

# PERIODIC SAFETY FACTOR ASSESSMENT

**CFR 257.73(e)(1)**

East Bottom Ash Pond

Pirkey Power Plant  
Hallsville, Texas

October, 2016

Prepared for: Southwest Electric Power Company – Pirkey Power Plant  
Hallsville, Texas

Prepared by: American Electric Power Service Corporation  
1 Riverside Plaza  
Columbus, OH 43215



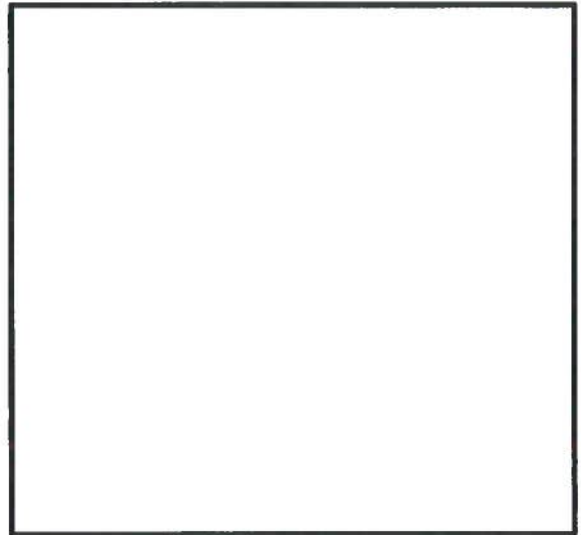
**Document ID Number: GERS-16-143**

PERIODIC SAFETY FACTOR ASSESSMENT  
CFR 257.73(e)(1)  
PIRKEY POWER PLANT  
EAST BOTTOM ASH PONDS

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APPROVED BY Gary F. Zych DATE 10/14/2016  
Gary F. Zych, P.E.  
Department Manager – AEP Geotechnical Engineering



I certify to the best of my knowledge, information, and belief that the information contained in this the safety factor assessment meets the requirements of 40 CFR 257.73(e)(1).

## **1.0 INTRODUCTION**

In April of 2015, the USEPA formally published national regulations for disposal of coal combustion Residuals (CCR) from electric utilities. As part of the rule, the owner or operator of the CCR unit must Obtain a certification from a qualified professional engineer stating that the CCR impoundments are in accordance with the rules. This report provides the documentation needed to fulfill the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*

## **2.0 PROJECT INFORMATION**

The Henry W. Pirkey Power Station is located at 2400 FM 3251 and south of Hallsville, Texas. It is owned and operated by Southwest Electric Power Company (SWEPCO). The facility operates two surface impoundments for storing CCR materials called the East Bottom Ash Pond (East BAP) and the West Bottom Ash Pond (West BAP).

The East BAP is incised on three sides with a splitter dike on the west side. The splitter dike is shared with West BAP and its stability is covered under the West BAP stability report titled Initial Safety Factor Assessment – West Bottom Ash Pond. A copy of the West BAP Safety Factor Assessment report is attached.

**Initial Safety Factor Assessment – West Ash Pond  
Pirkey Power Generating Station  
Hallsville, Texas**

**Auckland Project No. 2015-008C (Revision No. 2)  
January 14, 2016**

Prepared For:

American Electric Power Company  
1 Riverside Plaza  
Columbus, Ohio 43215

Prepared By:

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Jacksonville, Texas

TBPE Firm Registration No. F-16721  
Expires 2/29/2016



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## **1.0 Introduction and Embankment Information**

### **1.1 Introduction**

The following report and evaluation provides the Initial Safety Factor Assessment of the West Ash Pond, an existing CCR impoundment (as defined by 40 CFR §257.2) located at the Pirkey Power Station near Hallsville, Texas. In accordance with 40 CFR §257.73(e)(1)(i) through (iv) this initial assessment provides field and laboratory data, model outputs (detailing multiple stability conditions) and summary of safety factors for the West Ash Pond. In accordance with 40 CFR §257.73(e)(2) this report provides the Initial Safety Factor Assessment certification for the West Ash Pond.

### **1.2 Referenced Information and Data**

Soils data, comprised of field and laboratory testing, utilized in the preparation of this assessment were completed by E TTL Engineers and Consultants, Inc. and documented in the report *Pirkey Power Station, Existing Ash, Surge, Lignite and Limestone Runoff, and Landfill Stormwater Ponds Embankment Investigation, Hallsville, Texas* dated October 12, 2010. Based on a review of the provided field and laboratory data, it appears to be accurate and appropriate for use in the initial structural stability assessment of the West Ash Pond [40 CFR §257.73(e)(1)]. Furthermore, based on a recent site visit (October 2015), no modifications or elevation alterations have been made to the embankment since the referenced investigation. No additional field or laboratory activities were conducted. Soil data utilized in this evaluation is provided in the Appendix of this report.

To supplement existing data collected in the above reference report, an additional eight (8) Cone Penetrometer Test (CPT) soundings were advanced both along the crest and southern toe of the West Ash Pond. Sounding depths ranged between approximately 14 feet and 40 feet before encountering refusal. The data collected generally supports the findings from the 2010 study and confirms that embankment and foundation soils are relatively consistent. The location of and data from these CPT soundings are provided in the Appendix of this report.

The impoundment pool elevation data cited herein were provided in a separate hydrology and hydraulic (H&H) analysis report completed by Akron Consulting, LLC titled *Hydrology & Hydraulic Report, East & West Ash Ponds, H.W. Pirkey Power Plant – Hallsville, Texas*, dated December 15, 2015 (not included herein). The referenced report generally meets the demonstration requirements of 40 CFR §257.82(a).

Embankment profile dimensions and elevations were determined by using existing information provided by the client or representatives of the client. This information is also included in the Appendix of this report.

### **1.3 Embankment Evaluation Criteria**

Based on information provided by the client, the existing embankment is constructed of lean clay (CL) and fat clay (CH) with existing side slopes (both up- and downstream) of approximately 3:1 (H:V), maximum embankment height of 20 feet and top of dam elevation of 358.0 feet (MSL). The upstream base elevation of the impoundment is approximately 347.0 feet (MSL). The crest width of the embankment is approximately 25 feet. Two (2) critical sections were evaluated for this initial safety factor assessment. Section No. 1 represents the northwest corner of the West Ash embankment and Section No. 2 represents the southern berm of the embankment.

It is our understanding that the maximum storage elevation of impounded CCR ash is 355.0 feet (MSL); however, the facility is managed to maintain an ash level less than this maximum level. The downstream toe of the West Ash Pond is not adjacent to other water bodies and therefore not subject to 40 CFR §257.73(d)(1)(A)(3)(vii).

In accordance with 40 CFR §257.73(e)(1)(i) and (ii), the maximum storage pool elevation for the West Ash Pond as determined by the 25-year, 24-hour storm event is 354.81 feet (MSL). For the purposes of this evaluation, the maximum storage pool elevation of 355.0 feet (MSL) was utilized. Likewise, the maximum (or flood) surcharge loading elevation as determined by the 100-year, 24-hour event is 355.01 feet (MSL), for this evaluation a maximum surcharge loading elevation of 355.0 feet (MSL) was utilized. Storage pool elevations were determined in accordance with 40 CFR §257.82(a).

## **2.0 Slope Stability Analyses**

### **2.1 General**

Soil parameters used for stability analyses of the existing embankment are based on findings of previous laboratory and field testing programs. The probable failure planes were analyzed using the analytical slope stability software, SLIDE by Rocscience, Inc. Methods of evaluation used in SLIDE are considered to be limited equilibrium methods of analysis, where each individual shear plane is evaluated to determine the resulting shear stress at the point of failure. For the purposes of this evaluation the Bishop Method of analysis, which analyzes circular failure planes through the slope was utilized.

Per 40 CFR §257.73(e)(1)(i) through (iii), three (3) modeled scenarios (presented below) were utilized to evaluate the stability of the existing embankment: steady state seepage (long term) condition under maximum storage pool, steady state seepage (long term) condition under maximum surcharge pool, and steady state seepage condition with seismic loading under maximum storage pool conditions. The following minimum factors of safety (FS) and soil stress parameters were utilized in modeling. Minimum factors of safety are based on demonstration requirements provided in 40 CFR §257.73(e)(1).

Summary of Embankment Condition and Factor of Safety		
Embankment Condition	Soil Parameters	Minimum Factor of Safety
Steady State Seepage – Maximum Pool	Effective Stress	1.50
Steady State Seepage – Surcharge Pool	Effective Stress	1.40
Steady State Seepage (Seismic) – Maximum Pool	Total Stress	1.00
<b>NOTE:</b> Minimum factors of safety based on demonstration requirements provided in 40 CFR §257.82 (e)(1).		

For evaluation of steady state seepage (long term) conditions with seismic, peak ground acceleration for this location was obtained from the USGS National Seismic Hazard Mapping Project (<http://earthquake.usgs.gov/hazards>). Based on the seismic survey data, the anticipated site specific peak ground acceleration (PGA) of 0.06g (acceleration at rock sites) for two (2) percent probability of exceedance in 50 years (40 CFR Part 257, Preamble page 21384). Correcting for acceleration at soft soil sites (Seismic Site Classification D) yields an estimated PGA of 0.13g. The seismic coefficient (k) used for pseudo static analysis is determined by reducing the estimated PGA by 50% yielding a seismic coefficient of 0.065g.

## 2.2 Liquefaction Assessment

Liquefaction of soils occurs when horizontal shearing stresses exceed the strength of existing loose, saturated sand. This sudden loss of shear strength and subsequent soil structure is typically associated with earthquake-induced horizontal movement. Recent engineering publications<sup>1</sup> provide criteria to assess liquefaction potential of sands (little to no fines) and clayey soils of low plasticity (e.g. clayey sands, silts). These criteria indicate that water content of fine-grained or cohesive soils needs to be high ( $\geq 0.85 \times \text{Liquid Limit [LL]}$ ), a clay fine content (defined as grains smaller than 0.002 mm) of less than 10 percent ( $< 10\%$ ), and relatively low soil density (assessed in terms of SPT blow counts). In addition, the accepted minimum seismic threshold acceleration to cause liquefaction in loose sands is 0.10g, the anticipated site specific PGA for this site is 0.06g.

Native fine grained (or cohesive) material underlying the West Ash Pond generally consist of medium dense to very dense clayey sand (SC), clayey gravel (GC) and silty clayey sand (SC-SM) Based on these soil characteristics and that the West Ash Pond is located in a zone of low peak ground acceleration (PGA), the risk of either embankment or underlying soils liquefying are negligible [40 CFR §257.73(e)(1)(iv)].

<sup>1</sup> Seed, R.B., et al, Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework, 26<sup>th</sup> Annual ASCE Los Angeles Spring Seminar, April 2003

## 2.3 Embankment and Foundation Stratigraphy

The models developed for this evaluation are based on the existing embankment geometry, results of field and laboratory testing and hydrologic site information provided by the client and recent field activities. Selection of critical slope sections (Section Nos. 1 and 2) was based on both height and subsurface sensitivity to loading. The following tables provide a summary of soil parameters used for these analyses. Specific soil parameters used for each model are presented in the Appendix.

<b>Summary of Long Term, Total Stress Soil Parameters, Section No. 1:</b>			
<b>Material Type</b>	<b>Unit Weight (pcf)</b>	<b>Consolidated-Undrained Cohesion (psf)</b>	<b>Consolidated-Undrained Angle of Internal Friction (degrees)</b>
Embankment Fill	125	450	12
Lean Clay/Fat Clay (CL/CH)	125	530	13
Silty Sand/Clayey Sand (SM/SC)	125	0	28
Ash	100	0	30
<b>NOTE:</b> Properties used for Steady State Seepage with Seismic analysis.			

<b>Summary of Long Term, Effective Stress Soil Parameters, Section No. 1</b>			
<b>Material Type</b>	<b>Unit Weight (pcf)</b>	<b>Consolidated-Drained Cohesion (psf)</b>	<b>Consolidated-Drained Angle of Internal Friction (degrees)</b>
Embankment Fill	125	590	16
Lean Clay/Fat Clay (CL/CH)	125	320	17
Silty Sand/Clayey Sand (SM/SC)	125	430	28
Ash	100	0	30
<b>NOTE:</b> Properties used for Steady State Seepage analysis. Consolidated-drained conditions determined based on pore pressure measurements made during Consolidated-Undrained (CU) triaxial testing.			

<b>Summary of Long Term, Total Stress Soil Parameters, Section No. 2</b>			
<b>Material Type</b>	<b>Unit Weight (pcf)</b>	<b>Consolidated-Undrained Cohesion (psf)</b>	<b>Consolidated-Undrained Angle of Internal Friction (degrees)</b>
Embankment Fill	125	450	12
Lean Clay/Fat Clay (CL/CH)	125	530	13
Clayey Sand/Silty Sand (SC/SM)	125	0	28
Lean Clay (CL)	125	260	20
Ash	100	0	30
<b>NOTE:</b> Properties used for Steady State Seepage with Seismic analysis.			

<b>Summary of Long Term, Effective Stress Soil Parameters, Section No. 2</b>			
<b>Material Type</b>	<b>Unit Weight (pcf)</b>	<b>Consolidated-Drained Cohesion (psf)</b>	<b>Consolidated-Drained Angle of Internal Friction (degrees)</b>
Embankment Fill	125	590	16
Lean Clay/Fat Clay (CL/CH)	125	320	17
Clayey Sand/Silty Sand (SC/SM)	125	0	28
Lean Clay (CL)	125	290	22
Ash	100	0	30
<b>NOTE:</b> Properties used for Steady State Seepage analysis. Consolidated-drained conditions determined based on pore pressure measurements made during Consolidated-Undrained (CU) triaxial testing.			

## 2.4 Seepage Analysis Parameters

The analysis of embankment seepage is based on laboratory results and estimated values for permeability for various embankment and native foundation soils. These soil parameters were utilized in the models to establish a long term steady state condition and corresponding phreatic surface in the embankment. Hydraulic conductivity test results are provided in the Appendix. Hydraulic conductivity properties utilized in the seepage analysis are provided in the below table.

<b>Hydraulic Conductivity of Embankment Soils, Section Nos. 1 and 2</b>	
<b>Material Type</b>	<b>Permeability (ft/sec)</b>
Embankment Fill	$1 \times 10^{-8}$
Lean Clay/Fat Clay (CL/CH)	$1 \times 10^{-8}$
Clayey Sand/Silty Sand (SC/SM)	$1 \times 10^{-5}$
Lean Clay (CL)	$1 \times 10^{-8}$
Ash	$1 \times 10^{-4}$

## 2.5 Stability Analysis Results

The following tables provides the results of the stability analysis for each of the conditions cited herein, as required by 40 CFR §257.73(e)(1)(i) through (iii). The graphical representations of each analysis are included in the Appendix.

<b>Summary of Stability Analyses – Safety Factors, Section No. 1</b>		
<b>Modeled Condition</b>	<b>Factor of Safety</b>	
	<b>Actual</b>	<b>Minimum</b>
Steady State Seepage – Maximum Pool	2.21	1.50
Steady State Seepage – Surcharge Pool	2.21	1.40
Steady State Seepage with Seismic – Maximum Pool	1.35	1.00

Summary of Stability Analyses – Safety Factors, Section No. 2		
Modeled Condition	Factor of Safety	
	Actual	Minimum
Steady State Seepage – Maximum Pool	1.83	1.50
Steady State Seepage – Surcharge Pool	1.83	1.40
Steady State Seepage with Seismic – Maximum Pool	1.50	1.00

Based on the findings of this analysis, the evaluated embankments appear to be stable under the modeled conditions and demonstrate the minimum safety factors, as required by 40 CFR §257.73(e)(1)(i) through (iii).

### 3.0 Report Limitations

This report has been prepared for the exclusive use of our client for the specific application to the project discussed and has been prepared in accordance with the generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. The analyses contained in the report are based on the data obtained from the referenced soil borings performed within the project site. This report does not reflect variations that may occur between borings or across the site. Soil borings do not necessarily reflect strata variations that may exist at other locations within the project site.



#### 4.0 Initial Structural Stability Assessment Certification

By means of this certification, (i) I have reviewed the requirements of 40 CFR §257.73(e)(1) – *Periodic Safety Factor Assessments*, (ii) I or my agent has visited and examined the facility, (iii) the referenced data used in this evaluation to the best of my knowledge appears correct and appropriate for use, (iv) and this Initial Safety Factor Assessment for the West Ash Pond (Pirkey Power Station) has been prepared to the best of my knowledge in accordance with §257.73(e)(1).

By:  \_\_\_\_\_

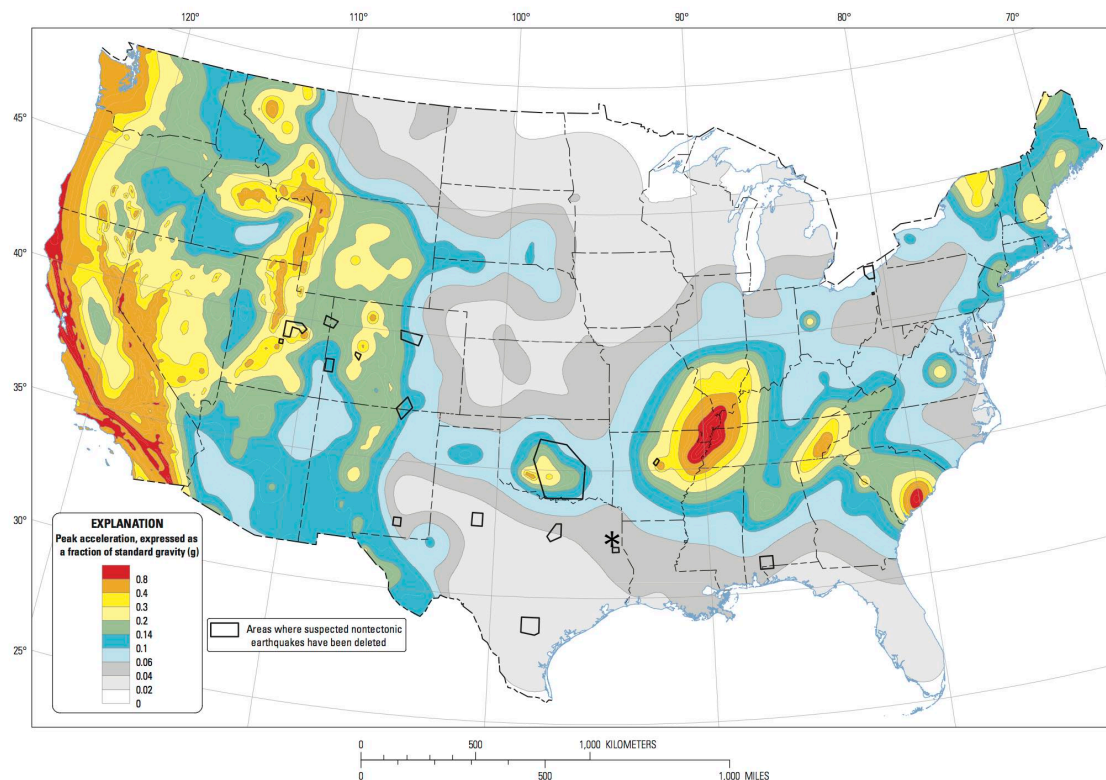
Dated: January 14, 2016



TBPE Firm Registration No. F-16721  
Expires 2/29/2016

## **Appendix**

**Stability Analyses  
Reference Data**



**Two-percent probability of exceedance in 50 years map of peak ground acceleration**

\* Approximate location of Pirkey Power Generating Station

Provided by USGS National Seismic Hazard Mapping Project.

