INITIAL SAFETY FACTOR ASSESSMENT

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Possum Point Power Station CCR Surface Impoundment: Pond E

Dominion Energy[SM]

Submitted To: Possum Point Power Station
19000 Possum Point Road
Dumfries, VA 22026

Submitted By: Golder Associates Inc.
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Richmond, VA 23227

April 2018 **Project No. 16-62150**

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Golder Associates

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1.0 CERTIFICATION

This Initial Safety Factor Assessment for the Possum Point's Pond E was prepared by Golder Associates Inc. (Golder). The document and Certification/Statement of Professional Opinion are based on and limited to information that Golder has relied on from Dominion and others, but not independently verified, as well as work products produced by Golder.

On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that this document has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, at the same time, and in the same locale. It is my professional opinion that the document was prepared consistent with the requirements of the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments," published in the Federal Register on April 17, 2015, with an effective date of October 19, 2015 [40 CFR §257.73(e)], as well as with the requirements in §257.100 resulting from the EPA's "Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; Extension of Compliance Deadlines for Certain Inactive Surface Impoundments; Response to Partial Vacatur" published in the Federal Register on August 5, 2016 with an effective date of October 4, 2016 (40 CFR §257.100).

The use of the word "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion, and is not and shall not be interpreted or construed as a guarantee, warranty, or legal opinion.

Daniel McGrath	Associate and Senior Consultant
Print Name	Title
Daniel McGrath	4/13/18
Signature	Date

COMMONWEALTH OF VIRGINIA
Daniel McGrath
DANIEL P. McGRATH
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4/13/18
PROFESSIONAL ENGINEER

2.0 INTRODUCTION

This document discusses Golder's stability evaluation of the Pond E impoundment structure at Dominion Energy Virginia's Possum Point Power Station in Dumfries, VA as it relates to the requirements in the USEPA's 2015 Final Rule on the Disposal of Coal Combustion Residuals (CCR; EPA Rule). According to section § 257.73(e) of the rule, stability of earth structures must be assessed under the following four loading conditions:

- Normal Storage Pool (§ 257.73(e)(i))
- Maximum Surcharge Pool (§ 257.73(e)(ii))
- Seismic Loading Conditions (§ 257.73(e)(iii))
- Post-Seismic Liquefaction Conditions (when liquefaction susceptible materials are present; § 257.73(e)(iv)).

3.0 SLOPE STABILITY ASSESSMENT METHODOLOGY

Stability safety factors were evaluated for each of the loading scenarios using the computer program SLIDE 7.0 Version 7.031 (2018). As required by the EPA rule, a general limit equilibrium (GLE) method (Morgenstern and Price) was used to calculate factors of safety. The factor of safety is calculated by dividing the resisting forces by the driving forces along the critical slip surface.

Stability was evaluated along five cross-sections as shown in Figure 1 in Attachment 4. Subsurface stratigraphy at each cross-section was developed from cone penetration tests (CPTs) completed during Golder's subsurface exploration in December 2017 and geotechnical data reported in Schnabel Engineering's 2011 report titled "Slope Stability Evaluation of Pond E, Dominion Resources Services, Inc., Possum Point Power Station, Prince William County, Virginia." Similarly, material properties were developed for the dike and foundation materials from these sources. The Material Properties Calculation Package (Attachment 1) provides more details on Golder's geotechnical exploration and evaluation of geotechnical data.

3.1 Normal Storage Pool

The water level in Pond E is maintained at or lower than mean sea level through pumping efforts. Thus, the normal storage pool was set to elevation 0 feet mean sea level (ft-msl) for stability analyses.

3.2 Maximum Surcharge Pool

For the maximum surcharge pool, the peak water level within Pond E was calculated for the 100 year, 24-hour rain event. This event was calculated to cause a temporary rise in water level within the pond to approximate elevation 2.5 ft-msl. For further details, refer to the hydraulic and hydrology stormwater routing calculations presented in the *Inflow Design Flood Control Plan* (Golder 2018).

3.3 Pseudostatic Stability Analysis

Factors of safety for stability under seismic loading conditions were calculated based on the earthquake hazard corresponding to a probability of exceedance of 2% in 50 years (2,475 year return period). Golder used the displacement-based seismic slope stability screening method as described in Bray and Travasarou (2009) to evaluate the seismic stability. For this method, a pseudo-static coefficient corresponding to an allowable displacement of six inches (15 cm) was used. The pseudo-static coefficient was calculated to be 0.01g. Details on the calculation of the pseudo-static coefficient are available in the Seismic Hazard Calculation Package (Attachment 2).

For stability analysis, Golder modeled the shear strength of each soil under seismic conditions using the minimum of the drained and the undrained strength of the soil. Please refer to Material Properties Package (Attachment 1) for more details about the drained and undrained strengths.

3.4 Post-Earthquake Liquefaction Loading Conditions

Golder evaluated the liquefaction susceptibility of the site soils as presented in the Liquefaction Assessment Calculation Package (Attachment 3). The calculated factor of safety against liquefaction is above 1.2 for all materials analyzed including dike soils and foundation soils. Thus, slope stability analyses evaluating the impact of liquefaction are not necessary. For more detail on the liquefaction analysis, please refer to the Liquefaction Assessment Calculation Package (Attachment 3).

3.5 Rapid Drawdown Conditions

Golder also considered the impacts of rapid drawdown of slopes as described in § 257.73(d)(vii) of the USEPA CCR Rule. The mapped (FIRM zone VE) 100-year flood level in the Quantico Creek is elevation 8 ft-msl. The toe areas of the downstream slopes are generally at elevation 6 ft-msl or higher; thus the dikes around Pond E are not expected to be significantly impacted by rapid drawdown. Therefore, additional rapid drawdown analyses are not necessary.

4.0 SLOPE STABILITY ASSESSMENT RESULTS

The table below presents the results of the slope stability analyses of the dikes surrounding Pond E. For all cases analyzed, the calculated factors of safety are in excess of those required in Sections § 257.73(e)(i) to (iv) of the EPA Rule for all analyzed sections except Section B-B’ and Section E-E’. At Sections B-B’ and E-E’, the calculated factors of safety are below the target factors of safety specified in the CCR Rule for the normal storage pool and maximum surcharge pool conditions. The detailed stability result figures are available in Attachment 4.

Table 1. Slope Stability Assessment Results

Analysis Case	Normal Storage Pool	Max. Surcharge Pool	Seismic	Post-Earthquake Liquefaction
Rule Section	§ 257.73(e)(i)	§ 257.73(e)(ii)	§ 257.73(e)(iii)	§ 257.73(e)(iv)
Target Factor of Safety	1.5	1.4	1.0	1.2
Cross-Sections	**Factor of Safety**			
A-A’	1.8	1.8	1.7	Soils Calculated to Not Liquefy
B-B’	1.3	1.2	1.2	
C-C’	1.5	1.5	1.5	
D-D’	1.6	1.6	1.5	
E-E’	1.3	1.3	1.3	

The following actions are or will be implemented as preventative measures against the factor of safety values found in Cross-Sections B-B’ and E-E’:

- Prohibition of vehicle traffic on the embankment crest;
- Removal by pumping of stormwater as needed to prevent accumulation of water against the embankment;
- Weekly inspections by qualified personnel and annual professional engineer inspections; and,
- Plans for embankment height reduction, breaching the impoundment structure, and installation of drainage features to prevent storage of water during pond final closure.

5.0 CONCLUSION

Golder evaluated the slope stability of the Pond E impoundment structure at Dominion Energy Virginia’s Possum Point Power Station in accordance with the EPA Rule on the Disposal of Coal Combustion Residuals. Specifically, the dikes were evaluated for stability in the four loading scenarios presented in section § 257.73(e) of the EPA Rule:

- Normal Storage Pool (§ 257.73(e)(i))
- Maximum Surcharge Pool (§ 257.73(e)(ii))
- Seismic Loading Conditions (§ 257.73(e)(iii))
- Post-Seismic Liquefaction Conditions (when liquefaction susceptible materials are present; § 257.73(e)(iv))

For each loading case, the dikes were calculated to meet the target factor of safety presented in the EPA rule at all cross-sections except Section B-B’ and Section E-E’. The calculated factors of safety for Section B-B’ and Section E-E’ are below the target factors of safety for the normal storage pool and maximum surcharge pool loading scenarios.

In recognition of these sections not meeting the target factor of safety, the water level in Pond E is kept low (at or below elevation 0 ft msl) and routine weekly inspections are conducted to observe for changes in the embankment. There are no plans to impound water or other material behind the Pond E embankment, and monitoring will continue until the pond achieves final closure through removal and reduction in the embankment height.

6.0 REFERENCES

Bray, J.D., and Travasarou, T. 2009. Pseudostatic Coefficient for Use in Simplified Seismic Slope Stability Evaluation. Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 9: pp. 1336-1340.

Golder (2018), Inflow Design Flood Control System Plan

Rocscience (2018), SLIDE Version 7.031.

Schnabel Engineering (2011). “Geotechnical Engineering Study, Slope Stability Evaluation of Ash Pond E, Dominion Resources Services, Inc., Possum Point Power Station, Prince William County, Virginia.” April 29, 2011.

USEPA (2015), Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities, § 40 CFR Parts 257 and 261.

ATTACHMENT 1

Material Properties Calculation Package

CALCULATIONS

Date:	March 15, 2018	**Made by:**	G. Martin
Project No.:	1662150	**Checked by:**	L. Jin
Site Name:	Possum Point – Pond E	**Reviewed by:**	**G.** Hebeler
Subject	**MATERIAL PROPERTIES PACKAGE**		

1.0 OBJECTIVE

The objective of this package is to characterize materials found at Pond E of Dominion Energy's Possum Point Power Station in Dumfries, VA. Specifically, Golder assessed the dike soils and foundation soils at Pond E to support stability and liquefaction analyses of the dikes.

2.0 METHODOLOGY

Site materials were grouped into six representative strata for further analysis:

- Dike Fill
- Fine Grained / Organic Alluvium
- Coarse Grained Alluvium
- Fine Grained Terrace Deposits
- Coarse Grained Terrace Deposits
- Cretaceous Sediments

For each layer, Golder developed material properties for use in stability and liquefaction analyses. Material properties were evaluated based on geotechnical data available from the following sources:

- Schnabel Engineering's 2011 report titled "Slope Stability Evaluation of Ash Pond E, Dominion Resources Services, Inc., Prince William County, Virginia"
- Law Engineering Testing Company's 1985 geotechnical testing results summary titled "Soil Investigation at Possum Point Ash Pond"
- Golder's geotechnical exploration completed in December 2017.

2.1 Schnabel Engineering Report

Schnabel Engineering (Schnabel) completed a stability assessment of dikes surrounding Pond E in April 2011. Their report includes Standard Penetration Test (SPT) borehole data and qualitative hand auger logs in the dikes surrounding Pond E. Schnabel supplemented their field data with laboratory testing including two consolidated-undrained (CU) triaxial tests. One CU test was performed on the upper dike soils (noted as Fine-Grained Embankment Fill, Stratum A1 in the report), and the other CU test was conducted on the lower dike soils (identified as Coarse-Grained Embankment Fill, Stratum A2).

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Site Name:	Possum Point – Pond E Inactive Pond Demonstration	Checked by:	L. Jin
Date:	March 2018	Reviewed by:	G. Hebeler

Schnabel categorized the dike and foundation soils into seven groups in their report, and for each group, Schnabel determined representative total and effective strengths and unit weights. Golder used the same groupings for analyses, except Golder modeled the dike fill soils as a single stratum. Schnabel divided the dike fill soils into a fine-grained unit and a coarse-grained unit, but this distinction was not apparent in the CPT data Golder collected in December 2017. Golder found the dike soils to be more closely represented by Schnabel's fine-grained fill.

2.2 Law Engineering Testing Company Data

In 1985, Law Engineering Testing Company (Law) completed SPT boreholes on the dikes of Pond E. Law also conducted laboratory testing on samples obtained from these boreholes. SPT and laboratory results were found to be consistent with the borehole data collected by Schnabel and CPT results obtained by Golder in 2017. These results could be found in a letter to Dominion dated April 8, 1985.

2.3 Golder Geotechnical Explorations

Golder completed seven cone penetration tests (CPTs) to characterize the dike and foundation materials. These tests were conducted by ConeTec on December 18, 19, and 20 of 2017 under the direction and supervision of Golder engineer Sarah Fick. Table 1 lists general information on the CPTs.

Table 1: Golder CPT Locations and Testing Notes

Sounding ID	Date	Total Depth (ft)	Latitude (deg)	Longitude (deg)	Elevation (ft-msl)	Testing Notes
PP-E-SCPT-01	12/18/17	101.6	38.55141	-77.29381	40.6	Seismic CPT
PP-E-CPT-02	12/18/17	98.3	38.55212	-77.29361	40.1	
PP-E-CPT-03	12/19/17	62.2	38.55296	-77.29318	41.2	
PP-E-CPT-04	12/19/17	33.1	38.54926	-77.29092	13.1	
PP-E-CPT-05	12/18/17	45.7	38.54902	-77.29029	15.1	
PP-E-CPT-06	12/20/17	36.1	38.54986	-77.29247	11.2	
PP-E-CPT-07	12/20/17	36.4	38.55306	-77.29340	23.0	

Notes:
1. Latitude/Longitude - WGS 84. Coordinates were recorded with a handheld GPS unit and should be considered approximate.

CPT logs presenting raw measurements (tip, sleeve, and pore pressure) and correlated shear strengths with depth are presented in the attachment following this text. The CPT correlation to undrained strength

Project No.:	1662150	Made by:	G. Martin
Site Name:	Possum Point – Pond E Inactive Pond Demonstration	Checked by:	L. Jin
Date:	March 2018	Reviewed by:	G. Hebeler

does not properly model the strength of the cretaceous layer; thus, Golder excluded the undrained shear strength correlation in this layer from the CPT logs.

3.0 SELECTED MATERIAL PROPERTIES

Golder selected strength parameters and unit weights for use in stability analyses based on data available in Schnabel's report and CPT data collected during Golder's geotechnical exploration. Golder found the values presented in Schnabel's report to be consistent with CPT data, so Golder used a modified version of Schnabel's properties. The following modifications were made to the values presented by Schnabel:

- All dike fill was modeled as a single unit.
- Dike fill drained properties were modeled using a higher friction angle and lower cohesion than presented by Schnabel to better match conditions observed from CPT data. Dike fill undrained properties were based on Schnabel's fine-grained dike fill properties.
- The Fine Grained / Organic Alluvium was modeled using a stress-dependent strength derived from CPT measurements.
- The Coarse Grained Alluvium was modeled with drained strengths for all analyses. CPT data indicates this material will not behave in an undrained state during the scenarios considered in stability analyses.

The selected properties used for stability analyses are listed in Table 2. Also, the selected strengths are plotted with the CPT correlated values on the attached CPT logs.

Table 2: Selected Material Properties for Use in Slope Stability Analysis

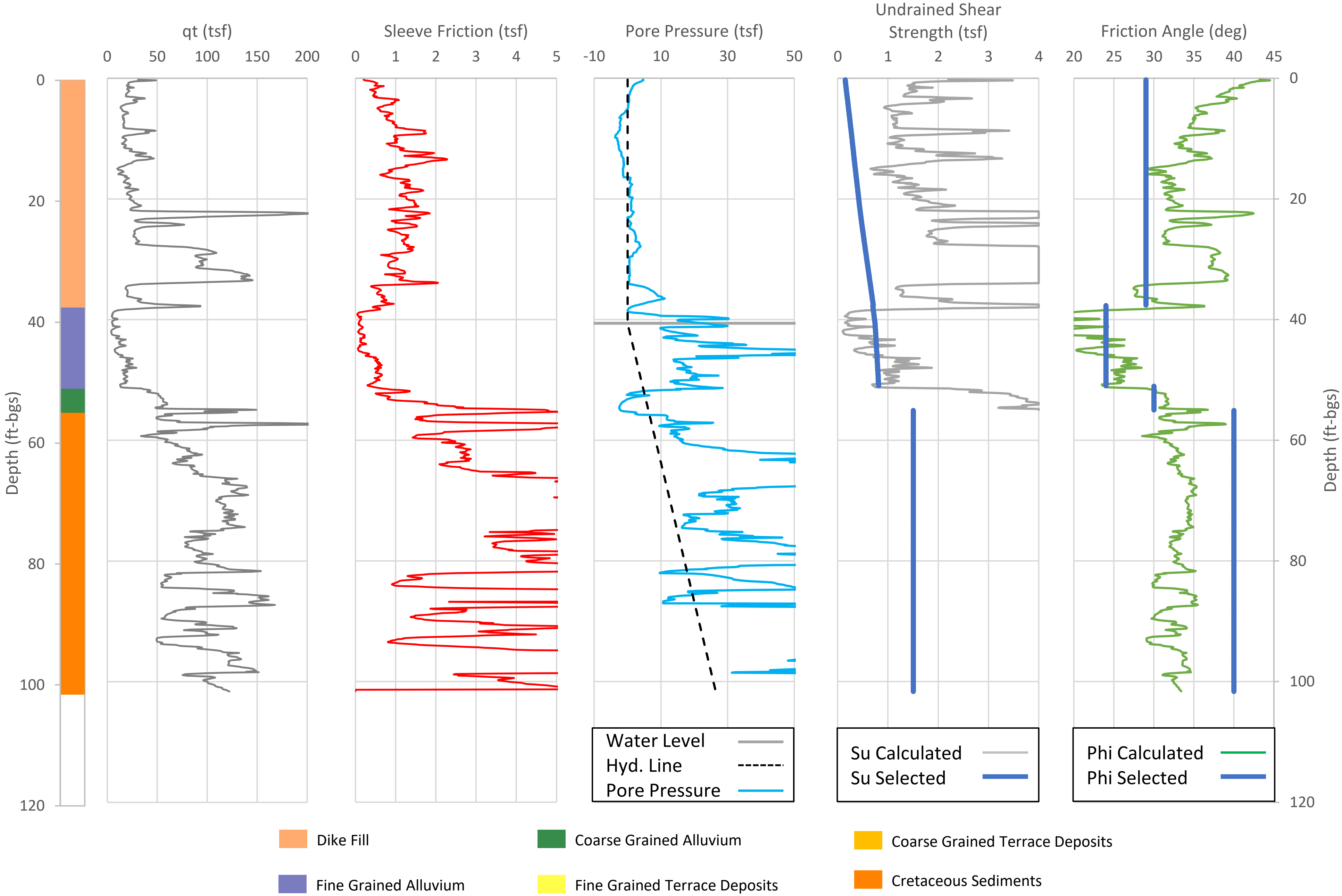
Material	Drained Strength		Undrained Strength		Unit Weight (pcf)
	ϕ' (degrees)	c' (psf)	ϕ (degrees)	c (psf)	
Dike Fill	29	100	14	290	120
Fine Grained / Organic Alluvium	24	0	12.4	400	100
Coarse Grained Alluvium	30	0	N/A	N/A	120
Fine Grained Terrace Deposits	28	75	12.4	400	120
Coarse Grained Terrace Deposits	34	0	N/A	N/A	125
Cretaceous Sediments	40	0	0	3000	130

4.0 REFERENCES

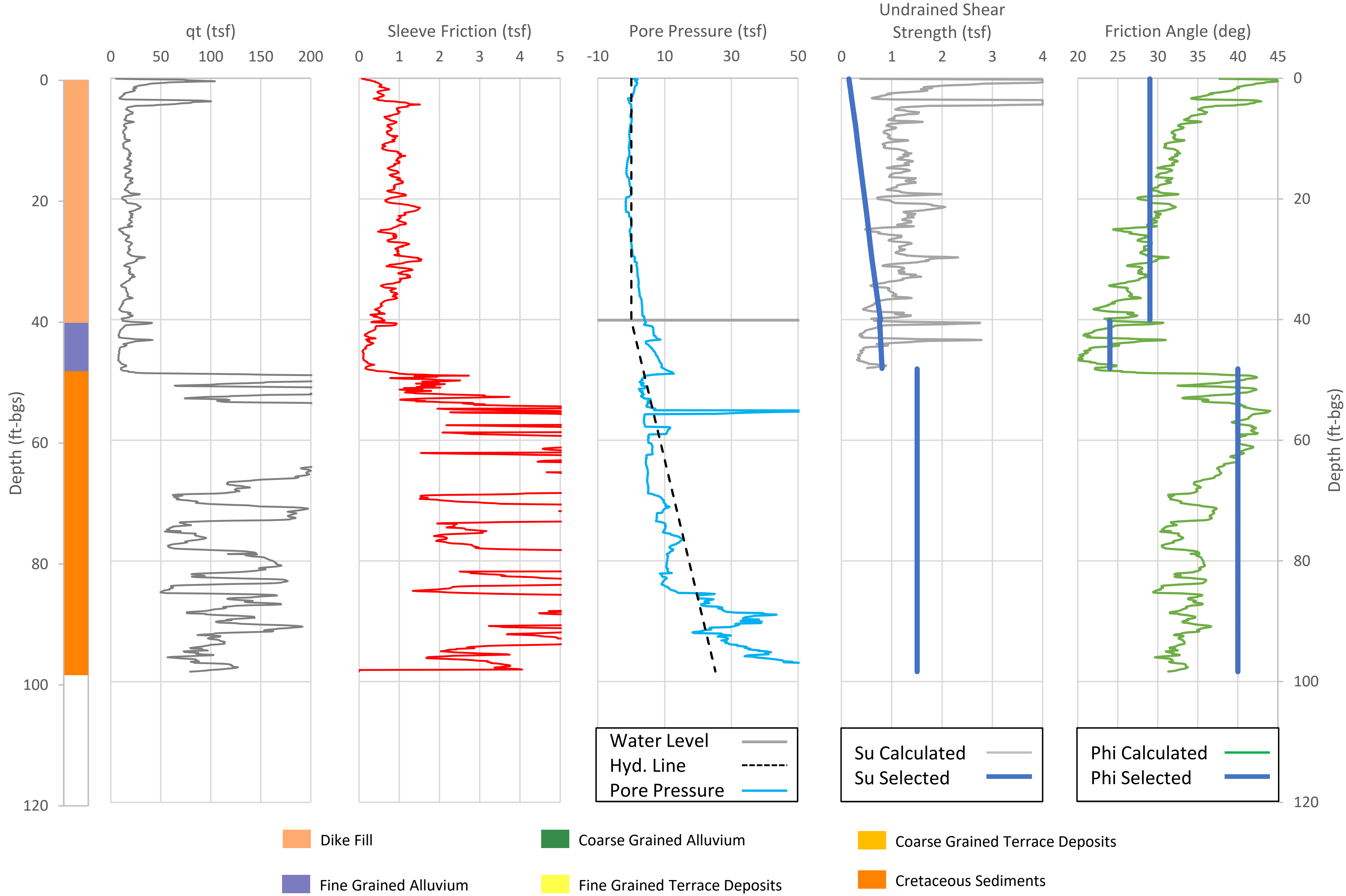
Schnabel Engineering (2011). "Geotechnical Engineering Study, Slope Stability Evaluation of Ash Pond E, Dominion Resources Services, Inc., Possum Point Power Station, Prince William County, Virginia." April 29, 2011.

