	166.97	74.34
14	172.98	79.61
15	178.30	85.59
16	179.95	88.00

Factor Of Safety For The Preceding Specified Surface =-17.915

The Factor Of Safety For The Trial Failure Surface Defined By The Coordinates Listed Below Is Misleading.

Failure Surface Defined By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	80.00	82.33
2	85.92	76.95
3	92.39	72.24
4	99.32	68.26
5	106.65	65.05
6	114.28	62.65
7	122.13	61.09
8	130.10	60.40
9	138.10	60.56
10	146.03	61.60
11	153.81	63.48
12	161.33	66.20
13	168.52	69.71
14	175.28	73.98
15	181.54	78.96
16	187.23	84.59
17	190.00	88.00

Factor Of Safety For The Preceding Specified Surface =-10.732

Following Are Displayed The Ten Most Critical Of The Trial
Page 3

cross734seismicconditions.OUT
 Failure Surfaces Examined. They Are Ordered - Most Critical
 First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.00	80.00
2	6.83	74.52
3	13.01	69.45
4	19.53	64.80
5	26.34	60.61
6	33.42	56.88
7	40.74	53.65
8	48.25	50.91
9	55.94	48.69
10	63.76	46.99
11	71.67	45.83
12	79.65	45.20
13	87.65	45.12
14	95.63	45.57
15	103.57	46.56
16	111.42	48.09
17	119.16	50.15
18	126.73	52.72
19	134.12	55.80
20	141.27	59.37
21	148.18	63.42
22	154.79	67.92
23	161.08	72.86
24	167.03	78.21
25	172.59	83.96
26	176.02	88.00

Circle Center At X = 84.9 ; Y = 163.4 and Radius, 118.3

*** 1.663 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.16	80.00
2	10.88	74.41
3	17.00	69.25
4	23.48	64.56
5	30.28	60.35
6	37.37	56.65
7	44.72	53.48
8	52.28	50.86
9	60.00	48.79
10	67.86	47.30

cross734seismicconditions.OUT

11	75.81	46.38
12	83.80	46.05
13	91.80	46.31
14	99.76	47.14
15	107.63	48.56
16	115.38	50.55
17	122.96	53.10
18	130.33	56.20
19	137.46	59.83
20	144.31	63.98
21	150.83	68.61
22	157.00	73.71
23	162.77	79.24
24	168.13	85.18
25	170.32	88.00

Circle Center At X = 84.3 ; Y = 155.3 and Radius, 109.3

*** 1.665 ***

1

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	13.47	80.00
2	19.15	74.36
3	25.24	69.17
4	31.70	64.45
5	38.50	60.24
6	45.59	56.54
7	52.95	53.39
8	60.52	50.80
9	68.26	48.79
10	76.13	47.37
11	84.09	46.55
12	92.09	46.33
13	100.08	46.71
14	108.02	47.69
15	115.86	49.27
16	123.56	51.43
17	131.08	54.17
18	138.37	57.47
19	145.39	61.30
20	152.10	65.66
21	158.47	70.50
22	164.45	75.82
23	170.01	81.56
24	175.13	87.72
25	175.33	88.00

Circle Center At X = 91.0 ; Y = 152.5 and Radius, 106.1

*** 1.668 ***

cross734seismicconditions.OUT
Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.00	80.00
2	6.68	74.37
3	12.77	69.18
4	19.22	64.44
5	26.00	60.20
6	33.07	56.46
7	40.40	53.26
8	47.95	50.60
9	55.67	48.50
10	63.52	46.98
11	71.47	46.05
12	79.46	45.70
13	87.46	45.94
14	95.41	46.76
15	103.29	48.17
16	111.04	50.16
17	118.62	52.71
18	126.00	55.81
19	133.12	59.45
20	139.96	63.60
21	146.47	68.24
22	152.63	73.35
23	158.39	78.90
24	163.73	84.86
25	166.15	88.00

Circle Center At X = 80.2 ; Y = 154.3 and Radius, 108.6

*** 1.668 ***

1

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.00	80.00
2	6.86	74.56
3	13.08	69.52
4	19.63	64.93
5	26.48	60.80
6	33.60	57.14
7	40.95	53.99
8	48.50	51.34
9	56.21	49.21
10	64.05	47.62
11	71.98	46.57
12	79.97	46.07
13	87.97	46.11
14	95.94	46.70
15	103.86	47.84
16	111.69	49.51
17	119.37	51.72

cross734seismicconditions.OUT

18	126.89	54.45
19	134.21	57.69
20	141.29	61.42
21	148.09	65.63
22	154.59	70.29
23	160.76	75.39
24	166.56	80.89
25	171.97	86.79
26	172.94	88.00

Circle Center At X = 83.3 ; Y = 162.8 and Radius, 116.7

*** 1.690 ***

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	17.63	80.00
2	23.37	74.42
3	29.51	69.30
4	36.02	64.65
5	42.88	60.52
6	50.02	56.93
7	57.42	53.89
8	65.03	51.43
9	72.81	49.55
10	80.71	48.27
11	88.68	47.60
12	96.68	47.54
13	104.66	48.09
14	112.58	49.25
15	120.38	51.01
16	128.03	53.36
17	135.47	56.29
18	142.67	59.78
19	149.58	63.81
20	156.17	68.35
21	162.39	73.38
22	168.20	78.88
23	173.58	84.80
24	176.08	88.00