### Seismic Probability Map

Scale: N/A

Auckland Project No. 2015-008C

**Pirkey Power Generating Station  
Initial Safety Factor Assessment - West Ash Pond  
Hallsville, Texas**



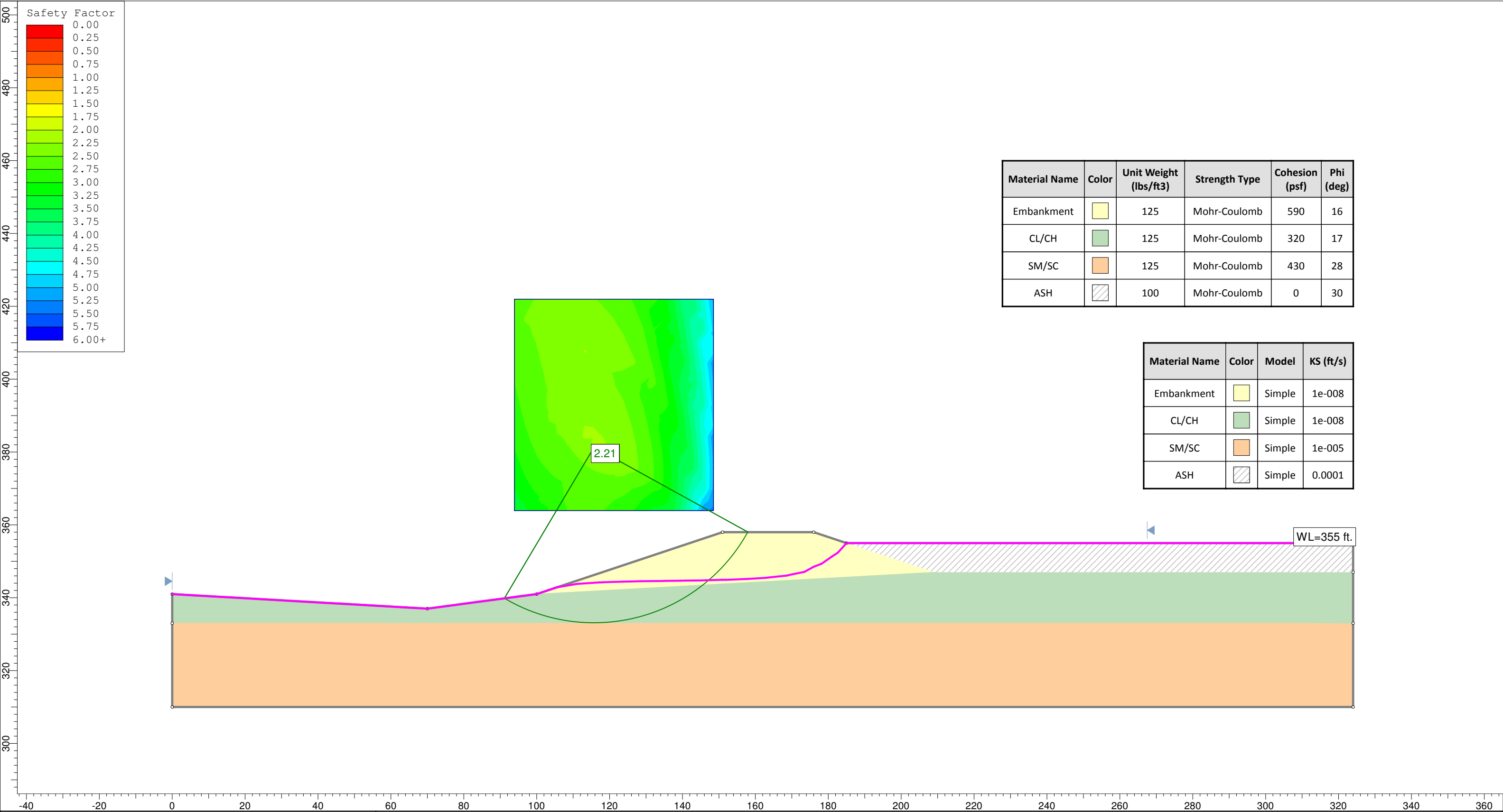
Provided by Google Earth.

### Cone Penetrometer Test (CPT) Location Map

Scale: N/A

Auckland Project No. 2015-008C

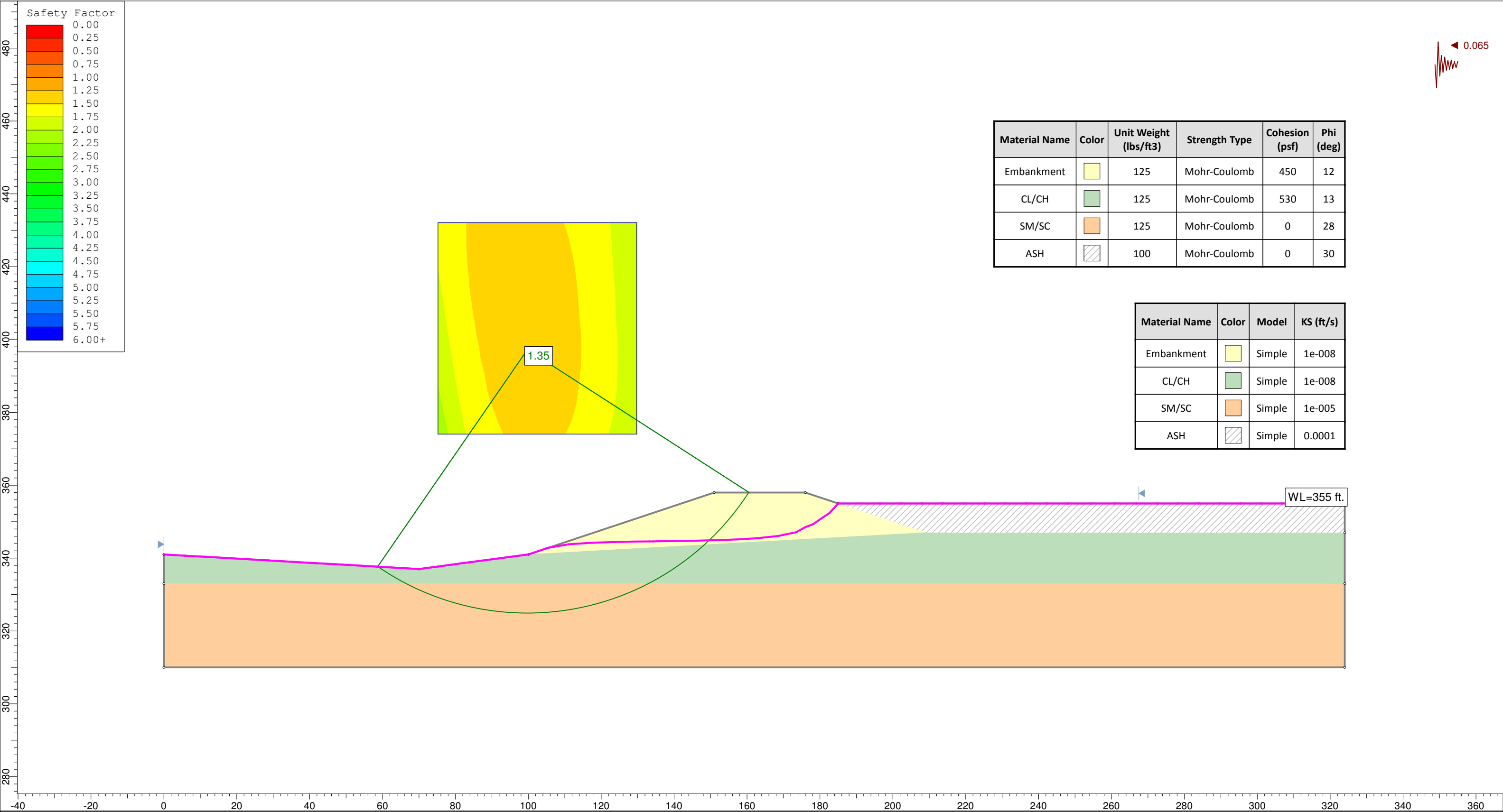
**Pirkey Power Generating Station  
Initial Safety Factor Assessment - West Ash Pond  
Hallsville, Texas**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment	<div></div>	125	Mohr-Coulomb	590	16
CL/CH	<div></div>	125	Mohr-Coulomb	320	17
SM/SC	<div></div>	125	Mohr-Coulomb	430	28
ASH	<div></div>	100	Mohr-Coulomb	0	30

Material Name	Color	Model	KS (ft/s)
Embankment	<div></div>	Simple	1e-008
CL/CH	<div></div>	Simple	1e-008
SM/SC	<div></div>	Simple	1e-005
ASH	<div></div>	Simple	0.0001

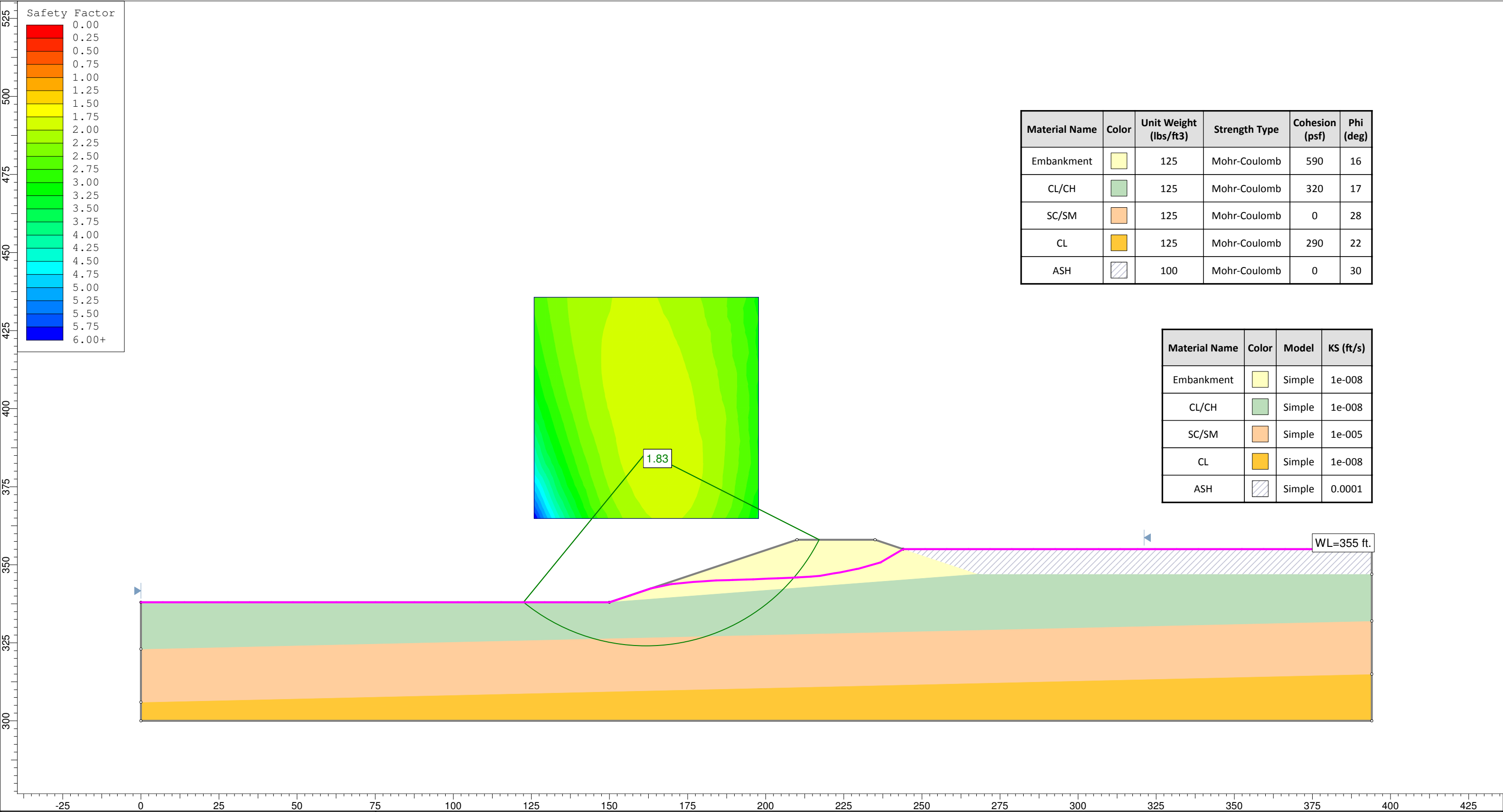
<div><div>Auckland Consulting LLC</div><div>PO Box 8155</div><div>Jacksonville, Texas 75766</div></div>	Project		Pirkey Power Station - West Ash Pond, Section No. 1	
	Analysis Description		Steady State Seepage at Maximum and Surcharge Pool	
	Drawn By		JJT	Company
	Date		12/15/2015	File Name
SLIDEINTERPRET 6.036		WEST ASH_Section 1_SSS_25yr.slim		



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment	<div></div>	125	Mohr-Coulomb	450	12
CL/CH	<div></div>	125	Mohr-Coulomb	530	13
SM/SC	<div></div>	125	Mohr-Coulomb	0	28
ASH	<div></div>	100	Mohr-Coulomb	0	30

Material Name	Color	Model	KS (ft/s)
Embankment	<div></div>	Simple	1e-008
CL/CH	<div></div>	Simple	1e-008
SM/SC	<div></div>	Simple	1e-005
ASH	<div></div>	Simple	0.0001

<div><div>Auckland Consulting LLC</div><div>PO Box 8155</div><div>Jacksonville, Texas 75766</div></div>	Project	Pirkey Power Station - West Ash Pond, Section No. 1	
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	Drawn By	JJT	Company
	Date	12/23/2015	File Name
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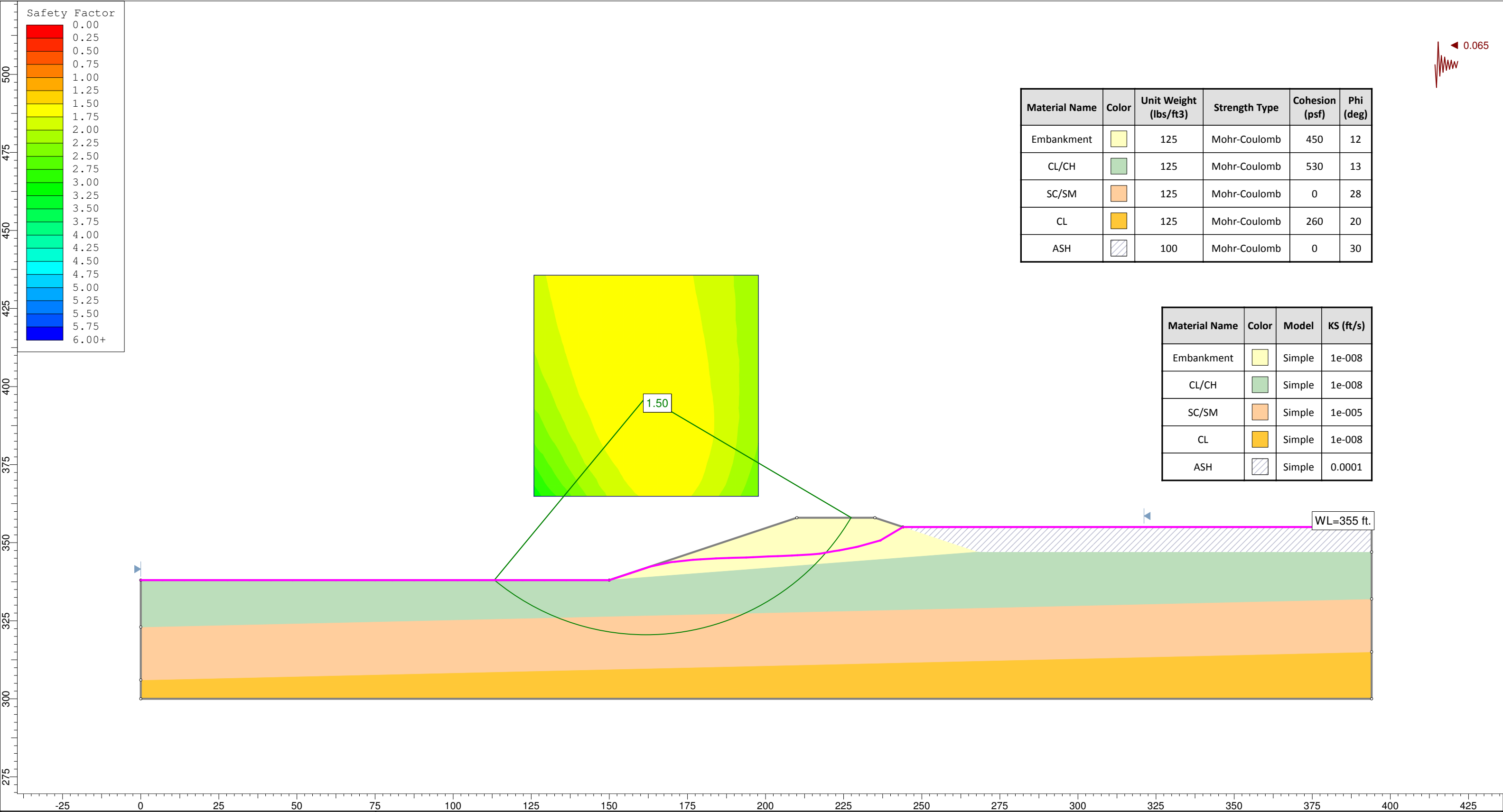