Law Engineering Testing Company (1985). "Soil Investigation at Possum Point Ash Pond, Dumfries, Virginia, LETCO Job No. W4-4744." April 8, 1985

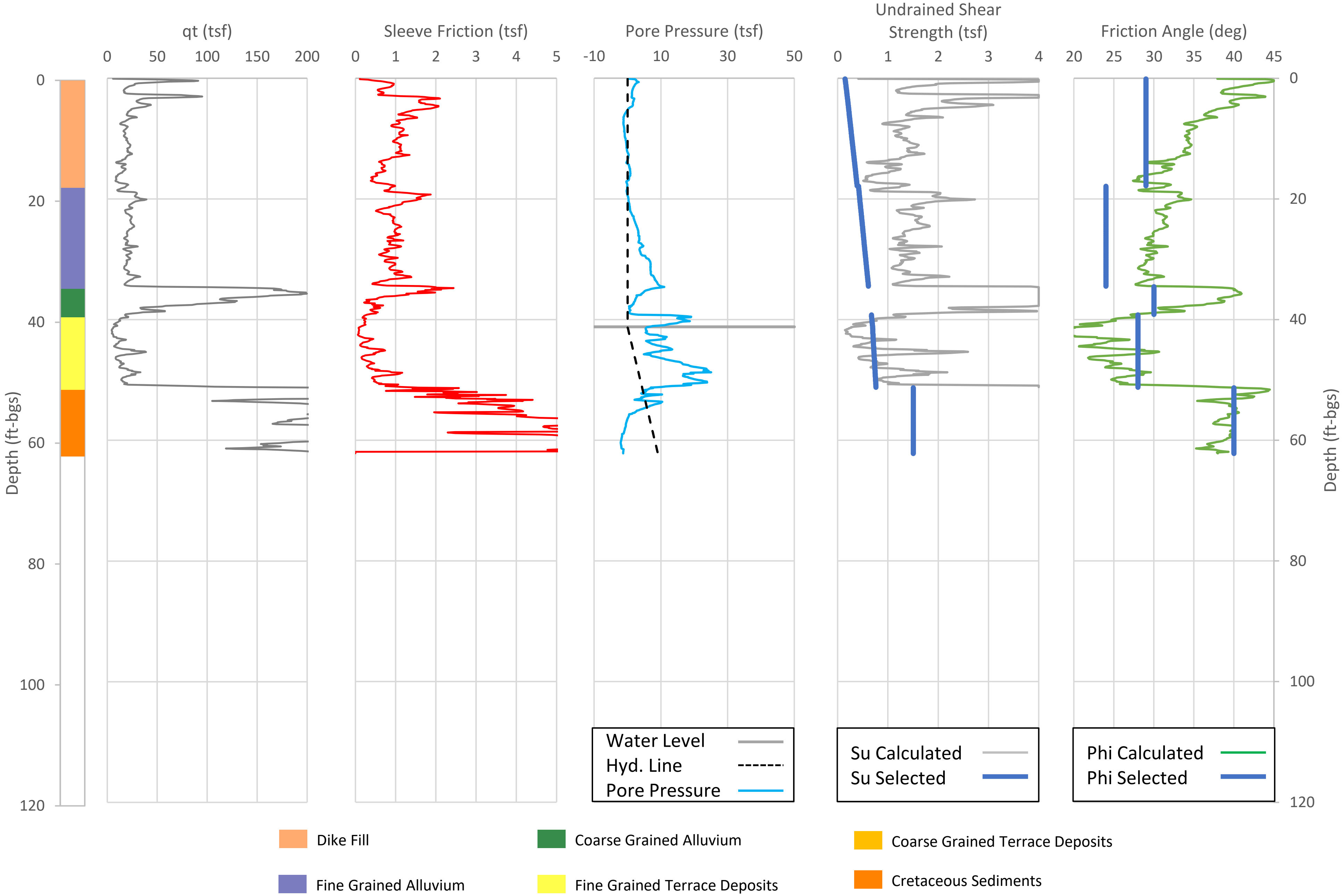
Test ID:	**CPT-E-01**	**CPT Rig Type:**	**Truck**		**Project #:**	**1662150**
GS Elev. (ft-msl):	**40.6**	**Location:**	**Possum Point**		**Project Name:**	**Inactive Pond Demonstrations**
Test Depth (ft):	**101.6**	**Groundwater Depth (ft-bgs):**		**40.6**	**Client:**	**Domnion Energy**



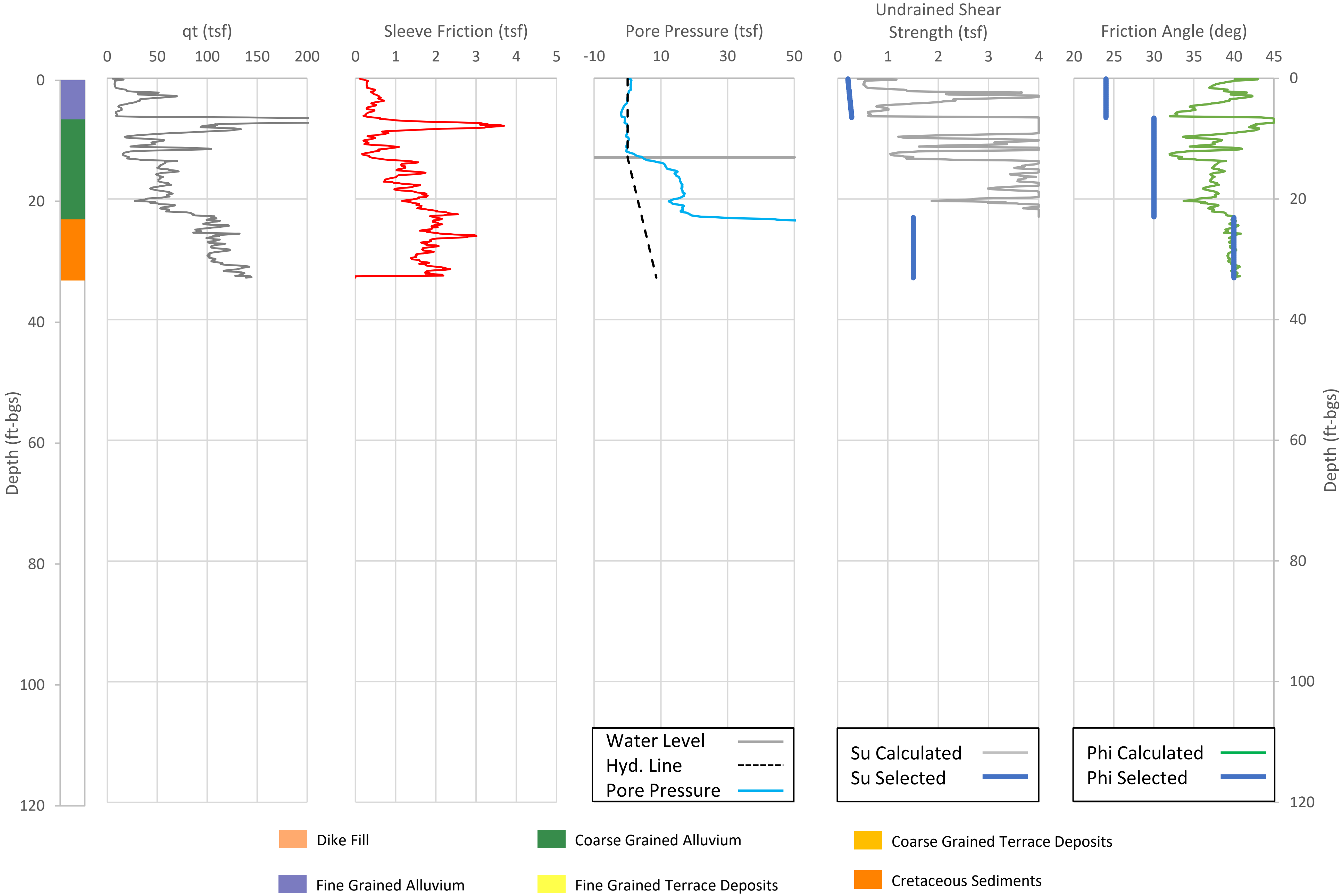
Test ID:	**CPT-E-02**	**CPT Rig Type:**	**Truck**	**Project #:**	**1662150**
GS Elev. (ft-msl):	**40.1**	**Location:**	**Possum Point**	**Project Name:**	**Inactive Pond Demonstrations**
Test Depth (ft):	**98.3**	**Groundwater Depth (ft-bgs):**	**40.1**	**Client:**	**Domnion Energy**



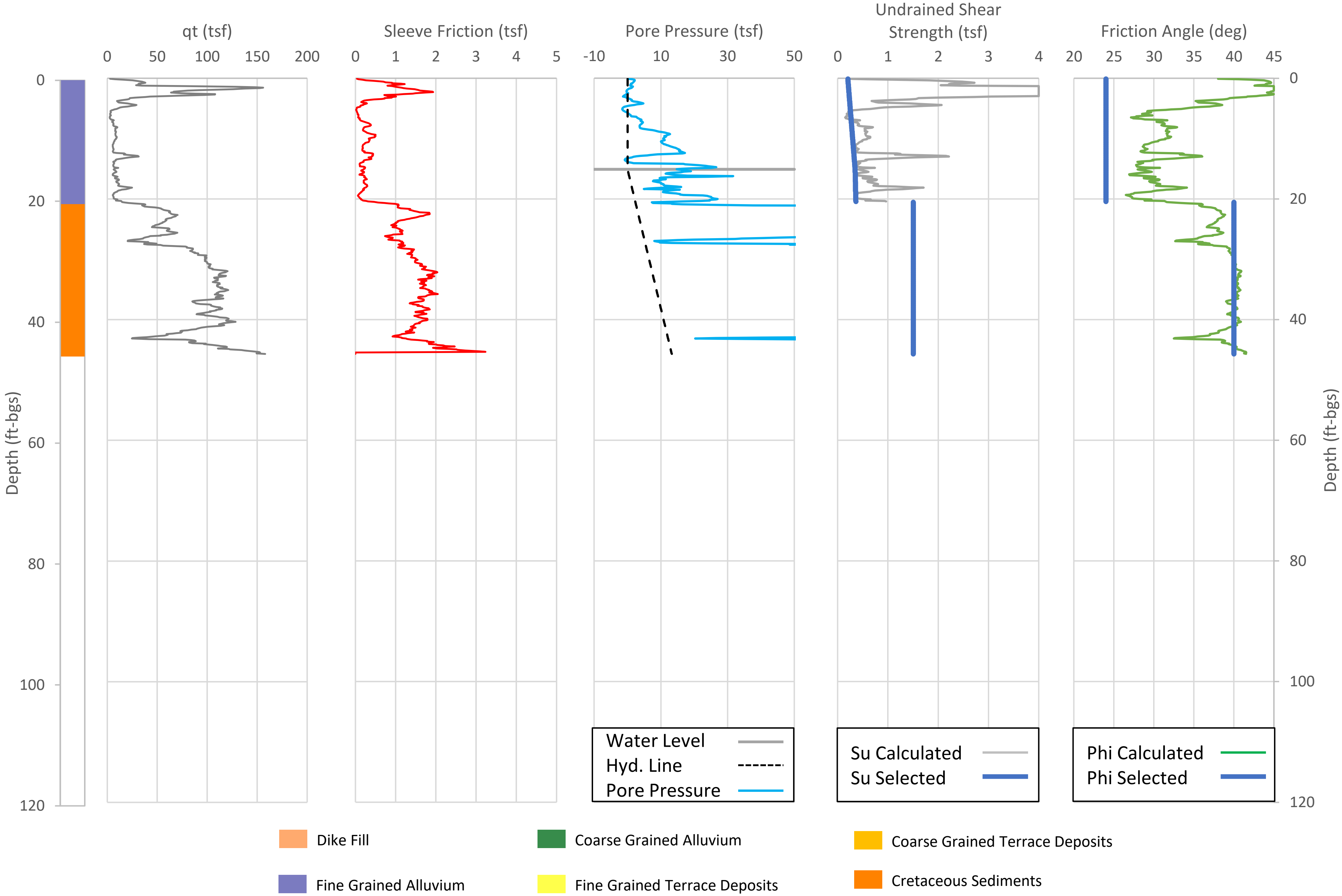
Test ID:	**CPT-E-03**	**CPT Rig Type:**	**Track**	**Project #:**	**1662150**
GS Elev. (ft-msl):	**41.2**	**Location:**	**Possum Point**	**Project Name:**	**Inactive Pond Demonstrations**
Test Depth (ft):	**62.2**	**Groundwater Depth (ft-bgs):**	**41.2**	**Client:**	**Domnion Energy**



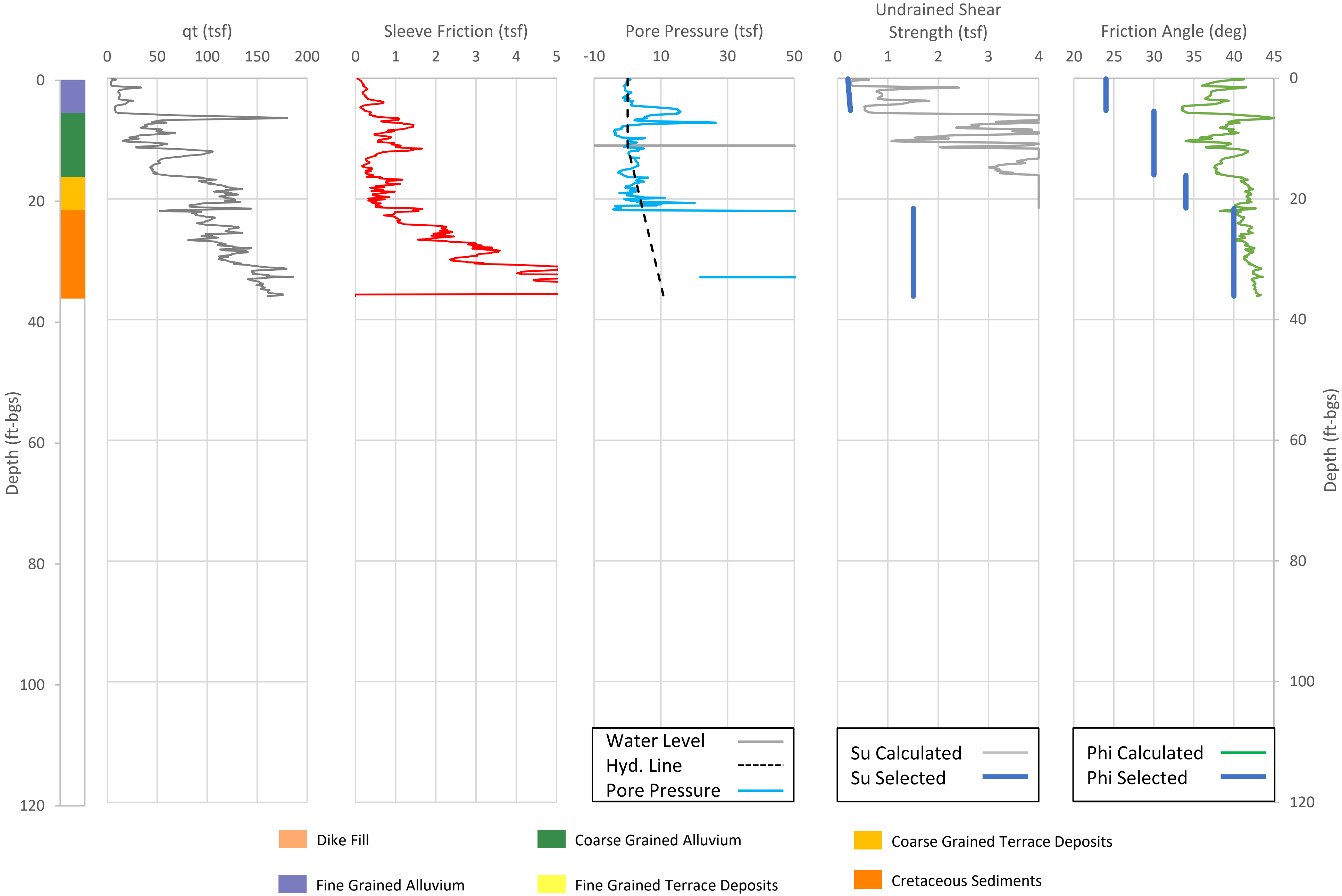
Test ID:	**CPT-E-04**	**CPT Rig Type:**	**Track**	**Project #:**	**1662150**
GS Elev. (ft-msl):	**13.1**	**Location:**	**Possum Point**	**Project Name:**	**Inactive Pond Demonstrations**
Test Depth (ft):	**33.1**	**Groundwater Depth (ft-bgs):**	**13.1**	**Client:**	**Domnion Energy**



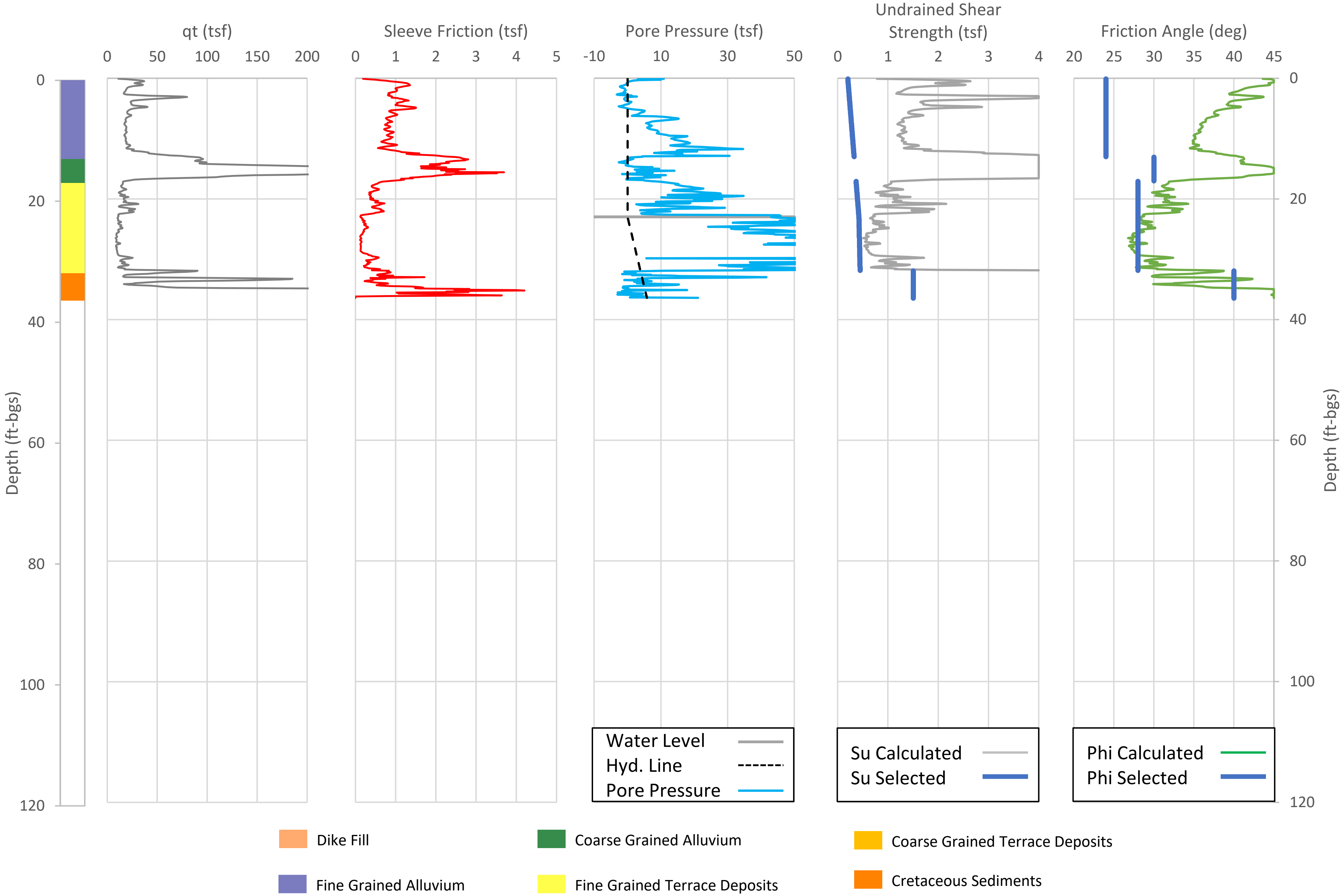
Test ID:	**CPT-E-05**	**CPT Rig Type:**	**Track**	**Project #:**	**1662150**
GS Elev. (ft-msl):	**15.1**	**Location:**	**Possum Point**	**Project Name:**	**Inactive Pond Demonstrations**
Test Depth (ft):	**45.7**	**Groundwater Depth (ft-bgs):**	**15.1**	**Client:**	**Domnion Energy**