Circle Center At X = 93.5 ; Y = 152.2 and Radius, 104.7

*** 1.704 ***

1

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.16	80.00

cross734seismicconditions.OUT

2	11.15	74.70
3	17.49	69.82
4	24.15	65.39
5	31.10	61.42
6	38.30	57.93
7	45.72	54.95
8	53.33	52.48
9	61.09	50.53
10	68.96	49.12
11	76.91	48.25
12	84.91	47.92
13	92.90	48.14
14	100.87	48.91
15	108.76	50.22
16	116.54	52.07
17	124.18	54.44
18	131.64	57.33
19	138.89	60.72
20	145.89	64.60
21	152.60	68.94
22	159.00	73.74
23	165.07	78.96
24	170.76	84.59
25	173.77	88.00

Circle Center At X = 85.7 ; Y = 165.0 and Radius, 117.1

*** 1.746 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.32	80.00
2	15.30	74.69
3	21.64	69.81
4	28.30	65.37
5	35.24	61.41
6	42.45	57.93
7	49.88	54.96
8	57.49	52.50
9	65.26	50.58
10	73.13	49.20
11	81.09	48.36
12	89.09	48.07
13	97.08	48.34
14	105.04	49.16
15	112.92	50.52
16	120.69	52.42
17	128.31	54.85
18	135.75	57.81
19	142.96	61.27
20	149.92	65.21
21	156.59	69.63
22	162.94	74.50
23	168.94	79.79
24	174.56	85.49
25	176.72	88.00

cross734seismicconditions.OUT

Circle Center At X = 89.2 ; Y = 164.1 and Radius, 116.0

*** 1.747 ***

1

Failure Surface Specified By 28 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.00	80.00
2	6.89	74.59
3	13.11	69.55
4	19.62	64.91
5	26.41	60.67
6	33.45	56.87
7	40.71	53.51
8	48.16	50.61
9	55.78	48.17
10	63.54	46.22
11	71.40	44.74
12	79.34	43.76
13	87.33	43.27
14	95.33	43.27
15	103.31	43.77
16	111.25	44.76
17	119.11	46.25
18	126.86	48.21
19	134.48	50.66
20	141.93	53.57
21	149.19	56.94
22	156.23	60.75
23	163.01	64.99
24	169.52	69.64
25	175.73	74.68
26	181.61	80.10
27	187.15	85.88
28	188.95	88.00

Circle Center At X = 91.3 ; Y = 172.3 and Radius, 129.1

*** 1.792 ***

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.32	80.00
2	14.97	74.34
3	21.00	69.08
4	27.36	64.23
5	34.04	59.82
6	40.99	55.87

cross734seismicconditions.OUT

7	48.20	52.40
8	55.62	49.42
9	63.23	46.94
10	70.99	44.98
11	78.86	43.54
12	86.80	42.64
13	94.80	42.27
14	102.79	42.44
15	110.76	43.15
16	118.67	44.39
17	126.47	46.16
18	134.13	48.45
19	141.63	51.24
20	148.92	54.54
21	155.97	58.32
22	162.75	62.56
23	169.23	67.25
24	175.39	72.36
25	181.18	77.88
26	186.59	83.77
27	189.98	88.00