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment	<div></div>	125	Mohr-Coulomb	590	16
CL/CH	<div></div>	125	Mohr-Coulomb	320	17
SC/SM	<div></div>	125	Mohr-Coulomb	0	28
CL	<div></div>	125	Mohr-Coulomb	290	22
ASH	<div></div>	100	Mohr-Coulomb	0	30

Material Name	Color	Model	KS (ft/s)
Embankment	<div></div>	Simple	1e-008
CL/CH	<div></div>	Simple	1e-008
SC/SM	<div></div>	Simple	1e-005
CL	<div></div>	Simple	1e-008
ASH	<div></div>	Simple	0.0001

<div><div>Auckland Consulting LLC</div><div>PO Box 8155</div><div>Jacksonville, Texas 75766</div></div>	Project	Pirkey Power Station - West Ash Pond, Section No. 2	
	Analysis Description	Steady State Seepage at Maximum and Surge Pool	
	Drawn By	JJT	Company
	Date	12/15/2015	File Name

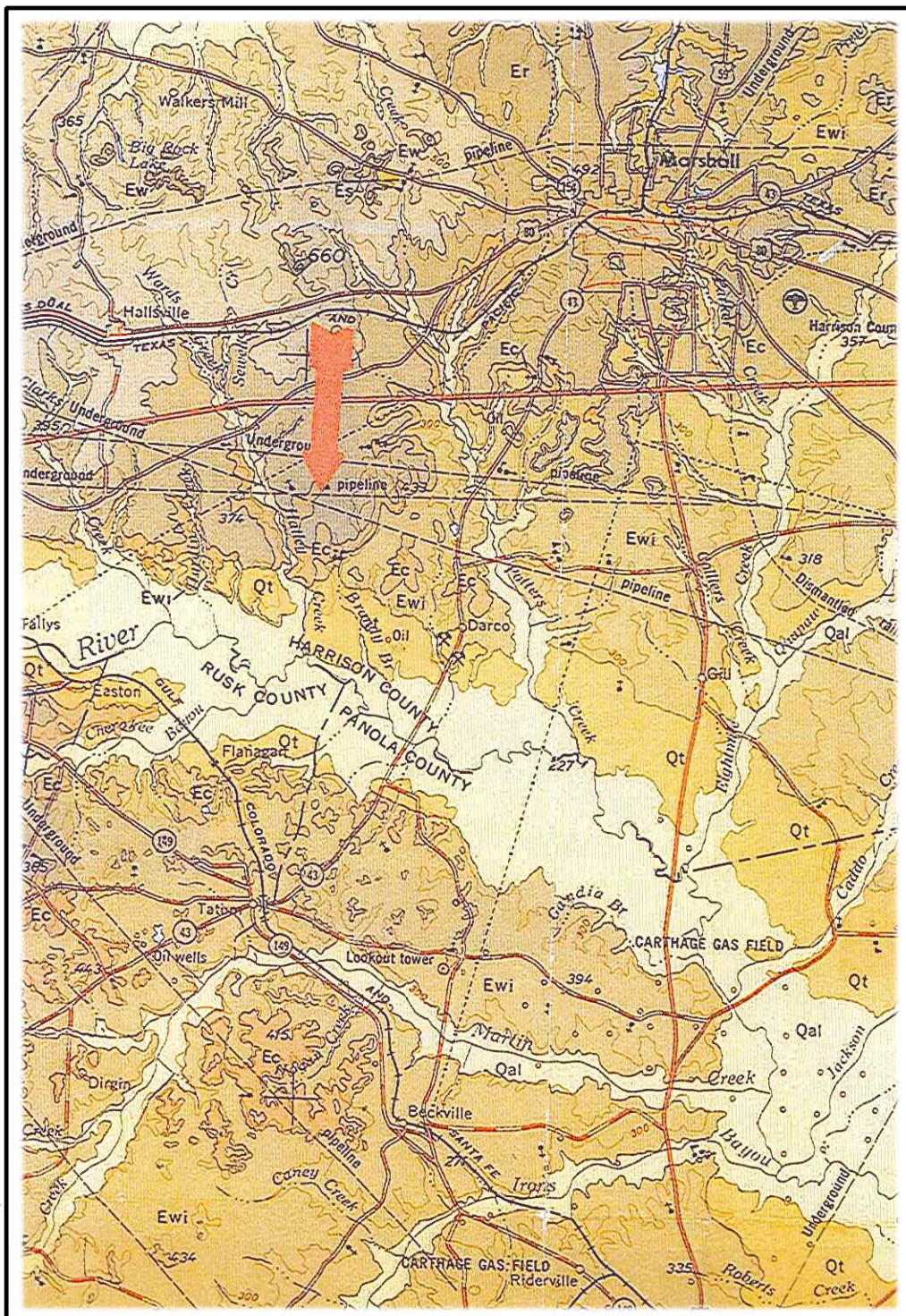




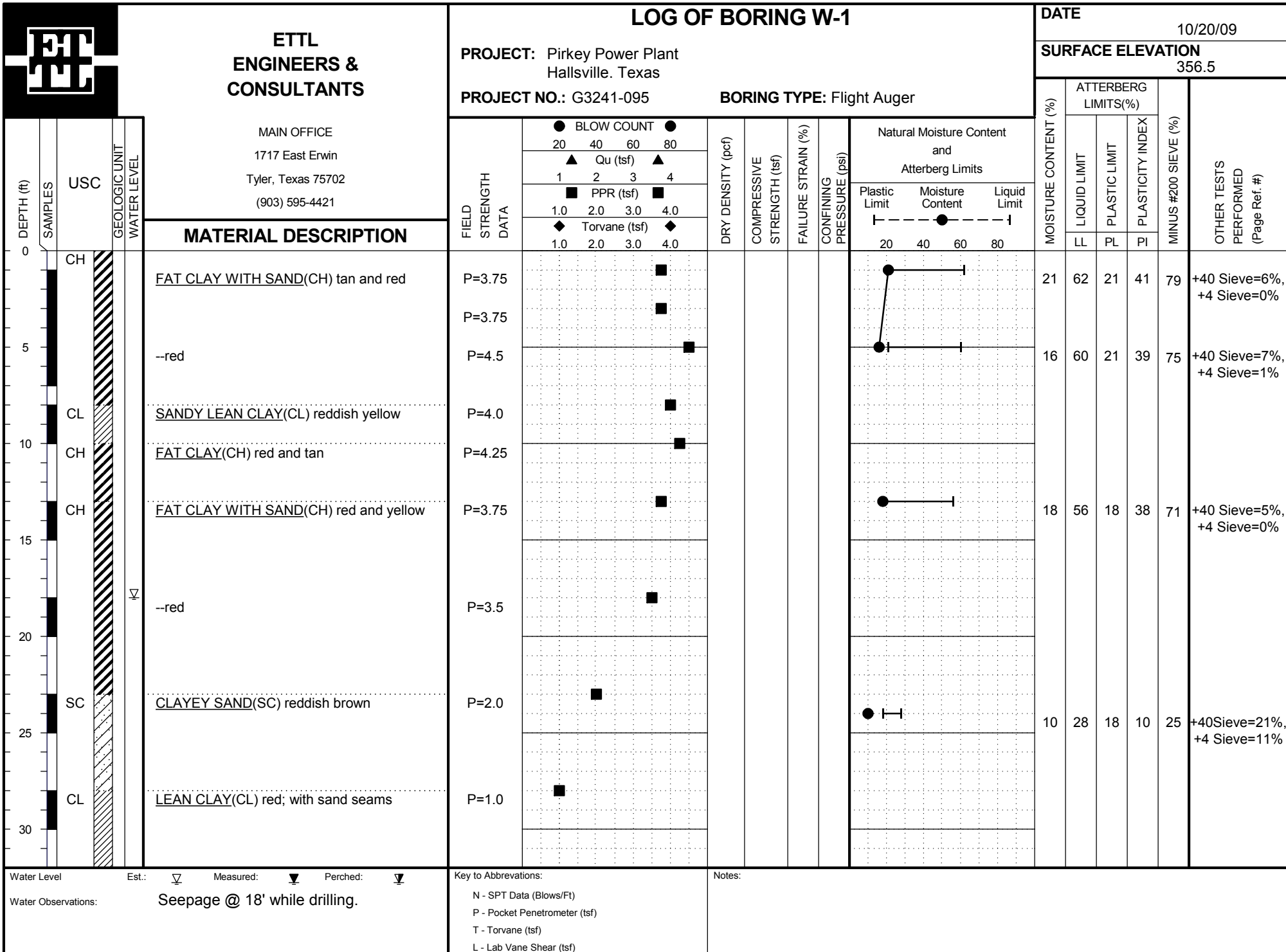
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment	<div></div>	125	Mohr-Coulomb	450	12
CL/CH	<div></div>	125	Mohr-Coulomb	530	13
SC/SM	<div></div>	125	Mohr-Coulomb	0	28
CL	<div></div>	125	Mohr-Coulomb	260	20
ASH	<div></div>	100	Mohr-Coulomb	0	30

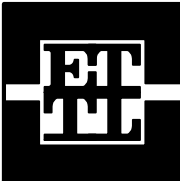
Material Name	Color	Model	KS (ft/s)
Embankment	<div></div>	Simple	1e-008
CL/CH	<div></div>	Simple	1e-008
SC/SM	<div></div>	Simple	1e-005
CL	<div></div>	Simple	1e-008
ASH	<div></div>	Simple	0.0001











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**MATERIAL DESCRIPTION**

CLAYEY SAND(SC) grayish brown

--tannish gray

--gray

SILTY CLAYEY SAND(SM-SC) gray

Bottom of Boring @ 50'

**LOG OF BORING W-1**

**PROJECT:** Pirkey Power Plant  
Hallsville. Texas

**PROJECT NO.:** G3241-095

**BORING TYPE:** Flight Auger

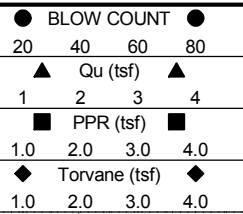
**DATE**

10/20/09

**SURFACE ELEVATION**

356.5

FIELD  
STRENGTH  
DATA



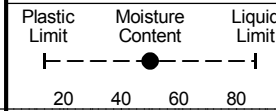
DRY DENSITY (pcf)

COMPRESSIVE  
STRENGTH (tsf)

FAILURE STRAIN (%)

CONFINING  
PRESSURE (psi)

Natural Moisture Content  
and  
Atterberg Limits



MOISTURE CONTENT (%)

ATTERBERG  
LIMITS(%)

LIQUID LIMIT

PLASTIC LIMIT

PLASTICITY INDEX

MINUS #200 SIEVE (%)

OTHER TESTS  
PERFORMED  
(Page Ref. #)

17

29

19

10

25

+40 Sieve=1%,  
+4 Sieve=0%

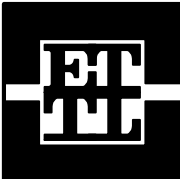
Water Level Est.: Measured: Perched:

Water Observations: Seepage @ 18' while drilling.

Key to Abbreviations:

N - SPT Data (Blows/Ft)  
P - Pocket Penetrometer (tsf)  
T - Torvane (tsf)  
L - Lab Vane Shear (tsf)

Notes:



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**MATERIAL DESCRIPTION**

SANDY LEAN CLAY(CL) stiff; red and gray

--hard

--gray, red, and tan

CLAYEY SAND(SC) very dense; red and tan

--medium dense; tan and gray

--very dense; gray and tan

--green

Bottom of Boring @ 30'

**LOG OF BORING W-2**

**PROJECT:** Pirkey Power Plant  
Hallsville. Texas

**PROJECT NO.:** G3241-095

**BORING TYPE:** Flight Auger

**DATE**

10/21/09

**SURFACE ELEVATION**

341.7

FIELD STRENGTH DATA	● BLOW COUNT ● 20 40 60 80				DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	Natural Moisture Content and Atterberg Limits			MOISTURE CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
	▲ Qu (tsf) ▲ 1 2 3 4																
	■ PPR (tsf) ■ 1.0 2.0 3.0 4.0																
	◆ Torvane (tsf) ◆ 1.0 2.0 3.0 4.0																
	Plastic Limit      Moisture Content      Liquid Limit ┌───┴───┬───┴───┬───┴───┐ 20      40      60      80																
N=9	●								●	┌───┴───┬───┴───┬───┴───┐ 20      40      60      80	17	48	19	29	65	+40 Sieve=6%, +4 Sieve=2%	
P=4.5+				■					●	┌───┴───┬───┴───┬───┴───┐ 20      40      60      80							
N=50																	
N=50/5"									●	┌───┴───┬───┴───┬───┴───┐ 20      40      60      80	16	28	18	10	27	+40 Sieve=7%, +4 Sieve=2%	
P=1.5			■						●	┌───┴───┬───┴───┬───┴───┐ 20      40      60      80							
N=62																	
N=50/5"									●	┌───┴───┬───┴───┬───┴───┐ 20      40      60      80	22	28	19	9	33	+40 Sieve=6%, +4 Sieve=2%	
N=56																	

Water Level Est.: Measured: Perched:   
Water Observations: Seepage @ 13' while drilling. Water level @ 21' and open upon completion.

Key to Abbreviations:  
N - SPT Data (Blows/Ft)  
P - Pocket Penetrometer (tsf)  
T - Torvane (tsf)  
L - Lab Vane Shear (tsf)

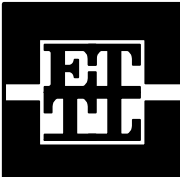
Notes:

+40 Sieve=6%,  
+4 Sieve=2%

+40 Sieve=7%,  
+4 Sieve=2%

+40 Sieve=13%,  
+4 Sieve=5%

+40 Sieve=6%,  
+4 Sieve=2%



**ETTL  
ENGINEERS &  
CONSULTANTS**

MAIN OFFICE  
1717 East Erwin  
Tyler, Texas 75702  
(903) 595-4421

**MATERIAL DESCRIPTION**

SANDY LEAN CLAY(CL) stiff; white and tan

SANDY FAT CLAY(CH) very stiff; red, tan,  
and white  
--white, tan, and red

SANDY LEAN CLAY(CL) very stiff; red and  
yellow  
--hard; red and yellow

FAT CLAY WITH SAND(CH) very stiff; red  
and yellow

--hard

--stiff

SILTY SAND(SM) very dense; yellow and red

**LOG OF BORING W-3**

**PROJECT:** Pirkey Power Plant  
Hallsville. Texas

**PROJECT NO.:** G3241-095

**BORING TYPE:** Flight Auger

**DATE**

10/20/09

**SURFACE ELEVATION**

356.3

FIELD STRENGTH DATA	● BLOW COUNT ●				DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	Natural Moisture Content and Atterberg Limits			MOISTURE CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
	20 40 60 80								Plastic Limit	Moisture Content	Liquid Limit						
	▲ Qu (tsf) ▲																
	1 2 3 4																
	■ PPR (tsf) ■																
1.0 2.0 3.0 4.0																	
◆ Torvane (tsf) ◆																	
1.0 2.0 3.0 4.0																	
P=1.75												18	46	17	29	61	+40 Sieve=7%, +4 Sieve=2%
P=3.25																	
P=3.5												17	55	18	37	68	
P=2.25																	+40 Sieve=6%, +4 Sieve=0%
P=4.0																	
P=2.5												24	68	22	46	80	
P=4.5+																	+40 Sieve=4%, +4 Sieve=0%
P=2.0												24	52	18	34	69	
N=88																	

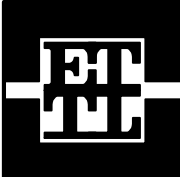
Water Level Est.: ☐ Measured: ☒ Perched: ☐

Water Observations: Seepage @ 34' while drilling.

Key to Abbreviations:

N - SPT Data (Blows/Ft)  
P - Pocket Penetrometer (tsf)  
T - Torvane (tsf)  
L - Lab Vane Shear (tsf)

Notes:



**ETTL  
ENGINEERS &  
CONSULTANTS**

MAIN OFFICE  
1717 East Erwin  
Tyler, Texas 75702  
(903) 595-4421

**MATERIAL DESCRIPTION**

SANDY LEAN CLAY(CL) very stiff; gray; with  
iron oxide cemented sandstone gravel

CLAYEY SAND(SC) very dense; dark gray

SILTY CLAYEY SAND(SM-SC) very dense;  
gray; saturated

CLAYEY SAND(SC) very dense; dark gray

Bottom of Boring @ 50'

**LOG OF BORING W-3**

**PROJECT:** Pirkey Power Plant  
Hallsville. Texas

**PROJECT NO.:** G3241-095

**BORING TYPE:** Flight Auger

**DATE**

10/20/09

**SURFACE ELEVATION**  
356.3

FIELD STRENGTH DATA	● BLOW COUNT ● 20 40 60 80				DRY DENSITY (pcf)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	Natural Moisture Content and Atterberg Limits			MOISTURE CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	MINUS #200 SIEVE (%)	OTHER TESTS PERFORMED (Page Ref. #)
	▲ Qu (tsf) ▲ 1 2 3 4								Plastic Limit	Moisture Content	Liquid Limit						
	■ PPR (tsf) ■ 1.0 2.0 3.0 4.0																
	◆ Torvane (tsf) ◆ 1.0 2.0 3.0 4.0																
	1.0 2.0 3.0 4.0																
P=3.25				■													
			■														
P=4.5+										●	├──┤						
N=59				●													
N=50/4"																	

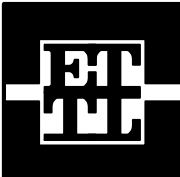
Water Level      Est.: ▽      Measured: ▼      Perched: ▼

Water Observations:      Seepage @ 34' while drilling.