Test ID:	**CPT-E-06**	**CPT Rig Type:**	**Track**		**Project #:**	**1662150**
GS Elev. (ft-msl):	**11.2**	**Location:**	**Possum Point**		**Project Name:**	**Inactive Pond Demonstrations**
Test Depth (ft):	**36.1**	**Groundwater Depth (ft-bgs):**		**11.2**	**Client:**	**Domnion Energy**



Test ID:	**CPT-E-07**	**CPT Rig Type:**	**Track**	**Project #:**	**1662150**
GS Elev. (ft-msl):	**23.0**	**Location:**	**Possum Point**	**Project Name:**	**Inactive Pond Demonstrations**
Test Depth (ft):	**36.4**	**Groundwater Depth (ft-bgs):**	**23.0**	**Client:**	**Domnion Energy**



ATTACHMENT 2

Seismic Hazard Calculation Package

CALCULATIONS

Date:	January 9, 2018	**Made by:**	L. Jin
Project No.:	1662150	**Checked by:**	G. Martin
Subject:	Seismic Hazard Assessment	**Reviewed by:**	G. Hebeler
Project:	**POSSUM POINT POND E – INACTIVE POND DEMONSTRATION**		

1.0 OBJECTIVE

This calculation package identifies and summarizes the seismic hazard at the project site located at 77.286˚W and 38.547˚N. The seismic hazard assessment is necessary for geotechnical design evaluations of stability under earthquake loading and liquefaction susceptibility.

2.0 SEISMIC HAZARD SUMMARY

For ash pond closures, the United State Environmental Protection Agency's (USEPA) CCR Rule has specified seismic analyses be completed for a seismic event with a 2% probability of exceedance in 50 years (2% / 50yr), equivalent to a return period of approximately 2,500 years. The United States Geological Survey (USGS) has provided online tools associated with this hazard for its 2014 seismic hazard model. The sections below detail the use of these tools to obtain seismic hazard data for use in analyses.

3.0 PEAK GROUND AND SPECTRAL ACCELERATION

The peak ground acceleration (PGA) and spectral ground accelerations (S_a) corresponding to a range of spectral periods are necessary for many engineering analyses including slope stability analysis and liquefaction analysis. For a 2% probability of exceedance (PE) in 50 years, The USGS provides a reference PGA and spectral accelerations corresponding to a reference site on the border between the National Earthquake Reductions Hazard Program (NEHRP) site classes B (Rock) and C (Dense Soil) with an average shear wave velocity in the upper 30 m (V_{s30}) of 760 m/s. These reference accelerations are often referenced with a BC subscript (e.g. PGA_{BC}) and are scaled as appropriate to match site conditions and analysis input requirements. Figure 1 below shows the project site on the 2014 seismic hazard map for PGA_{BC}, and Figure 2 displays the uniform hazard response spectrum curve, which plots the reference spectral acceleration, or ground motion, for various spectral periods. The uniform hazard response spectrum curve is presented in tabular form in Table 1.

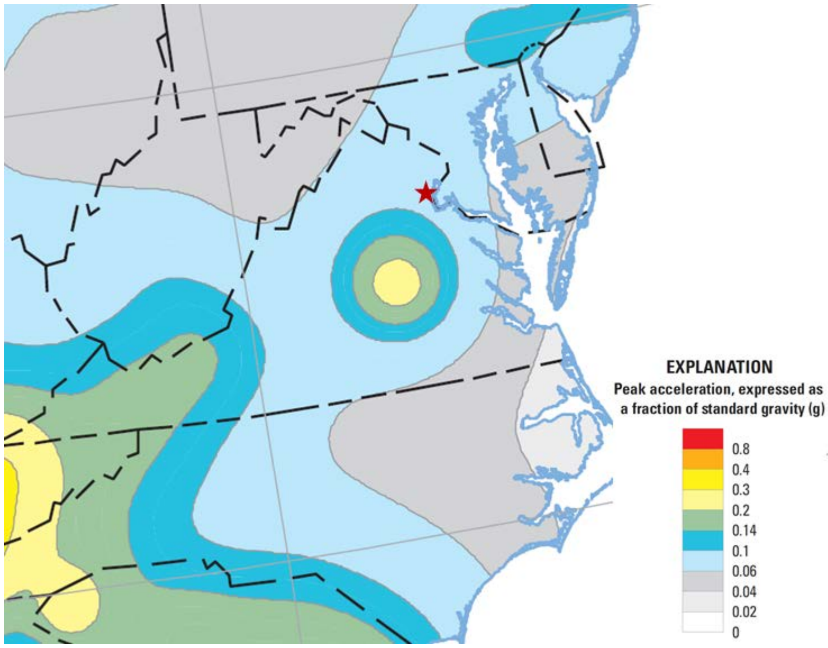


Figure 1: PGA_{BC} for the 2% PE in 50 years at the project site (red star). (USGS 2014).

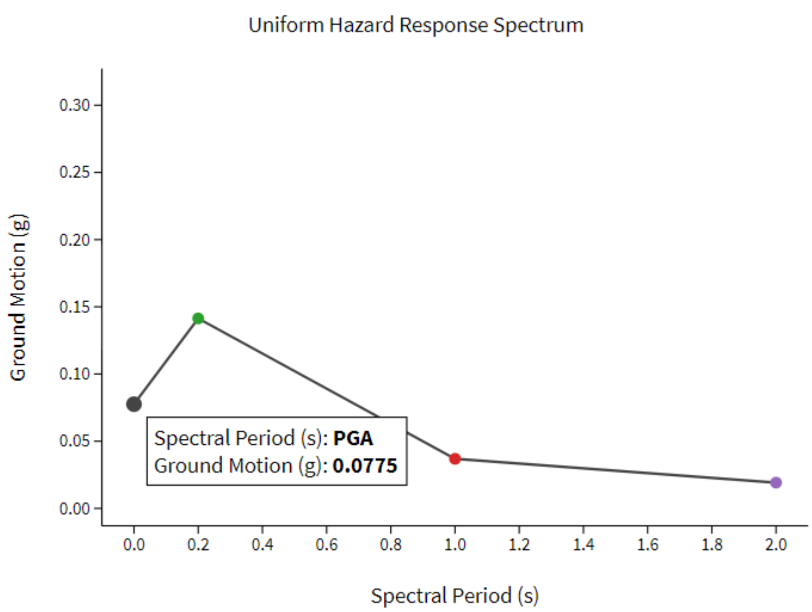


Figure 2: Uniform Hazard Response Spectrum for the 2% PE in 50 years Seismic Hazard at the Project Site (USGS 2014).

Table 1: Reference site (BC) PGA and Spectral Acceleration for the 2% PE in 50 year Seismic Hazard at the Project Site (USGS 2014).

Spectral Period (s)	Acceleration, BC (g)
0 (PGA)	0.0775
0.2	0.1414
1.0	0.0369
2.0	0.0192

3.1 Seismic Hazard Deaggregation

The seismic hazard is compiled from multiple predictive models which consider many seismic sources of varying combinations of earthquake magnitude and distance from the project site. For each magnitude and distance pair, models predict the resulting accelerations and activity rates for the project site. The results of these predictive models are aggregated to produce the seismic hazard model for specified return periods. The seismic hazard model can be deaggregated to obtain the contribution to hazard percentage of each magnitude and distance combination. This information is necessary for analyzes requiring earthquake magnitude (e.g. liquefaction susceptibility) or distance. Figure 3 below displays a deaggregation plot of the PGA_{BC} at the project site for a 2% PE in 50 years with descriptive statistics available through the USGS online tools.

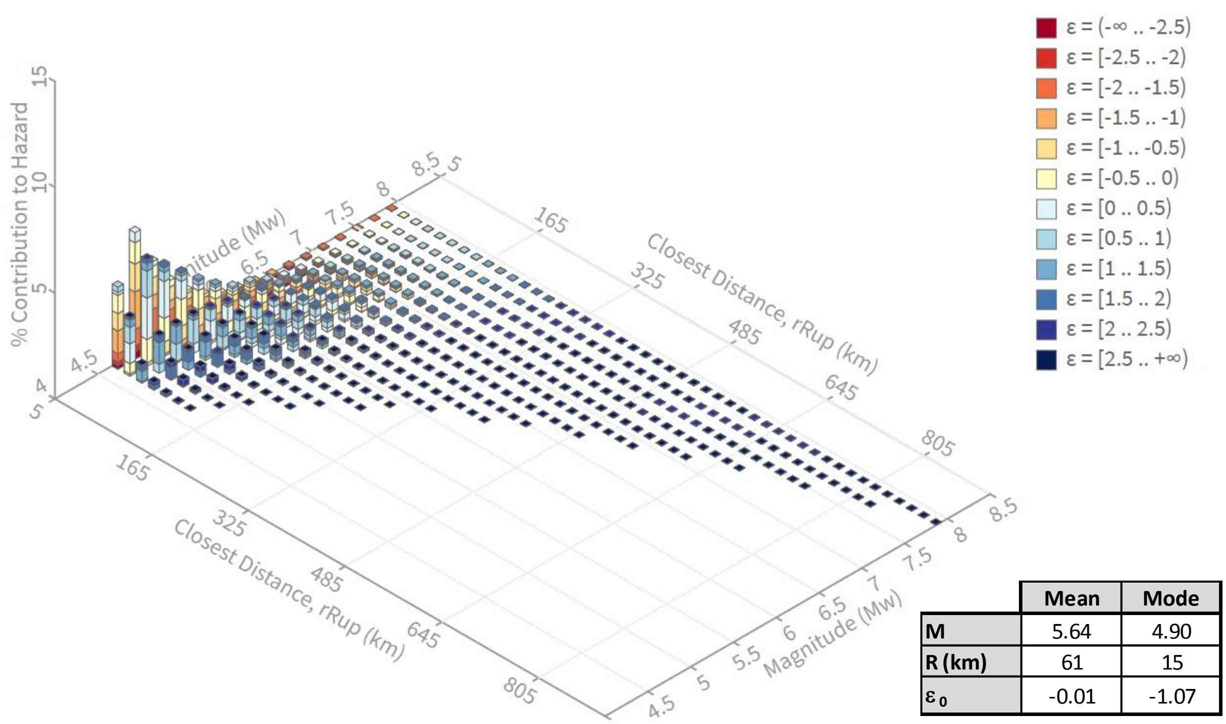


Figure 3: Deaggregation Plot of the PGA_{BC} at the Project Site for a 2% PE in 50 Years

3.2 Design Earthquake Magnitude

Some seismic analysis methods require a design earthquake magnitude as an input. One such analysis is the liquefaction screening method. Based on its application in the liquefaction screening, a design earthquake magnitude of 5.50 was selected. Additional details on the design earthquake magnitude are available in the Liquefaction Assessment Calculation Package. This design earthquake magnitude was used in all analyses for consistency.

4.0 DETERMINATION OF SITE-SPECIFIC PEAK GROUND ACCELERATION

For liquefaction analysis, the site-specific peak ground acceleration at the surface, a_{max}, was calculated from the site reference peak ground acceleration (PGA_{BC}). The PGA_{BC} was multiplied by an amplification factor calculated from the average shear wave velocity in the upper 30 meters (Vs30) to obtain a representative a_{max}. The shear wave velocity was directly measured every meter in CPT-E-01, and a representative shear wave velocity was derived from these measurements. Figure 4 shows the measured shear wave velocities and the representative shear wave velocity profile. The Vs30 (listed in Table 2) was calculated from the representative profile to be 904 ft/s.

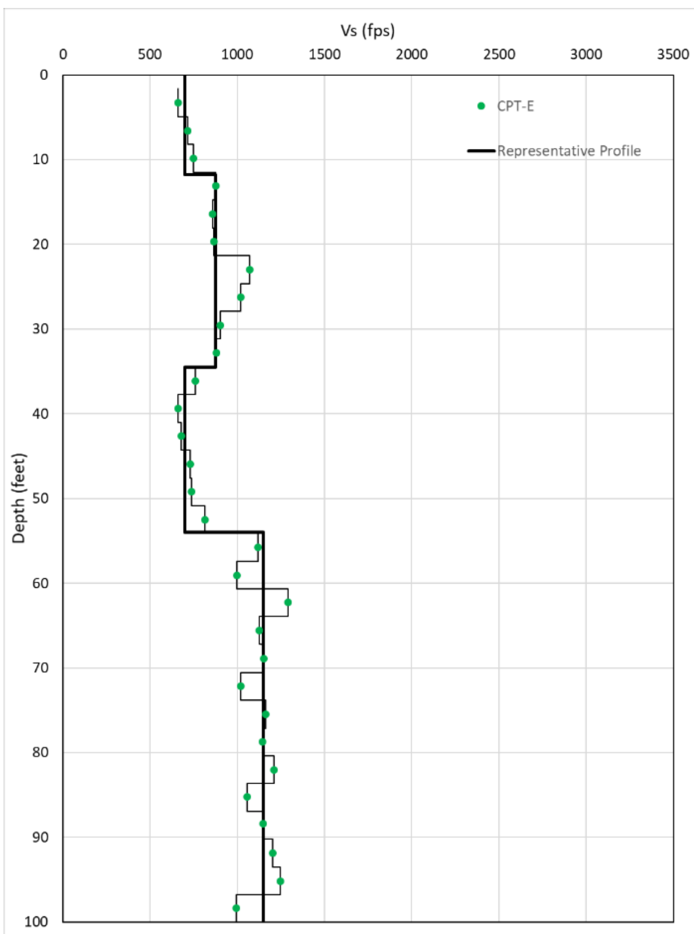


Figure 4. Shear wave velocity profile for Pond E

Table 2: Representative Shear Wave Velocity in the Upper 30 m (Vs30)

Pond ID	Vs30 (ft/s)	Vs30 (m/s)
E	904	276

4.1 Determination of site coefficient F_a

An amplification factor was evaluated from two sources:

- Atkinson and Boore's 2006 publication on earthquake ground-motion prediction equations for Eastern North America
- the International Building Code (IBC, 2012)

Atkinson and Boore's publication provides a site response term which is used to amplify the PGA_{BC}, and the IBC provides a site coefficient F_a (amplification factor) as well. Amplification factors from these two sources were averaged to obtain a representative amplification factor.

Table 3: Site coefficient F_a

Pond ID	Atkinson and Boore (2006)	IBC (2012)	Selected for Analysis
E	1.53	1.59	1.56

4.2 Site-specific peak ground acceleration a_{max}

$$a_{max} = PGA_{BC} * F_a = 0.0775g * 1.39 = 0.12\ g \quad (1)$$

With an amplification factor F_a of 1.56, Golder calculated the site-specific peak ground acceleration a_{max} to be 0.12 g for the considered seismic hazard.

Table 4: a_{max} at Pond E, Possum Point

Pond ID	a_{max}
E	0.12 g

5.0 PSEUDOSTATIC COEFFICIENT

For slope stability analyses, Golder used the Bray and Travasarou (2009) screening method which models the seismic loading using a pseudostatic coefficient (k). This section details the calculation of the pseudostatic coefficient for the project site. Details on the slope stability analysis are available in a separate calculation package.

Stability under seismic conditions is calculated using the pseudo-static method to model horizontal seismic forces as the product of a seismic coefficient (k) and the weight of the sliding mass. Bray and Travasarou

(2009) proposed screening methodology to determine the seismic coefficient k based on the degraded period of the sliding mass and an allowable seismic displacement threshold. The screening method includes an equation to calculate the pseudostatic coefficient for periods of 0.2 and 0.5 seconds, which encompasses the range of typical slope periods. A period of 0.2 s is more conservative, so for this analysis, Golder used the equation associated with a period of 0.2 s and an allowable seismic displacement of 15 cm:

$$\boldsymbol{k_{15\,cm} = (0.036M_w - 0.004)S_a - 0.030 > 0.0,\ for\ S_a = S_a(T = 0.2\ s) < 2.0}\ \mathrm{g} \tag{2}$$

Where, k_{15cm} = pseudostatic coefficient

M_w = Design Earthquake Magnitude

S_a = Spectral acceleration at the base of the sliding mass

As noted in Section 3.0, the BC spectral acceleration at a period of 0.2 s is 0.1414 g. This value is multiplied by an amplification factor to obtain the acceleration at the base of the sliding mass. Golder used an amplification factor of 1.6 as prescribed by the international building code (IBC 2012) for a site class D. The project site was classified as D according to the representative shear wave velocity in the upper 30 meters or 100 feet (Vs30). Thus, the spectral acceleration S_a used in the equation is 0.226 g (0.1414g x 1.6). The pseudostatic coefficient was calculated to be 0.01 g as shown in the table below.

Table 5: $\boldsymbol{k_{15\,cm}}$ at Pond E, Possum Point

Pond ID	$\boldsymbol{k_{15\,cm}}$
E	0.01 g

6.0 REFERENCE

Atkinson, G.M. and D.M. Boore (2006) "Earthquake Ground-Motion Prediction Equations for Eastern North America," Bulletin of the Seismological Society of America, Vol. 96, No. 6, pp. 2181-2205.

Bray, J.D., and Travasarou, T. (2009). Pseudostatic Coefficient for Use in Simplified Seismic Slope Stability Evaluation. Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 9: pp. 1336-1340.

United States Geologic Survey (2018), Unified Hazard Tool. Accessed January 9, 2018. https://earthquake.usgs.gov/hazards/interactive/.

International Code Council, Inc. (2012), "2012 Insertional Building Code", Section 1613.3

ATTACHMENT 3

Liquefaction Assessment Calculation Package

CALCULATIONS

Date:	March 7 2018	**Made by:**	L. Jin
Project No.:	1662150	**Checked by:**	G. Martin
Subject:	Liquefaction Assessment	**Reviewed by:**	G. Hebeler
Project:	**POSSUM POINT POND E – INACTIVE POND DEMONSTRATION**		

1.0 OBJECTIVE

The objective of this calculation is to assess the liquefaction potential of the foundation soils and dikes surrounding Ash Pond E at Dominion Energy's Possum Point Power Station in Dumfries, VA. Liquefaction potential is assessed for the final closure condition of these ponds.

This liquefaction assessment uses the screening-level assessment described in Youd et al. (2001). Cone Penetration Test (CPT) data is used to characterize soils for this assessment with updates suggested by Robertson (2009).

2.0 LIQUEFACTION ASSESSMENT METHODOLOGY

Seismically-induced liquefaction susceptibility was evaluated using the National Center for Earthquake Engineering Research (NCEER) simplified procedure with CPT data (Youd et al., 2001). The simplified procedure is an empirical method used to calculate the factor of safety against liquefaction. The factor of safety is defined as a ratio of the cyclic resistance ratio (CRR) to the cyclic stress ratio (CSR). The CRR is a measure of a soil's resistance to liquefaction and was estimated using CPT data. The CSR is a measure of the seismic demand on the soil and was estimated using seismic hazard assessment resources provided by the United States Geologic Survey (USGS) as described in Golder's Seismic Hazard Assessment package.