Circle Center At X = 96.3 ; Y = 161.3 and Radius, 119.0

*** 1.797 ***

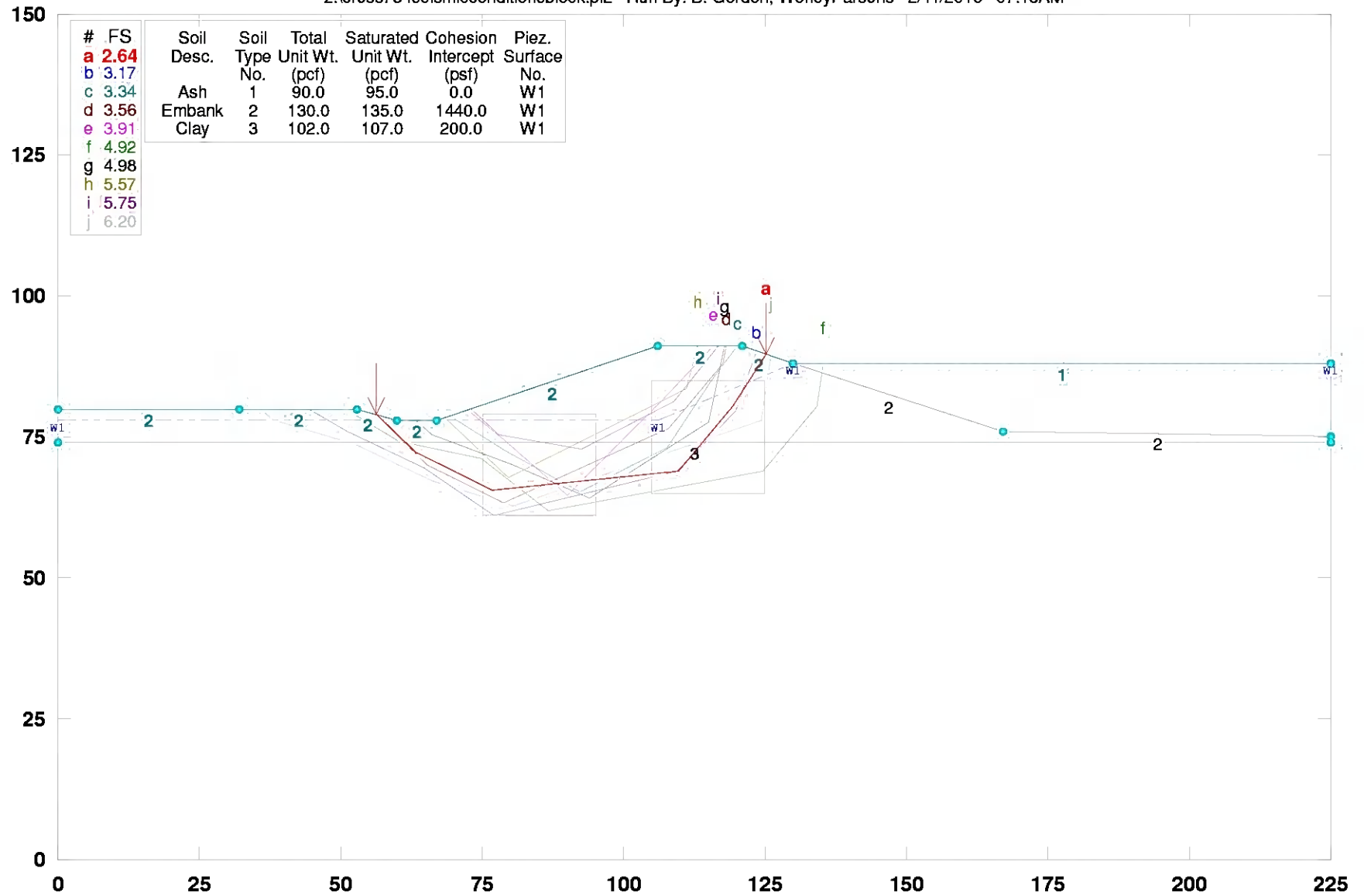
1

	Y	A	X	I	S	F	T
	0.00	28.13	56.25	84.38	112.50	140.63	
X	0.00	+	-----+	-----+	*-*	-----+	-----+
	-				152		
	-				278		
	-				1083		
	-				1.23.6		
	-				2.36..		
	28.13	+			218.6...		
	-				1073....*		
	-				2386.....		
	-				1086.....		
	-				123.....		
	-				236.....*		
A	56.25	+			106.....		
	-				.23.....*		
	-				916.....*		
	-				.13.....		
	-				236.....		
	-				016.....		
X	84.38	+			.23.....		
	-				916.....		
	-				914.....		
	-				.2.....		
	-				091.....		
	-				27.....W...*		
I	112.50	+			0914.....		
	-				.9.14.....		
	-				..32.....*		

cross734seismicconditions.OUT

Cross BA Pond Section 734, Seismic Conditions, Block

z:\cross734seismicconditionsblock.pl2 Run By: B. Gordon, WorleyParsons 2/11/2016 07:13AM



STABL6H FSmin=2.64

Safety Factors Are Calculated By The Modified Janbu Method

**** STABL6H ****

by

Purdue University

--Slope Stability Analysis--

Simplified Janbu, Simplified Bishop

or Spencer's Method of Slices

Run Date: 2/11/2016

Time of Run: 07:13AM

Run By: B. Gordon, WorleyParsons

Input Data Filename: Z:\cross734seismicconditionsblock.in

Output Filename: Z:\cross734seismicconditionsblock.OUT

Plotted Output Filename: Z:\cross734seismicconditionsblock.PLT

PROBLEM DESCRIPTION Cross BA Pond

Section 734, Seismic Conditions, Block

BOUNDARY COORDINATES

8 Top Boundaries

11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	80.00	32.00	80.00	2
2	32.00	80.00	53.00	80.00	2
3	53.00	80.00	60.00	78.00	2
4	60.00	78.00	67.00	78.00	2
5	67.00	78.00	106.00	91.00	2
6	106.00	91.00	121.00	91.00	2
7	121.00	91.00	130.00	88.00	2
8	130.00	88.00	225.00	88.00	1
9	130.00	88.00	167.00	76.00	2
10	167.00	76.00	225.00	75.00	2
11	0.00	74.00	225.00	74.00	3

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param. (psf)	Pressure Constant (psf)	Piez. Surface No.
1	90.0	95.0	0.0	0.0	0.00	0.0	1
2	130.0	135.0	1440.0	0.0	0.00	0.0	1
3	102.0	107.0	200.0	0.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	78.00
2	106.00	78.00
3	130.00	88.00
4	225.00	88.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

20 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 15.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	75.00	70.00	95.00	70.00	18.00
2	105.00	75.00	125.00	75.00	20.00