Key to Abbreviations:

N - SPT Data (Blows/Ft)  
P - Pocket Penetrometer (tsf)  
T - Torvane (tsf)  
L - Lab Vane Shear (tsf)

Notes:



**ETTL  
ENGINEERS &  
CONSULTANTS**

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Tyler, Texas 75702  
(903) 595-4421

**MATERIAL DESCRIPTION**

CLAYEY SAND(SC) stiff, brown, red, and yellow

--with gravel

--red and tan; with iron oxide cemented sandstone

--dense; red and white; with clay seams

--medium dense; orangish gray; with gravel

CLAYEY GRAVEL(GC) dense; dark gray

SILTY SAND(SM) dense; dark gray

SANDY LEAN CLAY(CL) very dense; gray

Bottom of Boring @ 30'

**LOG OF BORING W-4**

**PROJECT:** Pirkey Power Plant  
Hallsville, Texas

**PROJECT NO.:** G3241-095

**BORING TYPE:** Flight Auger

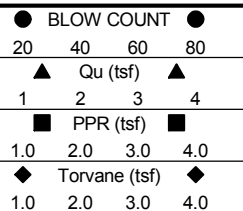
**DATE**

10/20/09

**SURFACE ELEVATION**

338.0

FIELD  
STRENGTH  
DATA

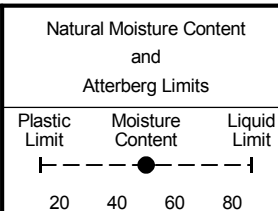


DRY DENSITY (pcf)

COMPRESSIVE  
STRENGTH (tsf)

FAILURE STRAIN (%)

CONFINING  
PRESSURE (psi)



MOISTURE CONTENT (%)

ATTERBERG  
LIMITS(%)

LIQUID LIMIT

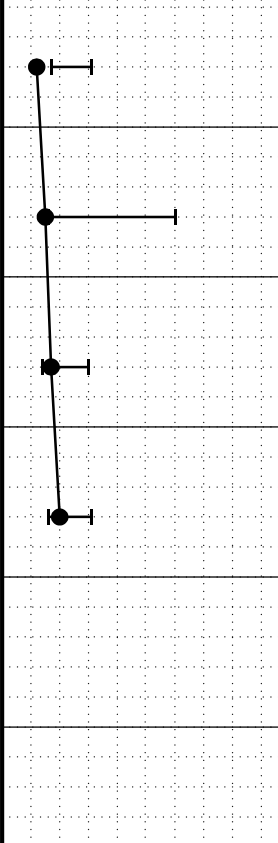
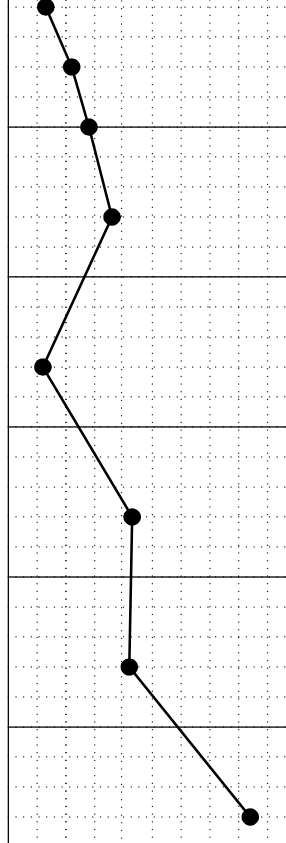
PLASTIC LIMIT

PLASTICITY INDEX

MINUS #200 SIEVE (%)

OTHER TESTS  
PERFORMED  
(Page Ref. #)

N=13  
N=22  
N=28  
N=36  
N=12  
N=43  
N=42  
N=84



12  
15  
17  
20

31  
60  
30  
31

17  
16  
14  
16

14  
44  
16  
15

35  
39  
22  
7

+40Sieve=31%,  
+4 Sieve=16%  
+40Sieve=11%,  
+4 Sieve=4%  
+40Sieve=28%,  
+4 Sieve=17%  
+40Sieve=68%,  
+4 Sieve=52%

Water Level Est.: Measured: Perched:

Water Observations: Seepage @ 19' while drilling.

Key to Abbreviations:

N - SPT Data (Blows/Ft)  
P - Pocket Penetrometer (tsf)  
T - Torvane (tsf)  
L - Lab Vane Shear (tsf)

Notes:









# ETTL Engineers & Consultants Inc.

GEOTECHNICAL \* MATERIALS \* ENVIRONMENTAL \* DRILLING \* LANDFILLS

## HYDRAULIC CONDUCTIVITY DETERMINATION FLEXIBLE WALL PERMEAMETER - CONSTANT VOLUME (Mercury Permometer Test)

Project :	Pirkey Power Plants Embankments, Hallsville, Texas							
Date:	11/3/2009	Panel Number :	P 2 ; ASTM D 5084					
Project No. :	G 3241-09	Permometer Data						
Boring No.:	W - 2	ap =	0.031416 cm2	Set Mercury to Dinat Dnat	Equilibrium	1.8	cm3	
Sample:		aa =	0.767120 cm2		Pipet Rp	6.7	cm3	
Depth (ft):	13' to 16'	M1 =	0.030180	C =	0.00043252	Annulus Ra	1.5	cm3
Other Location:		M2 =	1.040953	T =	0.203782344			
Material Description :	Tan & Gray Clayey Sand							

### SAMPLE DATA

Wet Wt. sample + ring or tare :	571.51 g			Before Test		After Test	
Tare or ring Wt. :	0.0 g			Tare No.:	T 13	Tare No.:	T 16
Wet Wt. of Sample :	571.51 g			Wet Wt.+tare:	660.71	Wet Wt.+tare:	733.72
Diameter :	2.78 in	7.06 cm2		Dry Wt.+tare:	588.03	Dry Wt.+tare:	625.10
Length :	2.78 in	7.06 cm		Tare Wt:	219.71	Tare Wt:	151.95
Area:	6.06 in^2	39.10 cm2		Dry Wt.:	368.32	Dry Wt.:	473.15
Volume :	16.85 in^3	276.12 cm3		Water Wt.:	72.68	Water Wt.:	108.62
Unit Wt.(wet):	129.15 pcf	2.07 g/cm^3		% moist.:	19.7	% moist.:	23.0
Unit Wt.(dry):	107.87 pcf	1.73 g/cm^3					
Specific Gravity:	2.80	Max Dry Density(pcf) =	107.9147	OMC =	19.732841		
		% of max =	100.0	+/- OMC =	0.00		
Calculated % saturation:	103.59	Void ratio (e) =	0.62	Porosity (n)=	0.38		

### TEST READINGS

Z1(Mercury Height Difference @ t1):		5.1		cm		Hydraulic Gradient =		9.12	
Date	elapsed t	Z	$\Delta Z\pi$	temp	$\alpha$	k	k		
	(seconds)	(pipet @ t)	(cm )	(deg C)	(temp corr)	(cm/sec)	(ft./day)	Reset = *	
11/3/2009	76	4.5	2.1571965	24.5	0.899	2.96E-06	8.40E-03		
11/3/2009	106	4	2.6571965	24.5	0.899	2.86E-06	8.11E-03		
11/3/2009	140	3.5	3.1571965	24.5	0.899	2.87E-06	8.12E-03		
11/3/2009	182	3	3.6571965	24.5	0.899	2.92E-06	8.29E-03		

### SUMMARY

ka =	2.90E-06 cm/sec	Acceptance criteria =	25 %		
ki		Vm			
k1 =	2.96E-06 cm/sec	2.1 %		Vm =	$\frac{ ka-ki }{ka} \times 100$
k2 =	2.86E-06 cm/sec	1.4 %			
k3 =	2.87E-06 cm/sec	1.3 %			
k4 =	2.92E-06 cm/sec	0.7 %			

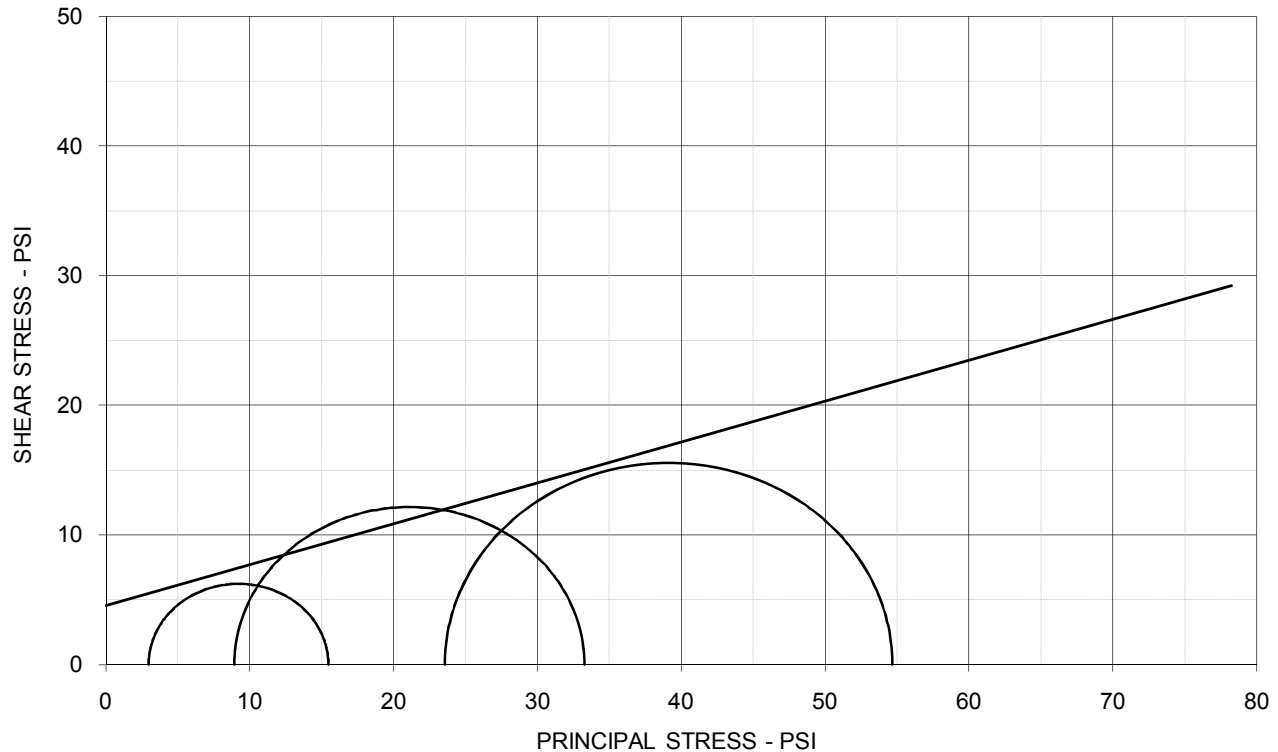
Hydraulic conductivity	k =	2.90E-06 cm/sec	8.23E-03 ft/day
Void Ratio	e =	0.62	
Porosity	n =	0.38	
Bulk Density	$\gamma$ =	2.07 g/cm3	129.2 pcf
Water Content	W =	0.34 cm3/cm3	( at 20 deg C)
Intrinsic Permeability	kint =	2.97E-11 cm2	( at 20 deg C)

Liquid Limit LL	
Plastic Limit PL	
Plasticity Index PI	
- 200 Sieve	%
+ No 40 Sieve	%
+ No 4 Sieve	%

Respectfully Submitted

Robert M. Duke, P.E.

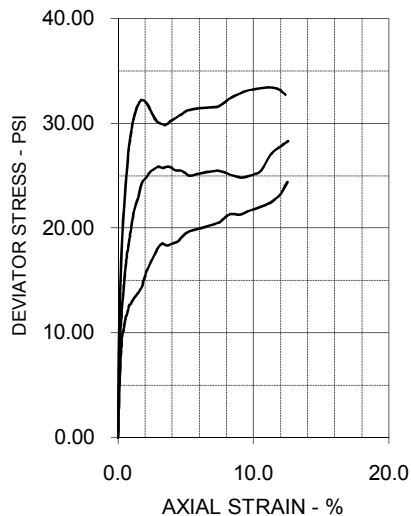
## TRIAXIAL SHEAR TEST REPORT



### EFFECTIVE STRESS PARAMETERS

$\phi' = 17.5 \text{ deg}$

$c' = 4.6 \text{ psi}$



#### SPECIMEN NO.

1

2

3

4

#### INITIAL

Moisture Content - %

25.3

23.6

23.9

Dry Density - pcf

96.5

100.5

101.1

Diameter - inches

2.05

2.02

2.04

Height - inches

3.98

4.00

3.95

#### AT TEST

Final Moisture - %

28.8

28.1

24.5

Dry Density - pcf

96.5

102.9

104.0

Calculated Diameter (in.)

2.07

2.01

2.03

Height - inches

4.02

3.98

3.91

Effect. Cell Pressure - psi

10.0

20.0

40.0

Failure Stress - psi

12.49

24.34

31.06

Total Pore Pressure - psi

57.0

61.1

66.4

Strain Rate - inches/min.

0.00050

0.00050

0.00050

Failure Strain - %

1.0

2.1

1.5

$\sigma_1'$  Failure - psi

15.49

33.26

54.65

$\sigma_3'$  Failure - psi

3.00

8.92

23.59

### TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP  
 SAMPLE TYPE: Shelby Tube Sample  
 DESCRIPTION: Red, Tan & Gray Fat Clay w/ Sand  
 Sampled on Site, W-1 13' to 20' deep  
 ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve 5%  
 LL: 56 PL: 18 PI: 38 Percent -200: 71%  
 REMARKS: Both Ends and Diameter Trimmed + #4 Sieve 0%  
 G 3241 095, W 1 13' 20'.xls

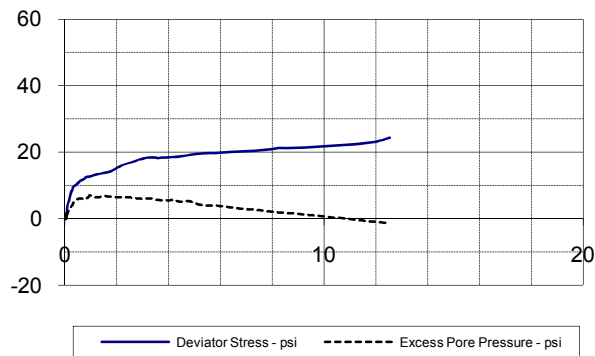
### PROJECT INFORMATION

PROJECT: Pirkey Power Plant Embankments  
 LOCATION: Hallsville, Texas  
 PROJECT NO: G 3241 - 095  
 CLIENT:  
 November 2009

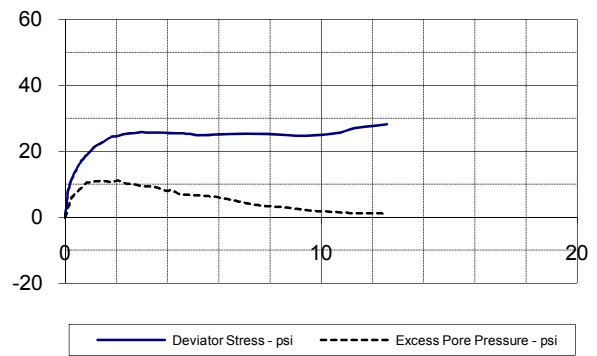
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PLATE: B.1