2.1 CSR Determination

The CSR is defined as:

$$CSR = \frac{\tau_{ave}}{\sigma'_v} = 0.65\left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_v}{\sigma'_v}\right)r_d$$

where a_{max} is the peak horizontal acceleration at the ground surface, g is the acceleration due to gravity, σ_v is the total vertical overburden stress, σ'_v is the effective vertical overburden stress, and r_d is a depth-dependent stress reduction factor defined as:

$$r_d = 1.0 - 0.00765z \quad for\ z \leq 9.15\ m$$

$$r_d = 1.174 - 0.0267z \quad for\ 9.15\ m < z \leq 23\ m$$

$$r_d = 0.744 - 0.008z \quad for\ 23\ m < z \leq 30\ m$$

$$r_d = 0.50 \quad for\ z > 30\ m$$

where z is the depth in meters (m). The determination of the a_{max} (0.12 g) is provided in the Golder's Seismic Hazard Calculation Package.

2.2 CRR Determination

The second major step in assessing the liquefaction susceptibility using the simplified approach is to estimate the CRR. Robertson and Wride (1998) developed the procedure for calculating CRR from the CPT as a function of the "clean sand" cone penetration resistance normalized to 1 atmosphere (atm; approximately 100 kilopascals; kPa) and given as $(q_{c1N})_{cs}$. The CRR is based on an earthquake magnitude of 7.5 and a magnitude scaling factor (MSF) adjusts the CRR for magnitudes other than 7.5.

The CRR for an earthquake magnitude (M) of 7.5 is given as:

$$(q_{c1N})_{cs} < 50 \quad CRR_{7.5} = 0.833\left[\frac{(q_{c1N})_{cs}}{1000}\right] + 0.05$$

$$50 \leq (q_{c1N})_{cs} < 160 \quad CRR_{7.5} = 93\left[\frac{(q_{c1N})_{cs}}{1000}\right]^3 + 0.08$$

where $(q_{c1N})_{cs}$ is the clean sand cone penetration resistance normalized to 1 atm (approximately 100 kPa or 1 ton per square foot; tsf).

The tip resistance (q_c) is normalized to obtain q_{c1N} as:

$$q_{c1N} = C_Q\left(\frac{q_c}{P_a}\right)$$

$$C_Q = \left(\frac{P_a}{\sigma'_v}\right)^n$$

where C_Q is the normalizing factor for cone penetration resistance, P_a is 1 atm of pressure, n is an exponent that is dependent on the soil type, and q_c is the cone tip penetration resistance (q_c is replaced by q_t the cone tip resistance corrected for geometric impacts of the pore pressure measurement in all instances).

The method adopted in this assessment calculates the exponent, n, according to a method developed by Robertson (2009) and represents a small modification from the standard NCEER approach. The exponent, n, is calculated as:

$$n = 0.381 I_c + 0.05\left(\frac{\sigma'_{vo}}{P_a}\right) - 0.15 \leq 1.0$$

where

$$I_c = [(3.47 - log Q_{t1})^2 + (1.22 + log F_r)^2]^{0.5}$$

$$Q_{t1} = \left[\frac{q_c - \sigma_{vo}}{\sigma'_{vo}}\right]$$

$$F_r = \left[\frac{f_s}{q_c - \sigma_{vo}}\right] \times 100\%$$

2.2.1 Clean Sand Equivalent Cone Penetration Resistance $(q_{c1N})_{cs}$

According to the NCEER approach, the presence of fines affects the liquefaction resistance of soils. A correction factor, K_c, is applied to the normalized penetration resistance (q_{c1N}) to determine the clean sand equivalent $(q_{c1N})_{cs}$ where

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

$$for\ I_c \leq 1.64 \quad K_c = 1.0$$

$$for\ I_c > 1.64 \quad K_c = -0.403 I_c^4 + 5.581 I_c^3 - 21.63 I_c^2 + 33.75 I_c - 17.88$$

2.2.2 Magnitude Scaling Factor (MSF)

The magnitude scaling factor (MSF) adjusts the CRR for magnitudes other than 7.5 (Youd et al. 2001) where the factor of safety against liquefaction is calculated as

$$FS = \frac{CRR_{7.5}}{CSR} \times MSF$$

A number of different MSF values are discussed in the NCEER approach. The MSF values used in this assessment are the revised Idriss values (which are considered a lower bound set of values), and are calculated as:

$$MSF = \frac{10^{2.24}}{M^{2.56}}$$

Where M is the design earthquake magnitude.

A probabilistic seismic hazard analysis was used to estimate the ground acceleration, and while such an analysis includes the aggregate contributions of all possible combinations of magnitude and distance from all sources, a design earthquake magnitude is not specified in the probabilistic tools provided by the USGS.

The simplified approach requires the selection of a single earthquake magnitude. Since liquefaction is sensitive to ground motion duration, which is correlated to earthquake magnitude, this selection is an important issue in liquefaction assessments.

The selection of either the mean or modal magnitude produces inconsistent risks of liquefaction because the relationship between duration (represented by magnitude) and liquefaction potential is non-linear. Kramer (2008) suggests that the best way to handle this issue is to perform liquefaction calculations for all magnitudes and to weight the results according to the relative contribution of each magnitude.

Golder has implemented this approach by recognizing that the MSF is the only term in the simplified approach that is affected by the magnitude selection. Golder calculated a weighted-average MSF (weighted by the relative contribution of each magnitude) and then calculated the magnitude corresponding to that MSF.

Golder calculated the earthquake magnitude to be 5.50. This value is less than the mean magnitude (5.64), and is greater than the modal magnitude (4.90).

2.3 Factor of Safety Against Liquefaction

The factor of safety was calculated as:

$$FS = \frac{CRR_{7.5}}{CSR} \times MSF$$

The factor of safety was calculated for every recorded depth reading in each CPT. Liquefaction calculations for each CPT including the calculated factors of safety are graphically presented in the figures attached to the end of this text.

3.0 RESULTS AND CONCLUSIONS

The USEPA's 2015 Final Rule on the Disposal of Coal Combustion Residuals (CCR, EPA Rule) specify a required factor of safety of 1.2 against liquefaction for pond impoundment structures in section § 257.73(e)(iv). The dikes and foundation soils at Possum Point Pond E meet this requirement as all calculated factors of safety against liquefaction for both dike and foundation materials are in excess of 1.2 for all CPT soundings analyzed.

4.0 REFERENCES

Atkinson, G.M. and D.M. Boore (2006) "Earthquake Ground-Motion Prediction Equations for Eastern North America," *Bulletin of the Seismological Society of America,* Vol. 96, No. 6, pp. 2181-2205.

Kramer, S.L. (2008). "Evaluation of Liquefaction Hazards in Washington State" Final Research report WA-RD 668.1, December 2008.

Robertson, P.K. and C.E. (Fear) Wride (1998) “Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test,” *Canadian Geotechnical Journal*, Vol. 35, pp. 442-459.

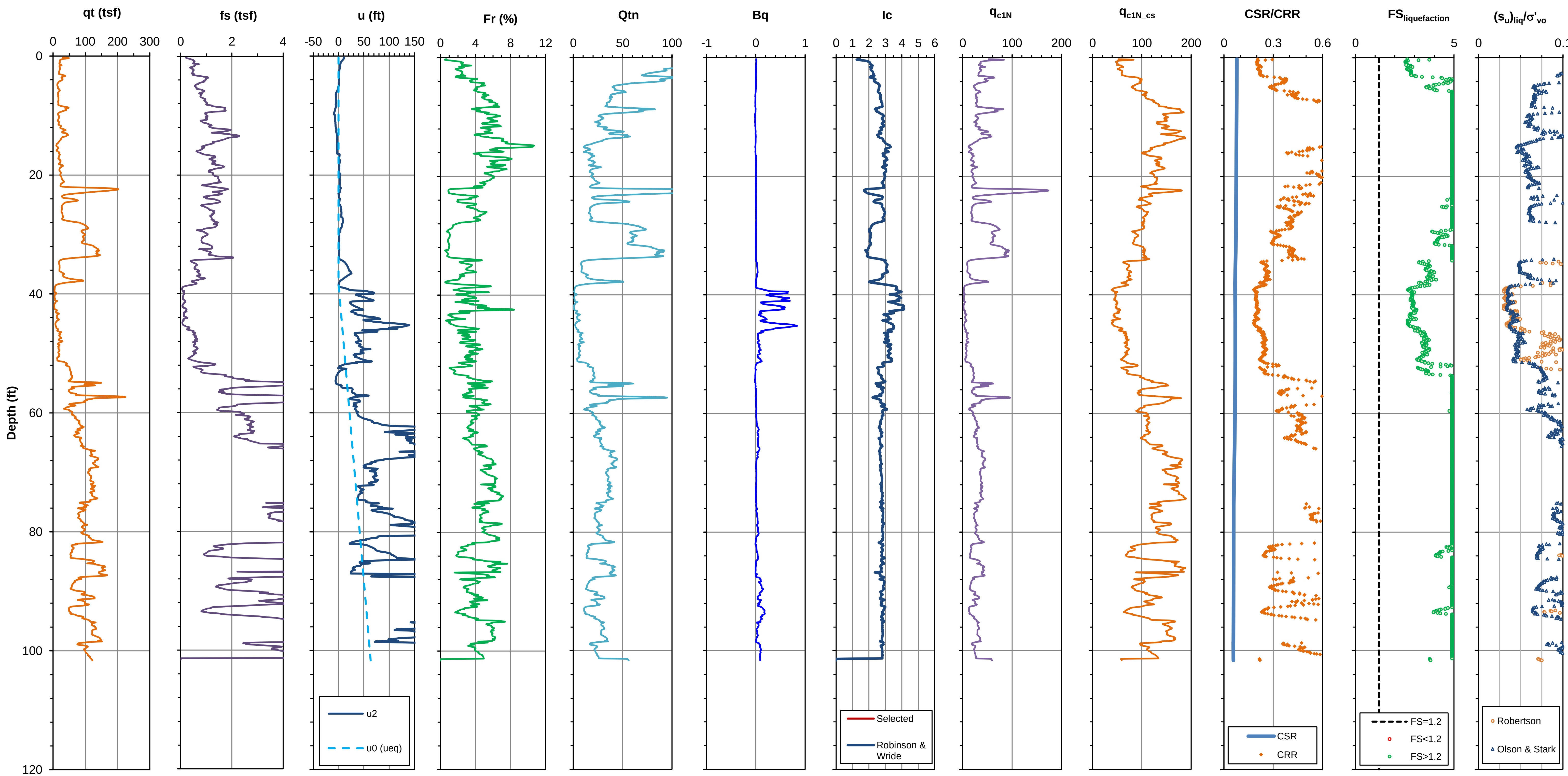
Youd, T.L. et al. (2001). “Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF workshops on Evaluation of Liquefaction Resistance of Soils”, Journal of Geotechnical and Geoenvironmental Engineering, vol. 127, No. 4, April 2001.

5.0 ATTACHMENTS

Liquefaction Factor of Safety Results

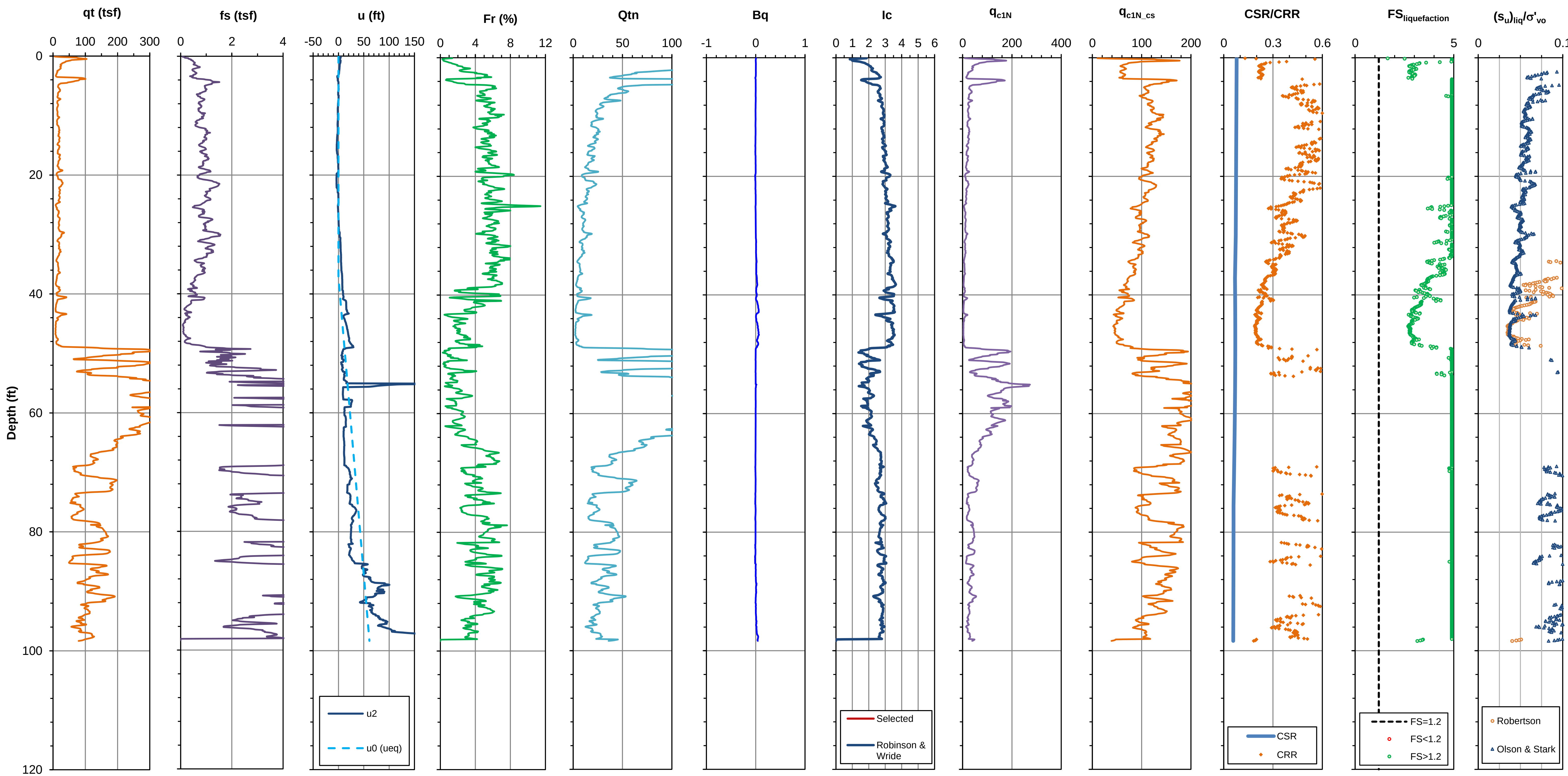
Test Date:	12/18/2017	**Project:**	Possum Point Pond E	**Test Type:**	CPTU	**Water Table:**	38.2 ft	**2% PE in 50 years Seismic Hazard**	
Test ID:	CPT-E-01	**Location:**	Dumfries, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	LJ	**Magnitude:**	5.5
Latitude	38.55141	**Client:**	Dominion Energy	**Standard:**	ASTM D5778	**Check**	JGM	$\mathbf{a_{max}}$:	0.12 g
Longitude	-77.29381	**Proj No.:**	1662150	**Push Co.:**	ConeTec	**Review:**			
Elevation:	40.6 ft	**Termination:**	60.2 ft-bgs	**Operator:**	ConeTec				

Golder Associates



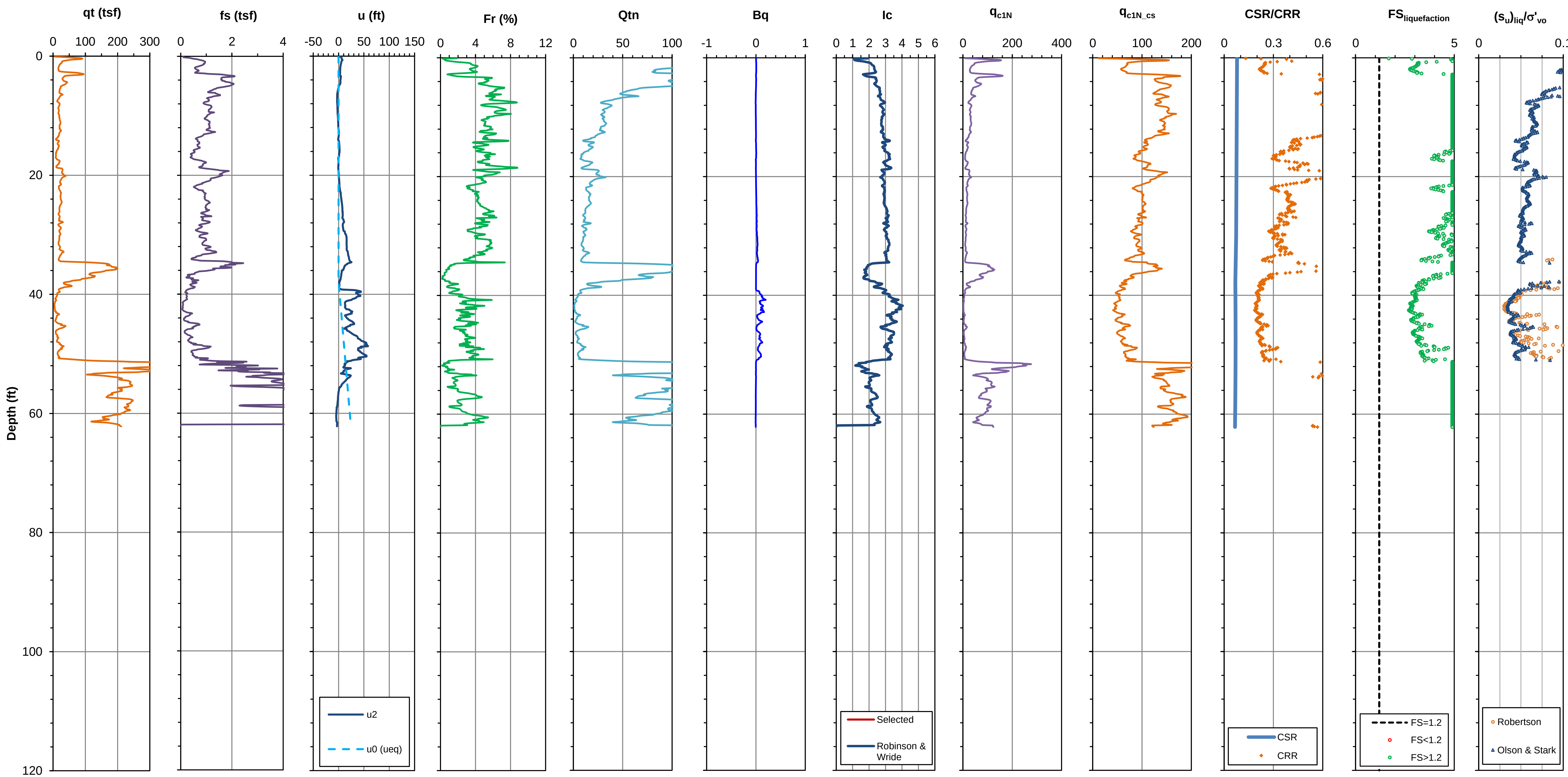
Test Date:	12/18/2017	**Project:**	Possum Point Pond E	**Test Type:**	CPTU	**Water Table:**	37.2 ft	**2% PE in 50 years Seismic Hazard**	
Test ID:	CPT-E-02	**Location:**	Dumfries, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	LJ	**Magnitude:**	5.5
Latitude	38.55212	**Client:**	Dominion Energy	**Standard:**	ASTM D5778	**Check**	JGM	**a_{max}:**	0.12 g
Longitude	-77.29361	**Proj No.:**	1662150	**Push Co.:**	ConeTec	**Review:**			
Elevation:	40.1 ft	**Termination:**	60.2 ft-bgs	**Operator:**	ConeTec				