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 6 Coordinate Points

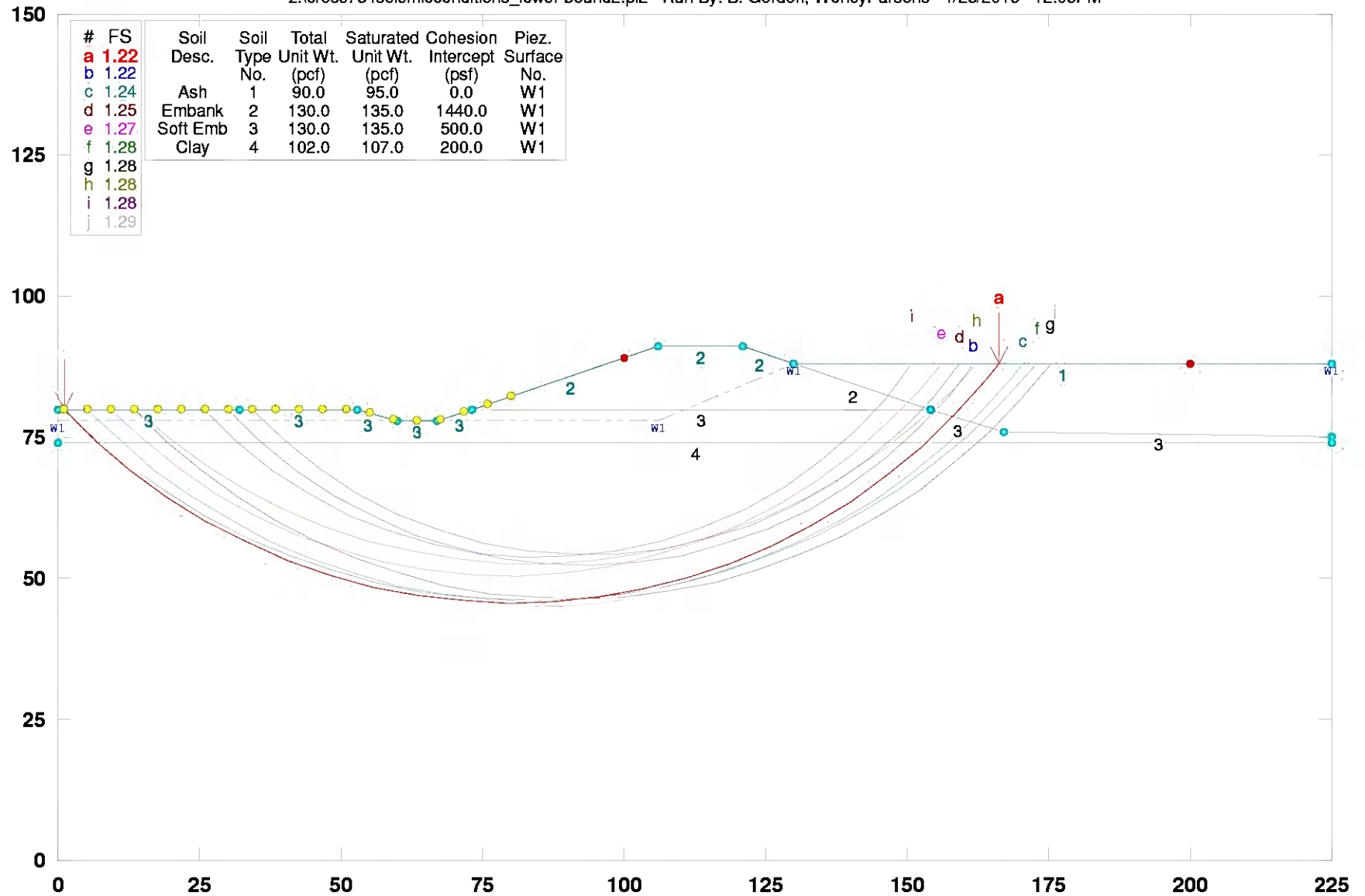
Point No.	X-Surf (ft)	Y-Surf (ft)
1	56.18	79.09
2	63.42	72.34
3	76.73	65.42
4	109.65	68.81
5	119.14	80.42

6	125.08	89.64
***	2.639	***
Failure Surface Specified By 7 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	44.47	80.00
2	51.23	76.07
3	64.66	69.39
4	77.18	61.12
5	109.32	68.87
6	119.88	79.52
7	123.50	90.17
***	3.165	***
Failure Surface Specified By 6 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	69.31	78.77
2	78.98	72.56
3	92.14	65.36
4	107.60	73.00
5	116.01	85.42
6	120.03	91.00
***	3.344	***
Failure Surface Specified By 6 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	56.31	79.05
2	65.29	70.10
3	78.65	63.27
4	108.01	76.45
5	117.61	87.98
6	118.09	91.00
***	3.564	***
Failure Surface Specified By 5 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	72.37	79.79
2	78.72	74.51
3	90.01	64.64
4	106.57	81.41
5	115.96	91.00
***	3.910	***
Failure Surface Specified By 7 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	50.84	80.00
2	60.09	74.38
3	74.74	71.16
4	86.61	62.00
5	124.73	68.80
6	134.04	80.56
7	135.17	88.00
***	4.921	***
Failure Surface Specified By 6 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	63.34	78.00
2	66.23	75.31
3	80.32	70.16
4	94.00	64.00
5	114.93	77.59
6	117.80	91.00
***	4.981	***
Failure Surface Specified By 5 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	68.42	78.47
2	68.70	78.20
3	79.59	67.88
4	111.22	83.53