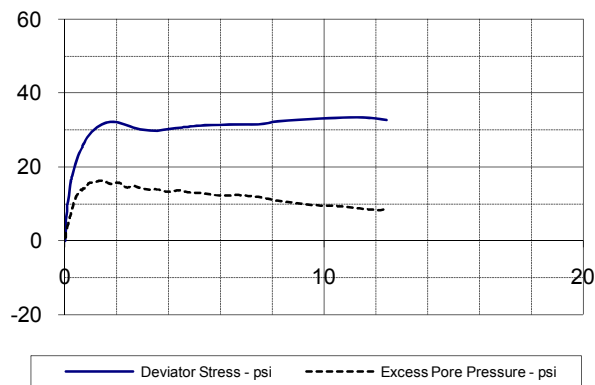
SPECIMEN NO. 1



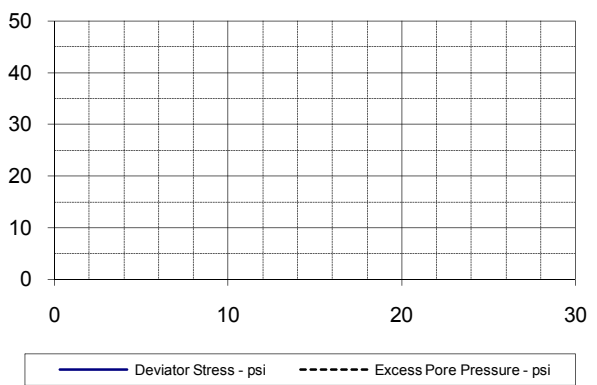
SPECIMEN NO. 2



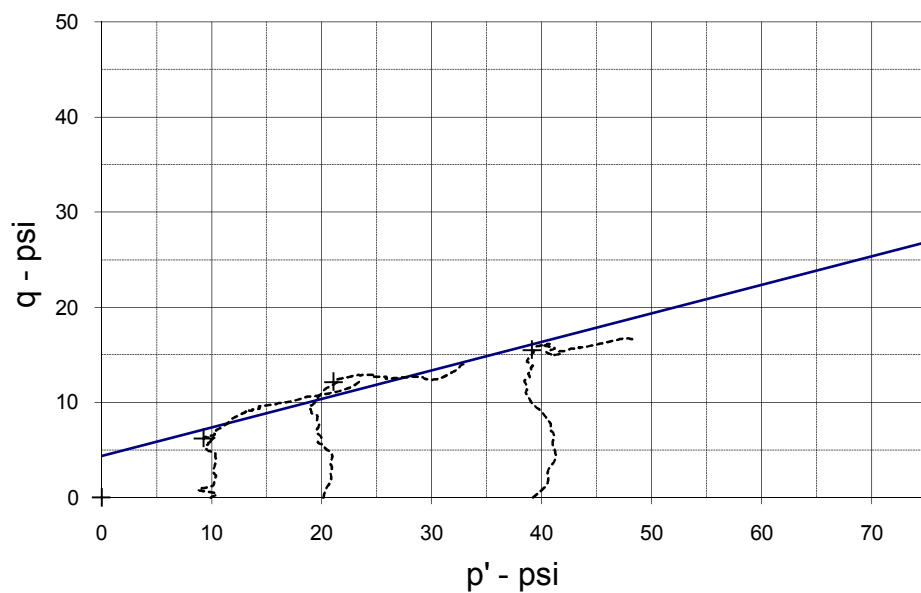
SPECIMEN NO. 3



SPECIMEN NO. 4



p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS

 $R^2 = 0.93$  $\alpha \text{ (deg)} = 16.7$  $a \text{ (psi)} = 4.4$ 

PROJECT: Pirkey Power Plant Embankments

TYPE OF TEST &amp; NO: CU with PP

PROJECT NO: G 3241 - 095

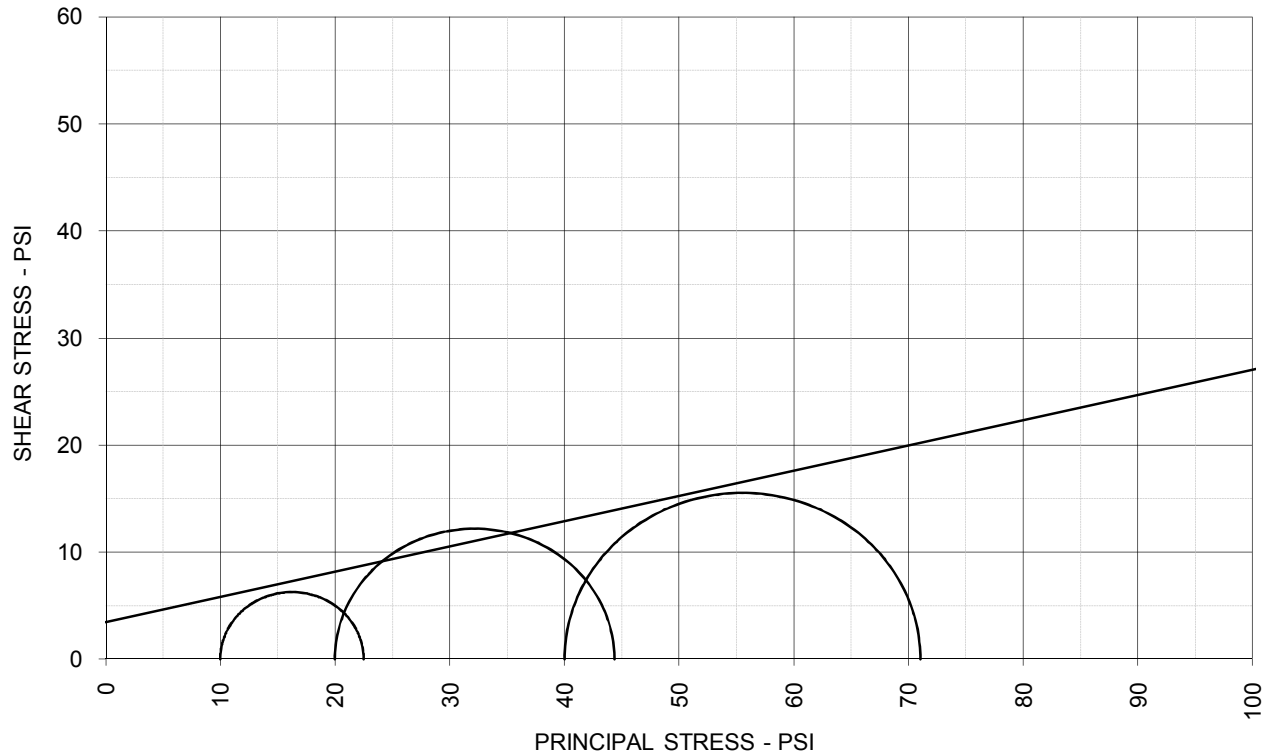
DESCRIPTION: Red, Tan &amp; Gray Fat Clay w/ Sand

ETTL ENGINEERS &amp; CONSULTANTS

PLATE: B.2

G 3241-095, W-1 13'-20'.xls

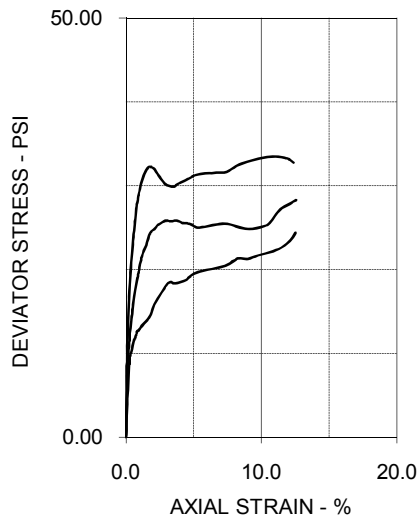
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 13.3$  deg

$c = 3.5$  psi



## SPECIMEN NO.

1

2

3

4

## INITIAL

Moisture Content - %	25.3	23.6	23.9
Dry Density - pcf	96.5	100.5	101.1
Diameter - inches	2.05	2.02	2.04
Height - inches	3.98	4.00	3.95

## AT TEST

Final Moisture - %	28.8	28.1	24.5
Dry Density - pcf	96.5	102.9	104.0
Calculated Diameter (in.)	2.07	2.01	2.03
Height - inches	4.02	3.98	3.91
Effect. Cell Pressure - psi	10.0	20.0	40.0
Failure Stress - psi	12.49	24.34	31.06
Total Pore Pressure - psi	57.0	61.1	66.4
Strain Rate - inches/min.	0.00050	0.00050	0.00050
Failure Strain - %	1.0	2.1	1.5
$\sigma_1$ Failure - psi	22.49	44.34	71.06
$\sigma_3$ Failure - psi	10.00	20.00	40.00

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP  
 SAMPLE TYPE: Shelby Tube Sample  
 DESCRIPTION: Red, Tan & Gray Fat Clay w/ Sand  
 Sampled on Site, W-1 13' to 20' deep  
 ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve 5%  
 LL: 56 PL: 18 PI: 38 Percent -200: 71%  
 REMARKS: Both Ends and Diameter Trimmed + # 4 Sieve 0%

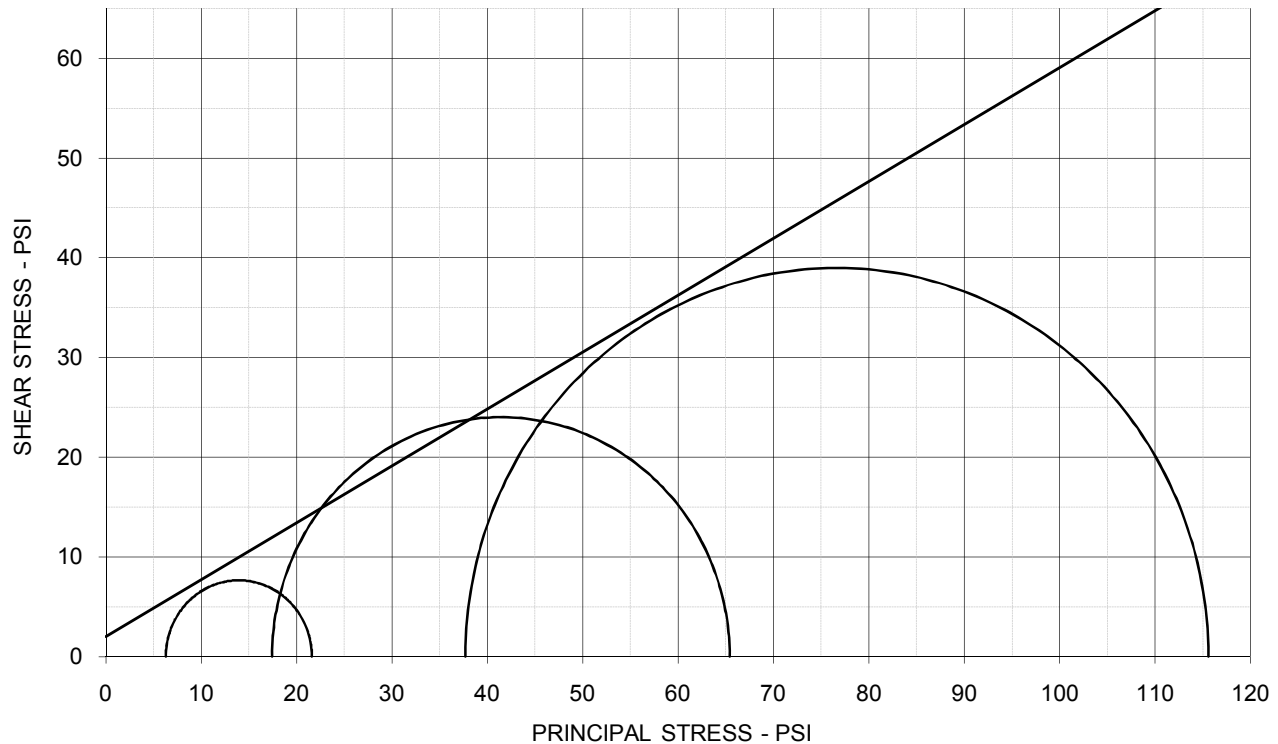
## PROJECT INFORMATION

PROJECT: Pirkey Power Plant Embankments  
 LOCATION: Hallsville, Texas  
 PROJECT NO: G 3241 - 095  
 CLIENT:  
 November 2009

ETTL ENGINEERS & CONSULTANTS

PLATE: B.3

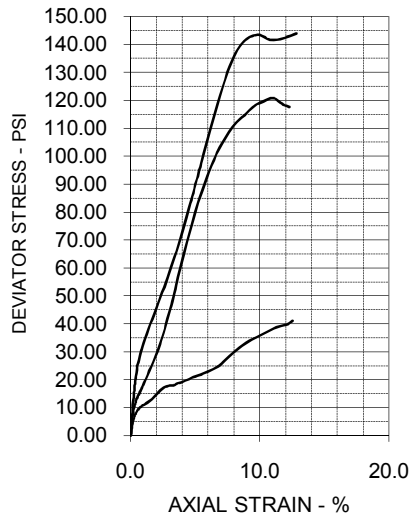
## TRIAxIAL SHEAR TEST REPORT



### EFFECTIVE STRESS PARAMETERS

$\phi' = 29.7 \text{ deg}$

$c' = 2.0 \text{ psi}$



#### SPECIMEN NO.

1

2

3

4

#### INITIAL

Moisture Content - %

18.7

19.2

18.5

Dry Density - pcf

108.5

105.5

104.8

Diameter - inches

2.04

2.04

2.02

Height - inches

4.25

4.18

4.37

#### AT TEST

Final Moisture - %

21.3

21.7

20.7

Dry Density - pcf

108.9

106.7

106.7

Calculated Diameter (in.)

2.03

2.02

2.00

Height - inches

4.21

4.13

4.31

Effect. Cell Pressure - psi

10.0

20.0

40.0

Failure Stress - psi

15.27

47.96

77.89

Total Pore Pressure - psi

63.7

52.6

52.3

Strain Rate - inches/min.

0.00050

0.00050

0.00050

Failure Strain - %

2.1

3.2

4.3

$\sigma_1'$  Failure - psi

21.58

65.38

115.61

$\sigma_3'$  Failure - psi

6.31

17.42

37.72

### TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP

SAMPLE TYPE: Native Shelby Tube Sample

DESCRIPTION: Dark Gray Clayey Sand

Sampled on Site, W-1 38' to 41' deep

ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve 1%

LL: 29 PL: 19 PI: 10 Percent -200: 25%

REMARKS: Diameter and Both Ends Trimmed. + #4 Sieve 0%

### PROJECT INFORMATION

PROJECT: Pirkey Power Plant Embankments

LOCATION: Hallsville, Texas

PROJECT NO: G 3241 - 095

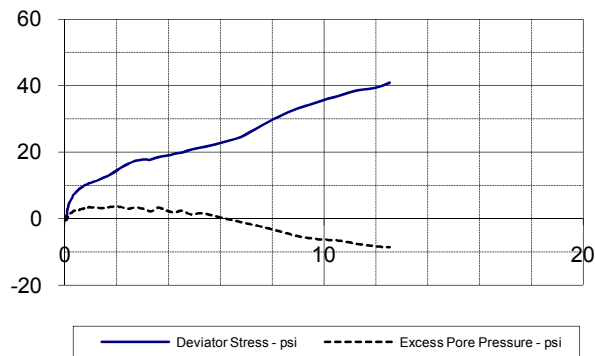
CLIENT:

November 2009

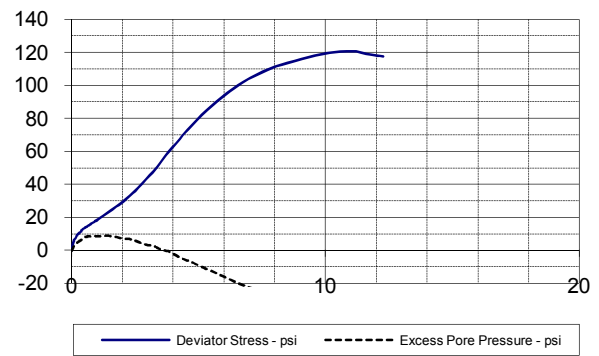
ETTL ENGINEERS & CONSULTANTS

PLATE: B.1

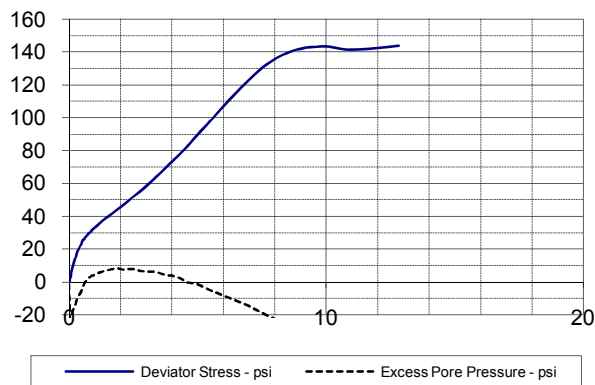
SPECIMEN NO. 1



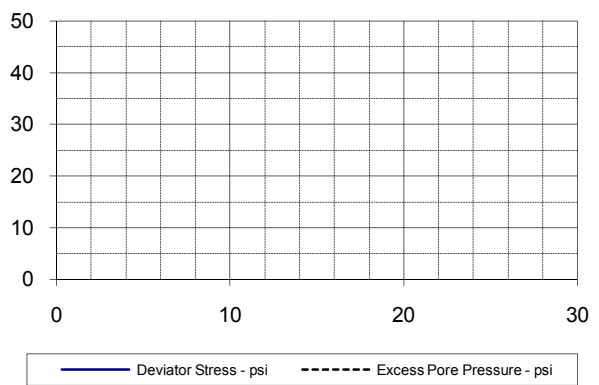
SPECIMEN NO. 2



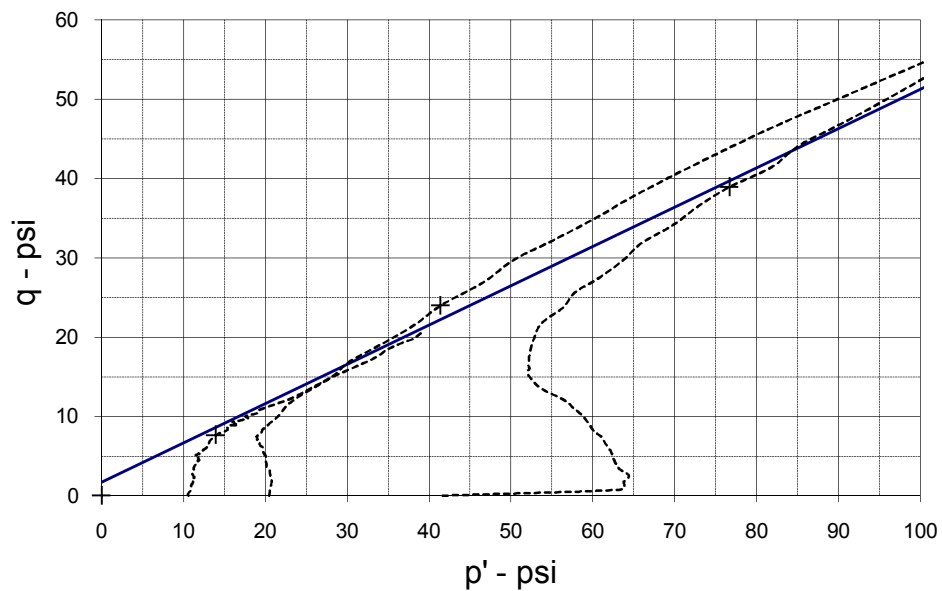
SPECIMEN NO. 3



SPECIMEN NO. 4



p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS

 $R^2 = 0.99$  $\alpha$  (deg) = 26.4

a (psi) = 1.7

PROJECT: Pirkey Power Plant Embankments

TYPE OF TEST &amp; NO: CU with PP

PROJECT NO: G 3241 - 095

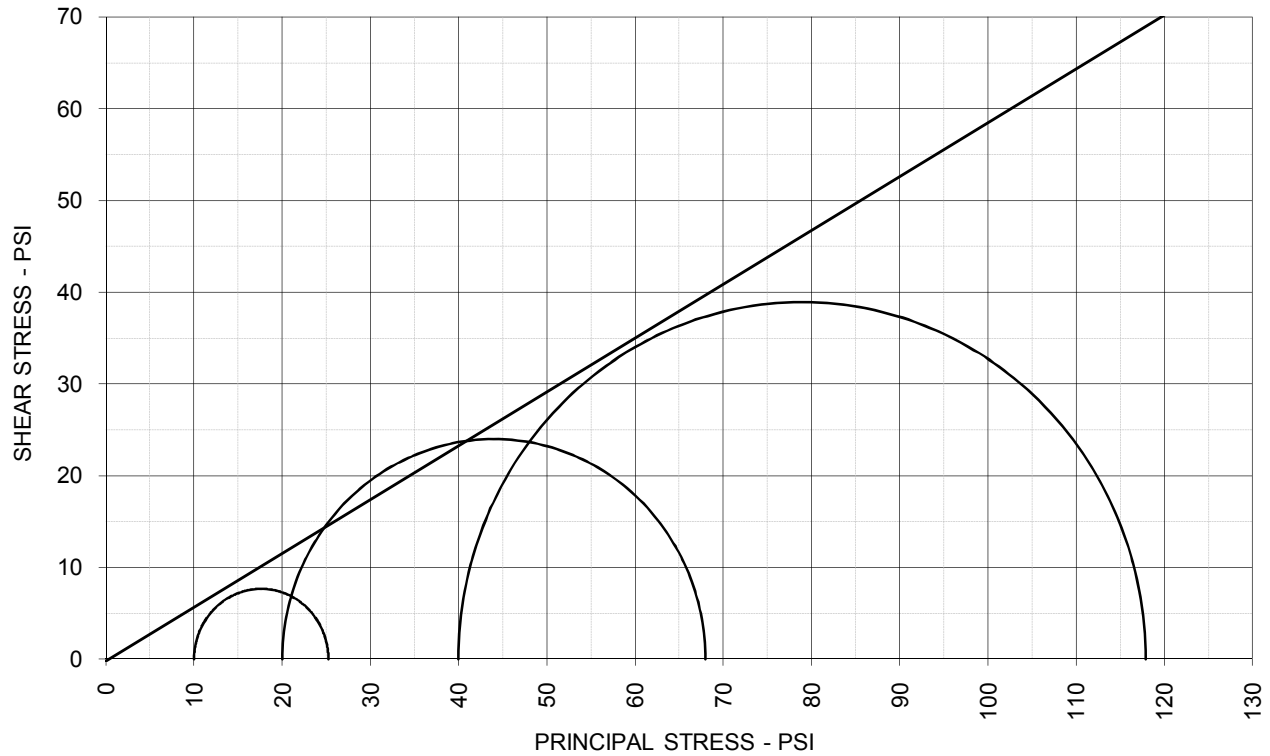
ETTL ENGINEERS &amp; CONSULTANTS

PLATE: B.2

DESCRIPTION: Dark Gray Clayey Sand

G 3241-095, W-1 38'-41' Native.xls

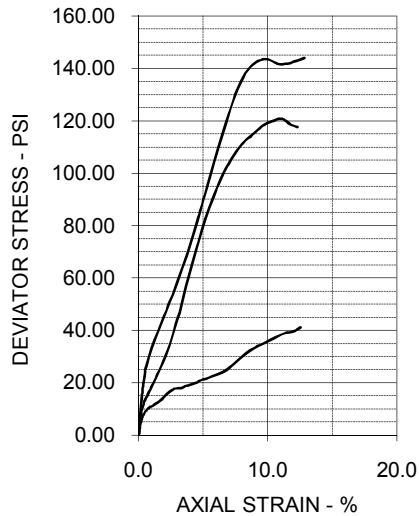
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 30.4 \text{ deg}$