Golder Associates

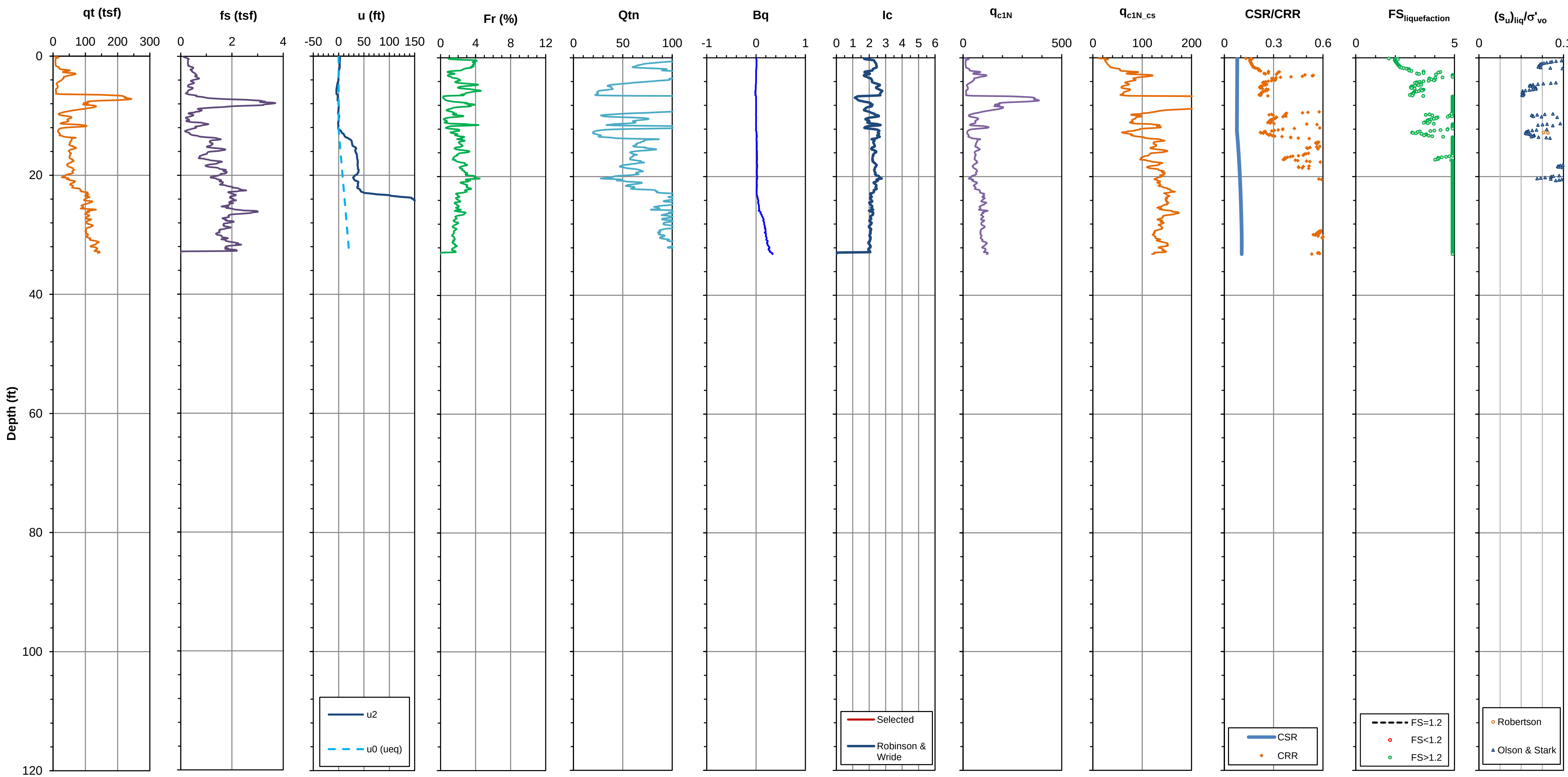


Test Date:	12/19/2017	**Project:**	Possum Point Pond E	**Test Type:**	CPTU	**Water Table:**	37.8 ft	**2% PE in 50 years Seismic Hazard**	
Test ID:	CPT-E-03	**Location:**	Dumfries, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	LJ	**Magnitude:**	5.5
Latitude	38.55296	**Client:**	Dominion Energy	**Standard:**	ASTM D5778	**Check**	JGM	**a_{max}:**	0.12 g
Longitude	-77.29318	**Proj No.:**	1662150	**Push Co.:**	ConeTec	**Review:**			
Elevation:	41.2 ft	**Termination:**	60.2 ft-bgs	**Operator:**	ConeTec				

Golder Associates



Test Date:	12/19/2017	**Project:**	Possum Point Pond E	**Test Type:**	CPTU	**Water Table:**	12.3 ft	**2% PE in 50 years Seismic Hazard**	
Test ID:	CPT-E-04	**Location:**	Dumfries, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	LJ	**Magnitude:**	5.5
Latitude	38.54926	**Client:**	Dominion Energy	**Standard:**	ASTM D5778	**Check**	JGM	**a_{max}:**	0.12 g
Longitude	-77.29092	**Proj No.:**	1662150	**Push Co.:**	ConeTec	**Review:**			
Elevation:	13.1 ft	**Termination:**	60.2 ft-bgs	**Operator:**	ConeTec				



Test Date:	12/18/2017	**Project:**	Possum Point Pond E	**Test Type:**	CPTU	**Water Table:**	6.0 ft	**2% PE in 50 years Seismic Hazard**	
Test ID:	CPT-E-05	**Location:**	Dumfries, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	LJ	**Magnitude:**	5.5
Latitude	38.54902	**Client:**	Dominion Energy	**Standard:**	ASTM D5778	**Check**	JGM	**a_{max}:**	0.12 g
Longitude	-77.29029	**Proj No.:**	1662150	**Push Co.:**	ConeTec	**Review:**			
Elevation:	15.1 ft	**Termination:**	60.2 ft-bgs	**Operator:**	ConeTec				

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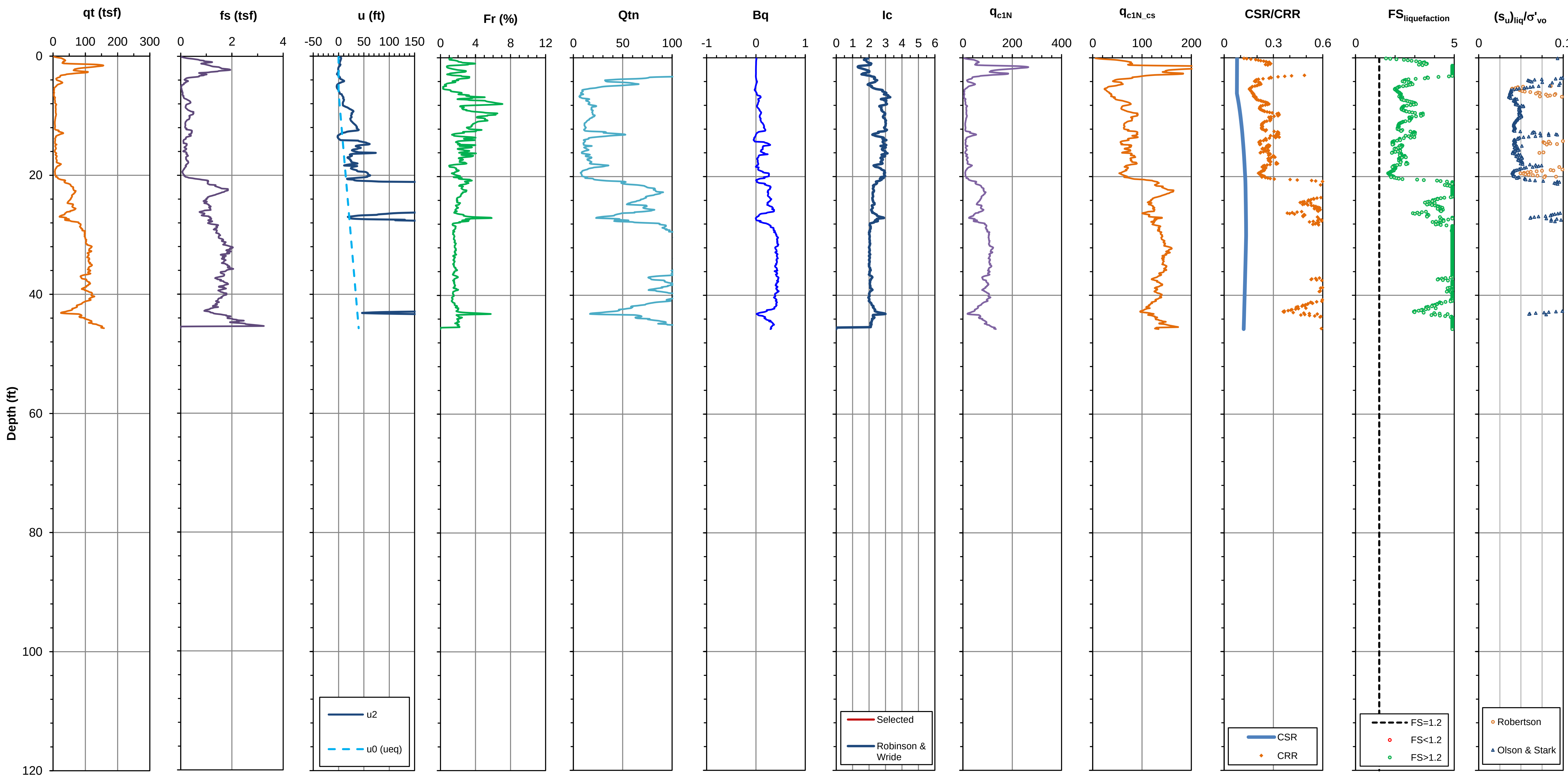
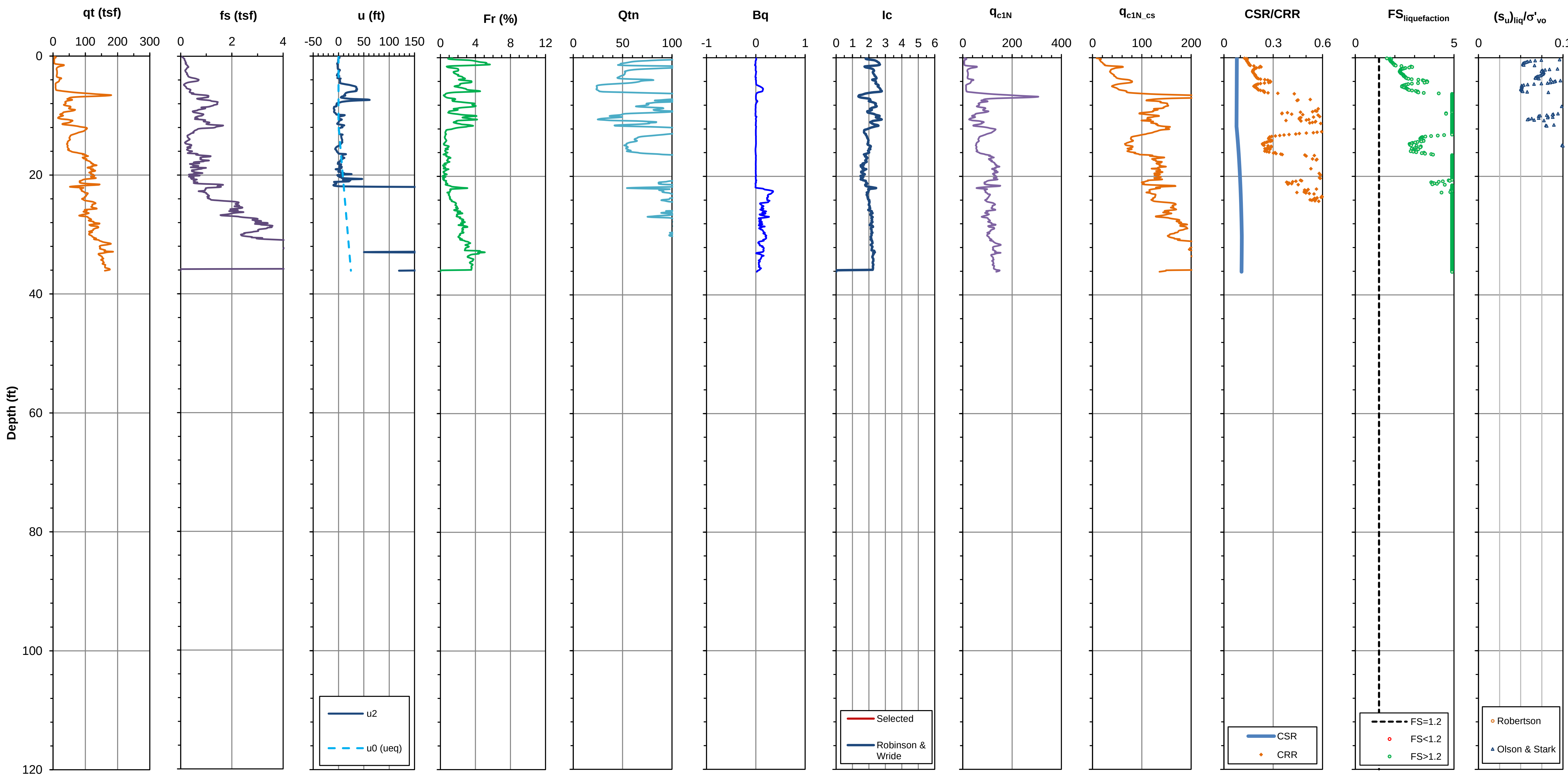
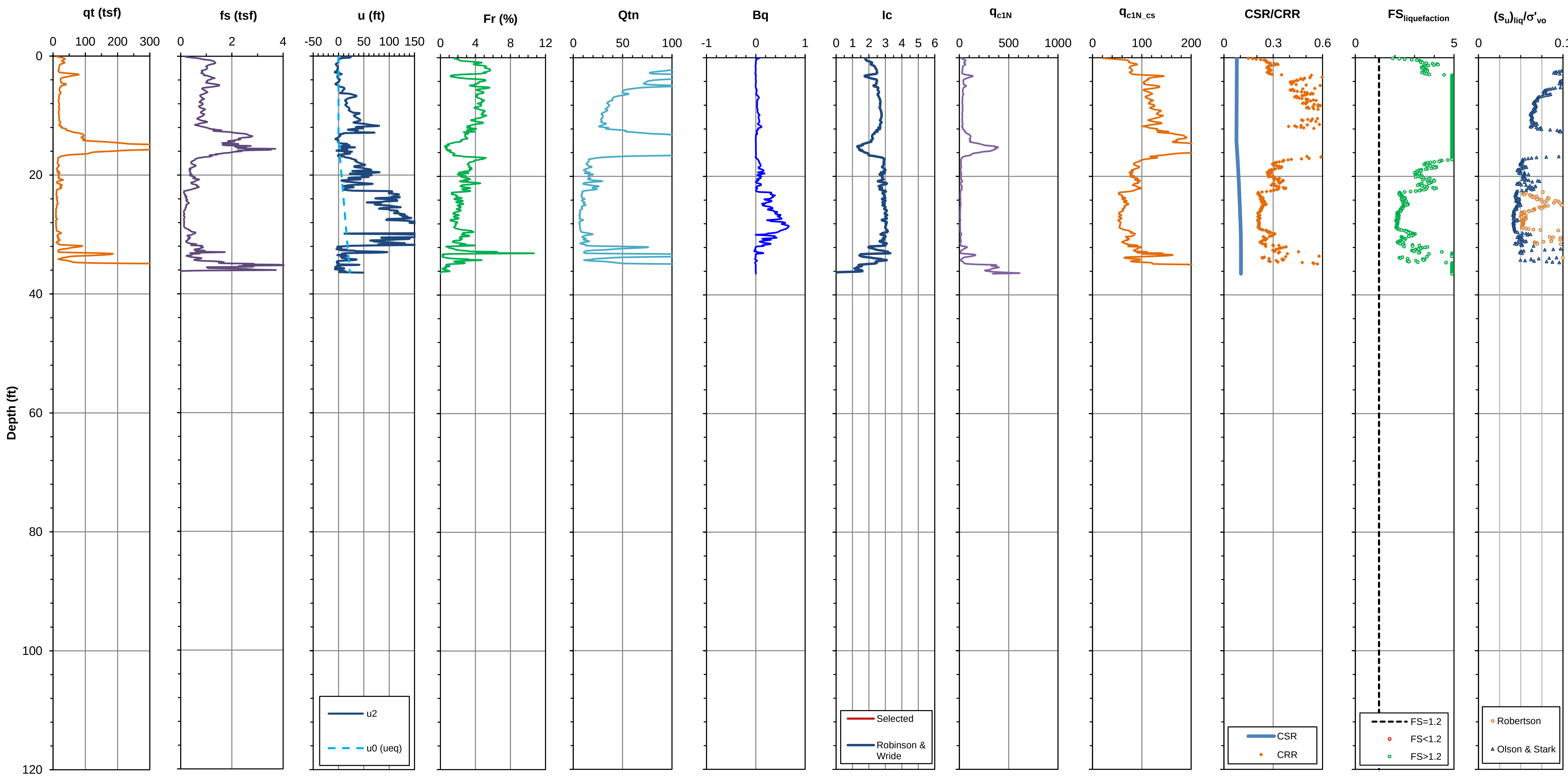


Test Date:	12/20/2017	**Project:**	Possum Point Pond E	**Test Type:**	CPTU	**Water Table:**	11.6 ft	**2% PE in 50 years Seismic Hazard**	
Test ID:	CPT-E-06	**Location:**	Dumfries, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	LJ	**Magnitude:**	5.5
Latitude	38.54986	**Client:**	Dominion Energy	**Standard:**	ASTM D5778	**Check**	JGM	**a_{max}:**	0.12 g
Longitude	-77.29247	**Proj No.:**	1662150	**Push Co.:**	ConeTec	**Review:**			
Elevation:	11.2 ft	**Termination:**	60.2 ft-bgs	**Operator:**	ConeTec				



Test Date:	12/20/2017	**Project:**	Possum Point Pond E	**Test Type:**	CPTU	**Water Table:**	14.1 ft	**2% PE in 50 years Seismic Hazard**	
Test ID:	CPT-E-07	**Location:**	Dumfries, VA	**Device:**	10 cm^2, Type 2 filter	**Golder Eng:**	LJ	**Magnitude:**	5.5
Latitude	38.55306	**Client:**	Dominion Energy	**Standard:**	ASTM D5778	**Check**	JGM	**a_{max}:**	0.12 g
Longitude	-77.29340	**Proj No.:**	1662150	**Push Co.:**	ConeTec	**Review:**			
Elevation:	23.0 ft	**Termination:**	60.2 ft-bgs	**Operator:**	ConeTec				

Golder Associates



ATTACHMENT 4

Stability Figures

LEGEND

- EXISTING CONTOURS, REF 1
- EXISTING CONTOURS, REF 2
- EXISTING UNPAVED ROAD
- EXISTING PAVED ROAD
- EXISTING EDGE OF WATER
- EXISTING STRUCTURE
- GOLDER CPT

REFERENCE

1. TOPOGRAPHY PROVIDED BY MCKENZIE SNYDER, INC., DATED APRIL 28, 2017.

2. TOPOGRAPHY PROVIDED BY KEDDAL AERIAL MAPPING, DATED 2011.

0 100 200
1" = 200' FEET

CLIENT
DOMINION ENERGY

PROJECT
POSSIUM POINT - POND E
INACTIVE POND DEMONSTRATION

TITLE
POND E - GEOTECHNICAL STABILITY SECTION LOCATIONS PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2018/02/09
DESIGNED	OAE
PREPARED	RMS
REVIEWED	JGM
APPROVED	GLH

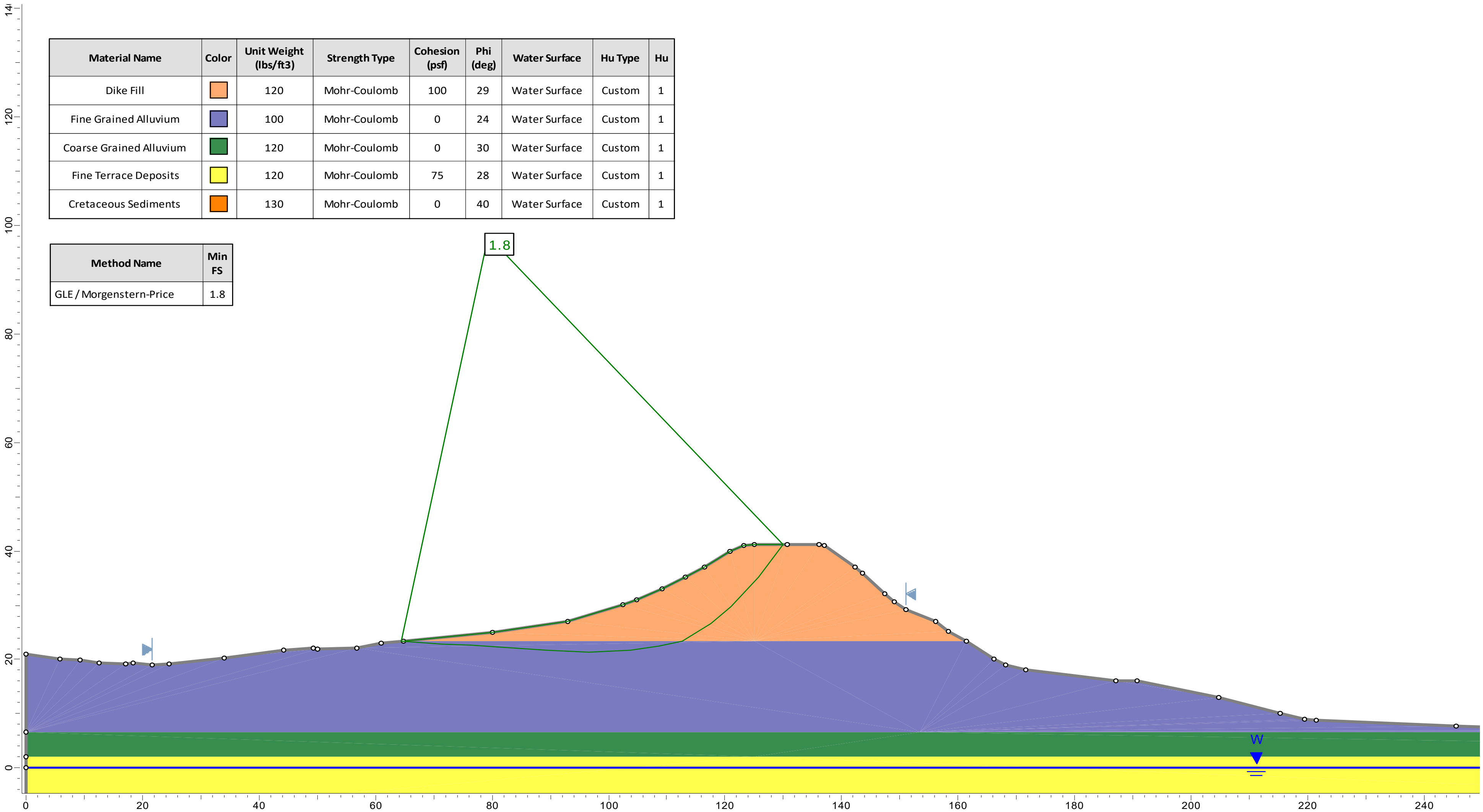
PROJECT NO.	CONTROL	REV.	FIGURE
1662150		----	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Path: \\atlanta\Cadd\Dominion\1662150 Possum Point\PRODUCTION\GEOTECHNICAL INVESTIGATION\ | File Name: 1662150 00 GEOTECH INVESTIGATION.dwg