5	113.17	91.00
***	5.574	***
Failure Surface Specified By 5 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	73.03	80.01
2	77.81	75.26
3	92.64	72.96
4	108.76	81.32
5	116.72	91.00
***	5.750	***
Failure Surface Specified By 7 Coordinate Points		
Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	35.67	80.00
2	38.20	77.86
3	52.65	73.81
4	66.15	67.28
5	80.44	62.72
6	124.30	77.99
7	126.08	89.31
***	6.204	***

Cross BA Pond Section 734, Lower Bound Seismic

z:\cross734seismicconditions_lower bound2.pl2 Run By: B. Gordon, WorleyParsons 1/28/2016 12:05PM



STABL6H FSmin=1.22

Safety Factors Are Calculated By The Modified Bishop Method

cross734seismicconditions_Lower Bound2.OUT
 ** STABL6H **
 by
 Purdue University

1

--Slope Stability Analysis--
 Simplified Janbu, Simplified Bishop
 or Spencer's Method of Slices

Run Date: 1/28/2016
 Time of Run: 12:05PM
 Run By: B. Gordon, WorleyParsons
 Input Data Filename: Z:cross734seismicconditions_Lower Bound2.in

Output Filename: Z:cross734seismicconditions_Lower Bound2.OUT

Plotted Output Filename: Z:cross734seismicconditions_Lower Bound2.PLT

PROBLEM DESCRIPTION Cross BA Pond
 Section 734, Lower Bound Seismic

BOUNDARY COORDINATES

9 Top Boundaries
 14 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	80.00	32.00	80.00	3
2	32.00	80.00	53.00	80.00	3
3	53.00	80.00	60.00	78.00	3
4	60.00	78.00	67.00	78.00	3
5	67.00	78.00	73.00	80.00	3
6	73.00	80.00	106.00	91.00	2
7	106.00	91.00	121.00	91.00	2
8	121.00	91.00	130.00	88.00	2
9	130.00	88.00	225.00	88.00	1
10	130.00	88.00	154.00	80.00	2
11	73.00	80.00	154.00	80.00	3
12	154.00	80.00	167.00	76.00	3
13	167.00	76.00	225.00	75.00	3
14	0.00	74.00	225.00	74.00	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit wt. (pcf)	Saturated Unit wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	95.0	0.0	0.0	0.00	0.0	1
2	130.0	135.0	1440.0	0.0	0.00	0.0	1
3	130.0	135.0	500.0	0.0	0.00	0.0	1
4	102.0	107.0	200.0	0.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	78.00
2	106.00	78.00
3	130.00	88.00
4	225.00	88.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 1.00 ft.
and X = 80.00 ft.

Each Surface Terminates Between X = 100.00 ft.
and X = 200.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

8.00 ft. Line Segments Define Each Trial Failure Surface.

The Factor Of Safety For The Trial Failure Surface Defined
By The Coordinates Listed Below Is Misleading.

Failure Surface Defined By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	80.00	82.33
2	85.70	76.72
3	92.05	71.86
4	98.96	67.82
5	106.32	64.68
6	114.01	62.48
7	121.91	61.25
8	129.91	61.01
9	137.87	61.78
10	145.68	63.52
11	153.21	66.23
12	160.34	69.85
13	166.97	74.34
14	172.98	79.61
15	178.30	85.59
16	179.95	88.00

Factor Of Safety For The Preceding Specified Surface =~12.315

The Factor Of Safety For The Trial Failure Surface Defined By The Coordinates Listed Below Is Misleading.

Failure Surface Defined By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	80.00	82.33
2	85.92	76.95
3	92.39	72.24
4	99.32	68.26
5	106.65	65.05
6	114.28	62.65
7	122.13	61.09
8	130.10	60.40
9	138.10	60.56
10	146.03	61.60
11	153.81	63.48
12	161.33	66.20
13	168.52	69.71
14	175.28	73.98
15	181.54	78.96
16	187.23	84.59
17	190.00	88.00

cross734seismicconditions_Lower Bound2.OUT
Factor Of Safety For The Preceding Specified Surface = -7.600

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.00	80.00
2	6.68	74.37
3	12.77	69.18
4	19.22	64.44
5	26.00	60.20
6	33.07	56.46
7	40.40	53.26
8	47.95	50.60
9	55.67	48.50
10	63.52	46.98
11	71.47	46.05
12	79.46	45.70
13	87.46	45.94
14	95.41	46.76
15	103.29	48.17
16	111.04	50.16
17	118.62	52.71
18	126.00	55.81
19	133.12	59.45
20	139.96	63.60
21	146.47	68.24
22	152.63	73.35
23	158.39	78.90
24	163.73	84.86
25	166.15	88.00

Circle Center At X = 80.2 ; Y = 154.3 and Radius, 108.6

*** 1.222 ***

Failure Surface Specified By 20 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.11	80.00
2	35.76	74.35
3	41.93	69.25
4	48.55	64.76
5	55.57	60.91
6	62.91	57.74
7	70.52	55.28

cross734seismicconditions_Lower Bound2.OUT

8	78.33	53.55
9	86.27	52.56
10	94.27	52.33
11	102.25	52.85
12	110.15	54.12
13	117.89	56.13
14	125.41	58.86
15	132.64	62.29
16	139.52	66.38
17	145.97	71.10
18	151.95	76.42
19	157.41	82.27
20	161.81	88.00

Circle Center At X = 92.8 ; Y = 137.0 and Radius, 84.7

*** 1.224 ***

1

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.16	80.00
2	10.88	74.41
3	17.00	69.25
4	23.48	64.56
5	30.28	60.35
6	37.37	56.65
7	44.72	53.48
8	52.28	50.86
9	60.00	48.79
10	67.86	47.30
11	75.81	46.38
12	83.80	46.05
13	91.80	46.31
14	99.76	47.14
15	107.63	48.56
16	115.38	50.55
17	122.96	53.10
18	130.33	56.20
19	137.46	59.83
20	144.31	63.98
21	150.83	68.61
22	157.00	73.71
23	162.77	79.24
24	168.13	85.18
25	170.32	88.00

Circle Center At X = 84.3 ; Y = 155.3 and Radius, 109.3

*** 1.243 ***

Failure Surface Specified By 19 Coordinate Points

cross734seismicconditions_Lower Bound2.OUT

Point No.	X-Surf (ft)	Y-Surf (ft)
1	34.26	80.00
2	39.98	74.41
3	46.23	69.41
4	52.94	65.05
5	60.05	61.38
6	67.48	58.43
7	75.17	56.23
8	83.04	54.80
9	91.02	54.15
10	99.02	54.30
11	106.96	55.24
12	114.77	56.96
13	122.38	59.44
14	129.70	62.67
15	136.67	66.60
16	143.21	71.20
17	149.27	76.43
18	154.77	82.23
19	159.26	88.00

Circle Center At X = 93.5 ; Y = 134.9 and Radius, 80.8

*** 1.247 ***

1

Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.32	80.00
2	15.12	74.49
3	21.35	69.48
4	27.98	65.00
5	34.95	61.07
6	42.22	57.73
7	49.74	55.00
8	57.46	52.90
9	65.32	51.43
10	73.28	50.62
11	81.28	50.46
12	89.26	50.96
13	97.18	52.12
14	104.98	53.91
15	112.60	56.35
16	119.99	59.40
17	127.11	63.04
18	133.91	67.26
19	140.34	72.03
20	146.35	77.30
21	151.92	83.05
22	155.97	88.00

Circle Center At X = 79.2 ; Y = 147.8 and Radius, 97.4

cross734seismicconditions_Lower Bound2.OUT

*** 1.266 ***

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.00	80.00
2	6.86	74.56
3	13.08	69.52
4	19.63	64.93
5	26.48	60.80
6	33.60	57.14
7	40.95	53.99
8	48.50	51.34
9	56.21	49.21
10	64.05	47.62
11	71.98	46.57
12	79.97	46.07
13	87.97	46.11
14	95.94	46.70
15	103.86	47.84
16	111.69	49.51
17	119.37	51.72
18	126.89	54.45
19	134.21	57.69
20	141.29	61.42
21	148.09	65.63
22	154.59	70.29
23	160.76	75.39
24	166.56	80.89
25	171.97	86.79
26	172.94	88.00

Circle Center At X = 83.3 ; Y = 162.8 and Radius, 116.7

*** 1.275 ***

1

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	13.47	80.00
2	19.15	74.36
3	25.24	69.17
4	31.70	64.45
5	38.50	60.24
6	45.59	56.54
7	52.95	53.39
8	60.52	50.80
9	68.26	48.79
10	76.13	47.37
11	84.09	46.55

cross734seismicconditions_Lower Bound2.OUT

12	92.09	46.33
13	100.08	46.71
14	108.02	47.69
15	115.86	49.27
16	123.56	51.43
17	131.08	54.17
18	138.37	57.47
19	145.39	61.30
20	152.10	65.66
21	158.47	70.50
22	164.45	75.82
23	170.01	81.56
24	175.13	87.72
25	175.33	88.00

Circle Center At X = 91.0 ; Y = 152.5 and Radius, 106.1

*** 1.276 ***

Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	13.47	80.00
2	19.57	74.82
3	26.04	70.12
4	32.85	65.92
5	39.97	62.27
6	47.35	59.17
7	54.94	56.64
8	62.70	54.71
9	70.59	53.38
10	78.55	52.65
11	86.55	52.54
12	94.54	53.04
13	102.46	54.15
14	110.27	55.87
15	117.93	58.18
16	125.39	61.07
17	132.61	64.53
18	139.54	68.53
19	146.14	73.04
20	152.37	78.05
21	158.21	83.53
22	162.29	88.00

Circle Center At X = 84.0 ; Y = 156.7 and Radius, 104.2

*** 1.279 ***

1

Failure Surface Specified By 19 Coordinate Points

Point	X-Surf	Y-Surf
-------	--------	--------

No.	cross734seismicconditions_Lower Bound2.OUT (ft)	(ft)
1	25.95	80.00
2	31.61	74.34
3	37.80	69.28
4	44.47	64.87
5	51.55	61.14
6	58.96	58.13
7	66.64	55.89
8	74.51	54.42
9	82.48	53.74
10	90.48	53.87
11	98.42	54.79
12	106.24	56.51
13	113.84	58.99
14	121.16	62.23
15	128.12	66.18
16	134.64	70.80
17	140.68	76.05
18	146.16	81.88
19	150.85	88.00

Circle Center At X = 85.2 ; Y = 133.6 and Radius, 79.9

*** 1.280 ***

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.00	80.00
2	6.83	74.52
3	13.01	69.45
4	19.53	64.80
5	26.34	60.61
6	33.42	56.88
7	40.74	53.65
8	48.25	50.91
9	55.94	48.69
10	63.76	46.99
11	71.67	45.83
12	79.65	45.20
13	87.65	45.12
14	95.63	45.57
15	103.57	46.56
16	111.42	48.09
17	119.16	50.15
18	126.73	52.72
19	134.12	55.80
20	141.27	59.37
21	148.18	63.42
22	154.79	67.92
23	161.08	72.86
24	167.03	78.21
25	172.59	83.96
26	176.02	88.00

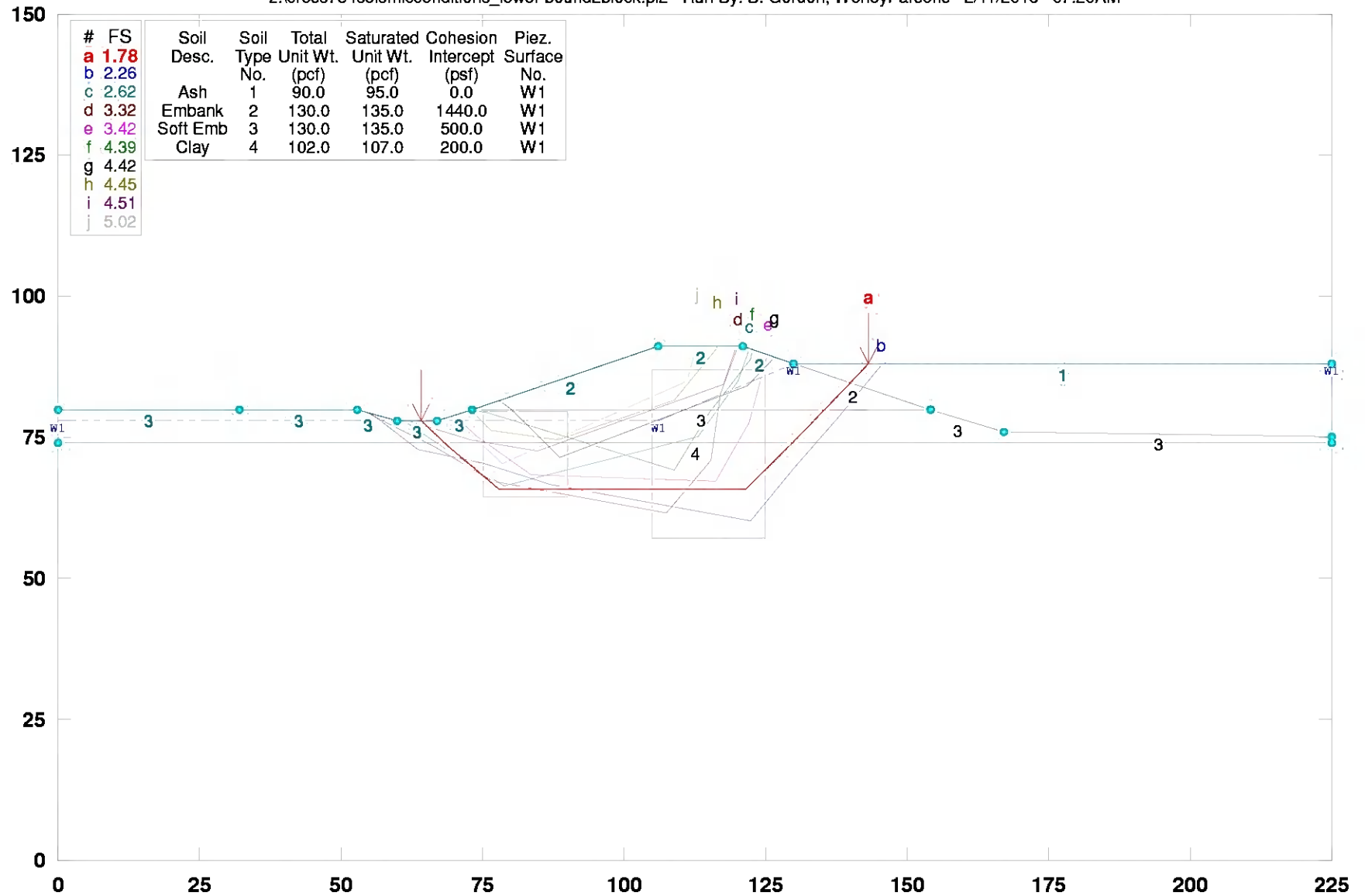
Circle Center At X = 84.9 ; Y = 163.4 and Radius, 118.3
Page 9

*** 1.285 ***

	Y	A	X	I	S	F	T
	0.00	28.13	56.25		84.38	112.50	140.63
X	0.00	+-----+-----+-----*-*			+-----+-----+		
	-			163			
	-			3.5			
	-			15.7			
	-			1.378.			
	-			3.5...			
	28.13	+-----	165.8..2				
	-		1.57..9.*				
	-		37...92..				
	-		1.589.24..				
	-		1378.2.4...				
	-		375.94....*				
A	56.25	+-----	1.58.2.....				
	-		.378.24....*				
	-		.15.94....*				
	-		.16.82.....				
	-		37594.....*				
	-		.1.52.....				
X	84.38	+-----	.37.2.....				
	-		.1.54.....				
	-		.31.2.....				
	-		.3.4.....				
	-		.1.2.....				
	-		3.24.....W...*				
I	112.50	+-----	.01.49.....				
	-		.3128.....				
	-		.73.49.....*				
	-		.6125.9.....				
	-		.73128.....*				
	-		.03..49.....				
S	140.63	+-----	.70612.59....				
	-		.731285.9..				
	-		.63..2..59				
	-		.061.*4.5				
	-		.7061284				
	-		.73.11				
	168.75	+-----	*0633				
	-		.06				
	-		.0				
	-		.				
	-		.				
	-		.				
F	196.88	+-----	.				
	-		.				
	-		.				
	-		.				
	-		.				
T	225.00	+-----		** *	*		

Cross BA Pond Section 734, Lower Bound Seismic, Block

z:\cross734seismicconditions_lower bound2block.pl2 Run By: B. Gordon, WorleyParsons 2/11/2016 07:20AM



STABL6H FSmin=1.78

Safety Factors Are Calculated By The Modified Janbu Method

**** STABL6H ****

by

Purdue University

--Slope Stability Analysis--

Simplified Janbu, Simplified Bishop

or Spencer's Method of Slices

Run Date: 2/11/2016

Time of Run: 07:20AM

Run By: B. Gordon, WorleyParsons

Input Data Filename: Z:\cross734seismicconditions_lower bound2block.in

Output Filename: Z:\cross734seismicconditions_lower bound2block.OUT

Plotted Output Filename: Z:\cross734seismicconditions_lower bound2block.PLT

PROBLEM DESCRIPTION Cross BA Pond

Section 734, Lower Bound Seismic, Block

BOUNDARY COORDINATES

9 Top Boundaries

14 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	80.00	32.00	80.00	3
2	32.00	80.00	53.00	80.00	3
3	53.00	80.00	60.00	78.00	3
4	60.00	78.00	67.00	78.00	3
5	67.00	78.00	73.00	80.00	3
6	73.00	80.00	106.00	91.00	2
7	106.00	91.00	121.00	91.00	2
8	121.00	91.00	130.00	88.00	2
9	130.00	88.00	225.00	88.00	1
10	130.00	88.00	154.00	80.00	2
11	73.00	80.00	154.00	80.00	3
12	154.00	80.00	167.00	76.00	3
13	167.00	76.00	225.00	75.00	3
14	0.00	74.00	225.00	74.00	4

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param. (psf)	Pressure Constant (psf)	Piez. Surface No.
1	90.0	95.0	0.0	0.0	0.00	0.0	1
2	130.0	135.0	1440.0	0.0	0.00	0.0	1
3	130.0	135.0	500.0	0.0	0.00	0.0	1
4	102.0	107.0	200.0	0.0	0.00	0.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	78.00
2	106.00	78.00
3	130.00	88.00
4	225.00	88.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

20 Trial Surfaces Have Been Generated.

2 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of

Sliding Block Is 12.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	75.00	72.00	90.00	72.00	15.00
2	105.00	72.00	125.00	72.00	30.00

Following Are Displayed The Ten Most Critical Of The Trial

Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	64.06	78.00

2	68.80	73.35
3	78.03	65.67
4	121.41	65.78
5	129.82	74.34
6	138.31	82.83
7	143.11	88.00

*** 1.778 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	55.26	79.35
2	63.60	72.80
3	75.34	70.32
4	86.81	66.77
5	122.33	60.24
6	129.86	69.58
7	137.85	78.54
8	145.43	87.85
9	145.48	88.00

*** 2.255 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.06	78.00
2	68.54	72.94
3	78.63	66.45
4	113.00	75.07
5	120.01	84.81
6	121.96	90.68

*** 2.617 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	54.94	79.45
2	55.64	78.75
3	66.32	73.28
4	76.69	67.23
5	107.52	61.52
6	115.19	70.74
7	117.11	82.59
8	120.11	91.00

*** 3.321 ***

Failure Surface Specified By 7 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.98	78.99
2	73.69	75.28
3	83.42	68.25
4	116.10	67.19
5	121.95	77.66
6	125.25	89.20
7	125.53	89.49

*** 3.424 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	72.85	79.95
2	75.83	79.30
3	108.80	69.12
4	115.03	79.37
5	122.48	88.78
6	122.73	90.42

*** 4.390 ***

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	77.97	81.66
2	80.08	79.74
3	88.61	71.31
4	121.85	84.19

5 126.44 89.19
 *** 4.416 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	72.73	79.91
2	76.37	76.31
3	88.23	74.46
4	108.76	81.48
5	116.38	90.75
6	116.42	91.00
***	4.453	***

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	61.98	78.00
2	72.87	74.58
3	84.68	72.44
4	117.47	84.47
5	119.76	91.00
***	4.512	***

Failure Surface Specified By 5 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	69.41	78.80
2	69.73	78.49
3	78.45	70.23
4	111.22	84.80
5	112.84	91.00
***	5.022	***