$c = -0.2 \text{ psi}$



## SPECIMEN NO.

1

2

3

4

## INITIAL

Moisture Content - %

18.7

19.2

18.5

Dry Density - pcf

108.5

105.5

104.8

Diameter - inches

2.04

2.04

2.02

Height - inches

4.25

4.18

4.37

## AT TEST

Final Moisture - %

21.3

21.7

20.7

Dry Density - pcf

108.9

106.7

106.7

Calculated Diameter (in.)

2.03

2.02

2.00

Height - inches

4.21

4.13

4.31

Effect. Cell Pressure - psi

10.0

20.0

40.0

Failure Stress - psi

15.27

47.96

77.89

Total Pore Pressure - psi

63.7

52.6

52.3

Strain Rate - inches/min.

0.00050

0.00050

0.00050

Failure Strain - %

2.1

3.2

4.3

$\sigma_1$  Failure - psi

25.27

67.96

117.89

$\sigma_3$  Failure - psi

10.00

20.00

40.00

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP

SAMPLE TYPE: Native Shelby Tube Sample

DESCRIPTION: Dark Gray Clayey Sand

Sampled on Site, W-1 38' to 41' deep

ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve 1%

LL: 29 PL: 19 PI: 10 Percent -200: 25%

REMARKS: Diameter and Both Ends Trimmed. + # 4 Sieve 0%

## PROJECT INFORMATION

PROJECT: Pirkey Power Plant Embankments

LOCATION: Hallsville, Texas

PROJECT NO: G 3241 - 095

CLIENT:

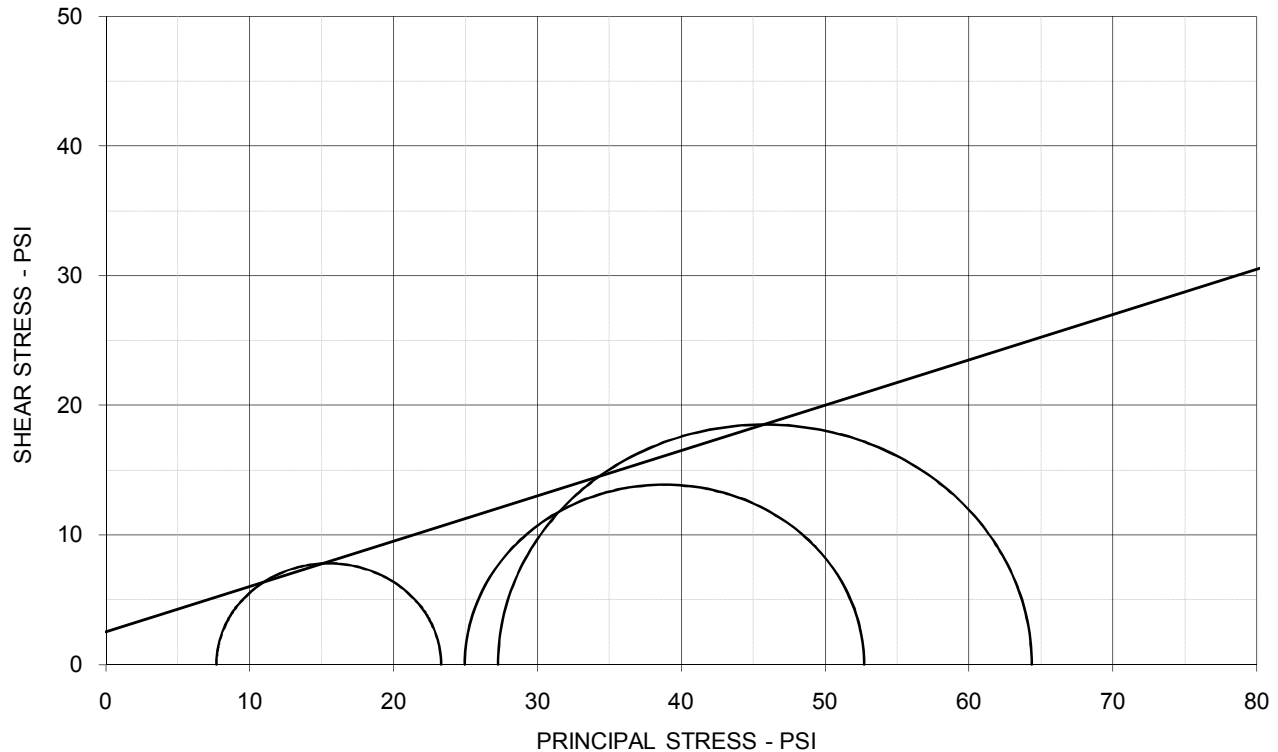
November 2009

ETTL ENGINEERS & CONSULTANTS

PLATE: B.3



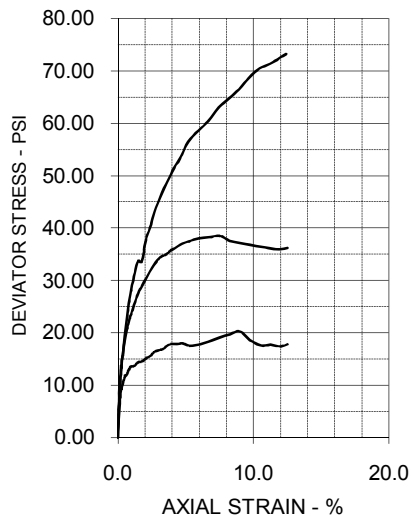
## TRIAXIAL SHEAR TEST REPORT



### EFFECTIVE STRESS PARAMETERS

$\phi' = 19.3$  deg

$c' = 2.5$  psi



#### SPECIMEN NO.

1

2

3

4

#### INITIAL

Moisture Content - %

23.4

21.5

23.6

Dry Density - pcf

99.0

104.7

98.6

Diameter - inches

1.99

2.01

2.00

Height - inches

4.01

3.99

4.01

#### AT TEST

Final Moisture - %

27.8

20.6

27.1

Dry Density - pcf

99.4

105.8

99.5

Calculated Diameter (in.)

1.98

2.01

1.99

Height - inches

3.99

3.97

3.98

Effect. Cell Pressure - psi

10.0

20.0

40.0

Failure Stress - psi

15.62

27.77

37.08

Total Pore Pressure - psi

52.3

45.0

62.7

Strain Rate - inches/min.

0.00050

0.00050

0.00050

Failure Strain - %

2.4

1.0

4.8

$\sigma_1'$  Failure - psi

23.30

52.73

64.35

$\sigma_3'$  Failure - psi

7.68

24.96

27.27

### TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP  
 SAMPLE TYPE: Shelby Tube Sample  
 DESCRIPTION: Red, Tan & Gray Fat Clay w/ Sand  
 Sampled on Site, W-3 10' to 20' deep  
 ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve 6%  
 LL: 68 PL: 22 PI: 46 Percent -200: 80%  
 REMARKS: Both Ends and Diameter Trimmed + #4 Sieve 0%  
 G 3241 095, W 3 10' 20'.xls

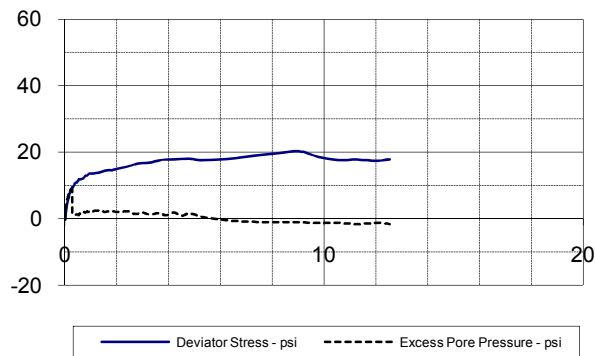
### PROJECT INFORMATION

PROJECT: Pirkey Power Plant Embankments  
 LOCATION: Hallsville, Texas  
 PROJECT NO: G 3241 - 095  
 CLIENT:  
 November 2009

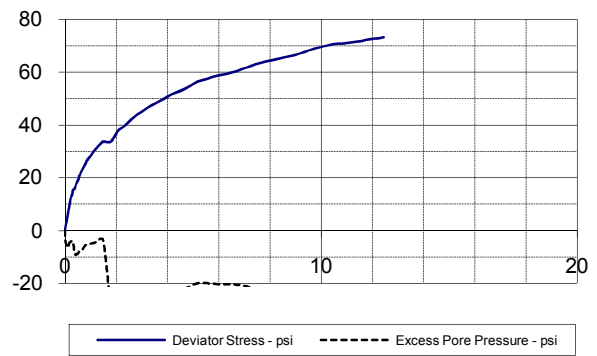
ETTL ENGINEERS & CONSULTANTS

PLATE: B.1

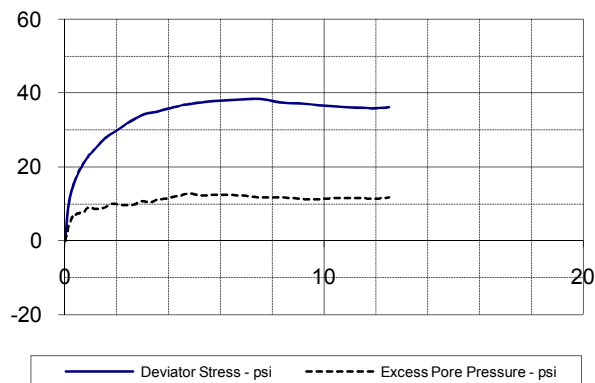
SPECIMEN NO. 1



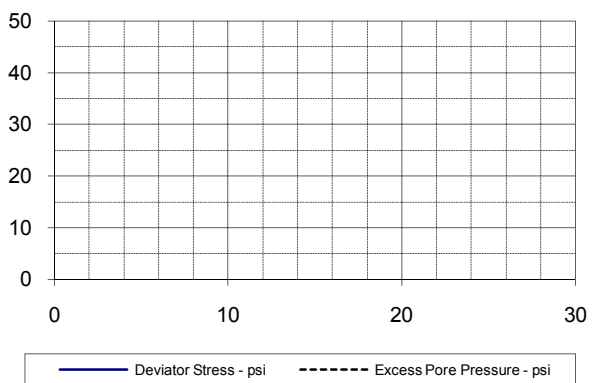
SPECIMEN NO. 2



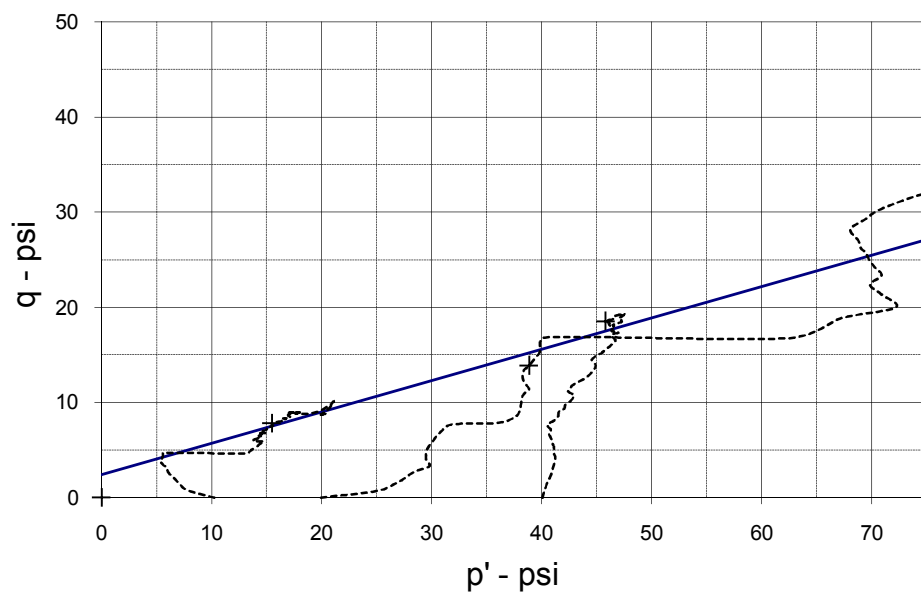
SPECIMEN NO. 3



SPECIMEN NO. 4



p - q DIAGRAM



EFFECTIVE STRESS PARAMETERS

 $R^2 = 0.95$  $\alpha$  (deg) = 18.3

a (psi) = 2.4

PROJECT: Pirkey Power Plant Embankments

TYPE OF TEST &amp; NO: CU with PP

PROJECT NO: G 3241 - 095

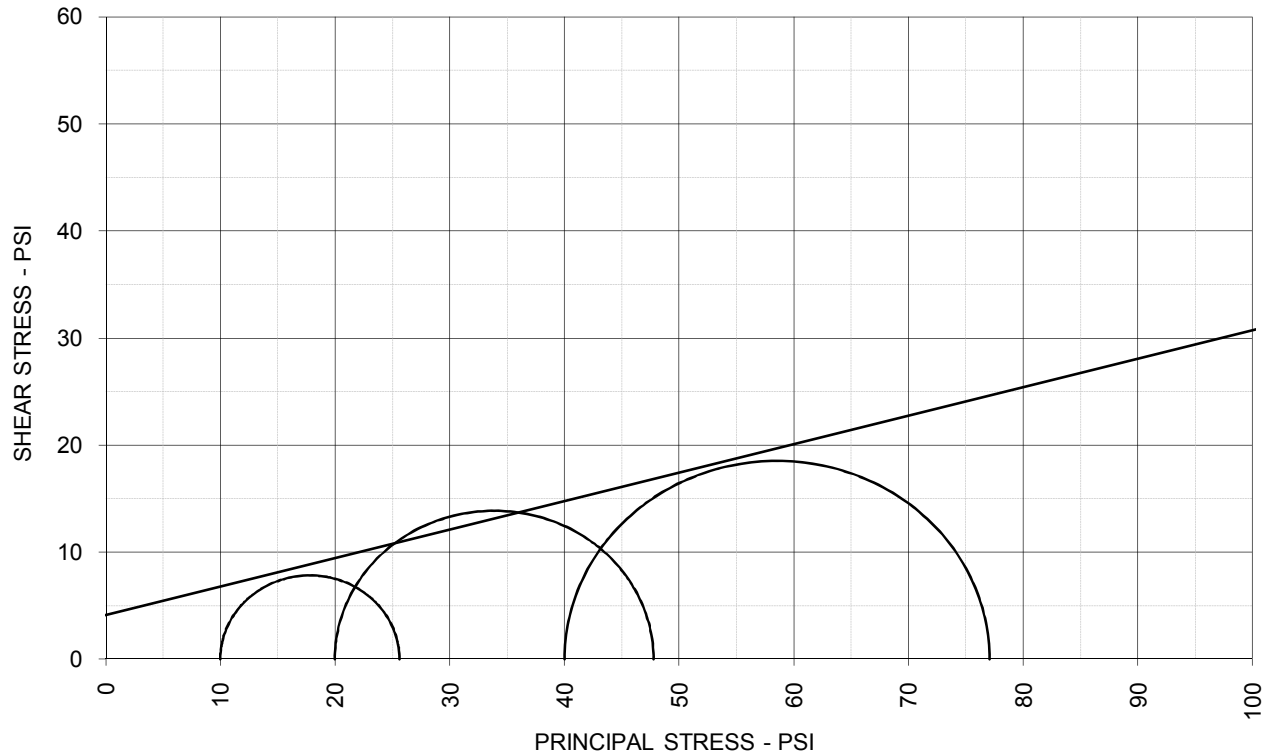
ETTL ENGINEERS &amp; CONSULTANTS

PLATE: B.2

DESCRIPTION: Red, Tan &amp; Gray Fat Clay w/ Sand

G 3241-095, W-3 10'-20'.xls

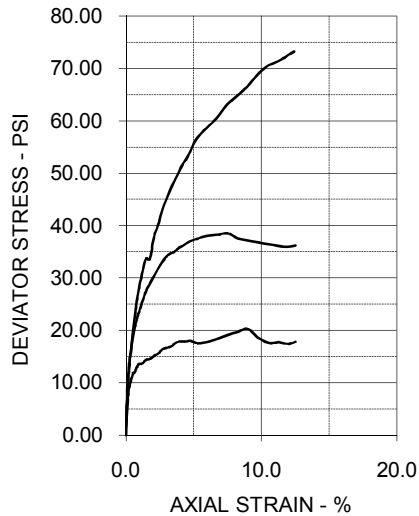
# TRIAXIAL SHEAR TEST REPORT



## TOTAL STRESS PARAMETERS

$\phi = 14.9 \text{ deg}$

$c = 4.1 \text{ psi}$



### SPECIMEN NO.

1

2

3

4

### INITIAL

Moisture Content - %	23.4	21.5	23.6
Dry Density - pcf	99.0	104.7	98.6
Diameter - inches	1.99	2.01	2.00
Height - inches	4.01	3.99	4.01