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Fine Grained Alluvium		100	Mohr-Coulomb	0	24	Water Surface	Custom	1
Coarse Grained Alluvium		120	Mohr-Coulomb	0	30	Water Surface	Custom	1
Fine Terrace Deposits		120	Mohr-Coulomb	75	28	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.8



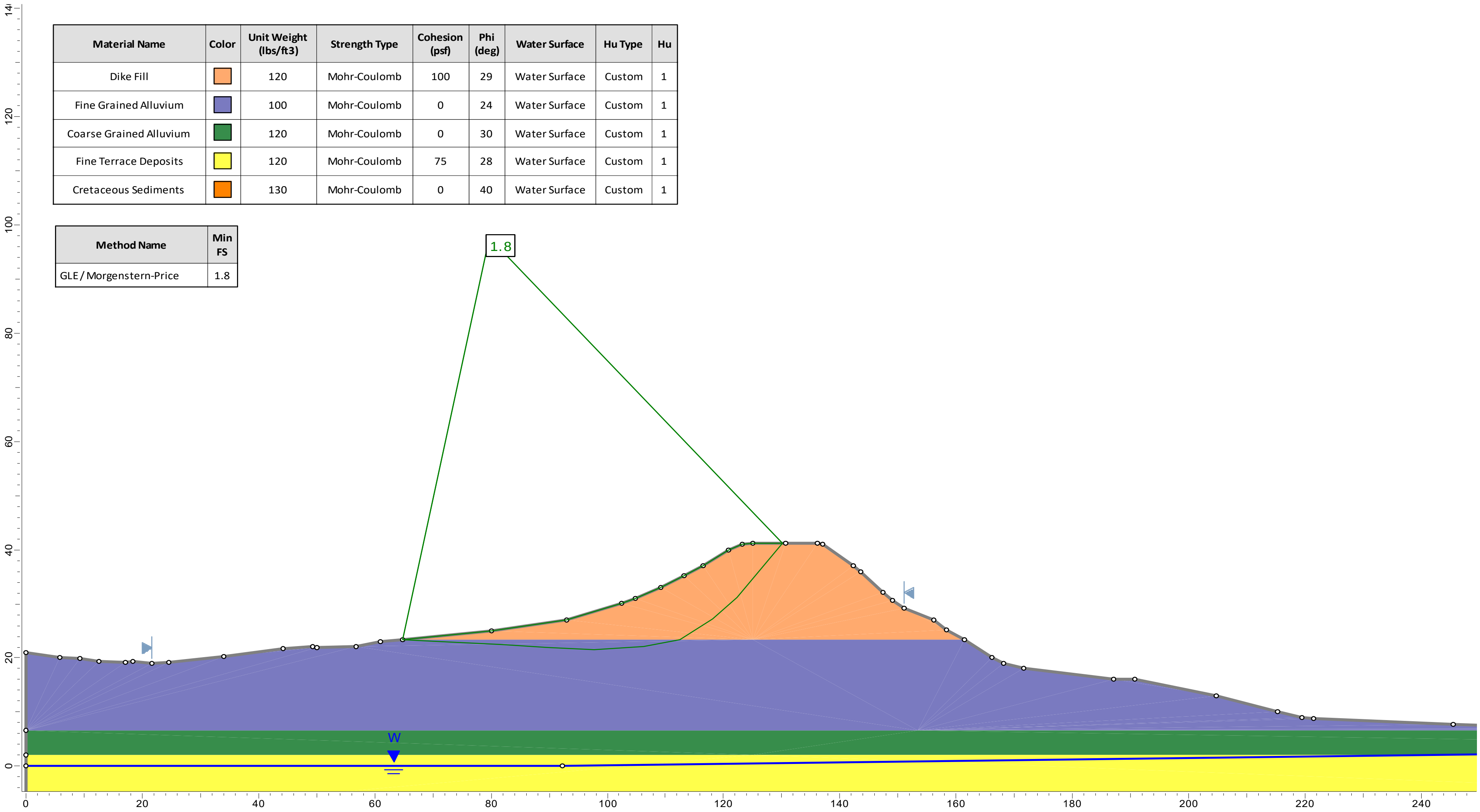
SCALE	AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
DATE	Feb 2018	TITLE	Section A-A Long Term, Normal Storage Pool
MADE BY	LJ		
CAD	-		
CHECK	JGM	CLIENT	Dominion Energy
REVIEW		FIGURE	2(a)

FILE STABILITY

PROJECT No. 1662150 REV. 0

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Fine Grained Alluvium		100	Mohr-Coulomb	0	24	Water Surface	Custom	1
Coarse Grained Alluvium		120	Mohr-Coulomb	0	30	Water Surface	Custom	1
Fine Terrace Deposits		120	Mohr-Coulomb	75	28	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

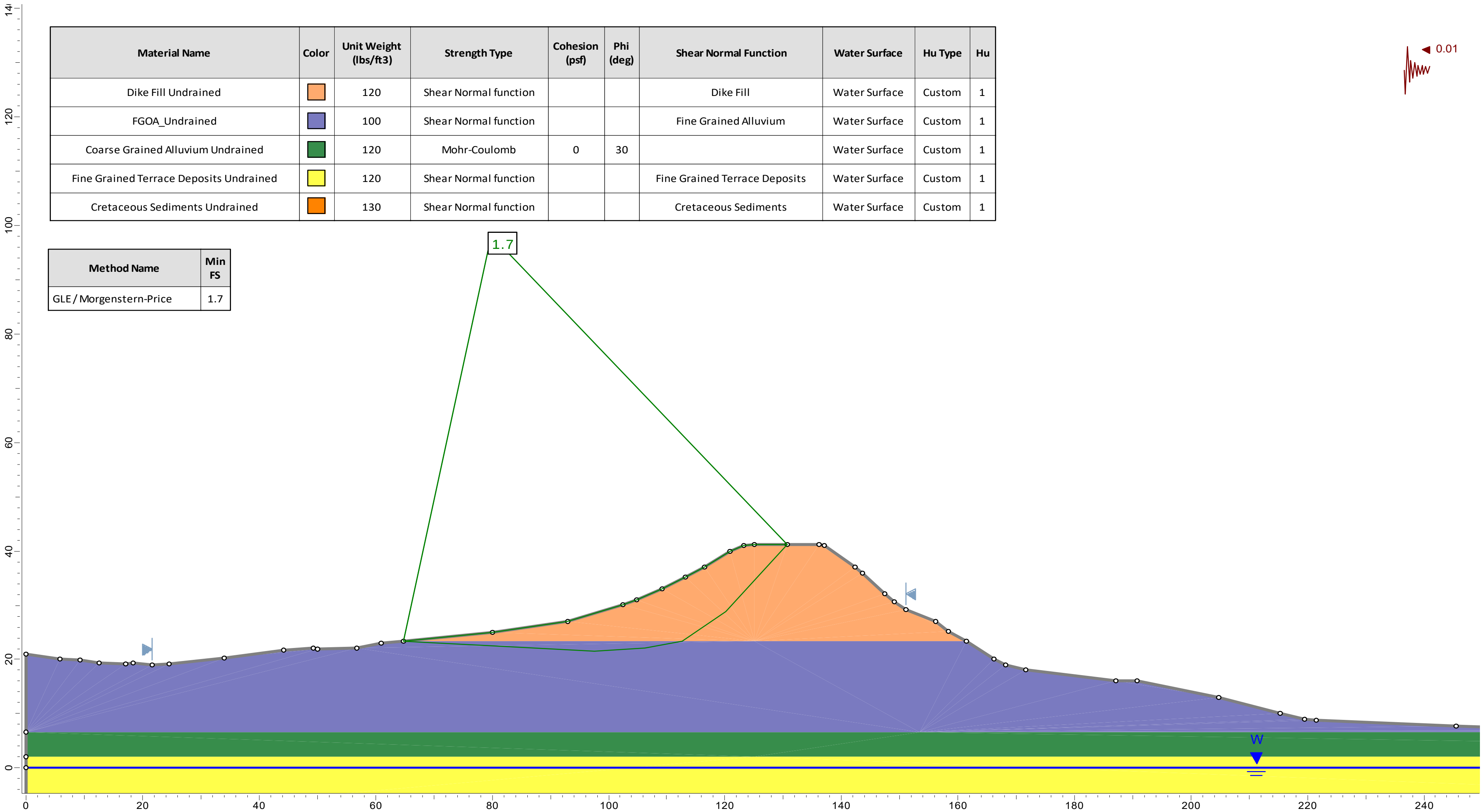
Method Name	Min FS
GLE / Morgenstern-Price	1.8



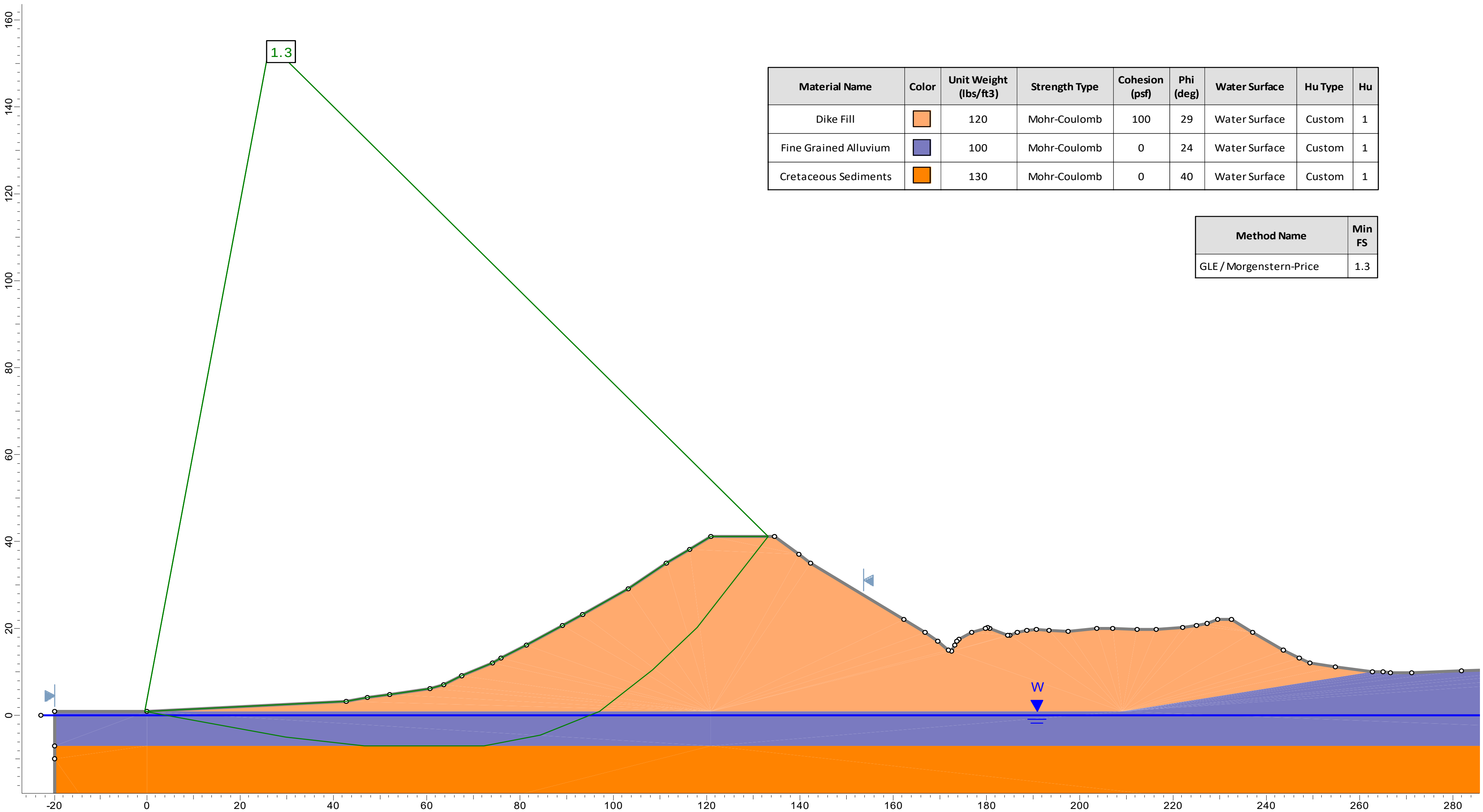
Golder Associates	SCALE AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
	DATE Feb 2018	TITLE	Section A-A Maximum Surchage Pool
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	Dominion Energy
PROJECT No. 1662150 REV. 0	REVIEW	FIGURE	2(b)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Hu Type	Hu
Dike Fill Undrained		120	Shear Normal function			Dike Fill	Water Surface	Custom	1
FGOA_Undrained		100	Shear Normal function			Fine Grained Alluvium	Water Surface	Custom	1
Coarse Grained Alluvium Undrained		120	Mohr-Coulomb	0	30		Water Surface	Custom	1
Fine Grained Terrace Deposits Undrained		120	Shear Normal function			Fine Grained Terrace Deposits	Water Surface	Custom	1
Cretaceous Sediments Undrained		130	Shear Normal function			Cretaceous Sediments	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.7



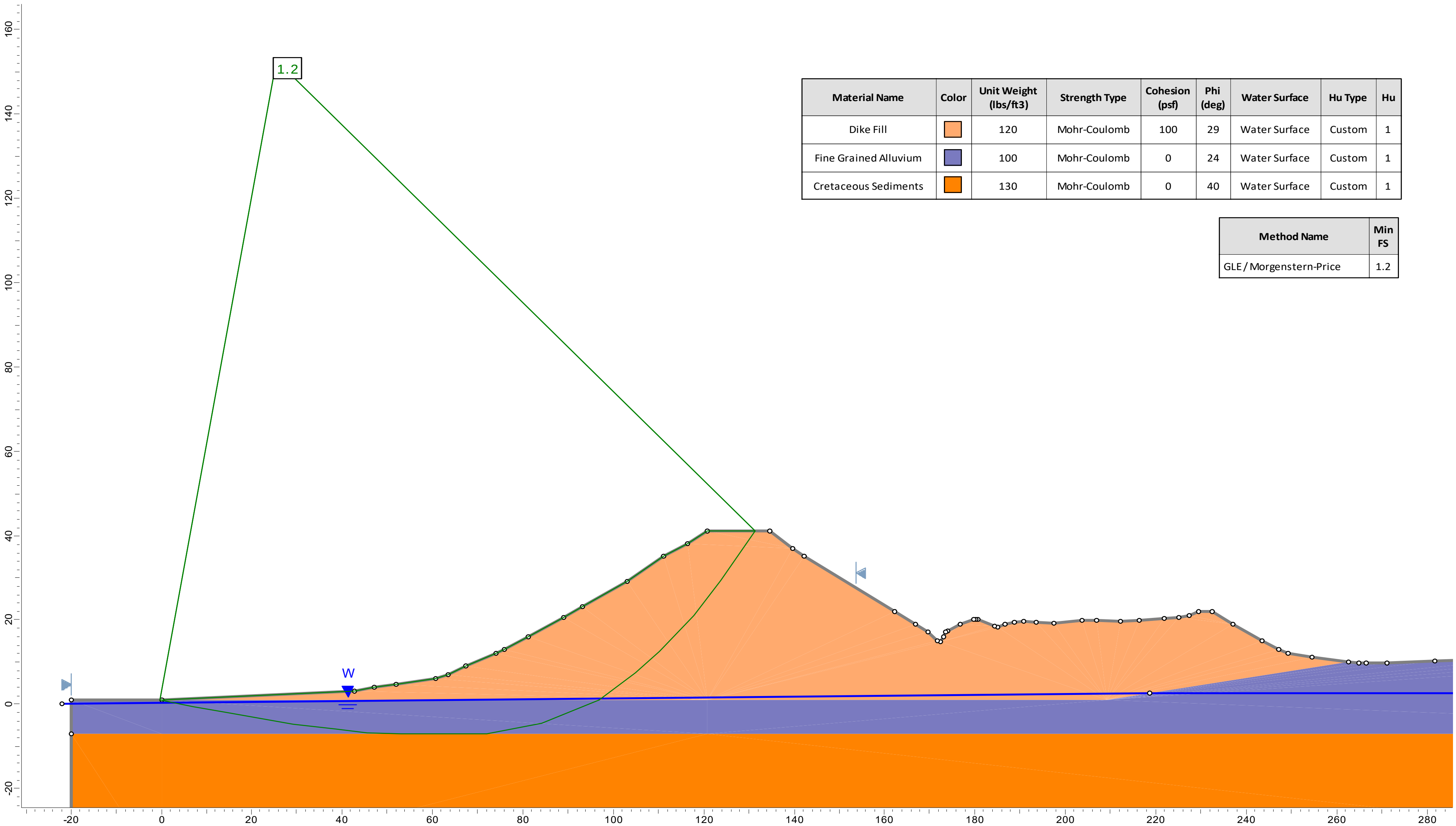
Golder Associates	SCALE AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
	DATE Feb 2018	TITLE	Section A-A Seismic Screening
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	Dominion Energy
PROJECT No. 1662150 REV. 0	REVIEW	FIGURE	2(c)



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Fine Grained Alluvium		100	Mohr-Coulomb	0	24	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.3

Golder Associates	SCALE AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
	DATE Feb 2018	TITLE	Section B-B Long Term, Normal Storage Pool
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	Dominion Energy
PROJECT No. 1662150 REV. 0	REVIEW	FIGURE	3(a)



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Fine Grained Alluvium		100	Mohr-Coulomb	0	24	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

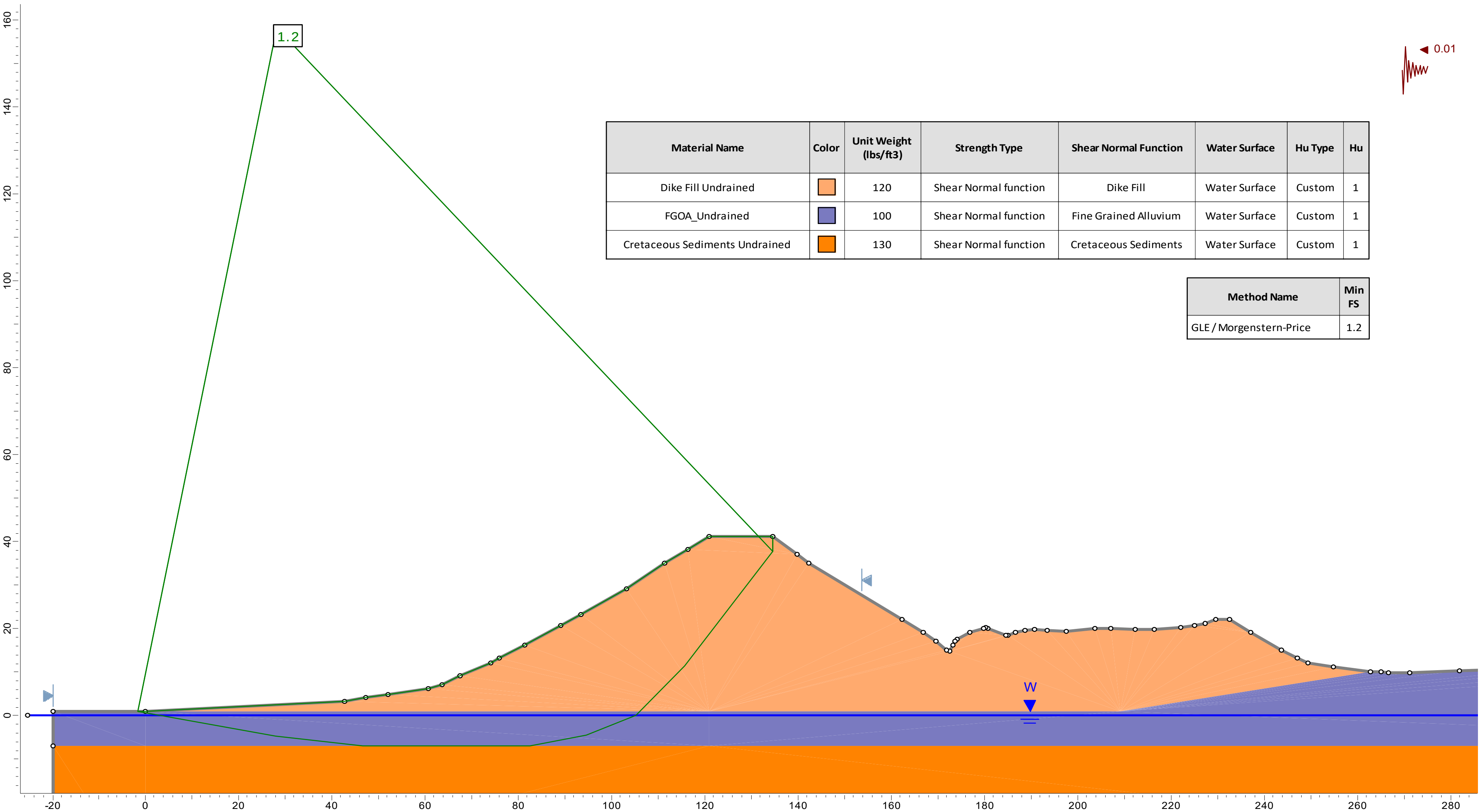
Method Name	Min FS
GLE / Morgenstern-Price	1.2