### AT TEST

Final Moisture - %	27.8	20.6	27.1
Dry Density - pcf	99.4	105.8	99.5
Calculated Diameter (in.)	1.98	2.01	1.99
Height - inches	3.99	3.97	3.98
Effect. Cell Pressure - psi	10.0	20.0	40.0
Failure Stress - psi	15.62	27.77	37.08
Total Pore Pressure - psi	52.3	45.0	62.7
Strain Rate - inches/min.	0.00050	0.00050	0.00050
Failure Strain - %	2.4	1.0	4.8
$\sigma_1$ Failure - psi	25.62	47.77	77.08
$\sigma_3$ Failure - psi	10.00	20.00	40.00

## TEST DESCRIPTION

TYPE OF TEST & NO: CU with PP  
 SAMPLE TYPE: Shelby Tube Sample  
 DESCRIPTION: Red, Tan & Gray Fat Clay w/ Sand  
 Sampled on Site, W-3 10' to 20' deep  
 ASSUMED SPECIFIC GRAVITY: 2.7 + 40 Sieve 6%  
 LL: 68 PL: 22 PI: 46 Percent -200: 80%  
 REMARKS: Both Ends and Diameter Trimmed + # 4 Sieve 0%

## PROJECT INFORMATION

PROJECT: Pirkey Power Plant Embankments  
 LOCATION: Hallsville, Texas  
 PROJECT NO: G 3241 - 095  
 CLIENT:  
 November 2009

**ETTL ENGINEERS & CONSULTANTS**

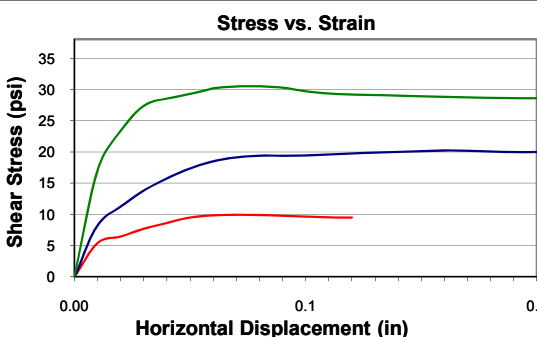
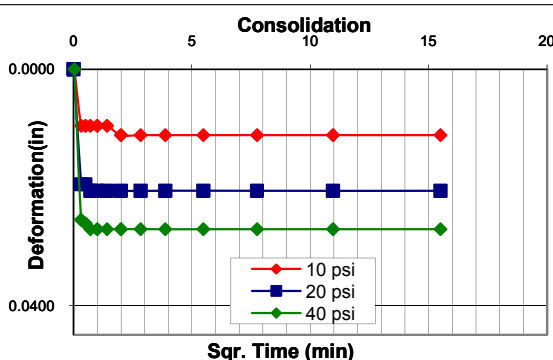
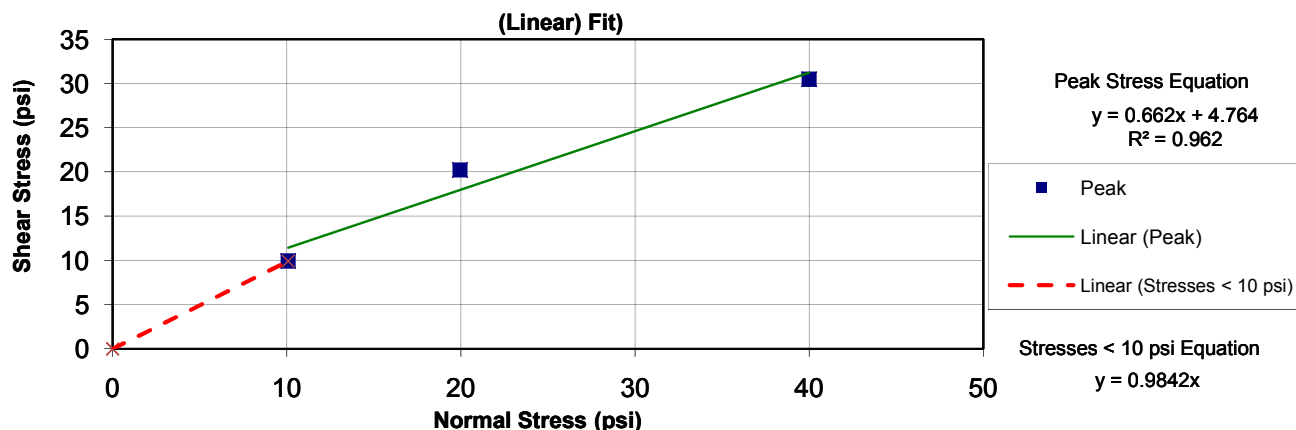
**PLATE: B.3**



# ETTL Engineers & Consultants Inc.

GEOTECHNICAL \* MATERIALS \* ENVIRONMENTAL \* DRILLING \* LANDFILLS

## ASTM 3080 Direct Shear Test Report



Peak Strength Parameters				
Friction Angle	Peak		Residual	
	33.5		-	
Cohesion	(deg)		(deg)	
	4.76	686.0	-	-
		(psi)	(psf)	(psi)
		(psf)	(psi)	(psf)
Friction Angle Stresses < 10psi				
Specimen Number				
Initial				
Moisture Content - %				
Dry Density- lb/ft <sup>3</sup>				
Height-inches				
Diameter- inches				
Final				
Moisture Content - %				
Dry Density- lb/ft <sup>3</sup>				
Height after shear-(inches)				
Height after consolidation (inches)				
Normal Stress-(psi)				
Peak Failure Stress-(psi)				
Residual Failure Stress-(psi)				
Strain Rate - (inches/min)				

### Project Information

<b>Project :</b>		Pirkey Power Plant Embankments AEP Hallsville, Tx Tan & Brown Clayey Sand with ferric seams		LL	PL	PI
<b>Client:</b>				32	17	15
<b>Material Origin:</b>				-200%	31	
<b>Material Description:</b>				<b>Remarks</b>  When Calculating stresses < 10 psi: use appropriate Equation above (assuming no Cohesion)		
<b>Job No:</b>	G 3241-095	<b>Technician:</b>	Owen Sanderson			
<b>Boring No:</b>	W-2	<b>Sample Type:</b>	Shelby Tube			
<b>Depth:</b>	13'-16'	<b>Sampling method:</b>	Shelby Tube			
<b>Date:</b>	October 31, 2009	<b>Testing Device:</b>	Soiltest B-124BY 2.5 in. round			

C. Brandon Quinn, P.E.

*C. Brandon Quinn*

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 870-216-2413 Fax

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 903-595-6113 Fax  
 www.ettlinc.com

707 West Cotton Street  
 Longview, Texas 75604-5505  
 903-758-0915 Phone  
 903-758-8245 Fax



EUSTIS ENGINEERING

H W Pirkey Power Plant  
West Primary Ash Pond  
Future Landfill at K-Area  
Hallsville, Texas  
Project No: L0441

CPT ID/Net Area Ratio: DSG0709 / 0.8

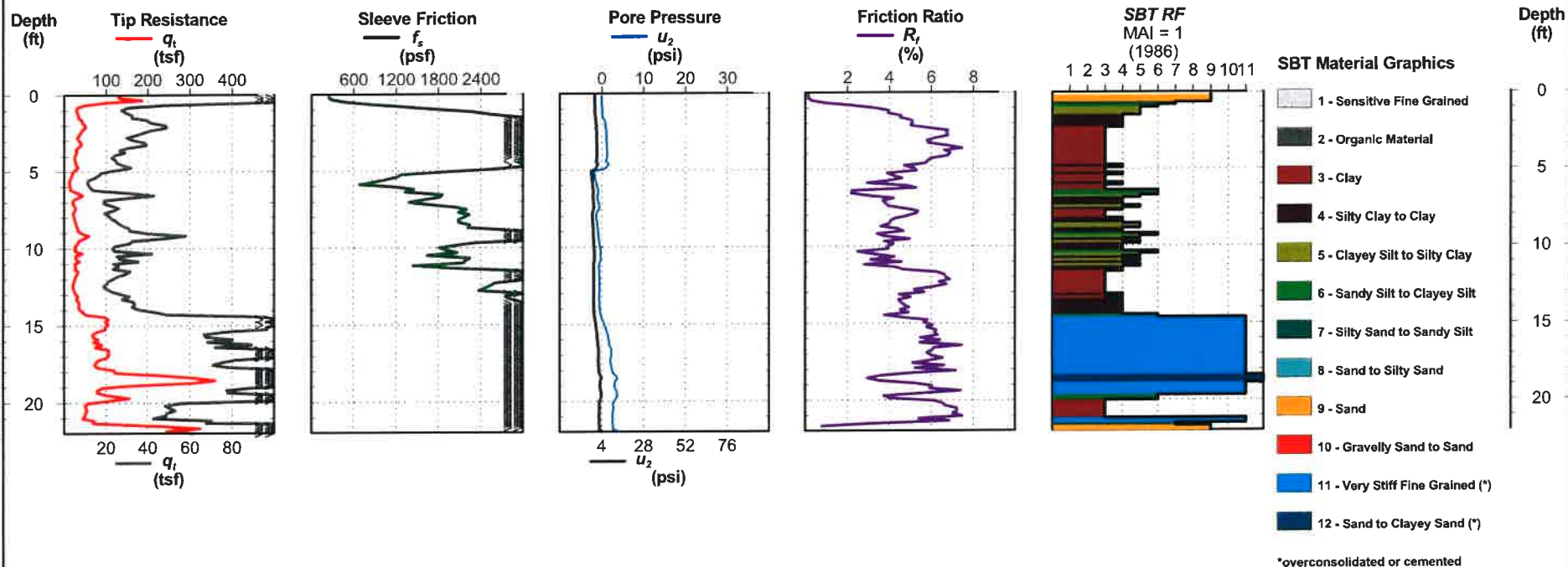
# Cone Penetration Test

CPT-1

Latitude: 32.46619  
Longitude: -94.48989

Date: 12/8/15  
Operator: P. Thurmond

Water Depth: See Text  
Total Depth: 22.0 ft



Notes: Soil behavior type was determined using friction ratio classification chart (after Robertson *et al.*, 1986).  
Test performed in general accordance with ASTM D5778-12.



EUSTIS ENGINEERING

H W Pirkey Power Plant  
West Primary Ash Pond  
Future Landfill at K-Area  
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Project No: L0441

CPT ID/Net Area Ratio: DSG0709 / 0.8

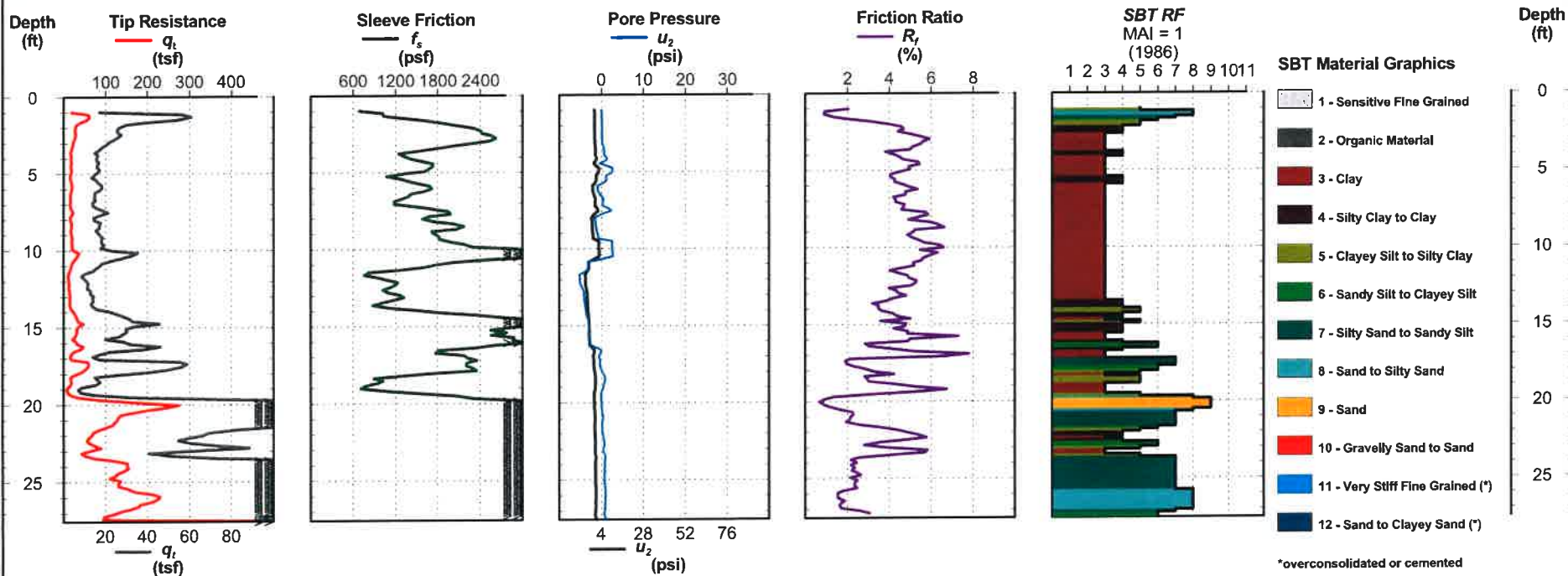
# Cone Penetration Test

CPT-2

Latitude: 32.46613  
Longitude: -94.49157

Date: 12/8/15  
Operator: P. Thurmond

Water Depth: See Text  
Total Depth: 27.6 ft



Notes: Soil behavior type was determined using friction ratio classification chart (after Robertson *et al.*, 1986).  
Test performed in general accordance with ASTM D5778-12.



EUSTIS ENGINEERING

H W Pirkey Power Plant  
West Primary Ash Pond  
Future Landfill at K-Area  
Hallsville, Texas  
Project No: L0441

CPT ID/Net Area Ratio: DSG0709 / 0.8

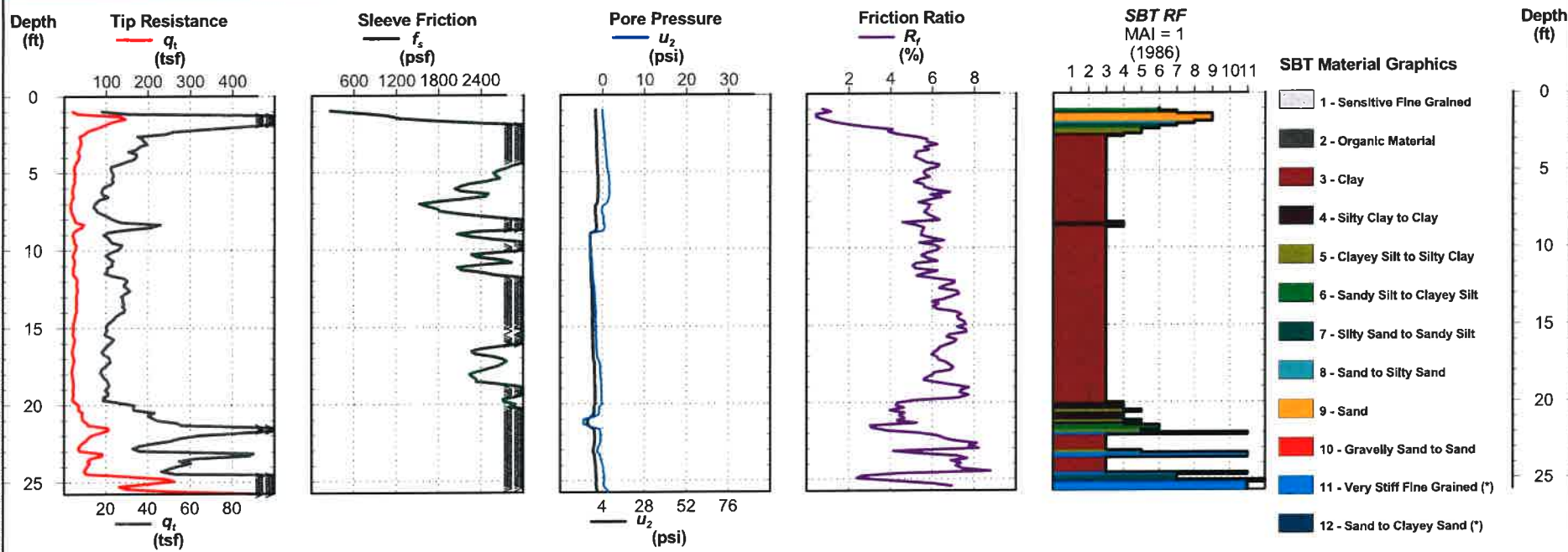
# Cone Penetration Test

## CPT-3

Latitude: 32.46587  
Longitude: -94.49313

Date: 12/8/15  
Operator: P. Thurmond

Water Depth: See Text  
Total Depth: 25.8 ft



Notes: Soil behavior type was determined using friction ratio classification chart (after Robertson *et al.*, 1986).  
Test performed in general accordance with ASTM D5778-12.





EUSTIS ENGINEERING

H W Pirkey Power Plant  
West Primary Ash Pond  
Future Landfill at K-Area  
Hallsville, Texas  
Project No: L0441

CPT ID/Net Area Ratio: DSG0709 / 0.8

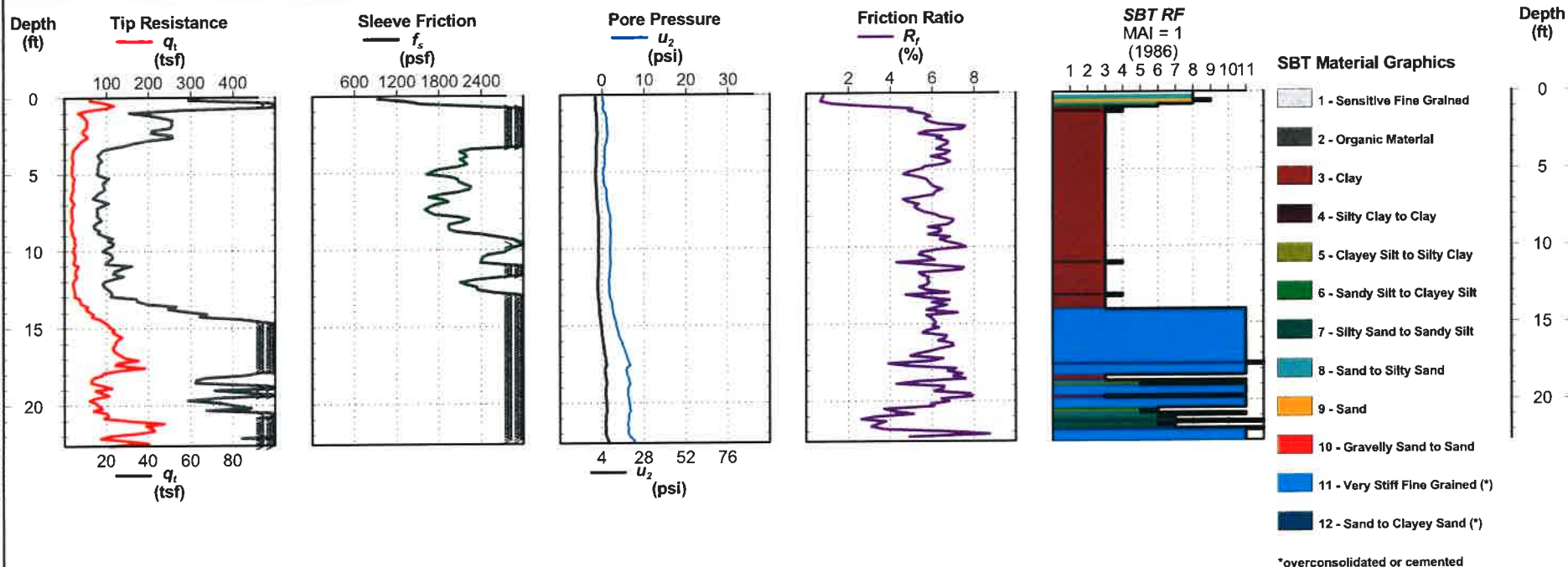
# Cone Penetration Test

CPT-4

Latitude: 32.46672  
Longitude: -94.49400

Date: 12/8/15  
Operator: P. Thurmond

Water Depth: See Text  
Total Depth: 22.6 ft



Notes: Soil behavior type was determined using friction ratio classification chart (after Robertson *et al.*, 1986).  
Test performed in general accordance with ASTM D5778-12.





EUSTIS ENGINEERING

H W Pirkey Power Plant  
West Primary Ash Pond  
Future Landfill at K-Area  
Hallsville, Texas  
Project No: L0441

CPT ID/Net Area Ratio: DSG0709 / 0.8

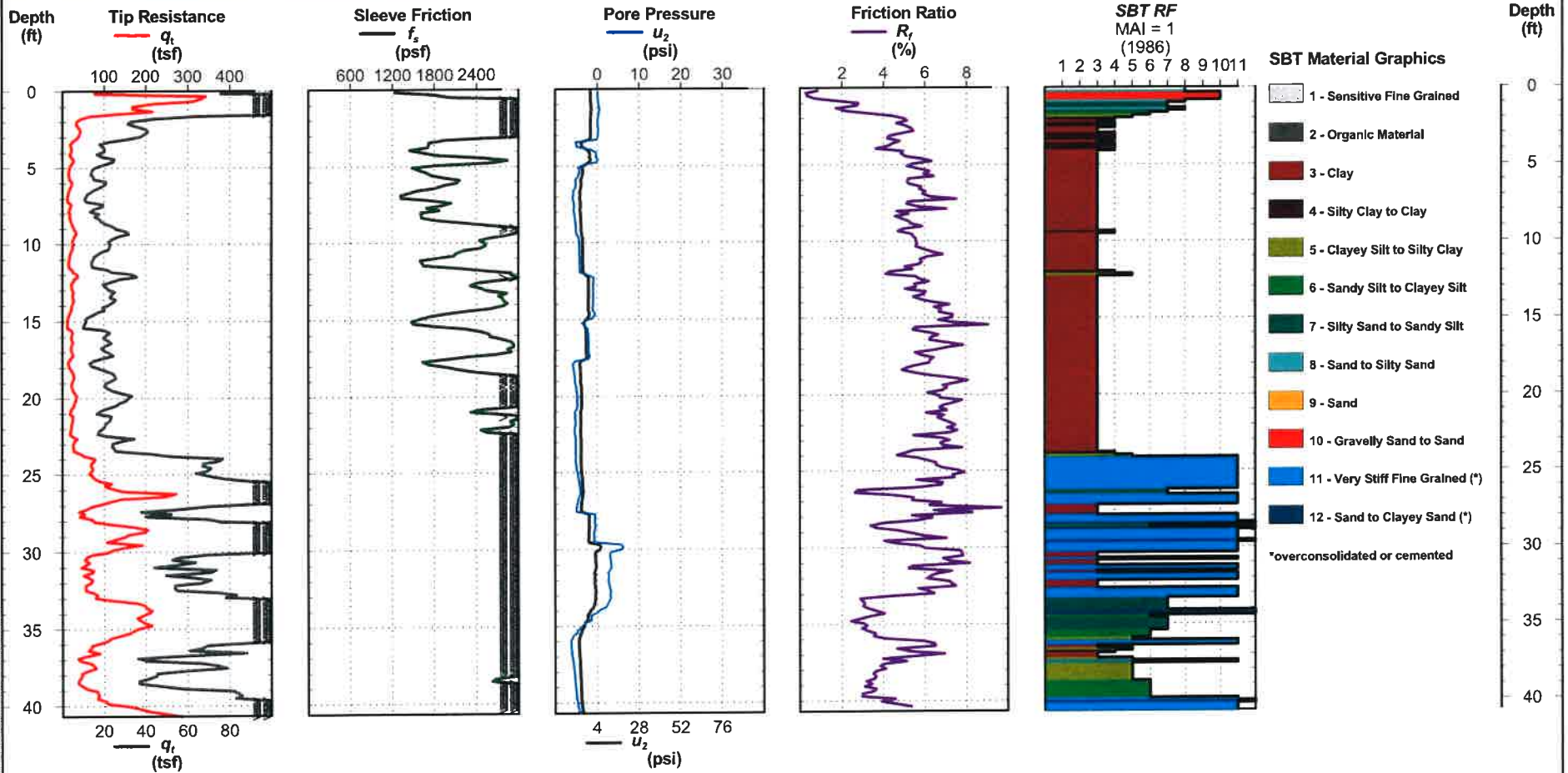
# Cone Penetration Test

CPT-5

Latitude: 32.46803  
Longitude: -94.49390

Date: 12/9/15  
Operator: P. Thurmond

Water Depth: See Text  
Total Depth: 40.7 ft



Notes: Soil behavior type was determined using friction ratio classification chart (after Robertson *et al.*, 1986).  
Test performed in general accordance with ASTM D5778-12.



EUSTIS ENGINEERING

H W Pirkey Power Plant  
West Primary Ash Pond  
Future Landfill at K-Area  
Hallsville, Texas  
Project No: L0441

CPT ID/Net Area Ratio: DSG0709 / 0.8

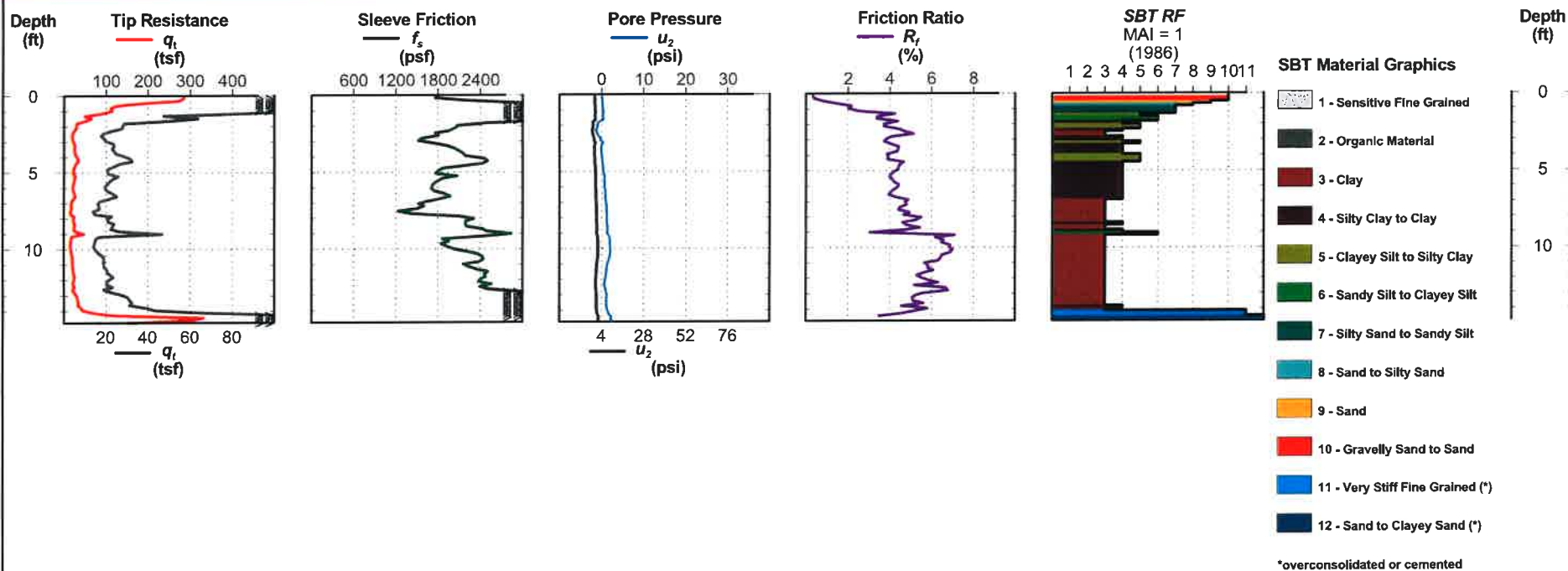
# Cone Penetration Test

CPT-6

Latitude: 32.46887  
Longitude: -94.49243

Date: 12/9/15  
Operator: P. Thurmond

Water Depth: See Text  
Total Depth: 14.8 ft



Notes: Soil behavior type was determined using friction ratio classification chart (after Robertson *et al.*, 1986).  
Test performed in general accordance with ASTM D5778-12.



EUSTIS ENGINEERING

H W Pirkey Power Plant  
West Primary Ash Pond  
Future Landfill at K-Area  
Hallsville, Texas  
Project No: L0441

CPT ID/Net Area Ratio: DSG0709 / 0.8

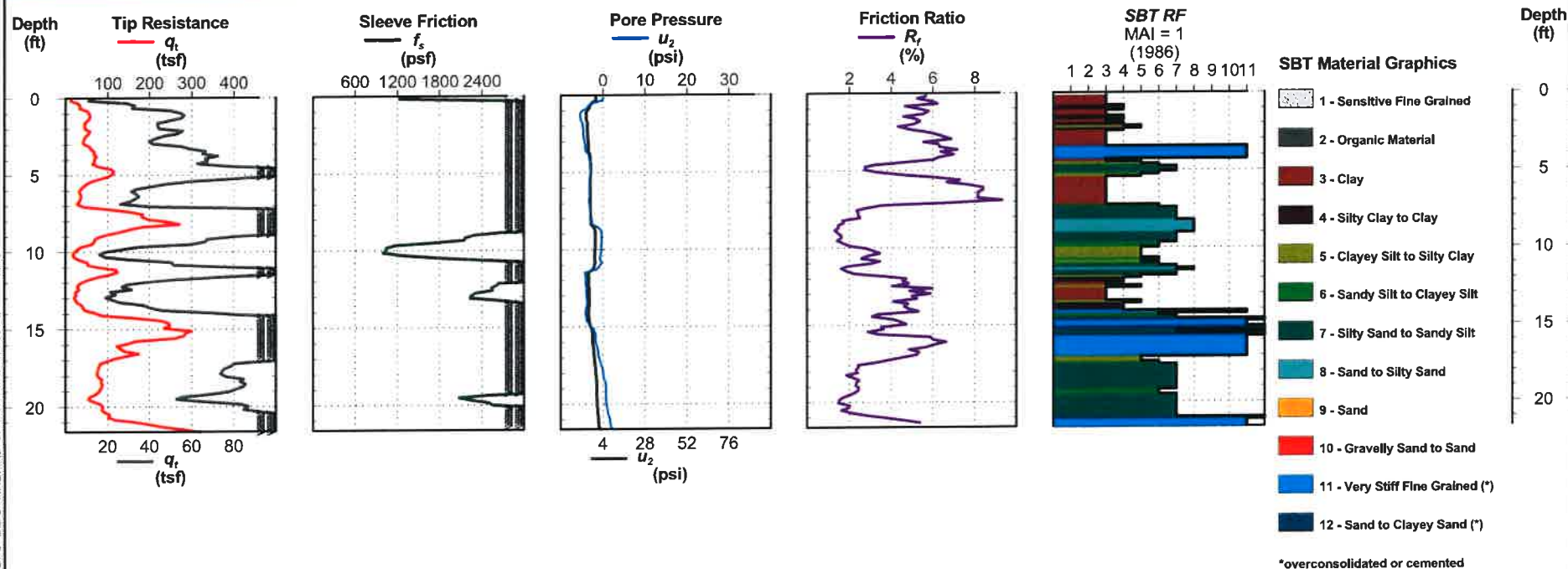
# Cone Penetration Test

CPT-7

Latitude: 32.46572  
Longitude: -94.49256

Date: 12/9/15  
Operator: P. Thurmond

Water Depth: See Text  
Total Depth: 21.7 ft



Notes: Soil behavior type was determined using friction ratio classification chart (after Robertson *et al.*, 1986).  
Test performed in general accordance with ASTM D5778-12.



EUSTIS ENGINEERING

H W Pirkey Power Plant  
West Primary Ash Pond  
Future Landfill at K-Area  
Hallsville, Texas  
Project No: L0441

CPT ID/Net Area Ratio: DSG0709 / 0.8

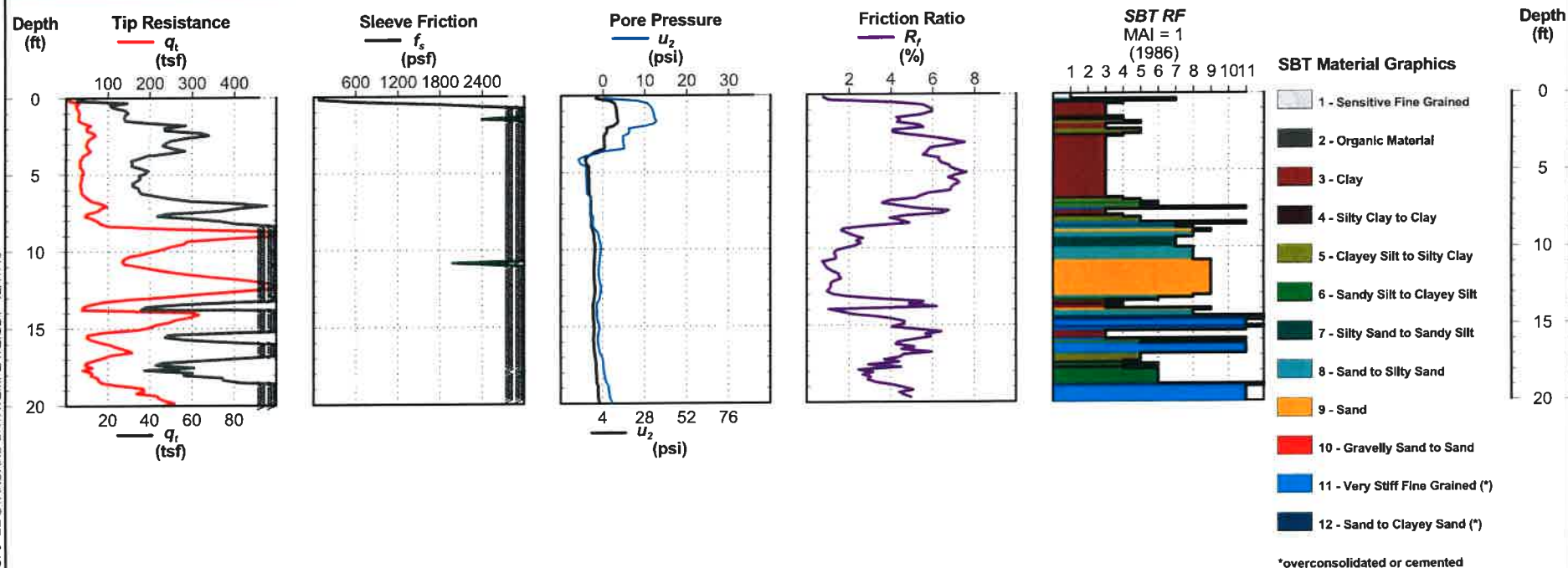
# Cone Penetration Test

CPT-8

Latitude: 32.46603  
Longitude: -94.49087

Date: 12/9/15  
Operator: P. Thurmond

Water Depth: See Text  
Total Depth: 20.0 ft



Notes: Soil behavior type was determined using friction ratio classification chart (after Robertson *et al.*, 1986).  
Test performed in general accordance with ASTM D5778-12.