Golder Associates

SCALE	AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
DATE	Feb 2018	TITLE	Section B-B Maximum Surchage Pool
MADE BY	LJ		
CAD	-		
CHECK	JGM	CLIENT	Dominion Energy
REVIEW		FIGURE	3(b)

FILE STABILITY

PROJECT No. 1662150 REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear Normal Function	Water Surface	Hu Type	Hu
Dike Fill Undrained		120	Shear Normal function	Dike Fill	Water Surface	Custom	1
FGOA_Undrained		100	Shear Normal function	Fine Grained Alluvium	Water Surface	Custom	1
Cretaceous Sediments Undrained		130	Shear Normal function	Cretaceous Sediments	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.2

Golder Associates

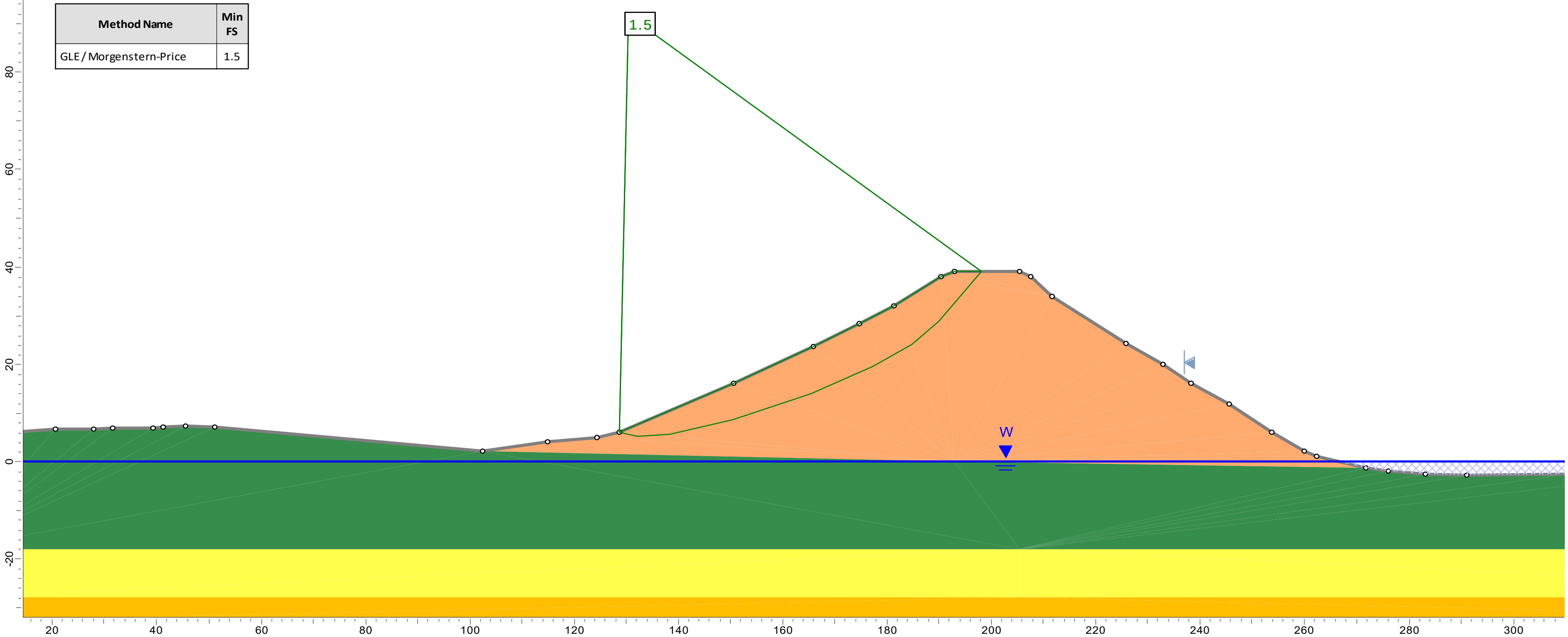
SCALE	AS SHOWN	PROJECT	**Possum Point Pond E - Inactive Pond Demonstration**
DATE	Feb 2018	TITLE	**Section B-B Seismic Screening**
MADE BY	LJ		
CAD	-		
CHECK	JGM	CLIENT	**Dominion Energy**
REVIEW		FIGURE	**3(c)**

FILE: STABILITY

PROJECT No. 1662150 | REV. 0

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Coarse Grained Alluvium		120	Mohr-Coulomb	0	30	Water Surface	Custom	1
Fine Terrace Deposits		120	Mohr-Coulomb	75	28	Water Surface	Custom	1
Coarse Grained Terrace Deposits		125	Mohr-Coulomb	0	34	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.5



Golder Associates

SCALE	AS SHOWN
DATE	Feb 2018
MADE BY	LJ
CAD	-
CHECK	JGM
REVIEW	
FILE	STABILITY
PROJECT No.	1662150
REV.	0

PROJECT **Possum Point Pond E - Inactive Pond Demonstration**

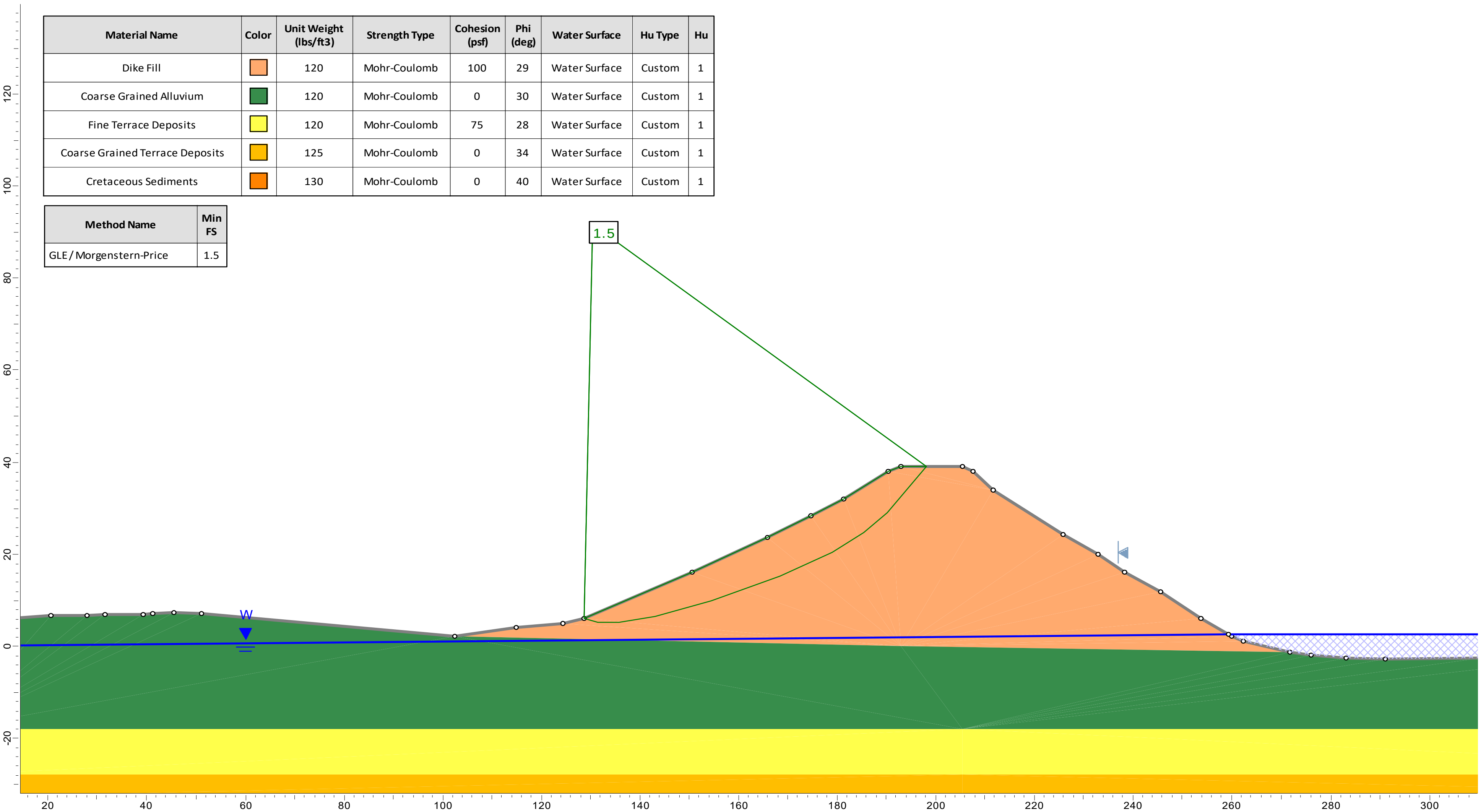
TITLE **Section C-C Long Term, Normal Storage Pool**

CLIENT **Dominion Energy**

FIGURE **4(a)**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Coarse Grained Alluvium		120	Mohr-Coulomb	0	30	Water Surface	Custom	1
Fine Terrace Deposits		120	Mohr-Coulomb	75	28	Water Surface	Custom	1
Coarse Grained Terrace Deposits		125	Mohr-Coulomb	0	34	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

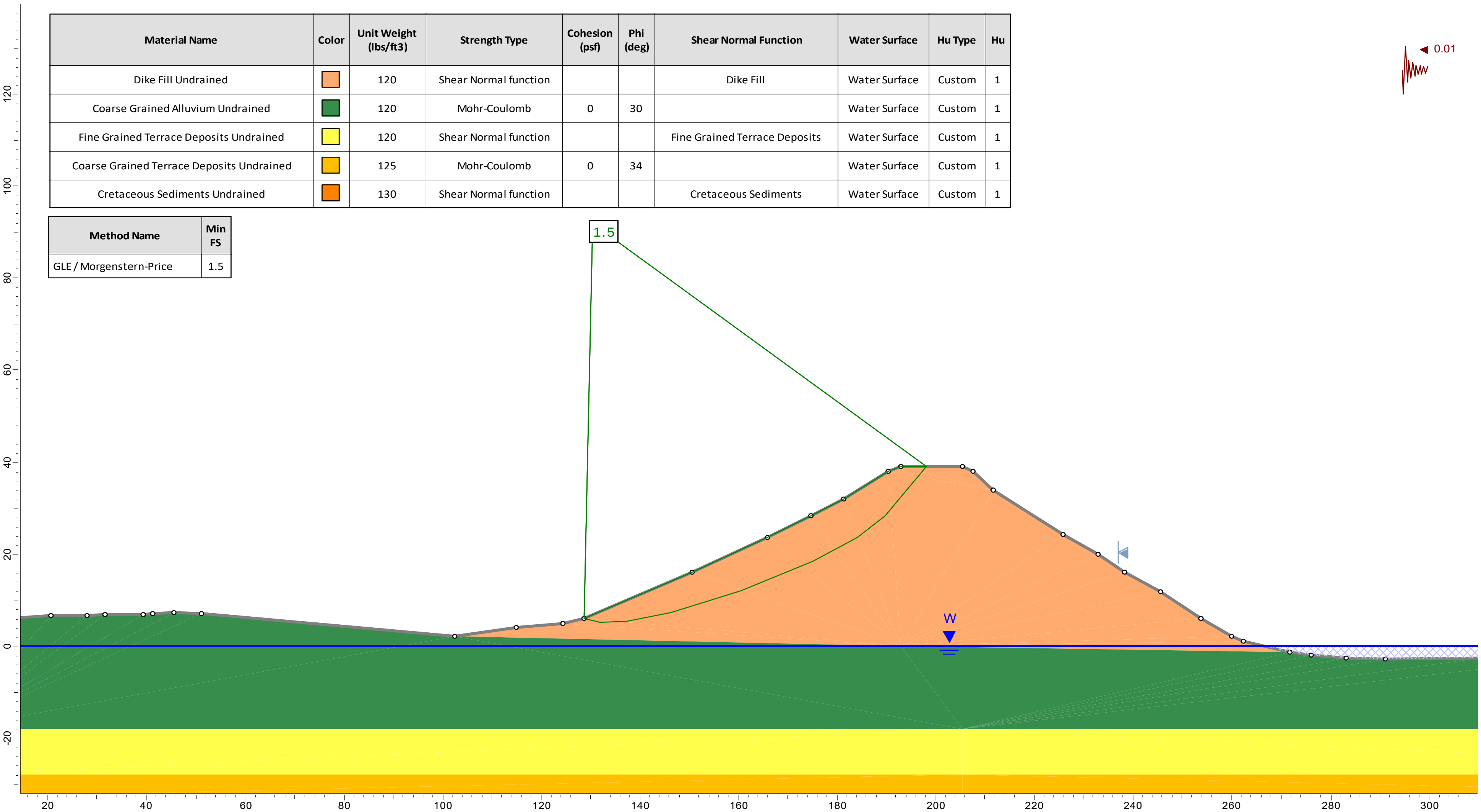
Method Name	Min FS
GLE / Morgenstern-Price	1.5



Golder Associates	SCALE AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
	DATE Feb 2018	TITLE	Section C-C Maximum Surchage Pool
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	Dominion Energy
PROJECT No. 1662150 REV. 0	REVIEW	FIGURE	4(b)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Hu Type	Hu
Dike Fill Undrained		120	Shear Normal function			Dike Fill	Water Surface	Custom	1
Coarse Grained Alluvium Undrained		120	Mohr-Coulomb	0	30		Water Surface	Custom	1
Fine Grained Terrace Deposits Undrained		120	Shear Normal function			Fine Grained Terrace Deposits	Water Surface	Custom	1
Coarse Grained Terrace Deposits Undrained		125	Mohr-Coulomb	0	34		Water Surface	Custom	1
Cretaceous Sediments Undrained		130	Shear Normal function			Cretaceous Sediments	Water Surface	Custom	1

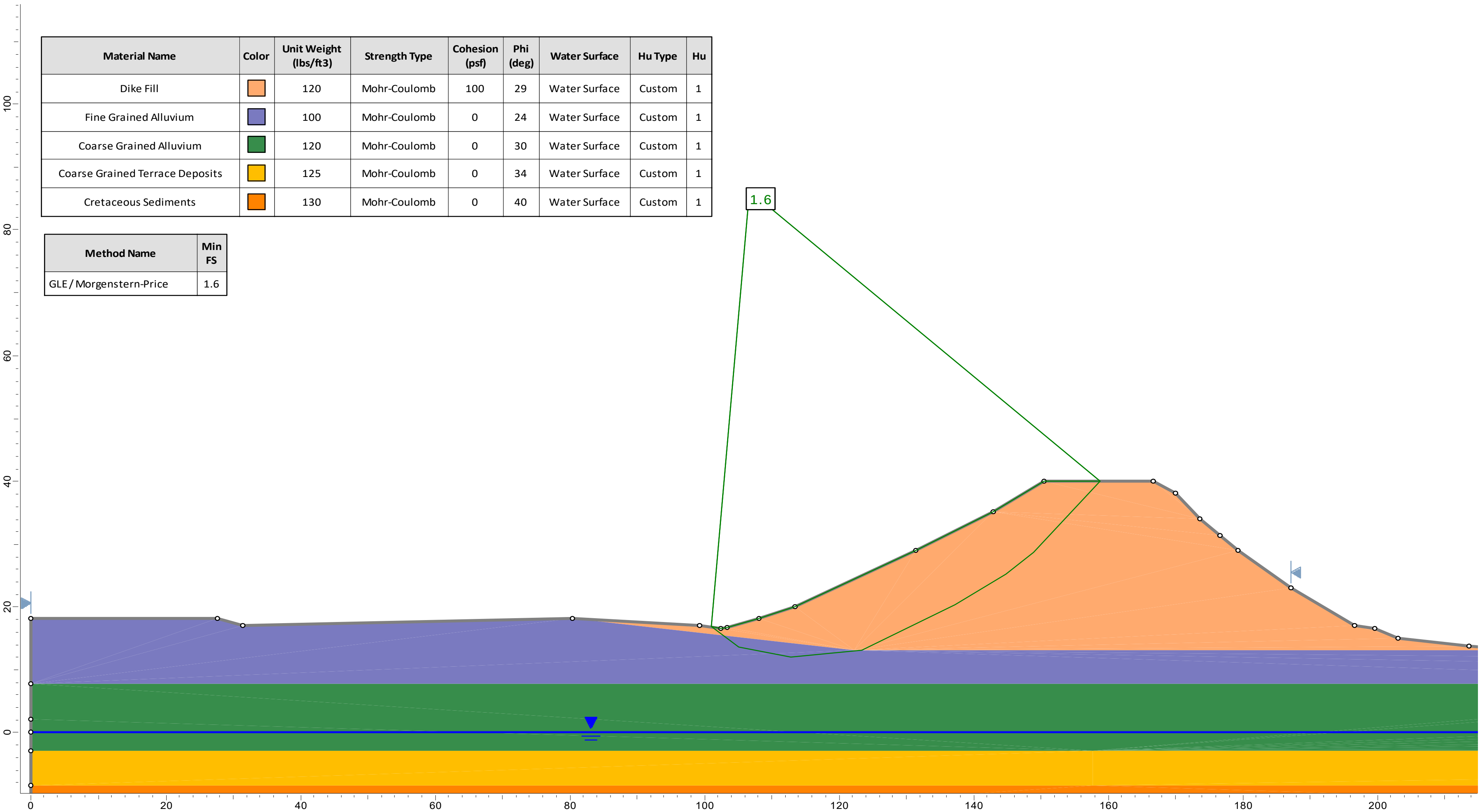
Method Name	Min FS
GLE / Morgenstern-Price	1.5



Golder Associates	SCALE: AS SHOWN	PROJECT	**Possum Point Pond E - Inactive Pond Demonstration**
	DATE: Feb 2018	TITLE	**Section C-C Seismic Screening**
	MADE BY: LJ		
	CAD: -		
FILE: STABILITY	CHECK: JGM	CLIENT	**Dominion Energy**
PROJECT No. 1662150 / REV. 0	REVIEW	FIGURE	**4(c)**

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Fine Grained Alluvium		100	Mohr-Coulomb	0	24	Water Surface	Custom	1
Coarse Grained Alluvium		120	Mohr-Coulomb	0	30	Water Surface	Custom	1
Coarse Grained Terrace Deposits		125	Mohr-Coulomb	0	34	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

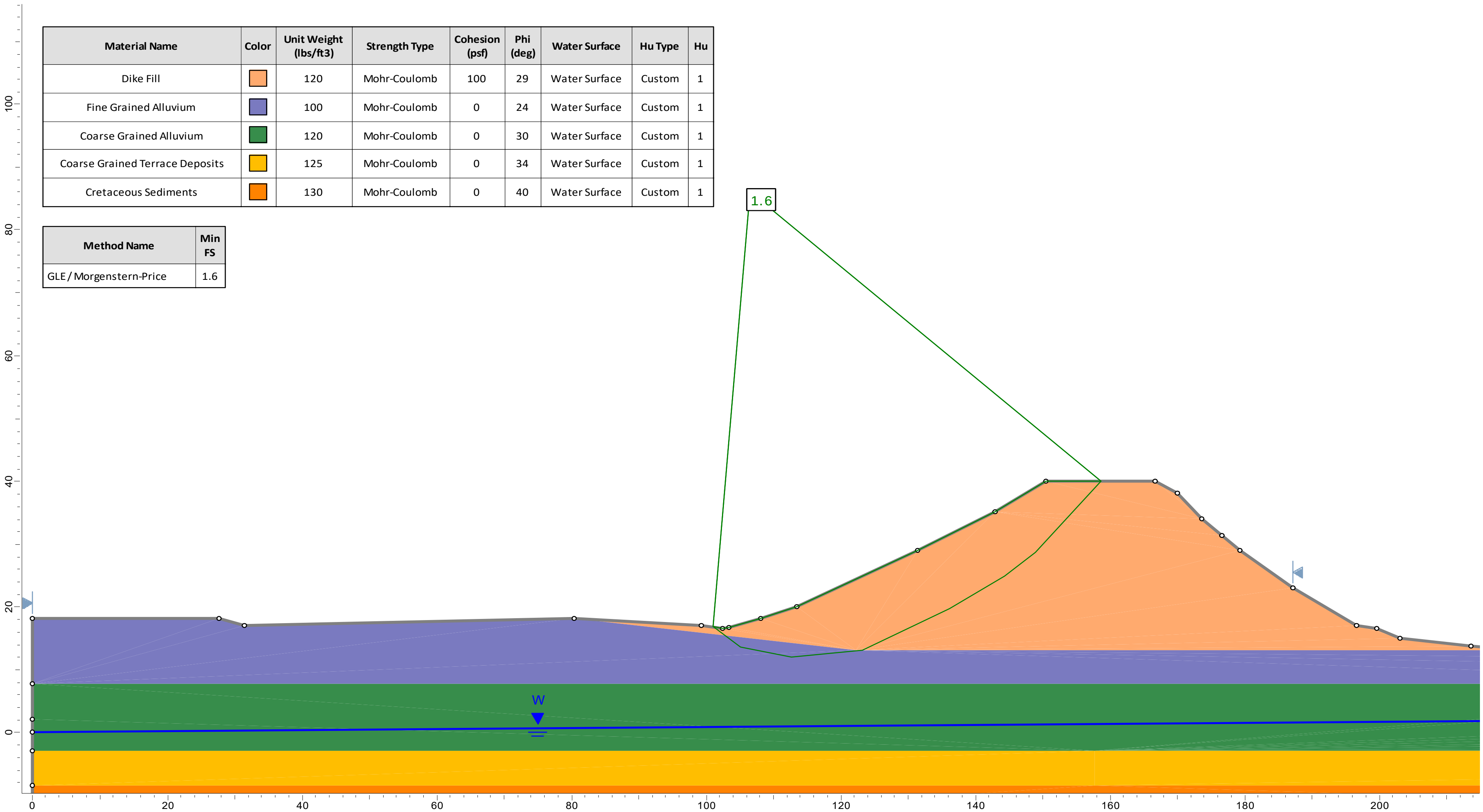
Method Name	Min FS
GLE / Morgenstern-Price	1.6



Golder Associates	SCALE: AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
	DATE: Feb 2018	TITLE	Section D-D Long Term, Normal Storage Pool
	MADE BY: LJ		
	CAD: -		
FILE: STABILITY	CHECK: JGM	CLIENT: Dominion Energy	FIGURE: 5(a)
PROJECT No. 1662150 / REV. 0	REVIEW		

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Fine Grained Alluvium		100	Mohr-Coulomb	0	24	Water Surface	Custom	1
Coarse Grained Alluvium		120	Mohr-Coulomb	0	30	Water Surface	Custom	1
Coarse Grained Terrace Deposits		125	Mohr-Coulomb	0	34	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

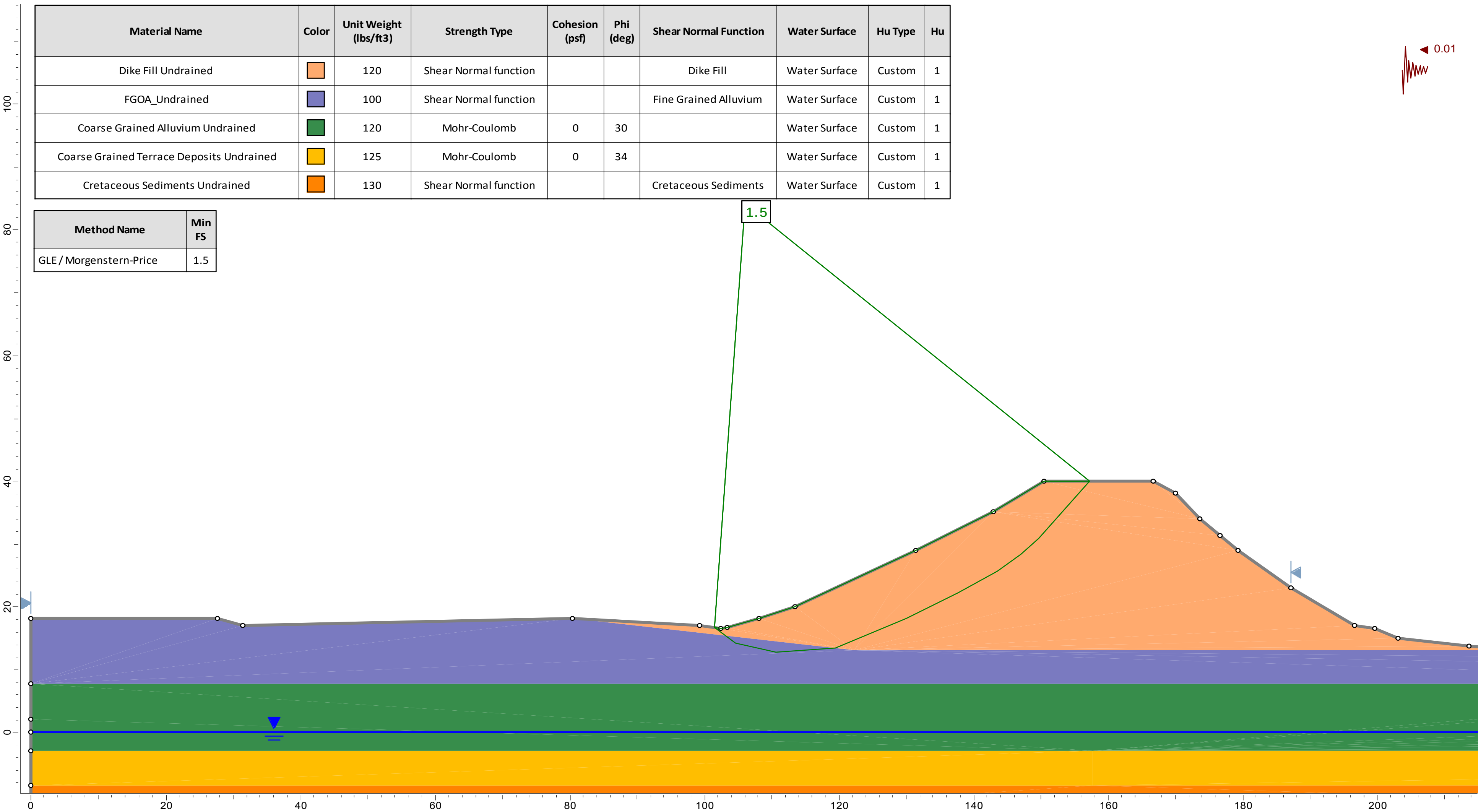
Method Name	Min FS
GLE / Morgenstern-Price	1.6



Golder Associates	SCALE AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
	DATE Feb 2018	TITLE	Section D-D Maximum Surchage Pool
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	Dominion Energy
PROJECT No. 1662150 REV. 0	REVIEW	FIGURE	5(b)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Hu Type	Hu
Dike Fill Undrained		120	Shear Normal function			Dike Fill	Water Surface	Custom	1
FGOA_Undrained		100	Shear Normal function			Fine Grained Alluvium	Water Surface	Custom	1
Coarse Grained Alluvium Undrained		120	Mohr-Coulomb	0	30		Water Surface	Custom	1
Coarse Grained Terrace Deposits Undrained		125	Mohr-Coulomb	0	34		Water Surface	Custom	1
Cretaceous Sediments Undrained		130	Shear Normal function			Cretaceous Sediments	Water Surface	Custom	1

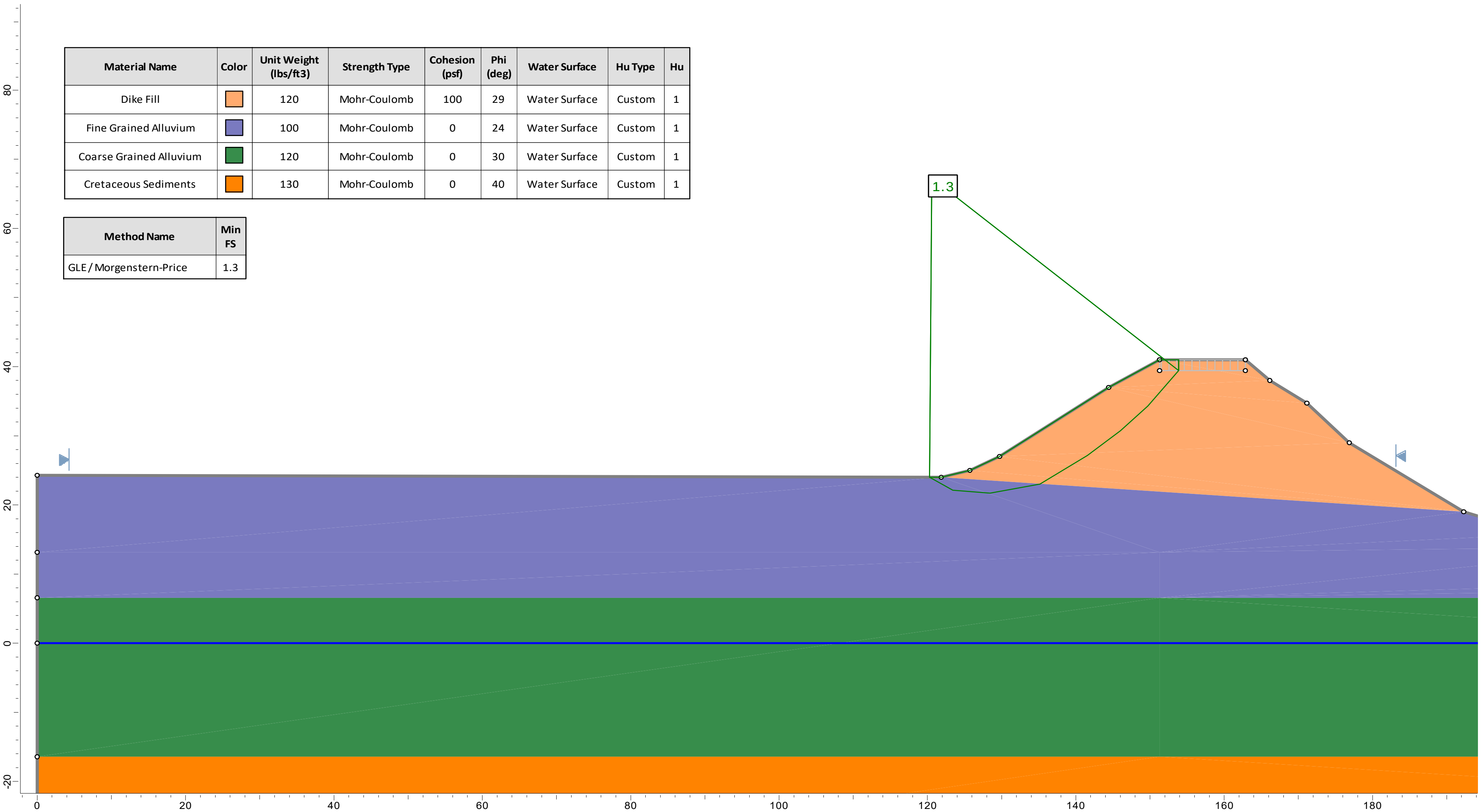
Method Name	Min FS
GLE / Morgenstern-Price	1.5



Golder Associates	SCALE AS SHOWN	PROJECT	**Possum Point Pond E - Inactive Pond Demonstration**
	DATE Feb 2018	TITLE	**Section D-D Seismic Screening**
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	**Dominion Energy**
PROJECT No. 1662150 REV. 0	REVIEW	FIGURE	5(c)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Fine Grained Alluvium		100	Mohr-Coulomb	0	24	Water Surface	Custom	1
Coarse Grained Alluvium		120	Mohr-Coulomb	0	30	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

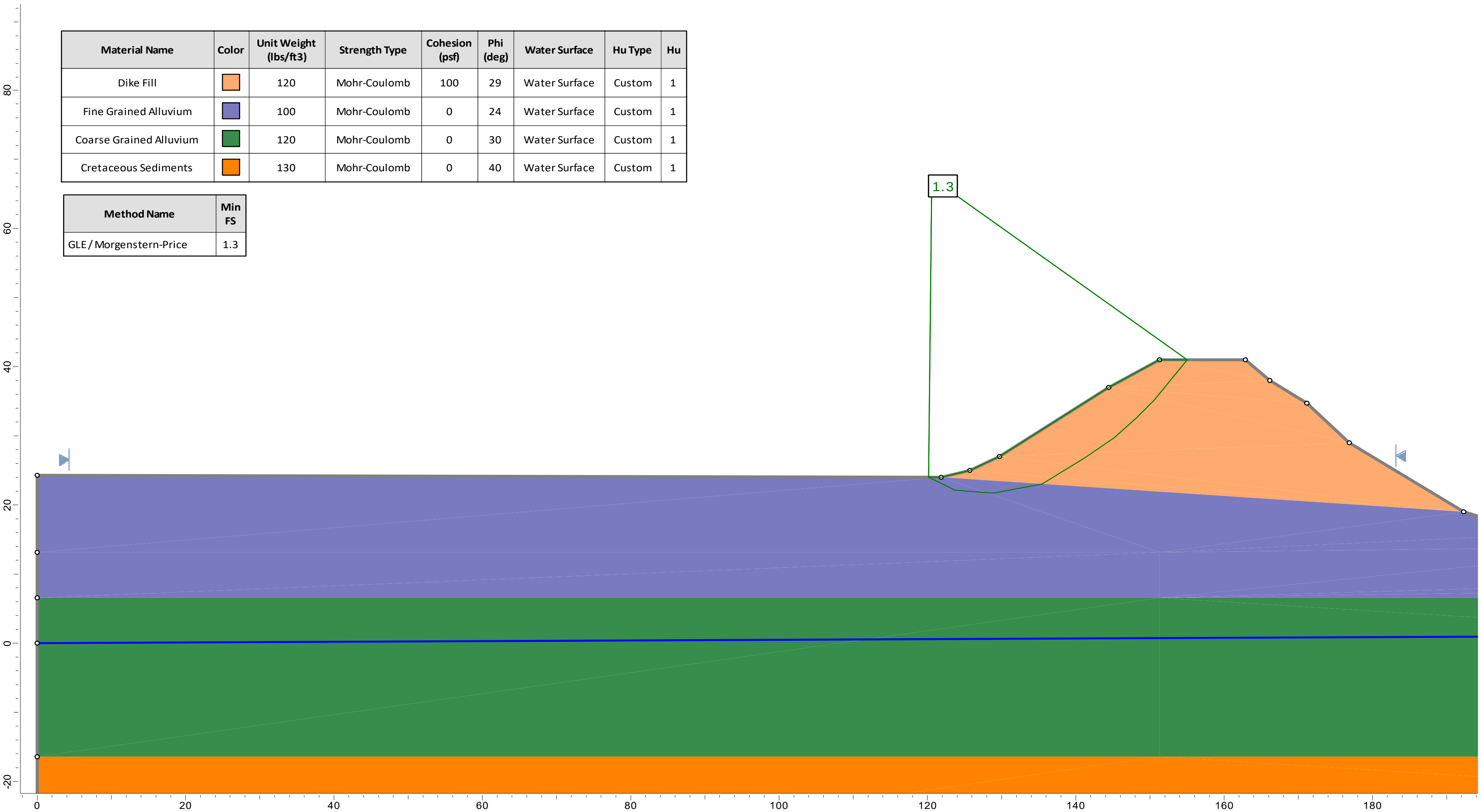
Method Name	Min FS
GLE / Morgenstern-Price	1.3



Golder Associates	SCALE AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
	DATE Feb 2018	TITLE	Section E-E Long Term, Normal Storage Pool
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	Dominion Energy
PROJECT No. 1662150 REV. 0	REVIEW	FIGURE	6(a)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Dike Fill		120	Mohr-Coulomb	100	29	Water Surface	Custom	1
Fine Grained Alluvium		100	Mohr-Coulomb	0	24	Water Surface	Custom	1
Coarse Grained Alluvium		120	Mohr-Coulomb	0	30	Water Surface	Custom	1
Cretaceous Sediments		130	Mohr-Coulomb	0	40	Water Surface	Custom	1

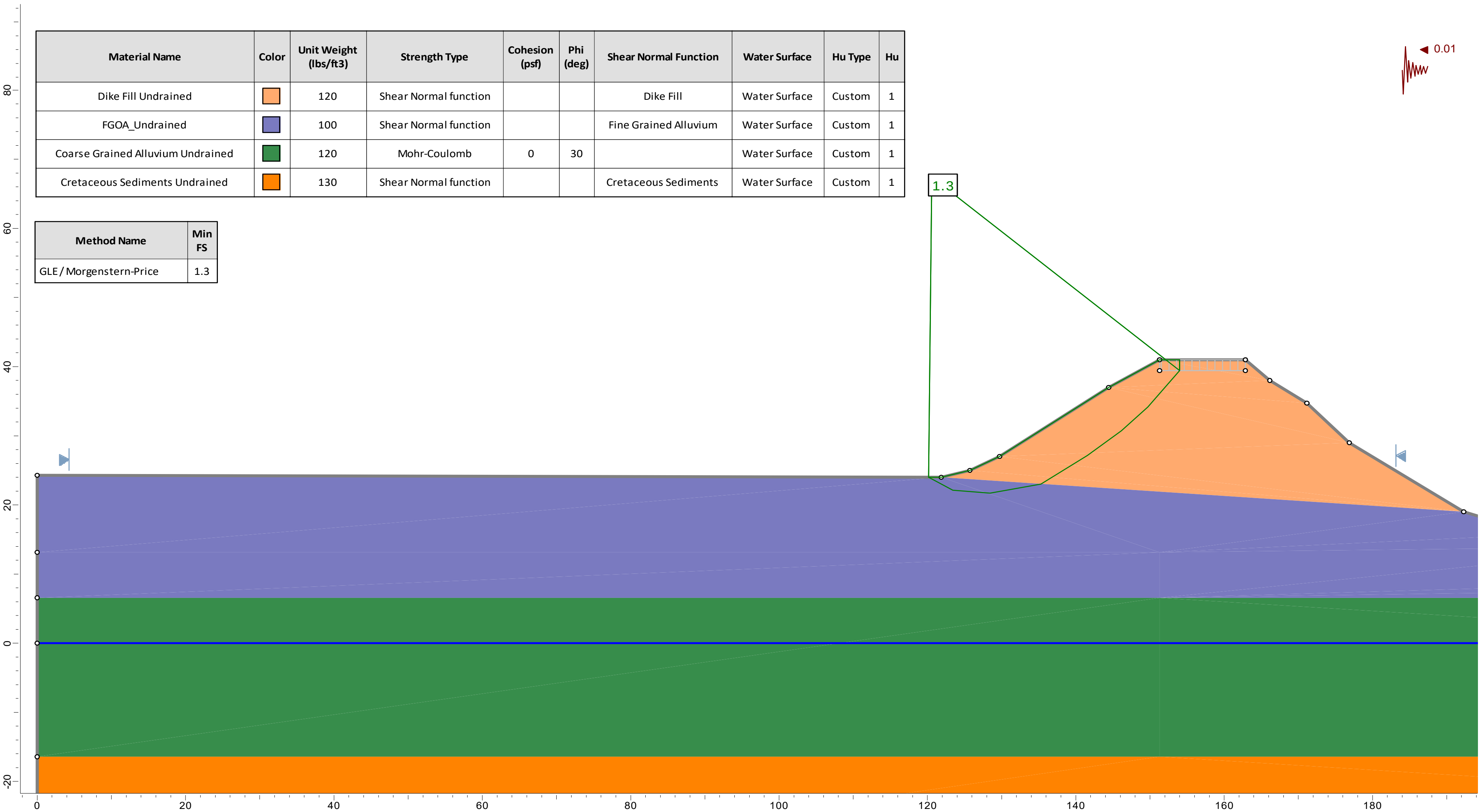
Method Name	Min FS
GLE / Morgenstern-Price	1.3



Golder Associates	SCALE AS SHOWN	PROJECT	Possum Point Pond E - Inactive Pond Demonstration
	DATE Feb 2018	TITLE	Section E-E Maximum Surchage Pool
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	Dominion Energy
PROJECT No. 1662150 REV. 0	REVIEW	FIGURE	6(b)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Hu Type	Hu
Dike Fill Undrained		120	Shear Normal function			Dike Fill	Water Surface	Custom	1
FGOA_Undrained		100	Shear Normal function			Fine Grained Alluvium	Water Surface	Custom	1
Coarse Grained Alluvium Undrained		120	Mohr-Coulomb	0	30		Water Surface	Custom	1
Cretaceous Sediments Undrained		130	Shear Normal function			Cretaceous Sediments	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.3



Golder Associates	SCALE AS SHOWN	PROJECT	**Possum Point Pond E - Inactive Pond Demonstration**
	DATE Feb 2018	TITLE	**Section E-E Seismic Screening**
	MADE BY LJ		
	CAD -		
FILE STABILITY	CHECK JGM	CLIENT	**Dominion Energy**
PROJECT No. 1662150 / REV. 0	REVIEW	FIGURE	**6(c)**

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Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity