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June 6, 2024

Keegan MacDonna
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1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794

Re: Illinois Power Generating Company - Coffeen Power Plant
Log No. 2021-100009
Bureau ID: W1350150004
Initial Review Letter Response - Part 845 Construction/Operating Permit Application(s)

Mr. MacDonna:

Illinois Power Generating Company (IPGC) received the Coffeen Power Plant CCR Surface Impoundment Operating and Construction Permit Application Review Letter dated October 12, 2023. At this time, we submit the below responses to Illinois Environmental Protection Agency's (IEPA's) initial comments.

As discussed more specifically below, IPGC will produce data and information requested by IEPA in two productions starting concurrently with this letter by producing data and information that is reasonably and readily available and producing the remaining information, as indicated in the below responses, when it is available. All documents and responses will be provided in hard copy, as requested by IEPA, as well as through a courtesy email and temporary file-sharing service. As noted below, IPGC will also be producing electronic data deliverables ("EDDs"), which can only be shared electronically and will be provided via the temporary file-sharing service.

Within the below responses, IPGC requests additional information and clarification regarding several comments. To further discuss those requests, IPGC will schedule meetings with IEPA to ensure IPGC is providing complete responses.

<u>Initial Operating Permit Application(s)</u>

History of Construction [35 Ill. Adm. Code 845.230(d)(3)(A)]

Comment 1: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(3)(A), the applicant must provide a written history of construction containing the information specified in 35 Ill. Adm. Code 845.220(a)(1). Pursuant to 35 Ill. Adm. Code 845.220(a)(1)(D-E), the applicant must provide a description* *of the physical and engineering properties of the foundation and abutment materials of the CCRSI, and a statement detailing physical and engineering properties of the materials used in construction each zone or stage of the CCRSI.*

Response: As submitted, IPGC's history of construction (HoC) provides an adequate description of the physical and engineering properties of the foundation and abutment materials and a statement detailing physical and engineering properties of the materials used in constructing each zone or stage of each of the ponds. Specifically, all of the information requirements in Adm. Code 845.220(a)(1)(D-E) is included in Tables 1 through 4 of the History of Construction document within the operating permit applications based on previous geotechnical explorations and laboratory testing, including:

a. Summary of Foundation and Abutment Material Engineering Properties (Table 1 of HoC)

b. Summary of Construction Material Engineering Properties for Embankments (Table 2 of HoC)

c. Approximate dates of construction of each successive stage of construction (Table 4 of HoC)

d. Listing of drawings containing items pertaining to the information requested (Table 5, Appendix B and Appendix C of HoC)

The attached full certification reports (Attachment A) also include all of the borings, lab testing, and analyses of the geotechnical aspects for all of the impoundments other than Ash Pond 2.

In preparing its Operating Permit application, IPGC reviewed all available files and identified and interviewed all employees that could potentially have relevant information. Additionally, IPGC conducted no less than 3 plant visits. Despite its efforts and due to the age of Ash Pond 2, IPGC was unable to find information related to the topics within the History of Construction that it previously identified as "not reasonably and readily available."

Comment 2: *To support the information provided to meet these requirements, the application should be revised to include geotechnical exploration data and laboratory testing data for the foundation, abutment, and zone/stage construction materials for each impoundment.*

Response: The attached full certification reports (Attachment A) include all of the borings, lab testing, and analyses of the geotechnical aspects of the impoundments other than Ash Pond No. 2. Part 845 does not require the requested information. Section 845.230(d)(3)(A) (incorporating Section 845.220(a)(1)(D-E)) requires a "description of the physical and engineering properties of the foundation and abutment materials of the CCRSI," 845.220(a)(1)(D), and "a statement detailing physical and engineering properties of the materials used in construction each zone or stage of the CCRSI." 35 Ill. Admin. Code 845.220(a)(1)(E). Section 845.220(a)(1)(D-E) does not require specific testing be performed. IPGC's History of Construction includes a description, based on previous geotechnical explorations and laboratory testing, of the physical and engineering properties of the soils, clays, and silts that make up the foundation and abutments of Ash Pond No. 1, Ash Pond No. 2, the GMF Pond, and the GMF Recycle Pond. *See, e.g.*, Coffeen Power Plant Ash Pond No. 1 Operating Permit Application, Attachment B at 3–5.

Comment 3: *The history of construction must also be revised to include provisions for surveillance, maintenance, and repair for Ash Pond No. 2 pursuant to the requirements of 35 Ill. Adm. Code 845.220(a)(1)(J).*

Response: Ash Pond No. 2 is inspected at least annually by a professional dam safety engineer and weekly by trained plant personnel. Additionally, inspections are performed after significant events such as storms. The inspections are performed to identify settlement, subsidence, erosion, or other damage that may adversely affect the integrity of the impoundment, final cover system, and stormwater management system. Noted evidence of damage, such as damage to geosynthetic components, rills, surface cracks, and settlement, will be repaired to maintain the integrity of the impoundment. Repair activities may include, but are not limited to, repairing or replacing damaged geosynthetic components, replacing and compacting soil cover, repairing drainage channels that have been eroded, filling in depressions with soil, regrading, and reseeding areas of failed vegetation, as necessary.

Emergency Action Plan [35 Ill. Adm. Code 845.230(d)(3)(D)]

Comment 4: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(3)(D), the applicant must provide a certified, written Emergency Action Plan containing the information specified in 35 Ill. Adm. Code 845.520. No written Emergency Action Plan was provided for Ash Pond No. 2. A written Emergency Action Plan for Ash Pond No. 2 must be submitted to the Agency in accordance with the requirements of 35 Ill. Adm. Code 845.520(a-c) and (e).*

Response: A written Emergency Action Plan containing the information specified in 35 Ill. Admin. Code § 845.520 for the Ash Pond No. 2 is enclosed as Attachment B.

Location Restrictions [35 Ill. Adm. Code 845.230(d)(2)(D)]

Comment 5: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(2)(D), the applicant must provide written demonstrations that an existing CCR surface impoundment complies with, or an explanation of how it does not comply with, the location restriction requirements specified in 35 Ill. Adm. Code 845.300-340. Written demonstrations were not submitted in the initial operating permit application(s) for Ash Pond No. 1, the GMF Gypsum Stack Pond, and the GMF Recycle Pond. Only memorandums certifying the demonstrations were submitted, regarding the location restriction requirements. Written demonstrations* *of compliance with the location restrictions for these impoundments must be submitted to the Agency in accordance with 35 Ill. Adm. Code 845.300-340.*

The submitted application contains two memorandums regarding certification of the location restriction demonstration for placement above the uppermost aquifer, for each of these impoundments. One memo from Haley & Aldrich, Inc., dated October 16, 2018, states that Ash Pond No. 1 does not meet the requirements of 40 CFR 257.60(a), which contains the same requirements as 35 Ill. Adm. Code 845.300(a), nearly verbatim. However, another memo from Burns McDonnell, dated October 25, 2021, states that the demonstration was previously certified that Ash Pond No. 1 meets the requirements of 40 CFR 257.60. Similar discrepancies were noted in the applications submitted for the GMF Gypsum Stack Pond and GMF Recycle Pond. Along with the demonstration for placement above the uppermost aquifer for each of these three impoundments, a new certification statement must be signed and stamped by an Illinois Registered Professional Engineer and submitted to the Agency to clarify the discrepancy.

Response: IPGC is reviewing and preparing additional demonstrations in response to IEPA's Comment 5, which it will submit in its second, responsive production.

Comment 6: *The Agency has determined that the GMF Recycle Pond is located in an underground mine buffer zone according to the Illinois State Geological Survey Mines Interactive Map. The demonstration for Unstable Areas pursuant to the requirements of 35 Ill. Adm. 845.340 should include details demonstrating whether or not the GMF Recycle Pond may be impacted by the nearby mines.*

Response: IPGC will provide the requested demonstration for unstable areas in its second, responsive production.

Comment 7: *Since the impoundments at the site are located within a seismic impact zone, demonstrations submitted for Ash Pond No. 1, the GMF Gypsum Stack Pond, and the GMF Recycle Pond must include details that demonstrate that all structural components, including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the site, pursuant to the requirements of 35 Ill. Adm. Code 845.330.*

Response: IPGC will provide the requested demonstrations in its second, responsive production.

Preliminary Written Closure Plan [35 Ill. Adm. Code 845.230(d)(2)(J)]

Comment 8: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(2)(J), the applicant must provide a preliminary written closure plan containing the information specified in 35 Ill. Adm. Code 845.720(a). No preliminary written closure plans were provided for Ash Pond No. 1, the GMF Gypsum Stack Pond, and the GMF Recycle Pond. The application(s) for these impoundments must be revised to include a preliminary written closure plan for each impoundment,* *pursuant to the requirements of 35 Ill. Adm. Code 845.230(d)(2)(J) and 35 Ill. Adm. Code 845.720(a).*

Response: The GMF Gypsum Stack Pond and the GMF Recycle Pond are required to close under 35 Ill. Admin. Code § 845.700. Therefore, preliminary closure plans are not required for the unit. Section 845.720(a)(1) requires a preliminary written closure plan only for those units "***not required to close under Section 845.700***." 35 Ill. Admin. Code § 845.720(a)(1) (emphasis added).

Certification of CCR Surface Impoundment Liner [35 Ill. Adm. Code 845.230(d)(2)(L)]

Comment 9: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(2)(L), the applicant must provide a certification that an existing CCR surface impoundment has a liner that meets the requirements of 35 Ill. Adm. Code 845.400(a), or a statement that it does not have a liner meeting those requirements. No certification of the liner for the GMF Recycle Pond was included in the initial operating permit application, nor did it contain a statement that the liner does not meet the aforementioned requirements. A certification that the liner meets the requirements of 35 Ill. Adm. Code 845.400(a) signed and stamped by a Registered Illinois Professional Engineer, or a statement otherwise, must be submitted to the Agency in accordance with 35 Ill. Adm. Code 845.230(d)(2)(L).*

Response: As required by Section 845.230(d)(2)(L), IPGC states that the GMF Recycle Pond does not have a liner that meets the requirements of Section 845.400(b) or (c).

Hydrogeologic Site Characterization [35 Ill. Adm. Code 845.230(d)(2)(I)(i) and 35 Ill. Adm. Code 845.230(d)(3)(E)(i)]

Comment 10: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(2)(I)(i) and 35 Ill. Adm. Code 845.230(d)(3)(E)(i), the applicant must provide a hydrogeologic site characterization meeting the requirements of 35 Ill. Adm. Code 845.620 for each CCR surface impoundment. The provided hydrogeologic site characterizations for each impoundment include boring logs up to 100 ft that do not encounter bedrock. The facility must monitor each hydrostratigraphic unit that is a potential migration pathway and provide supporting evidence for the pathways selected. The hydrogeologic site characterization for each impoundment must be revised to identify the potential migration pathways pursuant to the requirements of 35 Ill. Adm. Code 845.620(b)(11).*

The hydrogeologic site characterization provided in the application for Ash Pond No. 2 does not address climatic aspects of the site, including any seasonal or temporal fluctuations and precipitation estimates, nor does it identify nearby nature preserves. The hydrogeologic site characterization for Ash Pond No. 2 must be revised to address these factors pursuant to the requirements of 35 Ill. Adm. Code 845.620(b)(2) and 35 Ill. Adm. Code 845.620(b)(5).

Response: The Hydrogeologic Characterization Reports for all units other than Ash Pond No. 2 contain discussion of hydrostratigraphic units in Section 3.2.1, and potential migration pathways are described in Section 3.2.3. IPGC will provide a technical memorandum identifying nearby dedicated nature preserves and potential migration pathways as well as amending the characterization of Ash Pond No. 2 to include climatic aspects of the site, such as seasonal and temporal fluctuations in groundwater flow. The Memorandum will be provided in IPGC's second, responsive production.

Groundwater Monitoring Program [35 Ill. Adm. Code 845.230(d)(2)(I)(iii-iv) and 35 Ill. Adm. Code 845.230(d)(3)(E)(iii-iv)]

Comment 11: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(2)(I)(iii-iv) and 35 Ill. Adm. Code 845.230(d)(3)(E)(iii-iv), the applicant must provide details of proposed groundwater sampling, analysis, and monitoring programs meeting the requirements of 35 Ill. Adm. Code 845.640 and 650 for each CCR surface impoundment. For all CCR surface impoundments at the site, the applicant must provide laboratory reports, field stabilization records, and purge documentation to sufficiently address the requirements of 35 Ill. Adm. Code 845.640(a). Additionally, the applicant must identify the certified laboratory used for groundwater sample analysis of samples collected at each CCR surface impoundment pursuant to the requirements of 35 Ill. Adm. Code 845.640(j).*

Response: On December 19, 2023, IPGC technical staff and IEPA met to discuss IEPA's Initial Review Letter. Pursuant to that discussion, IPGC is producing the electronic data deliverable ("EDD") responsive to the above request concurrently with this response. Given the nature of the data to be shared, IPGC will provide IEPA with a link to a temporary file-sharing service containing the EDD.

Comment 12: *The data provided in Attachment I, Table 3-1 for each impoundment does not include appropriate minimum detection limits for each constituent in order to evaluate the constituent statistically for comparison with the numerical groundwater protection standards pursuant to 35 Ill. Adm. Code 845.600(a)(1). Additionally, the calculated protection/background values do not exhibit the correct use of the statistics pursuant to 35 Ill. Adm. Code 845.600(a)(2) for the following parameters: boron at Ash Pond No. 1, lead at Ash Pond No. 2 and the GMF Recycle Pond, and arsenic at the GMF Gypsum Stack Pond. The proposed monitoring program must be revised to address these issues.*

Response: IPGC has received and reviewed IEPA's December 28, 2023 letter regarding additional comments on statistical methods proposed in the initial operating permit applications. IPGC and IEPA met on May 2, 2024 to discuss the comments in this initial review letter and in the December 28, 2023 letter. Responses to the initial review letter are provided here, and IPGC will provide separate written responses to the December 28, 2023 letter.

Typical laboratory detection and reporting limits are summarized in the Groundwater Monitoring Plan/Attachment I, Table 4-2. All detection and reporting limits are equal to or less than the groundwater protection standards (GWPS) in 35 IAC § 845.600(a)(1). The electronic data deliverables (EDDs) submitted to IEPA contain the actual laboratory detection and reporting limits associated with each sample result. Only sample results above the reporting limits are considered detected values for statistical background determinations to avoid introduction of additional uncertainty or error associated with sample results below reporting limits. Sample results below reporting limits are considered non-detects for statistical calculations and handled as specified in the Statistical Analysis Plan included in the Groundwater Monitoring Plan as Appendix A. In very rare cases, the reporting limits for individual sample results may exceed the GWPS in 35 IAC § 845.600(a)(1) due to matrix effects requiring dilution of the sample before analysis. These results are specifically examined to make sure they do not disproportionately affect the statistical background determination, and are excluded for conservatism if they do. No samples included in the Coffeen background determinations had non-detect results with reporting limits exceeding the GWPS in 35 IAC § 845.600(a); therefore, background values calculated for boron at Ash Pond No. 1, lead at Ash Pond No. 2 and the GMF Recycle Pond, and arsenic at the GMF Gypsum Stack Pond were not affected by detection limits above the GWPS.

The background concentrations were determined using a tolerance interval established from the distribution of the background data, pursuant to 35 IAC §845.640(f)(1)(c) and as discussed with IEPA in the May 2 meeting. This method of determining a background level is consistent with methods in the USEPA guidance document Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance (2009).

History of Known Exceedances of the Groundwater Protection Standards [35 Ill. Adm. Code 845.230(d)(2)(M)]

Comment 13: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(2)(M), the applicant must provide a history of known exceedances of the groundwater protection standards in Section 845.600, and any corrective action taken to remediate the groundwater. The history of known exceedances provided for each impoundment at the site does not contain raw sample data, only the results of a statistical analysis. Raw data that is consistent with the data quality information required by 35 Ill. Adm. Code 845.640(a) must be provided to the Agency for all impoundments at the site.*

Response: On December 19, 2023, IPGC technical staff and IEPA met to discuss IEPA's Initial Review Letter. Pursuant to that discussion, IPGC is producing the EDD responsive to the above request concurrently with this response. Given the nature of the data to be shared, IPGC will provide IEPA with a link to a temporary file-sharing service containing the EDD.

Comment 14: *Additionally, appropriate minimum detection limits must be applied for the following parameters: boron, cobalt, and sulfate at Ash Pond 1, arsenic at the GMF Gypsum Stack Pond, and lead at the GMF Recycle Pond.*

Response: IPGC has received and reviewed IEPA's December 28, 2023 letter regarding additional comments on statistical methods proposed in the initial operating permit applications. IPGC and IEPA met on May 2, 2024 to discuss the comments in this initial review letter and in the December 28, 2023 letter. Responses to the initial review letter are provided here, and IPGC will provide separate written responses to the December 28, 2023 letter.

Typical laboratory detection and reporting limits are summarized in the Groundwater Monitoring Plan/Attachment I, Table 4-2. All detection and reporting limits are equal to or less than the groundwater protection standards (GWPS) in 35 IAC § 845.600(a)(1). The electronic data deliverables (EDDs) submitted to IEPA contain the actual laboratory detection and reporting limits associated with each sample result. Only sample results above the reporting limits are considered detected values in statistical background determinations to avoid introduction of additional uncertainty or error associated with sample results below reporting limits. Sample results below reporting limits are considered non-detects for statistical calculations and handled as specified in the Statistical Analysis Plan included in the Groundwater Monitoring Plan as Appendix A. In very rare cases, the reporting limits for individual sample results may exceed the GWPS in 35 IAC § 845.600(a)(1) due to matrix effects requiring dilution of the sample before analysis. These results are specifically examined to make sure they do not disproportionately affect the statistical background determination, and are excluded for conservatism if they do. No samples included in the Coffeen background determinations had non-detect results with reporting limits exceeding the GWPS in 35 IAC § 845.600(a); therefore, background values calculated for boron at Ash Pond No. 1, lead at Ash Pond No. 2 and the GMF Recycle Pond, and arsenic at the GMF Gypsum Stack Pond were not affected by detection limits above the GWPS.

Waste Characterization/CCR Characterization [35 Ill. Adm. Code 845.150(a)(1), 35 Ill. Adm. Code 845.230(d)(2)(B-C), 35 Ill. Adm. Code 845.600, 35 Ill. Adm. Code 845.640(a)]

Comment 15: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(2)(B-C), the applicant must provide an analysis of the chemical constituents found within the CCR located in or to be placed in a CCR surface impoundment (waste characterization) and an analysis of the chemical constituents of all waste streams, chemical additives and sorbent materials entering or contained in the CCR surface impoundment. CCR waste characterization must include all waste streams as* *defined by SW846, incorporated by reference, which includes an appropriate number of samples to characterize each waste type and identification of all waste types which includes solids, semi-solids, liquids, and air born parts that come from the CCR. The applicant must provide date and time sampled, number of samples collected, constituents analyzed for each sample, statistics or data reduction technical explanations, and laboratory reports for the analytical data for the following waste streams at Ash Pond No. 1, the GMF Gypsum Stack Pond, and the GMF Recycle Pond: CCR solids and semi-solids; leachate water, if any; surface water, if any; and any other waste stream as defined by SW846 Compendium.*

Response: The existing characterization is consistent with Part 845. While it is true that SW846 is incorporated by reference into Part 845 by Section 845.150, inclusion in the general "incorporations by reference" section of Part 845 does not create an affirmative obligation to use SW846 in all circumstances. The Board has explained that where Illinois rules incorporate analytical methods by reference via a "centralized listing of incorporations by reference" such as Section 845.150, "Illinois rules further indicate where each method is used *in the body of the substantive provisions*." *See In the Matter of: SDWA Update, USEPA Amendments (January 1, 2013 through June 30, 2013)*, R 2014-008, Opinion of the Board at 24–25 (Jan. 23, 2014) (emphasis added).

Further, Chapter 2 of SW846 states that the methods in that document are not "mandatory" unless specifically specified as such by regulation. United States Environmental Protection Agency ("USEPA"), *SW-846 Update V* at 1 (July 2014).[1] USEPA guidance also makes clear that SW846 is only legally required where "explicitly specified" in a regulation. USEPA, *Disclaimer for Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846)* at 1 (July 2014).[2] The only substantive provision of Part 845 specifically requiring analysis using SW846 is Section 845.640(e), which applies to analyzing groundwater monitoring samples under a groundwater monitoring program and is not at issue here. 35 Ill. Admin. Code § 845.640(e). There is no requirement to use SW846 under Section 845.230(d)(2). The plain language of Part 845 does not require the utilization of SW846 for purposes of waste and CCR characterization.

IPGC followed best practices in the industry in conducting its "analysis of the chemical constituents found within the CCR to be placed in the CCR surface impoundment" and "analysis of the chemical constituents of all waste streams, chemical additives and sorbent materials entering or contained in the CCR surface impoundment." IPGC collected porewater, which is the most representative of the chemical constituents from the leachate of the impoundment. Testing of the actual porewater from a CCR surface impoundment is more appropriate than SW846's use of leach test results to estimate a total potential for chemical leaching from CCR into groundwater. In promulgation of the Federal 257 CCR Rule (40 CFR 257),

[1] Available at https://www.epa.gov/sites/default/files/2015-10/documents/chap2_1.pdf.
[2] Available at https://www.epa.gov/sites/default/files/2015-10/documents/disclaim.pdf.

USEPA states that "[t]he use of porewater data is still considered the most appropriate approach to estimate constituent fluxes to groundwater for CCR surface impoundments" (USEPA, 2015, Preamble p. 21441) because porewater is water "collected from the interstitial water between waste particles in surface impoundments as it occurs in the field" and represents the material potentially leached from impoundments. The CCR materials are the primary source of constituents loading to the CCR porewater. Over an extended period (e.g., months or years), the CCR porewater (i.e., water) reaches equilibrium with the CCR materials. The concentrations within the porewater are "the most representative data available for impoundments because these data are field-measured concentrations of leachate" (USEPA, 2014, Risk Assessment). The porewater analysis used is the best and most accurate scientifically available information for source characterization. *See, e.g.,* US EPA, Industrial Environmental Research Laboratory, Chemical and Biological Characterization of Leachates from Coal Solid Wastes, EPA-600/7-80-039, March 1980; US EPA & TVA, Effects of Coal-ash Leachate on Ground Water Quality, EPA-600/7-80-066, March 1980; US EPA, Office of Research and Development, Characterization of Coal Combustion Residues from Electric Utilities – Leaching and Characterization Data, EPA-600/R-09/151, December 2009; see also X.Wang, et al., Leaching and Geochemical Evaluation of Oxyanion Partitioning Within an Active Coal Ash Management Unit, Chemical Engineering Journal, Vol. 454, Part 4, at 140406 (Feb. 15, 2023).

Prior to performing hydrogeologic investigations in 2021 as needed to support the operating permit applications, Ramboll completed a review of existing data to determine whether sufficient information existed to meet the requirements of 35 I.A.C. § 845. Based on the review, Ramboll developed an approach to fully characterize the CCR material as part of the 2021 investigation at the Coffeen Power Plant. Porewater wells and CCR solids sample collection at each of the three impoundments (AP1, GMF Stack Pond, and GMF Recycle Pond) were selected by evaluating the extent of CCR material through time on aerial photographs identifying visible differences (color) in surficial materials and capturing a representative spatial distribution (both vertically and horizontally; Figures 1 and 2 in Attachment C). Based on the aerial photos, no porewater wells were planned for the GMF Recycle Pond because no CCR material was visible in the most recent aerials. During the investigation, assessment of conditions at the GMF Stack Pond with the drilling subcontractor indicated that it was unsafe to traverse the unit with a drill rig. As a result, the proposed porewater well was not installed, however two solid samples were obtained using hand tools. At AP1, two porewater wells were installed and two composite samples of CCR were collected to provide spatial coverage of the Unit. Analytical results of solid samples are provided in tables from the Hydrogeologic Characterization Reports which have also been included in Attachment C.

Proposed Closure Prioritization Category [35 Ill. Adm. Code 845.230(d)(2)(T)]

Comment 16: *To comply with the application requirements of 35 Ill. Adm. Code 845.230(d)(2)(T), the applicant must provide a proposed closure priority categorization pursuant to the requirements of 35 Ill. Adm. Code 845.700(g). The proposed closure priority categorization for the GMF Gypsum Stack Pond indicates that it should be included in Category 5, which is reserved for existing CCRSIs that have exceedances of the groundwater protection standards in 35 Ill. Adm. 845.600. However, the history of known groundwater standard exceedances for this impoundment, provided in Attachment M of the application, indicates that there have been no known exceedances. The proposed closure priority categorization for the GMF Gypsum Stack Pond should be revised to include this impoundment in Category 7, which is reserved for existing CCRSIs that are in compliance with the groundwater protection standards in 35 Ill. Adm. Code 845.600.*

Response: While there were no known exceedances of the groundwater protection standards when the application was submitted, an exceedance of the groundwater protection standards was identified in the quarterly groundwater monitoring report for the GMF Gypsum Stack Pond submitted to the Agency on October 16, 2023. Therefore, IPGC's operating permit now correctly identifies the GMF Gypsum Stack Pond in Category 5, and no application amendment is necessary.

<u>Initial Construction Permit Application(s)</u>

Groundwater Modeling [35 Ill. Adm. Code 845.220(d)(3)(A)]

Comment 17: *To comply with the application requirements of 35 Ill. Adm. Code 845.220(d)(3)(A), the applicant must provide documentation of groundwater modeling, including the results of groundwater contaminant transport modeling and calculations showing how the closure will achieve compliance with the applicable groundwater standards.*

The provided groundwater modeling reports for Ash Pond No. 1, the GMF Gypsum Stack Pond, and the GMF Recycle Pond only include groundwater transport modeling for sulfate, in Sections 4.3.3 and 4.5. The groundwater modeling reports should be revised to include groundwater modeling results for all constituents listed in 35 Ill. Adm. Code 845.600 that have been found to be present in these impoundments. Groundwater modeling of sulfate alone does not represent the flow rate and leachability of all constituents with groundwater protection standards.

Response: Part 845 does not require that groundwater models developed in support of the closure alternative analysis evaluate all constituents listed in Section 845.600 that have been found to be present in the CCR surface impoundment. Part 845 requires that groundwater modeling evaluate only "how the closure alternative will achieve compliance with the applicable groundwater protection standards" 35 Ill. Admin. Code § 845.710(d)(2). 221-9587. There is no language in Part 845 requiring that the groundwater model must evaluate all constituents that have been detected in a surface impoundment. Further, as discussed in Attachment D, modeling selected constituents is a common industry approach for evaluation of environmental systems and is sufficient to achieve the modeling objectives in support of the closure alternatives analysis. Attachment D at 3. IPGC selected, as a surrogate, sulfate as the constituent at the site that will likely require the longest time to achieve the groundwater protection standards. This surrogate constituent is appropriate to determine when the closure of each unit will achieve the groundwater protection standards as required by Section 845.710(d)(2). Id. at 5, 8-10.

IPGC and IEPA met on May 30, 2024 where IPGC presented the groundwater modeling approach used to meet the requirements of Section 845.220 (d)(3) and 845.710(d)(2). IPGC will not evaluate the fate and transport of constituents listed in Section 845.600 that are not found to be present in porewater collected from CCR SIs. In addition to closure permit groundwater modeling, IPGC will be conducting fate and transport modeling for evaluation of potential corrective measures in the corrective action alternatives analysis (CAAA) report (due no later than June 2025 for all units) using sulfate as a surrogate constituent. A geochemical evaluation report will also be submitted concurrently with the CAAA that discusses the expected transport and fate of all constituents listed in Section 845.600 that have been detected above the groundwater protection standards (GWPS) and are attributable to a CCR unit. Within the geochemical evaluation IPGC will also describe the expected behavior of constituents listed in Section 845.600 that were detected in porewater but have not been detected above the GWPS.

In addition, IPGC will be providing hydrogeologic and geochemical conceptual site models as components of the nature and extent report required by 35 Ill. Admin. Code § 845.650(d)(1). The nature and extent report will be submitted concurrent with the corrective measures assessment report (due no later than June 2024 for all units). These activities will address the concerns posed by IEPA in its Initial Review Letter.

History of Construction [35 Ill. Adm. Code 845.220(a)]

Comment 18: *To comply with the application requirements of 35 Ill. Adm. Code 845.220(a)(1)(D-E), the applicant must provide a description of the physical and engineering properties of the foundation and abutment materials of the CCRSI, and a statement detailing physical and engineering properties of the materials used in construction each zone or stage of the CCRSI.*

Response: See response to comment 1.

Comment 19: *To support the information provided to meet these requirements for Ash Pond No. 1, the GMF Gypsum Stack Pond, and the GMF Recycle Pond, the application should be revised to include geotechnical exploration data and laboratory testing data for the foundation, abutment, and zone/stage construction materials.*

Response: See response to comment 2.

Waste Characterization/CCR Characterization [35 Ill. Adm. Code 845.150(a)(1), 35 Ill. Adm. Code 845.220(a)(2)(A), 35 Ill. Adm. Code 845.600, 35 Ill. Adm. Code 845.640(a)]

Comment 20: *To comply with the application requirements of 35 Ill. Adm. Code 845.220(a)(2)(A), the applicant must provide an analysis of the chemical constituents found within the CCR located in or to be placed in a CCR surface impoundment (waste characterization). CCR waste characterization must include all waste streams as defined by SW846, incorporated by reference, which includes appropriate number of samples to characterize each waste type and identification of all waste types which includes solids, semi-solids, liquids, and airborne parts that come from the CCR. The applicant must provide date and time sampled, number of samples collected, constituents analyzed for each sample, statistics or data reduction technical explanations, and laboratory reports for the analytical data for the following waste streams at Ash Pond No. 1, the GMF Gypsum Stack Pond, and the GMF Recycle Pond: CCR solids and semi-solids; leachate water, if any; surface water, if any; and any other waste stream as defined by SW846 Compendium.*

Response: See response to comment 15.

Final Closure Plan and Alternatives Analysis [35 Ill. Adm. Code 845.220(d), 35 Ill. Adm. Code 845.210, 35 Ill. Adm. Code 845.720(b), and 35 Ill. Adm. Code 845.750]

Comment 21: *To comply with the application requirements of 35 Ill. Adm. Code 845.220(d)(2), the applicant must provide a final closure plan pursuant to the requirements of 35 Ill. Adm. Code 845.720(b), including a closure alternatives analysis pursuant to the requirements of 35 Ill. Adm. Code 845.210. The final closure plans for closure-in-place of Ash Pond No. 1 and the GMF Gypsum Stack Pond in accordance with 35 Ill. Adm. Code 845.750 should include plans for surveying the final extents of the ponds at each of the following points in the construction schedule: prior to commencement of construction activities, after compaction and dewatering of the CCR, after completion of placement of the low permeability layer, and after completion of final grading and seeding.*

Response: IPGC will conduct a survey of the final extents of the CCR surface impoundments prior to commencement of construction activities and after closure has been completed and will include this information in the closure report required to be submitted to the Agency pursuant to Section 845.760(e).

Comment 22: *The final closure plans for Ash Pond No. 1 and the GMF Gypsum Stack Pond should also include steps to verify that the proposed cover system soils come from an uncontaminated borrow source, including lab testing for SVOCs, VOCs, and PCBs listed in 35 Ill. Adm. Code 620 and metals listed in 35 Ill. Adm. Code 845.600. Alternatively, the borrow source material must be certified "uncontaminated soil" to ensure that the borrow source material does not pose a risk to human health and the environment.*

Response: Part 845 does not require IPGC to verify that the proposed cover system soils come from an uncontaminated borrow source or, alternatively, to certify the borrow source as "uncontaminated soil." Further, to the extent IEPA is relying on 35 Ill. Admin. Code Part 1100 to require certified "uncontaminated soil" be used as fill material at the site, it does not. Part 1100's application is limited to uncontaminated soil fill operations and clean construction demolition debris (CCDD) fill operations. Ash Pond No. 1 and the GMF Gypsum Stack Pond are neither. None the less, IPGC is committed to using borrow sourced from a location that has no known surface soil contamination of such a level to pose a significant risk to human health or the environment.

Comment 23: *The final closure plans for Ash Pond No. 1, the GMF Gypsum Stack Pond, and the GMF Recycle Pond should include laboratory documents to validate the groundwater and surface water summary tables in Attachment G, Appendix A, specifically for Table 2.2 and Table 2.3. Table 2.2 does not include concentrations for pH pursuant to the requirements of 35 Ill. Adm. Code 845.600.*

Response: Measurements of pH were not included in the referenced tables because pH is not a parameter that is typically evaluated in risk assessments, as there are no risk-based criteria that have been developed for pH (i.e., pH is not included on the US EPA Regional Screening Levels (RSL) list). However, pH values were provided in Table 4-1 of Appendix E (the Hydrogeologic Characterization Report (Ramboll, 2021a,b,c)) and are provided in the EDDs referenced in Comment 9. With respect to the Closure Alternatives Analysis tables 2.2, 3.1, and 3.2 that did not include pH; review of the data indicates pH concentrations had the following ranges:

AP1 – pH in monitoring wells ranged from 6.3 to 7.4 Standard Units (SU) from 2015 to 2021. The GWPS for pH at the CPP AP1 is 6.5 to 9.0 SU. Three results fell below the lower GWPS, however this was only during a single event at G301 and two events at G312. No results exceeded the upper GWPS.

GMF GSP - pH in monitoring wells ranged from 6.2 to 7.7 Standard Units (SU) from 2015 to 2021. The GWPS for pH at the CPP GMF GSP is 6.5 to 9.0 SU. Only one result from G206 fell below the lower GWPS. No results exceeded the upper GWPS.

GMF RP - pH in monitoring wells ranged from 6.5 to 7.7 Standard Units (SU) from 2015 to 2021. The GWPS for pH at the CPP GMF RP is 6.5 to 9.0 SU. No results fell below the lower GWPS and no results exceeded the upper GWPS.

Given the isolated and limited detections of pH outside the GWPS, including pH does not change the results of the evaluation which concluded current conditions do not present a risk to human health or the environment. pH data from groundwater sampling is included in the EDDs discussed below.

On December 19, 2023, IPGC technical staff and IEPA met to discuss IEPA's Initial Review Letter. Pursuant to that discussion and follow up emails exchanged on December 20, 2023, IPGC is producing the EDD responsive to the above request concurrently with this response. Given the nature of the data to be shared, IPGC will provide IEPA with a link to a temporary file-sharing service containing the EDD. Note that the EDD will only contain groundwater data, and that the surface water data will be provided in the Nature and Extent Report that is currently being prepared and will be submitted in conjunction with the Corrective Measures Assessment due to IEPA on June 12, 2024.

Comment 24: *The final closure plan for the GMF Recycle Pond does not provide proof that the onsite landfill is permitted and approved to accept CCR contaminated concrete. This final closure plan should be revised to demonstrate that the landfill is permitted as such.*

Response: There is an existing onsite landfill with enough capacity to accept CCR and CCR contaminated concrete from the GMF Recycle Pond. The final closure plan posits that CCR from the GMF Recycle Pond will be disposed in the onsite landfill. *See* WSP, Permit Application Part 845 Construction Permit Application for GMF Recycle Pond, Appendix C (Final Closure Plan) at Attachment 1 (Closure Alternative Analysis), p. 5-1. While the onsite landfill's Initial Facility Report (IFR) does not currently specify the waste stream of CCR-contaminated concrete, the on site landfill is exempt from permits pursuant to Section 21(d) of the Environmental Protection Act and is able to receive wastes generated by such person's own activities which are stored, treated, or disposed within the site where such wastes are generated. The IFR will be updated to reflect the approved closure plans, once a closure permit is received.

Proposed Closure Prioritization Category [35 Ill. Adm. Code 845.220(d)(1)]

Comment 25: *To comply with the application requirements of 35 Ill. Adm. Code 845.220(d)(1), the applicant must provide a proposed closure priority categorization pursuant to the requirements of 35 Ill. Adm. Code 845.700(g). The proposed closure priority categorization for the GMF Gypsum Stack Pond indicates that it should be included in Category 5, which is reserved for existing CCRSIs that have exceedances of the groundwater protection standards in 35 Ill. Adm. 845.600. However, the history of known groundwater standard exceedances for this impoundment, provided in Attachment M of the application, indicates that there have been no known exceedances. The proposed closure priority categorization for the GMF Gypsum Stack Pond should be revised to include this impoundment in Category 7, which is reserved for existing CCRSIs that are in compliance with the groundwater protection standards in 35 Ill. Adm. Code 845.600.*

Response: See response to comment 17.

Should you have any questions or comments regarding the above responses, please contact Rhys Fuller at rhys.fuller@vistracorp.com or (618) 975-1799.

Sincerely,

Phil Morris, P.E.
Sr. Director, Environmental

Attachment A

AECOM

Submitted to
Illinois Power Generating Company
134 Cips Lane
Coffeen, IL 62017

Submitted by
AECOM
1001 Highlands Plaza Drive West, Suite 300
St. Louis, MO 63110

October 2016

CCR Certification Report: Initial Structural Stability Assessment, Initial Safety Factor Assessment, and Initial Inflow Design Flood Control System Plan

For

Ash Pond No. 1

At Coffeen Power Station

Table of Contents

Executive Summary

The initial structural stability assessment, initial safety factor assessment, and initial inflow design flood control system plan for Ash Pond No. 1 at the Coffeen Power Station have been prepared in accordance with the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule 40 Code of Federal Regulations (CFR) §257.73(d), §257.73(e), and §257.82, respectively. These regulations require that the specified structural stability, safety factor, and hydrologic and hydraulic (supporting the inflow design flood control system plan) assessments for an existing CCR surface impoundment be completed by October 17, 2016.

The engineering investigations, analyses, and evaluations determined that Ash Pond No. 1 meets all requirements for the safety factor assessment and hydrologic and hydraulic analysis, as summarized in **Table ES-1**. All requirements for structural stability are met, except for the structural integrity of hydraulic structures (§257.73(d)(1)(vi)), as applied to the 48-inch recycle intake pipe for which a closed circuit television (CCTV) pipe inspection has not been completed due to high sustained flows in the pipe that are essential to station operations. In accordance with §257.73(d)(2), AECOM recommends that a CCTV pipe inspection be performed on the recycle outflow pipe as soon as feasible and that this assessment report be updated with documentation of that inspection.

Table ES-1 – Certification Summary

Report Section	CCR Rule Reference	Requirement Summary	Requirement Met?	Comments
Initial Structural Stability Assessment				
3.1	§257.73(d)(1)(i)	Stable foundations and abutments	Yes	Foundations were found to be stable. Abutments are not present.
3.2	§257.73(d)(1)(ii)	Adequate slope protection	Yes	Slope protection is adequate.
3.3	§257.73(d)(1)(iii)	Sufficiency of dike compaction	Yes	Dike compaction is sufficient for expected ranges in loading conditions.
3.4	§257.73(d)(1)(iv)	Presence and condition of slope vegetation	Yes	Vegetation is present on interior and exterior slopes and is maintained.
3.5	§257.73(d)(1)(v)(A) and (B)	Adequacy of spillway design and management	Yes	Spillways are adequately designed and constructed and adequately manage flow during 1,000-year flood.
3.6	§257.73(d)(1)(vi)	Structural integrity of hydraulic structures	No	Requirement cannot be certified as met at this time due to inability to complete a CCTV inspection of the recycle intake pipe due to high sustained pipe flows needed for plant operations. AECOM recommends inspecting the pipe as soon as feasible to address this issue.
3.7	§257.73(d)(1)(vii)	Stability of downstream slopes inundated by water body	Not Applicable	Inundation of exterior slopes is not expected. This requirement is not applicable.
Initial Safety Factor Assessment				
4.1	§257.73(e)(1)(i)	Maximum storage pool safety factor must be at least 1.50	Yes	Safety factors were calculated to be 1.50 and higher.
4.2	§257.73(e)(1)(ii)	Maximum surcharge pool safety factor must be at least 1.40	Yes	Safety factors were calculated to be 1.49 and higher.
4.3	§257.73(e)(1)(iii)	Seismic safety factor must be at least 1.00	Yes	Safety factors were calculated to be 1.03 and higher.
4.4	§257.73(e)(1)(iv)	For dikes constructed of soils that have susceptibility to liquefaction safety factor must be at least 1.20	Not Applicable	Dike soils are not susceptible to liquefaction.
Initial Inflow Design Flood Control System Plan				
5.1	§257.82(a)(1), (2), (3)	Adequacy of inflow design flood control system	Yes	Flood control system adequately manages inflow and peak discharge during the 1,000 year, 24-hour, Inflow Design Flood.
5.2	§257.82(b)	Discharge from the CCR Unit	Yes	Discharges into Waters of the United States are not expected to occur during normal or 1,000 year, 24-hour Inflow Design Flood conditions.

1 Introduction

This report documents that the structural stability assessment, safety factor assessment, and inflow design flood control system plan meet the requirements specified in 40 CFR §257.73(d), §257.73(e), and §257.82, respectively, except as noted herein, to support the certification required under each of those regulatory provisions for the Coffeen Power Station Ash Pond No. 1. Ash Pond No. 1 is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the specified initial structural stability assessment, initial safety factor assessment, and initial inflow design flood control system plan (i.e., hydrologic and hydraulic analysis) for an existing CCR surface impoundment be completed by October 17, 2016.

The Coffeen Power Station has three existing CCR surface impoundments, the GMF Pond, the GMF Recycle Pond, and Ash Pond No. 1. Ash Pond No. 1 has been evaluated to determine whether the structural stability, safety factor, and inflow design flood control system plan requirements are met. The following sections describe the evaluations performed and the results from the analyses, as supported by the underlying data and analyses included in the appendices.

2 Facility Description and Location Map

2.1 Overview of Existing Surface Impoundments

The Coffeen Power Station is a coal-fired power plant located approximately 2.4 miles south-southwest of Coffeen, Illinois in Montgomery County. The Coffeen Power Station is located on a peninsula extending into Coffeen Lake, and Ash Pond No. 1 is located approximately 0.3 miles east of the Coffeen Power Station. A site location map showing the Coffeen Power Station is in **Figure 1**. **Figure 2** presents the Coffeen Power Station site plan.

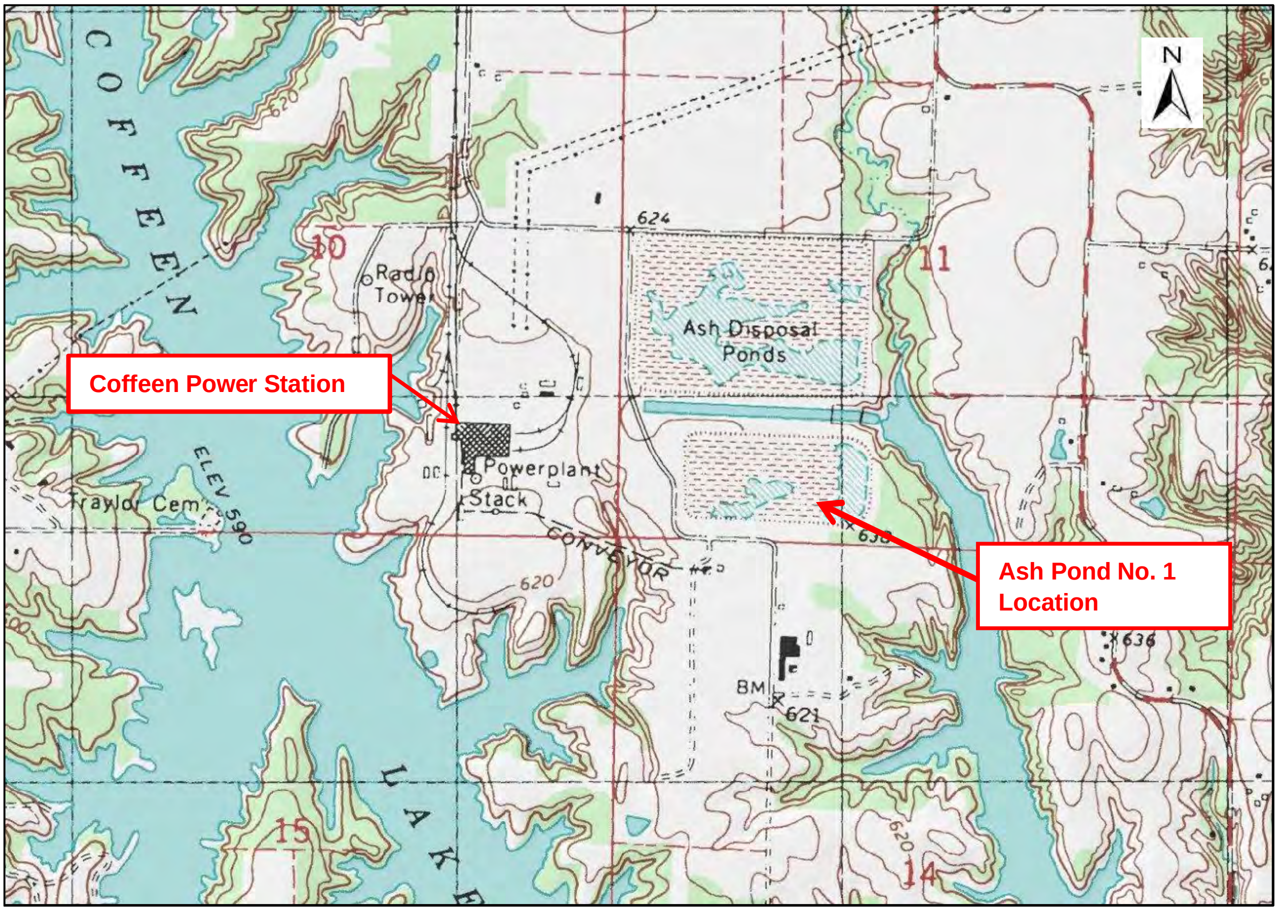

Figure 1 – Coffeen Power Station Location Map
(from United States Geological Survey Coffeen, Illinois 7.5' Topographic Maps, 1977)

Three active CCR surface impoundments – the GMF Pond, the GMF Gypsum Recycle Pond, and Ash Pond No. 1 – are utilized for managing CCRs generated by the Coffeen Power Station. This certification report only pertains to Ash Pond No. 1. Ash Pond No. 1 has a significant hazard potential, based on the initial hazard potential classification assessment performed by Stantec in 2016 in accordance with §257.73(a)(2).

Figure 2 – Coffeen Power Station Site Plan
(Imagery from Google Earth Pro, 2016)

Ash Pond No. 1 serves at the primary wet impoundment basin for bottom ash produced at the Coffeen Power Station. Ash Pond No. 1 was utilized as a flow-through structure, where outflow was ultimately discharged to Coffeen Lake, until approximately 1981, when the pond was modified by abandoning the penetrating discharge pipe in the northeast corner of the impoundment, adding a recycle intake structure in the northwest corner, removing some of the accumulated bottom ash, and regrading the remainder of the bottom ash to form a new impoundment floor. Currently, outflow from Ash Pond No. 1 flows into the recycle intake structure (outlet pipe) and is transferred back to the Coffeen Power Station for use as process water. An approximately 1,300-foot long interior dike creates an interior channel that leads to the recycle intake structure. Ash Pond No. 1 is operated as a closed-loop hydraulic system as outflow is transmitted back to the Coffeen Power Station during normal operational conditions. Some bottom ash is mechanically excavated from the southwest corner of Ash Pond No. 1 for offsite beneficial use.

Sluiced bottom ash from the Coffeen Power Station enters Ash Pond No. 1 through three steel sluice pipes, which discharge along the western embankment, on the south side of the interior dike. Additional clear water inflow from the plant enters Ash Pond No. 1 through two pipes, which discharge at a concrete structure approximately 120 feet north of the sluice pipes, and a

12-inch diameter iron pipe located at the northwest corner of the embankment. Outflow water is transferred back to the Coffeen Power Station via a concrete riser recycle intake structure and 48-inch steel recycle intake pipe located at the northwest corner of Ash Pond No. 1, which functions as the primary outflow pipe for Ash Pond No. 1. The pool level is controlled by a steel spillway gate, which allows for pool levels ranging from El. 624.5 feet to El. 631.0 feet (assumed to be NGDV29 datum, based on the date of the design drawings, but all other elevations in this report are in the NAVD88 datum unless otherwise noted). A secondary 24-inch pipe, which starts as corrugated metal pipe (CMP) and transitions to steel, is also connected to the 48-inch steel recycle intake pipe within the embankment, and is used to discharge excess flow into the recycle intake pipe during upset conditions, but the pipe does not transmit outflow during normal operations.

The surface area of Ash Pond No. 1 is approximately 26.2 acres. The embankment portion of Ash Pond No. 1 is comprised of a ring dike with a total length of approximately 4,350 feet and has a maximum height above exterior grade of 30 feet. The embankment was constructed as a homogenous earthen structure with well-compacted clayey fill. An approximately 570-foot long Hoesch 2500k steel sheet pile wall is located at the toe of the northeast corner of Ash Pond No. 1, in order to separate the embankment from the station process water flume. The process water flume transmits station cooling water back to Coffeen Lake over a series of weirs. The sheet pile wall was installed around the year 2000 and was driven approximately 13 feet into the foundation soils and has a maximum exposed height of 13.8 feet (10.3 feet above the normal pool in the process water flume). Downstream dike slopes, outside of the sheet pile wall area, range from approximately 1.4H:1V (horizontal to vertical) to 3H:1V and generally are covered in vegetation. Interior embankment slopes are partially covered in bottom ash or vegetation and exhibit an approximately 2H:1V orientation. The embankment crest width varies from approximately 14 to 22 feet. An engineered liner system is not present beneath Ash Pond No. 1.

As currently operated, the normal pool elevation of Ash Pond No. 1 is 631.0 feet and is controlled by the recycle intake structure and emergency overflow pipes. The minimum crest elevation is 635.0 feet. Additional details about the geometry and configuration of the impoundment is provided in the Geotechnical Report in **Appendix B** and the Hydrologic and Hydraulic Report in **Appendix C**.

3 Initial Structural Stability Assessment

40 CFR §257.73(d)(1)
The owner or operator of the CCR unit must conduct initial and periodic structural stability assessments and document whether the design, construction, operation, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater which can be impounded therein. The assessment must, at a minimum, document whether the CCR unit has been designed, constructed, operated, and maintained with [the standards in (d)(1)(i)-(vii)].

Analyses completed for the initial structural stability assessment of the Coffeen Power Station's Ash Pond No. 1 are described in this section. Data and analysis results in the following subsections were developed using recent and historical data provided by Illinois Power Generating Company (IPGC), including impoundment design information, spillway design information, survey data, historical data, analysis reports, and information about operational and maintenance procedures. These data were supplemented with subsurface investigation and laboratory data collected by AECOM in 2015.

IPGC's operation of Ash Pond No. 1 is consistent with the design and construction of the CCR unit. IPGC follows an established maintenance program that quickly identifies and resolves issues of concern.

3.1 Foundations and Abutments (§257.73(d)(1)(i))

CCR unit designed, constructed, operated, and maintained with stable foundations and abutments.

Stability of the foundations of Ash Pond No. 1 was evaluated by performing liquefaction/cyclic softening and slope stability analyses, and by reviewing soil consistencies and phreatic data estimated from Standard Penetration Test (SPT) values; Cone Penetration Test (CPT) tip resistances, side frictions, and pore pressures; and collected soil laboratory test data from the 2015 AECOM field investigation, which is discussed in more detail in **Section 4**. Based on these data, foundation materials generally consist of approximately 5 to 15 feet of medium stiff to stiff weathered loess (lean to fat clay with traces of sand and gravel) and 1 to 2 feet of soft to very soft clay, which in turn overlies very stiff to hard glacial till (clay) with some dense sand and trace gravel. Borings were terminated in the glacial till and were not extended to bedrock. The phreatic surface within the foundation is typically at the ground surface at the toe of the embankment and near the embankment/foundation interface beneath the crest. As Ash Pond No. 1 is a ring dike structure, abutments are not present.

This information was used to perform slope stability analyses as required by §257.73(e)(1), which is discussed in more detail in **Section 4**. Safety factors for slip surfaces passing through the dike and foundation were found to meet or exceed the minimum requirements required by §257.73(e)(1), which indicates that the foundation of Ash Pond No. 1 is stable.

In order to evaluate the stability of the foundation under post-seismic conditions, liquefaction/cyclic softening analyses as well as post-earthquake (i.e. "liquefaction") slope stability analyses were also performed. The liquefaction and cyclic softening triggering analyses were performed for the 2,500-year return period design seismic event in order to delineate soils susceptible to liquefaction within the foundations of Ash Pond No. 1. The analyses were performed using CPTs advanced into the foundations of Ash Pond No. 1, the methodology presented by Idriss and Boulanger (2008), and laboratory index and cyclic shear strength test data. The analyses found that the soft clay material within the foundation of Ash Pond No. 1 is susceptible to cyclic softening. This material is present between the bottom of the foundation clay and top of the glacial till. All other foundation soils evaluated at the site were not found to be susceptible to liquefaction or cyclic softening during the design seismic event.

Post-earthquake ("liquefaction" or post-cyclic softening) slope stability analyses were performed assuming residual cyclically-softened strengths in the soft clay and peak undrained shear strengths in all other embankment and foundation soils. Horizontal seismic loads are not included in this analysis, as it is intended to model the conditions immediately after earthquake shaking stops. The pool elevation and phreatic conditions were assumed to be the same as the Maximum Storage Pool case (**Section 4.1**), and correspond to normal operating conditions at Ash Pond No. 1. Resulting factors of safety were compared to the criteria presented in §257.73(e)(1)(iv). The factor of safety for slip surfaces passing through the foundation were found to meet the minimum factors of safety listed in §257.73(e)(1)(iv), which only applies to dike soils. The calculated factors of safety are identified in **Table 1.**

Table 1 – Summary of Factors of Safety – Post-Earthquake Conditions

Cross Section	Calculated Factor of Safety (§257.73 Minimum = 1.20)
13+00	1.49
30+00	1.44
36+50	1.34
39+00	1.31
46+50	1.30*

*Indicates critical cross section (i.e., lowest calculated factor of safety out of the five cross sections analyzed)

Based on this evaluation, Ash Pond No. 1 meets the requirements presented in §257.73(d)(1)(i). A detailed presentation of the field and laboratory data collected for the foundations and the completed slope stability analyses can be found in **Appendix B**.

3.2 Slope Protection (§257.73(d)(1)(ii))

CCR unit designed, constructed, operated, and maintained with adequate slope protection to protect against surface erosion, wave action and adverse effects of sudden drawdown.

The adequacy of slope protection present at Ash Pond No. 1 was evaluated by reviewing design drawings, operational and maintenance procedures, and conditions observed in the field during AECOM's June 11, 2015 site visit.

The exterior dike slopes have orientations ranging from 1.4H:1V to 3H:1V and are covered with vegetation for slope protection. IPGC regularly maintains the slopes, including repairing observed surface erosion and addressing areas of poor vegetation growth, as required. Where the exterior slopes are adjacent to a downstream water body (the process water flume), a steel sheet pile wall separates the exterior slopes from the downstream water body and protects the slopes against wave action and sudden drawdown. AECOM observed the vegetation and sheet pile wall to be adequately protecting against surface erosion.

The interior dike slopes have a 2H:1V orientation and are covered with vegetation and bottom ash. IPGC regularly maintains the slopes, including repairing observed surface erosion or wave action by backfilling the erosion and addressing areas of poor vegetation growth.

The pool level in Ash Pond No. 1 is maintained by the concrete recycle intake structure. The recycle intake structure has a steel gate that controls the pool level. Currently, the gate is operated such that the maximum normal pool level is El. 631.0 feet, but fully opening the gate would allow for the pool to be operated as low as El. 624.5 feet. Although lowering the pool level below El. 631.0 feet is not anticipated, IPGC has instituted operational controls to limit the rate of pool lowering to 1 foot per week. This rate is expected to allow phreatic water from the embankments to drain concurrently with the pool in Ash Pond No. 1, and to reduce the potential for sudden drawdown conditions developing in the embankment. Therefore, sudden drawdown conditions are not expected to occur due to the operational controls, and slope protection to protect against the adverse effects of sudden drawdown is not required.

Based on this evaluation, Ash Pond No. 1 meets the requirements in §257.73(d)(1)(ii).

3.3 Dike Compaction (§257.73(d)(1)(iii))

CCR unit designed, constructed, operated, and maintained with dikes mechanically compacted to a density sufficient to withstand the range of loading conditions in the CCR unit.

Compaction of the Ash Pond No. 1 dikes was evaluated using field data obtained from the 2015 AECOM geotechnical investigation and by reviewing design drawings and operational and operational and maintenance procedures. Based on the 2015 AECOM data, the dike materials consist of clay. SPT values and CPT tip resistances indicate that the dike material is medium stiff to stiff, which is indicative of mechanically compacted dikes. Slope stability analyses as required by §257.73(e)(1) found acceptable safety factors for each required loading condition, as presented in **Section 4**. Therefore, the dike compaction and density is sufficient for withstanding required ranges in loading conditions.

Based on this evaluation, Ash Pond No. 1 meets the requirements in §257.73(d)(1)(iii). A detailed presentation of the field and laboratory data collected for the dikes and the completed slope stability analyses can be found in **Appendix B**.

3.4 Vegetated Slopes (§257.73(d)(1)(iv))[1]

CCR unit designed, constructed, operated, and maintained with vegetated slopes of dikes and surrounding areas, except for slopes which have an alternate form or forms of slope protection.

The adequacy of slope vegetation at Ash Pond No. 1 was evaluated by reviewing conditions observed in the field during AECOM's June 11, 2015 site visit and by reviewing design drawings and operational and maintenance procedures. At the time of the site visit, the exterior slopes were vegetated, the upper portions of the interior slopes were vegetated, and the lower portions of the interior slopes were covered with bottom ash, which is an alternate form of slope protection. The vegetation on the exterior and interior slopes is well-maintained. Regular maintenance manages the vegetation as described in this section.

Based on this evaluation, Ash Pond No. 1 meets the requirements in §257.73(d)(1)(iv).

3.5 Spillways (§257.73(d)(1)(v))

CCR unit designed, constructed, operated, and maintained with a single spillway or a combination of spillways configured as specified in [paragraph (A) and (B)]:

(A) All spillways must be either:

(1) of non-erodible construction and designed to carry sustained flows; or

(2) earth- or grass-lined and designed to carry short-term, infrequent flows at non-erosive velocities where sustained flows are not expected.

(B) The combined capacity of all spillways must adequately manage flow during and following the peak discharge from a:

(1) Probable maximum flood (PMF) for a high hazard potential CCR surface impoundment; or

(2) 1000-year flood for a significant hazard potential CCR surface impoundment; or

(3) 100-year flood for a low hazard potential CCR surface impoundment.

The spillway system at Ash Pond No. 1 was evaluated using hydrologic and hydraulic analyses, conditions observed during AECOM's June 11, 2015 site visit, historic design and construction information provided by IPGC, and operational and maintenance procedures. Ash Pond No. 1 has a significant hazard potential; therefore, the 1,000-year storm event is the design flood event for Ash Pond No. 1, per §257.73(d)(1)(v)(B).

The spillway system for Ash Pond No. 1 includes a concrete recycle intake structure with a gated inlet to a 48-inch diameter steel recycle intake pipe, which acts as the primary outflow pipe for Ash Pond No. 1, and a secondary 24-inch CMP and steel overflow pipe that flows into the recycle intake pipe, which are all constructed of non-erodible materials designed to carry sustained flows. The capacity of the spillway was evaluated using hydrologic and hydraulic analyses. The analysis found that the spillway can adequately manage flow during peak discharge resulting from the 1,000-year storm event without overtopping of the embankments, as discussed in more detail in **Section 5**.

Based on these evaluations, Ash Pond No. 1 meets the requirements in §257.73(d)(1)(v). A detailed presentation of the hydraulic and hydrologic analyses can be found in **Appendix C**.

3.6 Stability and Structural Integrity of Hydraulic Structures (§257.73(d)(1)(vi))

CCR unit designed, constructed, operated, and maintained with hydraulic structures underlying the base of the CCR unit or passing through the dike of the CCR unit that maintain structural integrity and are free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris which may negatively affect the operation of the hydraulic structure.

The structural stability and integrity of the Ash Pond No. 1 hydraulic structures were evaluated using design drawings, operational and maintenance procedures, conditions observed in the field, and inspection data collected and performed by

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[1] As modified by court order issued June 14, 2016, Utility Solid Waste Activities Group v. EPA, D.C. Cir. No. 15-1219 (order granting remand and vacatur of specific regulatory provisions).

AECOM. There are two hydraulic structures at Ash Pond No. 1 that pass through the dike: the 48-inch steel recycle intake pipe and the 24-inch CMP and steel secondary overflow pipe. No other hydraulic structures are known to pass through the dike of or underlie the base of Ash Pond No. 1.

A review of design drawings and operational and maintenance procedures for the 24-inch secondary overflow pipe did not identify any issues. The 24-inch secondary overflow pipe was inspected on November 2, 2015, using CCTV inspection equipment. The inspection found that the outlet structure is free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris accumulation that may negatively affect the hydraulic operation of the structure. Some minor bulging and deterioration was noted. Per United States Army Corps of Engineers (USACE) Public Law 84-99 levee inspection guidance, such conditions are considered “minimally acceptable” for culverts and discharge pipes that penetrate a levee, which means that the intended function of the pipe will not be impacted during the flood event. A detailed presentation of the CCTV inspection of the 24-inch secondary overflow pipe can be found in **Appendix A**. Based on the evaluation, the 24 inch secondary overflow pipe meets the requirements of 40 CFR 257.73(d)(1)(vi).

An evaluation of the 48-inch recycle intake pipe design drawings, operational and maintenance procedures, and conditions observed in the field did not identify any issues. However, the 48-inch recycle intake pipe has not yet been inspected using CCTV equipment due to high sustained flows within the pipe, which are critical to station operations and preclude camera inspection. Because a thorough visual inspection of the 48-inch recycle intake pipe has not yet been completed, AECOM cannot currently conclude that the 257.73(d)(1)(vi) requirements have been met for the 48-inch recycle intake pipe. As a corrective measure, AECOM recommends that the 48-inch recycle intake pipe be inspected using CCTV equipment as soon as feasible and that this assessment be updated with documentation of the inspection at that time.

3.7 Downstream Slope Inundation/Stability (§257.73(d)(1)(vii))

CCR unit designed, constructed, operated, and maintained with, for CCR units with downstream slopes which can be inundated by the pool of an adjacent water body, such as a river, stream or lake, downstream slopes that maintain structural stability during low pool of the adjacent water body or sudden drawdown of the adjacent water body.

The structural stability of the downstream slope of Ash Pond No. 1 was evaluated by comparing the location of Ash Pond No. 1 relative to published flood maps for the area. Ash Pond No. 1 is outside the flood zone shown on the FEMA Federal Insurance Rate Map (FIRM) map for Montgomery County, Illinois. Therefore, adjacent water bodies that can inundate the downstream slopes of Ash Pond No. 1 are not present. **Figure 3** shows the footprint of Ash Pond No. 1 within the FIRM map (FEMA, 1981).

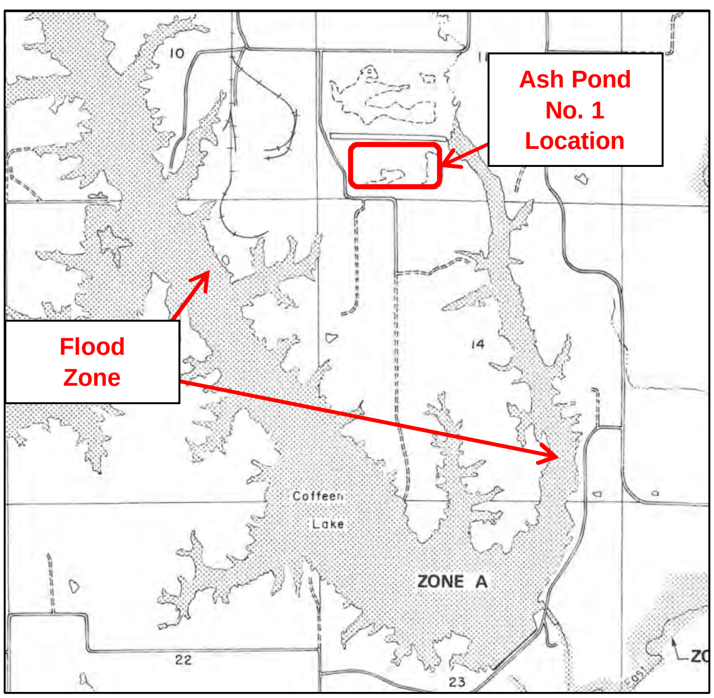

Figure 3. Ash Pond No. 1 Flood Zone Map
(from FEMA Flood Hazard Boundary Map, Montgomery County, Illinois, 1981)

It should be noted that the process water flume is adjacent to the northwest dike of Ash Pond No. 1. However, this flume carries water on the order of 3 feet in depth and the water level is controlled by a series of weirs before discharging into Coffeen Lake. Due to the shallow depth of water in the flume, and lack of a mechanism to draw down the water in the flume, drawdown or low pool in the flume is not expected to affect the structural stability of the downstream slopes of Ash Pond No. 1. Additionally, a steel sheet pile wall separates the Ash Pond No. 1 exterior slopes from the pool in the flume.

Based on this evaluation, the requirements in §257.73(d)(1)(vii) are not applicable to Ash Pond No. 1, as inundation of the downstream slopes by a water body such is a river, stream, or lake is not expected to occur, and the depth of water in the process water flume is shallow enough that drawdown would not be expected to affect the structural stability of the downstream slopes.

4 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

A geotechnical investigation program and stability analyses were performed by AECOM in 2015 to evaluate the design, performance, and condition of the earthen dikes of Ash Pond No. 1. The exploration consisted of 7 hollow-stem auger borings, 22 cone penetration tests, the installation of 5 standpipe and 3 vibrating-wire piezometers, and laboratory program including strength, hydraulic conductivity, consolidation, dispersion, and index testing. Data collected from the 2015 AECOM investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the embankment at Ash Pond No. 1 consists of medium stiff to stiff lean clay and overlies weathered loess and glacial till foundation materials. The foundation consists of approximately 5 to 15 feet of medium stiff to stiff weathered loess (lean to fat clay with traces of sand and gravel) overlying 1 to 2 feet of very soft to soft clay, which in turn overlies glacial till that is comprised of very stiff to hard clay with some dense sand and trace gravel. Borings were terminated in the glacial till and were not extended to bedrock. The phreatic surface within the subsurface is typically at the ground surface at the toe of the embankment and near the embankment/foundation interface beneath the crest.

Five (5) representative cross-sections (13+00, 30+00, 36+50, 39+00, and 46+50) were analyzed using GeoStudio SLOPE/W limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. Slip surface search routines in SLOPE/W relied on circular slip surfaces using entry and exit point-based and block-based methods to define the initial critical slip surface. The slip surface was then optimized to find a critical, non-circular or non-block slip surface, and factors of safety were calculated using the Spencer method. Where both circular and wedge surfaces were evaluated, the lower factor of safety from both methods is presented. This methodology was selected as it evaluates a wide range of slip surface geometries through the dike system and foundation, and the Spencer method satisfies both moment and force equilibrium. The sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Sections were generally selected to include the most critical configurations of the dike system along each side of the dike system, in terms of embankment height and slope and subsurface conditions. Each cross-section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The results of the initial safety factor assessment are summarized in the following sub-sections. A detailed presentation of the analyses performed, including development of site stratigraphy, strength parameters, stability analysis methodology, and figures showing the locations of cross-sections and exploration locations can be found in **Appendix B**.

4.1 Factor of Safety: Maximum Storage Pool Loading (§257.73(e)(1)(i))

The calculated static factor of safety under long-term, maximum storage pool loading condition must equal or exceed 1.50.

This calculation models the dike stability under static, long-term conditions, under the maximum operating pool level (El. 631.0 feet) within the impoundments, based on the configuration of the outfall structure (see **Section 5.1**). Drained (effective stress) shear strength parameters were used for all materials, and phreatic conditions were estimated based on available piezometer and boring data. The calculated minimum factors of safety are identified in **Table 2.**

Table 2 – Summary of Factors of Safety – Maximum Storage Pool Loading Condition

Cross Section	Calculated Factor of Safety (§257.73(e)(1)(i) Minimum = 1.50)
13+00	1.77
30+00	1.52
36+50	1.85
39+00	1.50*
46+50	1.50*

*Indicates critical cross section (i.e., lowest calculated factor of safety out of the five cross sections analyzed)

The calculated factors of safety meet or exceed 1.50 for all cross sections analyzed, which meets the requirements in §257.73(e)(1)(i).

4.2 Factor of Safety: Maximum Surcharge Pool Loading (§257.73(e)(1)(ii))

The calculated static factor of safety under maximum surcharge pool loading condition must equal or exceed 1.40.

This calculation models the dike stability under short-term, surcharge pool conditions. The pool level for analysis was modeled at an elevation of 632.0 feet, which is the 1,000-year flood pool (see **Section 5.1**). Drained soil strengths were used for analysis, as the relatively small increase in pool level is not expected to result in the development of undrained conditions in the downstream embankment slopes or foundation soils. Pore pressures in the embankment were assumed to be similar to the static drained conditions; however, the pool level in the Ash Pond No. 1 was increased to model additional loading from the surcharge pool. The calculated factors of safety are identified in **Table 3**.

Table 3 – Summary of Factors of Safety – Maximum Surcharge Pool Loading Condition

Cross Section	Calculated Factor of Safety (§257.73(e)(1)(ii) Minimum = 1.40)
13+00	1.77
30+00	1.52
36+50	1.85
39+00	1.49*
46+50	1.50

*Indicates critical cross section (i.e., lowest calculated factor of safety out of the five cross sections analyzed)

The calculated factors of safety exceeds 1.40 for all cross sections analyzed, which meets the requirements in §257.73(e)(1)(ii).

4.3 Factor of Safety: Seismic (§257.73(e)(1)(iii))

The calculated seismic factor of safety must equal or exceed 1.00.

This calculation models the dike stability under short-term, seismic loading conditions during the design 2,500-year return period seismic event. Seismic loading is modeled as a horizontal force acting outward on the dike and foundation. This analysis is intended to model conditions during earthquake shaking, when seismically-induced material strength losses have not yet occurred. Therefore, peak undrained (total stress) shear strength parameters were used in soils that are not considered to be rapidly draining materials, and peak drained strengths in soils considered to freely drain, as this analysis is intended to model conditions during earthquake shaking, when seismically-induced material strength losses have not yet occurred. The pool elevation and phreatic conditions were assumed to be the same as the Maximum Storage Pool case (**Section 4.1**), and correspond to maximum operating conditions at Ash Pond No. 1. The calculated factors of safety are identified in **Table 4**.

Table 4 – Summary of Factors of Safety – Seismic Loading Condition

Cross Section	Calculated Factor of Safety (§257.73(e)(1)(iii) Minimum = 1.00)
13+00	1.18
30+00	1.08
36+50	1.13
39+00	1.03*
46+50	1.07

*Indicates critical cross section (i.e., lowest calculated factor of safety out of the five cross sections analyzed)

The calculated factors of safety exceeds 1.00 for all cross sections analyzed, which meets the requirements in §257.73(e)(1)(iii).

4.4 Factor of Safety: Soils Susceptible to Liquefaction (§257.73(e)(1)(iv))

For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A liquefaction triggering analysis was performed to evaluate the requirements of §257.73(e)(1)(iv).

Liquefaction triggering analyses were performed for the 2,500-year return period design seismic even in order to delineate soils susceptible to liquefaction within the dike. The analyses were performed using CPTs advanced through the dike of Ash Pond No. 1, the methodology presented by Idriss and Boulanger (2008), and laboratory index test data. The analyses found that the materials comprising the Ash Pond No. 1 dikes were not susceptible to liquefaction during the design seismic event.

Based on this evaluation, the requirements in §257.73(e)(1)(iv) are not applicable to Ash Pond No. 1, as the dike soils are not susceptible to liquefaction.

5 Initial Inflow Design Flood Control System Plan

40 CFR §257.82

(a) The owner or operator of an existing … CCR surface impoundment … must design, construct, operate, and maintain an inflow design flood control system as specified in paragraphs (a)(1) and (2) of this section.

(1) The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood specified in paragraph (a)(3) of this section.

(2) The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood specified in paragraph (a)(3) of this section.

(3) The inflow design flood is:

(i) For a high hazard potential CCR surface impoundment, …, the probable maximum flood;

(ii) For a significant hazard potential CCR surface impoundment, …, the 1,000-year flood;

(iii) For a low hazard potential CCR surface impoundment, …, the 100-year flood; or

(iv) For an incised CCR surface impoundment, the 25-year flood.

(b) Discharge from the CCR unit must be handled in accordance with the surface water requirements under §257.3-3.

Analyses completed for the initial inflow design flood control system plan of Ash Pond No. 1 are described in the following subsections. Data and analysis results in the following subsection are based on spillway design information shown on design drawings, construction information, topographic surveys, information about operational and maintenance procedures provided by IPGC and field measurements collected by AECOM. The analysis approach and results of the hydrologic and hydraulic analyses are presented in the following subsections. A detailed presentation of the analyses performed can be found in **Appendix C**.

Ash Pond No. 1 has a significant hazard potential; therefore, the inflow design flood (IDF) is the 1,000-year flood.

5.1 Initial Inflow Design Flood Control Systems (§257.82(a))

An initial inflow design flood control system plan, supported by hydraulic and hydrologic analysis, was developed for Ash Pond No. 1 by evaluating the effects of a 24-hour duration design storm for the 1,000-year IDF using a hydraulic HydroCAD (Version 10) computer model and a starting water surface elevation of 631.0 feet, based on the characteristics of the outfall structure at Ash Pond No 1, which, in its current configuration, would allow for a normal pool elevation up this elevation. The computer model evaluated Ash Pond No. 1's ability to collect and control the 1,000-year IDF under existing operational and maintenance procedures. Rainfall data for the 1,000-year IDF was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14. The NOAA Atlas 14 rainfall depth is 9.13 inches.

The HydroCAD model results for Ash Pond No. 1 indicate that the CCR unit has sufficient storage capacity and spillway structures to adequately manage (1) flow into the CCR unit during and following the peak discharge of the 1,000-year IDF and (2) flow from the CCR unit to collect and control the peak discharge resulting from the 1,000-year IDF. The peak water surface elevation is 632.0 feet during the IDF, and the minimum crest elevation of the Ash Pond No. 1 dike is 635.0 feet. Therefore, overtopping is not expected.

Based on this evaluation, Ash Pond No. 1 meets the requirements in §257.82(a), and the hydrologic and hydraulic analysis is presented in **Appendix C**.

5.2 Discharge from the CCR Unit (§257.82(b))

40 CFR §257.82(b) provides that the discharge from the CCR unit must be handled in accordance with the surface water requirements under 40 CFR §257.3-3, which states the following:

> *(a) For purposes of section 4004(a) of the Act, a facility shall not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES) under section 402 of the Clean Water Act, as amended.*
>
> *(b) For purposes of section 4004(a) of the Act, a facility shall not cause a discharge of dredged material or fill material to waters of the United States that is in violation of the requirements under section 404 of the Clean Water Act, as amended.*
>
> *(c) A facility or practice shall not cause non-point source pollution of waters of the United States that violates applicable legal requirements implementing an areawide or Statewide water quality management plan that has been approved by the Administrator under section 208 of the Clean Water Act, as amended.*
>
> *(d) Definitions of the terms Discharge of dredged material, Point source, Pollutant, Waters of the United States, and Wetlands can be found in the Clean Water Act, as amended, 33 U.S.C. 1251 et seq., and implementing regulations, specifically 33 CFR part 323 (42 FR 37122, July 19, 1977).*

The handling of discharge was evaluated by reviewing design drawings, operational and maintenance procedures, conditions observed in the field by AECOM, and the inflow design flood control system plan developed per §257.82(a).

Based on this evaluation, Ash Pond No. 1 does not discharge into waters of the United States. Clear water from Ash Pond No. 1 is recycled to the Coffeen Power Station for use as process water. Hydraulic and hydrologic analyses performed as part of the initial inflow design flood control system plan found that Ash Pond No. 1 adequately manages outflow during normal and 1,000-year IDF conditions. Therefore, overtopping of Ash Pond No. 1 embankments is not expected.

Therefore, discharge into waters of the United States is not expected during normal or 1,000-year IDF conditions, and Ash Pond No. 1 meets the requirements in §257.82(b).

6 Conclusions

Ash Pond No. 1 at the Coffeen Power Station was evaluated relative to the USEPA CCR Rule requirements for initial structural stability assessments (§257.73(d)), initial safety factor assessments (§257.73(e)), and initial inflow design flood control system plan (§257.82). Based on the evaluations presented herein, the referenced requirements are satisfied for safety factor assessments and hydrologic and hydraulic analyses. The requirements for structural stability (§257.73(d)) are also satisfied, except for §257.73(d)(1)(vi).

At this time, the structural integrity of all of the hydraulic structures passing through the dikes of Coffeen Ash Pond No.1 cannot be certified because the recycle intake pipe has not been visually inspected using CCTV equipment due to high pipe flows needed for station operations. In accordance with §257.73(d)(2), AECOM recommends performing a CCTV inspection of the recycle intake pipe as soon as feasible, and updating this assessment once the inspection has been performed.

7 References

AECOM (2016). *Hydrologic and Hydraulic Summary Report- Coffeen Power Station, Ash Pond No. 1.* Coffeen, Illinois.

AECOM (2016). *Geotechnical Report- Dynegy Coffeen Power Station, Ash Pond No. 1.* Coffeen, Illinois.

Federal Emergency Management Agency (FEMA). (1981). Flood Hazard Boundary Map, Montgomery County, Illinois, Unincorporated Area, Panel 9 of 9. Community-Panel Number 170992 0009 A.

U.S. Army Corps of Engineers [USACE]. Flood Damage Reduction Segment / System Inspection Report. Not dated.

U.S. Environmental Protection Agency [USEPA]. (2015). *Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments.* 40 CFR Part 257, Subpart D. 80 Fed. Reg. 21468 April 17, 2015.

Weaver Consultants Group. (2015). Coffeen 2015 Aerial Topography, Existing Site Conditions, Coffeen, Illinois. December 1, 2015.

8 Appendices

A. Pipe Inspection Report

B. Geotechnical Report

C. Hydrologic and Hydraulic Report

Appendix A. Pipe Inspection Report

Blood Hound Inc.
750 Patricks Place
Brownsburg, IN
Tel: (888) 858-9830 (888)-858-9830
E-Mail: BHI@bhug.com bhi@bhug.com
Web: http://www.bhug.com http://www.bhug.com

Inspection Report

Date	Section #	Weather	Cleaning	Operator	Certificate #
11/2/2015	**1**	**Dry**	**No Pre-Cleaning**	**Mike Bennett**	**U-313-17480**

Street Name:	**134 Cips Lane**	Use of Sewer	**Stormwater**	Upstream MH	**Ash Pond 1 Overflow**
City	**Coffeen, Illinois**	Pipe Diameter	**24 inch**	Dowstream MH	**Discharge Flow**
		Pipe Material	**Corrugated Metal Pipe**	Dir. of Survey	**Upstream**
		Length surveyed	**262.00 ft**	Section Length	**262.00 ft**

Add. Information :

1:658

Discharge Flow

Position		Code	Observation
0.00		MWL	Water Level, 5 %of cross sectional area
0.00		ADP	Discharge Point / Survey Begins @ Discharge Flow
48.79	S1	SRI	Surface Roughness Increased, from 05 to 07 o'clock, within 8 inches of joint: YES, Start / Rust
88.59		SRC	Surface Reinforcement Corroded, from 07 to 09 o'clock, within 8 inches of joint: YES
89.04		MGO	General Observation / Slope Transition
93.43		MGO	General Observation / Possible Coating is Missing
129.44		SRC	Surface Reinforcement Corroded, from 03 to 05 o'clock, within 8 inches of joint: YES
169.34		MMC	Material Change, Steel pipe / CMP to Steel
201.12		IW	Infiltration Weeper, at 09 o'clock, within 8 inches of joint: YES
251.35		SRC	Surface Reinforcement Corroded, from 06 to 09 o'clock, within 8 inches of joint: YES
261.86	F1	SRI	Surface Roughness Increased, from 05 to 07 o'clock, within 8 inches of joint: YES, Finish
262.00		AEP	End of Pipe / Overflow Entry

Ash Pond 1 Overflow


0 FT


48.79 FT


88.59 FT


89.04 FT


93.43 FT

QSR	QMR	SPR	MPR	OPR	SPRI	MPRI	OPRI
531H	**2100**	**58**	**2**	**60**	**1.26**	**2**	**1.28**

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
Coffeen, Illinois	**134 Cips Lane**	**11/2/2015**		**1**

Photo: 45639-110215-01-AECOM-1021120151131211131212 1_A.JPG, 00:00:00
0FT, Discharge Point

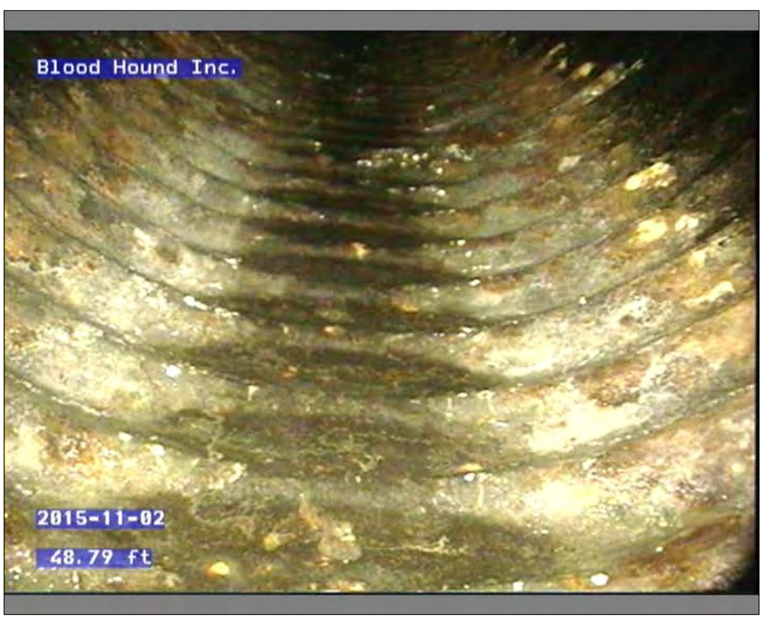

Photo: 45639-110215-01-AECOM-10211201511385511385555_A.JPG, 00:05:57
48.79FT, Surface Roughness Increased, from 05 to 07 o'clock, within 8 inches of
joint: YES, Start

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
Coffeen, Illinois	**134 Cips Lane**	**11/2/2015**		**1**

Photo: 45639-110215-01-AECOM-1021120151144571 1445757_A.JPG, 00:10:56
88.59FT, Surface Reinforcement Corroded, from 07 to 09 o'clock, within 8 inches of joint: YES

Photo: 45639-110215-01-AECOM-1021120151147531 1475353_A.JPG, 00:13:05
89.04FT, General Observation

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
Coffeen, Illinois	**134 Cips Lane**	**11/2/2015**		**1**

Photo: 45639-110215-01-AECOM-10211201511501311501313_A.JPG, 00:14:55
93.43FT, General Observation

Photo: 45639-110215-01-AECOM-10211201511543211543232_A.JPG, 00:18:27
129.44FT, Surface Reinforcement Corroded, from 03 to 05 o'clock, within 8 inches of joint: YES

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
Coffeen, Illinois	**134 Cips Lane**	**11/2/2015**		**1**

Photo: 45639-110215-01-AECOM-10211201511581211581212_A.JPG, 00:21:26
169.34FT, Material Change, Steel pipe

Photo: 45639-110215-01-AECOM-10211201511582111582121_B.JPG, 00:21:26
169.34FT, Material Change, Steel pipe

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
Coffeen, Illinois	**134 Cips Lane**	**11/2/2015**		**1**

Photo: 45639-110215-01-AECOM-10211201512010812010808_A.JPG, 00:23:59
201.12FT, Infiltration Weeper, at 09 o'clock, within 8 inches of joint: YES

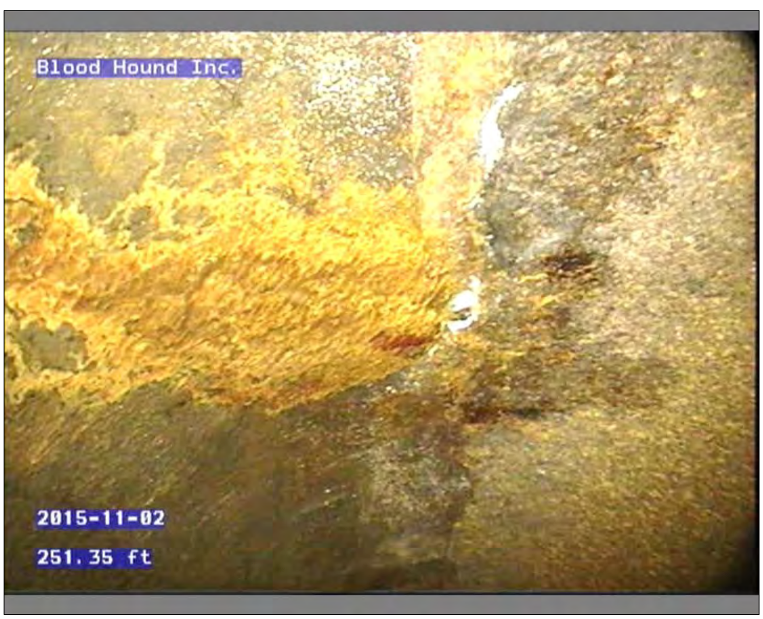

Photo: 45639-110215-01-AECOM-10211201512053112053131_A.JPG, 00:27:51
251.35FT, Surface Reinforcement Corroded, from 06 to 09 o'clock, within 8 inches of joint: YES

Blood Hound Inc.
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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
Coffeen, Illinois	**134 Cips Lane**	**11/2/2015**		**1**

Photo: 45639-110215-01-AECOM-10211201512081712081717_A.JPG, 00:29:27
261.86FT, Surface Roughness Increased, from 05 to 07 o'clock, within 8 inches of joint: YES, Finish

Photo: 45639-110215-01-AECOM-10211201512085712085757_A.JPG, 00:29:32
262FT, End of Pipe

Appendix B. Geotechnical Report

AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110-1337
www.aecom.com

314.429.0100 tel
314.429.0462 fax

October 7, 2016

Mr. Matt Ballance, PE
Senior Project Engineer
Dynegy Inc.
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

RE: Geotechnical Report
Coffeen Power Station
Ash Pond No. 1

Dear Mr. Ballance:

AECOM is pleased to provide this Geotechnical Report for the Illinois Power Generating Company, LLC (IPGC) Ash Pond No. 1 Coal Combustion Residuals (CCR) unit at the Coffeen Power Station located in Montgomery County, Illinois. This Geotechnical Report has been prepared to document the analyses performed to check that the facility meets the geotechnical stability requirements including Factors of Safety required by 40 CFR § 257.73.

AECOM looks forward to providing continued support to Illinois Power Generating Company, LLC (IPGC) and working together on this important program. Please do not hesitate to call Ron Hager at 314-429-0100 (office) / 440-591-7868 (mobile), if you have any questions or comments on this Geotechnical Report.

Sincerely,

AECOM

Victor Modeer, PE, D.GE
Site Manager
victor.modeer@aecom.com

Ronald Hager
Program Manager
ronald.hager@aecom.com

cc: Mark Rokoff, PE – AECOM

Attachments:
A. Figures
B. Boring Logs
C. Piezometer Logs
D. CPT Data Report
E. Lab Test Data
F. Analysis Section Development Calculations
G. Material Characterization Calculations
H. Slope Stability Analysis Calculations
I. Probabilistic Seismic Hazard Analysis Report
J. Dynamic Response Analysis Calculations
K. Liquefaction Analysis Calculations

1. INTRODUCTION

1.1. *Purpose of this Report*

This report presents the results of the geotechnical analysis prepared by AECOM for the Illinois Power Generating Company, LLC (IPGC)[1] Coal Combustion Residuals (CCR) Ash Pond No. 1 unit at the Coffeen Power Station located in Montgomery County, Illinois (see **Attachment A, Figure 1** for Location Map). The purpose of the geotechnical investigation and analyses performed is to evaluate the design, performance, and condition of each of the impoundments and associated structures using the data collected from surface and subsurface investigations, available design drawings, previous engineering investigations, reports and analyses, Station operating records, and other pertinent historic documents provided to AECOM by IPGC. This information was used to evaluate the design and operation of the surface impoundment against the regulatory standards set in 40 CFR § 257.73.

The geotechnical field evaluation was conducted between August 4 and August 30, 2015, consisting of conventional hollow stem auger (HSA) borings, Standard Penetration Testing (SPT), Cone Penetration testing (CPT), and piezometer installation. Laboratory testing was conducted on the materials obtained through various sampling techniques to assist in characterization of the subsurface conditions. AECOM performed stability analyses to evaluate the potential for slope instabilities in accordance with the Environmental Protection Agency (EPA) regulation 40 CFR 257.73(d) and (e).

A summary of the geotechnical field program, laboratory testing program and stability evaluations are presented herein. Detailed interpretation, calculations, and presentation of analysis results are provided in the Attachments to this report.

1.2. *Description of Impoundments*

Ash Pond No. 1 is a 26.2-acre active CCR Unit located directly to the east of Coffeen Power Station (see **Attachment A, Figure 1** for site location and vicinity maps). A continuous earthen embankment forms the perimeter (approximately 4,350 feet) of the pond. The pond currently receives bottom ash from the station. Embankment height ranges from approximately 10.5 feet (south embankment) to 30 feet (east embankment), as referenced to the downstream toe. Embankment downstream slopes range from approximately 1.4H:1V (north embankment) to 3.0H:1V (north embankment). Embankment crest width was approximately 10 feet, with some variation (± 2 feet).

2. SUMMARY OF FIELD INVESTIGATIONS

A subsurface exploration was performed at Ash Pond No. 1 including 7 soil borings, installation of 8 piezometers (5 open standpipe and 3 vibrating wire) to monitor phreatic water, and a program of 22 cone-penetration test CPT soundings, with seismic wave velocity measurements and pore pressure dissipation testing.

[1] Although Coffeen Power Station and Ash Pond No. 1 is owned and operated by IPGC, Dynegy Administrative Services Company, (Dynegy) contracted AECOM to develop this geotechnical report on behalf of IPGC. Therefore, “Dynegy” is referenced in materials attached to this geotechnical report.

AECOM's subcontractor Geotechnology, Inc. of St. Louis, MO, under the full-time supervision of AECOM geotechnical personnel, drilled the borings. Geotechnology used an All-Terrain Vehicle-mounted drill rig (CME 550x) and hollow stem augering (4¼-inch inner diameter) to drill the borings. The 5 open standpipe piezometers were also installed by Geotechnology, Inc. CPT soundings and the 3 vibrating wire piezometers were performed/installed by AECOM's subcontractor, ConeTec, Inc., again with full-time oversight by AECOM personnel.

Boring depths ranged from 25 to 60 feet, and CPT depths ranged from 13.5 to 38.6 feet below existing grades. Piezometer depths ranged from 12 to 45 feet below existing grades. The open standpipe piezometers were installed either directly in the borings or in offset borings (less than 10 feet of offset), and the vibrating wire piezometers were installed as part of the CPT push, at the bottom of the sounding. Boring and CPT locations are depicted in **Figure 1** (**Attachment A**), and piezometer locations are depicted in **Figure 2** (**Attachment A**). Boring and CPT exploration location data (ID, easting, northing, and ground surface elevation) are summarized in **Table 1**. Piezometer location and water level data are summarized in Table 3. Boring and piezometer logs are provided in **Attachments B** and **C**, respectively, and CPT data/plots are provided in **Attachment D**.

Representative soil samples were collected from each of the borings for classification and/or testing. The soil samples were obtained using SPT methodology with a split-spoon sampler, in general accordance with ASTM D 1586. Undisturbed samples of fly ash and/or fine-grained soils were obtained using 3-inch outside diameter steel (Shelby) tubes, either conventionally pushed in accordance with ASTM D 1587 or by utilizing a piston sampler in accordance with ASTM D 6519 (in ash and very soft soils).

Table 1
Boring and CPT Exploration Location Data

Exploration ID	Easting (ft. NAD83)	Northing (ft. NAD83)	Elevation (ft. NAVD88)
Borings			
COF-B001	2516693.6	871590.9	636.0
COF-B002	2516044.2	871459.0	636.8
COF-B003	2515128.2	871825.7	637.5
COF-B004	2516088.2	872193.3	636.3
COF-B005	2516696.9	872102.4	636.5
COF-B006[1]	2515234.7	871654.5	631.9
COF-B006A	2515194.6	871651.3	633.6
CPT Soundings			
COF-C001	2516707.7	871669.9	636.0
COF-C002	2516697.4	871670.5	635.7
COF-C004	2516680.0	871564.2	636.2
COF-C005	2516620.3	871489.3	635.8
COF-C006	2516733.0	871479.0	616.7
COF-C007	2516042.4	871473.8	636.4
COF-C008	2516044.2	871459.0	636.8
COF-C009	2516037.0	871418.1	621.8
COF-C010	2515367.7	871475.5	637.3
COF-C011	2515368.5	871461.5	637.2
COF-C012	2515373.3	871428.8	624.5
COF-C013	2515184.7	871641.2	634.6
COF-C014	2515086.4	871827.0	623.0
COF-C015	2515144.1	871827.2	637.4
COF-C016	2515158.4	872152.2	637.0
COF-C017	2515108.5	872206.5	618.3
COF-C018	2516086.5	872242.1	617.4
COF-C019	2516088.2	872193.3	636.3
COF-C020	2516801.3	872023.2	612.3
COF-C022	2516696.9	872102.4	636.5
COF-C023[1]	2516696.9	872102.4	636.5
COF-C024	2516726.6	871883.8	636.9

[1]COF-B006 and COF-C023 were not surveyed. Locations are approximate based on handheld GPS measurements taken during the investigation.

3. SUMMARY OF SITE-SPECIFIC SUBSURFACE CONDITIONS

3.1. *Site Stratigraphy*

Because the embankment and foundation materials encountered during the field investigation at Ash Ponds No. 1 and 2 were very similar, the strength characterization of the materials at Ash Pond No. 1 was based on the field and laboratory data obtained from both impoundments. Five representative material horizons were identified during the geotechnical investigation:

- Embankment Fill: Embankment fill encountered in the borings typically classified as silty clay, sandy lean clay, or lean clay with sand (CL), with trace amounts of fine gravel, was soft to very stiff in consistency, low to medium plasticity, moist to wet, and brown to gray. Trace amounts of organic material and ash were sometimes encountered. The embankment fill generally appeared to be well-compacted.

- Impounded Ash Materials: Bottom ash materials were encountered in two of the borings drilled in Ash Pond No. 1. The material was generally classified as well graded, medium- to coarse-grained sand (cinders), with trace amounts of silt or clay, very loose to medium dense, moist to wet, and black.

- Foundation Clay: Ash Pond No. 1 was underlain predominantly by a native clay of wind-blown origin (loess), with some coarse-grained layers. The fine grained soils (clays) encountered in the borings were generally classified as low- to medium-plasticity silty clay, sandy lean clay, or lean clay with sand (CL) often with trace amounts of gravel; or high plasticity fat clay (CH), often with trace amounts of sand. The CL and CH soils were soft to very stiff, moist to wet, and brown to gray. The coarse-grained soils encountered in the borings were classified as clayey sand (SC), silty sand (SM), or fine to coarse sand (SP), with trace amounts of gravel, loose to dense, wet, and brown to gray.

- Soft Clay: A thin layer of native silty or sandy lean clay (CL) was encountered in several borings and in CPT soundings between the foundation clay and underlying glacial till deposits. The clay was very soft to medium stiff, low to medium plasticity, wet, and orange brown to gray.

- Glacial Till: Glacial material encountered in the borings was generally classified as lean clay, or silty to sandy lean clay (CL), with trace amounts of fine gravel, hard, low plasticity, moist to wet, and brown to gray. In one boring, the till was classified as silty, fine- to coarse-grained sand (SP) underlain by fine- to coarse-grained clayey sand (SC) with trace amounts of gravel, very dense, wet, and brown.

Logs of the borings and CPT soundings are included in **Attachments B** and **D**, respectively, and laboratory test results are included in **Attachment E**. Summary plots of the field and laboratory data for the various material types are included in the Material Characterization Calculation Package in **Attachment G**.

3.2. ***Phreatic Water Conditions***

AECOM evaluated phreatic water level data from five piezometer measurement events (8/29/15, 10/5/15, 10/30/15, 11/23/15, and 12/23/15), conditions interpreted from CPT pore pressure dissipation (PPD) tests, and borehole water measured immediately after drilling. Piezometer readings were judged to be the most representative of in-situ, steady state phreatic conditions, while PPD tests were judged to be generally representative with the exception of some anomalous data. Boring water measurements were judged to be the least representative as phreatic conditions had not equilibrated in the low-permeability clay when measurements were taken immediately after drilling, as evidenced by inconsistency with piezometer and CPT data.

Piezometer locations and measurements data are summarized in **Table 2**.

Table 2
Piezometer Location and Water Level Data

PZ or VWP No.	Embankment	Northing	Easting	Ground Surface Elevation (feet)	Location	PZ Type	Total Depth (feet)	Water Surface Elevation (feet)				
								8/28/15	10/5/15	10/30/15	11/23/15	12/23/15
COF-P000	Southeast	871480.4	2516729.1	636.0	Crest	OSP_{stick}	27.9	617.2	618.4	618.2	619.4	619.8
COF-P001	Southeast	871590.8	2516693.6	616.9	Toe	VWP	12.0	615.6	N/M	614.6	616.0	616.1
COF-P002	South	871459.0	2516044.2	636.8	Crest	OSP_{stick}	39.3	625.4	625.2	625.2	626.3	626.7
COF-P003	West	871825.8	2515127.9	637.6	Crest	OSP_{stick}	48.0	621.3	620.8	620.7	621.9	623.2
COF-P005	North	872198.2	2516081.0	636.4	Crest	OSP_{stick}	23.2	620.7	621.5	622.2	622.6	622.5
COF-P006	Northeast	872102.4	2516696.9	636.5	Crest	OSP_{stick}	47.4	613.3	613.2	613.1	613.1	613.6
COF-P007	North	872242.0	2516084.0	617.4	Toe	VWP	15.0	611.3	N/M[5]	610.2	612.1	614.1
COF-P008	West	871825.3	2515082.9	622.7	Toe	VWP	19.0	620.1	N/M[5]	619.7	620.9	621.4

Notes:

1. For standpipe piezometers, stickup and WL measurement referenced to top edge of yellow protector cover with hinged cap open.
2. Total Depth = Approx. bottom of screen for standpipe piezometers, or installed depth for VWPs.
3. OSP = open standpipe piezometer.
4. VWP = vibrating wire piezometer installed at locations not accessible with drill rig.
4. Piezometers COF-P004, -P011, and -P013 were planned but not installed due to access issues.
5. N/M = Not measured.

4. SUMMARY OF LABORATORY TESTING

4.1. *Summary of Laboratory Testing Scope*

The laboratory testing program performed for Ash Pond No. 1 was intended to obtain information on index properties and shear strength properties of the subsurface conditions at the site. Shear strength tests from both Ash Ponds No. 1 and 2 were used for the material strength characterization. The laboratory testing program for characterization of the materials at Ash Pond No. 1 are summarized in **Table 3**.

Table 3
Summary of Laboratory Testing Program for Ash Pond No. 1

ASTM Designation	Test Type	Number of Tests					
		Total	Ash	Embankment	Foundation Clay	Soft Clay	Glacial Till
D2216	Moisture Content	66	-	30	26	-	10
D2937	Dry Unit Weight	15	-	6	9	-	
D4318	Atterberg Limits	29	-	12	12	-	5
T311, D1140, D422	Gradation/Hydrometer	19	2	6	8	-	3
D854	Specific Gravity	6	1	2	1	-	2
D5084	Hydraulic Conductivity	5	-	2	3	-	
D4221, D4647, D6572,	Dispersion	5	-	4	1	-	-
D2435	Consolidation	3	-	2	1	-	-
D4767	Consolidated Undrained Triaxial (CIU)	9[1]	-	5[1]	4[1]	-	-
D6528	Direct Simple Shear (DSS)	4[2]	-	-	3[2]	1[2]	-

Notes:

1. CIU Triaxial test numbers reported in the table include the tests on samples from Ash Pond No. 2 that were considered in the material characterization for Ash Pond No. 1 (3 on embankment material, and 2 on foundation clay material).
2. All of the DSS tests listed in the table were performed on samples from Ash Pond No. 2.

4.2. *Summary of Laboratory Testing Results*

A summary of laboratory test results for the impounded ash, embankment, foundation clay, and glacial till at Ash Pond No. 1 are presented in **Tables 4, 5, 6**, and **7**, respectively. Laboratory test data is included in **Attachment E**. Graphical displays of the shear strength characterization for the stratigraphic materials are included in the Material Characterization Calculation Package in **Attachment G**.

Table 4
Summary of Laboratory Test Results – Impounded Ash

Boring and Sample ID	Ground Surface Elevation (ft)	Material Description	Sample Depth	Moisture Content	Specific Gravity	Gradations				
						Sieve Analysis (3 inch to #200 Sieve)			Hydrometer	
						Gravel	Sand	Fines	Silt	Clay
			(ft)	(%)		(%)	(%)	(%)	(%)	(%)
COF-B006-S1	631.9	Ash	1	6.6		2	88.1	9.9		
COF-B006-S2	631.9	Ash	3.5	48.3	2.54					
COF-B006-S3	631.9	Ash	6	22.2		0	93.0	7.0		
COF-B006-S4	631.9	Ash	8.5	16.7						

Table 5
Summary of Laboratory Test Results[1] – Embankment Fill

Boring and Sample ID	Ground Surface Elevation (ft)	Material Description	Sample Depth	Moisture Content	Dry Unit Weight	Total Unit Weight	Specific Gravity	Atterberg Limits			Gradations					USCS	Hydraulic Conductivity	Dispersion			Consolidation	
								Liquid Limit	Plastic Limit	Plasticity Index	Sieve Analysis (3 inch to #200 Sieve)			Hydrometer				Crumb	Pinhole	Double Hydrometer	σ'max	OCR
											Gravel	Sand	Fines	Silt	Clay							
			(ft)	(%)	(pcf)	(pcf)		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)		(cm/sec)			(%)	(tsf)	
COF-B001-S1	634.8	Embankment	1	12.9																		
COF-B001-S2	634.8	Embankment	3.5	20.3			2.71	31	14	17												
COF-B001-S3	634.8	Embankment	6	15.4							5.0	38.8	56.2	36.4	19.8							
COF-B001-S4	634.8	Embankment	8.5	16.1							0	30.0	70.0	45.0	25.0			1	ND1	24		
COF-B001-S5	634.8	Embankment	13.5	14.7	116.7	133.9		35	15	20											3.0	3.2
COF-B001-S5	634.8	Embankment	13.5	18.8	109.0	129.5																
COF-B002-S1	635.4	Embankment	1	25.4																		
COF-B002-S2	635.4	Embankment	3.5	25.9				35	17	18												
COF-B002-S3	635.4	Embankment	6	25.9																		
COF-B002-S4	635.4	Embankment	8.5	17.8	114.2	134.5		40	15	25	0	25.0	75.0	53.0	22.0	CL	4.1E-09	1	ND1	26		
COF-B002-S5	635.4	Embankment	13.5	23.3							0	26.8	73.2	44.7	28.5							
COF-B002-S6	635.4	Embankment	15	26.7	94.9	120.2		25	18	7											2.0	2.1
COF-B003-S1	635.7	Embankment	1	14.2																		
COF-B003-S2	635.7	Embankment	3.5	18.1				42	16	26												
COF-B003-S3	635.7	Embankment	6	15.0			2.7															
COF-B003-S4	635.7	Embankment	8.5	17.4																		
COF-B003-S5	635.7	Embankment	13.5	21.8	104.7	127.5		54	18	36	0	10.0	90.0	50.5	39.5	CH		2	ND1	26		
COF-B004-S1	635.0	Embankment	1	18.0																		
COF-B004-S2	635.0	Embankment	3.5	10.9																		
COF-B004-S3	635.0	Embankment	6	11.0																		
COF-B004-S4	635.0	Embankment	8.5	12.8	121.4	136.9		39	15	24												
COF-B004-S5	635.0	Embankment	13.5	13.1				26	14	12												
COF-B005-S1	635.1	Embankment	1	21.1																		
COF-B005-S2	635.1	Embankment	3.5	8.0	126.5	136.6		22	13	9	0	42.0	58.0	47.0	11.0	CL	7.0E-07	2	ND1	58		
COF-B005-S3	635.1	Embankment	6	13.1																		
COF-B005-S4	635.1	Embankment	8.5	9.9				20	14	6												
COF-B005-S5	635.1	Embankment	13.5	10.3																		
COF-B005-S6	635.1	Embankment	18.5	9.4																		
COF-B006-S5	631.9	Embankment	13.5	24.4				57	20	37												
COF-B006-S6	631.9	Embankment	18.5	21.9																		

Note:
[1] Results of CIU triaxial tests are presented graphically in the Ash Pond No. 1 Material Characterization calculation package.
[2] Crumb: 1 – Nondispersive, 2 – Intermediate, 3 – Dispersive, 4 – Highly Dispersive; Pinhole: ND1 & ND2 – Nondispersive, ND3 & ND4 – Slightly to Moderately Dispersive, D1 & D2 – Dispersive; Double Hydrometer: Dispersion < 30% - Nondispersive, Dispersion > 60% - Dispersive.

Table 6
Summary of Laboratory Test Results[1] – Foundation Clay (including Soft Clay)

Boring and Sample ID	Ground Surface Elevation (ft)	Material Description	Sample Depth (ft)	Moisture Content (%)	Dry Unit Weight (pcf)	Total Unit Weight (pcf)	Specific Gravity	Atterberg Limits: Liquid Limit (%)	Atterberg Limits: Plastic Limit (%)	Atterberg Limits: Plasticity Index (%)	Gradations: Sieve Analysis (3 inch to #200 Sieve): Gravel (%)	Sand (%)	Fines (%)	Gradations: Hydrometer: Silt (%)	Clay (%)	USCS	Hydraulic Conductivity (cm/sec)	Dispersion: Crumb	Dispersion: Pinhole	Dispersion: Double Hydrometer (%)	Consolidation: σ'max (tsf)	Consolidation: OCR
COF-B001-S6	634.8	Foundation Clay	18.5	23.2																		
COF-B001-S7	634.8	Foundation Clay	21	23.4	101.8	125.6		66	22	44	0	2.0	98.0	57.5	40.5	CH	1.3E-08	3	ND1	22		
COF-B001-S7	634.8	Foundation Clay	21	28.7	93.0	119.7																
COF-B001-S8	634.8	Foundation Clay	23.5	19.6			2.68	41	15	26												
COF-B001-S9	634.8	Foundation Clay	28.5	16.8																		
COF-B002-S7	635.4	Foundation Clay	18.5	25.4				47	18	29												
COF-B002-S8	635.4	Foundation Clay	23.5	18.9																		
COF-B002-S9	635.4	Foundation Clay	28.5	13.6							3.0	80.0	17.0	12.7	4.3							
COF-B003-S6	635.7	Foundation Clay	18	26.0																		
COF-B003-S7	635.7	Foundation Clay	23.5	20.8				50	16	34	0	24.2	75.8	47.4	28.4	CH						
COF-B003-S8	635.7	Foundation Clay	28.5	12.5				21	15	6												
COF-B003-S9	635.7	Foundation Clay	30	11.8	126.7	141.7					7.0	53.5	39.5	31.2	8.3		2.2E-07					
COF-B003-S10	635.7	Foundation Clay	33.5								8.0	89.3	2.7									
COF-B004-S6	635.0	Foundation Clay	18.5	21.8																		
COF-B004-S7	635.0	Foundation Clay	23.5	20.6	107.4	129.5		51	17	34							5.0E-07					
COF-B004-S7	635.0	Foundation Clay	23.5	19.7	108.5	129.9																
COF-B004-S8	635.0	Foundation Clay	28.5	24.2				43	16	27												
COF-B005-S7	635.1	Foundation Clay	23.5	18.7	110.7	131.4		37	17	20												
COF-B005-S7	635.1	Foundation Clay	23.5	18.8	111.5	132.5																
COF-B005-S7	635.1	Foundation Clay	23.5	18.3	108.3	128.1															2.12	2.1
COF-B005-S8	635.1	Foundation Clay	28.5	21.9																		
COF-B005-S9	635.1	Foundation Clay	33.5	26.7				22	16	6	1.0	66.9	32.1	24.1	8.0	SC-SM						
COF-B005-S10	635.1	Foundation Clay	38.5	13.0							2.0	72.0	26.0									
COF-B005-S11	635.1	Foundation Clay	43.5	12.8				32	15	17	2.0	28.3	69.7	48.3	21.4	CL						
COF-B005-S12	635.1	Foundation Clay	48.5	15.5				32	15	17												
COF-B005-S13	635.1	Foundation Clay	53.5	23.2																		
COF-B006-S7	631.9	Foundation Clay	23.5	19.8				23	14	9												

Note: [1] Results of CIU triaxial tests and DSS tests are presented graphically in the Ash Pond No. 1 Material Characterization calculation package.
[2] Crumb: 1 – Nondispersive, 2 – Intermediate, 3 – Dispersive, 4 – Highly Dispersive; Pinhole: ND1 & ND2 – Nondispersive, ND3 & ND4 – Slightly to Moderately Dispersive, D1 & D2 – Dispersive; Double Hydrometer: Dispersion < 30% - Nondispersive, Dispersion > 60% - Dispersive.

Table 7
Summary of Laboratory Test Results – Glacial Till

Boring and Sample ID	Ground Surface Elevation (ft)	Material Description	Sample Depth	Moisture Content	Specific Gravity	Atterberg Limits			Gradations					USCS
						Liquid Limit	Plastic Limit	Plasticity Index	Sieve Analysis (3 inch to #200 Sieve)			Hydrometer		
									Gravel	Sand	Fines	Silt	Clay	
			(ft)	(%)		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	
COF-B001-S11	634.8	Till	33.5	11.7	2.73	30	13	17						
COF-B002-S10	635.4	Till	33.5	9.5		20	13	7						
COF-B003-S11	635.7	Till	38.5	9.5					7.0	44.8	48.2	39.8	8.4	
COF-B003-S12	635.7	Till	43.5	9.9										
COF-B004-S9	635.0	Till	33.5	8.4		21	13	8						
COF-B004-S10	635.0	Till	38.5	8.8	2.76									
COF-B004-S11	635.0	Till	43.5	14.8					1.0	38.0	61.0	50.3	10.7	
COF-B005-S14	635.1	Till	58.5	23.3		47	17	30	0	18.0	82.0	47.7	34.3	CL
COF-B006-S8	631.9	Till	28.5	16.1										
COF-B006-S9	631.9	Till	32	8.1		25	13	12						

5. SLOPE STABILITY ANALYSES

Slope stability analyses were performed for varying loading conditions at selected cross-sections, as described in the following sub-sections. Analysis section development, soil material properties, and seismic analyses related to the slope stability analysis are also discussed in the following sub-sections.

5.1. ***Cross-Sections for Analysis***

Five representative cross sections were identified for the stability evaluation of Ash Pond No. 1 perimeter embankments. Because the foundation conditions underneath the embankments were fairly uniform, the analysis sections for the west, south, east and north embankments were selected based on heights and steepness of the downstream embankment slopes. An analysis section was also identified at the northeast corner of Ash Pond No. 1, where a sheet pile wall was installed at the toe of the original embankment to allow for construction of the cooling water system mixing pond. The location of each analysis section is listed below and shown on **Figure 3** (**Attachment A**):

- Station 13+00: West embankment
- Station 30+00: South embankment
- Station 36+50: East embankment
- Station 39+00: Northeast Corner (Sheet pile wall)
- Station 46+50: North embankment

The section geometry for each analysis cross-section was determined based on the ground surface topographic contours shown on **Figure 3** (**Attachment A**) and subsurface information from the borings and CPT soundings. The relevant CPT soundings and test borings that were used to develop subsurface stratigraphy at the five analysis sections are shown on the geologic sections on **Figures 5** through **9** (**Attachment A**). The piezometric surfaces for each analysis section were determined based on the maximum operating pool elevation of 631.0 feet in the ash pond, water level readings in the piezometers, and static pore pressure profile determined from the CPT PPD tests. The development of the analysis sections is discussed in **Attachment F**.

5.2. ***Stability Analysis Conditions Considered***

Consistent with the criteria provided in the USEPA CRR Rule § 257.73(e), the stability of the Ash Pond No. 1 embankments was evaluated for four load cases:

Static, Steady-State, Normal Pool Condition*:* This case models the embankment under static, long-term conditions, at maximum operating pool elevation within the impoundment of 631.0 feet, as listed in AECOM's hydrologic and hydraulic report (AECOM, 2016) for Ash Pond No. 1. Drained (effective stress) shear strength parameters were used for all materials, and phreatic conditions were estimated based on available piezometer and CPT dissipation test data. ***Target Factor of Safety of 1.50.***

Static, Maximum Surcharge Pool Condition: This case models the conditions under a short-term surcharge pool elevation of 632.0 feet, as listed in AECOM's hydrologic and hydraulic report (AECOM, 2016) for Ash Pond No 1. Drained (effective stress) shear strength parameters were used for all materials in this analysis. This is because the increase in flood pool is relatively small (1.0 feet) and is not expected to result in the development of undrained conditions in the downstream embankment slope or foundation soils, which is where the critical slip surface from the normal pool condition was found. Therefore, the use of drained soil strengths is appropriate. It was also assumed that the temporary surcharge load was not of a sufficient duration to significantly alter the phreatic surface (i.e. saturation line within the embankment). Therefore, the phreatic surface was modeled equivalent to the steady state case; however, the pool level within Ash Pond No. 1 was increased to model the additional surcharge. ***Target Factor of Safety of 1.40.***

Seismic Slope Stability Analysis: These analyses incorporate a horizontal seismic coefficient k_h selected to be representative of expected loading during the design earthquake event (i.e., a "pseudostatic" analysis). The analyses utilized peak undrained strength parameters in soils that are not considered to be rapidly draining materials, and peak drained strengths in soils considered to freely drain. The phreatic surface and pore water pressures corresponding to the steady state pool from the static analyses were utilized. ***Target Factor of Safety of 1.00***.

Post-Liquefaction Condition: Liquefaction triggering analyses (see **Section 5.4.2.4**) identified the presence of soils susceptible to cyclic softening within the foundation at Ash Pond No. 1, and also identified that sluiced ash retained within Ash Pond No. 1 is susceptible to liquefaction. The triggering analyses did not identify soils susceptible to liquefaction or cyclic softening within the Ash Pond No. 1 dikes. Therefore, a post-earthquake (i.e. liquefaction triggering) slope stability analysis is not required per §257.73(e), as the dike soils are not susceptible to liquefaction. However, a post-earthquake slope stability analysis was performed to evaluate the effects of cyclic softening within the foundation at Ash Pond No. 1, in order to support the evaluation of foundation stability, per §257.73(d)(1)(i). The target factor of safety for post-earthquake analysis listed in §257.73(e) of 1.20 was also used as the target factor of safety for this analysis, as §257.73(d)(1)(1) does not specify a minimum factor of safety for post-earthquake slope stability analysis. No horizontal seismic coefficient is included in these analyses, but selection of strength parameters for the analyses takes into account the potential for softening/ weakening of the soils as a result of cyclic softening in clay-like materials due to the earthquake shaking. Sluiced CCRs retained by the dikes were assumed to liquefy for this analysis, although this material is not located within the dikes themselves or within the foundation. ***Target Factor of Safety of 1.20.***

5.3. *Material Properties*

Material properties for slope stability analyses were developed using both laboratory testing data (index and strength testing) and strength correlations from CPT and SPT data. Since the materials at Ash Ponds No. 1 and No. 2 are relatively similar, the field and laboratory test results from both sites were used to evaluate material properties. However, more emphasis was generally applied to the results from Ash Pond No. 1 to characterize materials at this site. The material characterization is described in **Attachment G**.

Unit weights for the materials were evaluated using laboratory test results from relatively undisturbed samples collected within the materials at Ash Pond No. 1. Embankment fill above the phreatic surface was conservatively assigned unit weights and shear strengths consistent with saturated embankment fill, since laboratory testing of samples above the phreatic surface demonstrated saturation values of 80% and above.

Shear strengths for the embankment fill and foundation clay layer were evaluated for the normal operating (steady-state) loading condition using results from the consolidated undrained triaxial (CIU) and direct simple shear (DSS) tests on samples collected at Ash Ponds No. 1 and No. 2. Shear strengths in the embankment and foundation clay were assigned based on the orientation of the failure plane. A shear strength envelope based primarily on the CIU test results was assigned within the embankment fill and in foundation clays under the embankment footprint, where the failure plane is oriented sub horizontal, consistent with the failure plane in a CIU test. A shear strength envelope based primarily on the DSS test results was used in the free-field, where the orientation of the failure plane is horizontal or above horizontal, consistent with the orientation of the failure plane in a DSS test. The peak drained shear strengths for the embankment fill and the foundation clay materials were characterized with a nonlinear strength envelope that assigns the shear strength as a function of the effective normal stress on the failure plane. The nonlinear envelope was curved at lower effective normal stresses, since the laboratory test data indicate that both the compacted embankment material and the native foundation clay are overconsolidated within the lower stress range. The peak undrained strength was characterized as a ratio of undrained shear strength (S_u) to steady-state vertical effective stress before the load is applied (p'). A minimum undrained shear strength was assigned for the undrained failure envelope based on correlations with CPT data. Liquefaction triggering analyses (discussed in **Section 5.4.2.3**), as well as a review of the CPT and laboratory test data, indicate that the embankment fill and foundation clay are not susceptible to liquefaction and are unlikely to be susceptible to cyclic softening under the design seismic loading. Therefore, peak undrained strengths were deemed appropriate for these materials under post-liquefaction (or post-earthquake) loading.

Shear strengths for the soft clay layer in the foundation were evaluated for the normal operating (steady-state) loading condition using results from the DSS test on a sample collected at Ash Pond No. 2. Correlated values from CPT data were used in conjunction with the DSS test result to characterize the peak undrained shear strength for the soft clay layer. Based on the results of liquefaction analyses, the soft clay foundation layer is susceptible to cyclic softening under the design seismic loading. The Soft Clay layer was therefore assigned a residual undrained shear strength for the post-earthquake loading condition based on correlated values for residual undrained strength from CPT results.

For the impounded ash and glacial till materials, where undisturbed Shelby tube samples were not obtained, unit weights and shear strengths were based on published correlations for SPT and CPT data, and previous experience with similar materials. The shear strengths selected for these materials are conservative with respect to correlated values for the SPT and CPT data, and because the analyzed slip surfaces for slope stability analyses did not pass through these materials when they were assigned conservative strengths, refinement of the characterization was not necessary. Based on the results of the liquefaction triggering analysis, the impounded ash is susceptible to liquefaction under the design seismic loading. The ash was therefore assigned a residual undrained shear strength for the post-earthquake loading condition based on correlated values for post-liquefaction residual undrained strength from CPT results. The liquefaction triggering analysis indicates that the glacial till was not susceptible to liquefaction or cyclic softening under the design event. The glacial till was assigned a peak undrained shear strength for post-earthquake loading condition.

The material properties developed for use in slope stability analysis for Ash Pond No. 1 are listed in **Table 8**.

Table 8
Material Properties for Slope Stability Analyses

Material	**Unit Weight (pcf)**	Peak Drained Shear Strength		Peak Undrained Shear Strength	**Post-Earthquake Shear Strength**
		Cohesion, c′ (psf)	Friction Angle, f ′ (deg)	S_u/p'	S_{ur}/p'
Impounded Ash	112	0	32	$S_u/p' = 0.40$	$S_{ur}/p' = 0.10$
Embankment Fill	135	0	31 *with curved envelope for* $s'_{ff} < 1440$ *psf* [1]	$S_u/p' = 0.60$, Minimum S_u = 450 psf	Peak Undrained
Foundation Clay (Under Embankment)	125	0	32 *with curved envelope for* $s'_{ff} < 2160$ *psf* [2]	$S_u/p' = 0.45$, Minimum S_u = 700 psf	Peak Undrained
Foundation Clay (Free Field)	125	0	30	$S_u/p' = 0.28$, Minimum S_u = 450 psf	Peak Undrained
Soft Foundation Clay	125	0	30	$S_u/p' = 0.28$, Minimum S_u = 275 psf	$S_u/p' = 0.16$, Minimum S_{ur} = 200 psf
Glacial Till	135	0	40	$S_u/p' = 0.64$, Minimum S_u = 700 psf	Peak Undrained

Notes:

1. Drained strength envelope for the embankment fill material is shown on Figure B.1 (Attachment G).
2. Drained strength envelope for the foundation clay material (under the embankment) is shown on Figure C.1 (Attachment G).

5.4. *Methodology of Analyses*

Limit equilibrium stability analysis was completed using the two-dimensional Slope/W (v. 8.15.1.11236 by GeoStudio) computer program. Factors of safety were calculated using Spencer's method and using both circular and wedge search routines to determine the critical failure surface for each analysis section and load case. The circular search routines included the optimization option, which allows the program to develop non-circular sliding planes through soft layers for the final solution. Critical surfaces were considered to be those which intersected the embankment crest and could result in a release of CCR materials. Pore pressures were assigned as hydrostatic pressure under the piezometric line.

The analysis methodology for Sta. 39+00 was modified to account for the Hoesch 2500 K steel sheet pile wall at the toe of the embankment. A structural analysis of the sheet pile wall was conducted to determine the maximum static load that the wall could sustain from a soil mass located above the critical sliding plane from slope stability analysis. The maximum force was found to be 3,900 lbs/ft, as shown in the structural calculations in **Attachment H**. The slope stability analysis for this section was first performed to find the critical slip surface without including the effects of the sheet pile wall. Once the critical slip surface was found, it was re-analyzed with the sheet pile static load applied as a resisting force on the last slice of the slip surface, which is where the sheet pile is present. The resulting factor of safety for the critical slip surface, when including the sheet pile resisting force, was then reported as the factor of safety for each loading condition.

A brief summary of the analyses is presented in the following sections. A more detailed discussion is provided in **Attachment H**.

5.4.1. *Static Analysis Conditions*

Static stability was evaluated for steady-state conditions using a normal pool elevation of 631.0 feet and a maximum flood surcharge pool elevation of 632.0 feet.

For the stability analysis at Station 39+00, the maximum stabilizing force provided by the sheet pile was based on an evaluation of the maximum load the sheet pile could sustain from the sliding mass without overturning. The load was determined using earth pressures in the glacial till corresponding to drained conditions because it resulted in a lower maximum load from the sliding mass than undrained loading conditions. Historic drawings do not include documentation of the sheet pile tip elevation at Station 39+00, but driving records from sheet pile installation indicate a minimum embedment depth of 13 feet was achieved at the site. The sheet pile analysis for Station 39+00 calculated a maximum point load on the sheet pile of 3,900 lb/ft, based on a minimum embedment depth of 13 feet. Details of the sheet pile wall calculations are provided in **Attachment H**.

5.4.2. *Earthquake Analysis Conditions*

A site-specific probabilistic seismic hazard assessment (PSHA) was performed to identify the earthquake loads at the site, and dynamic response analysis was performed to determine the appropriate seismic loads and material properties for the earthquake stability analysis load cases. Liquefaction triggering analyses were conducted to assess the potential for liquefaction or cyclic softening of the materials and determine the appropriate material properties for use in post-liquefaction slope stability analysis.

5.4.2.1. Probabilistic Seismic Hazard Analysis

A site-specific PSHA was completed for the Coffeen Power Station to develop 2,500-year earthquake ground motions for use in liquefaction and dynamic response analyses of the facility. The PSHA results were used to compute a 2,500-yr return period Uniform Hazard Spectrum (UHS) for top of rock (shear wave velocity = 9,200 ft/s). Parameters were developed including magnitude, distance, style of faulting, response spectra, and Arias Intensity for the current study. Faults considered seismically capable in the project region were considered. Near field and directivity effects were also considered. Because the top of hard rock at the Coffeen site is about 5,400 feet deep as discussed in the PSHA report (**Attachment I**), a one-dimensional site response analysis was performed to account for the effect of the overlying soft rock and quaternary glacial till (shear wave velocities ranging from about 2,200 to 8,500 ft/s) and generate a UHS for the top of the Glacial Till layer at this site.

Three sets of time histories were developed for the UHS at the top of the glacial till. The time histories represent the site-specific ground motions associated with the controlling near-field or far-field earthquake event, and consider the magnitude, distance, and Arias Intensity. The site-specific acceleration time histories for top of glacial till were developed for use in two-dimensional dynamic response analysis to estimate site-specific seismic loads for liquefaction triggering and seismic (pseudo-static) stability analysis.

The calculated site-specific peak ground acceleration (PGA) for a 2,500-year event was 0.19g for top of hard rock and 0.19g for top of glacial till. These values are comparable to the PGA value of 0.2g indicated for the Coffeen site on the USGS website. Because the majority of the PGA hazard at the site comes from background events with moment magnitudes (M) of 5 to 6.5, a magnitude of 6.5 was considered appropriate for use with simplified analysis using seismic loads defined by PGA and M. Details of the PSHA are included in **Attachment I**.

5.4.2.2. Dynamic Response Analysis

The dynamic response of the Ash Pond No. 1 embankments was evaluated by analyzing three of the stability cross-sections using the most recent version of the finite element program QUAD4M (Hudson et al. 1994). This is a modified version of the program QUAD4, originally developed by Idriss, et al. (1973). The dynamic response analysis was useful for more precisely estimating the amplification / attenuation characteristics of the embankment and local foundation soils to the design ground motions at the top of glacial till and to estimate site-specific PGA values at the embankment crest and toe for use in liquefaction triggering and seismic (pseudo-static) slope stability analysis. Input to the dynamic response analyses includes the acceleration time histories developed as part of the PSHA for the Coffeen Power Station.

The QUAD4M program uses a two-dimensional, dynamic finite-element formulation that utilizes equivalent-linear, strain-dependent modulus and damping properties. The program performs a time-domain analysis that allows variable damping throughout the model, and uses an iterative process to approximate the nonlinear behavior of soil. Shear moduli and damping ratios are estimated initially for each element in the model, and the system is analyzed using those properties. After each iteration, values of the effective shear strain are computed and the modulus and damping values are updated to correspond to the computed strain level for each element. The analysis iterations are repeated until compatibility between moduli, damping, and strain levels is achieved in all elements.

Dynamic response analysis was conducted for the analysis sections at Stations 30+00, 39+00, and 46+50, which were identified as critical sections with respect to seismic stability due to embankment geometry and subsurface conditions. The remaining analysis sections were less critical for seismic stability due to more favorable embankment and subsurface conditions. The calculated site-specific PGA values for a 2,500-year event were 0.40g at the embankment crest and 0.21g at the embankment toe, which were the highest PGA values from the QUAD4 analysis on all three sections. These values were used to define the earthquake loading for simplified liquefaction triggering analysis and pseudostatic stability analysis for all 5 sections. Details of the dynamic response analysis are included in **Attachment J**.

5.4.2.3. Seismic Coefficient

Seismic coefficients were calculated for use in the pseudostatic slope stability analysis based on the simplified procedure developed by Makdisi and Seed (1978). For the site-specific PGA value at the embankment crest of 0.40g and full-height slip surfaces (presented in **Attachment H**), a seismic coefficient of 0.14g was used in the pseudo-static analysis.

5.4.2.4. Liquefaction Triggering Analysis

A liquefaction triggering analysis was conducted to evaluate the potential for liquefaction or cyclic softening under the 2,500-year event in the dike and foundation soils. The analysis consists of comparing the calculated cyclic resistance ratio (CRR) from the CPT soundings to the cyclic stress ratio (CSR) calculated from a simplified site response analysis as described in Idriss and Boulanger (2008, 2014). The ratio of CRR to CSR is the triggering factor of safety. CRR values were calculated for liquefaction resistance of sand-like materials or for cyclic softening resistance of clay-like materials. CSR values were calculated using empirical correlations in the triggering analysis based on earthquake magnitude and site-specific PGA values at the ground surface. All of the CPT soundings advanced at Ash Pond 1 were evaluated for liquefaction triggering potential.

Details of the liquefaction triggering analysis are provided in **Attachment K**.

6. RESULTS

6.1. *Results of Static Stability Analyses*

The results of the limit equilibrium slope stability analyses for the static load cases are summarized in **Table 9**. The Slope/W output figures showing the slip surfaces and details of the analyses are included in **Attachment H**.

Table 9
Summary of Minimum Slope Stability Factors of Safety for Static Load Cases

Load Case	Program Criteria	Station 13+00	Station 30+00	Station 36+50	Station 39+00	Station 46+50
Steady State (Normal Pool)	FS ≥ 1.50	1.77	1.52	1.85	1.50	1.50
Surcharge Pool (Flood Pool)	FS ≥ 1.40	1.77	1.52	1.85	1.49	1.50

6.2. Results of Earthquake Stability Analyses

6.2.1. *Liquefaction Triggering Analysis*

The liquefaction triggering analysis found that the embankment fill, foundation clay, and glacial till soils are not susceptible to liquefaction or cyclic softening during the design seismic event. This means that the soils comprising the dike are not susceptible to liquefaction. In addition, the static laboratory strength test results do not indicate post-peak softening of these materials, which also indicates that the materials are not be susceptible to cyclic softening.

However, the liquefaction triggering analysis found that the soft clay layer is susceptible to cyclic softening during the design seismic event. The soft clay layer is located within the foundation of Ash Pond No. 1, between the bottom of the foundation clay and the top of the glacial till. In addition, the CPT data indicate residual undrained strengths for this material that are well below the correlated peak undrained strengths, which confirms the potential for cyclic softening. This material was therefore assigned residual strengths in the post-liquefaction slope stability analysis load case.

Liquefaction triggering analyses were also performed for sluiced ash retained within Ash Pond No. 1. Although this material is not located within the dike or foundation of Ash Pond No. 1, the liquefaction triggering analysis found that the material is susceptible to liquefaction during the design seismic event.

Based on the results of the liquefaction triggering analyses, post-earthquake (i.e. liquefaction) slope stability analyses were performed using peak undrained strengths in the embankment fill, foundation clay, and glacial till (as these soils are not susceptible to liquefaction), residual strengths in the soft clay layer within the foundation (as this soil is susceptible to cyclic softening), and residual strengths in the sluiced ash retained within Ash Pond No. 1 (as this soil is susceptible to liquefaction).

6.2.2. *Seismic and Post-Liquefaction Stability Analysis*

The results of the slope stability analyses for the seismic load cases are summarized in **Table 10**. The Slope/W output figures showing the slip surfaces and details of the analyses are included in **Attachment H**.

Table 10
Summary of Minimum Slope Stability Factors of Safety for Earthquake Load Cases

Load Case	Program Criteria	Station 13+00	Station 30+00	Station 36+50	Station 39+00	Station 46+50
Seismic (Pseudostatic)	FS ≥ 1.00	1.18	1.08	1.13	1.03	1.07
Post-Liquefaction	FS ≥ 1.20	1.49	1.44	1.34	1.31	1.30

7. CONCLUSIONS

The calculated factors of safety from the limit equilibrium slope stability analysis satisfy the USEPA CCR Rule § 257.73(e) requirements for all the load cases analyzed at the cross sections for each of the embankments that comprise the perimeter of Ash Pond No. 1. Load cases analyzed for this study included static (steady-state) normal pool, maximum flood surcharge pool, seismic (pseudo-static), and static post-liquefaction.

The factors of safety calculated for the embankment at the northeast corner (Station 39+00) are based on support loads provided by the sheet pile wall that were calculated based on a minimum sheet pile embedment of 13 feet, based on available information provided by IPGC.

8. LIMITATIONS

Background information, design basis, and other data have been furnished to AECOM by the CCR unit owner. AECOM has used this data in preparing this report. AECOM has relied on this information as furnished, and is not responsible for the accuracy of this information.

Borings have been spaced as closely as economically feasible, but variations in soil properties between borings, that may become evident at a later date, are possible. The conclusions developed in this report are based on the assumption that the subsurface soil, rock, and phreatic water conditions do not deviate appreciably from those encountered in the site-specific exploratory borings. If any variations or undesirable conditions are encountered in any future exploration, we should be notified so that additional analyses can be made, if necessary.

The conclusions presented in this report are intended only for the purpose, site location, and project indicated. The recommendations presented in this report should not be used for other projects or purposes. Conclusions or recommendations made from these data by others are their responsibility. The conclusions and recommendations are based on AECOM's understanding of current plant operations, maintenance, stormwater handling, and ash handling procedures at the station, as provided by the CCR unit owner. Changes in any of these operations or procedures may invalidate the findings in this report until AECOM has had the opportunity to review the findings, and revise the report if necessary.

This geotechnical investigation was performed in accordance with the standard of care commonly used as state-of-practice in our profession. Specifically, our services have been performed in accordance with accepted principles and practices of the geological and geotechnical engineering profession. The conclusions presented in this report are professional opinions based on the indicated project criteria and data available at the time this report was prepared. Our services were provided in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation is intended.

Attachment A. Figures

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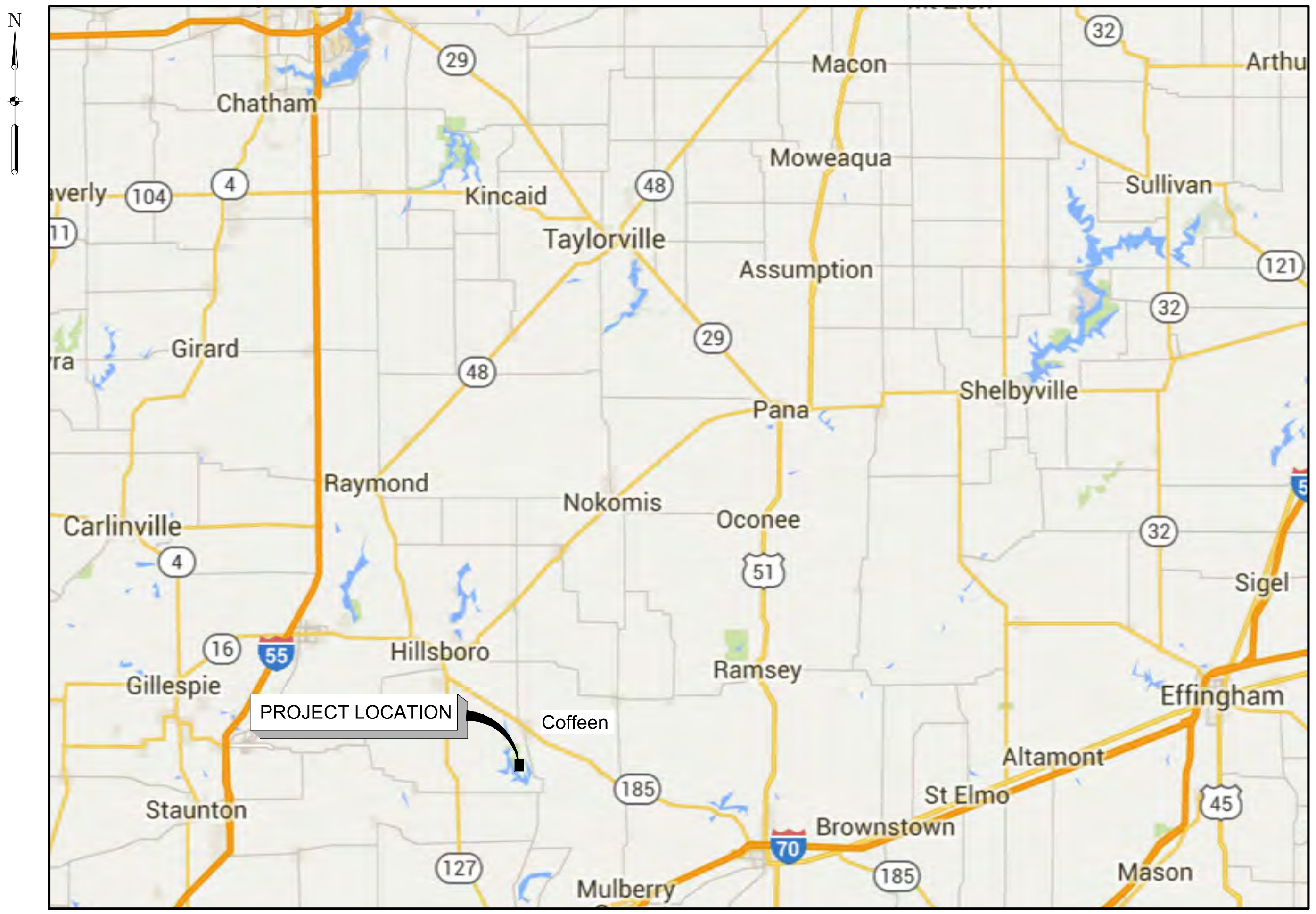

LOCATION MAP

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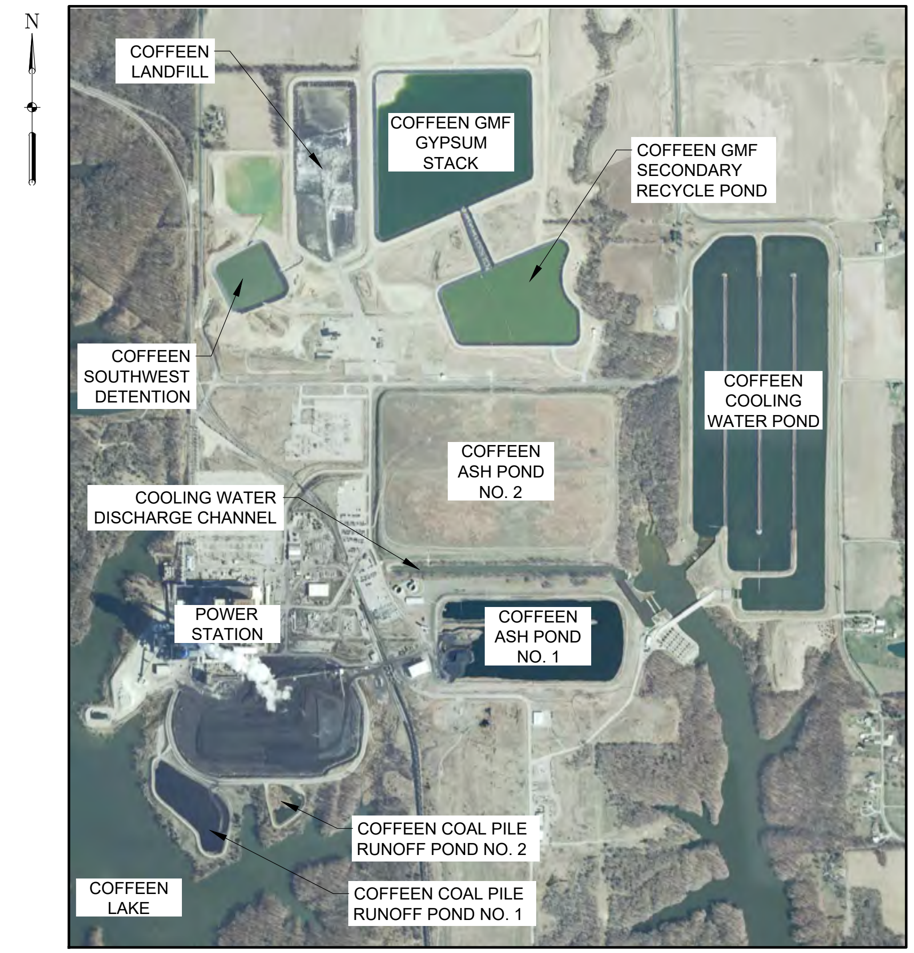

VICINITY MAP

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AECOM
1001 Highlands Plaza Drive, Suite 300
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314 429-0100 (phone)
314-429-0462 (fax)

DYNEGY
Dynegy Inc.
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Collinsville, IL 62234

CCR RULE ASSESSMENT OF PLANTS

COFFEEN POWER PLANT
COFFEEN, ILLINOIS

GEOTECHNICAL REPORT
ASH POND NO. 1

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REVISIONS

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DESIGNED BY:	EJV
CHECKED BY:	MCR
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PLOT DATE:	2/9/2016
SCALE:	AS SHOWN
ACAD VER:	2014

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LOCATION MAP &
SITE VICINITY MAP

1-1

SHEET 1 OF 4

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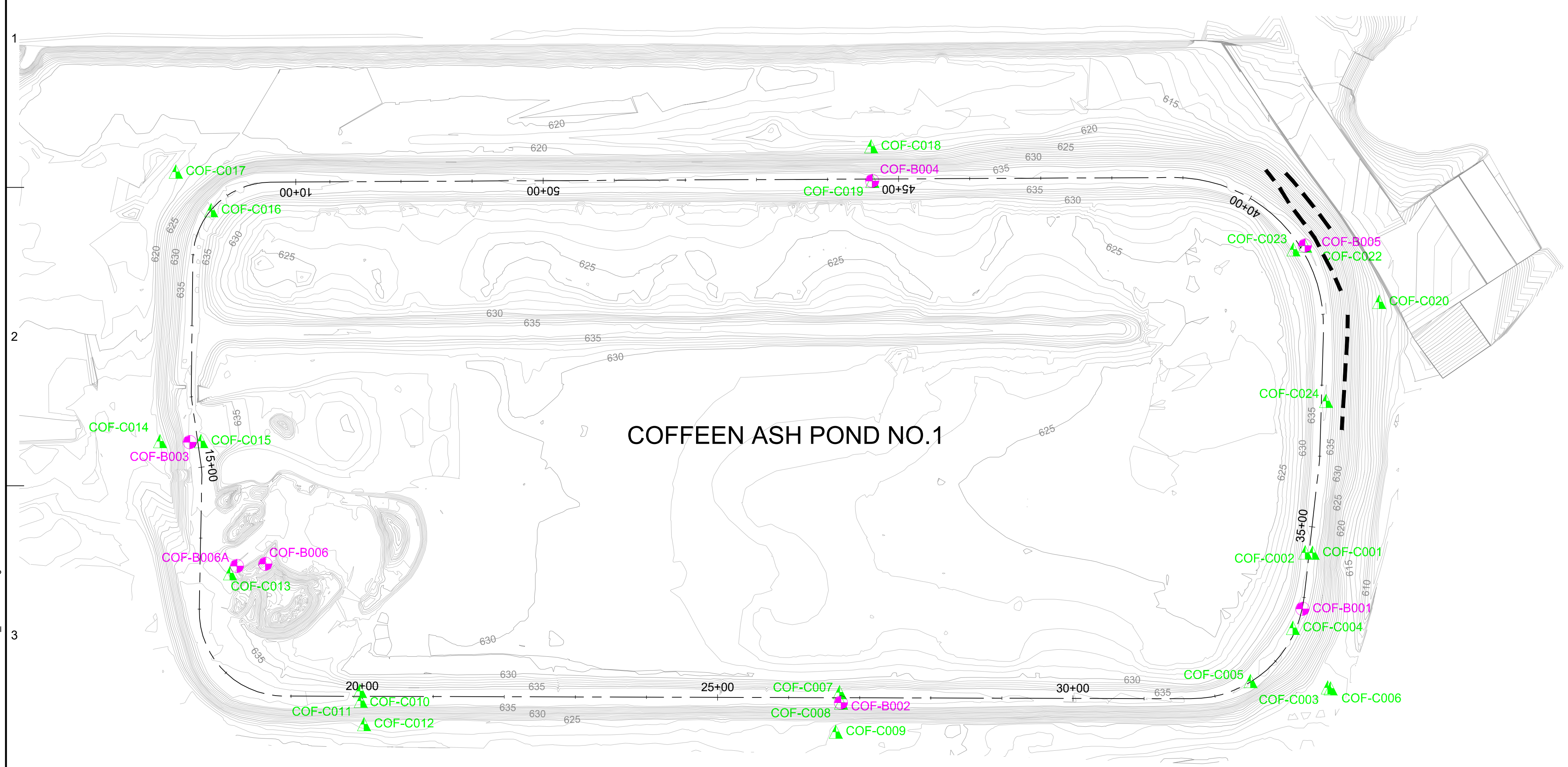

NOTES:

1. CONTOURS ARE 1 FOOT ELEVATION INTERVALS.
2. SURVEY BENCHMARKS WILL BE PROVIDED BY THE OWNER.
3. GROUND CONTOURS SOURCES: FINAL RESULTS OF SURVEY BY WEAVER CONSULTANTS DATED AUGUST 17 2015, DRAWINGS FOR COAL COMBUSTION BY-PRODUCT MANAGEMENT FACILITY PROJECT DATED JANUARY 2011, AND INTERPRETED FROM COFFEEN POWER STATION DRAWINGS DATED APRIL 1978.
4. BATHYMETRIC CONTOURS SOURCE: SURVEY BY WEAVER CONSULTANTS GROUP DATED SEPTEMBER 2015.
5. STATION 10+00 IS THE BEGINNING OF STATIONING.

LEGEND

COF-B000	AECOM BORING LOCATION
COF-C000	AECOM CONE PENETROMETER TESTING LOCATION
— — —	LOCATION OF GEOPHYSICAL INVESTIGATION

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EXPLORATION LOCATIONS

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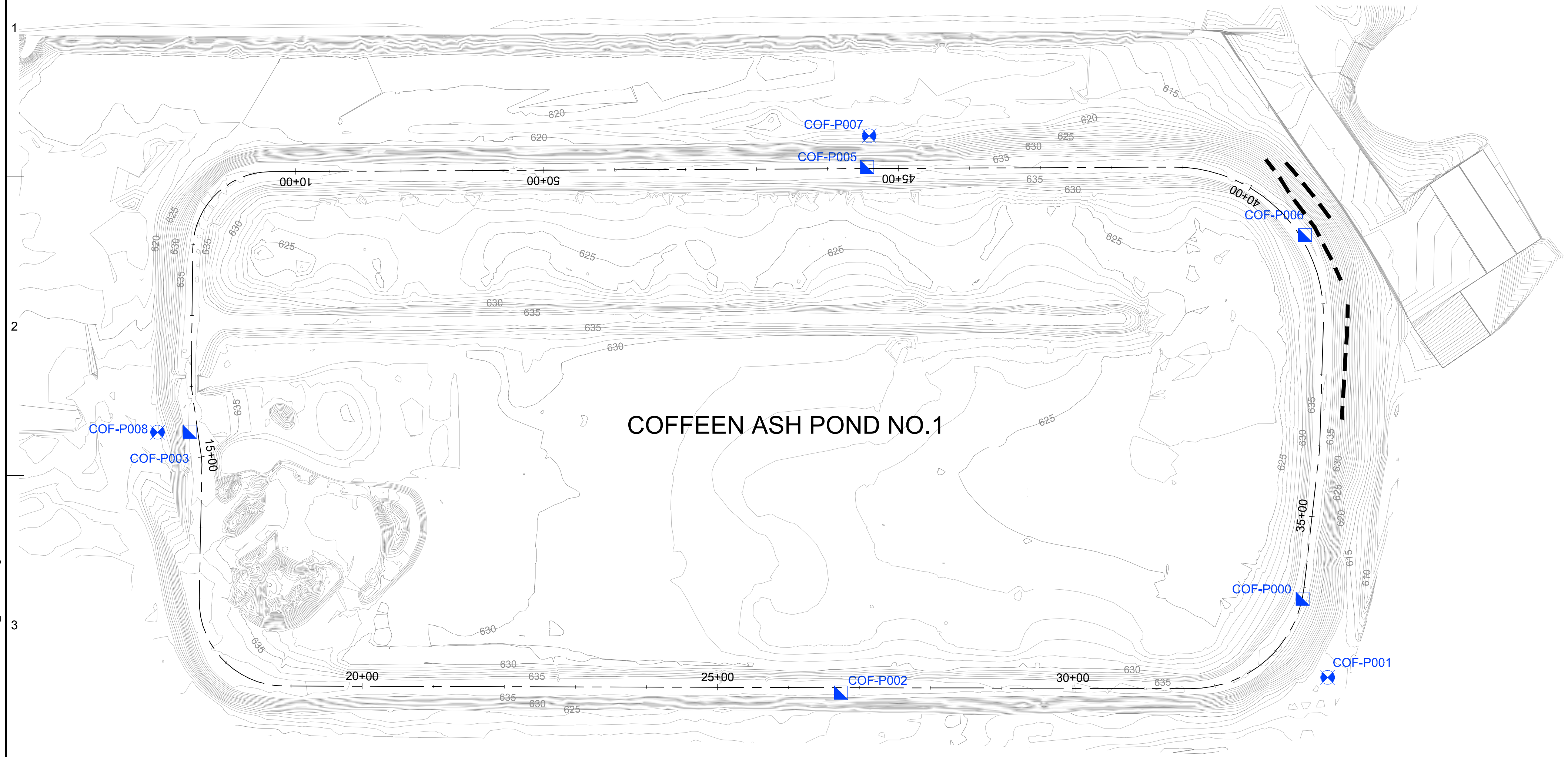
SHEET 2 OF 4



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5. STATION 10+00 IS THE BEGINNING OF STATIONING.

LEGEND

COF-P000	AECOM PIEZOMETER LOCATION
COF-P000	AECOM VIBRATING WIRE PIEZOMETER (VWP) LOCATION

N

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SCALE IN FEET

AECOM
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CCR RULE ASSESSMENT OF PLANTS

COFFEEN POWER PLANT
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PIEZOMETER LOCATIONS

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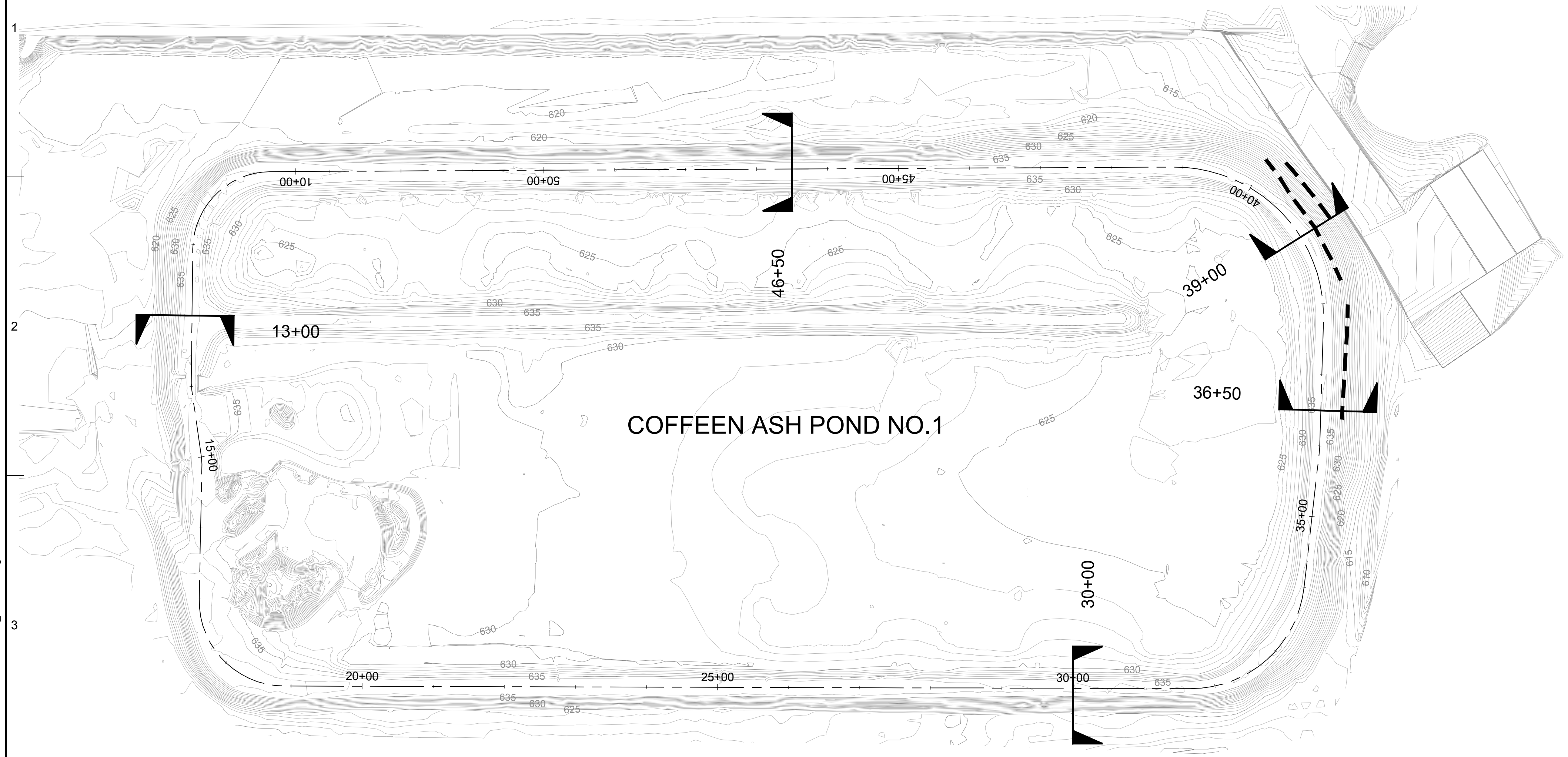

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LEGEND

STUDY SECTION

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CROSS SECTION LOCATIONS

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SHEET 4 OF 4

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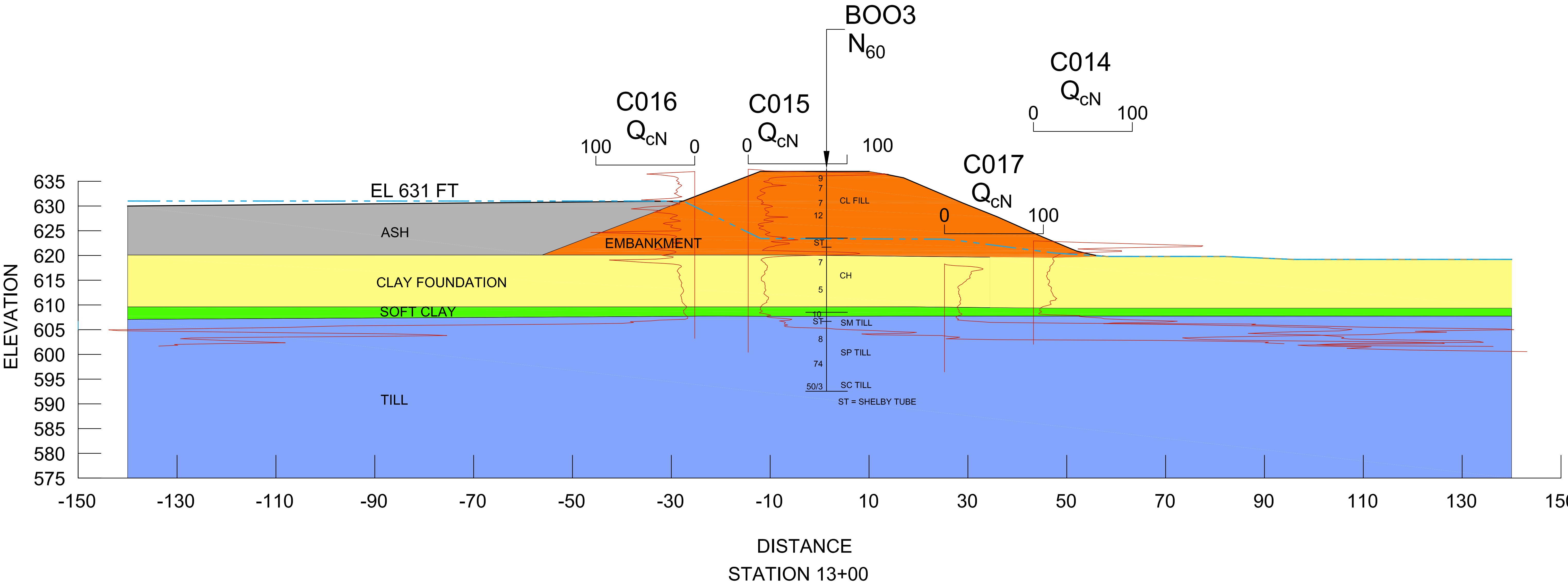

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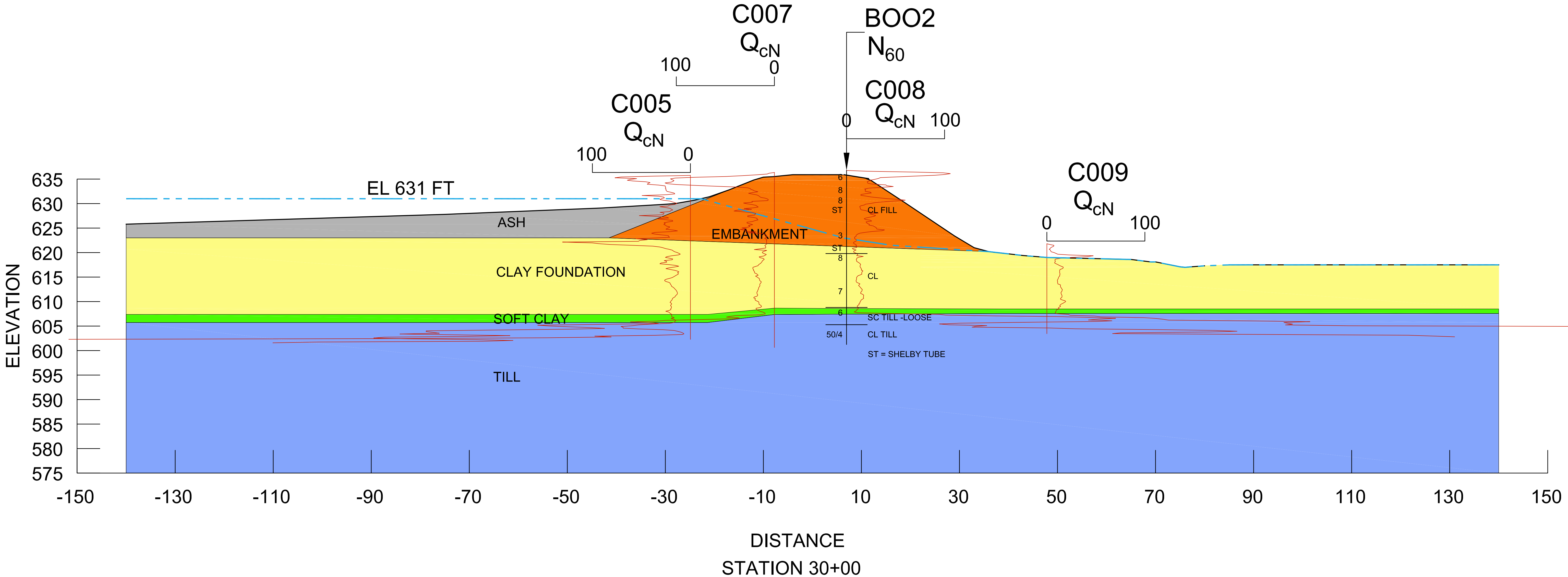
PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 13+00	FIGURE 5-1
	AECOM		



PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 30+00	FIGURE 5-2
	AECOM		

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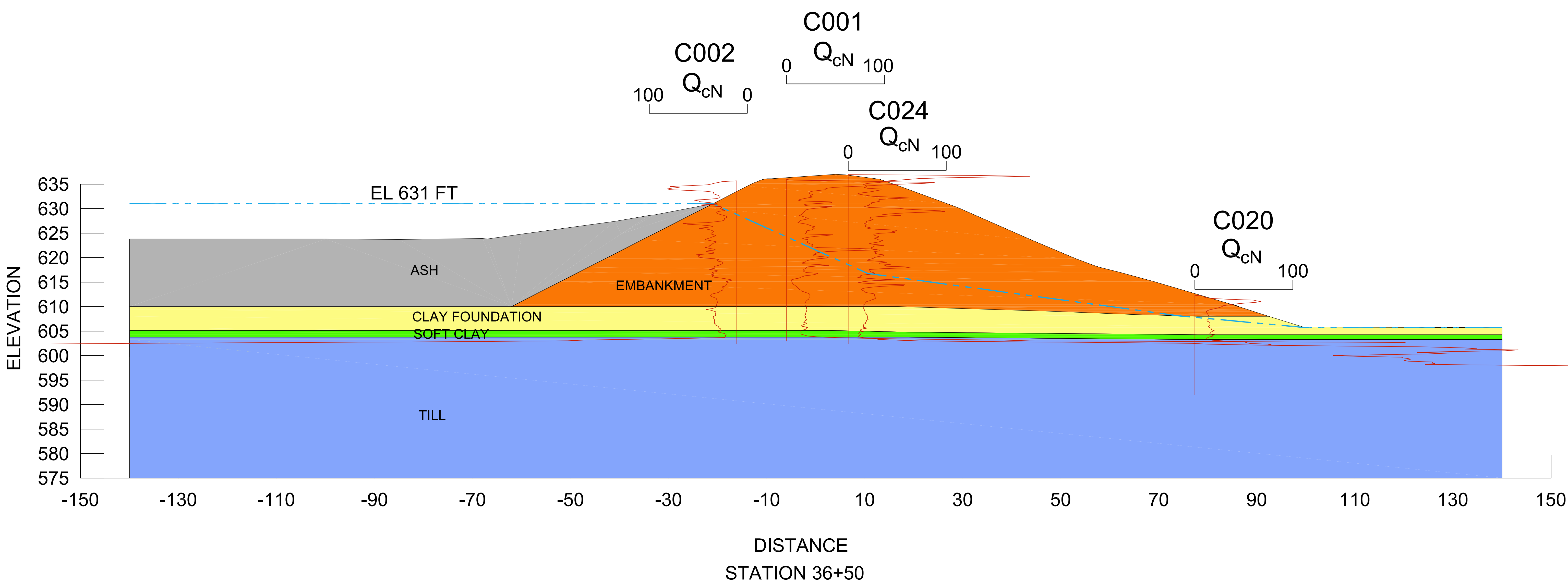
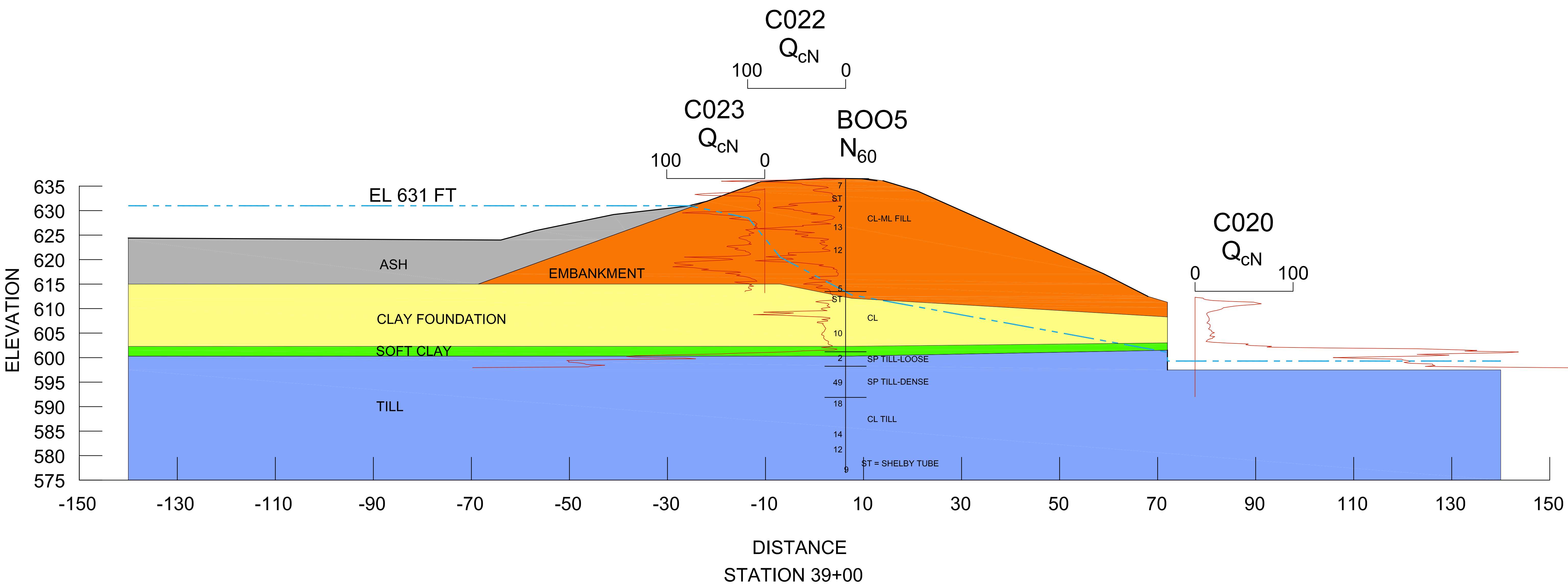
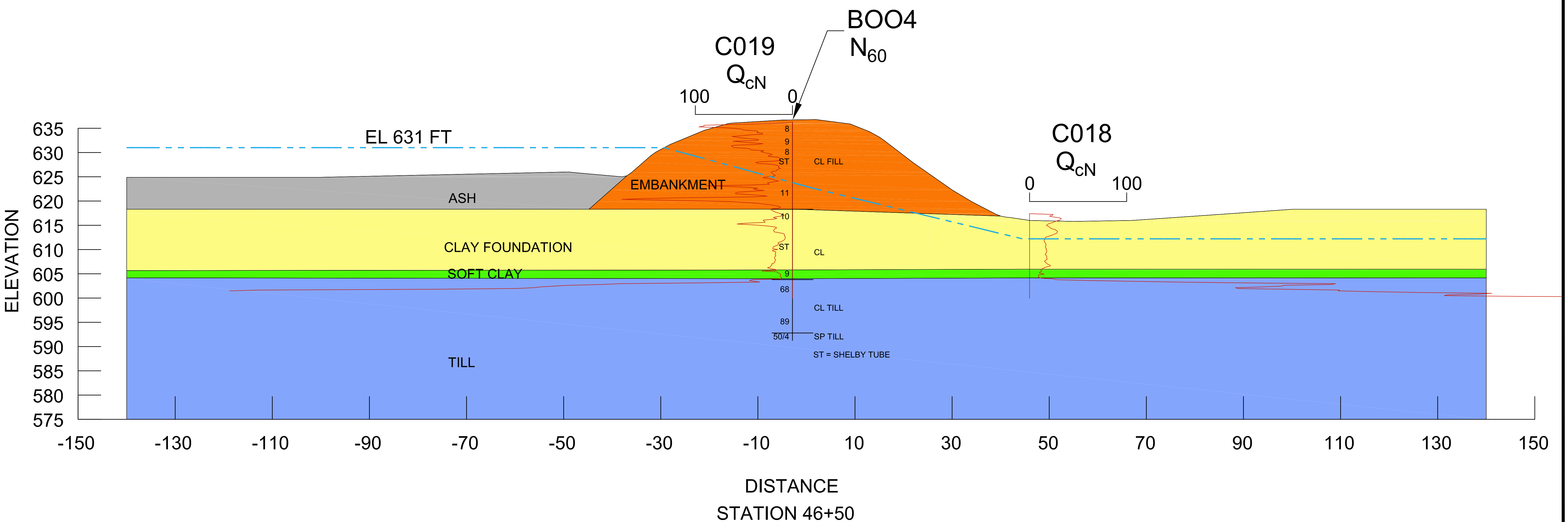


PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 36+50	FIGURE 5-3
	AECOM		



PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 39+00	FIGURE 5-4
	AECOM		



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PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1 AECOM	SECTION STATION 46+50	FIGURE 5-5

Attachment B. Boring Logs

Project:	DYNEGY CCR RULE ASSESSMENT OF PLANTS		
Project Location:	COFFEEN POWER STATION MONTGOMERY COUNTY, ILLINOIS		**Key to Soil Boring Logs**
Project Number:	60480701		

	Graphic Symbol	Description	USCS Classification
SAND AND GRAVEL		SAND poorly graded	SP
		Silty SAND	SM
		Clayey SAND	SC
LOW PLASTIC SILTS AND CLAYS		Inorganic low plastic CLAY	CL
HIGH PLASTIC CLAYS		Inorganic high plastic CLAY	CH
SURFACE MATERIAL		Ash	

NOTE: Dual classifications on the logs (eg. SP-SC) are represented by two graphical patterns.

TERMS DESCRIBING DENSITY OR CONSISTENCY

Coarse grained soils (major portion retained on No. 200 sieve) include gravels and sands. Density is based on the Standard Penetration Test (SPT).

Density	SPT blows per foot
Very loose	0 - 5
Loose	5 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	Greater than 50

Fine grained soils (major portion passing No. 200 sieve) include clays and silts. Consistency is rated according to shearing strength, as indicated by uncorrected SPT blows per foot.

Descriptive Term	SPT blows per foot	Estimated undrained shear strength (ksf)	Hand Test
Very soft	0-2	< 0.25	Extrudes between fingers
Soft	2-4	0.25-0.5	Molded by slight pressure
Medium stiff	4-8	0.5-1.0	Molded by strong pressure
Stiff	8-15	1.0-2.0	Indented by thumb
Very stiff	15-30	2.0-4.0	Indented by thumbnail
Hard	> 30	> 4.0	Difficult to indent

LEGEND AND NOMENCLATURE

Standard penetration split spoon test sample

Undisturbed shelby tube sample

PP qu	Pocket penetrometer unconfined compressive strength
NMC	Natural Moisture Content, %
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NP	Non-plastic
∇	Depth Groundwater enters at time of drilling.
▼	Groundwater Level at some specified time after drilling
Su	Undrained Shear Strength
TXUU	Triaxial Unconsolidated Undrained
DTW	Depth to water
N/A	Not Applicable

SAMPLING RESISTANCE

P	Sample pushed by hydraulic rig action.
3 6 9	Numbers indicate blows per 6 in. of sampler penetration. Standard penetration test sampler, (2-in O.D.) and oversize penetration sample (3-in O.D.) are driven by a 140 lb hammer falling freely 30-in
50/2	Number of blows (50) used to drive a penetration sampler a certain number of inches (2)
WOH	Weight of hammer
WOR	Weight of rods

ABBREVIATIONS USED UNDER "REMARKS"

HSA	Hollow Stem Auger	No.	Number
ATD	At Time of Drilling	CIU	Isotropically Consolidated Undrained
AD	After Drilling	ST	Shelby Tube
ID	Inside Diameter	SS	Split Spoon
OD	Outside Diameter		
RQD	Rock Quality Designation		
-#200	(% Pass #200 Sieve)		
Sa (%)	Sieve Analysis (% Passing #200)		

AECOM

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B001

Date(s) Drilled	08/07/2015 8:40 AM to 08/07/2015 4:10 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	35.0 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.016 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P000 5 ft South of COF-B001)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871590.925 E 2516693.603 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.0	0.0													
		SS	S1	3 4 6	67	Stiff, moist, brown and gray, silty and sandy CLAY, trace fine gravel, topsoil upper 2 inches, (CL) (EMBANKMENT FILL).	12.9				3.5			
		SS	S2	2 4 6	61	Stiff, moist, brown and gray, low plasticity, silty and sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	20.3		31	17	2.5			
		SS	S3	2 5 7	72	Stiff, very moist, brown and gray, low plasticity, silty and sandy CLAY, trace gravel (CL) (EMBANKMENT FILL).	15.4				1.75			
		SS	S4	2 4 5	83	Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, with gray silt seams, (CL) (EMBANKMENT FILL).	16.1				1.5			
		ST	S5		92	Very stiff, very moist, dark grayish brown with yellowish brown and dark gray, low plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).	14.7	129.4	35	20	2.5			
617.0	19.0					Very stiff to 19'								
		SS	S6	1 2 2	83	Soft, wet, brown and gray, low plasticity, silty CLAY, trace fine sand and decayed organic matter, organic odor, (CL) (NATIVE).	23.2							
615.0	21.0	ST	S7		92	Gray with yellowish brown, high plasticity, CLAY, with sand, (CH).	23.4	125.7	66	44				
613.0	23.0	SS	S8	1 4 5	100	Stiff, very moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL).	19.6		41	26	1.5			
606.5	29.5	SS	S9	1 3 3	100		16.8				< 0.25			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B001

Elevation (feet)	Depth (feet)	Samples: Type	Samples: Number	Samples: Sampling Resist. OR Core RQD (%)	Samples: Recovery (%)	Graphic Symbol	Material Description (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	Remarks
	30		S10		58		Medium stiff, very wet, orange brown, medium plasticity, sandy CLAY, trace silt, (CL).					4.5			*Pushed 14" then refused. Hard at tip of tube.*
605 / 604.8	31.2						Hard, sandy CLAY, trace fine gravel, trace silt, low plasticity, (CL) (TILL).								
			S11	8 17 24	78		Hard, brown and gray, low plasticity, CLAY, trace fine gravel, trace silt, (CL) (TILL).	11.7		30	17	4.5			
601.0	35.0						End of Boring at 35 ft								*Installed Piezometer COF-P000 with 5 ft offset to the South.*
600															
595	40														
590	45														
585	50														
580	55														
575	60														
	65														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B002

Date(s) Drilled	08/06/2015 9:30 AM to 08/06/2015 3:00 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	35.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.774 ft NAVD88
Borehole Backfill	Piezometer COF-P002	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871459.02 E 2516044.226 (ft NAD83)	Groundwater Level(s)	28 ft on 8/6/2015 1:00:00 PM		

Elevation (feet)	Depth (feet)	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.8	0.0												
635		S1	1 2 4	78	Medium stiff, very moist, brown and gray, low plasticity, CLAY, trace organics, (CL) (EMBANKMENT FILL).	25.4				2.0			
	5	S2	2 3 5	89	Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	25.9		35	18	1.0			
630		S3	1 3 5	83	Medium stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	25.9				1.25			
	10	S4		100	Very stiff, very moist, gray with yellowish brown, medium plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).	17.8	134.5	40	25	3.5			
625													
	15	S5	1 1 2	78	Soft, moist to wet, brown and gray, low plasticity, CLAY, with fine sand, trace fine gravel, (CL) (EMBANKMENT FILL).	23.3				0.75			
		S6		100	Soft, very moist, gray with brown, low plasticity, silty CLAY, (CL) (EMBANKMENT FILL).	26.7	120.2	25	7	0.75			
619.8	17.0												
	20	S7	2 3 5	94	Medium stiff, very moist, brown and gray, medium plasticity, CLAY, trace fine sand, with brown silt seams, (CL) (NATIVE).	25.4		47	29	1.5			
615													
	25	S8	2 3 4	100		18.9				0.75			
610													
608.8	28.0												
	30	S9	1 2 4		Loose, very wet, brown, fine to coarse clayey SAND, trace gravel, (SC) (NATIVE).	13.6							

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B002

Elevation (feet)	Depth (feet)	Samples: Type	Samples: Number	Samples: Sampling Resist. OR Core RQD (%)	Samples: Recovery (%)	Graphic Symbol	Material Description	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	Remarks
	30														*Till ~ 31.5' harder drilling*
605.3	31.5						Very dense, moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, with iron staining, (CL) (TILL).								
			S10	34/50 4"				9.5		20	7				
601.3	35.5						End of Boring at 35.5 ft								*Very hard drilling with new teeth. Installed Piezometer COF-P002 in boring.*

Elevation scale: 605, 600, 595, 590, 585, 580, 575

Depth scale: 30, 35, 40, 45, 50, 55, 60, 65

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B003

Date(s) Drilled	08/05/2015 11:30 AM to 08/05/2015 5:30 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	45.0 ft
Drill Rig Type	CME 550X (Rubber Tire ATV)	Drilling Contractor	Geotechnology	Surface Elevation	637.523 ft NAVD88
Borehole Backfill	Piezometer COF-P003	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871825.695 E 2515128.189 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	SAMPLES Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
637.5	0.0												
		S1	3 5 4	50	Stiff, dry, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, trace coarse ash, (CL) (EMBANKMENT FILL).	14.2				4.5			
		S2	2 3 4	67	Medium stiff, moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, trace coarse ash, (CL) (EMBANKMENT FILL).	18.1		42	26	1.25			
		S3	2 2 5	67	Medium stiff, moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	15.0				2.5			
		S4	2 4 8		Stiff, very moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	17.4				1.5			
623.5	14.0	S5		92	Stiff, very moist, dark gray to yellowish brown, high plasticity, CLAY, trace fine sand, (CH).	21.8	127.5	54	36	1.75			
		S6	2 3 4	83	Medium stiff, very moist, brown and gray, high plasticity, CLAY, trace fine sand, (CH).	26.0				1.75			
		S7	WOH 2 3	100	Medium stiff, very moist, brown and gray, medium-high plasticity, CLAY, with sand, with iron stained seams, (CL-CH).	20.8		50	34	1.75			
608.5	29.0	S8	2 1 9	100	Stiff, very moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, (CL).	12.5		21	6	3.5			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B003

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30		S9		100			11.8	141.7			4.5			S9 refusal at 30.8'
606.5	31.0						Dense, wet, dark yellowish brown with grayish brown, silty SAND, trace gravel, (SM).								
604.0	33.5		S10	2 2 6			Loose, very wet, brown, fine to coarse SAND, (SP).								Top of S10 full of water
599.0	38.5		S11	19 34 40	61		Very dense, very wet, brown, silty fine to coarse SAND, trace gravel, (SP) (TILL).	9.5							
594.0	43.5		S12	30 60 50/3"	100		Very dense, very wet, brown and gray, fine to coarse clayey SAND, trace fine gravel, (SC) (TILL).	9.9							Installed Piezometer COF-P003 in boring.
592.5	45.0						End of Boring at 45 ft								

Elevation scale: 605, 600, 595, 590, 585, 580, 575

Depth scale: 30, 35, 40, 45, 50, 55, 60, 65

AECOM

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B004

Date(s) Drilled	08/04/2015 10:20 AM to 08/05/2015 11:00 AM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	45.0 ft
Drill Rig Type	CME 550X (Rubber Tire ATV)	Drilling Contractor	Geotechnology	Surface Elevation	636.258 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P005 5 ft West of COF-B004)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 872193.263 E 2516088.178 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.3	0.0													
		SS	S1	2 3 5	67	Medium stiff, moist, brown, low plasticity, CLAY, with fine sand, trace fine gravel, (CL) (EMBANKMENT FILL).	18.0				1.75			
		SS	S2	3 4 5	67	Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	10.9				3.5			
		SS	S3	2 4 4	72	Medium stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	11.0				2.25			
		ST	S4		79	Medium stiff, moist, yellowish brown with gray, low plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).	12.8	136.6	39	24	2.25			
		SS	S5	3 5 6	94	Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	13.1		26	12	4.0			
618.3	18.0													
		SS	S6	2 3 7	83	Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, with gray silt seams, (CL) (NATIVE).	21.8				1.75			
		ST	S7		92	Very stiff, very moist, reddish brown, high plasticity, silty CLAY, trace fine sand, with dark gray silt seams, (CL).	20.6	129.5	51	34	2.75			
		SS	S8	1 4 5	100	Stiff, very moist, brown and gray silt seams, medium plasticity, CLAY, with fine to medium sand, (CL).	24.2		43	27	1.75			

Elevation scale: 635, 630, 625, 620, 615, 610. Depth scale: 0, 5, 10, 15, 20, 25, 30.

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B004

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Material Description	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	Remarks
603.8	32.5					Hard, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (TILL).								
			S9	16 31 37	100		8.4		21	8	4.5+			
			S10	14 45 44	83	Hard, moist, brown and gray, low plasticity, sandy silty CLAY, trace fine to coarse gravel, (CL) (TILL). 38.5' - 39.2' gray silt seams	8.8				4.5+			
592.8	43.5		S11	19 54 50/4"	94	Hard, wet, brown and gray, low plasticity, sandy silty CLAY, trace gravel, (CL) (TILL).	14.8				-			
591.3	45.0					End of Boring at 45 ft								*Installed Piezometer COF-P005 with 5 ft offset to the West.*

Elevation scale: 605, 600, 595, 590, 585, 580, 575. Depth scale: 30, 35, 40, 45, 50, 55, 60, 65.

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B005

Date(s) Drilled	08/08/2015 7:45 AM to 08/08/2015 12:00 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	60.0 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.496 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P006 5 ft South of COF-B005)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 872102.375 E 2516696.89 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.5	0.0														
635		SS	S1	2 3 4	83		Medium stiff, moist, brown and gray, low plasticity, CLAY, (CL) (EMBANKMENT FILL).	21.1				1.5			
	5	ST	S2		54		Stiff, moist, brown, low plasticity, sandy CLAY, (CL) (EMBANKMENT FILL).	8.0	136.6	22	9	3.0			
630		SS	S3	1 3 4	72		Medium stiff, moist, brown, low plasticity, sandy CLAY, (CL) (EMBANKMENT FILL).	13.1				0.75			
	10	SS	S4	2 7 6	89		Stiff, moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	9.9		20	6	3.0			*Shale in tip*
625															
	15	SS	S5	2 6 6	78		Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	10.3				2.0			
620															
	20	SS	S6	WOH 2 3	67		Medium stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	9.4				1.0			
615															
613.5	23.0														
	25	ST	S7		92		Stiff to very stiff, gray with grayish brown, low plasticity, CLAY, with sand, with organics, (CL) (NATIVE).	18.7	131.4	37	20	1.5			
610															
608.0	28.5														
	30	SS	S8	1 4 6	89		Stiff, brown and gray, low plasticity, CLAY, trace fine sand, trace organics, (CL).	21.9				2.0			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B005

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Material Description	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	Remarks
604.5	32.0					Very stiff, low plasticity, sandy CLAY, with organics, (CL).								
		SS	S9	1 1 1	100		26.7		22	6	2.5			
602.5	34.0					Very loose, saturated, brown and gray, silty, clayey SAND, (SC-SM).								35': Attempt ST refusal at 35.5'
601.0	35.5					Dense, wet, brown and gray, clayey SAND, trace fine gravel, (SC) (TILL)								
		SS	S10	8 22 27	100		11.6				-			
593.5	43.0					Very stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)								
		SS	S11	4 7 11	100		12.8		32	17	3.25			
		SS	S12	2 6 8	100	Stiff, saturated, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)	15.5		32	17	3.0			
		SS	S13	2 5 7	100	Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)	23.2				1.25			
		SS	S14	2 3 6	100	Stiff, brown and gray, medium plasticity, CLAY, with sand, (CL) (TILL)	23.3		47	30	1.25			
576.5	60.0					End of Boring at 60 ft								Installed Piezometer COF-P006 with 5 ft offset to the South.

Elevation scale: 605, 600, 595, 590, 585, 580, 575. Depth scale: 30, 35, 40, 45, 50, 55, 60, 65.

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B006

Date(s) Drilled	08/06/2015 4:00 PM to 08/07/2015 7:30 AM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	33.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	631.9* ft NAVD88
Borehole Backfill	Cement-Bentonite Grout	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871654.5 E 2515234.7* (ft NAD83)	Groundwater Level(s)	4 ft on 8/6/2015 5:00:00 PM		

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
631.9*	0.0					Medium dense, moist, black, well-graded sand (cinders), trace silt, trace fine gravel, (ASH).								
		SS	S1	5 13 15	78		6.6							
						Very loose, wet, black, well-graded sand (cinders), trace clay, (ASH).								
		SS	S2	2 2 2	100		48.3							
	5													
		ST	S3		17		22.2							
		SS	S4	3 4 6	100	Loose, wet, black, well-graded sand (cinders), trace clay, (ASH).	16.7							
	10													
-8846.6	14.0													
		SS	S5	WOH 2 3		Medium stiff, very moist, brown and gray, high plasticity, CLAY, trace fine sand, (CH) (NATIVE).	24.4		57	37	1.75			
	15													
		SS	S6	1 3 4	67		21.9				1.25			
	20													
-14533.7	23.0					Very soft, very wet, brown, low plasticity, sandy CLAY, (CL).								
		SS	S7	1 1 1	100		19.8		23	9	0.5			
	25													
-16429.4	26.0													
		SS	S8	20 50/4"		Hard, very wet, brown and gray, low plasticity, sandy CLAY, (CL) (TILL).	16.1							
	30													

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30														
-21168.7	33.5		S9	24 34 50/5"	94		Hard, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (TILL).	8.1		25	12				*Hard augering below 32'*
							*Final survey coordinates/elevation are not available. End of Boring at 33.5 ft								
	35														
	40														
	45														
	50														
	55														
	60														
	65														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B006A

Date(s) Drilled	08/19/2015 7:15 AM to 08/19/2015 10:15 AM	Logged By	A. Grossman	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	25.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	633.583 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout	Sampling Method(s)	Piston	Hammer Data	-
Boring Location	N 871651.263 E 2515194.552 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Samples: Type Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
633.6	0.0					Loose, moist, black, medium to coarse grained sand (cinders), (ASH).								
		PS-1		75										
		PS-2		20										
621.1	12.5					Stiff, light grayish brown, low plasticity, silty CLAY, some ash, (CL).								
		PS-3		70							1.25			
		PS-4		83							1.25			
		PS-5		73							1.25			
		PS-6		93		Stiff to very stiff, grayish brown, low plasticity, CLAY, (CL).					2.0			
608.1	25.5					End of Boring at 25.5 ft								*Auger refusal at 25.5' bgs.*

Attachment C. Piezometer Logs

Project: Dynegy

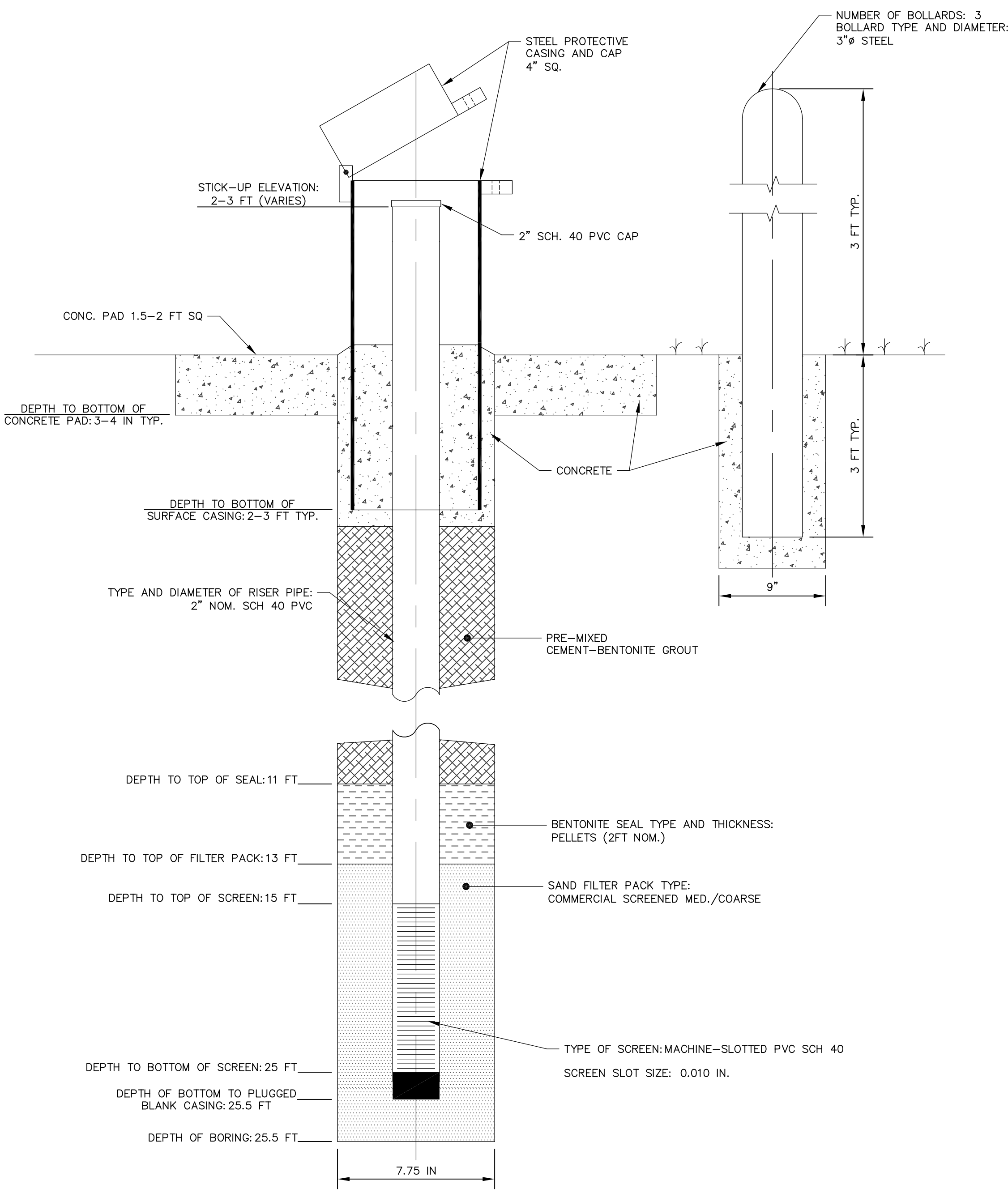
Project Location: COFFEEN POWER STATION, ILLINOIS

Project Number: 60440742

Log of Piezometer

Sheet 1 of 1

Piezometer Location	COF-P000	Date Installed	8/7/2015		
		Observed By	AECOM	Total Depth	25 FT
Method of Installation	HOLLOW STEM AUGER	Drilling Contractor	GEOTECHNOLOGY, INC.	Surface Elevation	635.986 FT
Screened Interval	15-25 FT	Completion Zone	EMBANKMENT/FOUNDATION		
Remarks	OFFSET 5 FT SOUTH FROM COF-B001	Groundwater Level(s)	17.9 FT ON 8/29/2015		



NOT TO SCALE

AECOM

Project: Dynegy

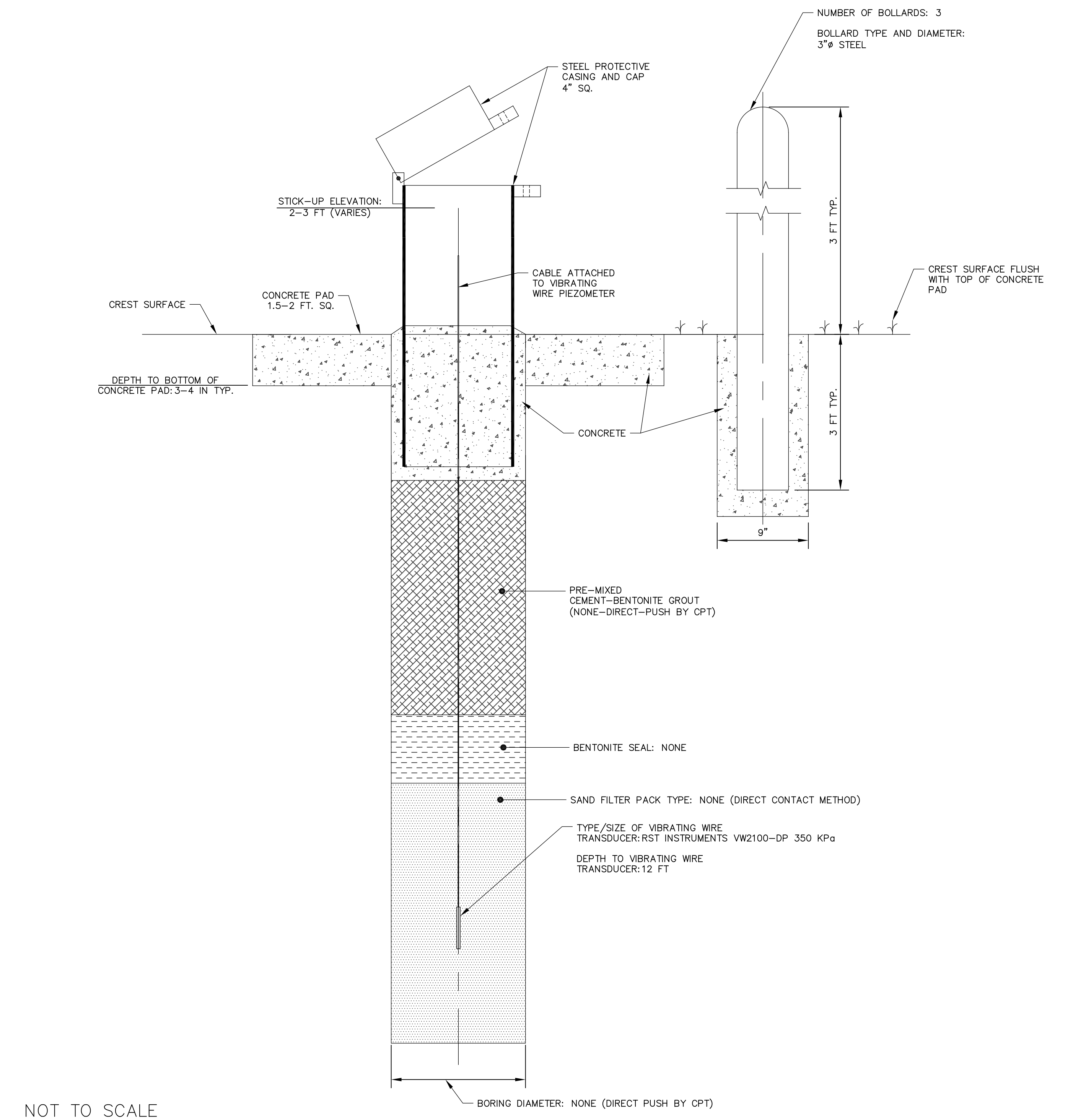
Project Location: COFFEEN POWER STATION, ILLINOIS

Project Number: 60440742

Log of Piezometer

Sheet 1 of 1

Piezometer Location	COF-P001	Date Installed	8/12/2015		
		Observed By	AECOM	Total Depth	12 FT
Method of Installation	CPT - DIRECT PUSH	Drilling Contractor	CONETEC, INC.	Surface Elevation	616.857 FT
Screened Interval	N/A	Completion Zone	POND #1 FOUNDATION		
Remarks		Groundwater Level(s)	1.3 FT ON 8/29/2015		

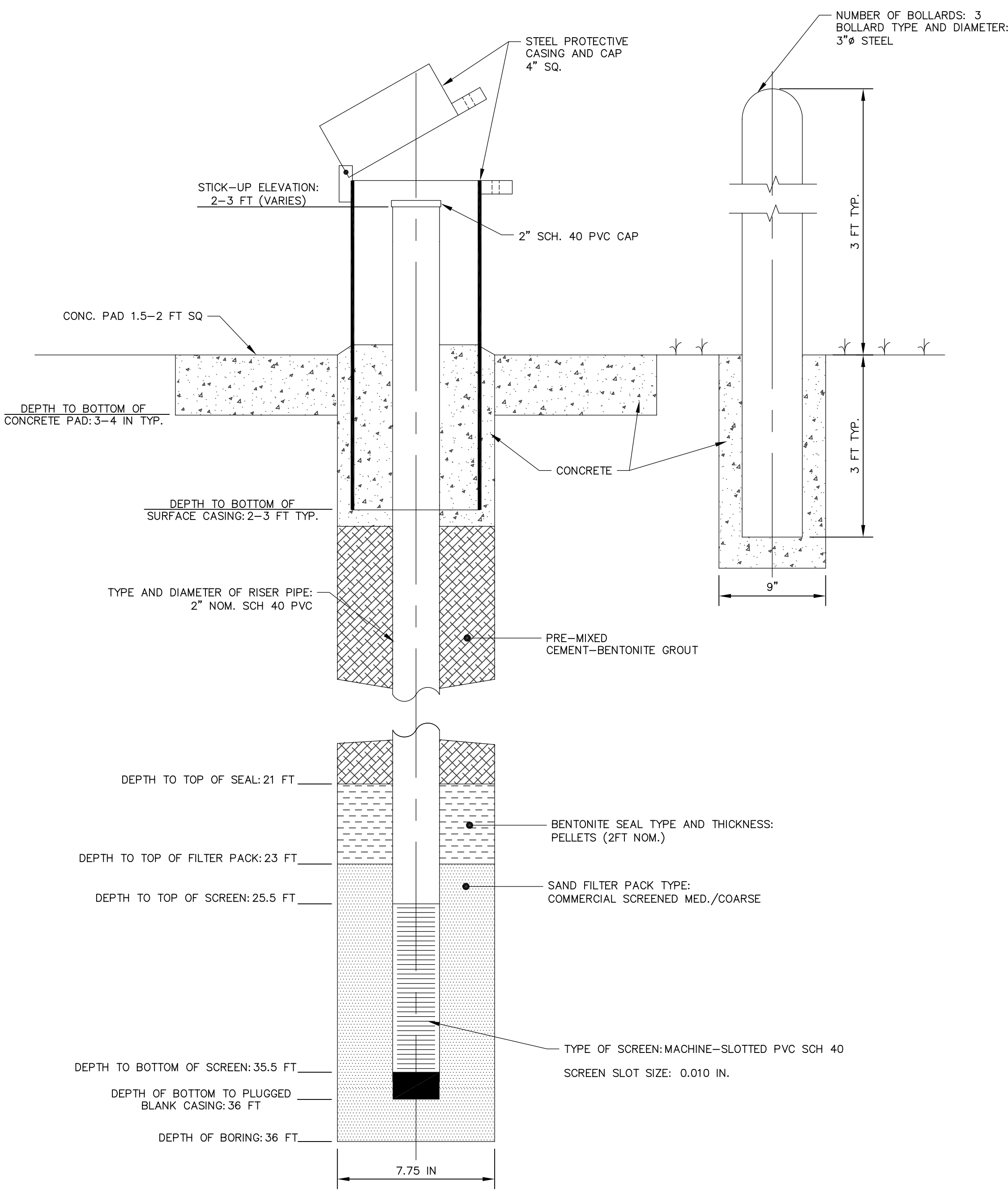


AECOM

NOT TO SCALE

Project: Dynegy	Log of Piezometer
Project Location: COFFEEN POWER STATION, ILLINOIS	
Project Number: 60440742	Sheet 1 of 1

Piezometer Location	COF-P002	Date Installed	8/6/2015		
		Observed By	AECOM	Total Depth	35.5 FT
Method of Installation	HOLLOW STEM AUGER	Drilling Contractor	GEOTECHNOLOGY, INC.	Surface Elevation	636.783 FT
Screened Interval	25.5-35.5 FT	Completion Zone	POND #1 FOUNDATION		
Remarks	INSTALL IN COF-B002	Groundwater Level(s)	10.5 FT ON 8/29/2015		

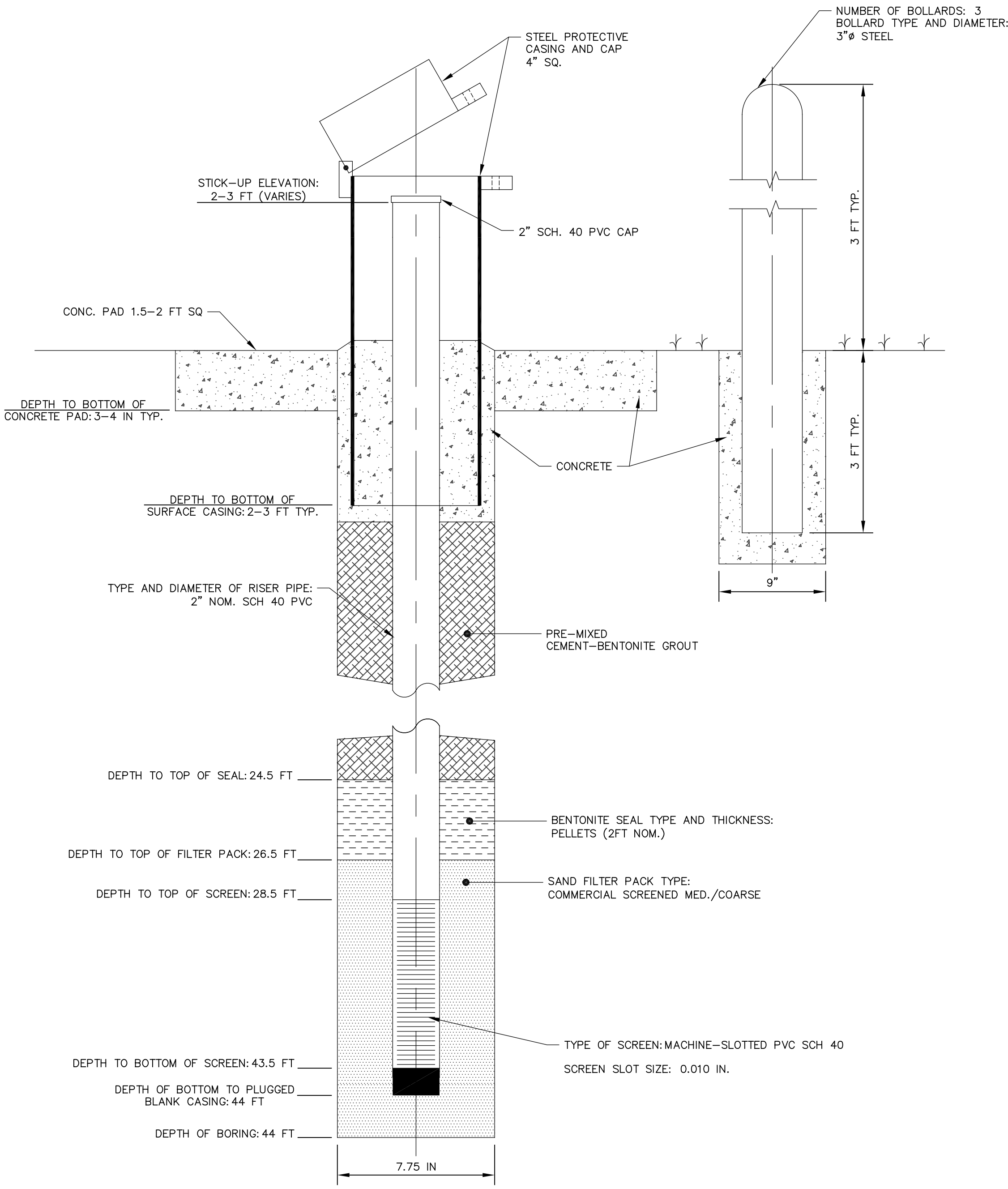


NOT TO SCALE

AECOM

Project: Dynegy	Log of Piezometer
Project Location: COFFEEN POWER STATION, ILLINOIS	
Project Number: 60440742	Sheet 1 of 1

Piezometer Location	COF-P003	Date Installed	8/5/2015		
		Observed By	AECOM	Total Depth	43.5 FT
Method of Installation	HOLLOW STEM AUGER	Drilling Contractor	GEOTECHNOLOGY, INC.	Surface Elevation	637.569 FT
Screened Interval	28.5-43.5 FT	Completion Zone	POND #1 FOUNDATION		
Remarks	INSTALL IN COF-B003	Groundwater Level(s)	15.3 FT ON 8/29/2015		

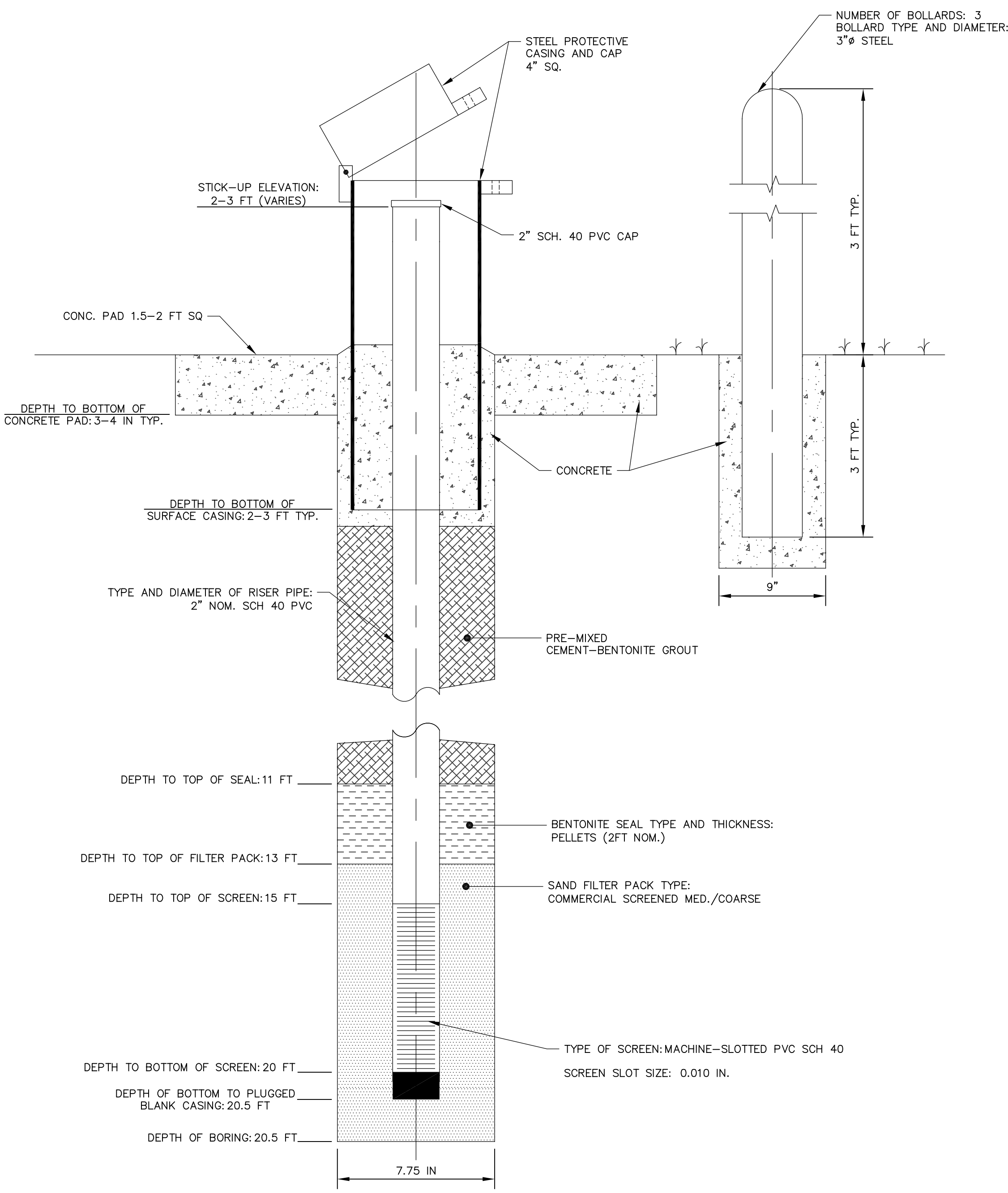


NOT TO SCALE

AECOM

Project: Dynegy	Log of Piezometer
Project Location: COFFEEN POWER STATION, ILLINOIS	
Project Number: 60440742	Sheet 1 of 1

Piezometer Location	COF-P005	Date Installed	8/5/2015		
		Observed By	AECOM	Total Depth	20 FT
Method of Installation	HOLLOW STEM AUGER	Drilling Contractor	GEOTECHNOLOGY, INC.	Surface Elevation	636.408 FT
Screened Interval	15-20 FT	Completion Zone	EMBANKMENT		
Remarks	OFFSET 5' WEST OF COF-B004	Groundwater Level(s)	14.4 FT ON 8/29/2015		



NOT TO SCALE

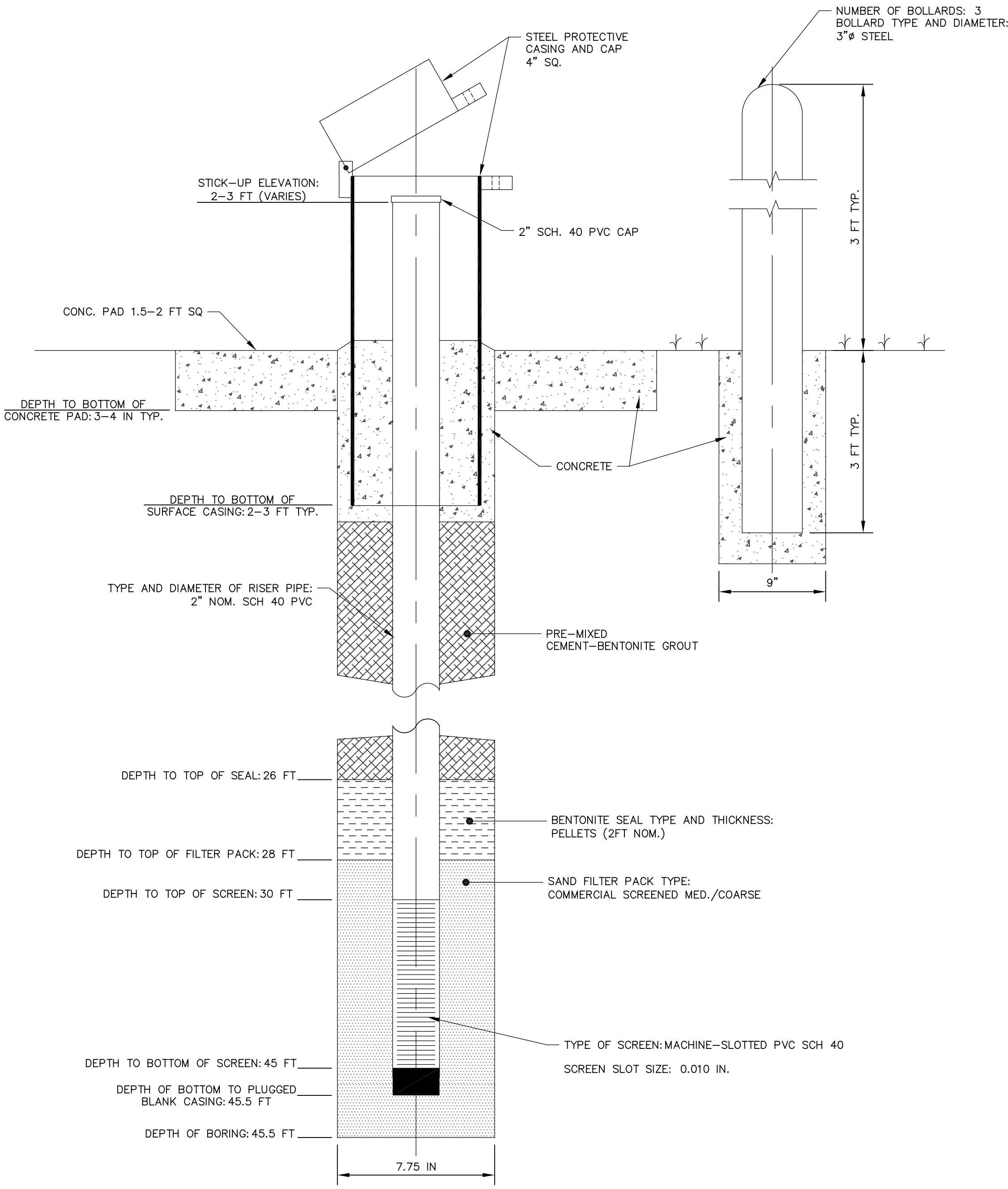
Project: Dynegy

Project Location: COFFEEN POWER STATION, ILLINOIS

Project Number: 60440742

Log of Piezometer

Piezometer Location	COF-P006	Date Installed	8/10/2015		
		Observed By	AECOM	Total Depth	45 FT
Method of Installation	HOLLOW STEM AUGER	Drilling Contractor	GEOTECHNOLOGY, INC.	Surface Elevation	636.537 FT
Screened Interval	30-45 FT	Completion Zone	POND #1 FOUNDATION		
Remarks	OFFSET 5' SOUTH FROM COF-B005	Groundwater Level(s)	22.2 FT ON 8/29/2015		



NOT TO SCALE

AECOM

Project: Dynegy

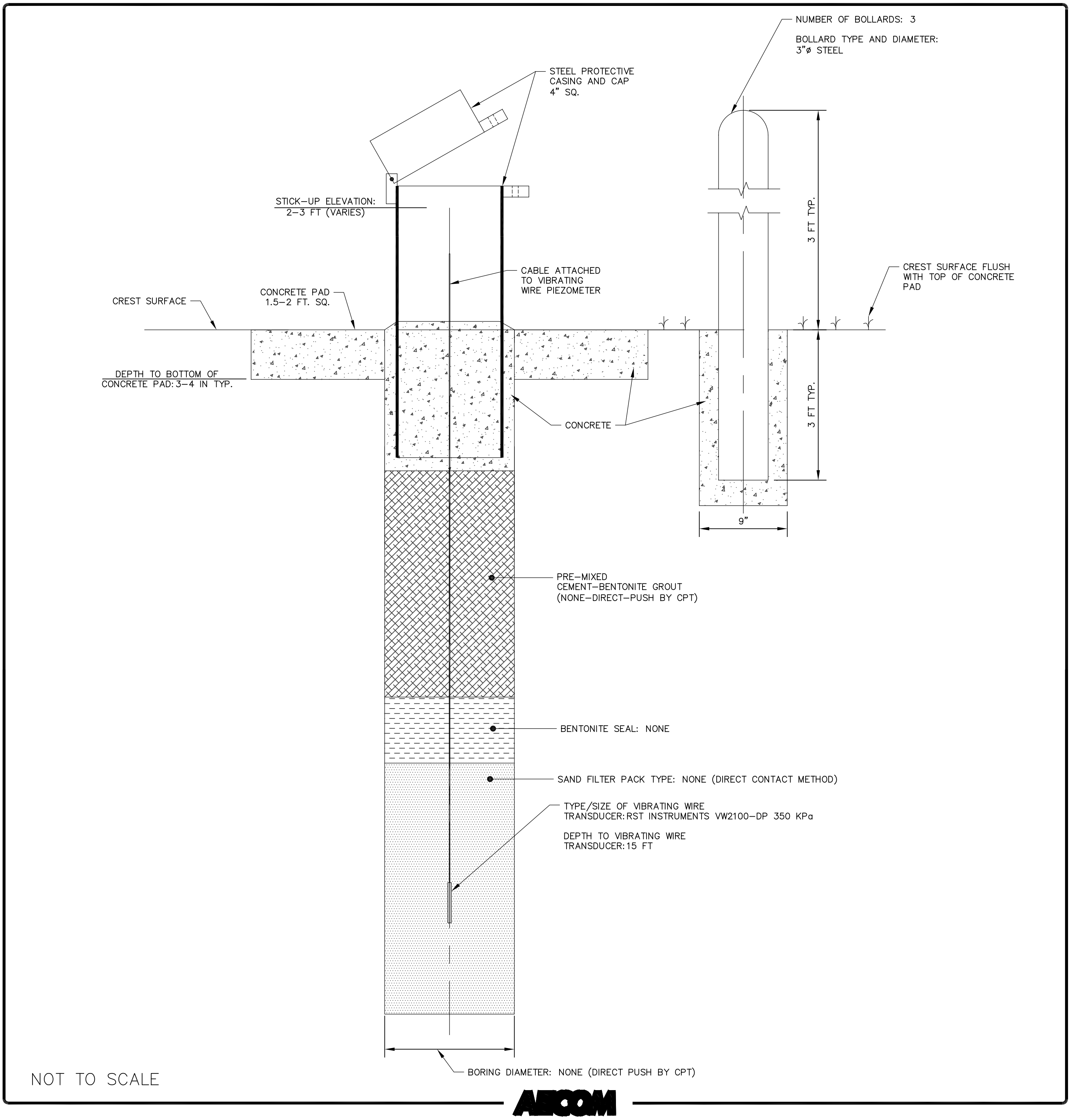
Project Location: COFFEEN POWER STATION, ILLINOIS

Project Number: 60440742

Log of Piezometer

Sheet 1 of 1

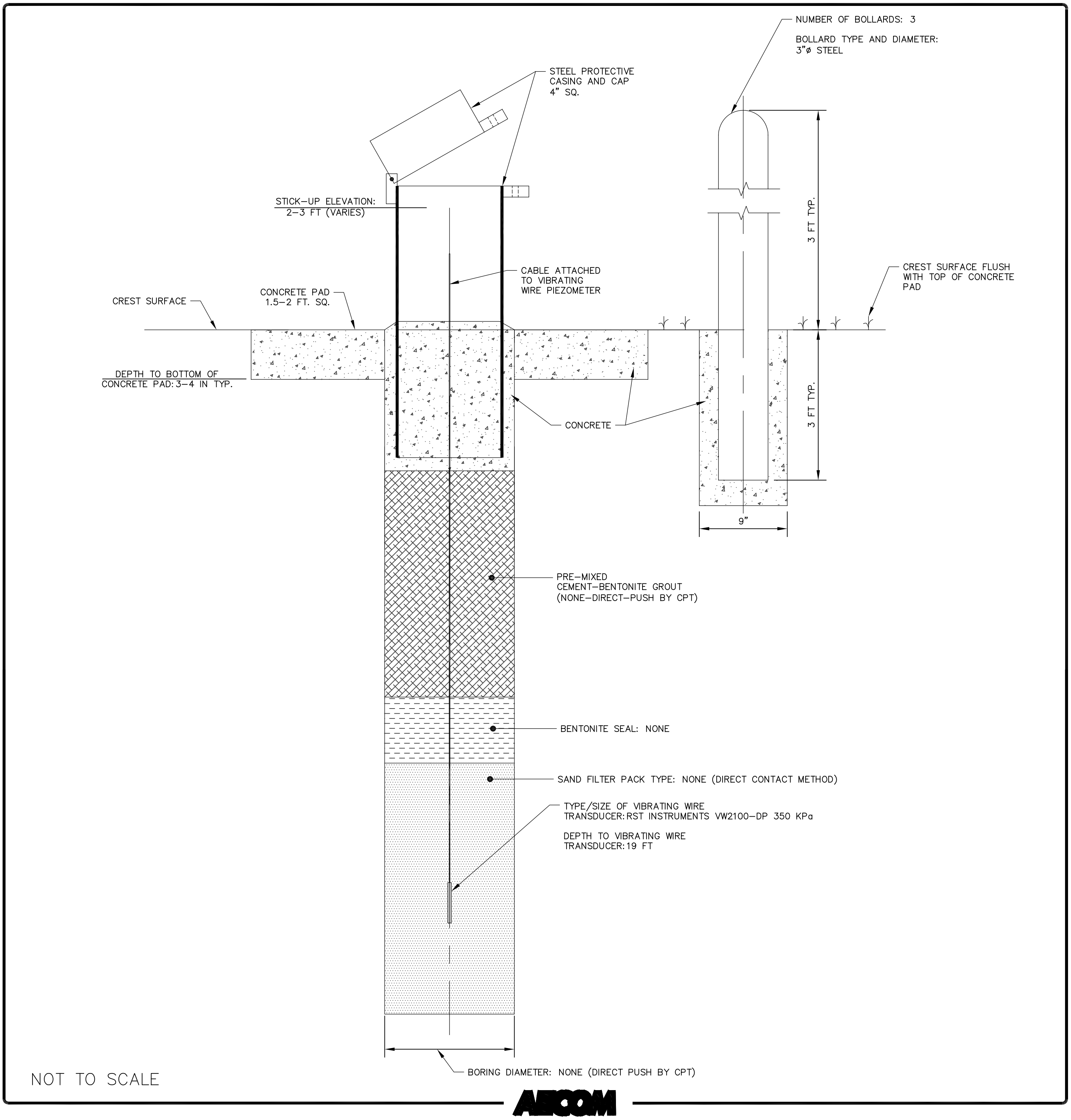
Piezometer Location	COF-P007	Date Installed	8/12/2015		
		Observed By	AECOM	Total Depth	15 FT
Method of Installation	CPT - DIRECT PUSH	Drilling Contractor	CONETEC, INC.	Surface Elevation	617.400 FT
Screened Interval	N/A	Completion Zone	POND #1 FOUNDATION		
Remarks		Groundwater Level(s)	6.1 FT ON 8/29/2015		



NOT TO SCALE

Project: Dynegy	Log of Piezometer
Project Location: COFFEEN POWER STATION, ILLINOIS	
Project Number: 60440742	Sheet 1 of 1

Piezometer Location	COF-P008	Date Installed	8/12/2015		
		Observed By	AECOM	Total Depth	19 FT
Method of Installation	CPT - DIRECT PUSH	Drilling Contractor	CONETEC, INC.	Surface Elevation	622.651 FT
Screened Interval	N/A	Completion Zone	POND #1 FOUNDATION		
Remarks		Groundwater Level(s)	2.6 FT ON 8/29/2015		



NOT TO SCALE

Attachment D. CPT Data Report

PRESENTATION OF SITE INVESTIGATION RESULTS

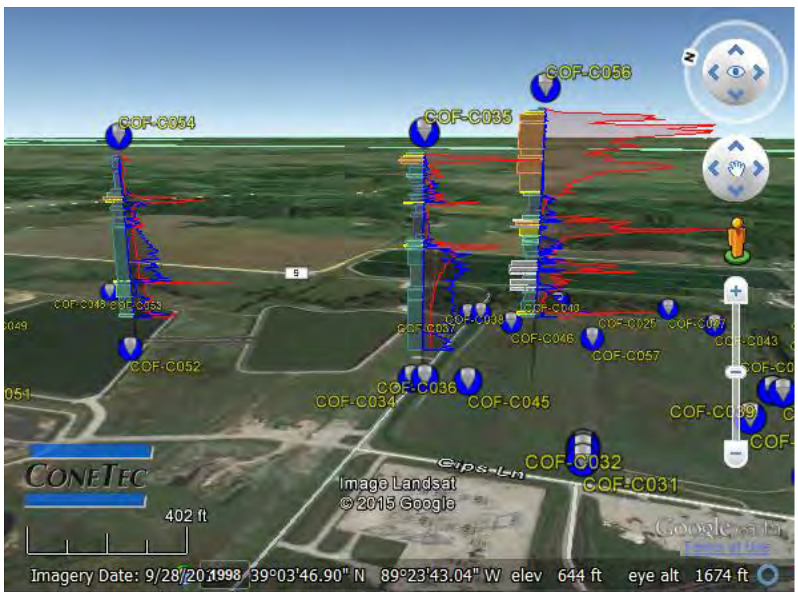
Coffeen Power Station
Coffeen, Illinois

Prepared for:

AECOM

ConeTec Job No: 15-53063

Project Start Date: 4-Aug-2015
Project End Date: 11-Aug-2015
Report Date: 30-Sep-2015



Prepared by:

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www.conetec.com
www.conetecdataservices.com

Introduction

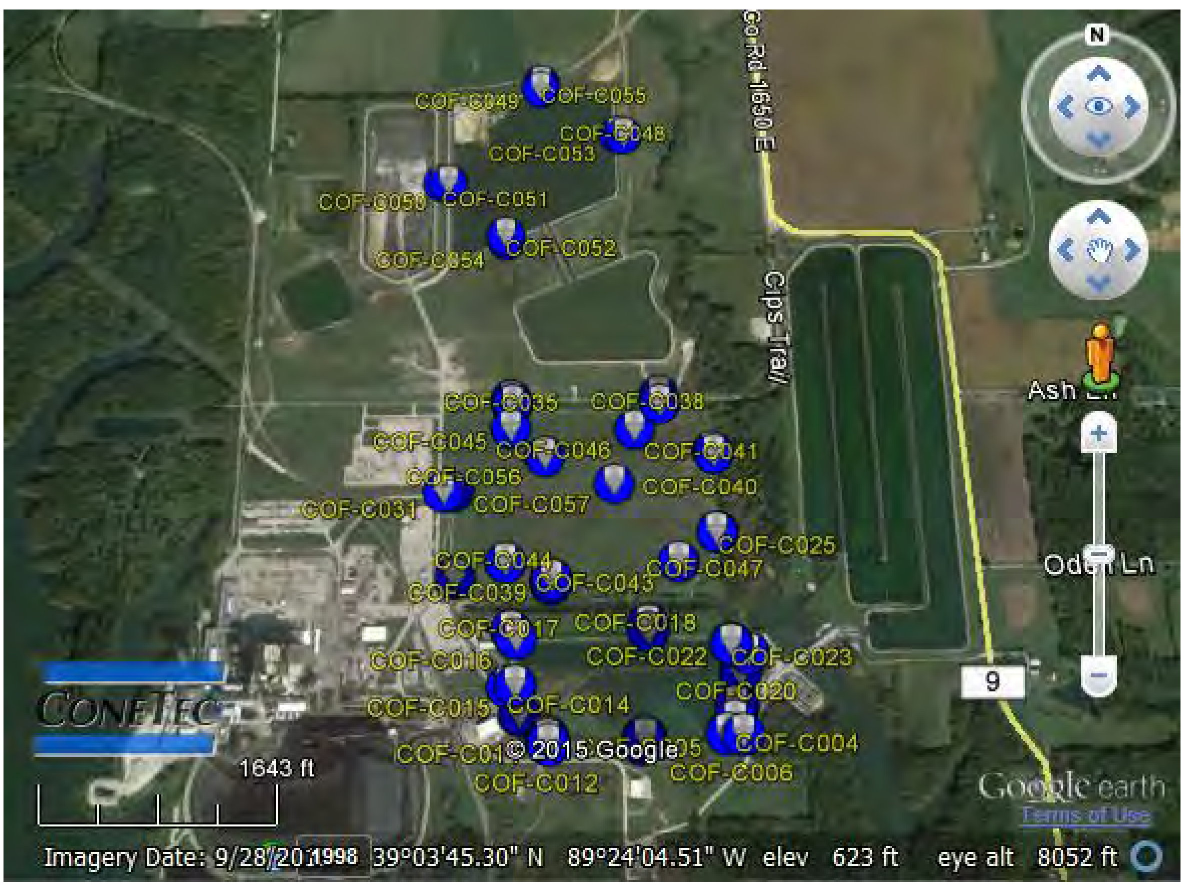
The enclosed report presents the results of a piezocone penetration testing (CPTu or CPT) and seismic piezocone penetration testing (SCPTu or SCPT) program carried out at the Coffeen Power Station site located in Coffeen, Illinois. The site investigation program was conducted by ConeTec Inc., under contract to AECOM of Denver Colorado.

A total of fifteen cone penetration tests and thirty seven seismic cone penetration tests were completed at fifty two locations. The CPT and SCPT program was performed to evaluate the subsurface soil conditions. CPT and SCPT sounding locations were selected and numbered under the supervision of AECOM personnel (Mr. Daryle Harrison and Mr. Adam Grossman).

Project Information

Project	
Client	AECOM
Project	Coffeen Power Station, Coffeen, IL
ConeTec project number	15-53063

A map from Google earth including the CPT test locations is presented below.



Rig Description	Deployment System	Test Type
CPT Truck Rig	25 ton truck mounted (twin cylinders)	CPT and SCPT
CPT Track Rig	20 ton track mounted (twin cylinders)	CPT and SCPT

Coordinates		
Test Type	Collection Method	EPSG Number
CPT and SCPT	GPS (Handheld)	32616 (WGS 84 / UTM North)

Cone Penetration Test (CPT)	
Depth reference	Ground surface at the time of the investigation.
Tip and sleeve data offset	0.1 meter. This has been accounted for in the CPT data files.
Pore pressure dissipation (PPD) tests	Eighty one pore pressure dissipation tests were completed primarily to determine the phreatic surface. Phreatic surfaces used in the calculated parameters, were obtained from AECOM.
Additional Comments	Shear wave velocity tests were conducted at varied depth intervals at thirty seven locations.

Cone Description	Cone Number	Cross Sectional Area (cm^2)	Sleeve Area (cm^2)	Tip Capacity (bar)	Sleeve Capacity (bar)	Pore Pressure Capacity (psi)
335:T1500F15U500	335	15	225	1500	15	500
374:T1500F15U500	374	15	225	1500	15	500

Limitations

This report has been prepared for the exclusive use of AECOM (Client) for the project titled “Coffeen Power Station, Coffeen, IL”. The report’s contents may not be relied upon by any other party without the express written permission of ConeTec, Inc. (ConeTec). ConeTec has provided site investigation services, prepared the factual data reporting, and provided geotechnical parameter calculations consistent with current best practices. No other warranty, expressed or implied, is made.

The information presented in the report document and the accompanying data set pertain to the specific project, site conditions and objectives described to ConeTec by the Client. In order to properly understand the factual data, assumptions and calculations, reference must be made to the documents provided and their accompanying data sets, in their entirety.

The cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd. of Richmond, British Columbia, Canada.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and a geophone sensor for recording seismic signals. All signals are amplified down hole within the cone body and the analog signals are sent to the surface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm^2 and 15 cm^2 tip base area configurations in order to maximize signal resolution for various soil conditions. The 15 cm^2 penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm^2 piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 mm diameter over a length of 32 mm with tapered leading and trailing edges) located at a distance of 585 mm above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u_2" position (ASTM Type 2). The filter is 6 mm thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meet or exceed those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

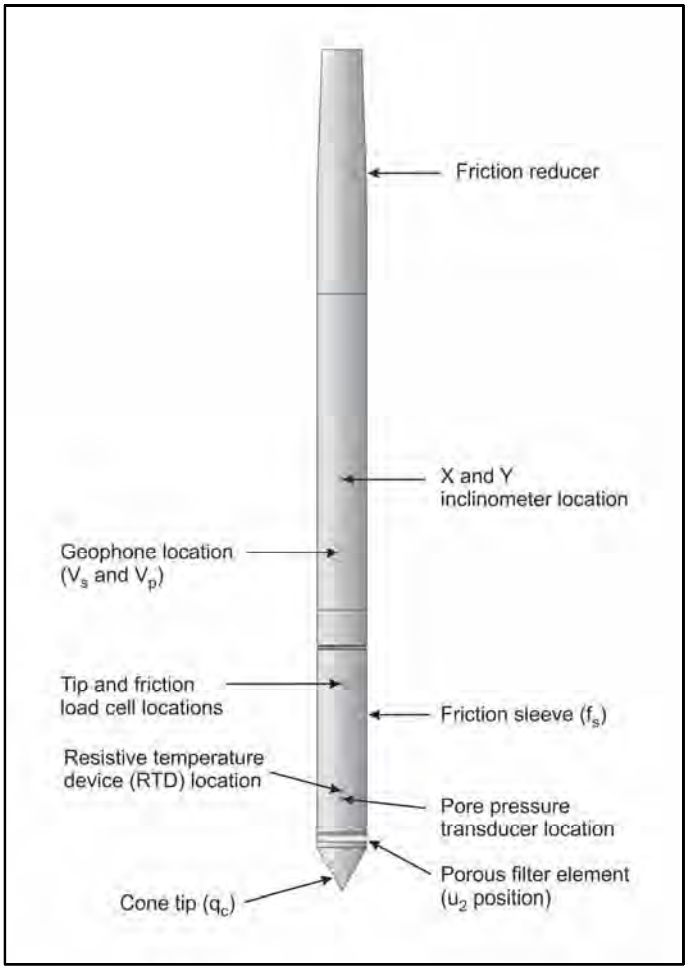


Figure CPTu. Piezocone Penetrometer (15 cm^2)

The ConeTec data acquisition systems consist of a Windows based computer and a signal conditioner and power supply interface box with a 16 bit (or greater) analog to digital (A/D) converter. The data is recorded at fixed depth increments using a depth wheel attached to the push cylinders or by using a spring loaded rubber depth wheel that is held against the cone rods. The typical recording intervals are either 2.5 cm or 5.0 cm depending on project requirements; custom recording intervals are possible. The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPT operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with either glycerin or silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of 2 cm/s, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil or glycerin under vacuum pressure prior to use
- Recorded baselines are checked with an independent multi-meter
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson (1990) and Robertson (2009). It should be noted that it is not always possible to accurately identify a soil type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behavior type.

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in Robertson et al, 1986:

$$q_t = q_c + (1\text{-}a) \bullet u_2$$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (Rf) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

A summary of the CPTu soundings along with test details and individual plots are provided in the appendices. A set of interpretation files were generated for each sounding based on published correlations and are provided in Excel format in the data release folder. Information regarding the interpretation methods used is included in an appendix.

For additional information on CPTu interpretations, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014) and Mayne and Peuchen (2012).

References

ASTM D5778-12, 2012, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM, West Conshohocken, US.

Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, “Cone Penetration Testing in Geotechnical Practice”, Blackie Academic and Professional.

Mayne, P.W., 2013, “Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests”, Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420.

Mayne, P.W. and Peuchen, J., 2012, “Unit weight trends with cone resistance in soft to firm clays”, Geotechnical and Geophysical Site Characterization *4,* Vol. 1 (Proc. ISC-4, Pernambuco), CRC Press, London: 903-910.

Mayne, P.W., 2014, “Interpretation of geotechnical parameters from seismic piezocone tests”, CPT’14 Keynote Address, Las Vegas, NV, May 2014.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, “Use of Piezometer Cone Data”, Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K., 1990, “Soil Classification Using the Cone Penetration Test”, Canadian Geotechnical Journal, Volume 27: 151-158.

Robertson, P.K., 2009, “Interpretation of cone penetration tests – a unified approach”, Canadian Geotechnical Journal, Volume 46: 1337-1355.

Shear wave velocity testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave (Vp) velocity is also determined.

ConeTec's piezocone penetrometers are manufactured with a horizontally active geophone (28 hertz) that is rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances an auger source or an imbedded impulsive source maybe used for both shear waves and compression waves. The hammer and beam act as a contact trigger that triggers the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded using an up-hole integrated digital oscilloscope which is part of the SCPTu data acquisition system. An illustration of the shear wave testing configuration is presented in Figure SCPTu-1.

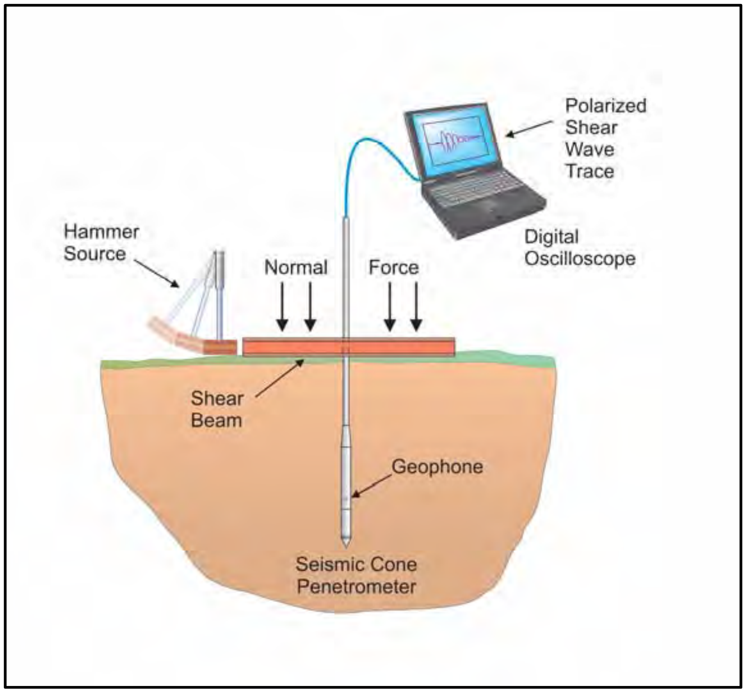


Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Multiple wave traces are recorded for quality control purposes. After reviewing wave traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). Figure SCPTu-2 presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to Robertson et.al. (1986).

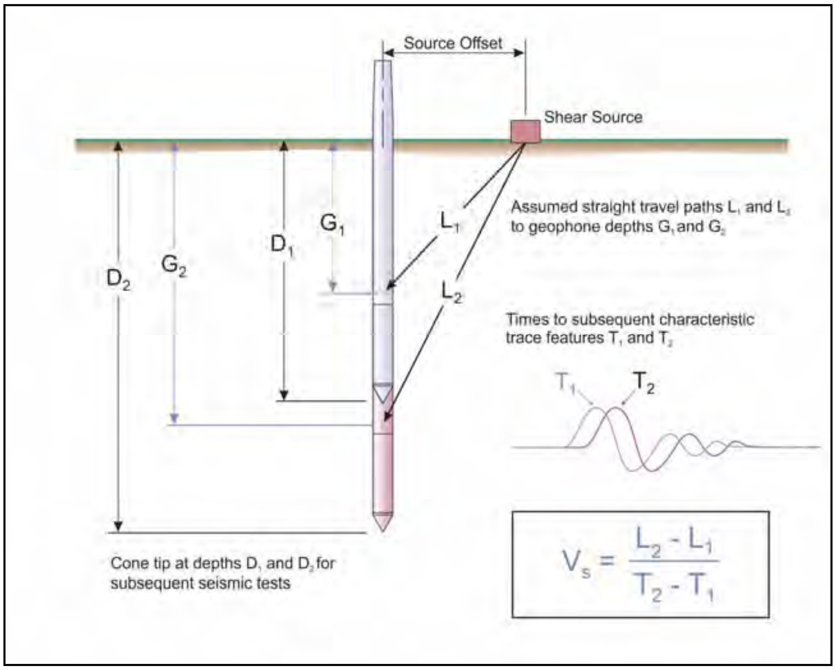


Figure SCPTu-2. Illustration of a seismic cone penetration test

Calculation of the interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the recorded wave sets and taking the difference in ray path divided by the time difference between subsequent features. Ray path is defined as the straight line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

The average shear wave velocity to a depth of 100 feet (30 meters) ($\bar{v}_s$) has been calculated and provided for all applicable soundings using the following equation presented in ASCE, 2010.

$$\bar{v}_s = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{v_{si}}}$$

where: $\bar{v}_s$ = average shear wave velocity ft/s (m/s)
d_i = the thickness of any layer between 0 and 100 ft (30 m)
v_{si} = the shear wave velocity in ft/s (m/s)
$\sum_{i=1}^{n} d_i$ = 100 ft (30 m)

Average shear wave velocity, $\bar{v}_s$ is also referenced to V_{s100} or V_{s30}.

The layer travel times refers to the travel times propagating in the vertical direction, not the measured travel times from an offset source.

Tabular results and SCPTu plots are presented in the relevant appendix.

References

American Society of Civil Engineers (ASCE), 2010, "Minimum Design Loads for Buildings and Other Structures", Standard ASCE/SEI 7-10, American Society of Civil Engineers, ISBN 978-0-7844-1085-1, Reston, Virginia.

Robertson, P.K., Campanella, R.G., Gillespie D and Rice, A., 1986, "Seismic CPT to Measure In-Situ Shear Wave Velocity", Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8: 791-803.

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

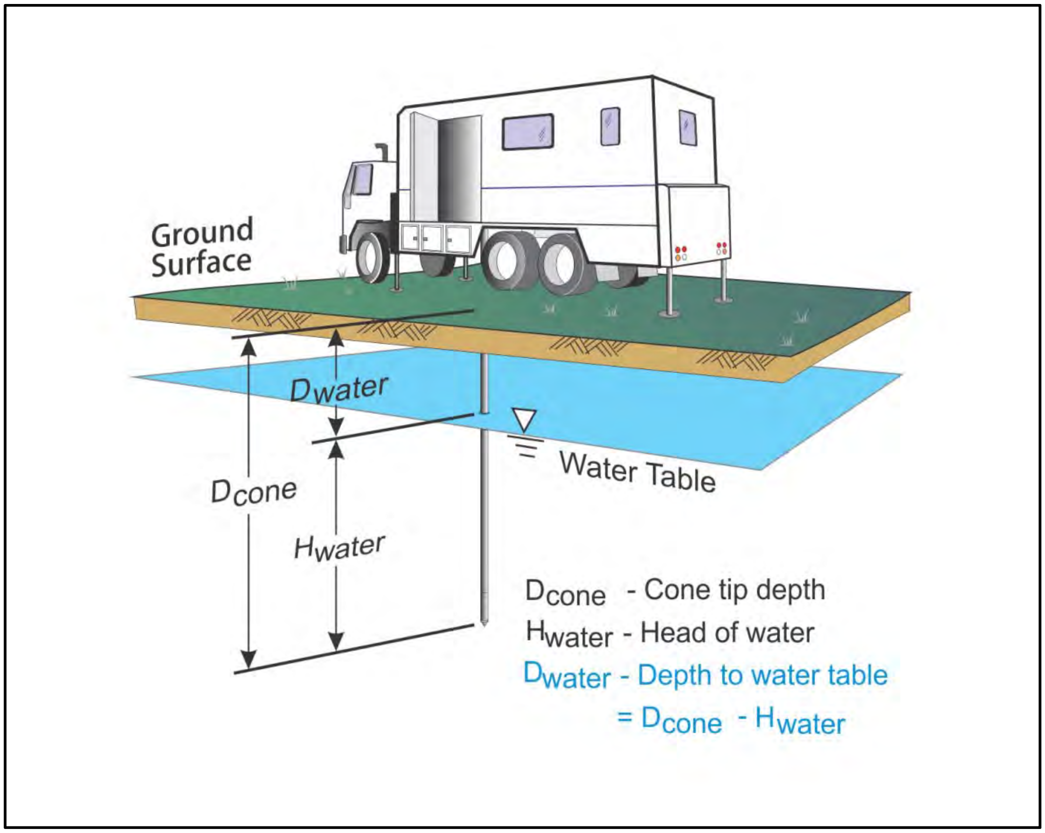


Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behavior.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

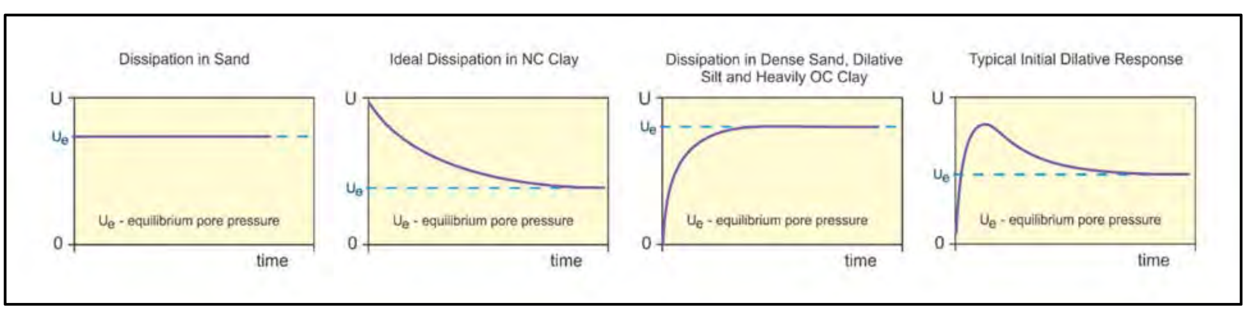


Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve of Figure PPD-2.

In fine grained deposits the point at which 100% of the excess pore pressure has dissipated is known as t_{100}. In some cases this can take an excessive amount of time and it may be impractical to take the dissipation to t_{100}. A theoretical analysis of pore pressure dissipations by Teh and Houlsby (1991) showed that a single curve relating degree of dissipation versus theoretical time factor (T*) may be used to calculate the coefficient of consolidation (c_h) at various degrees of dissipation resulting in the expression for c_h shown below.

$$c_h = \frac{T^* \cdot a^2 \cdot \sqrt{I_r}}{t}$$

Where:

T* is the dimensionless time factor (Table Time Factor)
a is the radius of the cone
I_r is the rigidity index
t is the time at the degree of consolidation

Table Time Factor. T* versus degree of dissipation (Teh and Houlsby, 1991)

Degree of Dissipation (%)	20	30	40	50	60	70	80
T* (u_2)	0.038	0.078	0.142	0.245	0.439	0.804	1.60

The coefficient of consolidation is typically analyzed using the time (t_{50}) corresponding to a degree of dissipation of 50% (u_{50}). In order to determine t_{50}, dissipation tests must be taken to a pressure less than u_{50}. The u_{50} value is half way between the initial maximum pore pressure and the equilibrium pore pressure value, known as u_{100}. To estimate u_{50}, both the initial maximum pore pressure and u_{100} must be known or estimated. Other degrees of dissipations may be considered, particularly for extremely long dissipations.

At any specific degree of dissipation the equilibrium pore pressure (u at t_{100}) must be estimated at the depth of interest. The equilibrium value may be determined from one or more sources such as measuring the value directly (u_{100}), estimating it from other dissipations in the same profile, estimating the phreatic surface and assuming hydrostatic conditions, from nearby soundings, from client provided information, from site observations and/or past experience, or from other site instrumentation.

For calculations of c_h (Teh and Houlsby, 1991), t_{50} values are estimated from the corresponding pore pressure dissipation curve and a rigidity index (I_r) is assumed. For curves having an initial dilatory response in which an initial rise in pore pressure occurs before reaching a peak, the relative time from the peak value is used in determining t_{50}. In cases where the time to peak is excessive, t_{50} values are not calculated.

Due to possible inherent uncertainties in estimating I_r, the equilibrium pore pressure and the effect of an initial dilatory response on calculating t_{50}, other methods should be applied to confirm the results for c_h.

Additional published methods for estimating the coefficient of consolidation from a piezocone test are described in Burns and Mayne (1998, 2002), Jones and Van Zyl (1981), Robertson et al. (1992) and Sully et al. (1999).

A summary of the pore pressure dissipation tests and dissipation plots are presented in the relevant appendix.

References

Burns, S.E. and Mayne, P.W., 1998, “Monotonic and dilatory pore pressure decay during piezocone tests”, Canadian Geotechnical Journal 26 (4): 1063-1073.

Burns, S.E. and Mayne, P.W., 2002, “Analytical cavity expansion-critical state model cone dissipation in fine-grained soils”, Soils & Foundations, Vol. 42(2): 131-137.

Jones, G.A. and Van Zyl, D.J.A., 1981, “The piezometer probe: a useful investigation tool”, Proceedings, 10th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, Stockholm: 489-495.

Robertson, P.K., Sully, J.P., Woeller, D.J., Lunne, T., Powell, J.J.M. and Gillespie, D.G., 1992, “Estimating coefficient of consolidation from piezocone tests”, Canadian Geotechnical Journal, 29(4): 551-557.

Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J., 1999, “An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils”, Canadian Geotechnical Journal, 36(2): 369-381.

Teh, C.I., and Houlsby, G.T., 1991, “An analytical study of the cone penetration test in clay”, Geotechnique, 41(1): 17-34.

Vibrating wire piezometers manufactured by RST Instruments Ltd., measure in situ water pressure and temperature. The pressure is determined by measuring the resonant frequency at which the internal tensioned wire vibrates. Calibration constants relate the recorded frequency to the applied pressure. Temperature is measured using a built-in thermistor.

Prior to deployment the piezometers are saturated as per the manufacturer's guidelines and the piezometer serial number and baselines are recorded.

The piezometers are pushed into the ground from ground surface with a CPT rig or drill rig and the installation depths are referenced to the existing ground surface at the time of installation.

An installation summary is provided in the relevant appendix.

For more details about RST vibrating wire piezometers, refer to the manufacturer's website. http://www.rstinstruments.com/Vibrating%20Wire%20Piezometer.html

The appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Seismic Cone Penetration Test Plots
- Seismic Cone Penetration Test Tabular Results
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots
- VW Piezometer Installation Summary

Cone Penetration Test Summary and

Standard Cone Penetration Test Plots

ConeTec

CONETEC

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station, Coffeen, IL
Start Date: 04-Aug-2015
End Date: 11-Aug-2015

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (ft)	Final Depth (ft)	Shear Wave Velocity Tests	Northing[2] (m)	Easting (m)	Refer to Notation Number
COF-C001	15-53063_SP01	05-Aug-2015	335:T1500F15U500	22.5	33.30	9	4325926	293076	5
COF-C002	15-53063_SP02	06-Aug-2015	374:T1500F15U500	0.0	33.30	3	4325927	293071	5
COF-C004	15-53063_SP04	06-Aug-2015	335:T1500F15U500	18.1	35.76	2	4325897	293066	5
COF-C005	15-53063_SP05	07-Aug-2015	335:T1500F15U500	14.8	33.46	8	4325871	293047	
COF-C006	15-53063_SP06	04-Aug-2015	335:T1500F15U500	0.0	13.45	6	4325869	293081	5
COF-C007	15-53063_SP07	07-Aug-2015	374:T1500F15U500	12.8	34.78	4	4325874	292869	5
COF-C008	15-53063_SP08	05-Aug-2015	335:T1500F15U500	11.6	33.96	2	4325870	292872	
COF-C009	15-53063_SP09	06-Aug-2015	374:T1500F15U500	0.0	17.88	3	4325860	292865	
COF-C010	15-53063_SP10	07-Aug-2015	374:T1500F15U500	13.3	32.97	5	4325884	292664	
COF-C011	15-53063_SP11	05-Aug-2015	335:T1500F15U500	14.2	31.99	3	4325878	292666	
COF-C012	15-53063_SP12	04-Aug-2015	335:T1500F15U500	1.3	19.52	5	4325868	292667	
COF-C013	15-53063_SP13	05-Aug-2015	335:T1500F15U500	5.6	31.33	5	4325931	292608	
COF-C014	15-53063_SP14	04-Aug-2015	335:T1500F15U500	3.5	21.33	6	4325991	292584	
COF-C015	15-53063_CP15	06-Aug-2015	335:T1500F15U500	15.8	35.27		4325992	292601	
COF-C016	15-53063_CP16	06-Aug-2015	374:T1500F15U500	1.2	33.79		4326091	292606	5
COF-C017	15-53063_CP17	04-Aug-2015	335:T1500F15U500	10.9	17.72		4326109	292596	5
COF-C018	15-53063_SP18	05-Aug-2015	335:T1500F15U500	5.9	17.22	2	4326107	292893	
COF-C019	15-53063_CP19	06-Aug-2015	335:T1500F15U500	0.0	34.78		4326092	292892	5
COF-C020	15-53063_SP20	06-Aug-2015	374:T1500F15U500	0.0	15.58	2	4326035	293106	5
COF-C022	15-53063_SP22	06-Aug-2015	335:T1500F15U500	14.5	38.55	10	4326059	293072	5
COF-C023	15-53063_SP23	07-Aug-2015	374:T1500F15U500	6.6	21.00	4	4326057	293071	5
COF-C024	15-53063_CP24	05-Aug-2015	335:T1500F15U500	0.0	34.94		4325994	293086	5
COF-C025	15-53063_SP25	10-Aug-2015	335:T1500F15U500	22.4	36.75	5	4326302	293062	
COF-C027	15-53063_CP27	08-Aug-2015	335:T1500F15U500	9.2	32.32		4326600	292953	5
COF-C028	15-53063_SP28	10-Aug-2015	335:T1500F15U500	21.0	32.97	5	4326205	292686	
COF-C030	15-53063_CP30	11-Aug-2015	335:T1500F15U500	18.0	35.43		4326229	292475	5
COF-C031	15-53063_SP31	08-Aug-2015	374:T1500F15U500	1.4	22.80	4	4326423	292452	5
COF-C032	15-53063_SP32	11-Aug-2015	335:T1500F15U500	16.7	32.15	3	4326423	292468	
COF-C033	15-53063_CP33	08-Aug-2015	335:T1500F15U500	17.0	32.64		4326423	292475	
COF-C034	15-53063_SP34	08-Aug-2015	374:T1500F15U500	0.0	60.20	8	4326634	292612	5
COF-C035	15-53063_CP35	08-Aug-2015	335:T1500F15U500	11.6	70.21		4326621	292615	5
COF-C036	15-53063_CP36	08-Aug-2015	335:T1500F15U500	16.8	30.84		4326618	292613	
COF-C037	15-53063_SP37	08-Aug-2015	374:T1500F15U500	10.6	11.48	2	4326629	292951	5
COF-C038	15-53063_SP38	11-Aug-2015	335:T1500F15U500	14.3	31.82	2	4326607	292952	5
COF-C039	15-53063_CP39	11-Aug-2015	335:T1500F15U500	5.3	34.12		4326216	292688	
COF-C040	15-53063_SP40	10-Aug-2015	335:T1500F15U500	0.0	50.03	4	4326487	293063	5
COF-C041	15-53063_SP41	10-Aug-2015	335:T1500F15U500	22.6	48.56	14	4326482	293067	
COF-C043	15-53063_SP43	10-Aug-2015	374:T1500F15U500	8.0	36.91	3	4326241	292969	
COF-C044	15-53063_SP44	11-Aug-2015	374:T1500F15U500	11.0	42.98	5	4326257	292588	
COF-C045	15-53063_SP45	08-Aug-2015	374:T1500F15U500	14.3	40.85	3	4326563	292609	5
COF-C046	15-53063_SP46	10-Aug-2015	374:T1500F15U500	10.7	39.04	4	4326548	292890	5
COF-C047	15-53063_CP47	08-Aug-2015	335:T1500F15U500	0.0	35.43		4326302	293060	5
COF-C048	15-53063_CP48	11-Aug-2015	374:T1500F15U500	0.0	20.01		4327303	292909	5
COF-C049	15-53063_SP49	07-Aug-2015	335:T1500F15U500	9.5	25.75	2	4327443	292710	
COF-C050	15-53063_CP50	07-Aug-2015	335:T1500F15U500	9.7	23.95		4327193	292474	
COF-C051	15-53063_SP51	11-Aug-2015	374:T1500F15U500	4.3	20.18	3	4327193	292459	

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station, Coffeen, IL
Start Date:	04-Aug-2015
End Date:	11-Aug-2015

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (ft)	Final Depth (ft)	Shear Wave Velocity Tests	Northing[2] (m)	Easting (m)	Refer to Notation Number
COF-C052	15-53063_SP52	07-Aug-2015	335:T1500F15U500	9.6	26.90	3	4327045	292612	5
COF-C053	15-53063_SP53	07-Aug-2015	335:T1500F15U500	12.8	53.64	10	4327306	292894	
COF-C054	15-53063_CP54	11-Aug-2015	374:T1500F15U500	2.2	65.62		4327033	292613	5
COF-C055	15-53063_SP55	11-Aug-2015	374:T1500F15U500	2.3	18.87	3	4327459	292712	
COF-C056	15-53063_SP56	10-Aug-2015	374:T1500F15U500	15.3	75.46	3	4326494	292684	5
COF-C057	15-53063_SP57	10-Aug-2015	374:T1500F15U500	9.2	37.40	4	4326423	292837	5
Totals	52 soundings				1747.19	169			

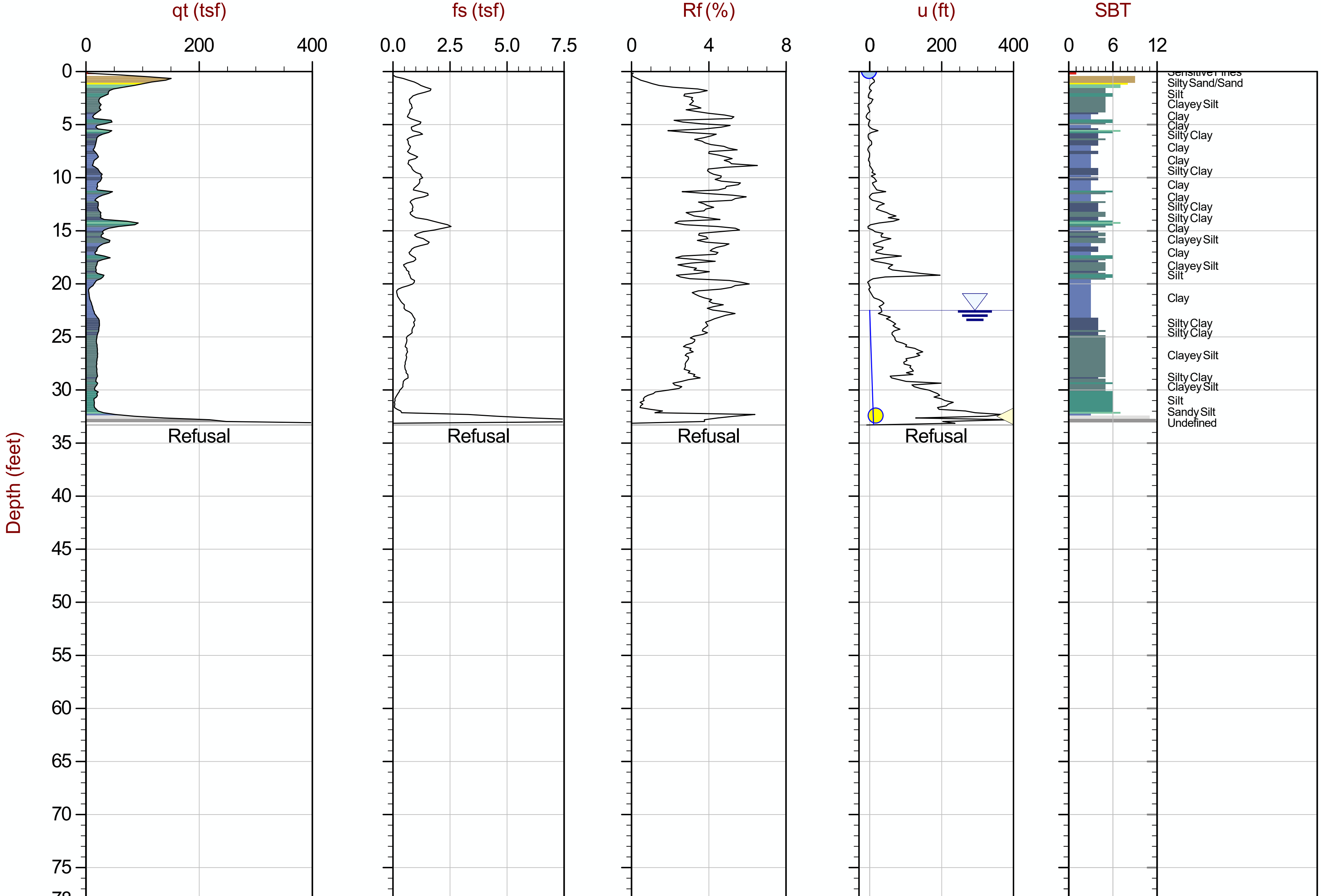
1. Assumed phreatic surface depths were determined from the pore pressure data unless otherwise noted. Hydrostatic data were used for calculated parameters.
2. Coordinates are WGS 84 / UTM Zone 16 and were collected using a handheld GPS Receiver.
3. Assumed phreatic surface estimated from dynamic pore pressure response.
4. No phreatic surface detected.
5. Phreatic surface obtained from the client.

CONETEC

AECOM

Job No: 15-53063
Date: 08:05:15 11:25
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C001
Cone: 335:T1500F15U500



Max Depth: 10.150 m / 33.30 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP01.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325926m E: 293076m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

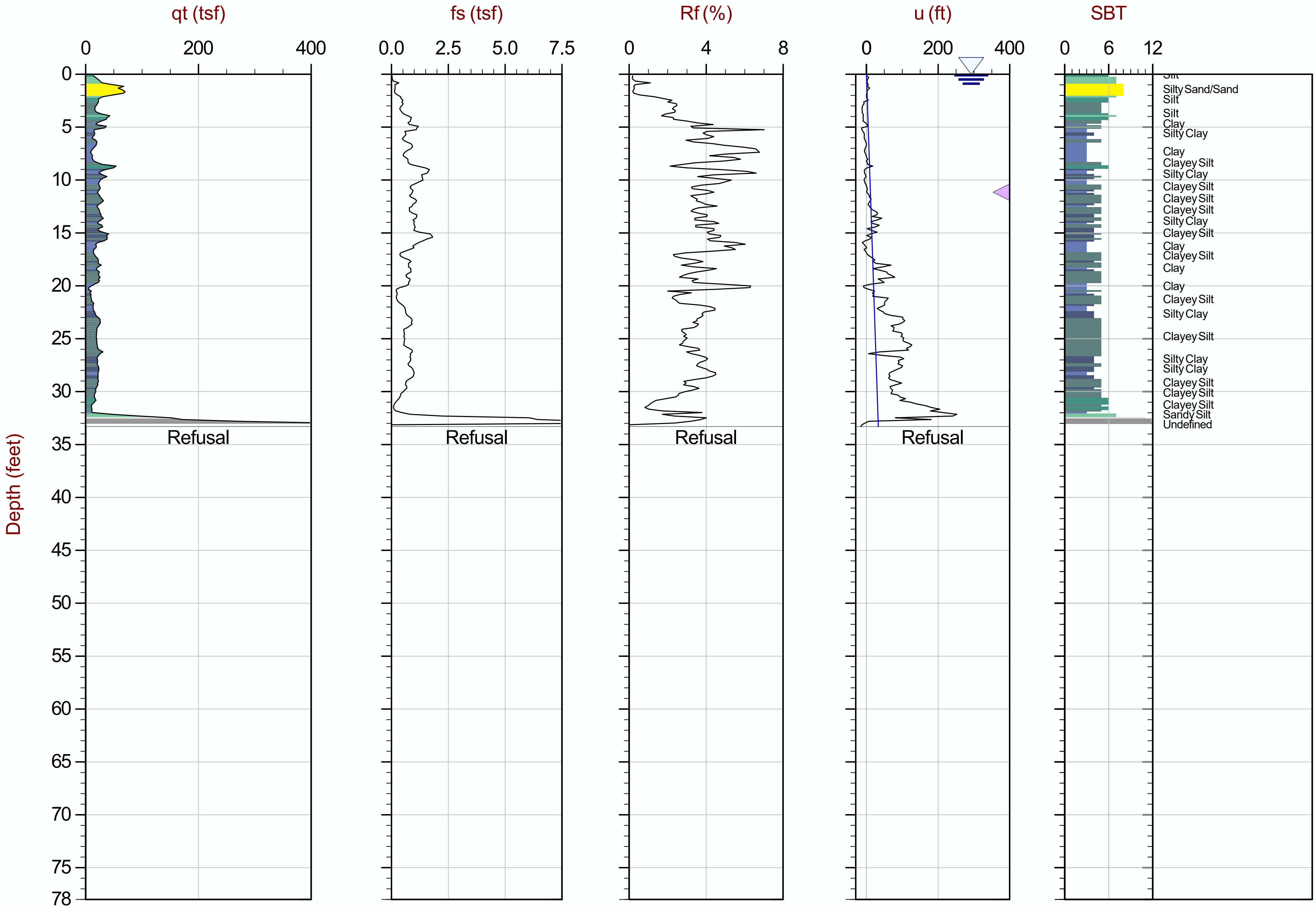
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:06:15 13:40
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C002
Cone: 374:T1500F15U500



Max Depth: 10.150 m / 33.30 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP02.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325927m E: 293071m

Hydrostatic Line · Ueq · Assumed Ueq · PPD, Ueq achieved · PPD, Ueq not achieved

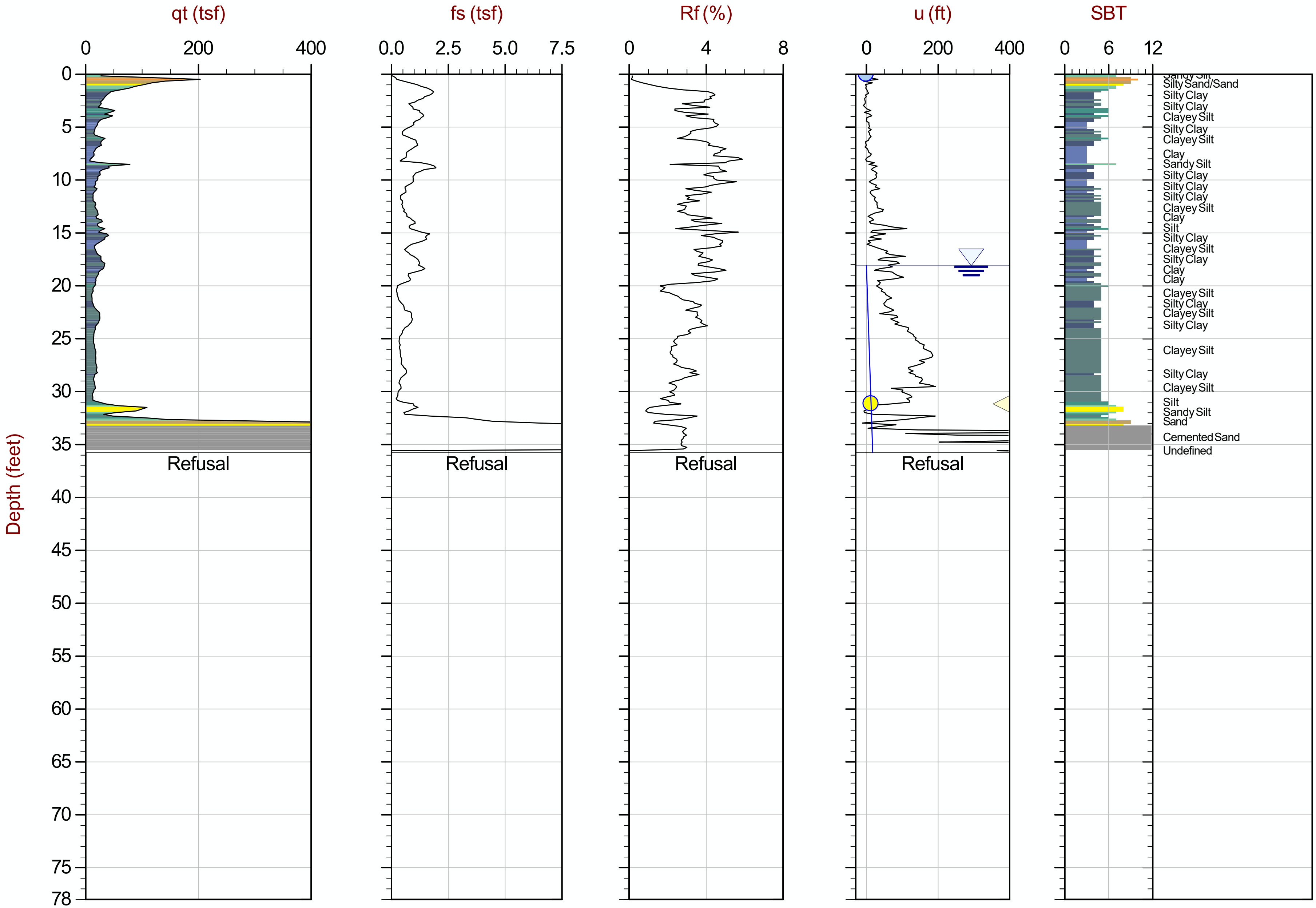
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:06:15 15:03
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C004
Cone: 335:T1500F15U500



Max Depth: 10.900 m / 35.76 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP04.COR

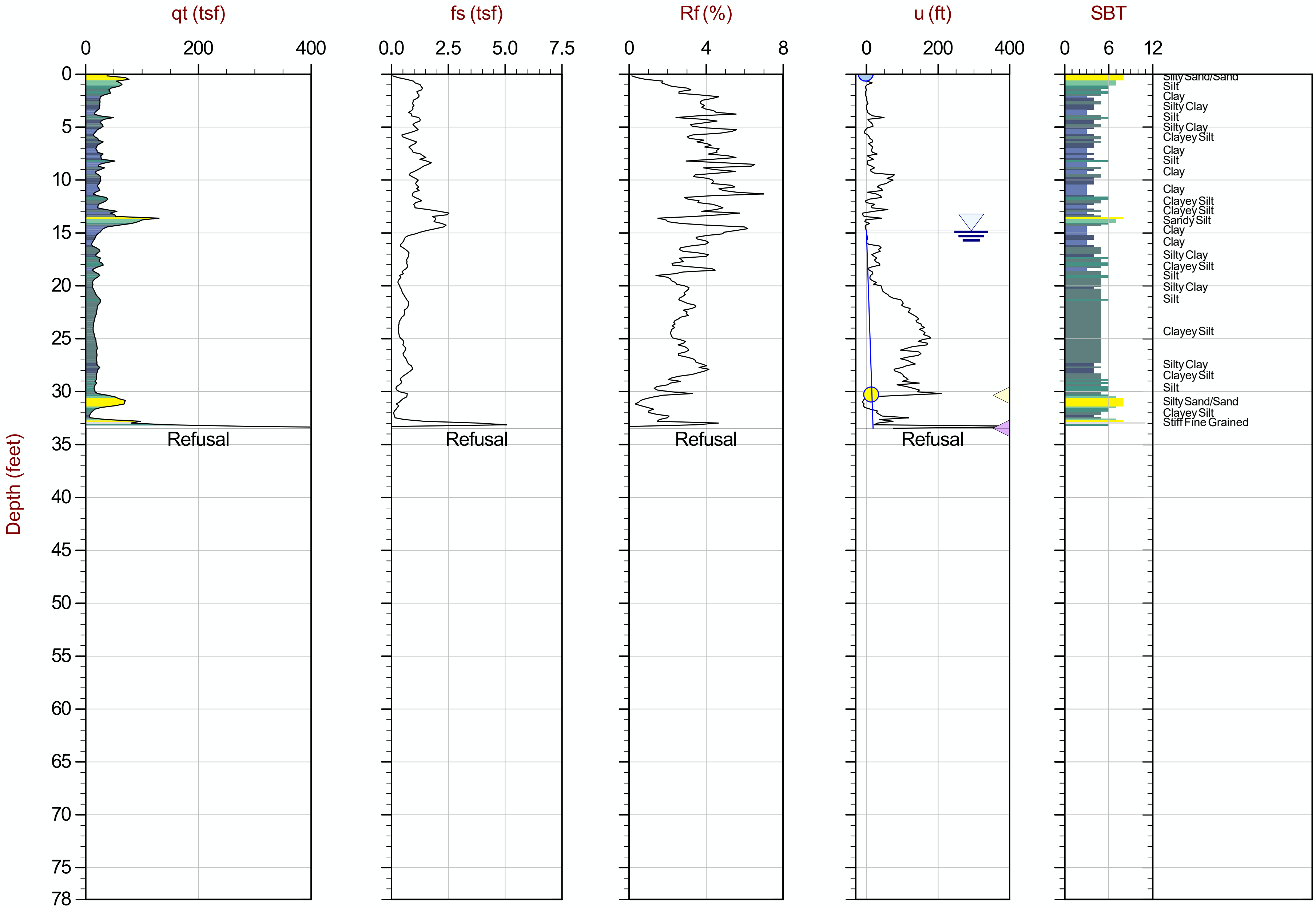
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325897m E: 293066m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec | AECOM

Job No: 15-53063
Date: 08:07:15 07:21
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C005
Cone: 335:T1500F15U500



Max Depth: 10.200 m / 33.46 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP05.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325871m E: 293047m

Hydrostatic Line · Ueq · Assumed Ueq · PPD, Ueq achieved · PPD, Ueq not achieved

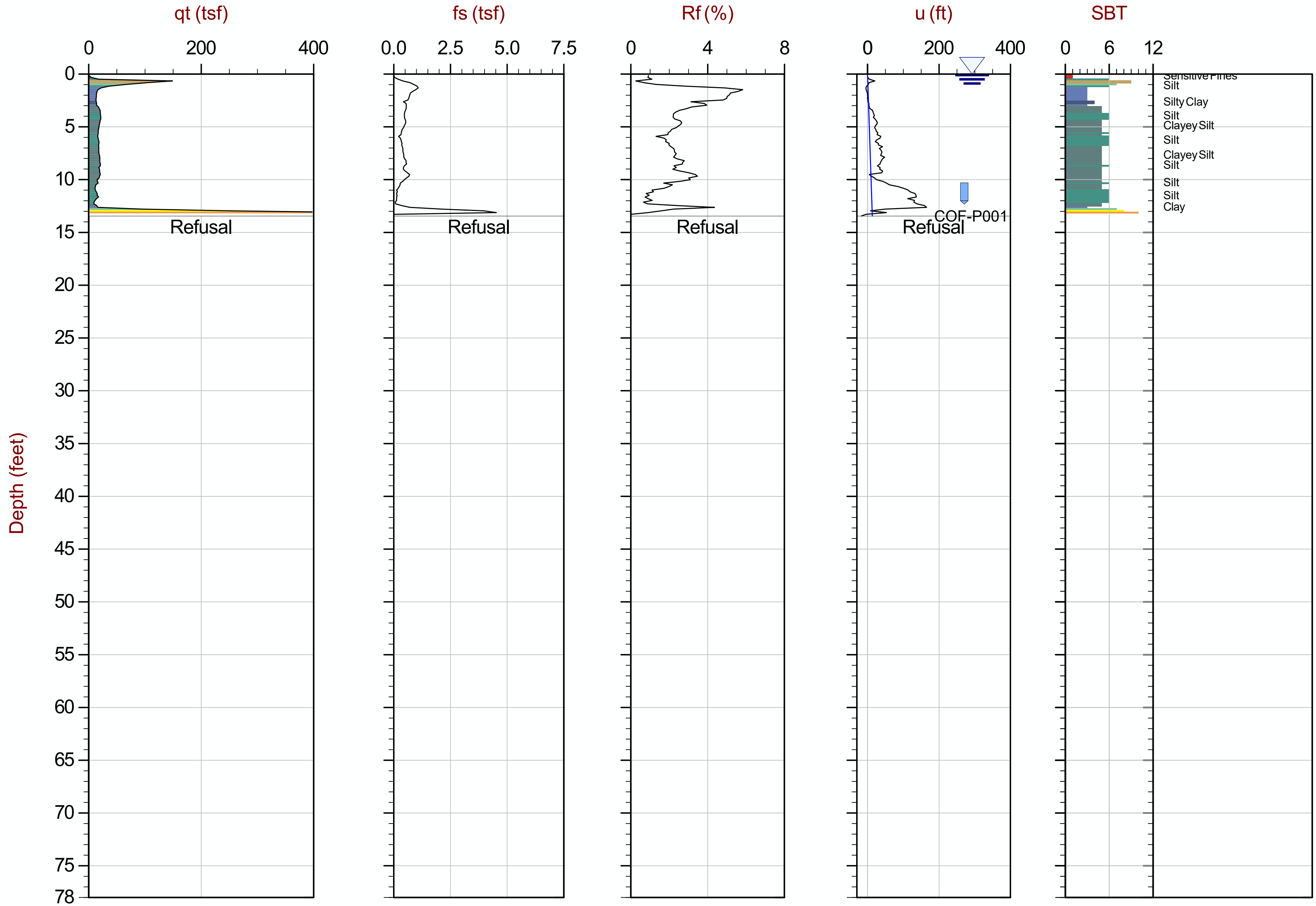
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:04:15 14:50
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C006
Cone: 335:T1500F15U500



Max Depth: 4.100 m / 13.45 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP06.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325869m E: 293081m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

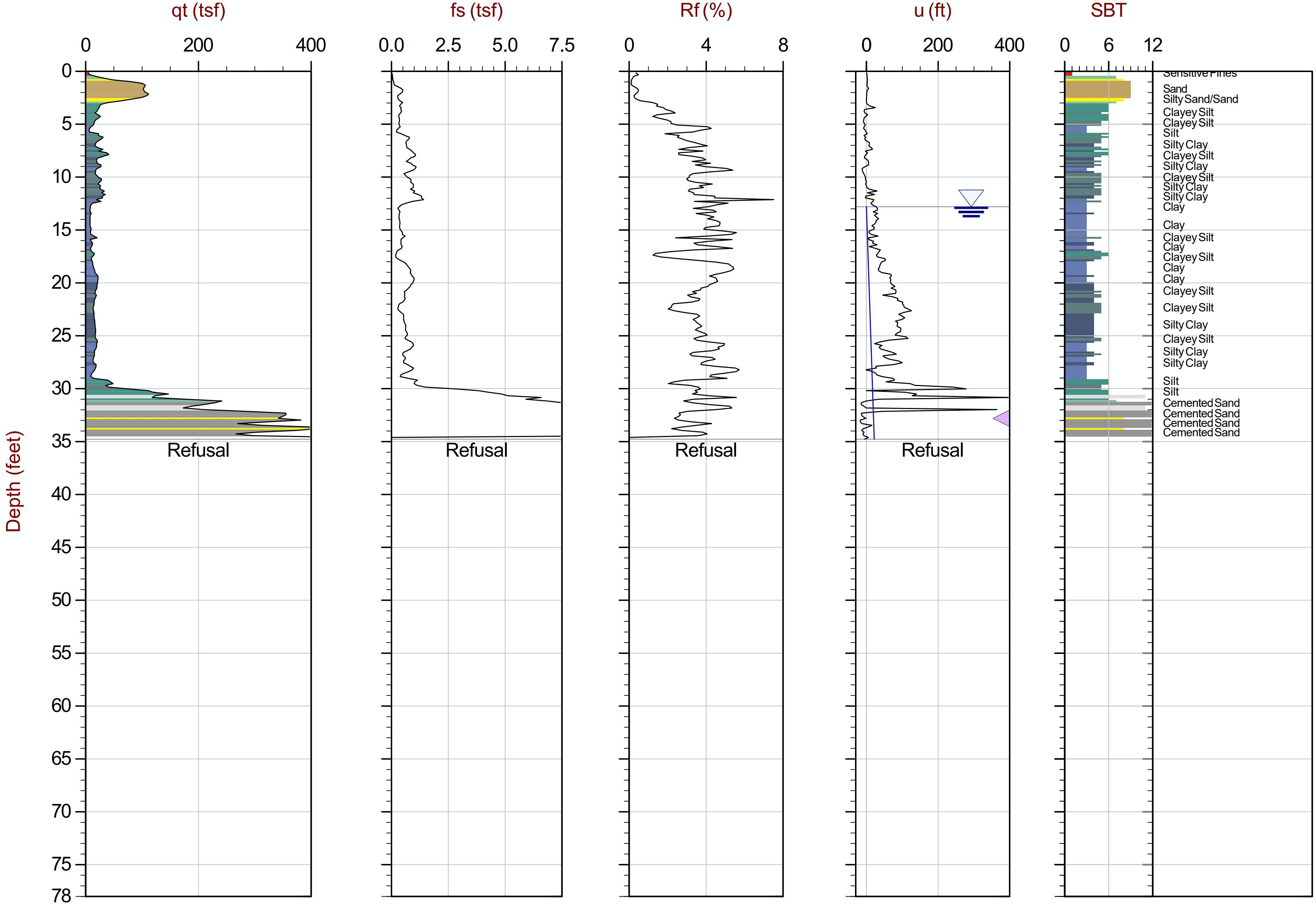
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 11:18
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C007
Cone: 374:T1500F15U500



Max Depth: 10.600 m / 34.78 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP07.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325874m E: 292869m

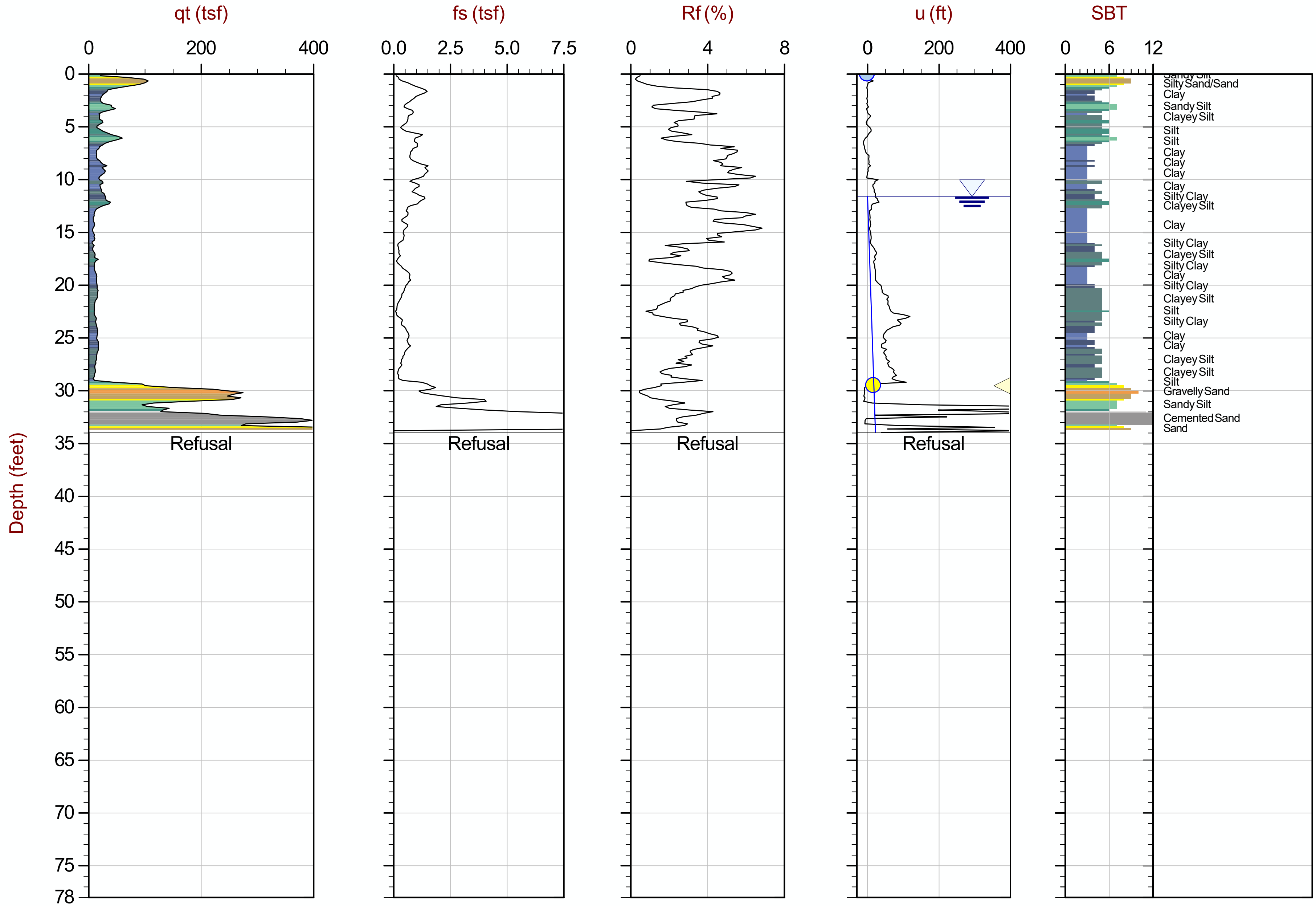
Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:05:15 09:57
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C008
Cone: 335:T1500F15U500



Max Depth: 10.350 m / 33.96 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

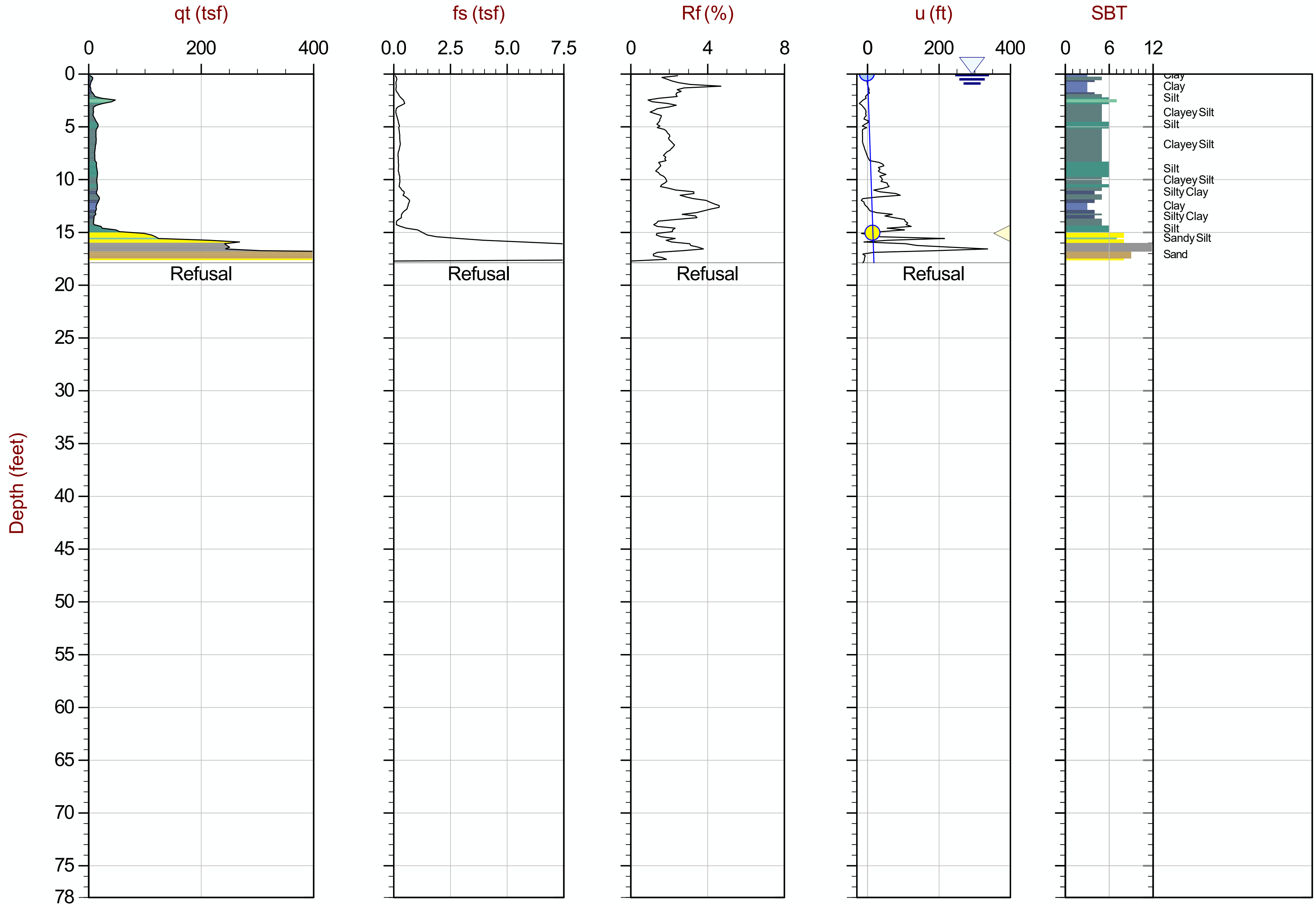
File: 15-53063_SP08.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325870m E: 292872m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM	Job No: 15-53063	Sounding: COF-C009
	Date: 08:06:15 16:06	Cone: 374:T1500F15U500
	Site: Coffeen Power Station, Coffeen, IL	



Max Depth: 5.450 m / 17.88 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP09.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325860m E: 292865m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

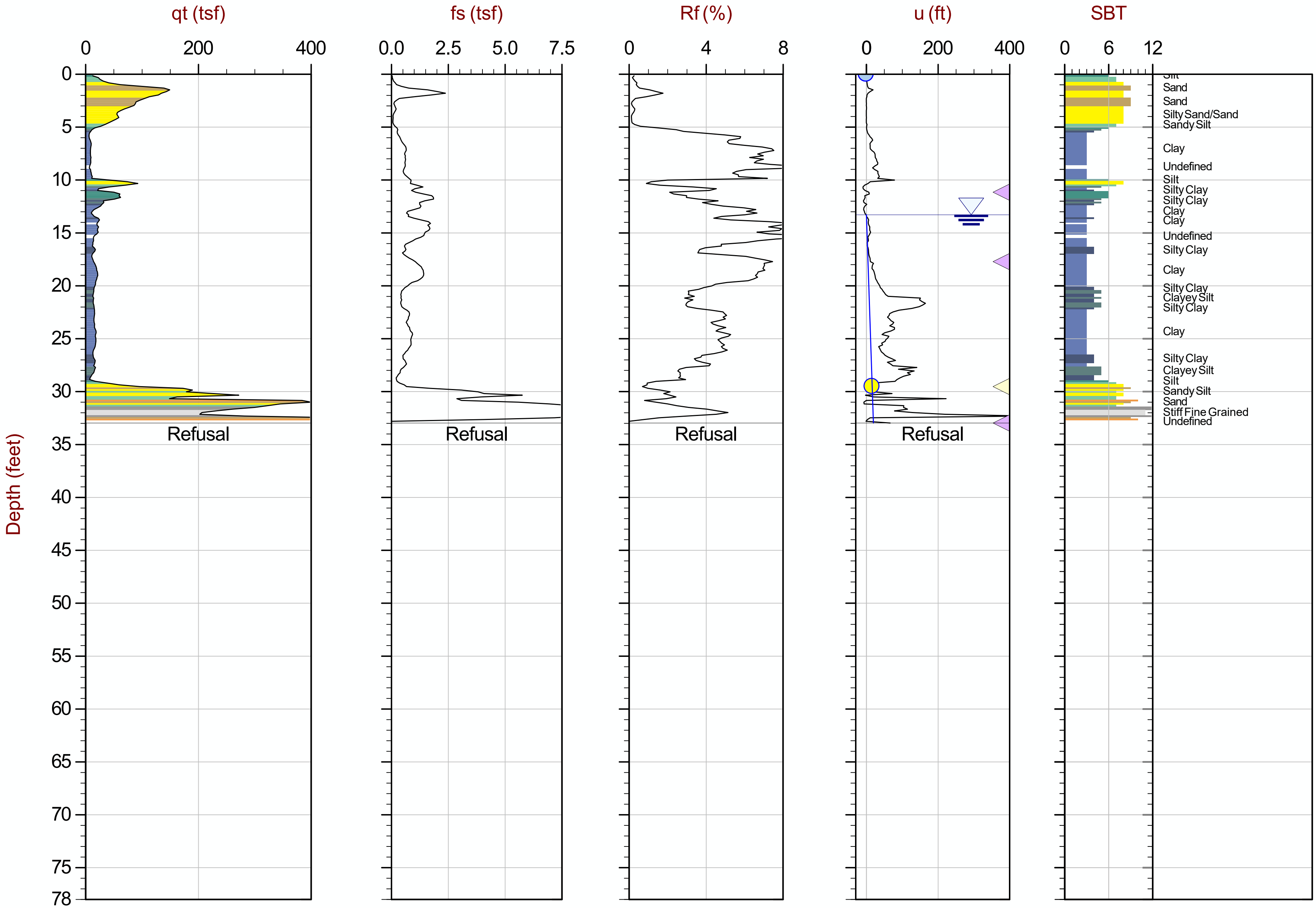
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 09:01
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C010
Cone: 374:T1500F15U500



Max Depth: 10.050 m / 32.97 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP10.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325884m E: 292664m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

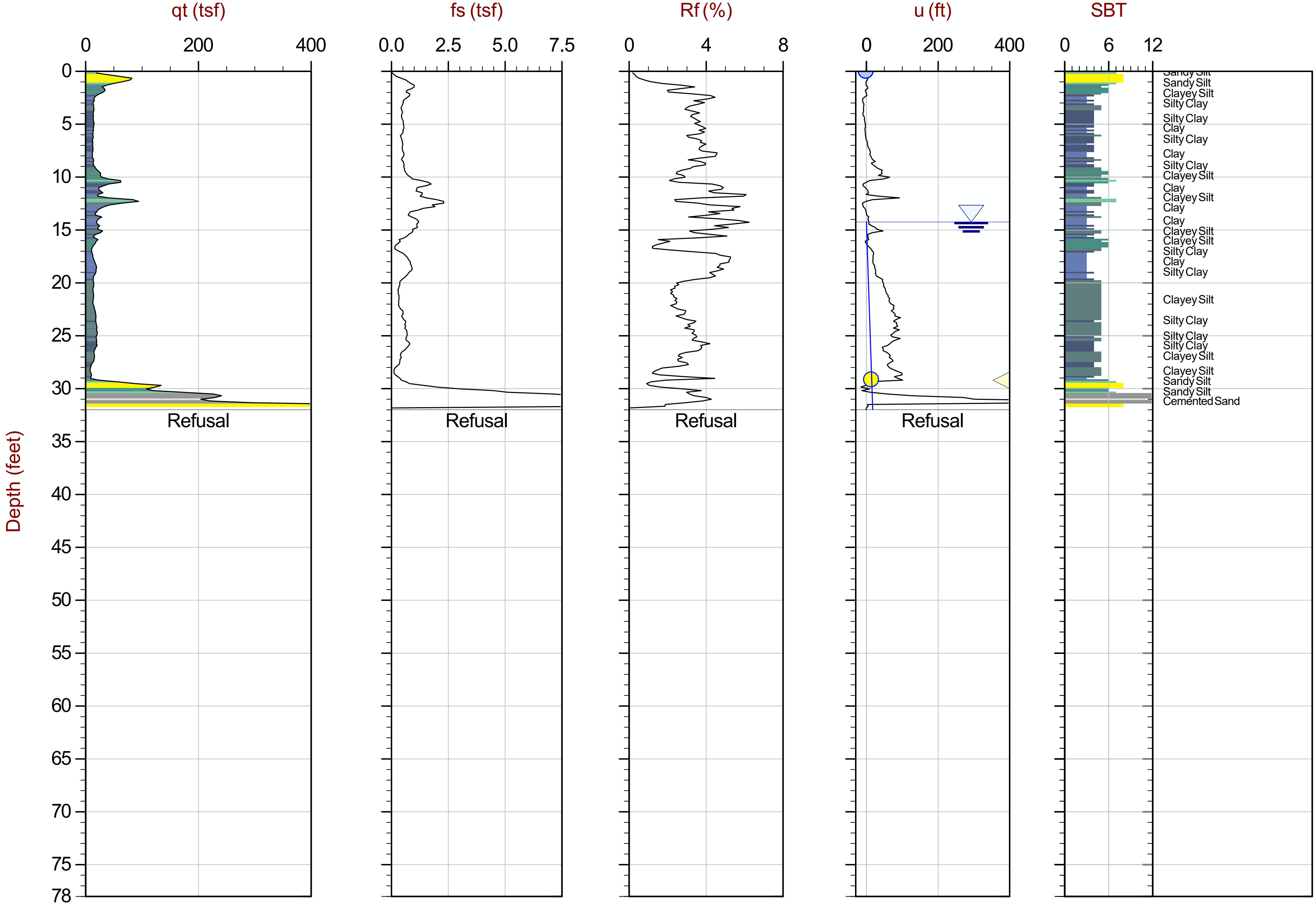
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:05:15 08:38
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C011
Cone: 335:T1500F15U500



Max Depth: 9.750 m / 31.99 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP11.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325878m E: 292666m

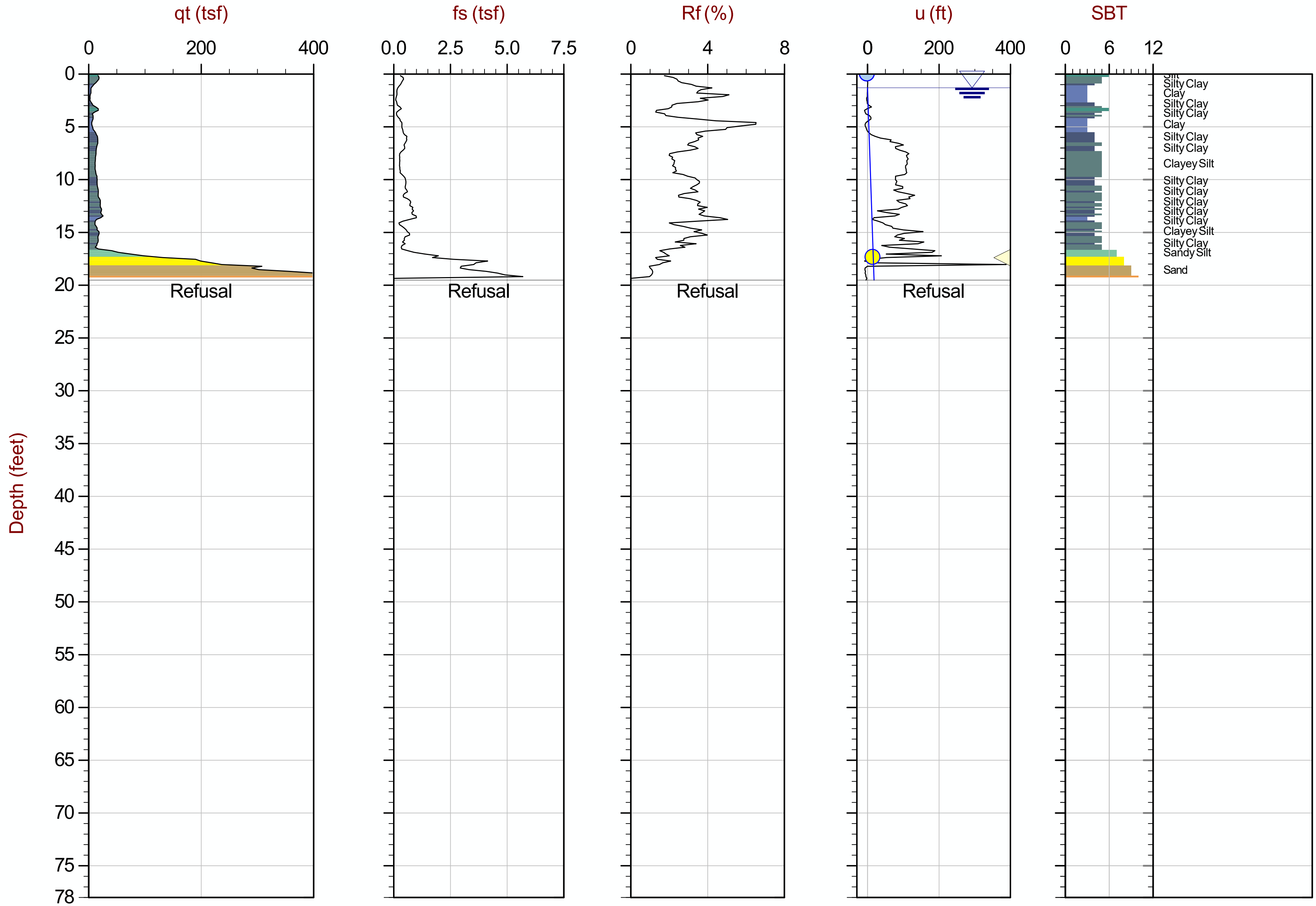
Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:04:15 12:36
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C012
Cone: 335:T1500F15U500



Max Depth: 5.950 m / 19.52 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP12.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325868m E: 292667m

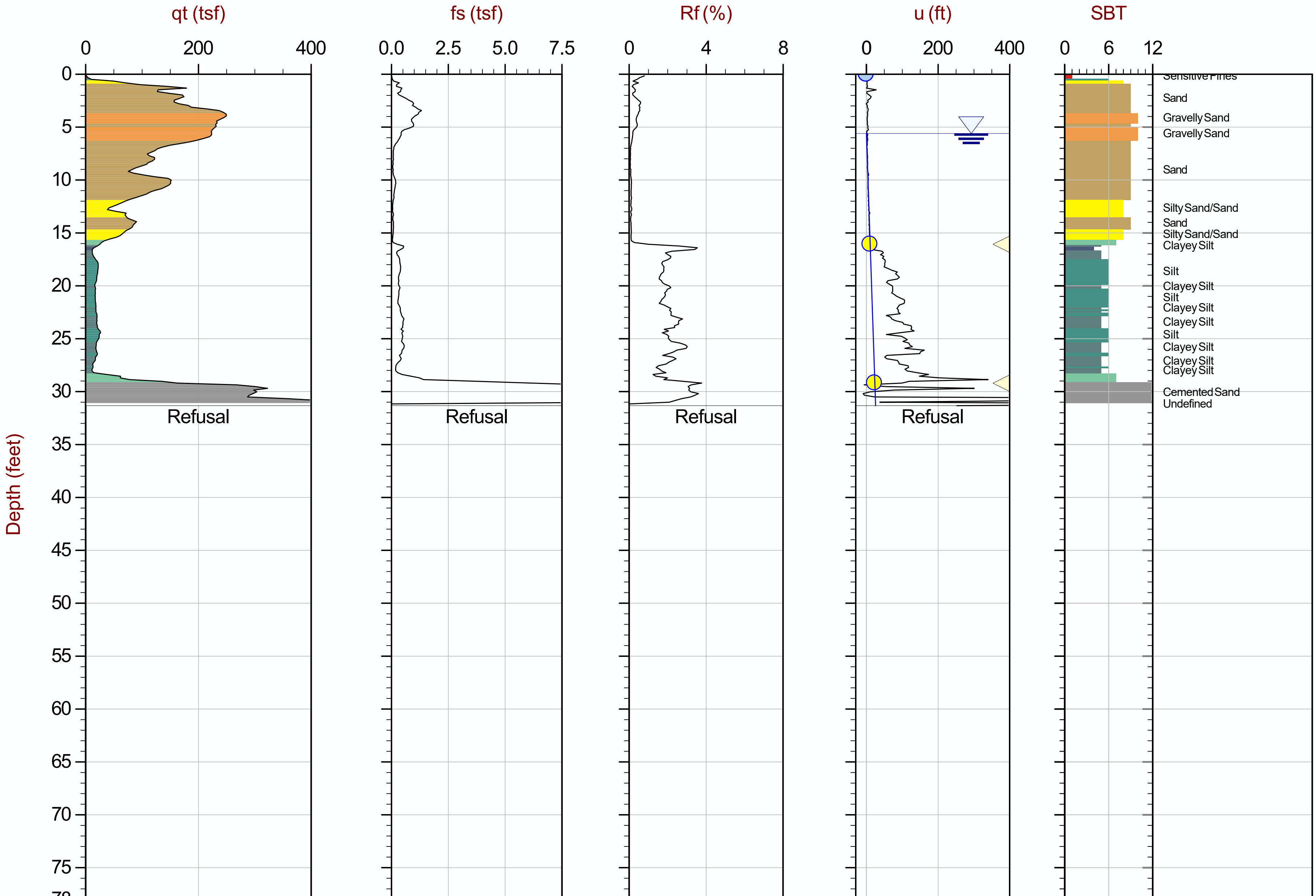
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:05:15 15:50
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C013
Cone: 335:T1500F15U500



Max Depth: 9.550 m / 31.33 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP13.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325931m E: 292608m

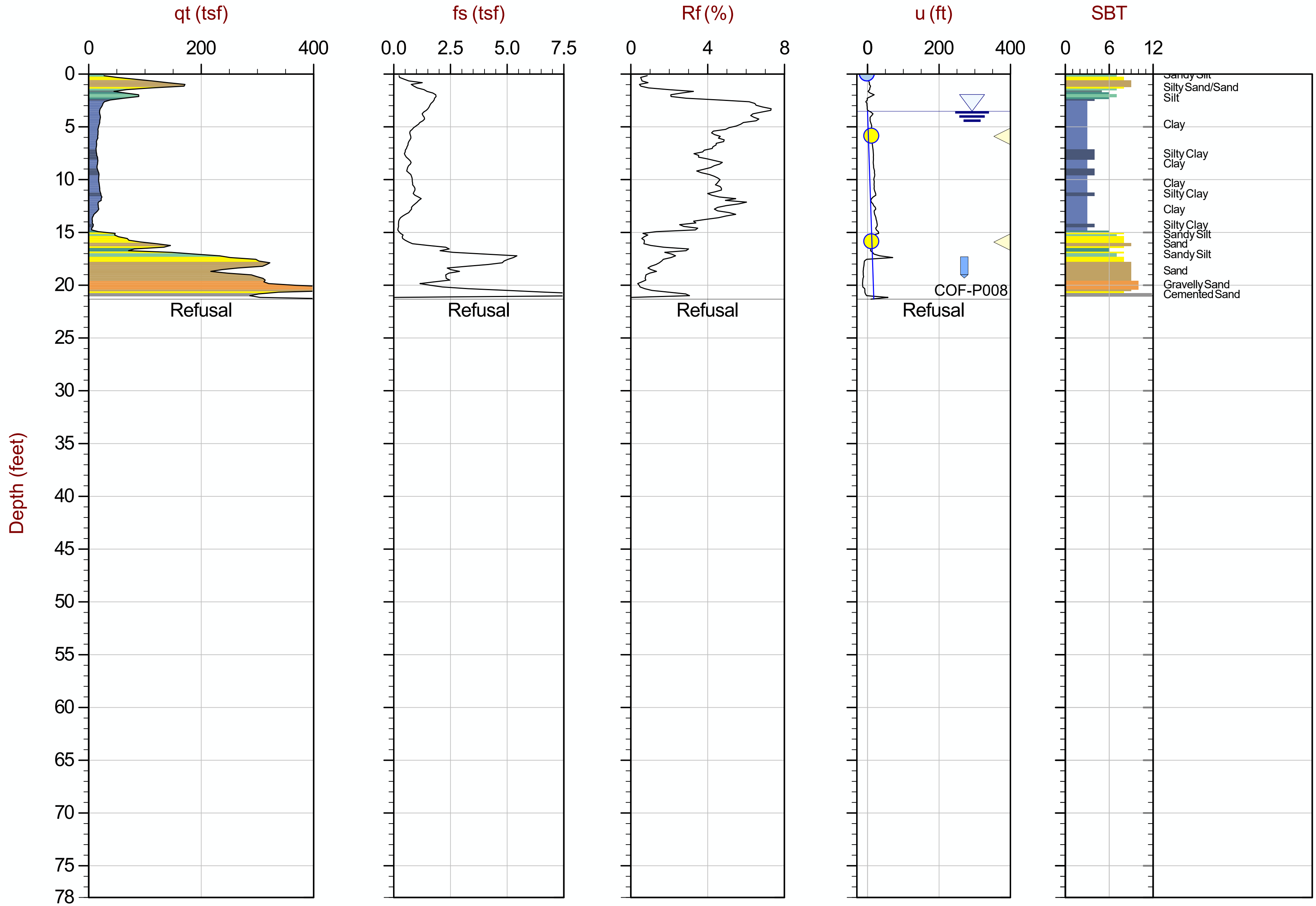
Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:04:15 10:48
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C014
Cone: 335:T1500F15U500



Max Depth: 6.500 m / 21.33 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP14.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325991m E: 292584m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

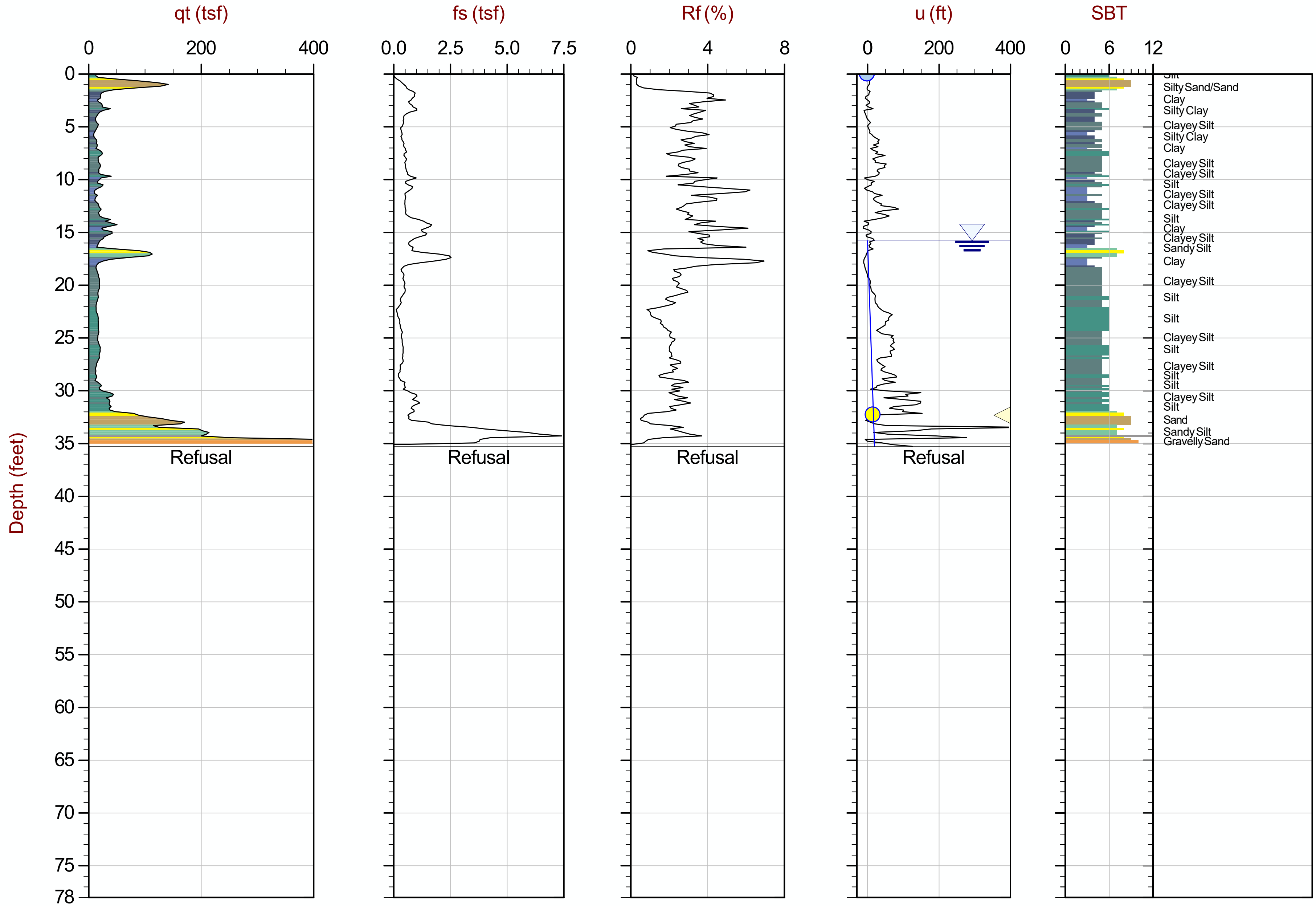
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:06:15 09:31
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C015
Cone: 335:T1500F15U500



Max Depth: 10.750 m / 35.27 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP15.COR

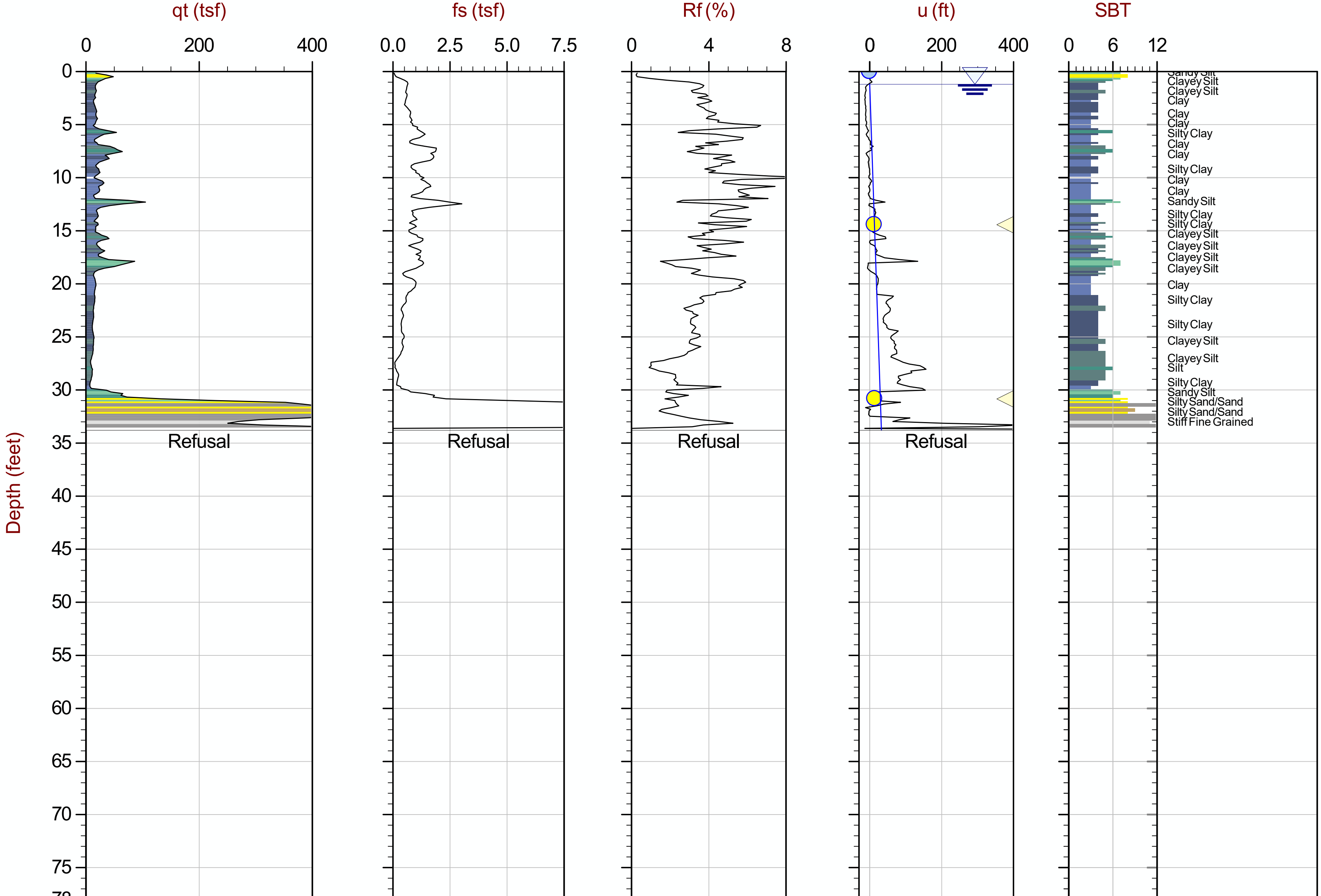
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325992m E: 292601m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:06:15 11:20
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C016
Cone: 374:T1500F15U500



Max Depth: 10.300 m / 33.79 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP16.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326091m E: 292606m

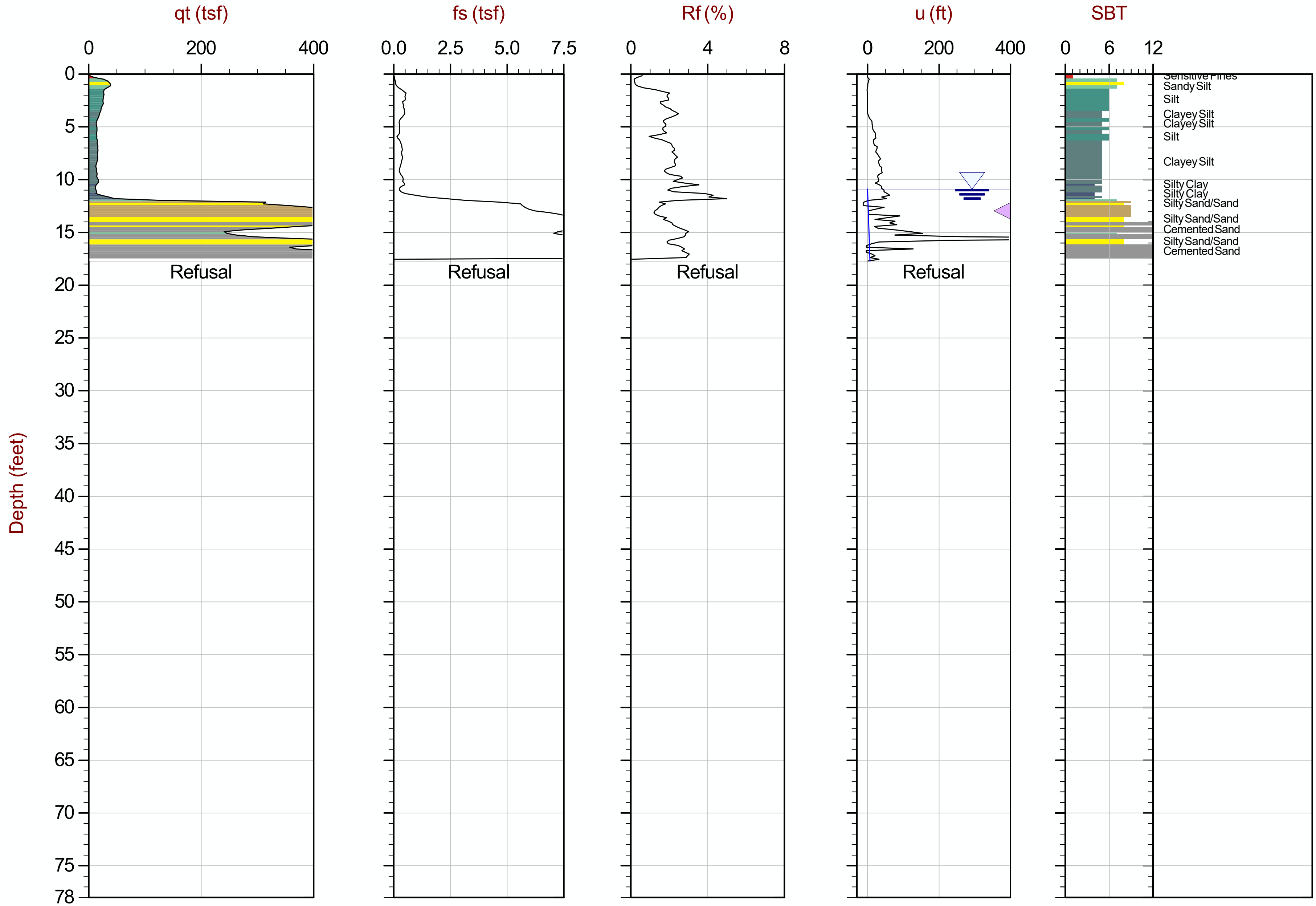
Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:04:15 16:08
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C017
Cone: 335:T1500F15U500



Max Depth: 5.400 m / 17.72 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP17.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326109m E: 292596m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

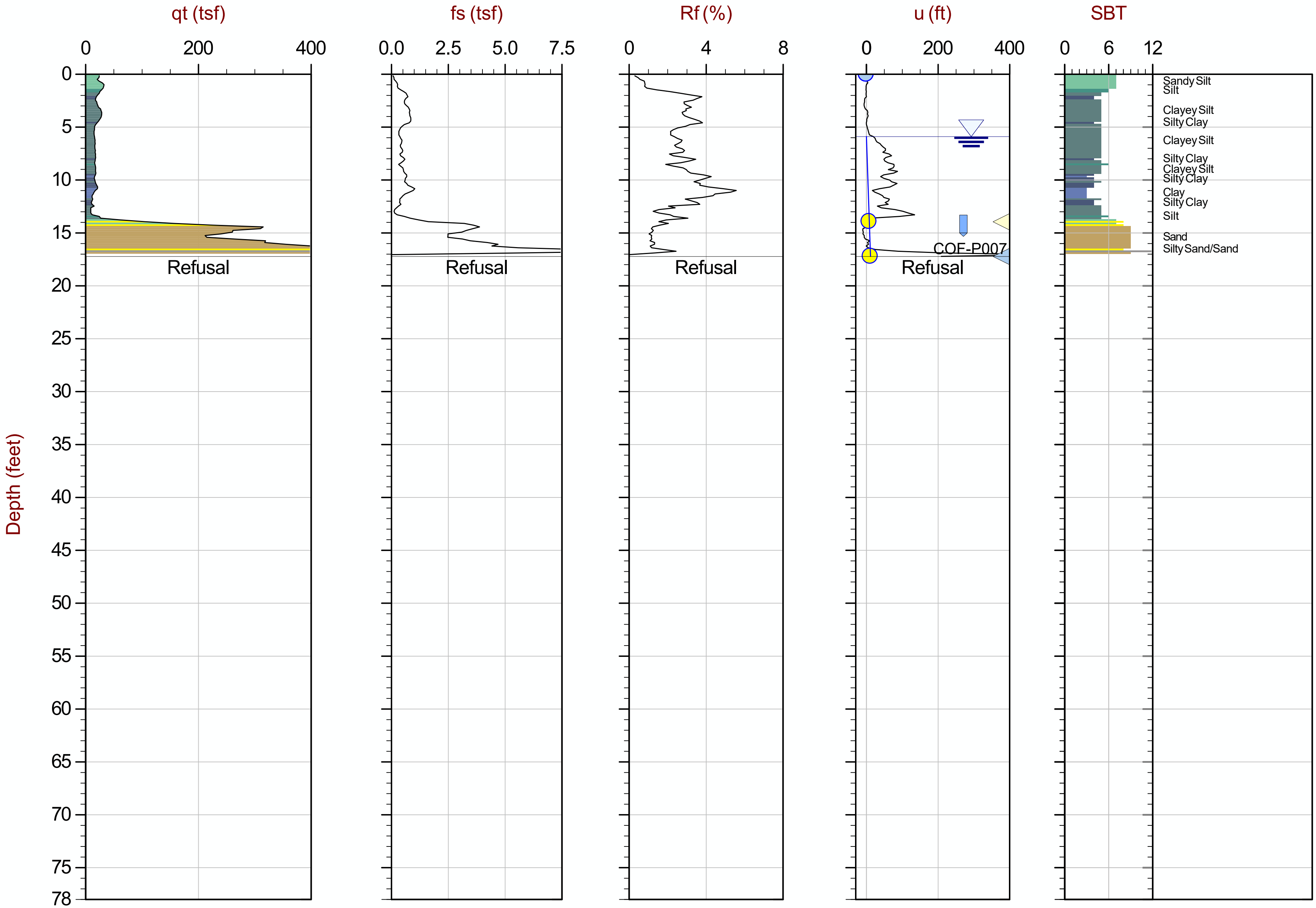
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:05:15 07:20
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C018
Cone: 335:T1500F15U500



Max Depth: 5.250 m / 17.22 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP18.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326107m E: 292893m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

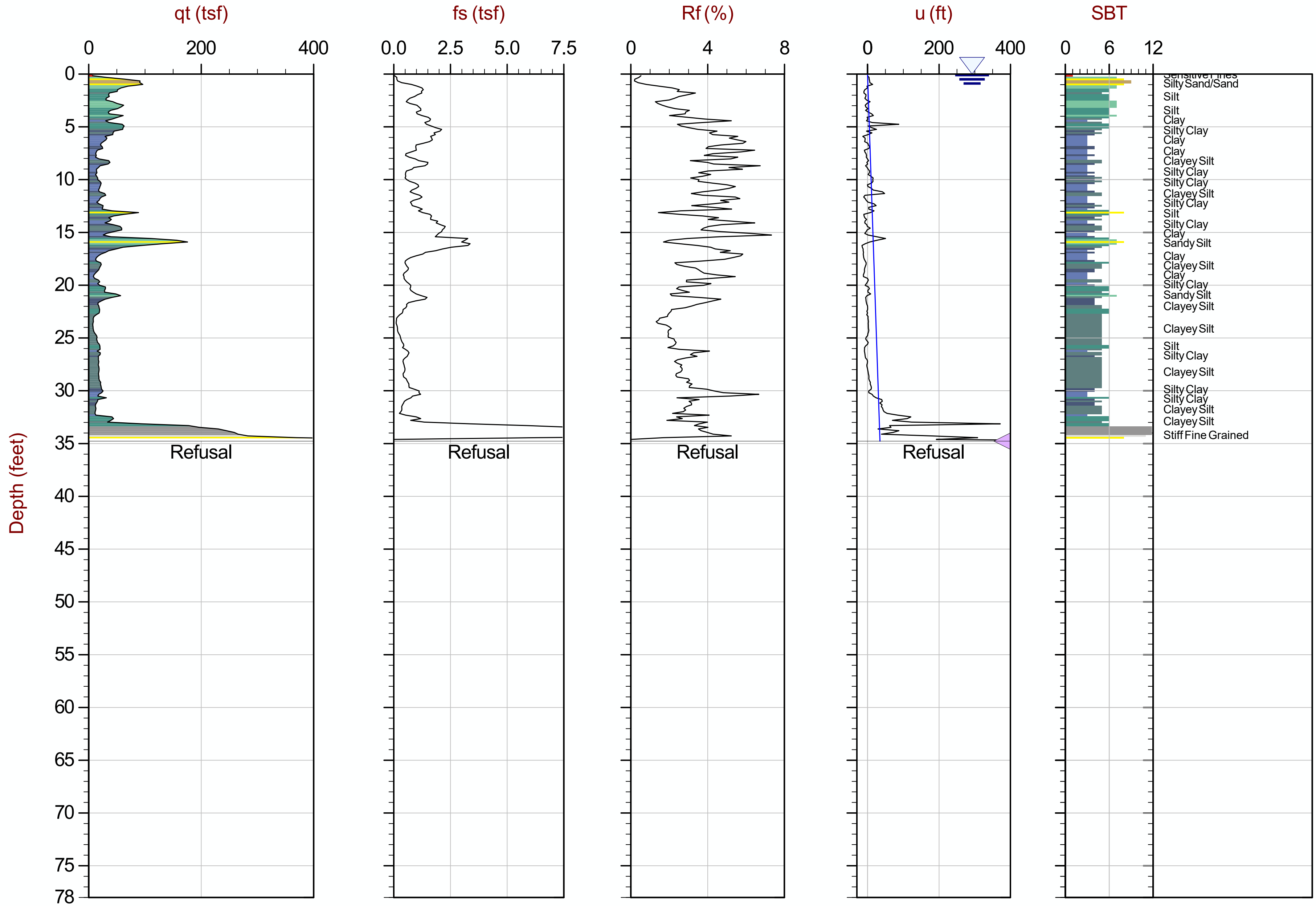
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:06:15 11:35
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C019
Cone: 335:T1500F15U500



Max Depth: 10.600 m / 34.78 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP19.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326092m E: 292892m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

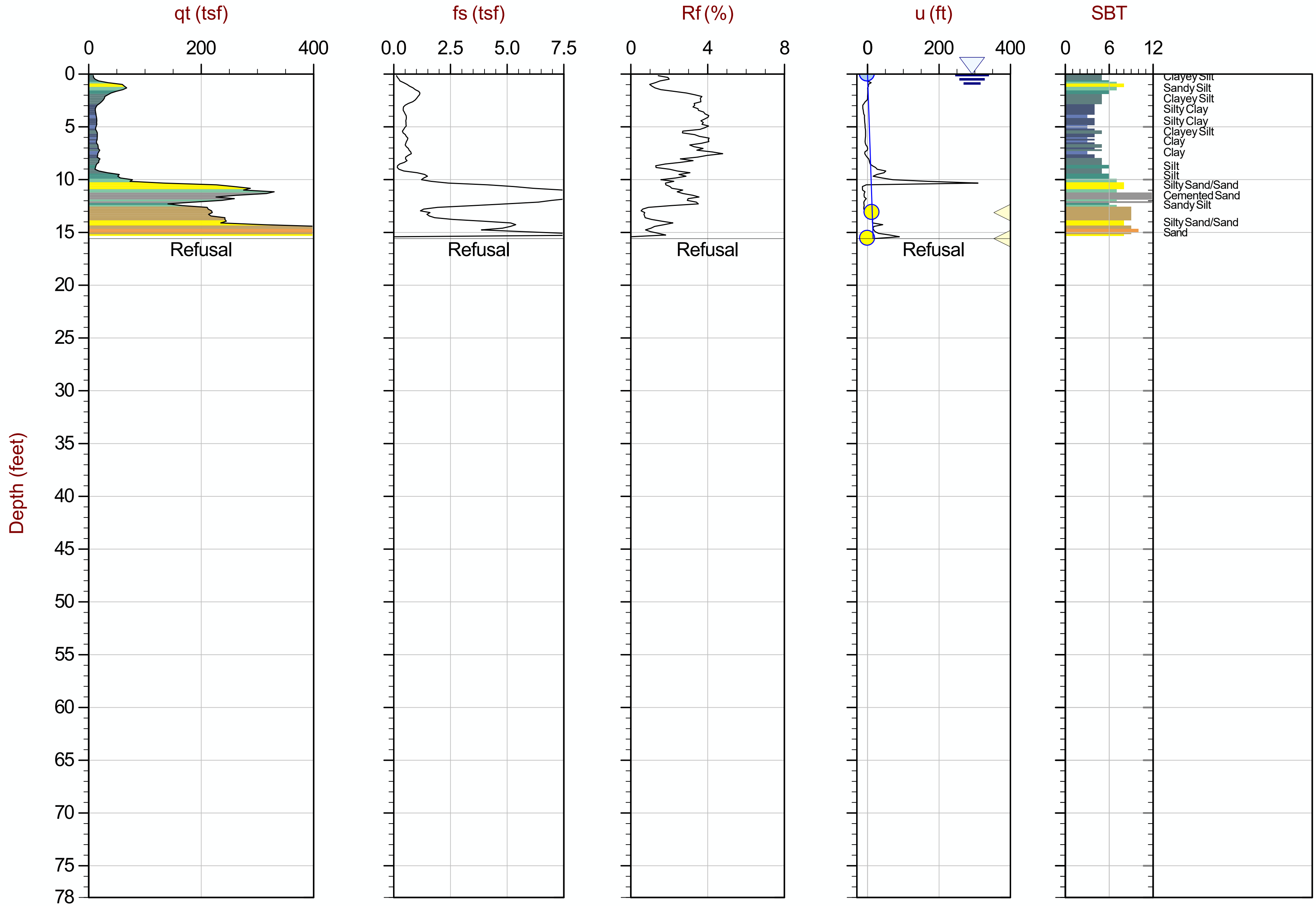
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:06:15 17:27
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C020
Cone: 374:T1500F15U500



Max Depth: 4.750 m / 15.58 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP20.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326035m E: 293106m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

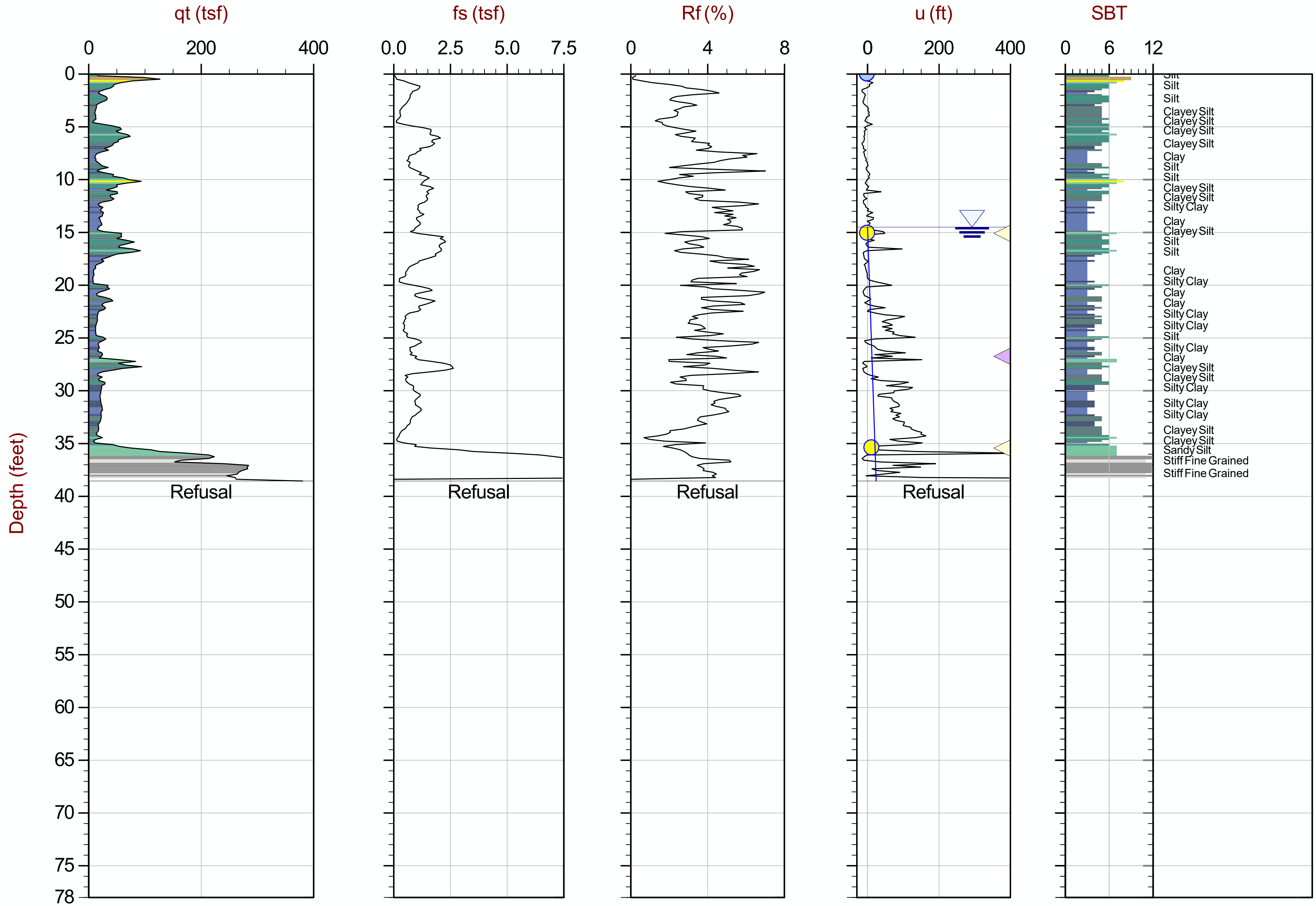
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:06:15 13:10
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C022
Cone: 335:T1500F15U500



Max Depth: 11.750 m / 38.55 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP22.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326059m E: 293072m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

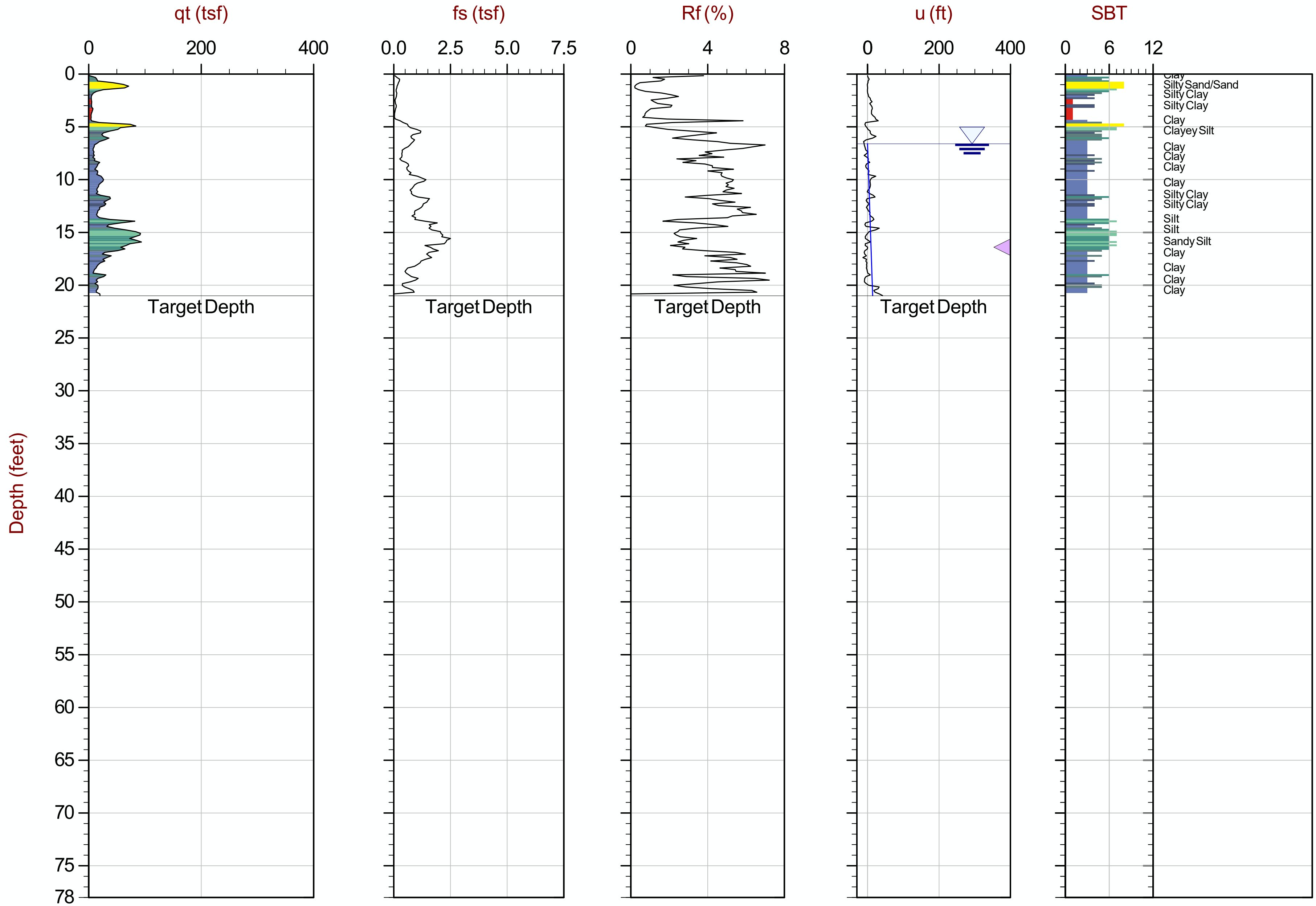
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 13:15
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C023
Cone: 374:T1500F15U500



Max Depth: 6.400 m / 21.00 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP23.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326057m E: 293071m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

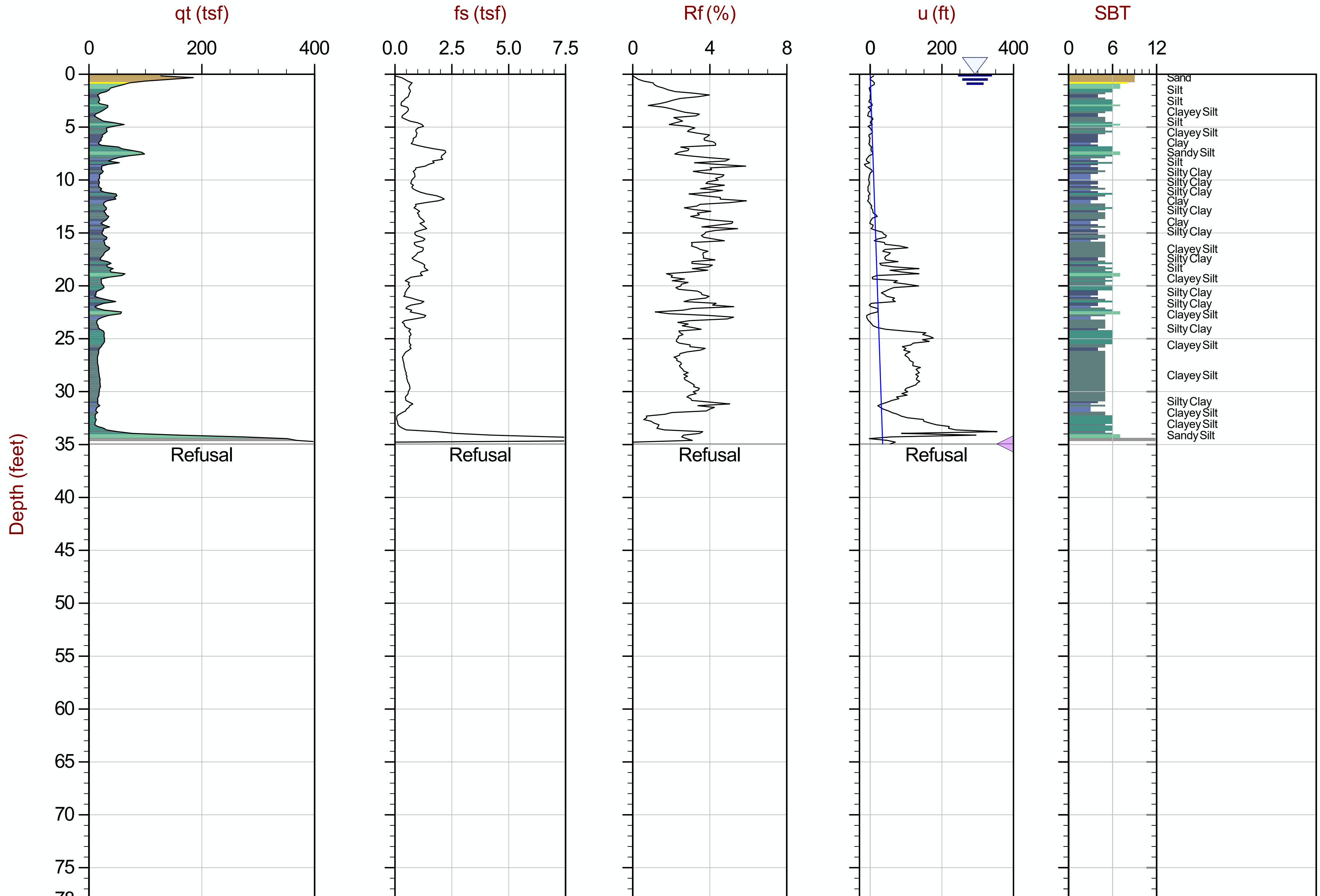
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:05:15 13:22
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C024
Cone: 335:T1500F15U500



Max Depth: 10.650 m / 34.94 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP24.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325994m E: 293086m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

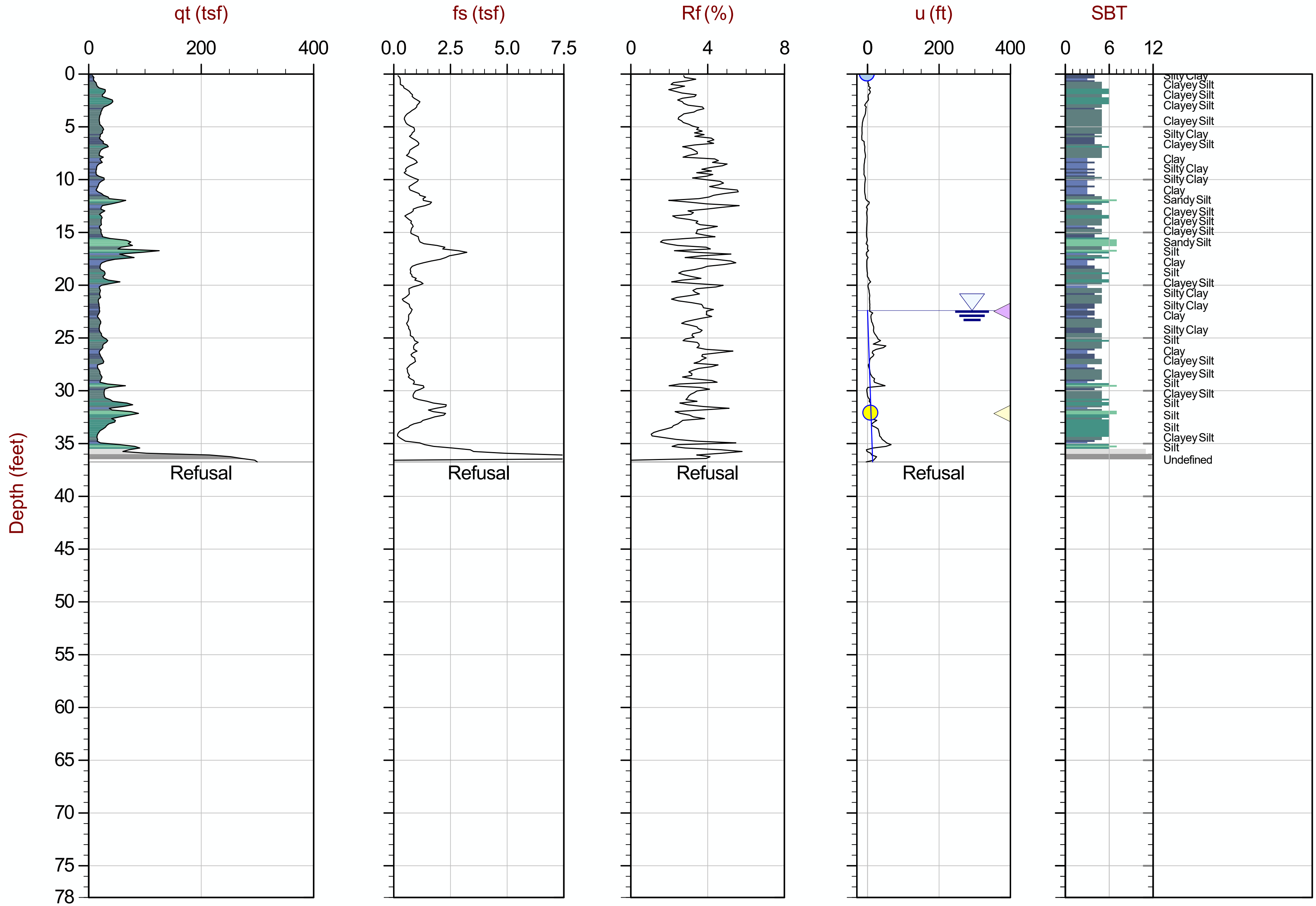
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 10:10
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C025
Cone: 335:T1500F15U500



Max Depth: 11.200 m / 36.74 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP25.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326302m E: 293062m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

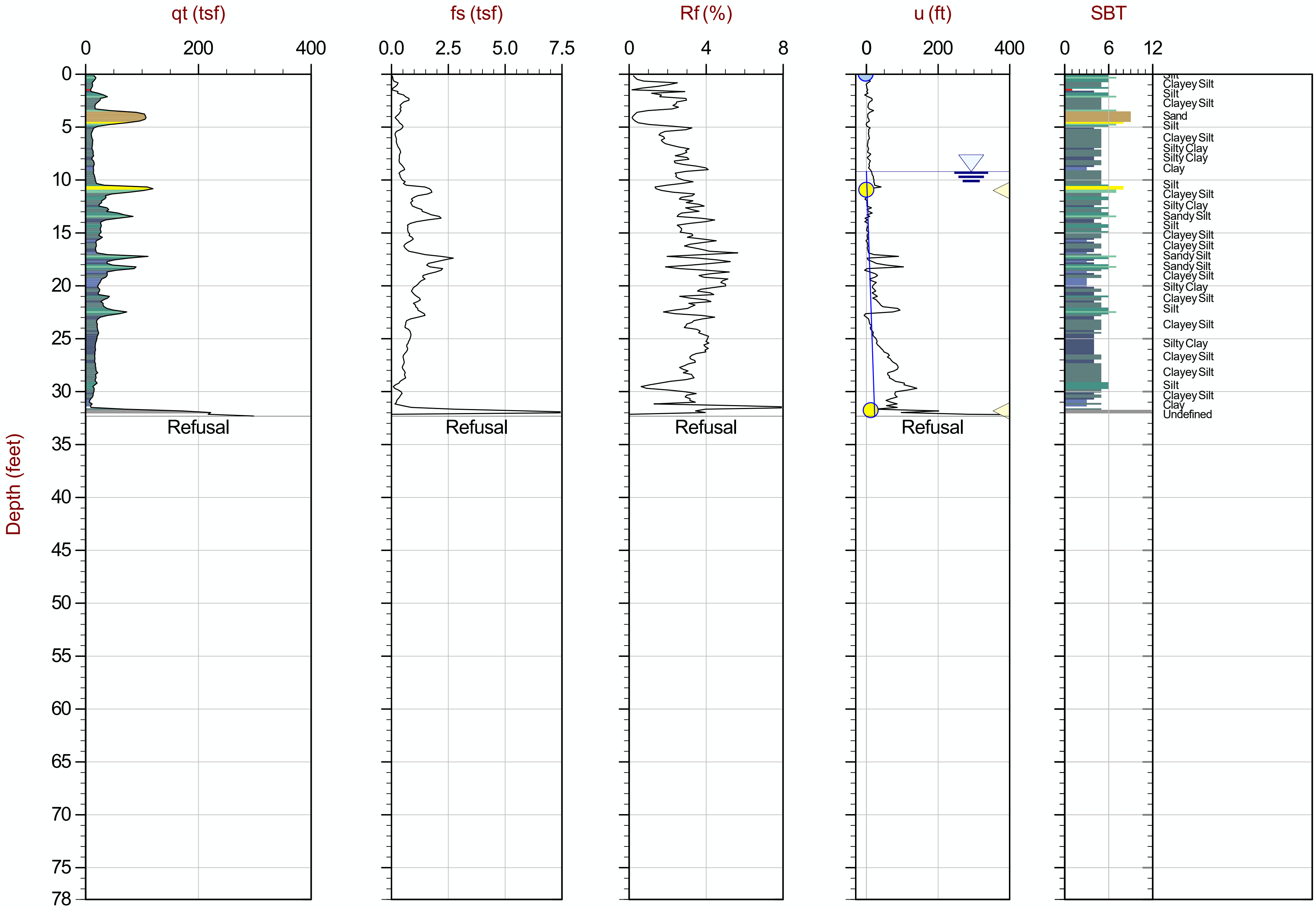
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:08:15 11:09
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C027
Cone: 335:T1500F15U500



Max Depth: 9.850 m / 32.32 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP27.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326216m E: 292688m

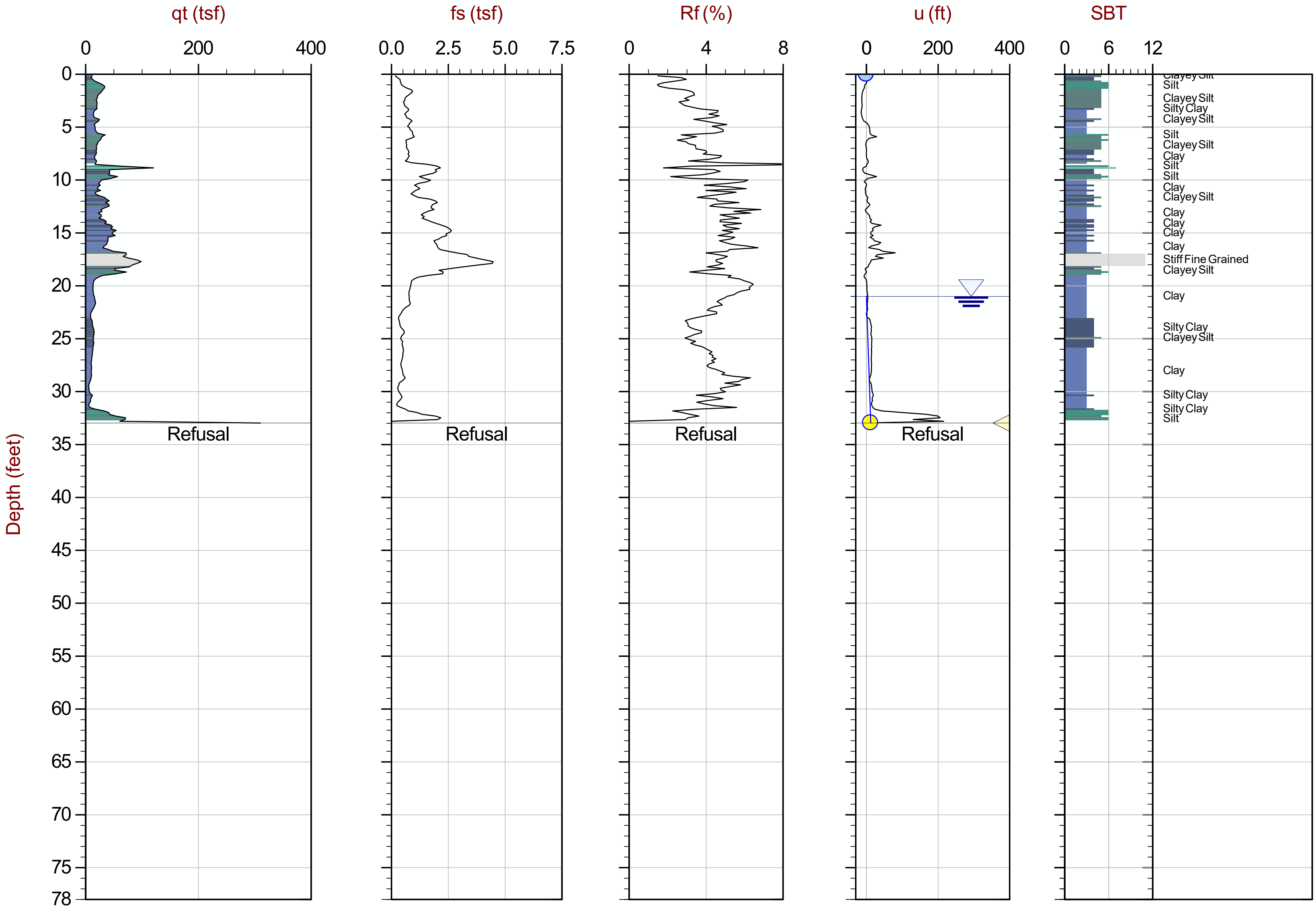
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 08:10
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C028
Cone: 335:T1500F15U500



Max Depth: 10.050 m / 32.97 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP28.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326205m E: 292686m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

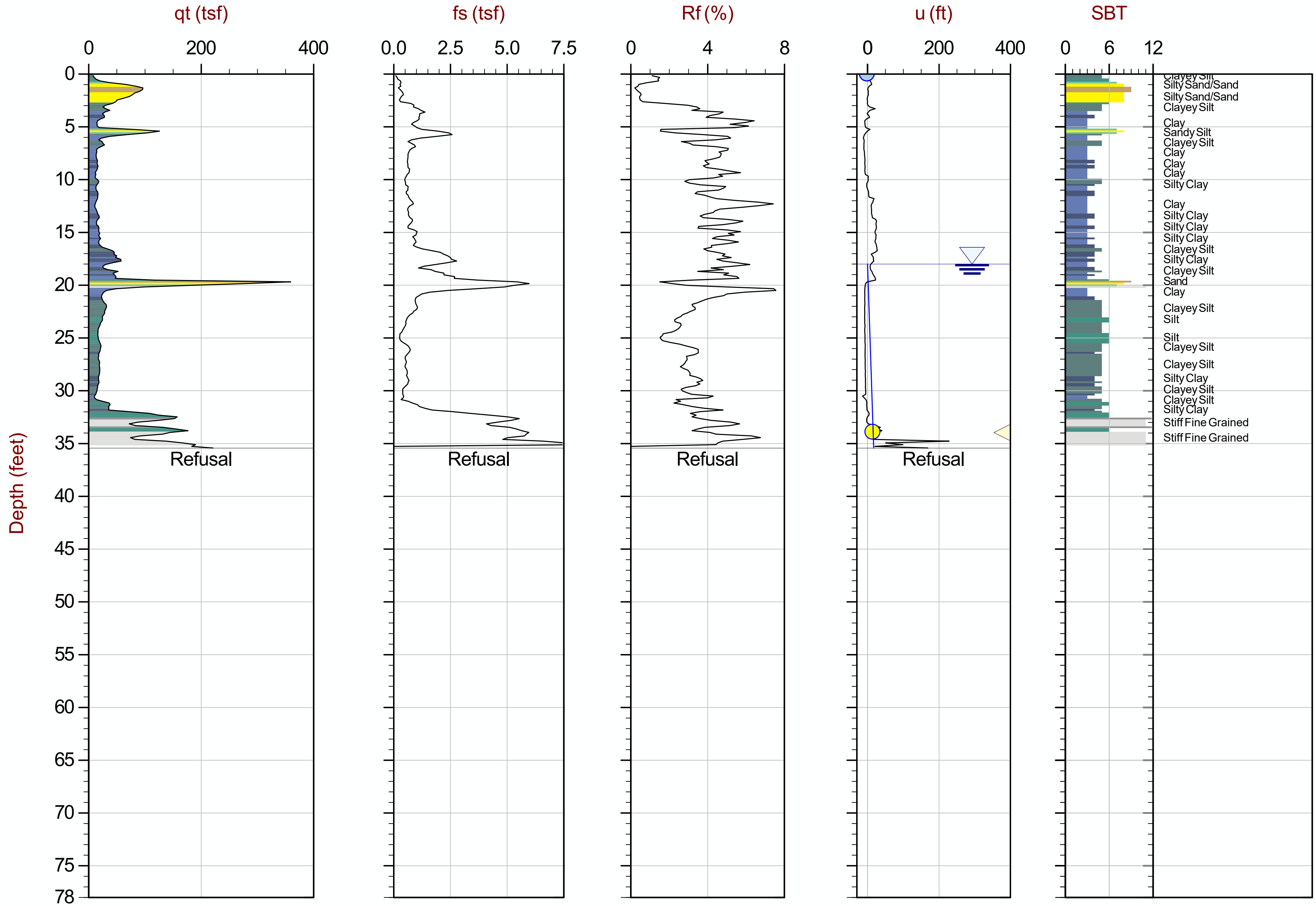
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:11:15 11:19
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C030
Cone: 335:T1500F15U500



Max Depth: 10.800 m / 35.43 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP30.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326229m E: 292474m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

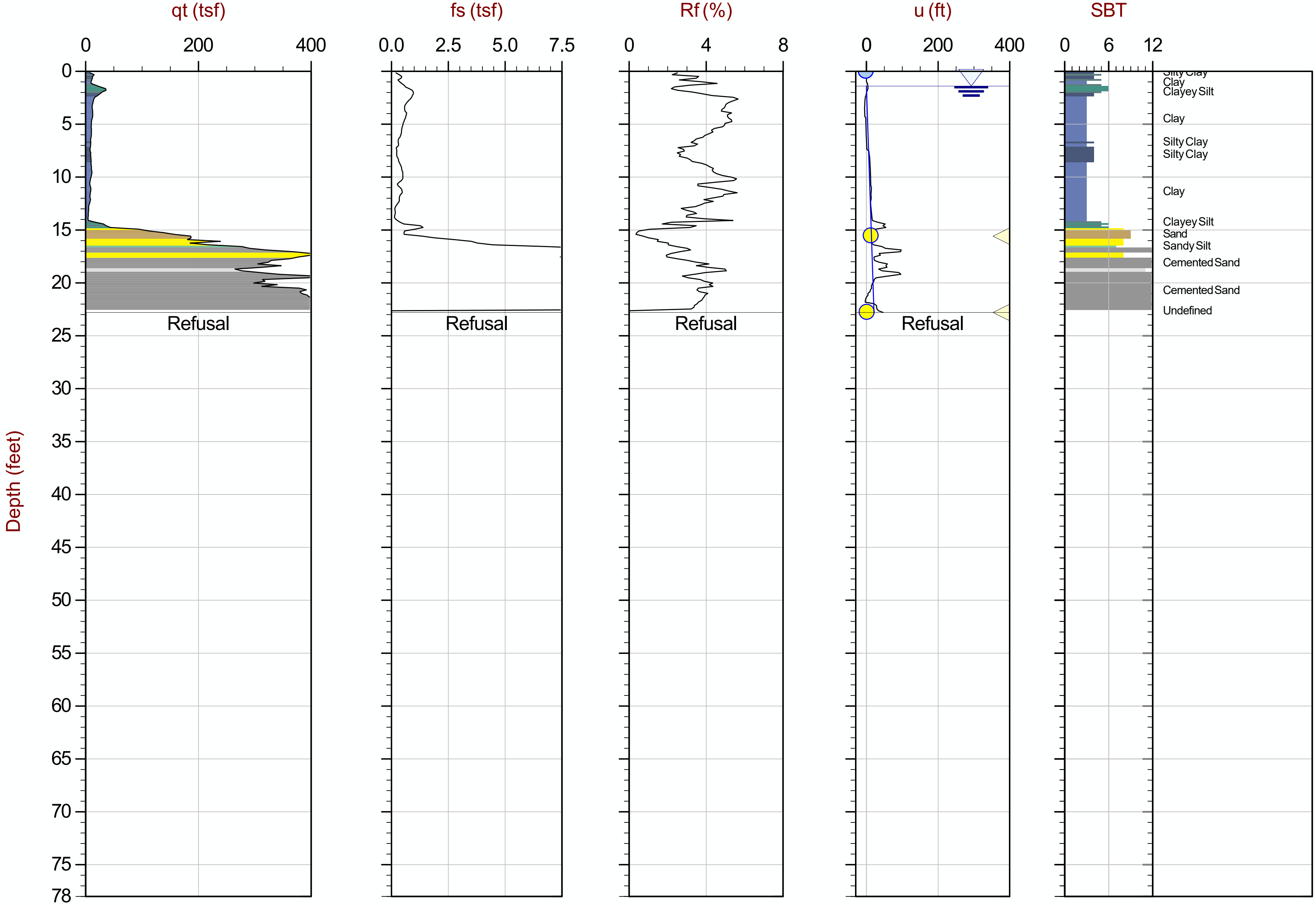
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:08:15 08:19
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C031
Cone: 374:T1500F15U500



Max Depth: 6.950 m / 22.80 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP31.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326423m E: 292452m

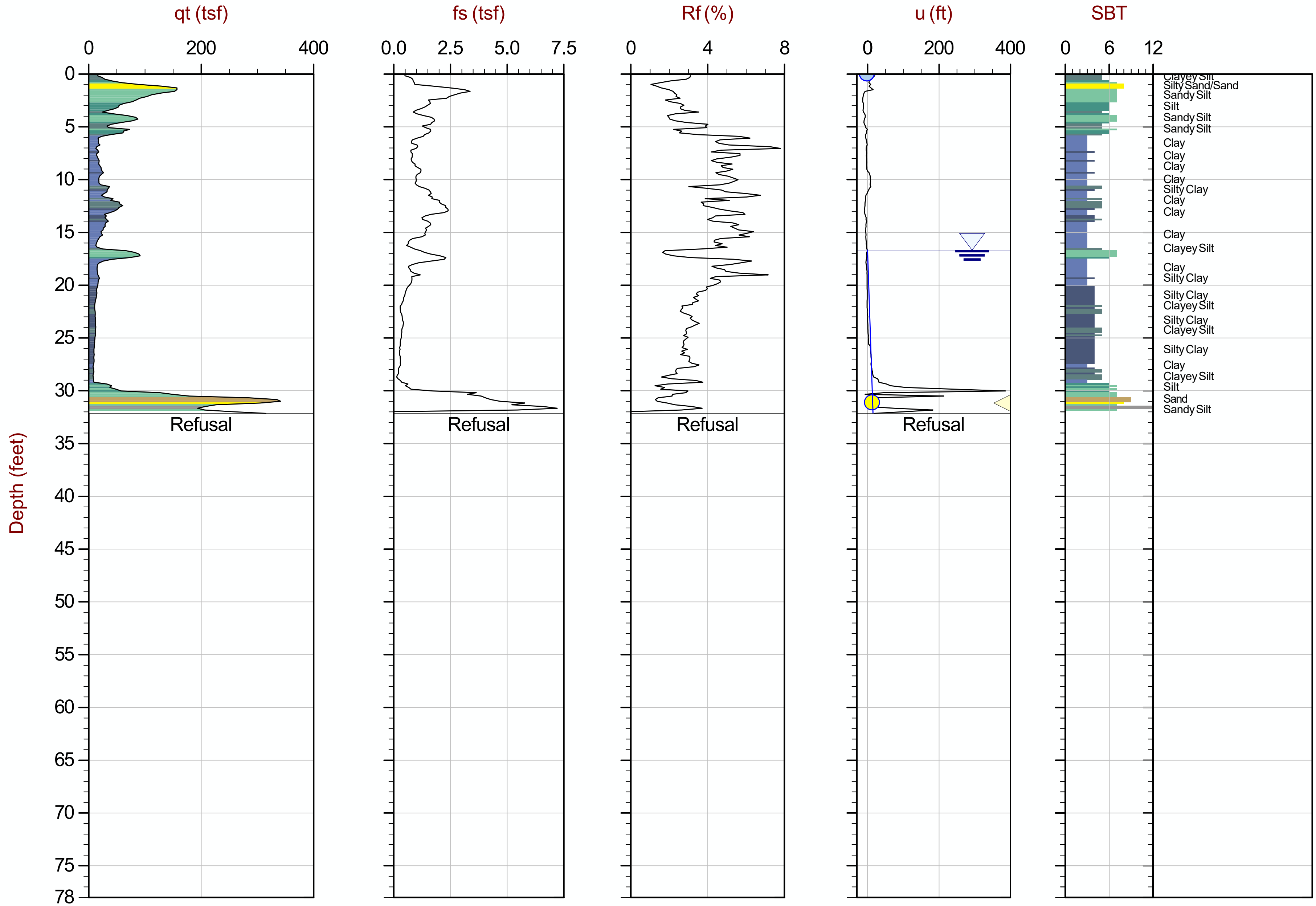
Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:11:15 13:07
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C032
Cone: 335:T1500F15U500



Max Depth: 9.800 m / 32.15 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP32.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326423m E: 292468m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

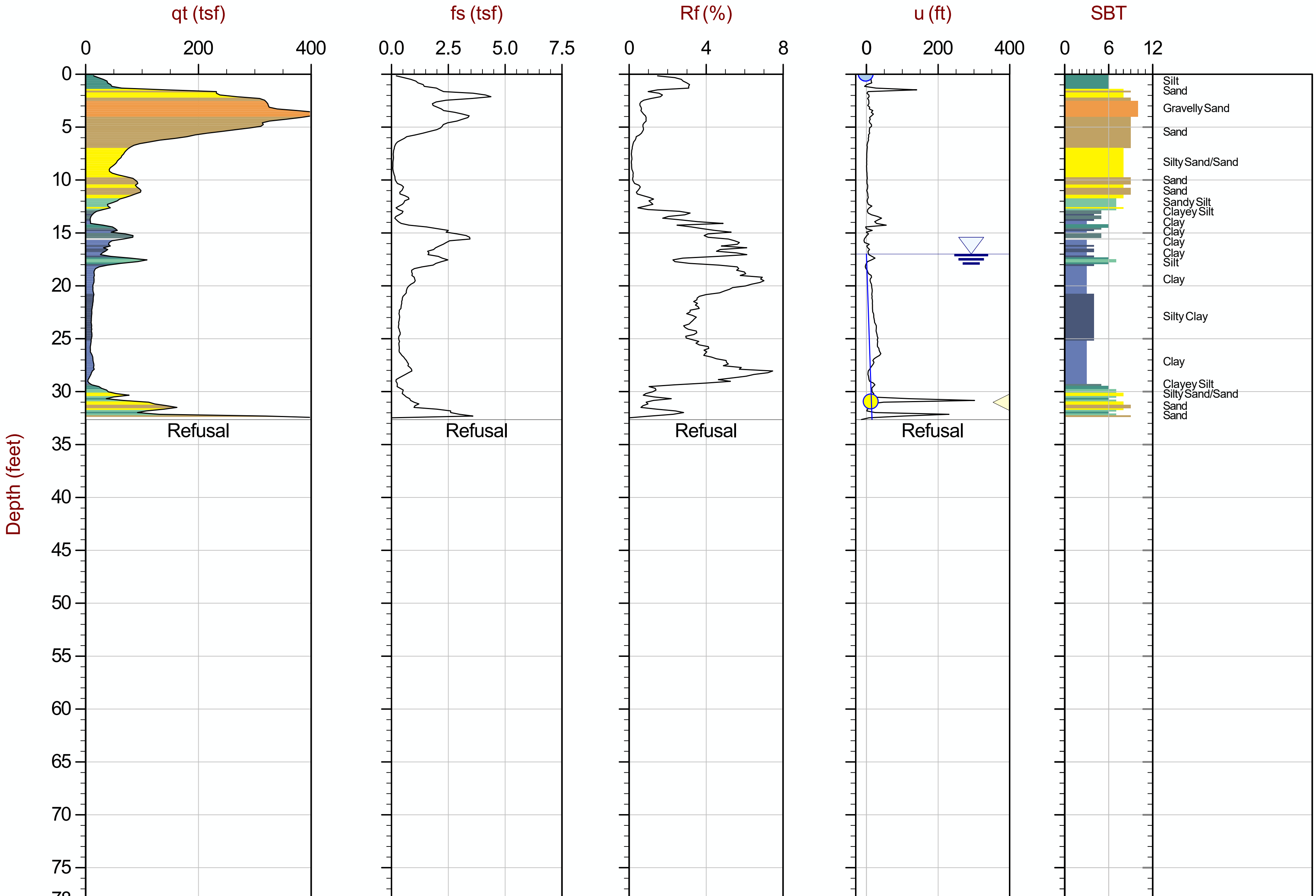
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:08:15 07:49
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C033
Cone: 335:T1500F15U500



Max Depth: 9.950 m / 32.64 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP33.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326423m E: 292475m

Hydrostatic Line · Ueq · Assumed Ueq · PPD, Ueq achieved · PPD, Ueq not achieved

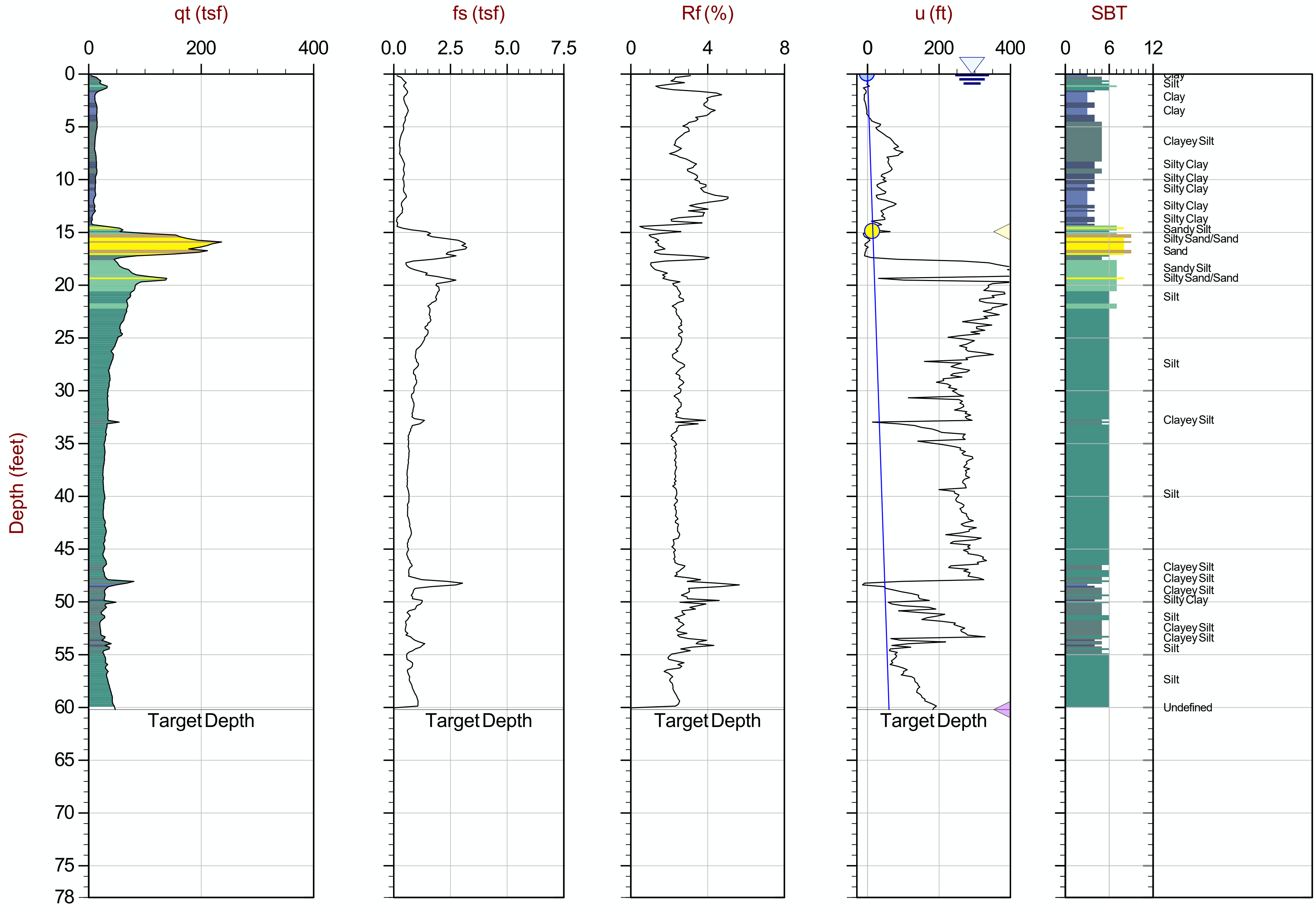
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:08:15 10:03
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C034
Cone: 374:T1500F15U500



Max Depth: 18.350 m / 60.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP34.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326634m E: 292612m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

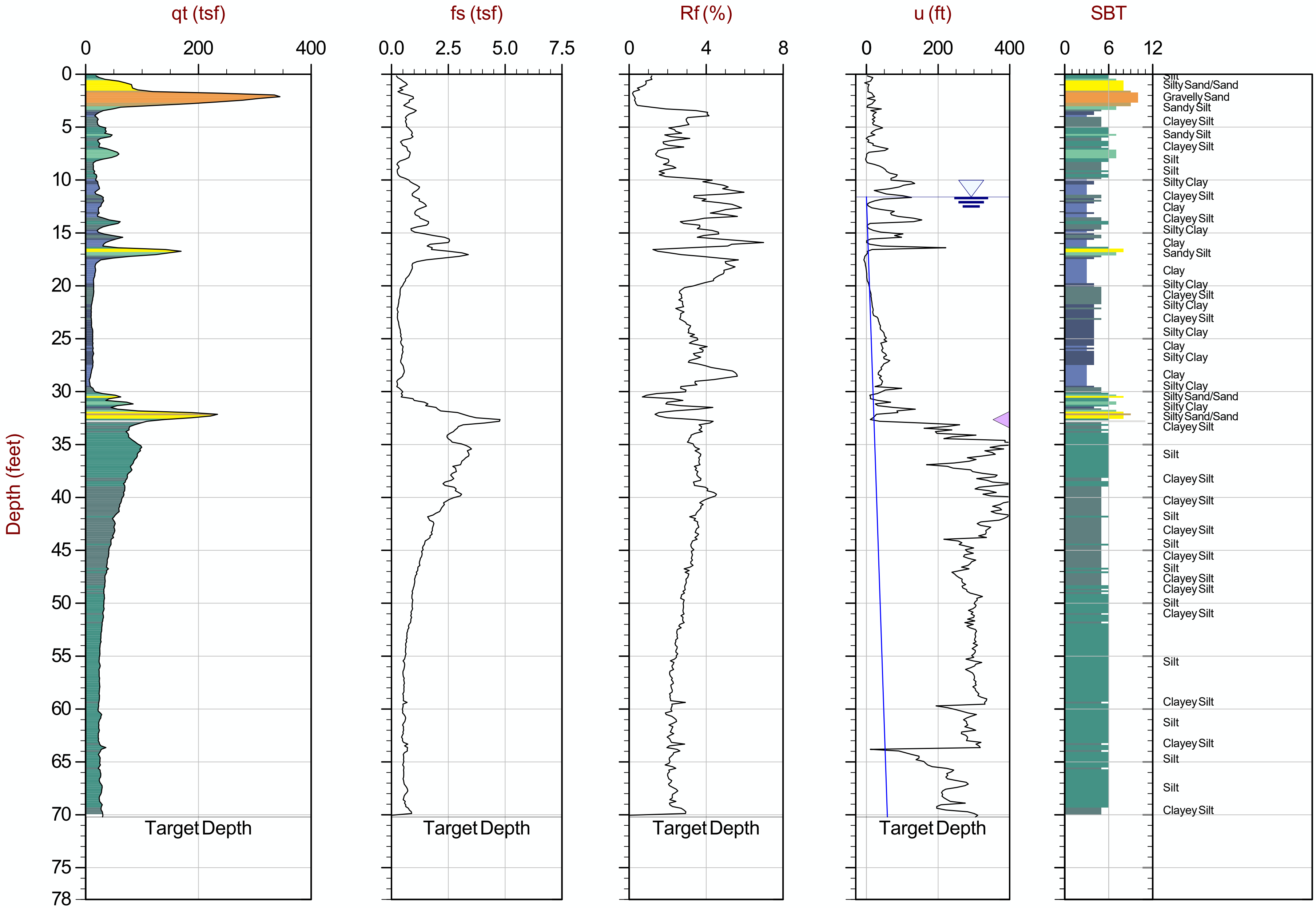
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:08:15 09:32
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C035
Cone: 335:T1500F15U500



Max Depth: 21.400 m / 70.21 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP35.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326621m E: 292615m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

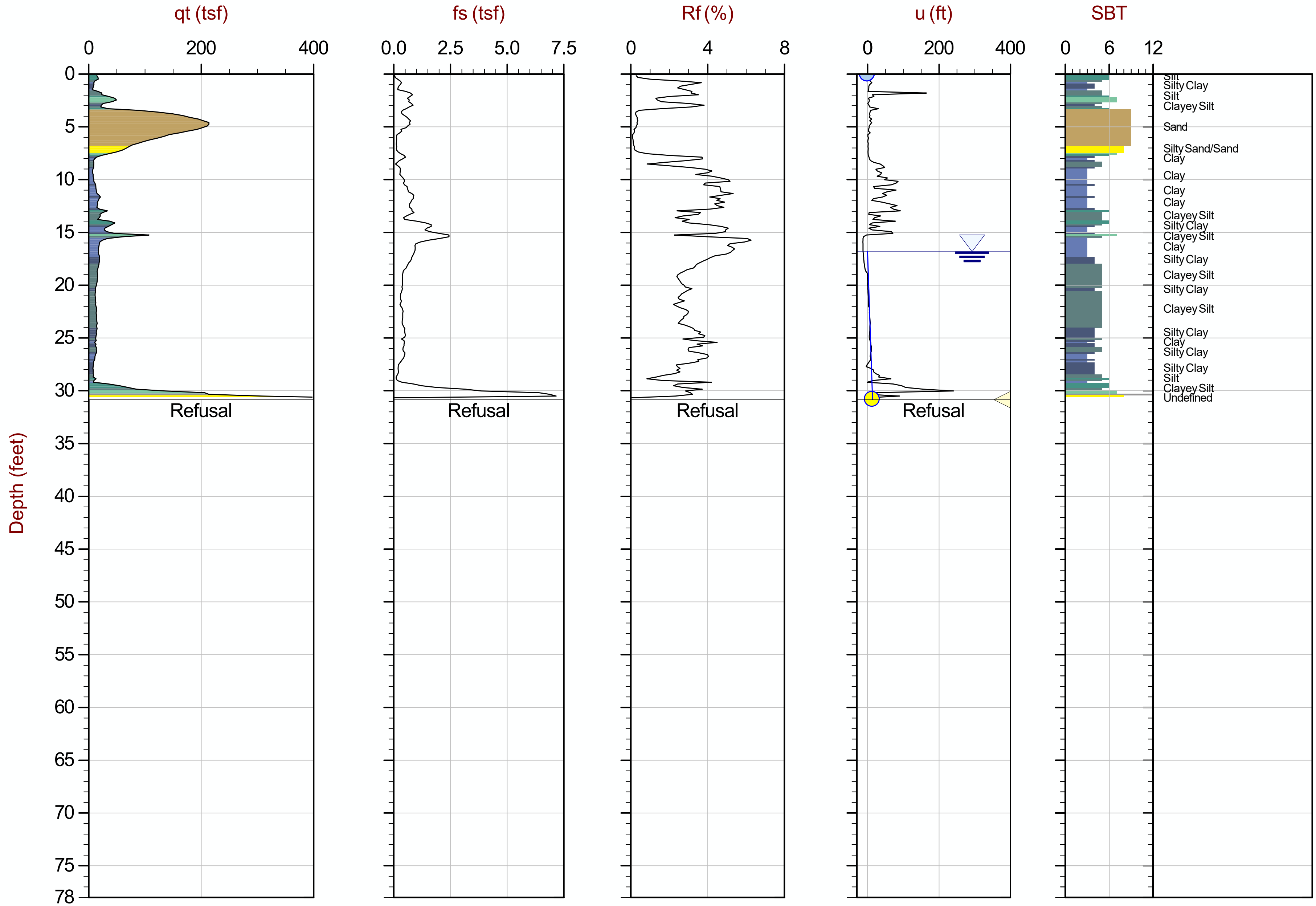
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:08:15 08:43
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C036
Cone: 335:T1500F15U500



Max Depth: 9.400 m / 30.84 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP36.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326618m E: 292613m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

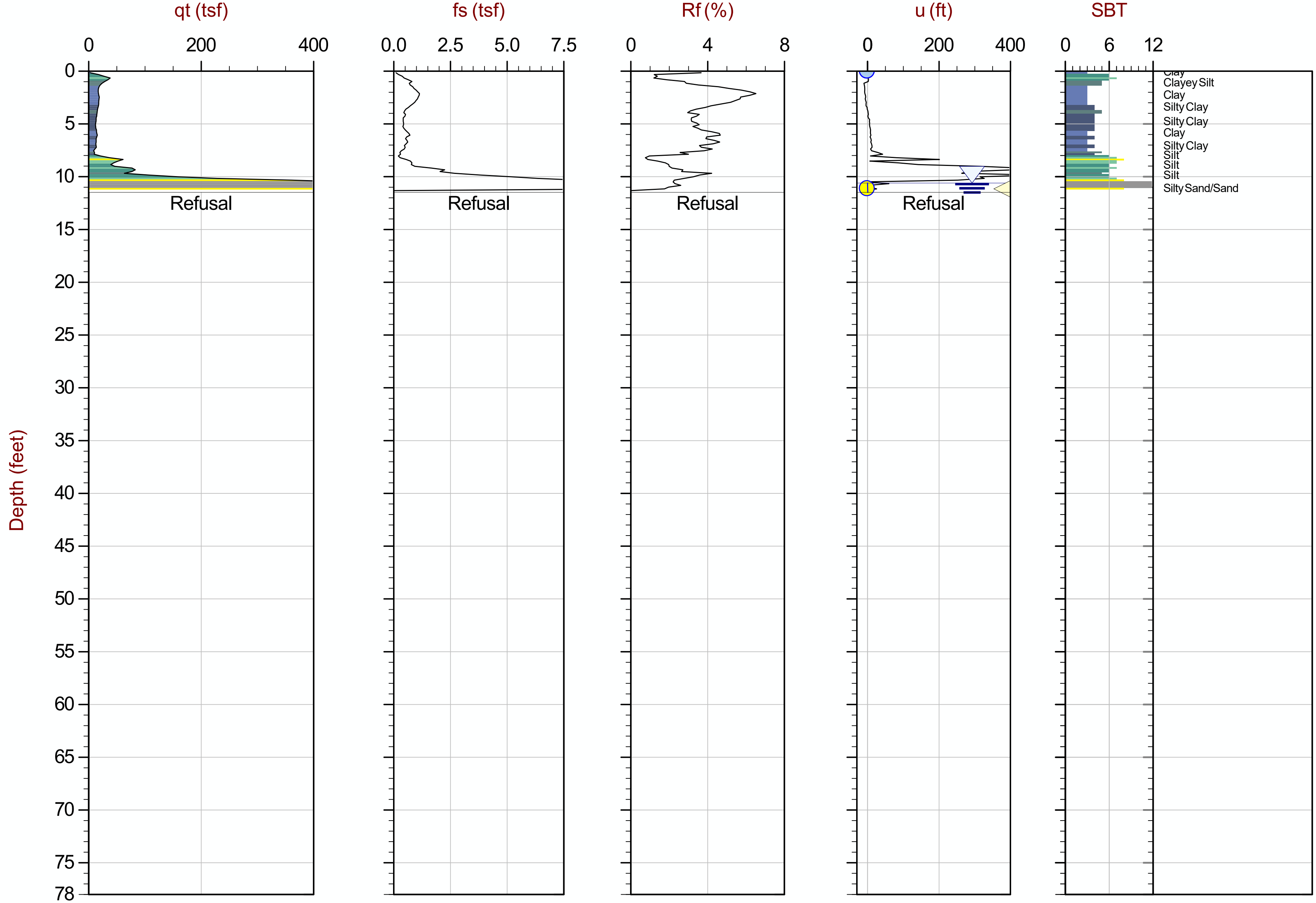
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:08:15 12:09
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C037
Cone: 374:T1500F15U500



Max Depth: 3.500 m / 11.48 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP37.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326629m E: 292951m

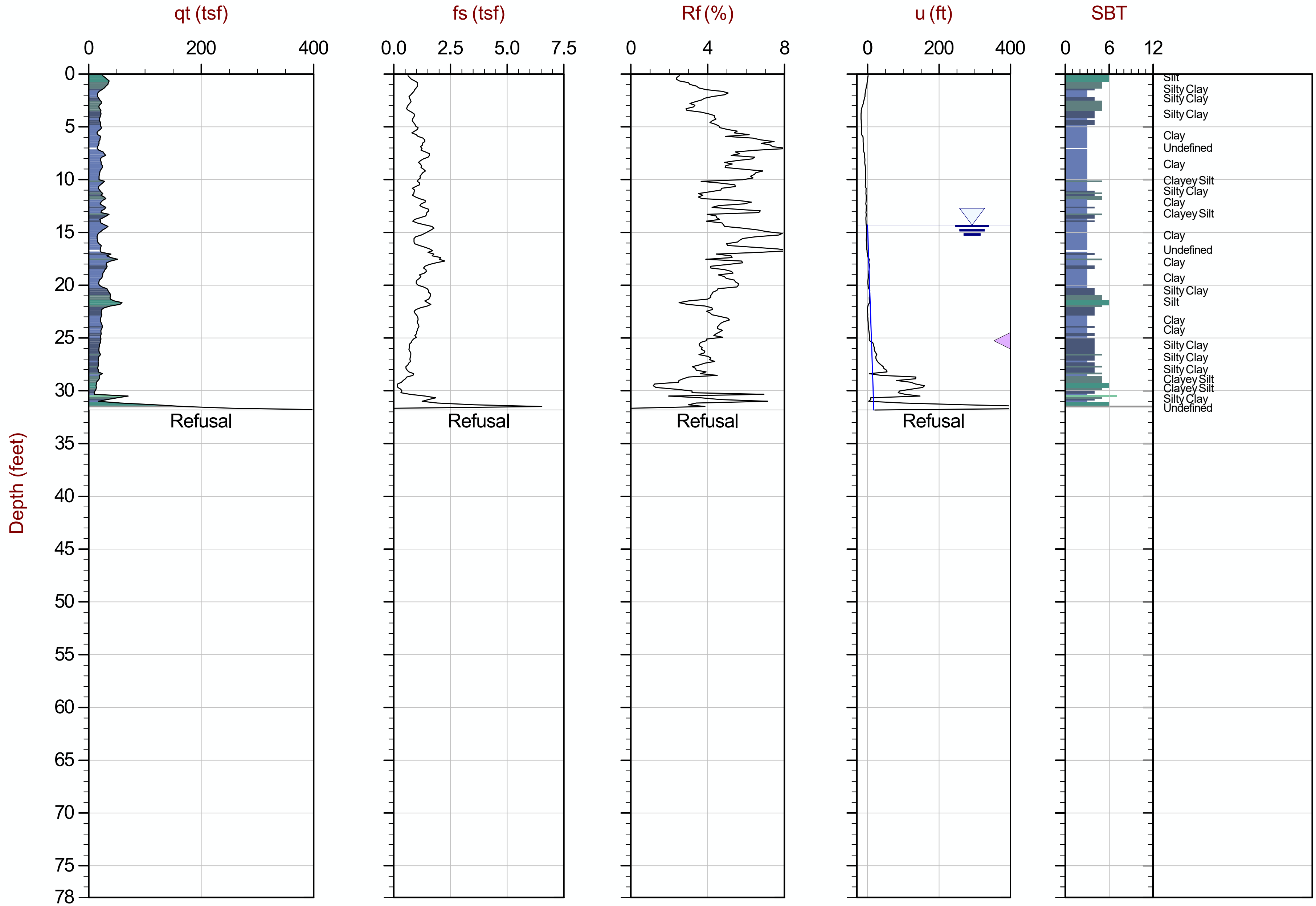
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:11:15 08:38
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C038
Cone: 335:T1500F15U500



Max Depth: 9.700 m / 31.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP38.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326607m E: 292952m

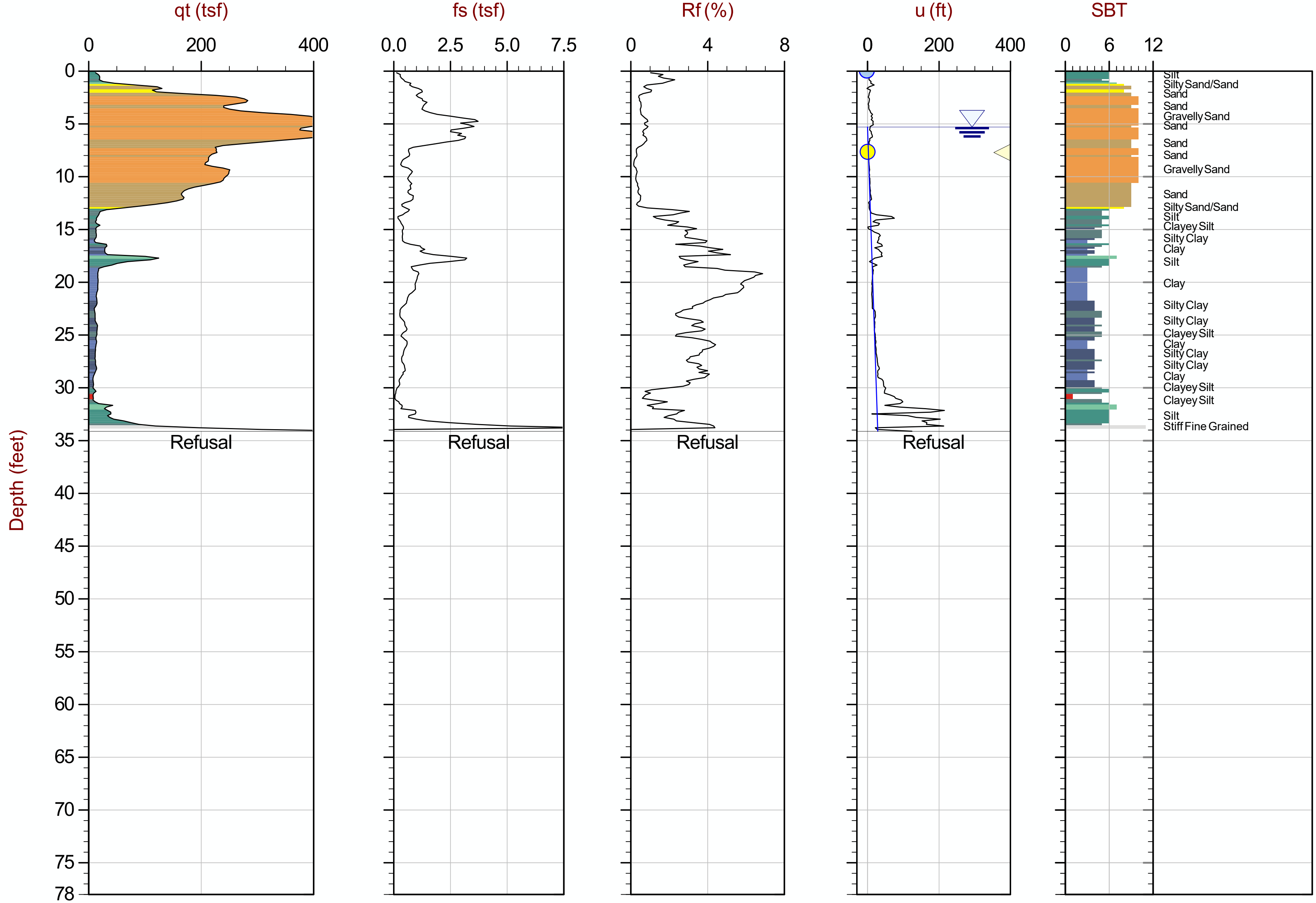
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:11:15 10:04
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C039
Cone: 335:T1500F15U500



Max Depth: 10.400 m / 34.12 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP39.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326216m E: 292688m

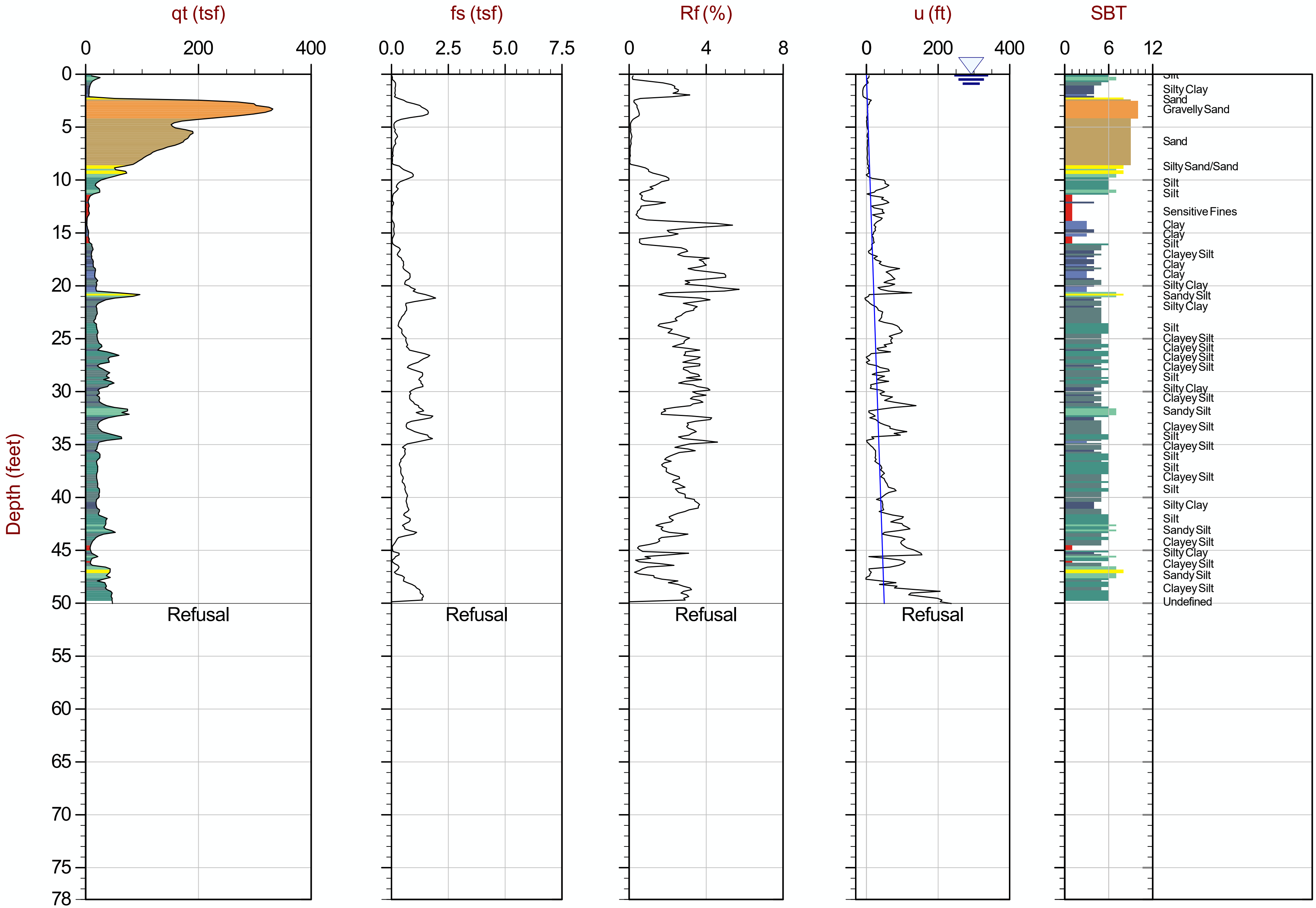
Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:10:15 12:09
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C040
Cone: 335:T1500F15U500



Max Depth: 15.250 m / 50.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP40.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326487m E: 293063m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

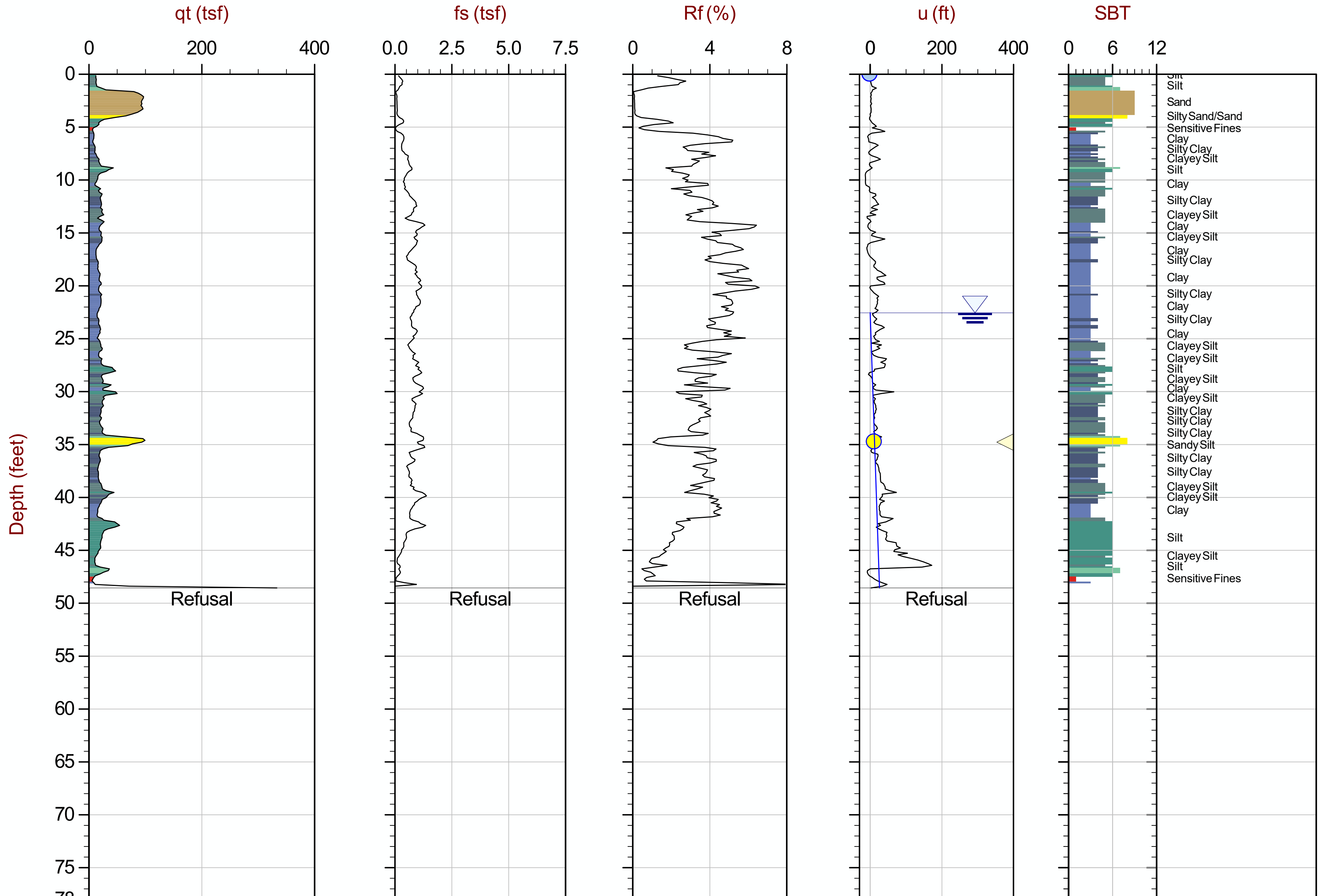
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 13:52
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C041
Cone: 335:T1500F15U500



Max Depth: 14.800 m / 48.56 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP41.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326482m E: 293067m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

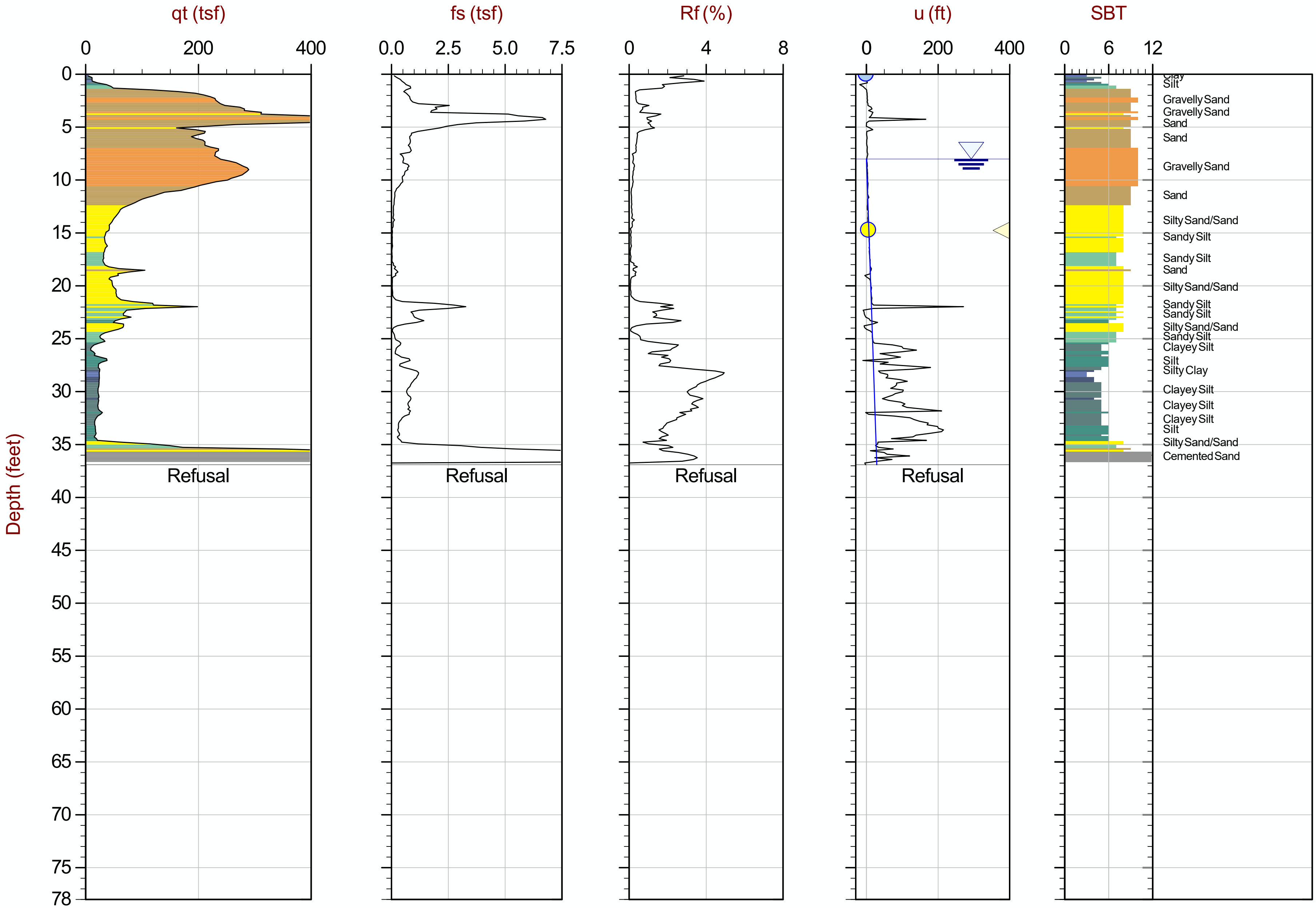
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 14:46
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C043
Cone: 374:T1500F15U500



Max Depth: 11.250 m / 36.91 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP43.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326241m E: 292969m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

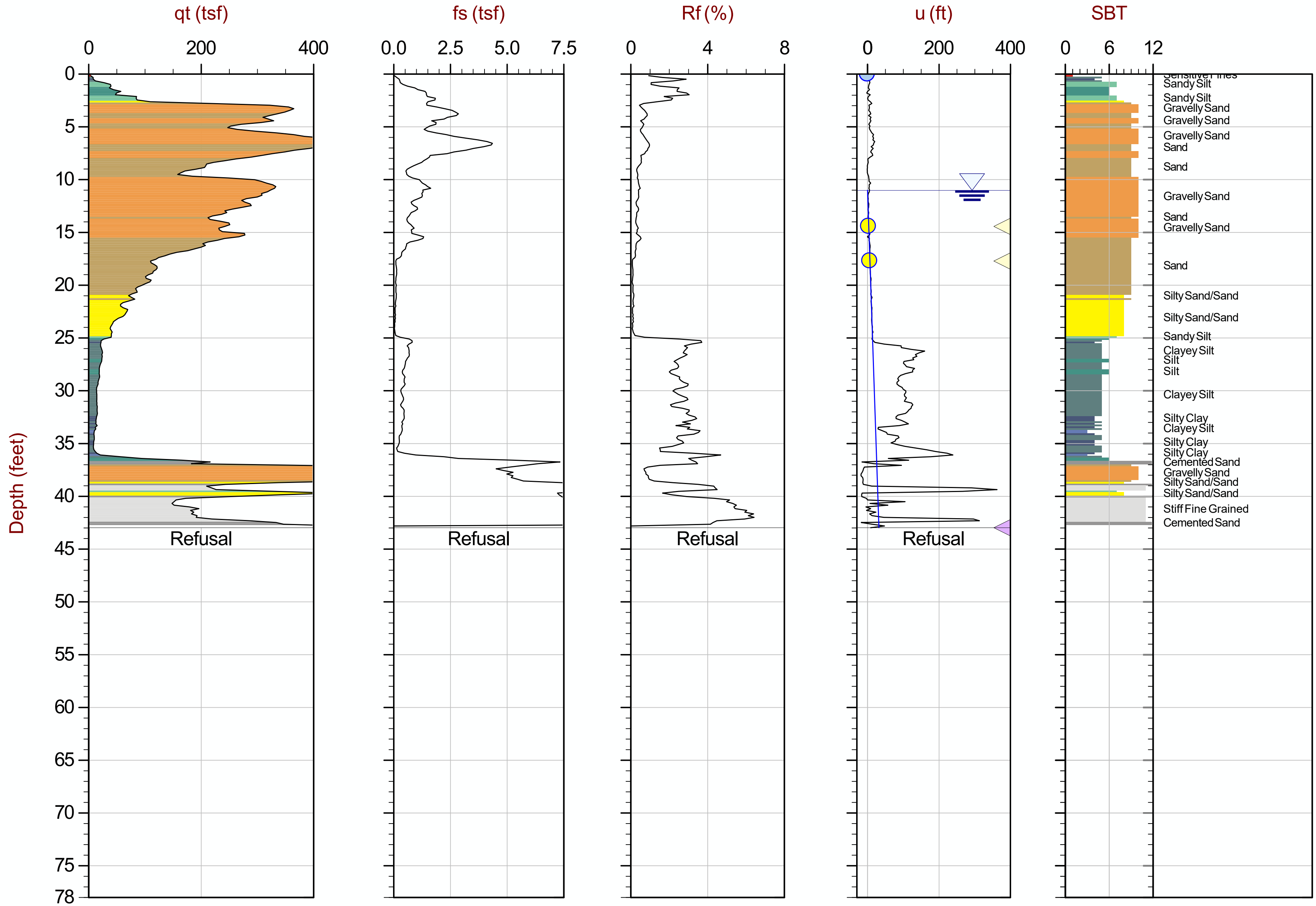
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:11:15 15:09
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C044
Cone: 374:T1500F15U500



Max Depth: 13.100 m / 42.98 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP44.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326257m E: 292588m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

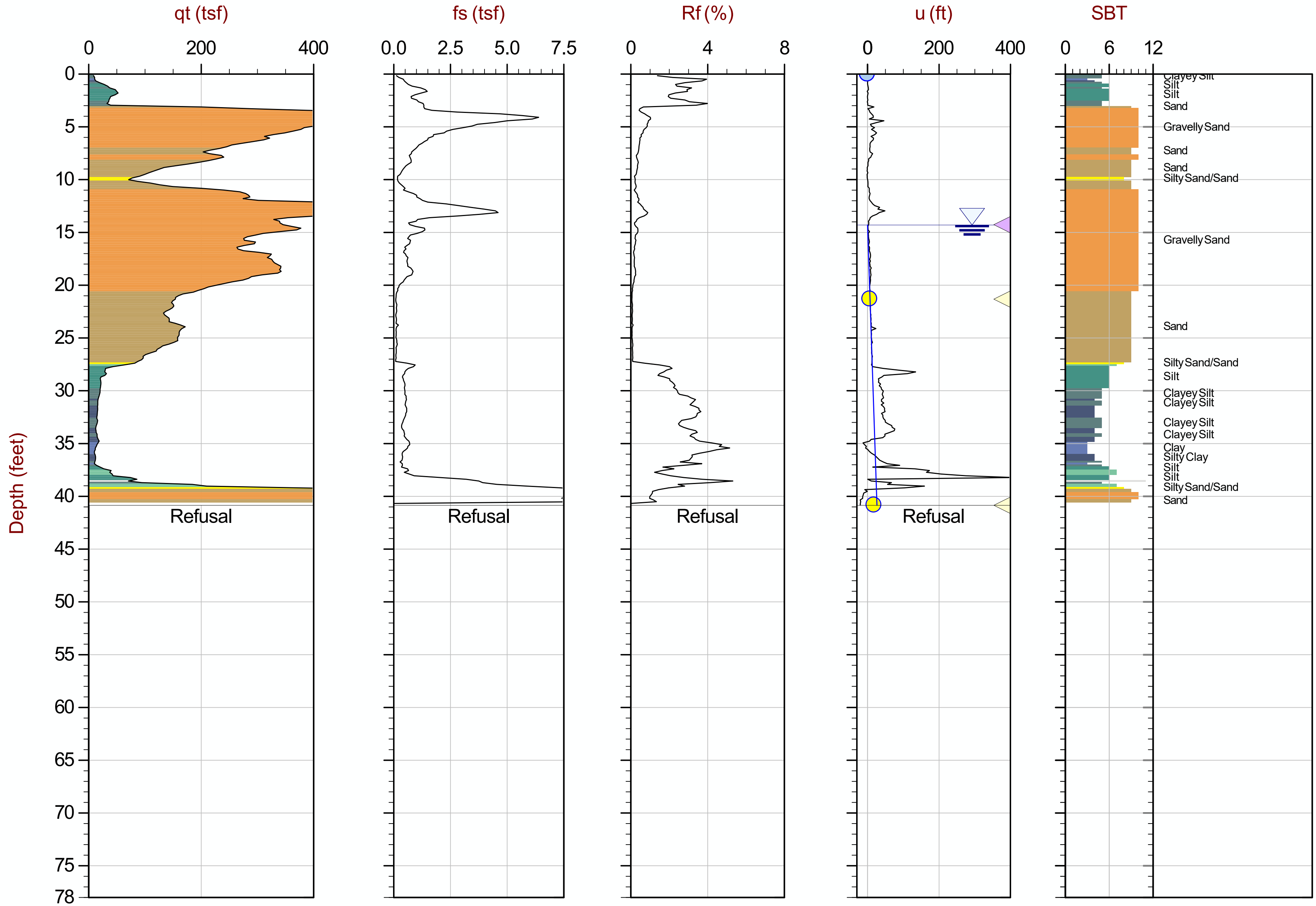
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:08:15 13:25
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C045
Cone: 374:T1500F15U500



Max Depth: 12.450 m / 40.85 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP45.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326563m E: 292609m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

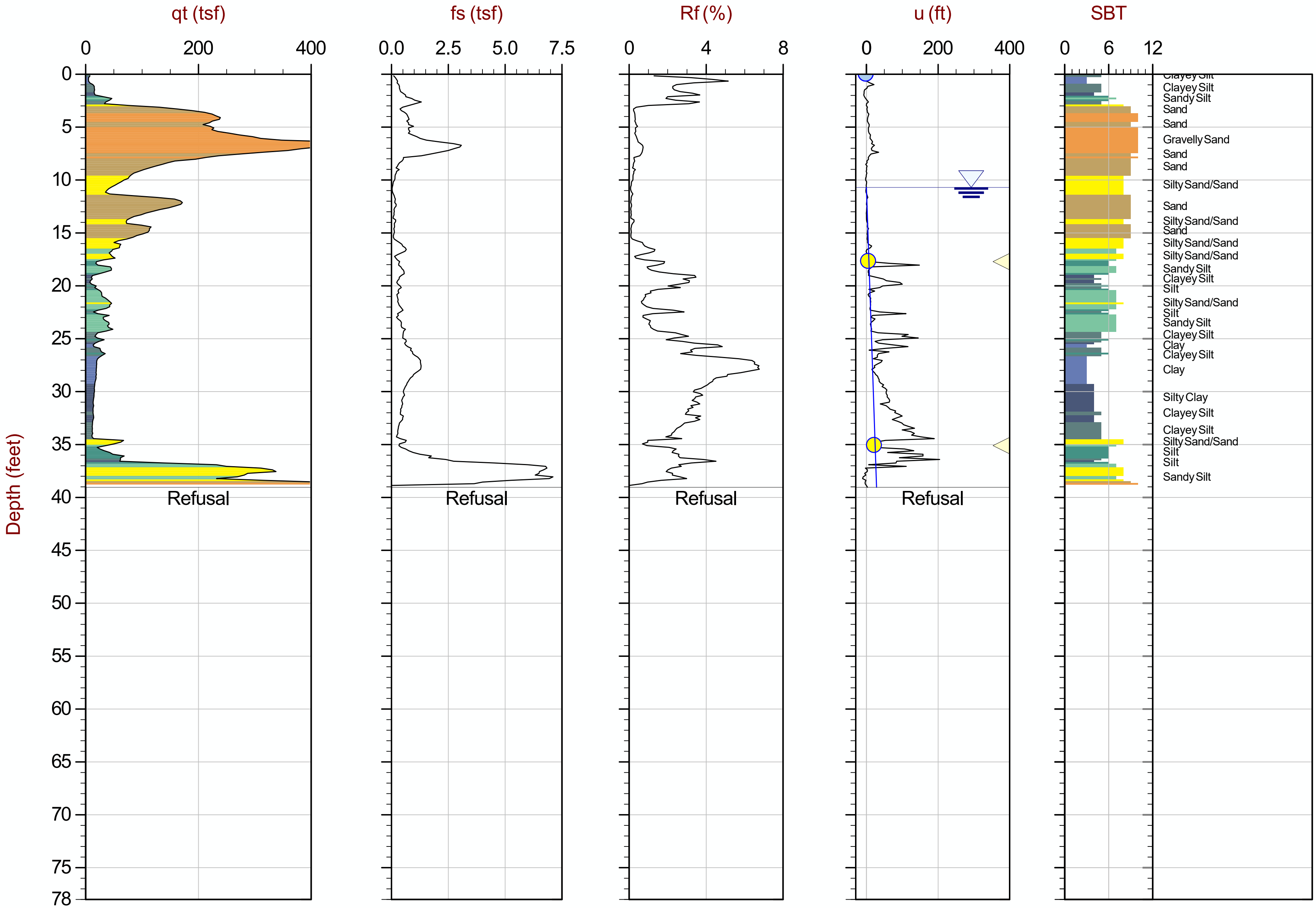
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 12:21
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C046
Cone: 374:T1500F15U500



Max Depth: 11.900 m / 39.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP46.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326548m E: 292890m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

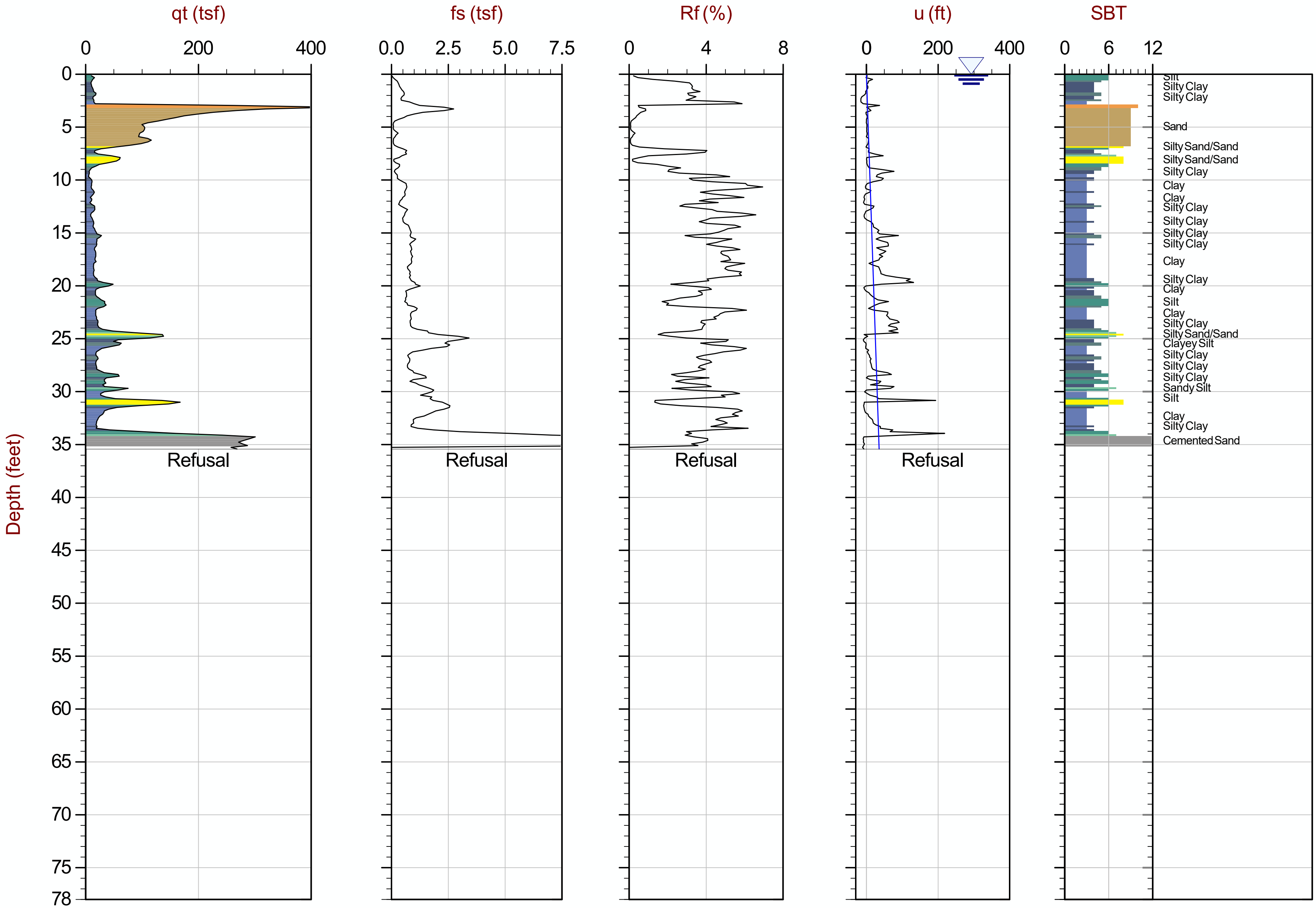
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:08:15 12:38
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C047
Cone: 335:T1500F15U500



Max Depth: 10.800 m / 35.43 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP47.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326302m E: 293060m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

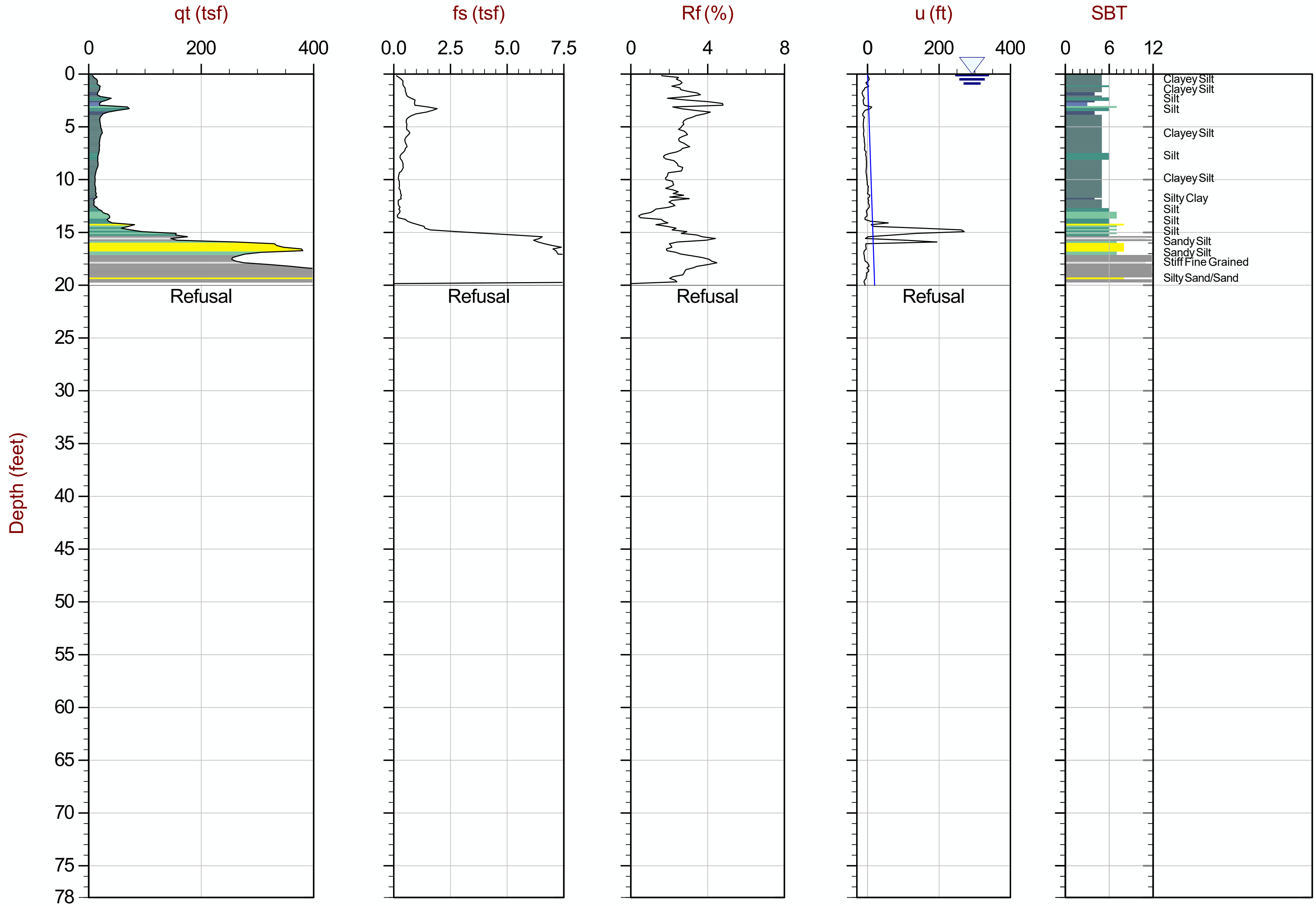
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:11:15 11:50
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C048
Cone: 374:T1500F15U500



Max Depth: 6.100 m / 20.01 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP48.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327303m E: 292909m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

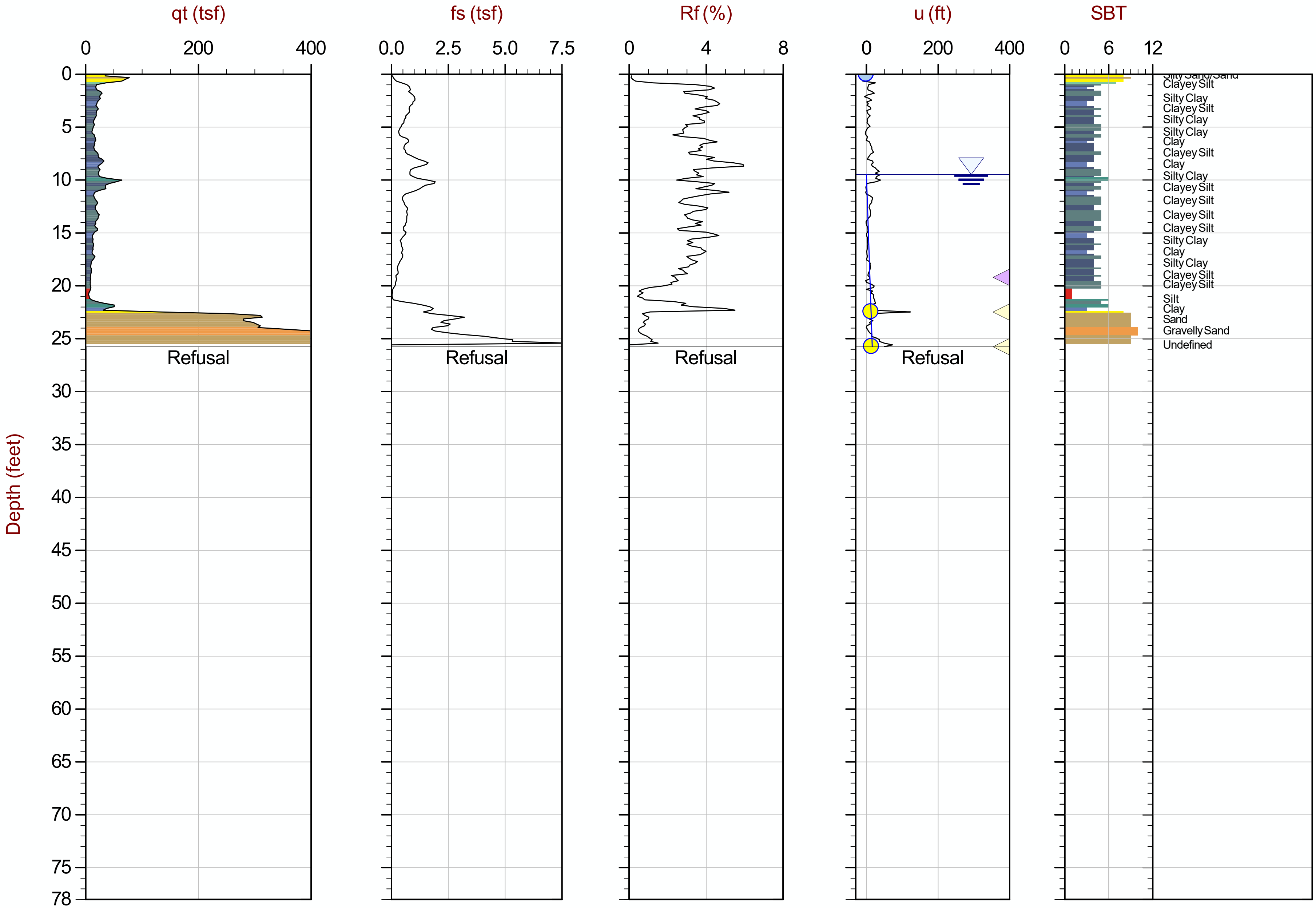
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:07:15 12:14
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335:T1500F15U500



Max Depth: 7.850 m / 25.75 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP49.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327443m E: 292710m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

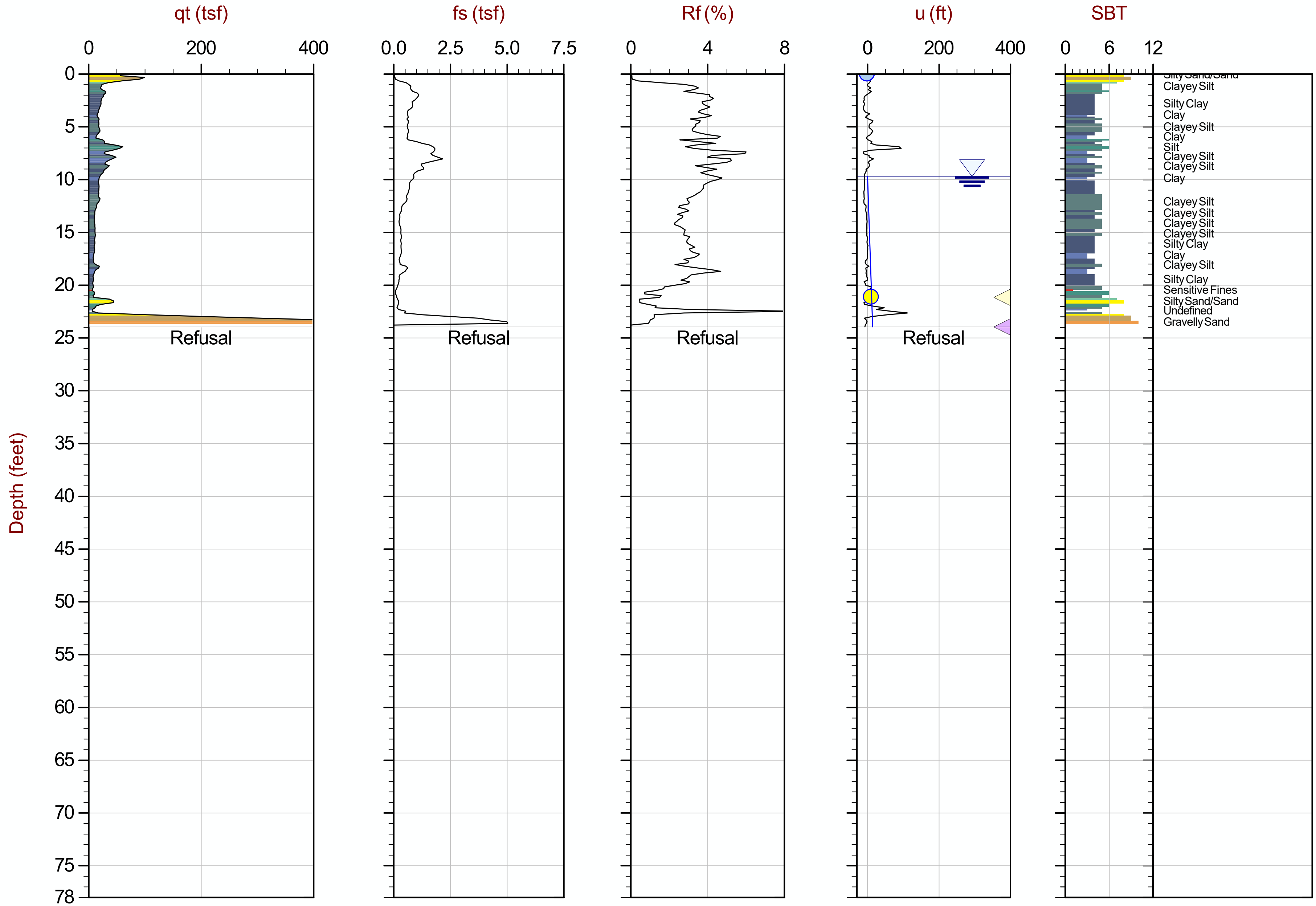
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 13:50
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C050
Cone: 335:T1500F15U500



Max Depth: 7.300 m / 23.95 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP50.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327193m E: 292474m

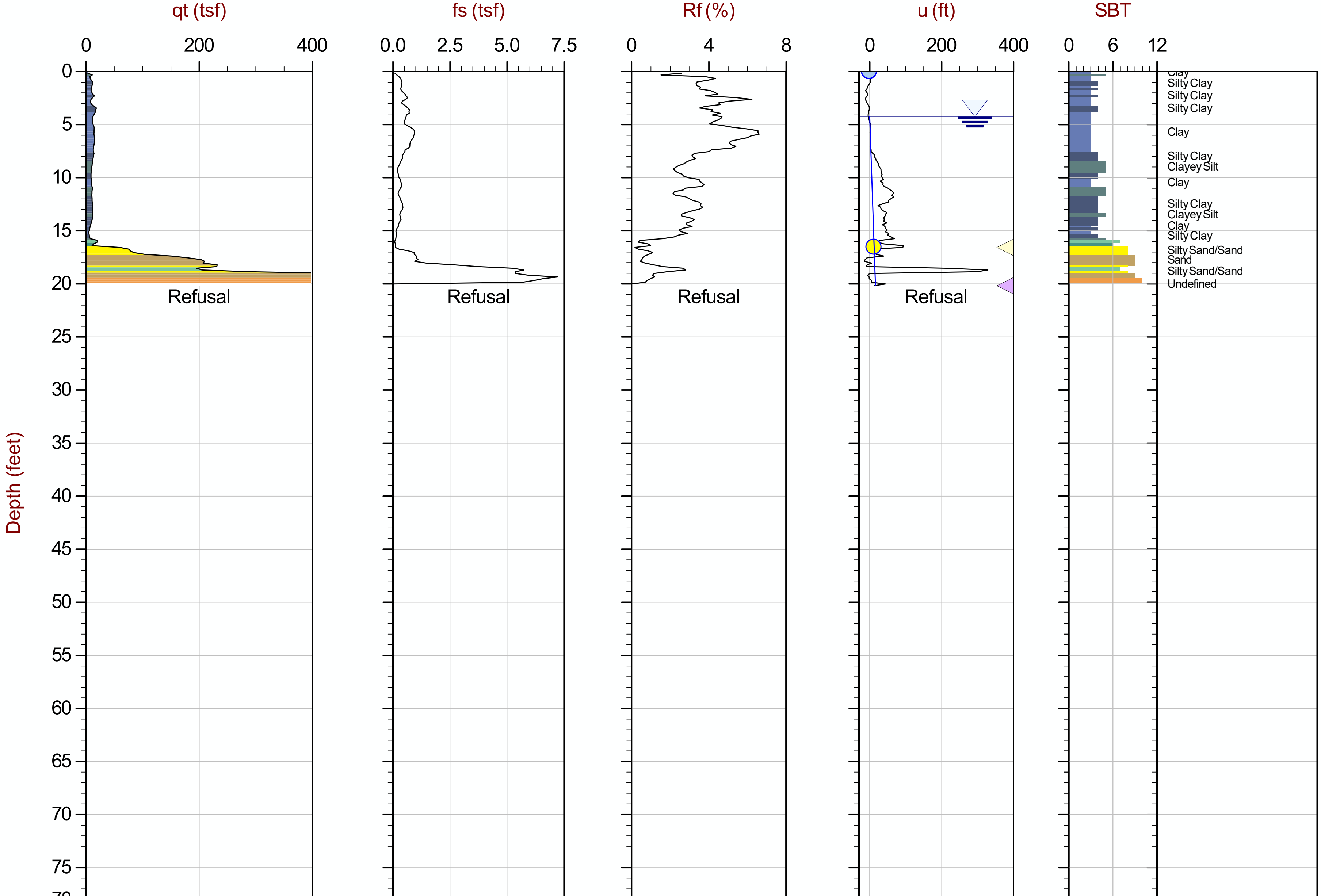
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:11:15 08:45
Site: Coffeen Power Plant, Coffeen, IL
Sounding: COF-C051
Cone: 374:T1500F15U500



Max Depth: 6.150 m / 20.18 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP51.COR

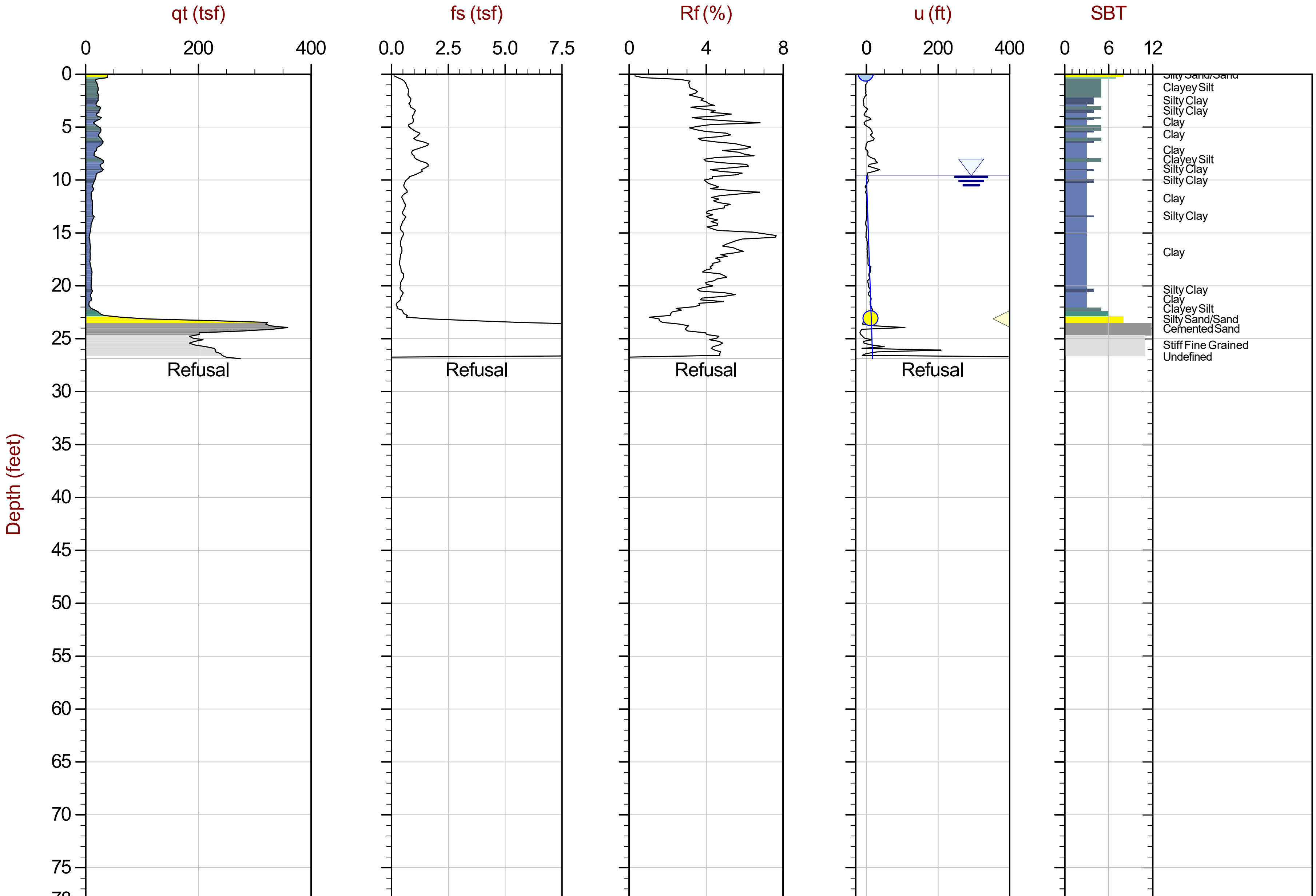
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327193m E: 292459m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:07:15 15:53
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C052
Cone: 335:T1500F15U500



Max Depth: 8.200 m / 26.90 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP52.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327045m E: 292612m

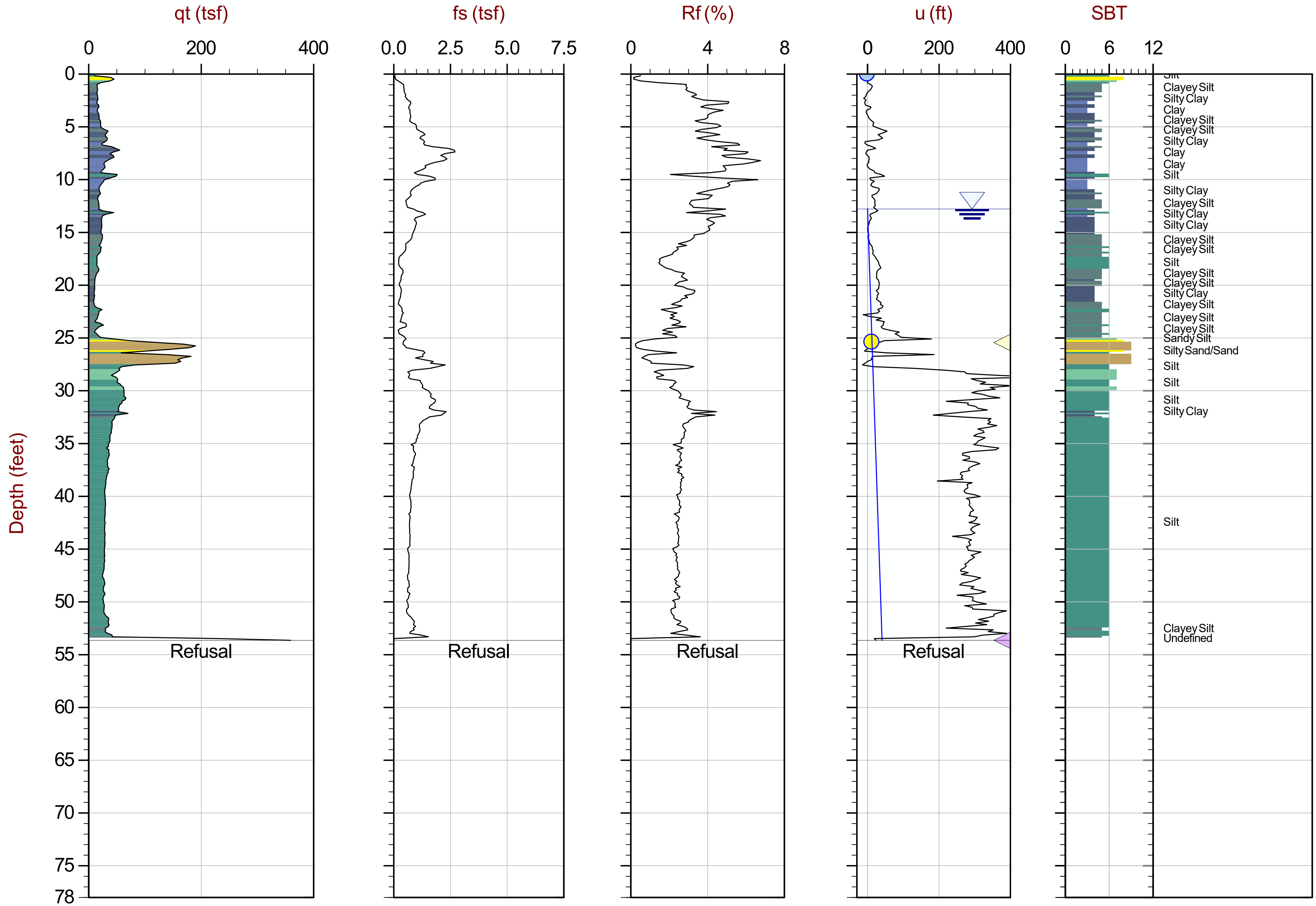
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 10:02
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C053
Cone: 335:T1500F15U500



Max Depth: 16.350 m / 53.64 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP53.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327306m E: 292894m

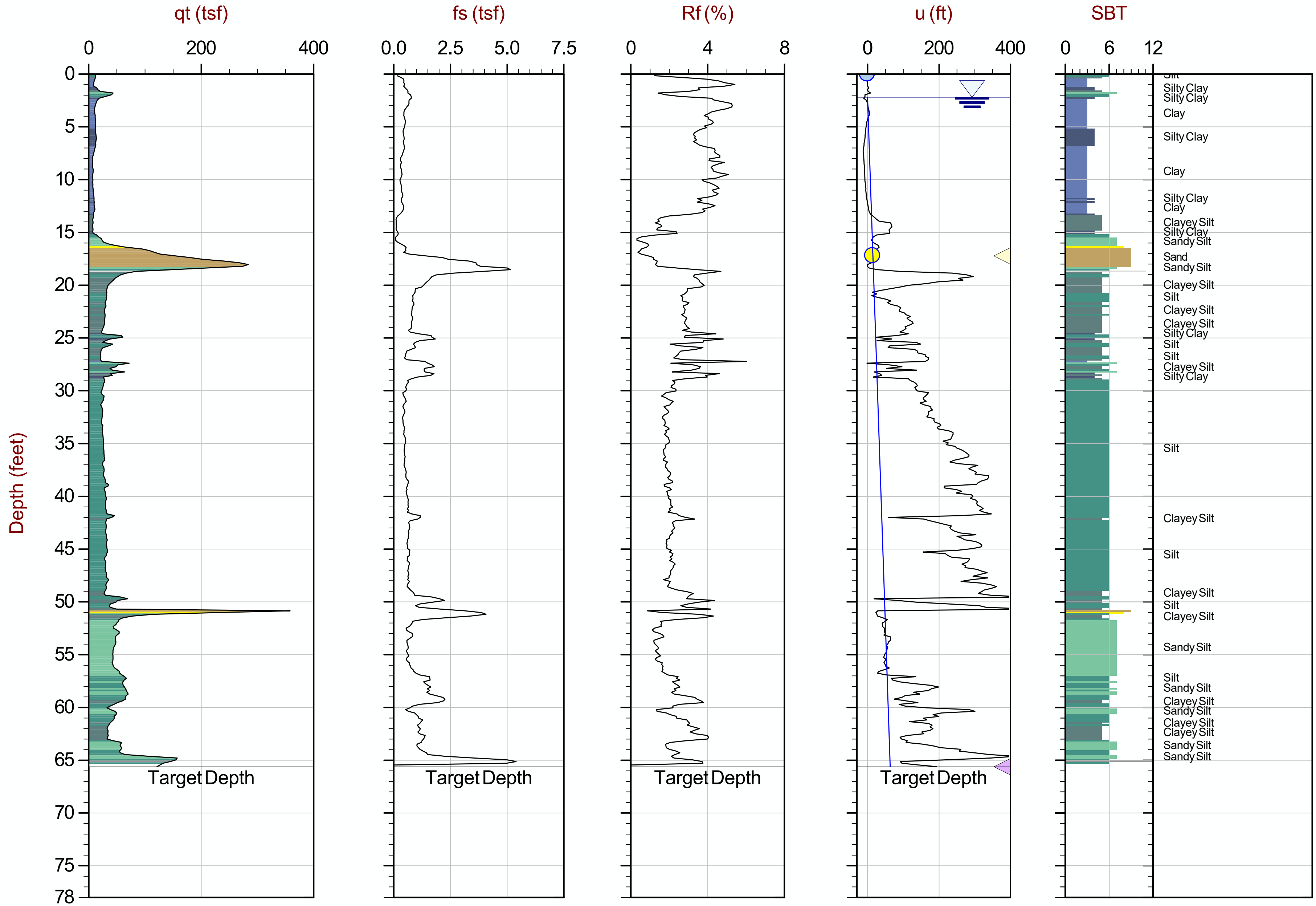
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:11:15 13:04
Site: Coffeen Power Plant, Coffeen, IL
Sounding: COF-C054
Cone: 374:T1500F15U500



Max Depth: 20.000 m / 65.62 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point
File: 15-53063_CP54.COR
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327033m E: 292613m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

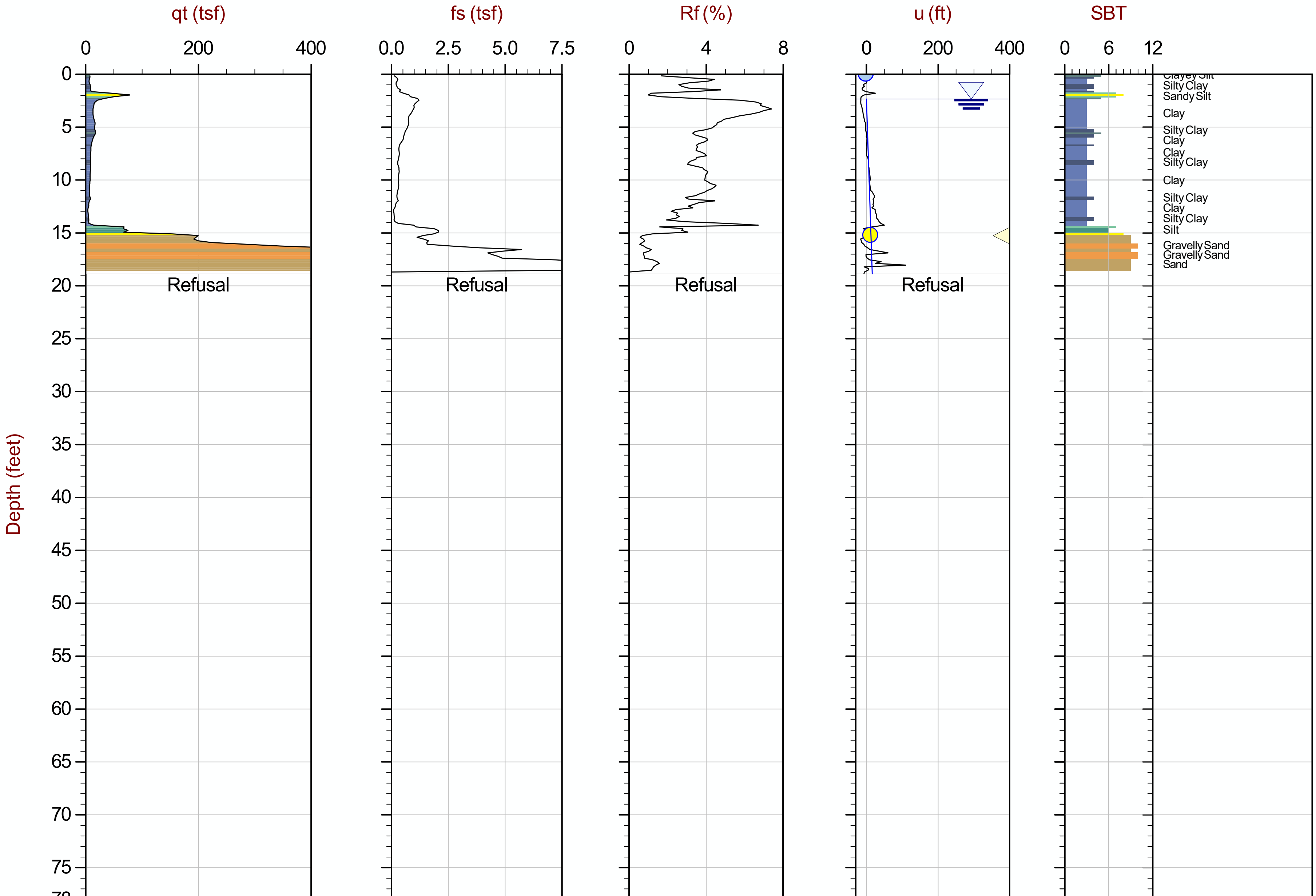
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:11:15 10:39
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C055
Cone: 374:T1500F15U500



Max Depth: 5.750 m / 18.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP55.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327459m E: 292712m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

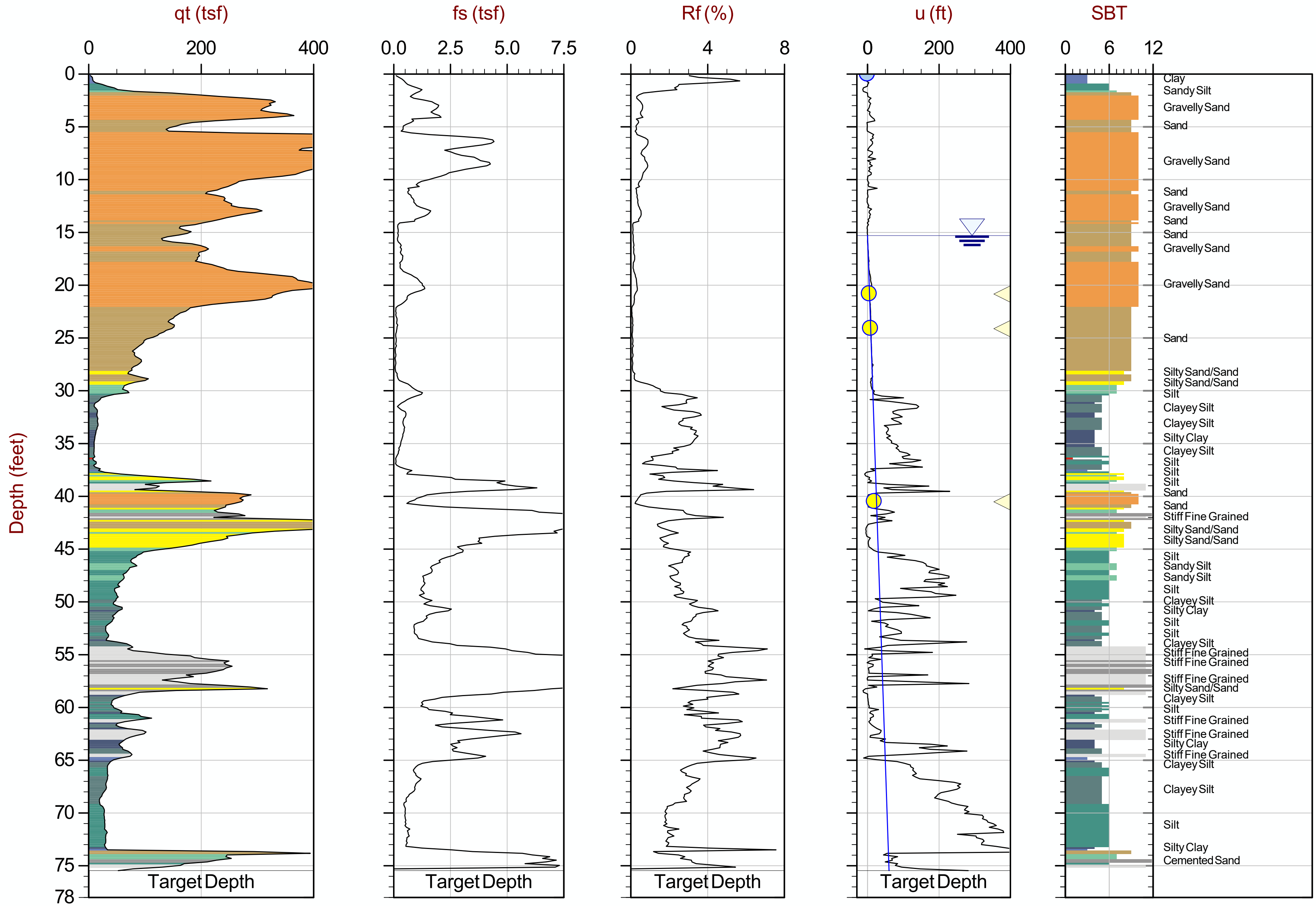
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:10:15 08:28
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C056
Cone: 374:T1500F15U500



Max Depth: 23.000 m / 75.46 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP56.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326494m E: 292684m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

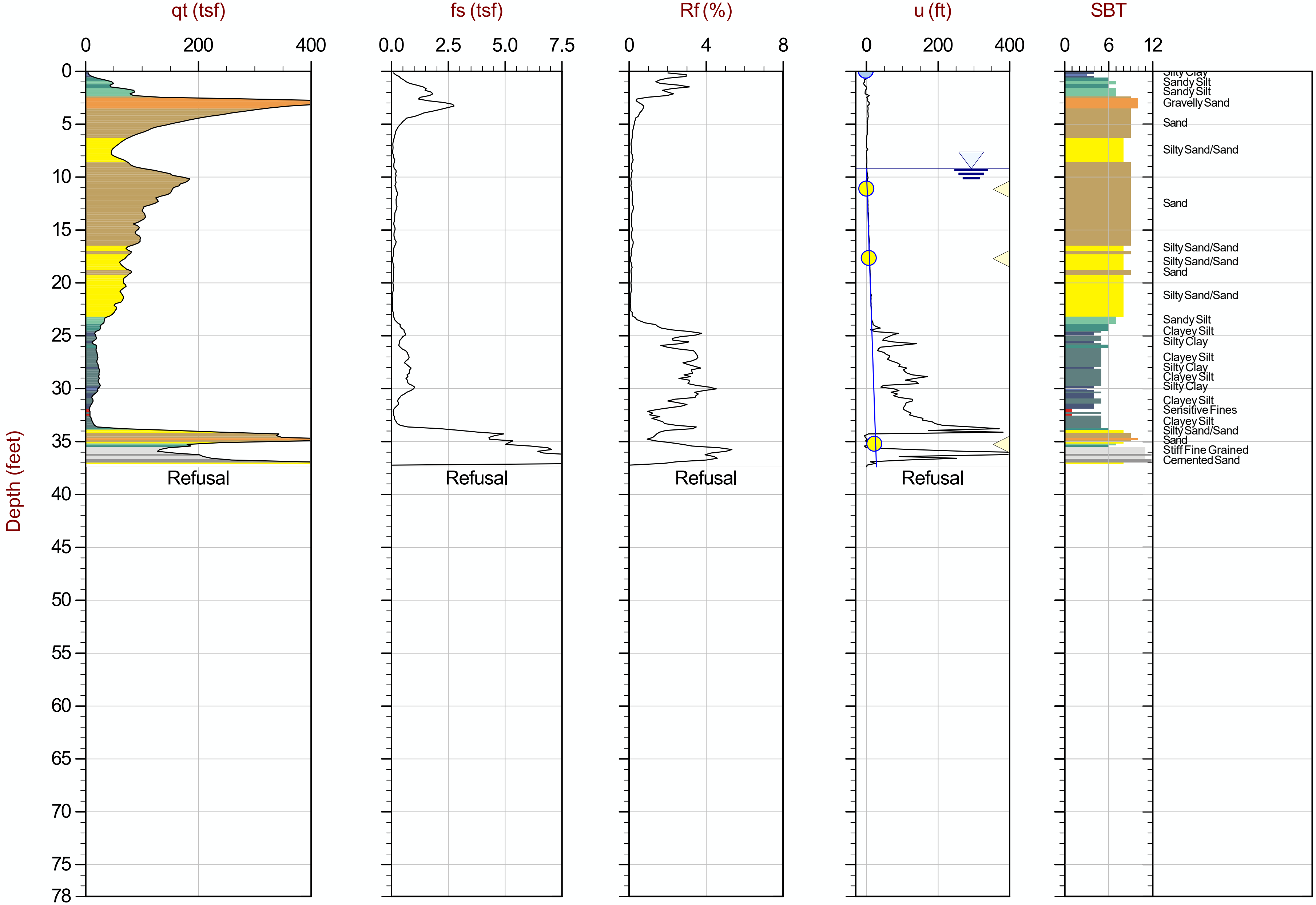
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 10:30
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C057
Cone: 374:T1500F15U500



Max Depth: 11.400 m / 37.40 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP57.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326423m E: 292837m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Plots

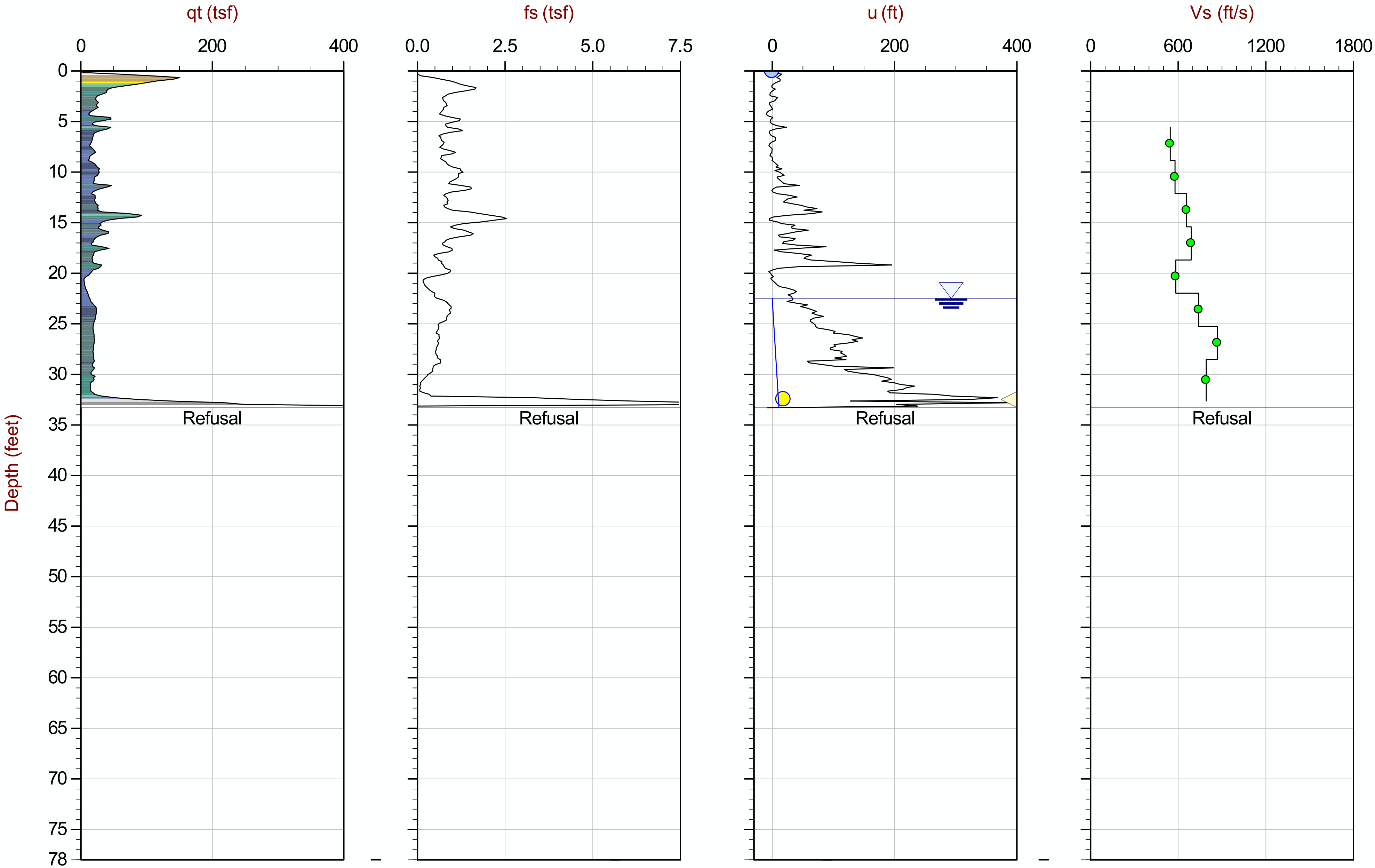
ConeTec

CONETEC

AECOM

Job No: 15-53063
Date: 08:05:15 11:25
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C001
Cone: 335:T1500F15U500



Max Depth: 10.150 m / 33.30 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP01.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325926m E: 293076m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

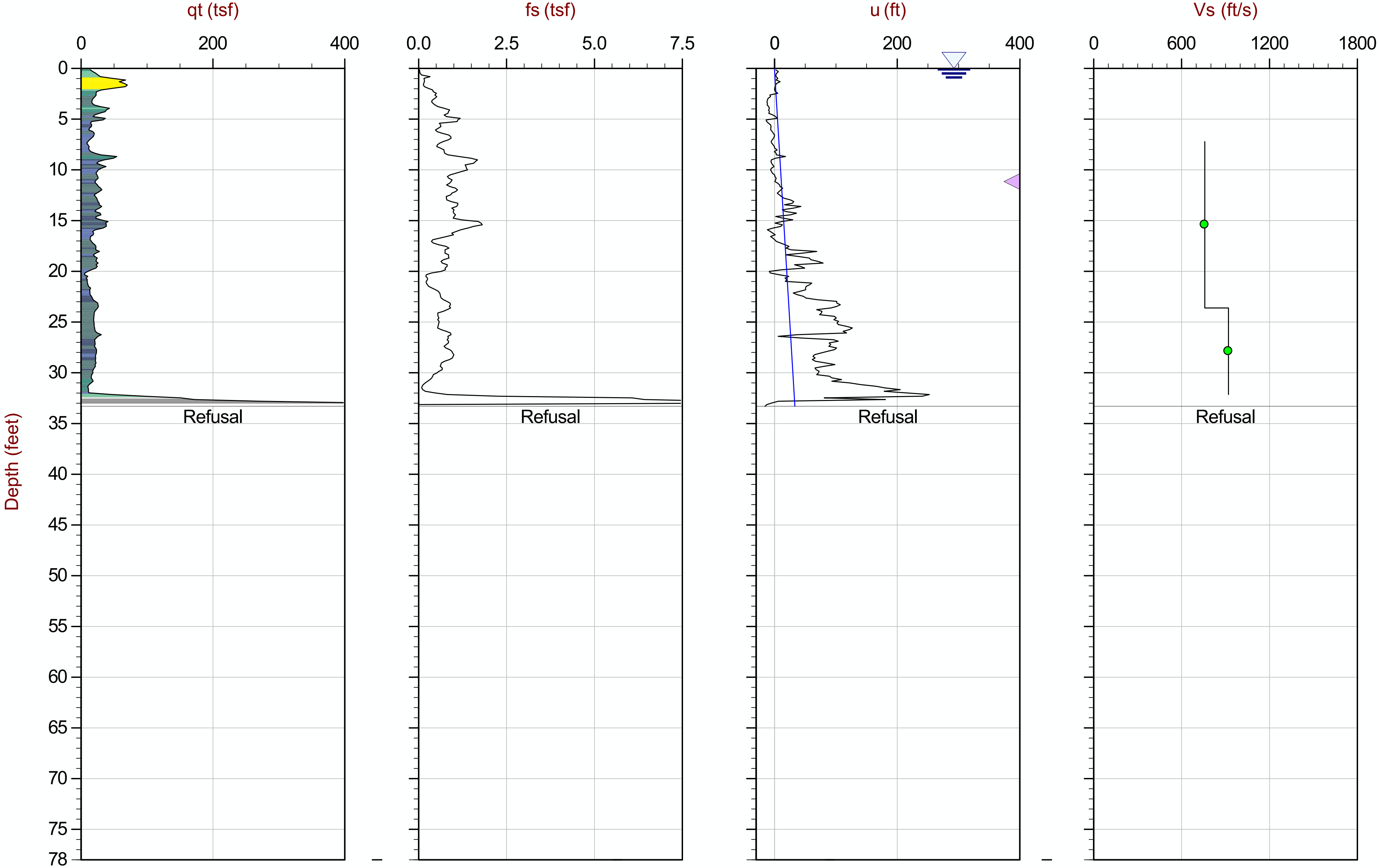
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:06:15 13:40
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C002
Cone: 374:T1500F15U500



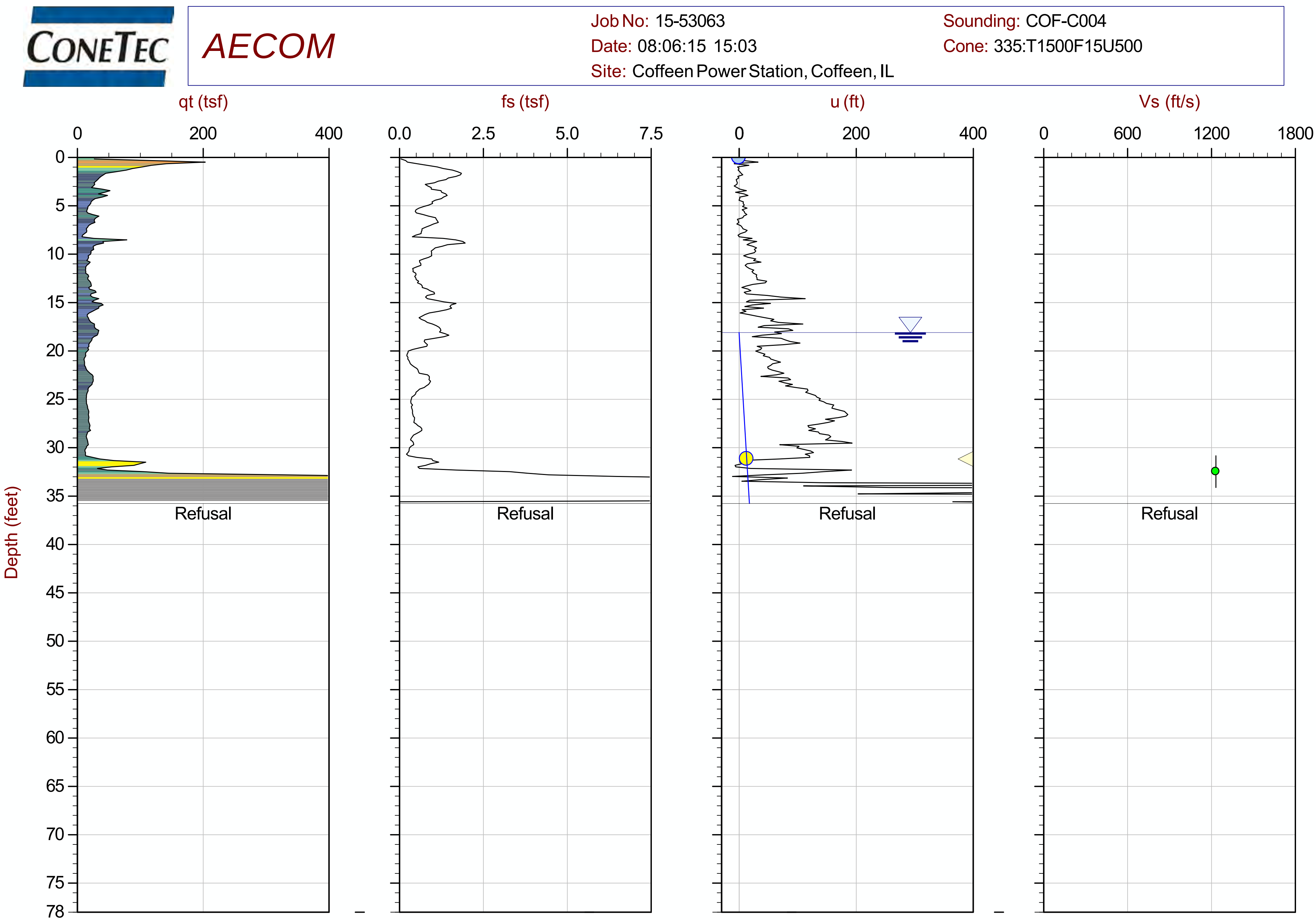
Max Depth: 10.150 m / 33.30 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP02.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325927m E: 293071m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.



Max Depth: 10.900 m / 35.76 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP04.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325897m E: 293066m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

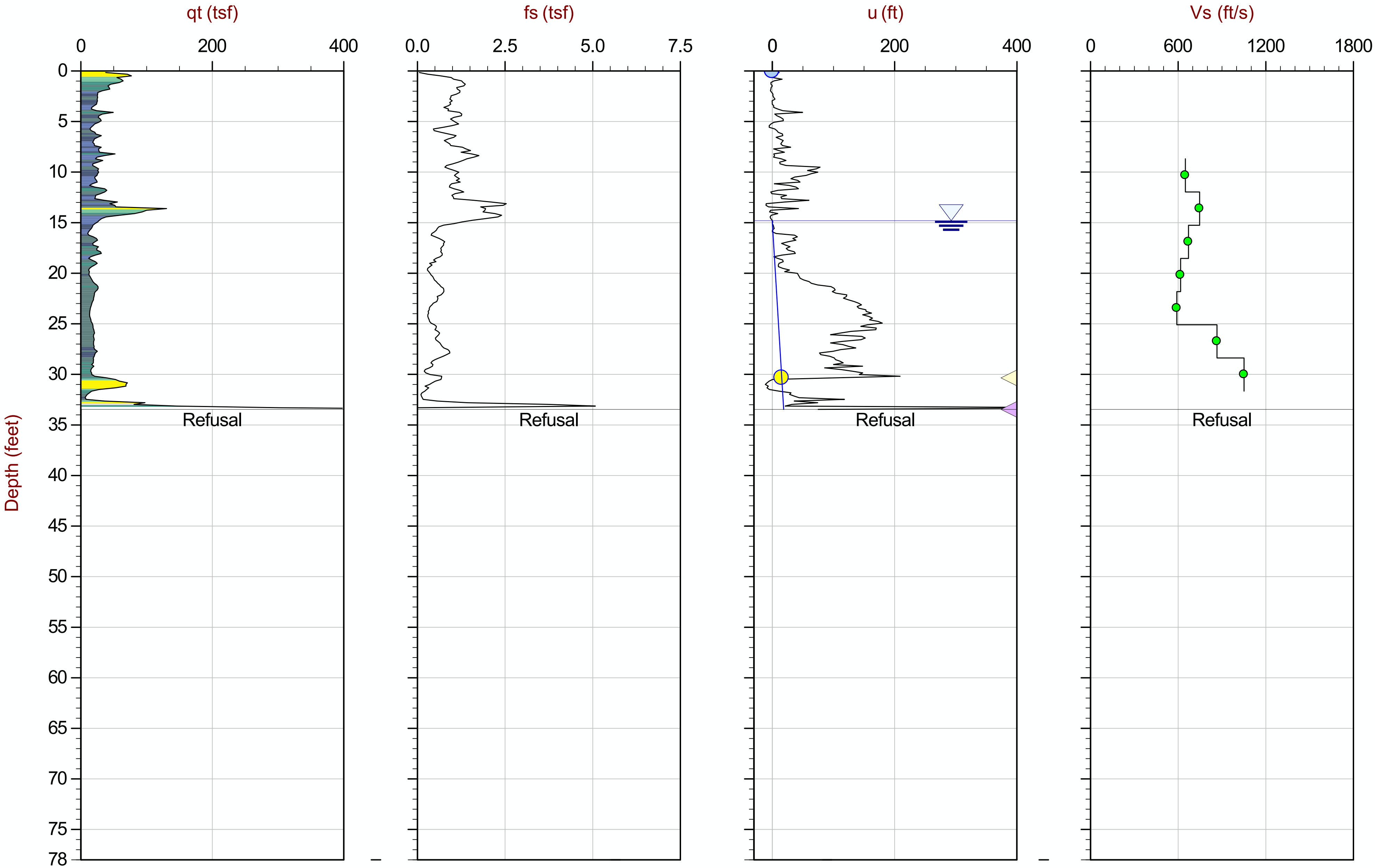
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:07:15 07:21
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C005
Cone: 335:T1500F15U500



Max Depth: 10.200 m / 33.46 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP05.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325871m E: 293047m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

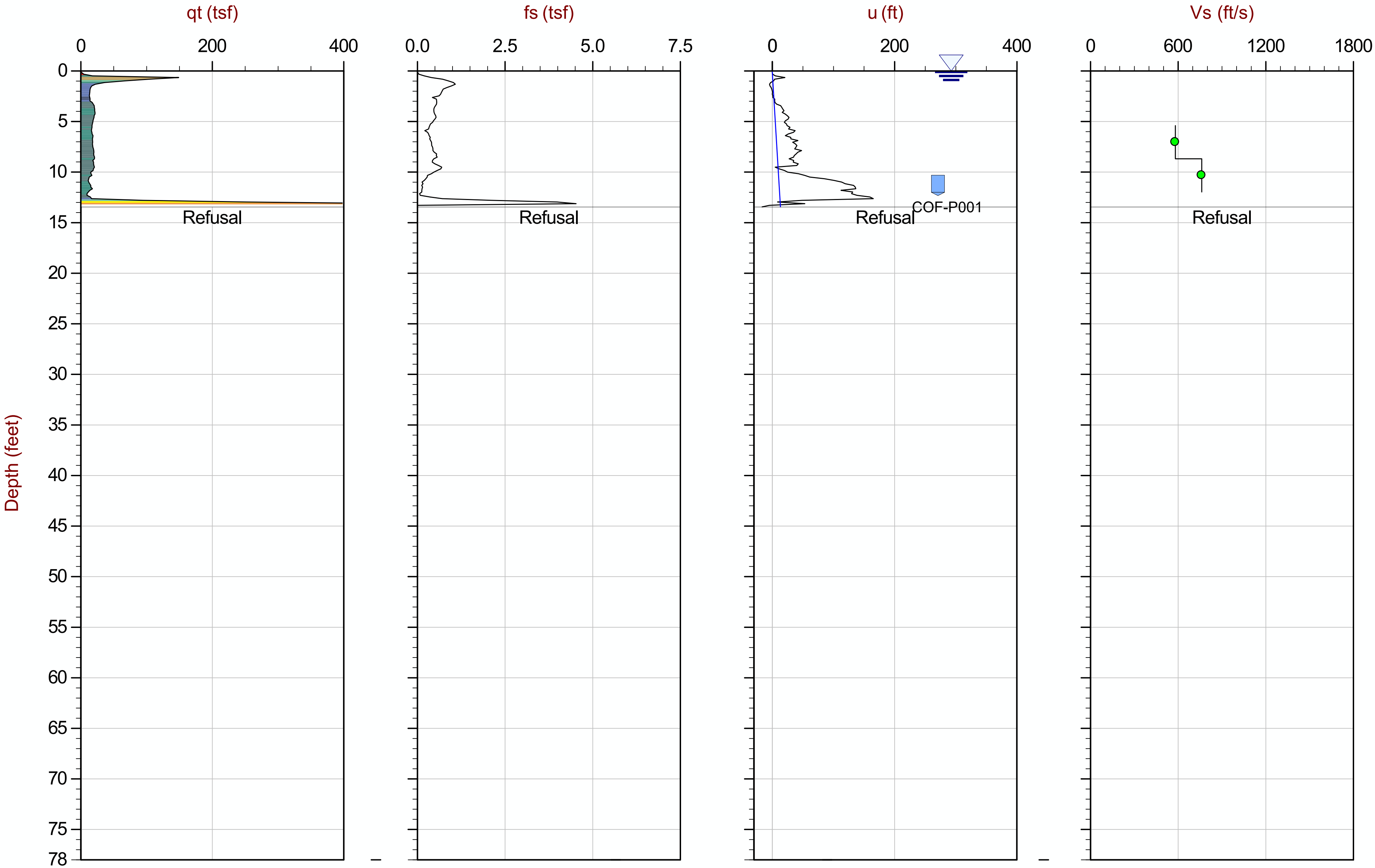
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:04:15 14:50
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C006
Cone: 335:T1500F15U500



Max Depth: 4.100 m / 13.45 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP06.COR

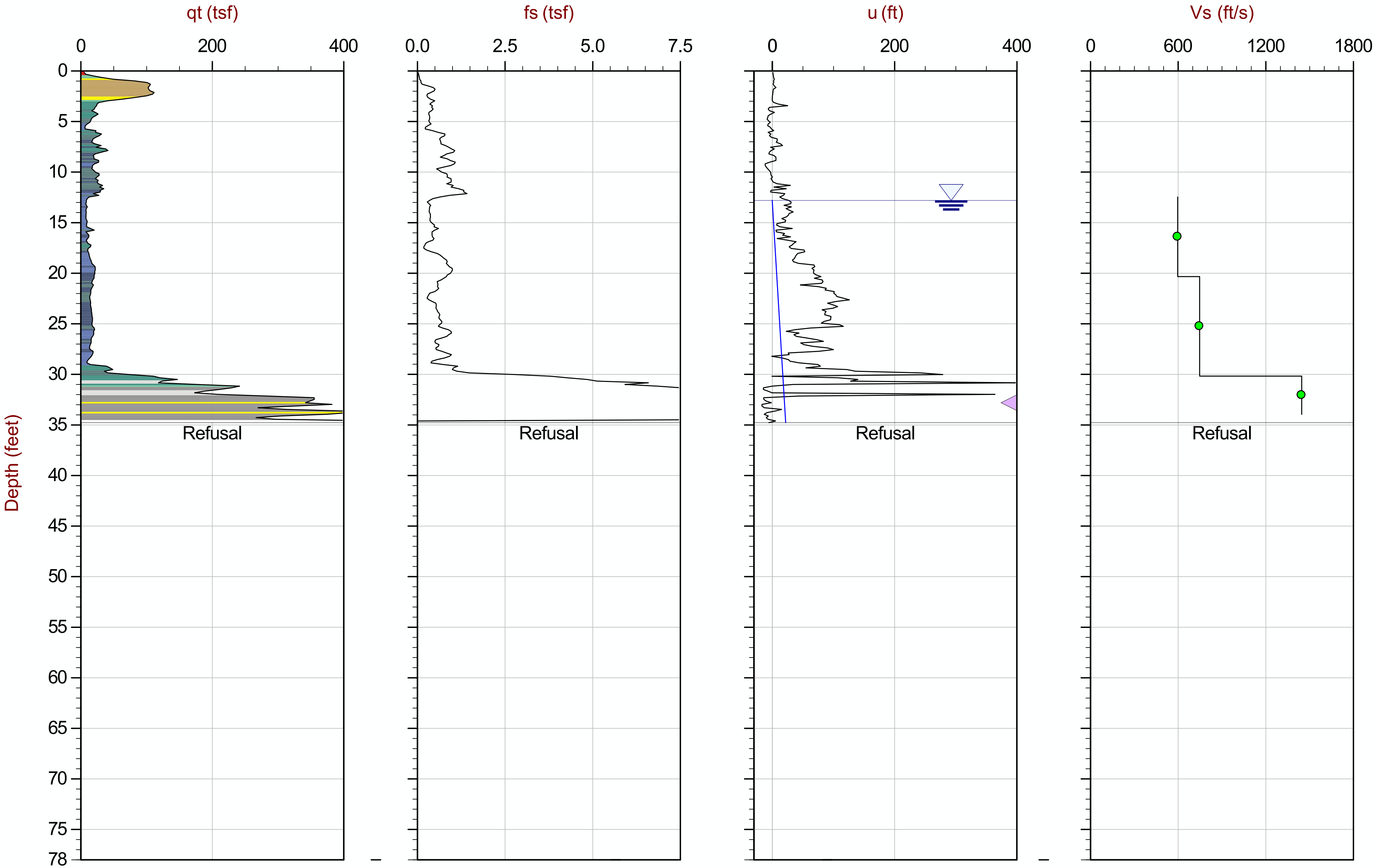
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325869m E: 293081m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 15-53063
Date: 08:07:15 11:18
Site: Coffeen Power Plant, Coffeen, IL
Sounding: COF-C007
Cone: 374:T1500F15U500

AECOM



Max Depth: 10.600 m / 34.78 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP07.COR

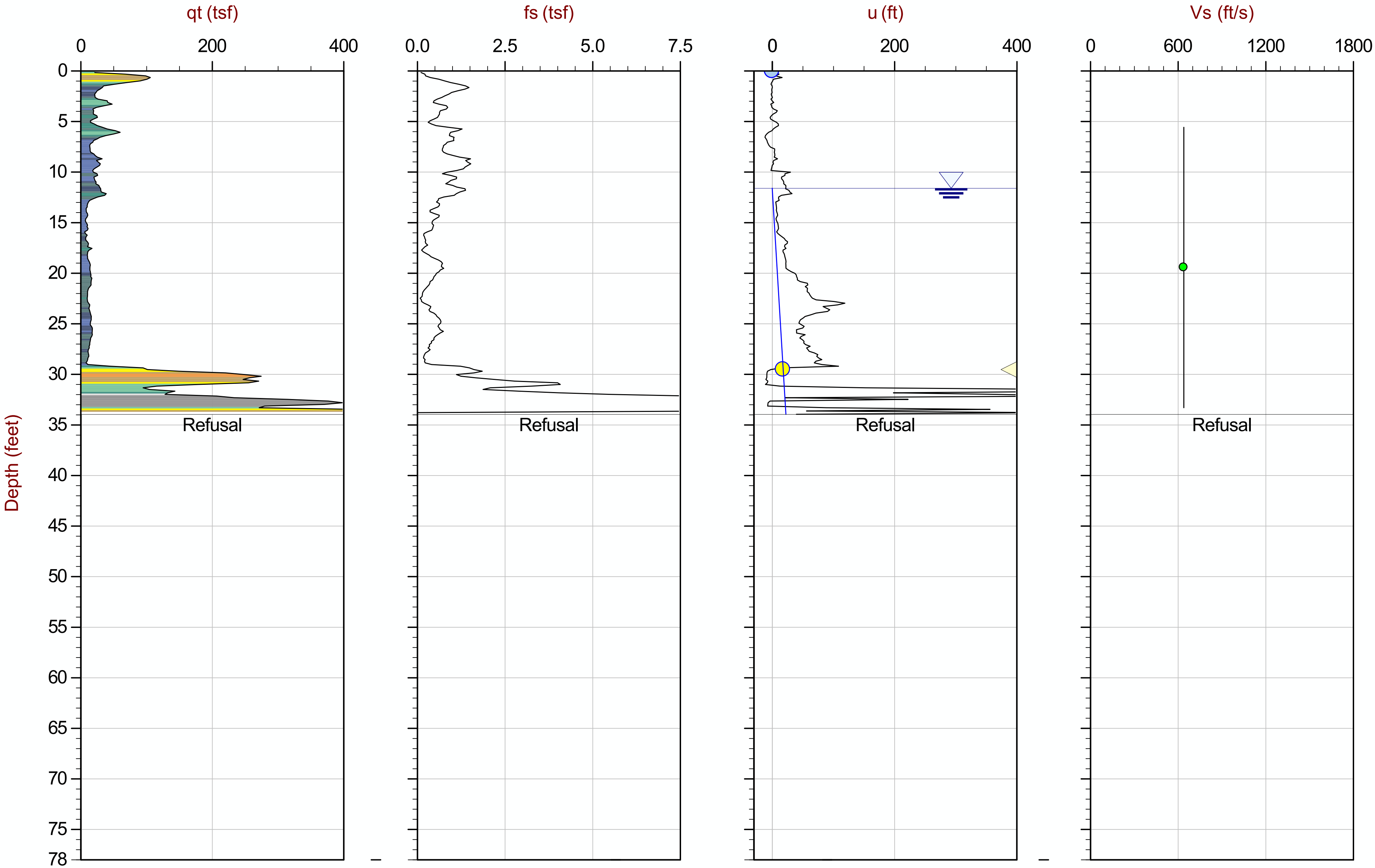
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325874m E: 292869m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:05:15 09:57
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C008
Cone: 335:T1500F15U500



Max Depth: 10.350 m / 33.96 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP08.COR

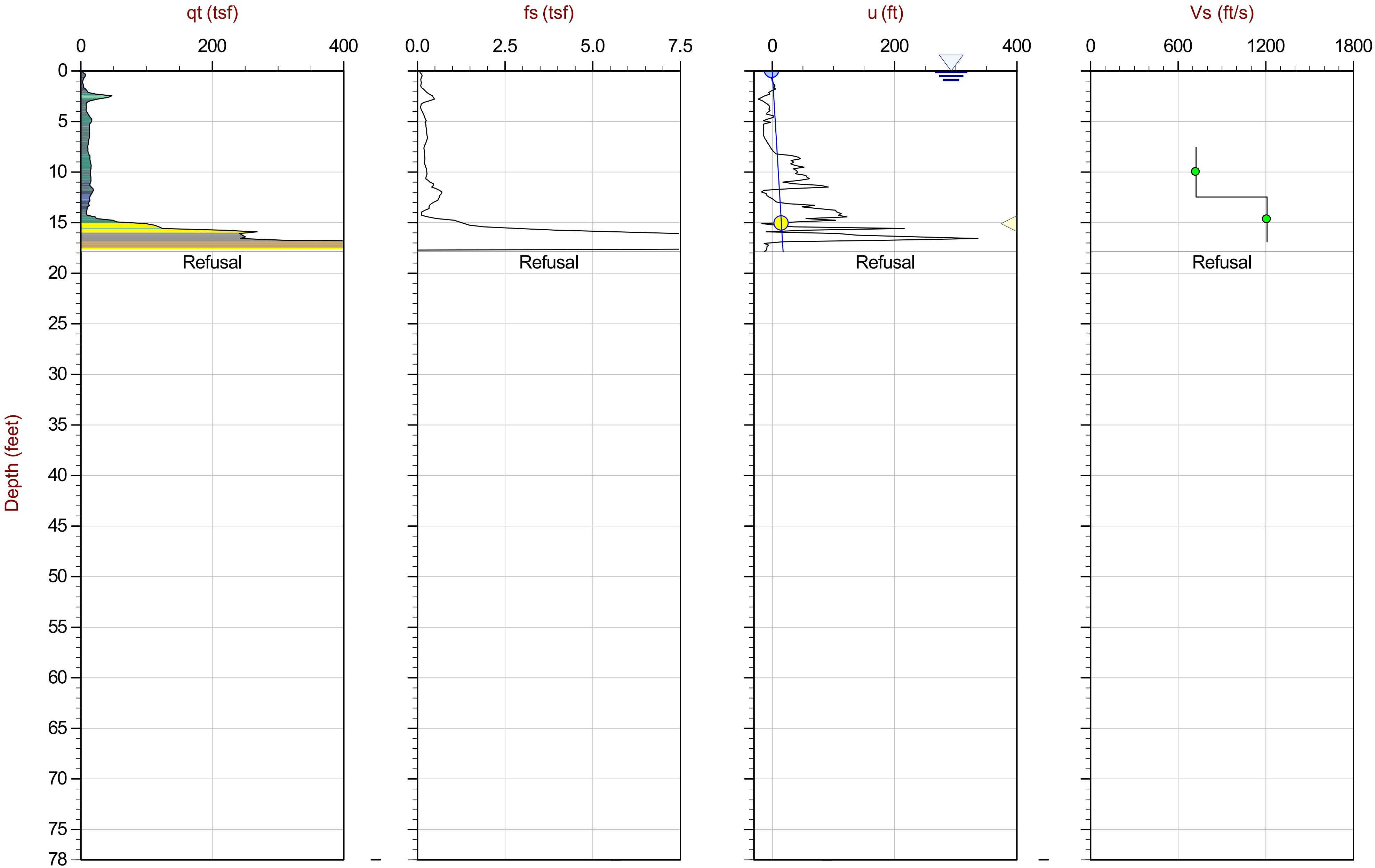
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325870m E: 292872m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 15-53063
Date: 08:06:15 16:06
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C009
Cone: 374:T1500F15U500

AECOM



Max Depth: 5.450 m / 17.88 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP09.COR

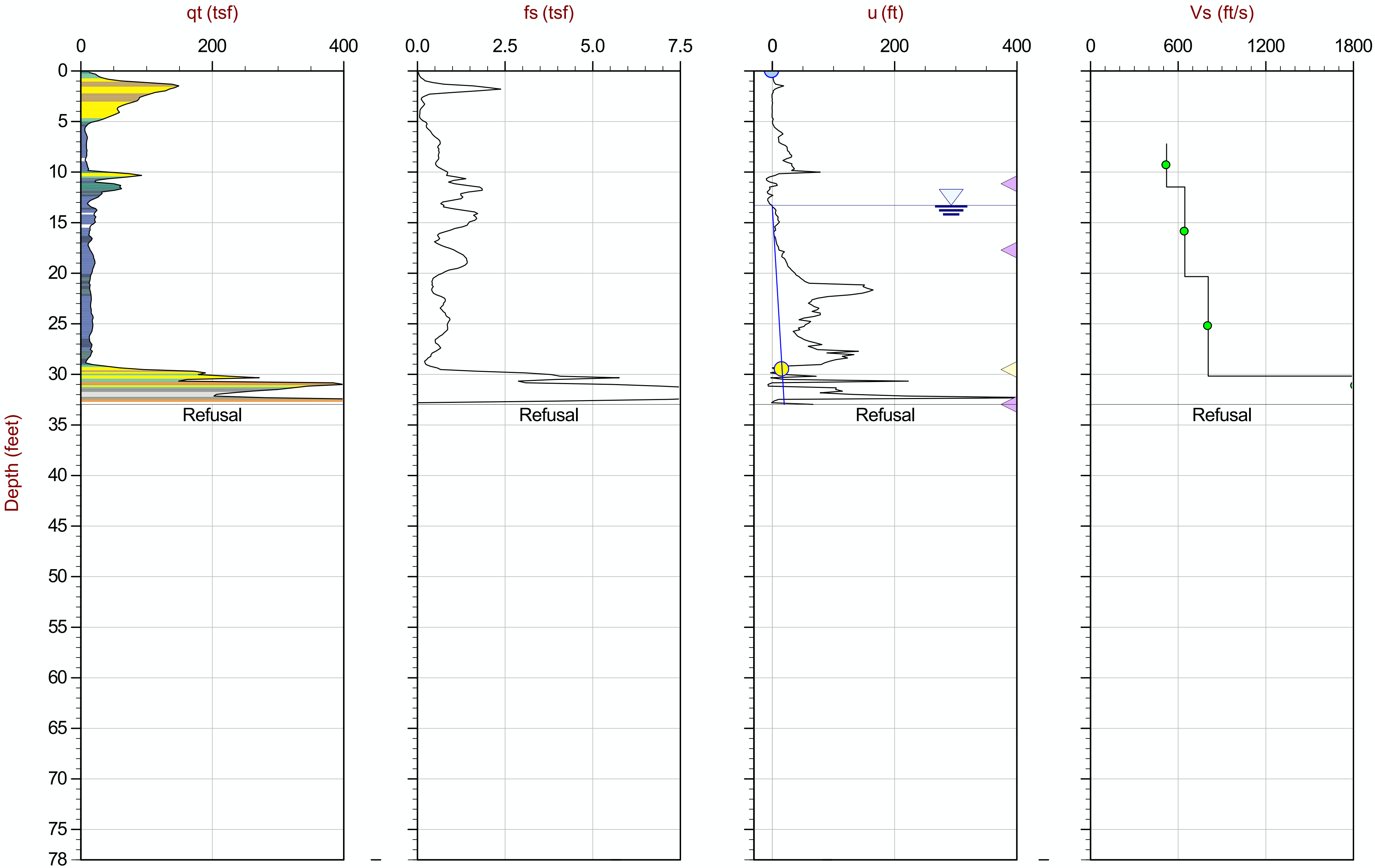
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325860m E: 292865m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:07:15 09:01
Site: Coffeen Power Plant, Coffeen, IL
Sounding: COF-C010
Cone: 374:T1500F15U500



Max Depth: 10.050 m / 32.97 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP10.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325884m E: 292664m

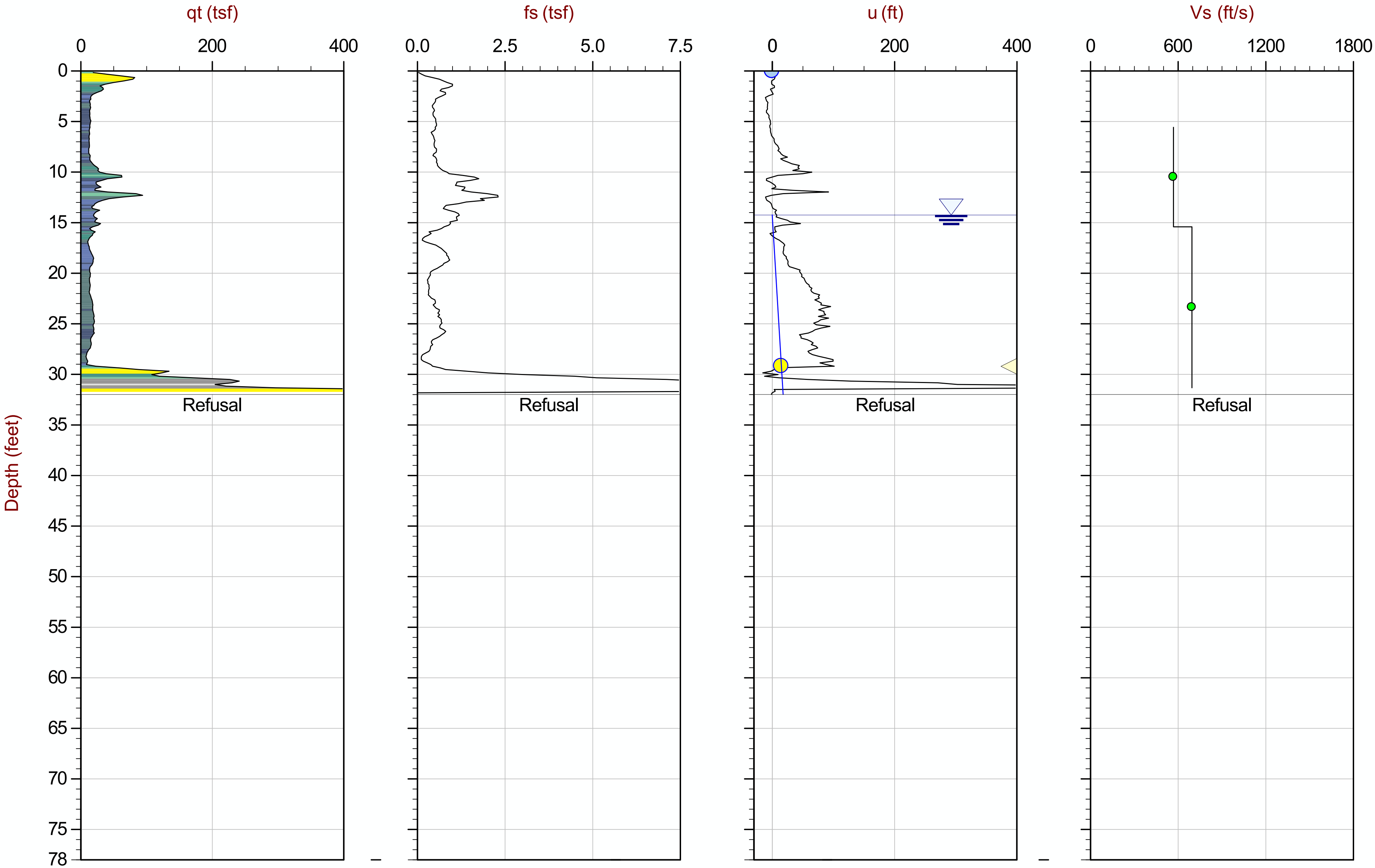
Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:05:15 08:38
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C011
Cone: 335:T1500F15U500



Max Depth: 9.750 m / 31.99 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP11.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325878m E: 292666m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

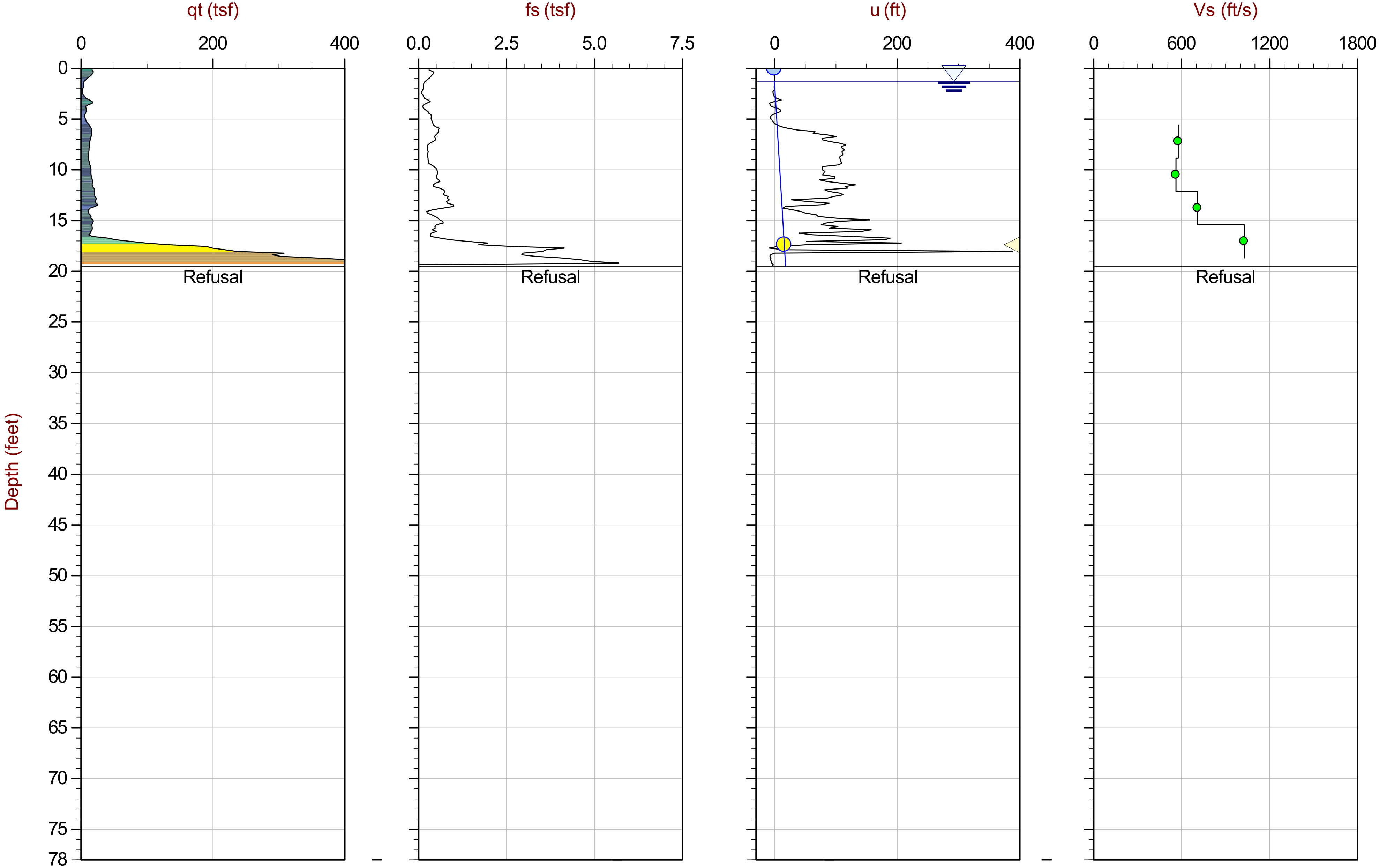
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:04:15 12:36
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C012
Cone: 335:T1500F15U500



Max Depth: 5.950 m / 19.52 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP12.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325868m E: 292667m

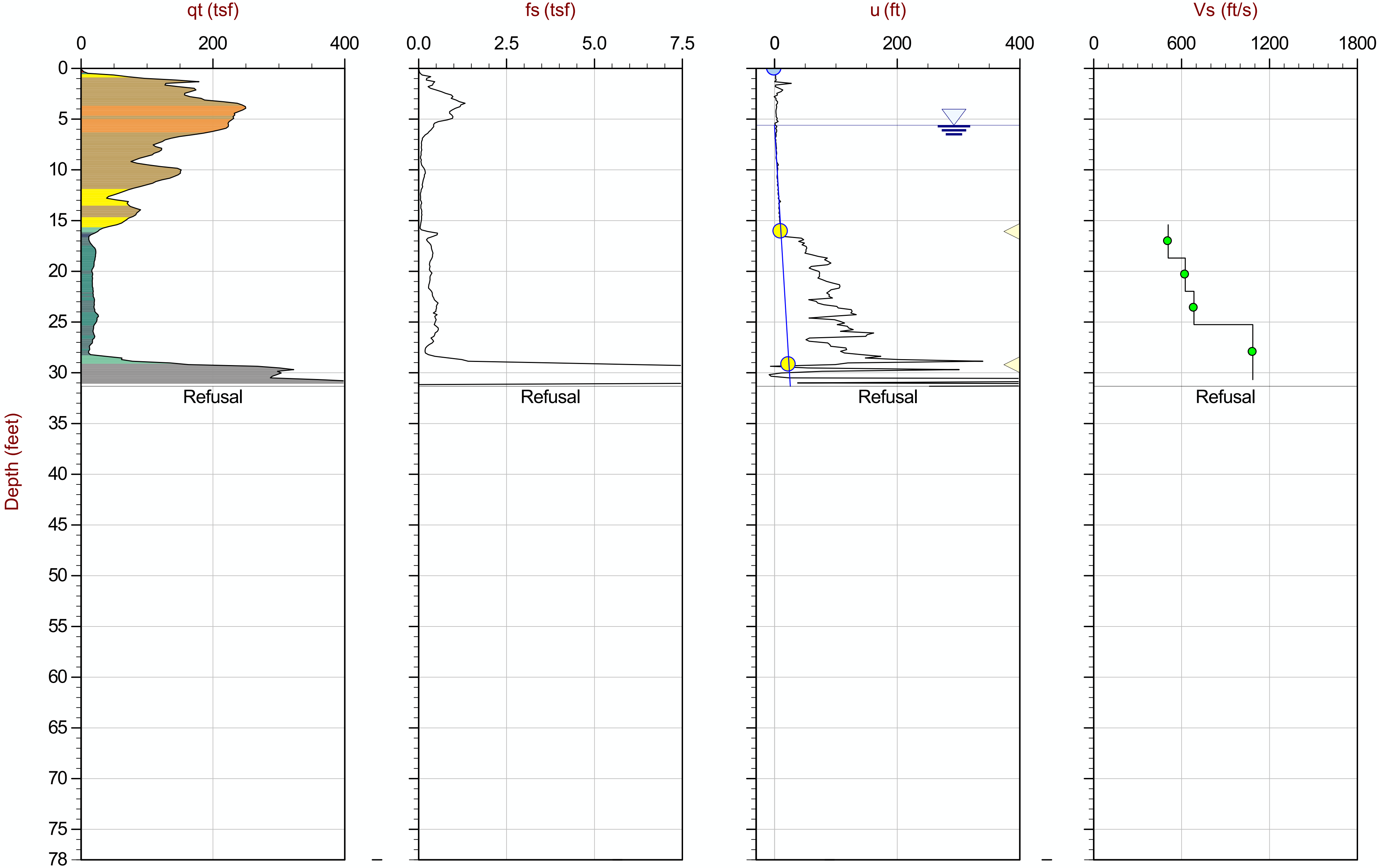
Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:05:15 15:50
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C013
Cone: 335:T1500F15U500



Max Depth: 9.550 m / 31.33 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP13.COR

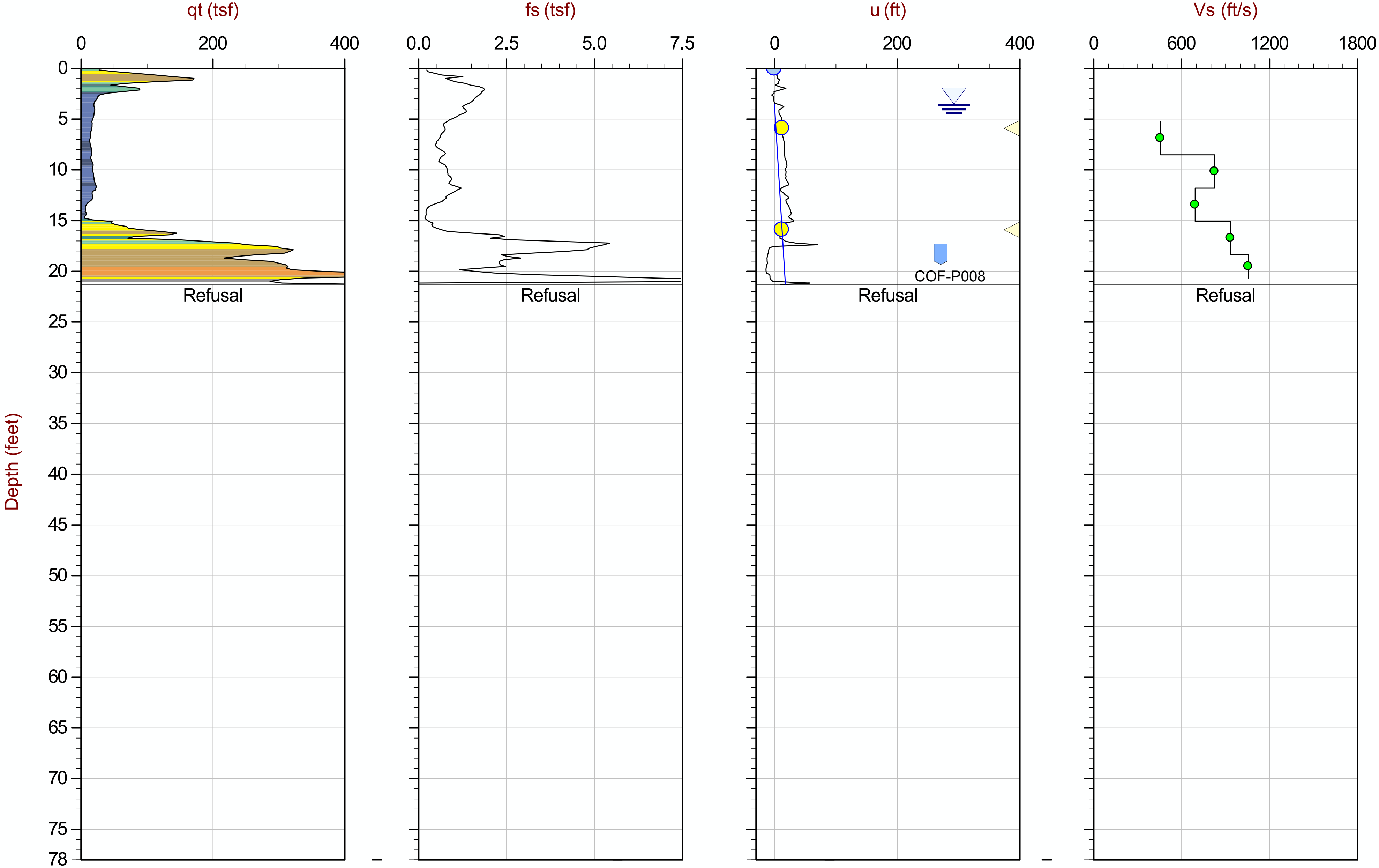
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325931m E: 292608m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:04:15 10:48
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C014
Cone: 335:T1500F15U500



Max Depth: 6.500 m / 21.33 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP14.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4325991m E: 292584m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

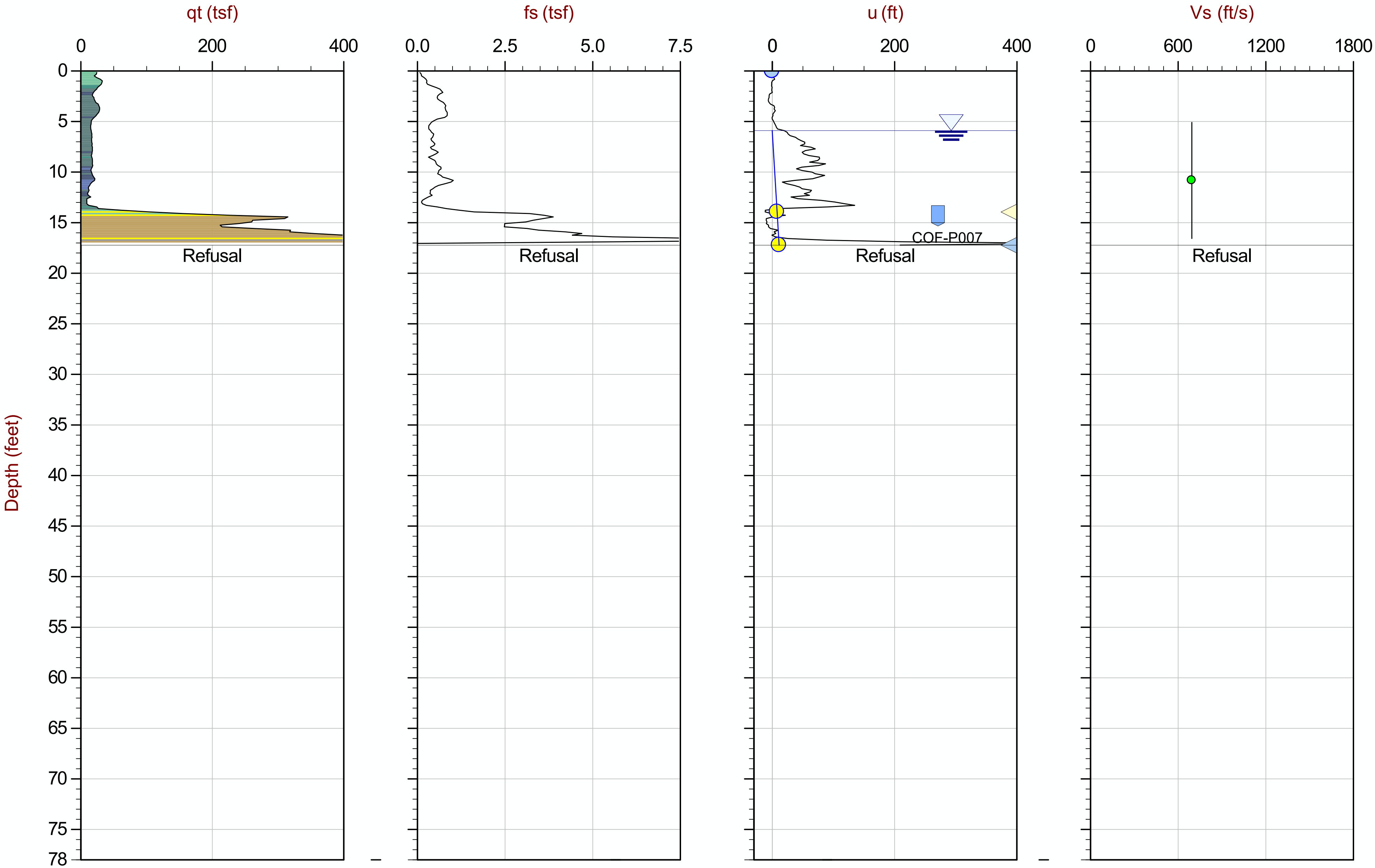
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:05:15 07:20
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C018
Cone: 335:T1500F15U500



Max Depth: 5.250 m / 17.22 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP18.COR

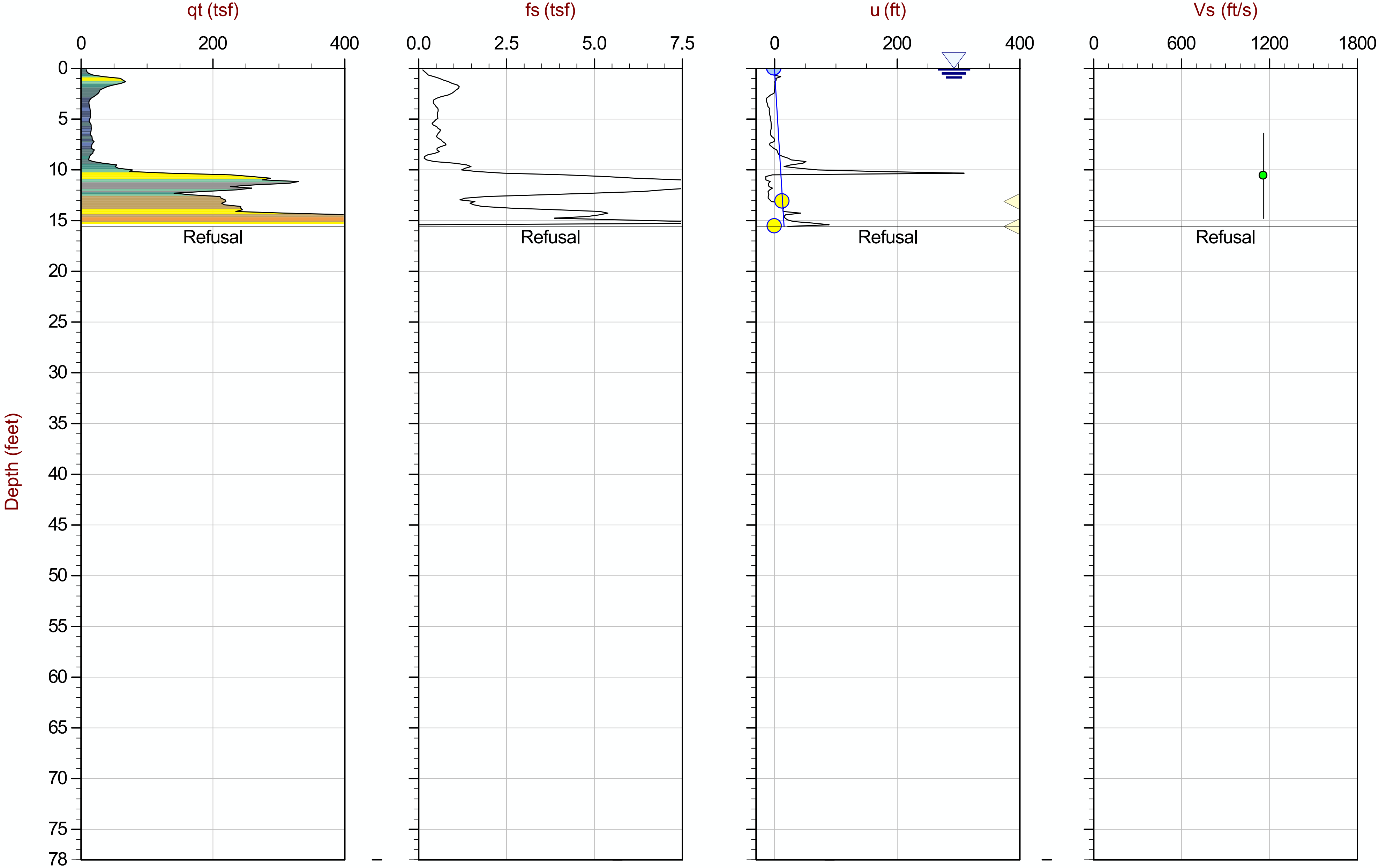
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326107m E: 292893m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:06:15 17:27
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C020
Cone: 374:T1500F15U500



Max Depth: 4.750 m / 15.58 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP20.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326035m E: 293106m

Hydrostatic Line · Ueq · Assumed Ueq · PPD, Ueq achieved · PPD, Ueq not achieved

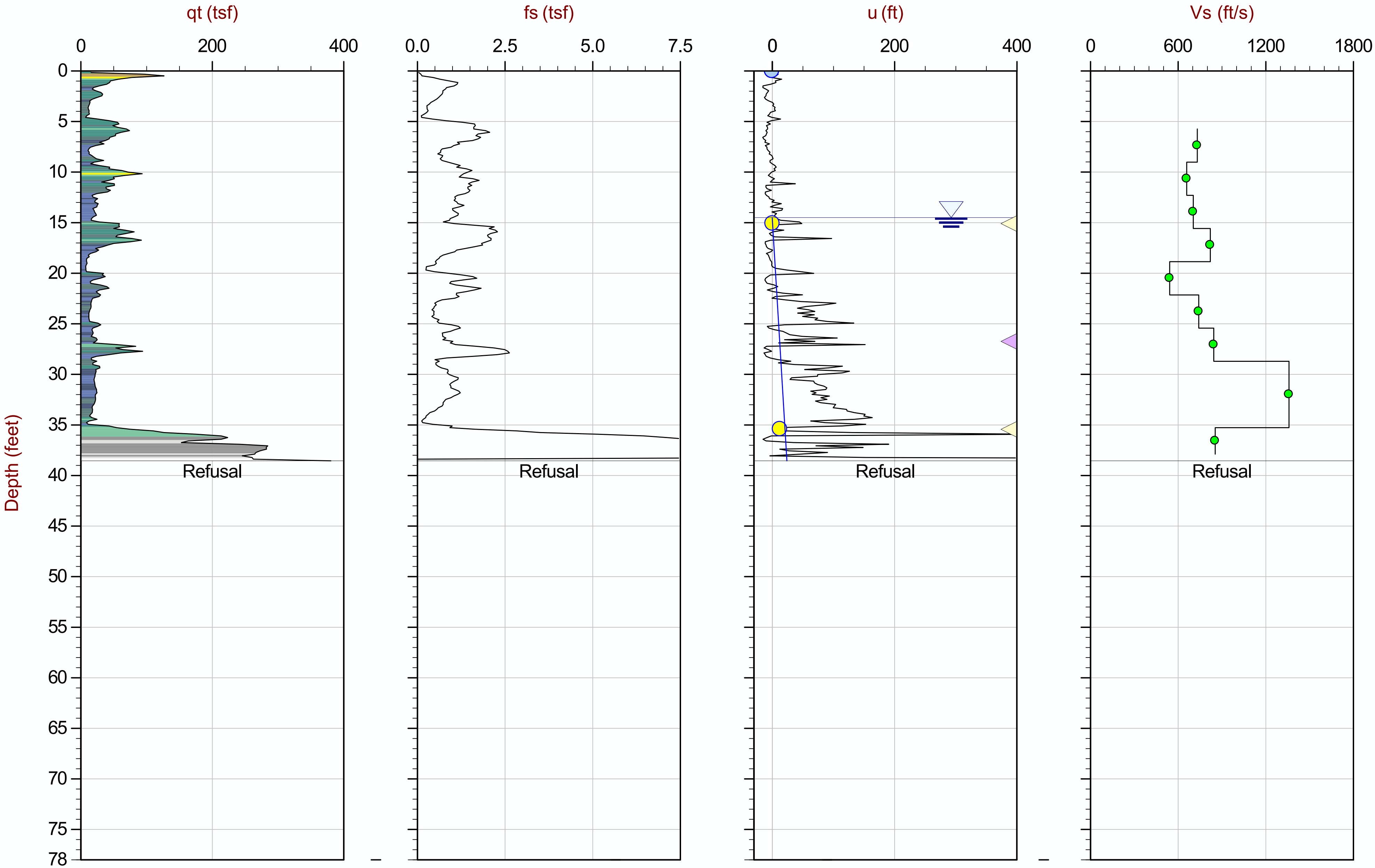
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:06:15 13:10
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C022
Cone: 335:T1500F15U500



Max Depth: 11.750 m / 38.55 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP22.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326059m E: 293072m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

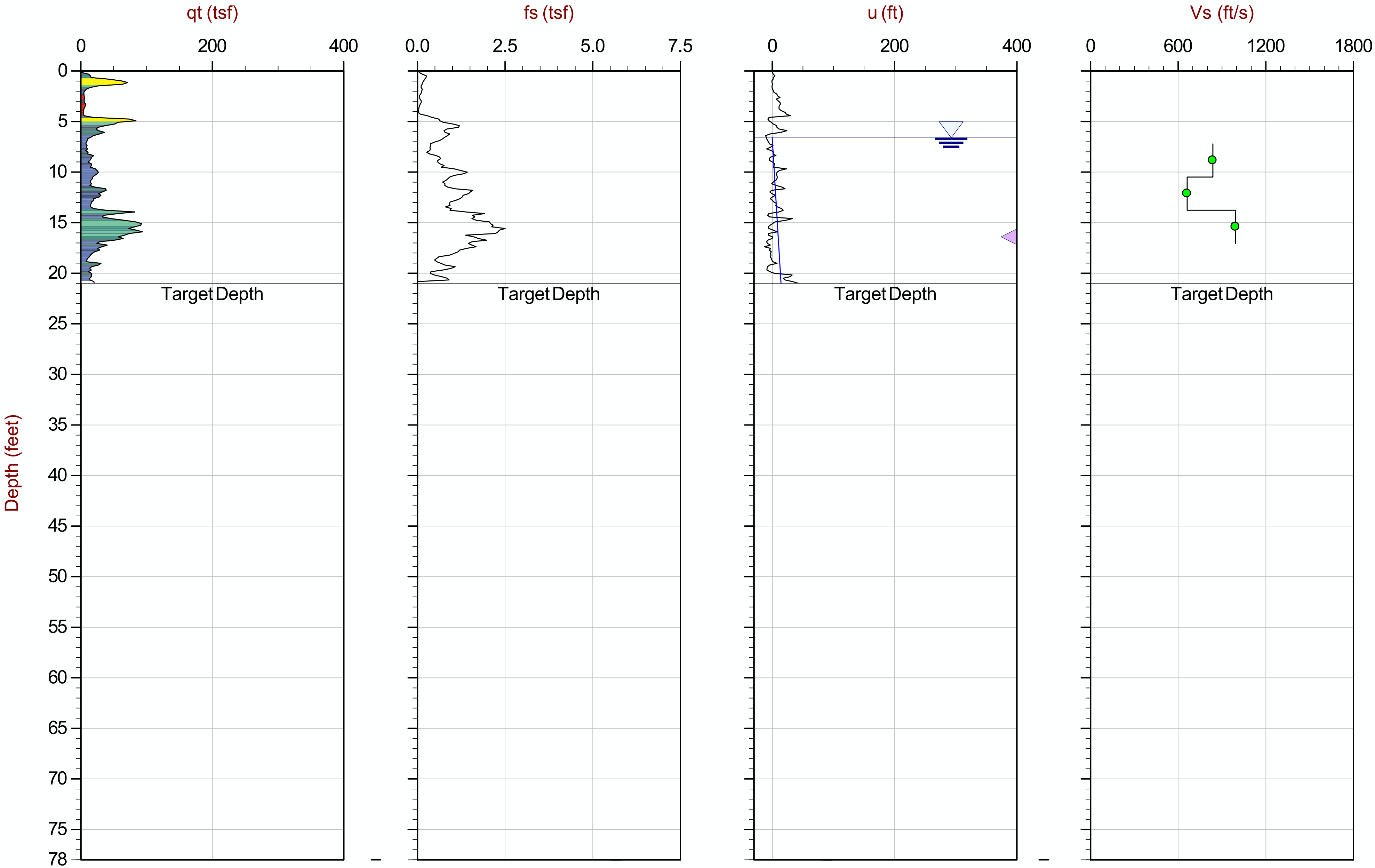
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 13:15
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C023
Cone: 374:T1500F15U500



Max Depth: 6.400 m / 21.00 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP23.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326057m E: 293071m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

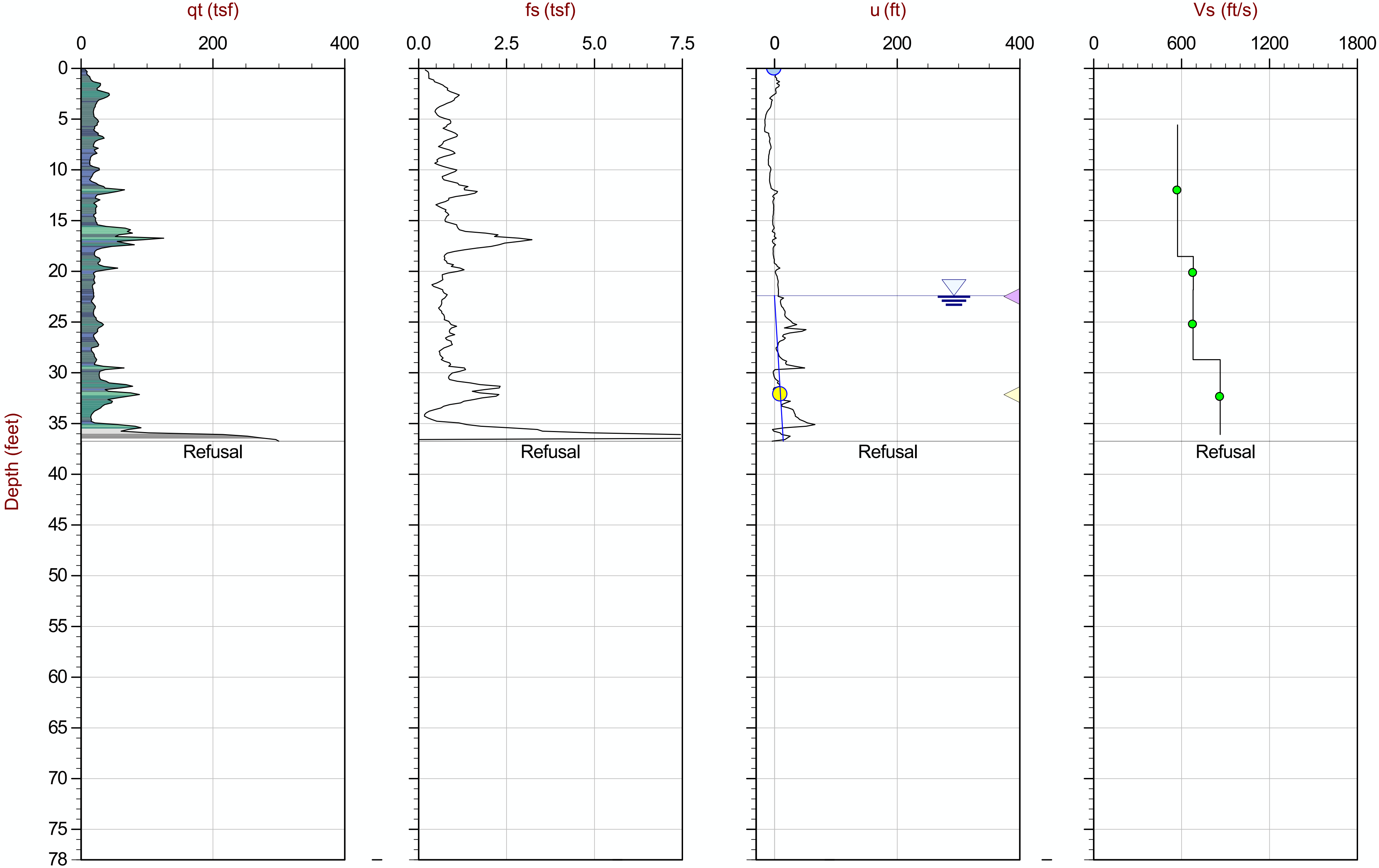
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:10:15 10:10
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C025
Cone: 335:T1500F15U500



Max Depth: 11.200 m / 36.74 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP25.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326302m E: 293062m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

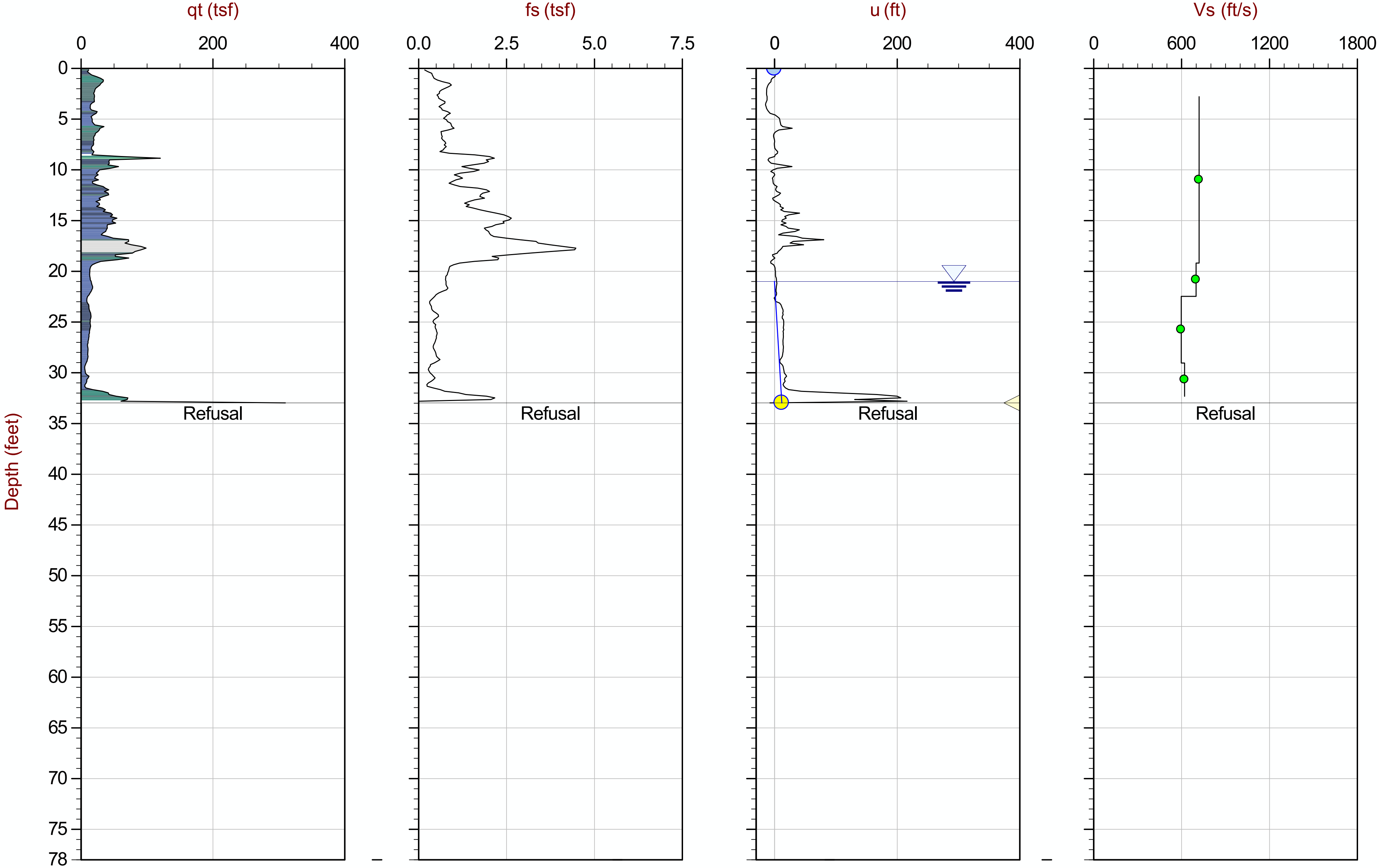
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 08:10
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C028
Cone: 335:T1500F15U500



Max Depth: 10.050 m / 32.97 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP28.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326205m E: 292686m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

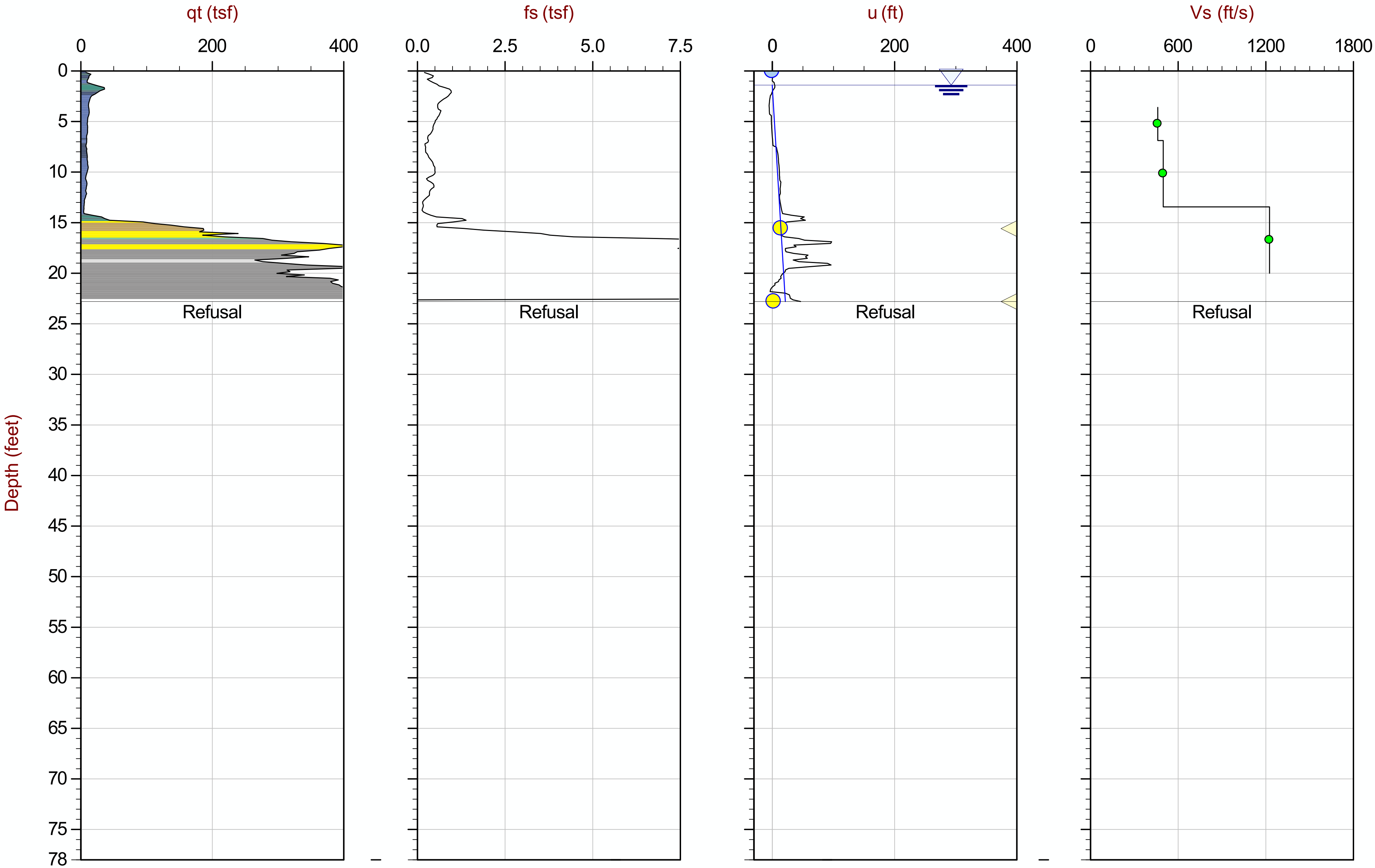
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:08:15 08:19
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C031
Cone: 374:T1500F15U500



Max Depth: 6.950 m / 22.80 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP31.COR

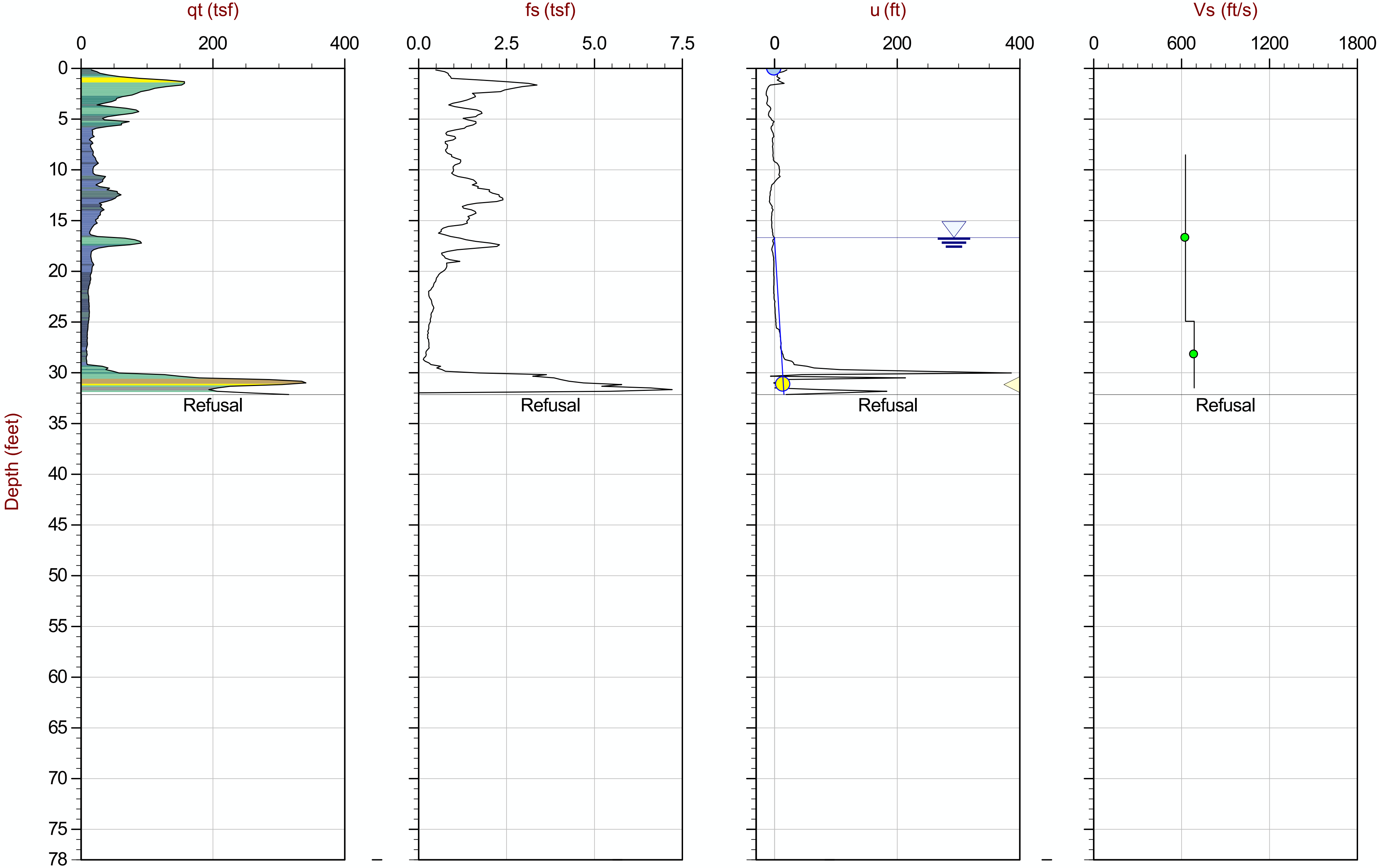
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326423m E: 292452m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:11:15 13:07
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C032
Cone: 335:T1500F15U500



Max Depth: 9.800 m / 32.15 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP32.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326423m E: 292468m

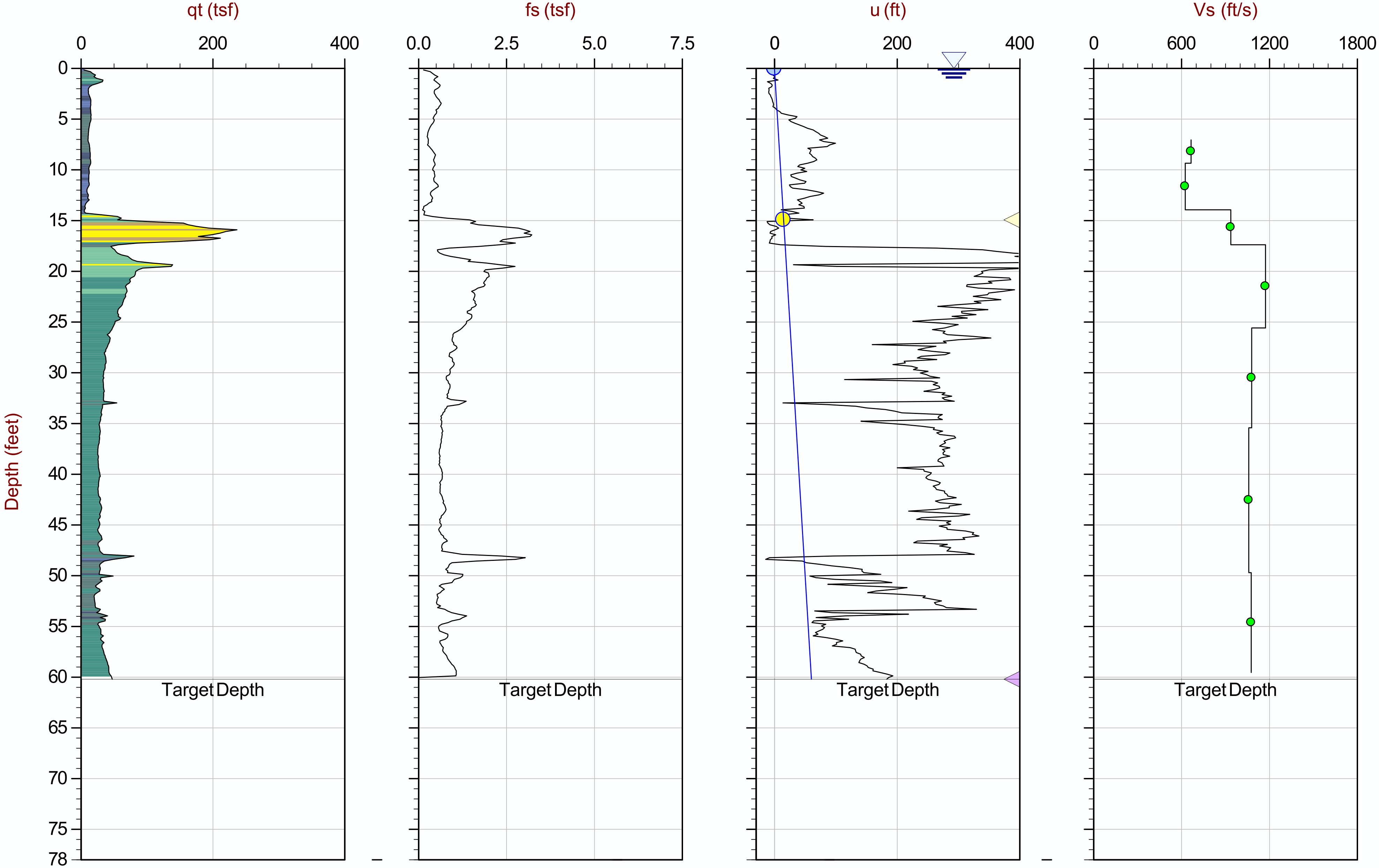
Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:08:15 10:03
Site: Coffeen Power Plant, Coffeen, IL
Sounding: COF-C034
Cone: 374:T1500F15U500



Max Depth: 18.350 m / 60.20 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP34.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326634m E: 292612m

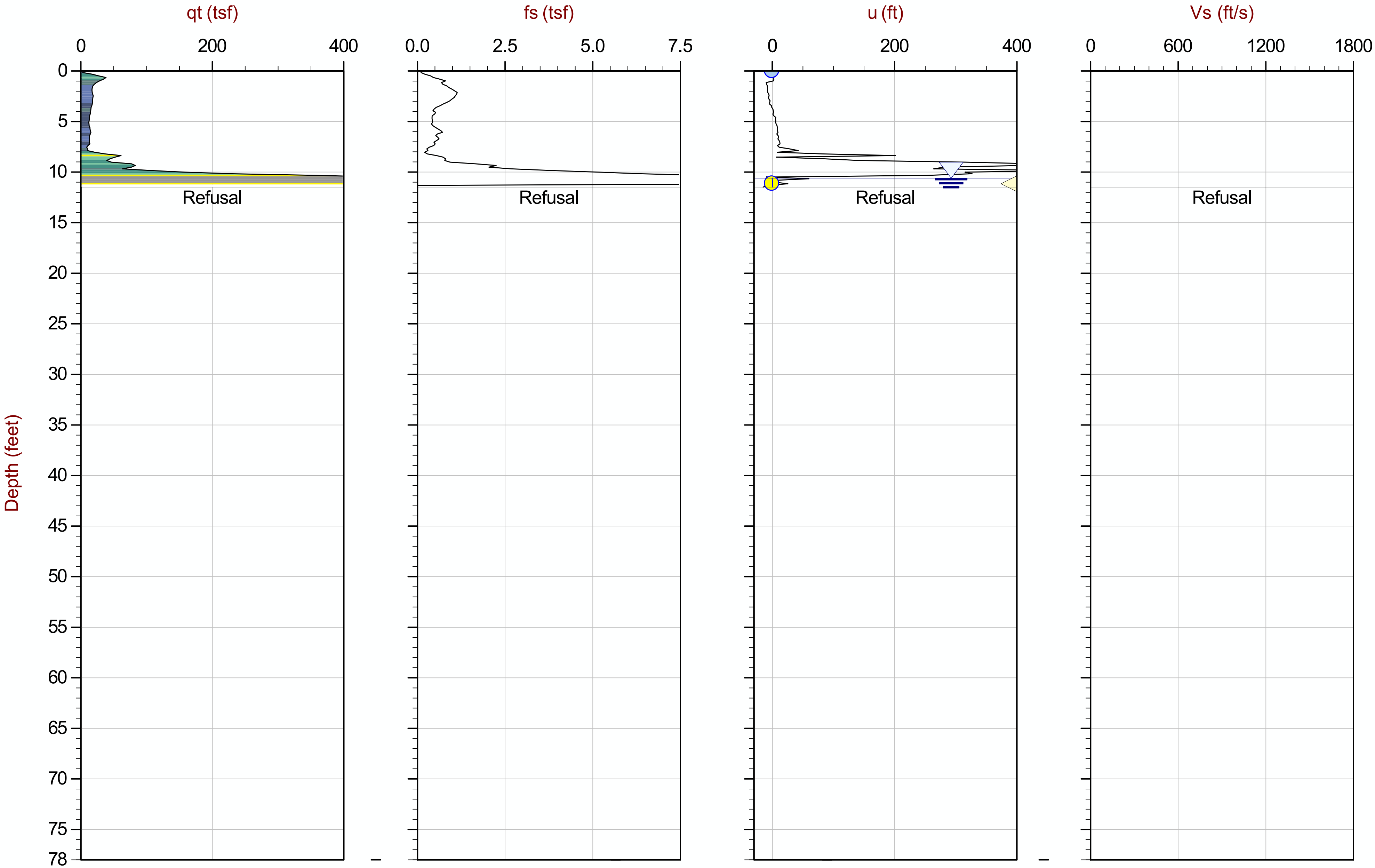
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:08:15 12:09
Site: Coffeen Power Plant, Coffeen, IL
Sounding: COF-C037
Cone: 374:T1500F15U500



Max Depth: 3.500 m / 11.48 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

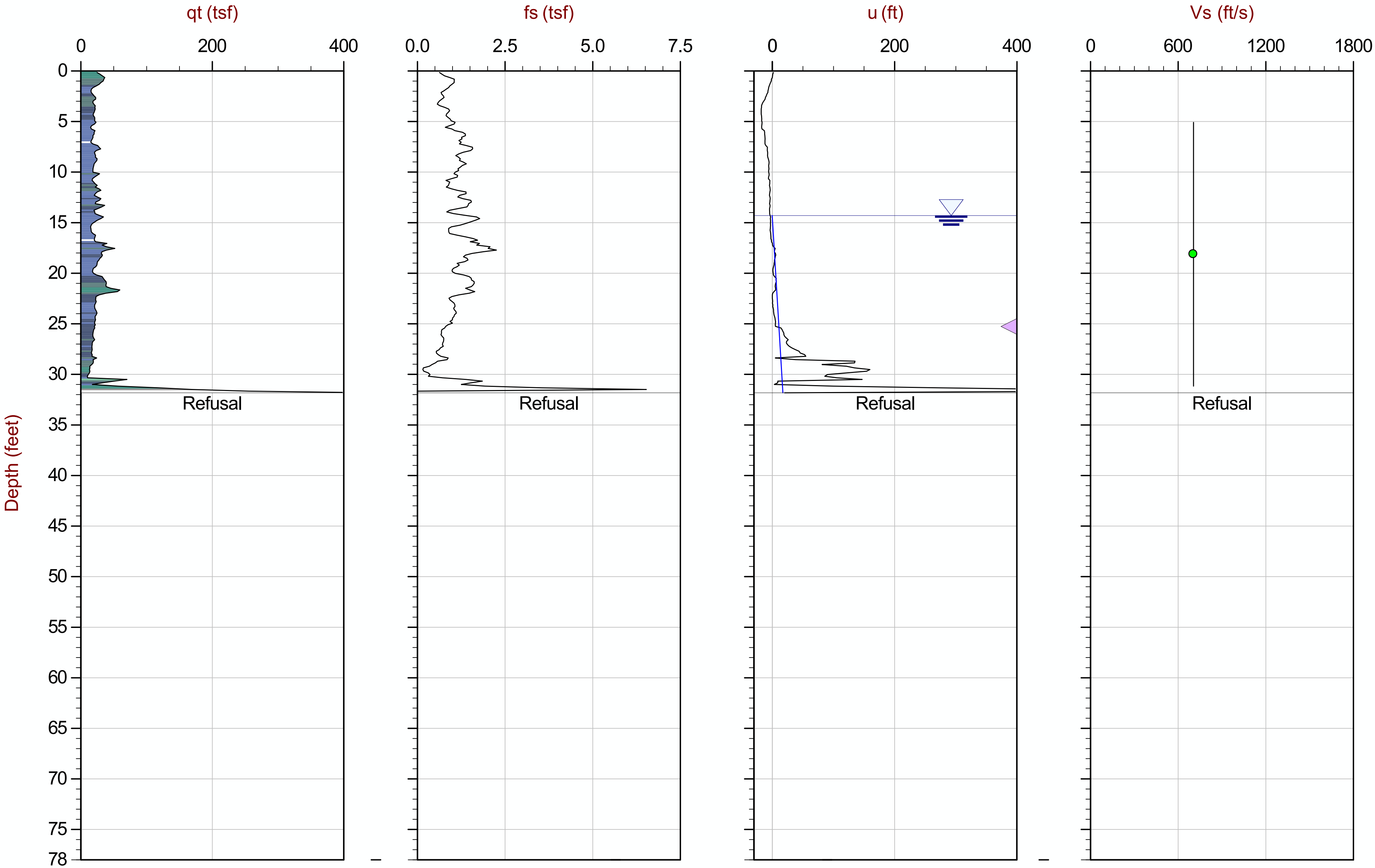
File: 15-53063_SP37.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326629m E: 292951m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC | AECOM | Job No: 15-53063 | Sounding: COF-C038
Date: 08:11:15 08:38 | Cone: 335:T1500F15U500
Site: Coffeen Power Station, Coffeen, IL



Max Depth: 9.700 m / 31.82 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP38.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326607m E: 292952m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

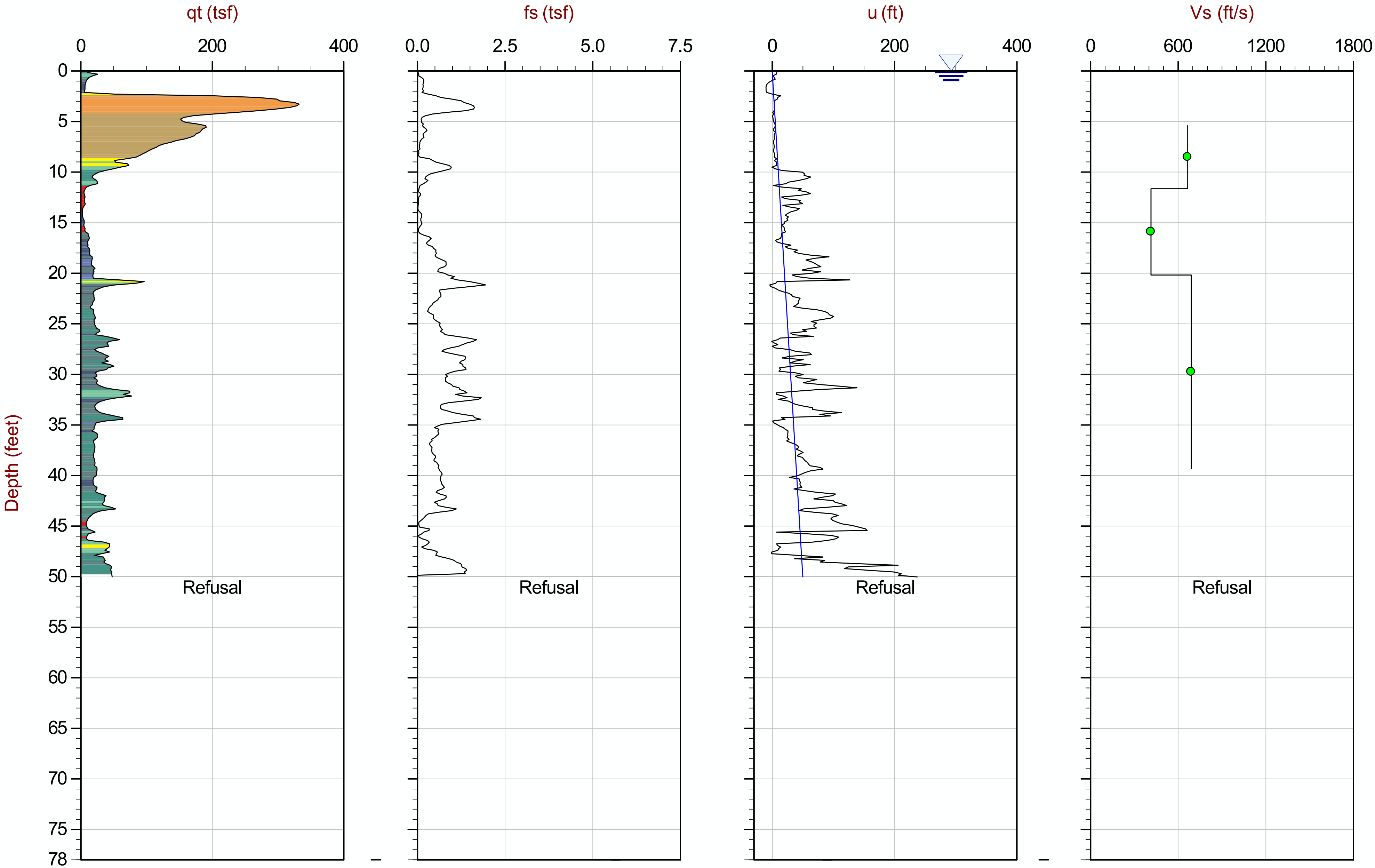
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 12:09
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C040
Cone: 335:T1500F15U500



Max Depth: 15.250 m / 50.03 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

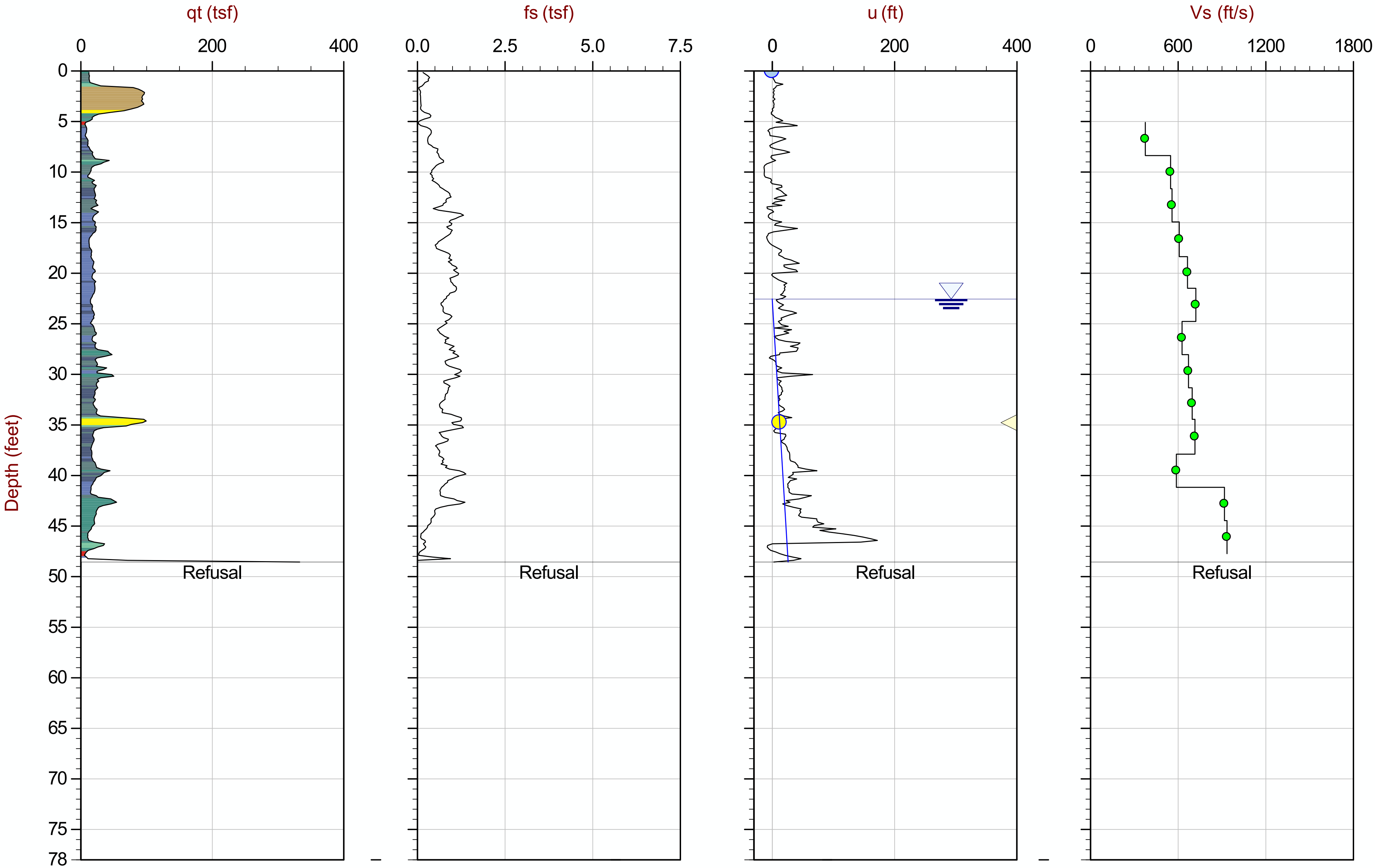
File: 15-53063_SP40.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326487m E: 293063m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM	Job No: 15-53063	Sounding: COF-C041
	Date: 08:10:15 13:52	Cone: 335:T1500F15U500
	Site: Coffeen Power Station, Coffeen, IL	



Max Depth: 14.800 m / 48.56 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP41.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326482m E: 293067m

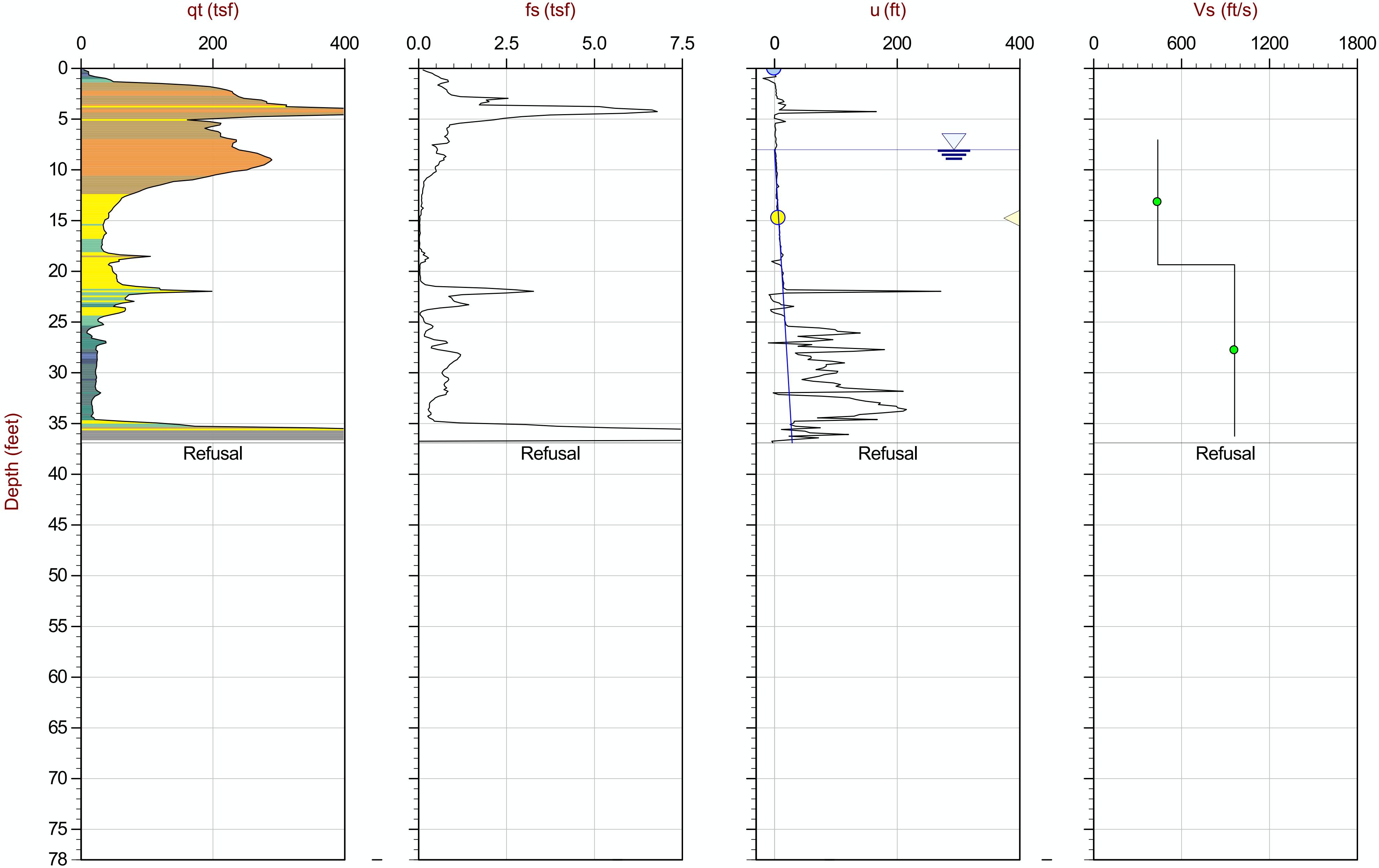
Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 14:46
Site: Coffeen Power Plant, Coffeen, IL
Sounding: COF-C043
Cone: 374:T1500F15U500



Max Depth: 11.250 m / 36.91 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP43.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326241m E: 292969m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

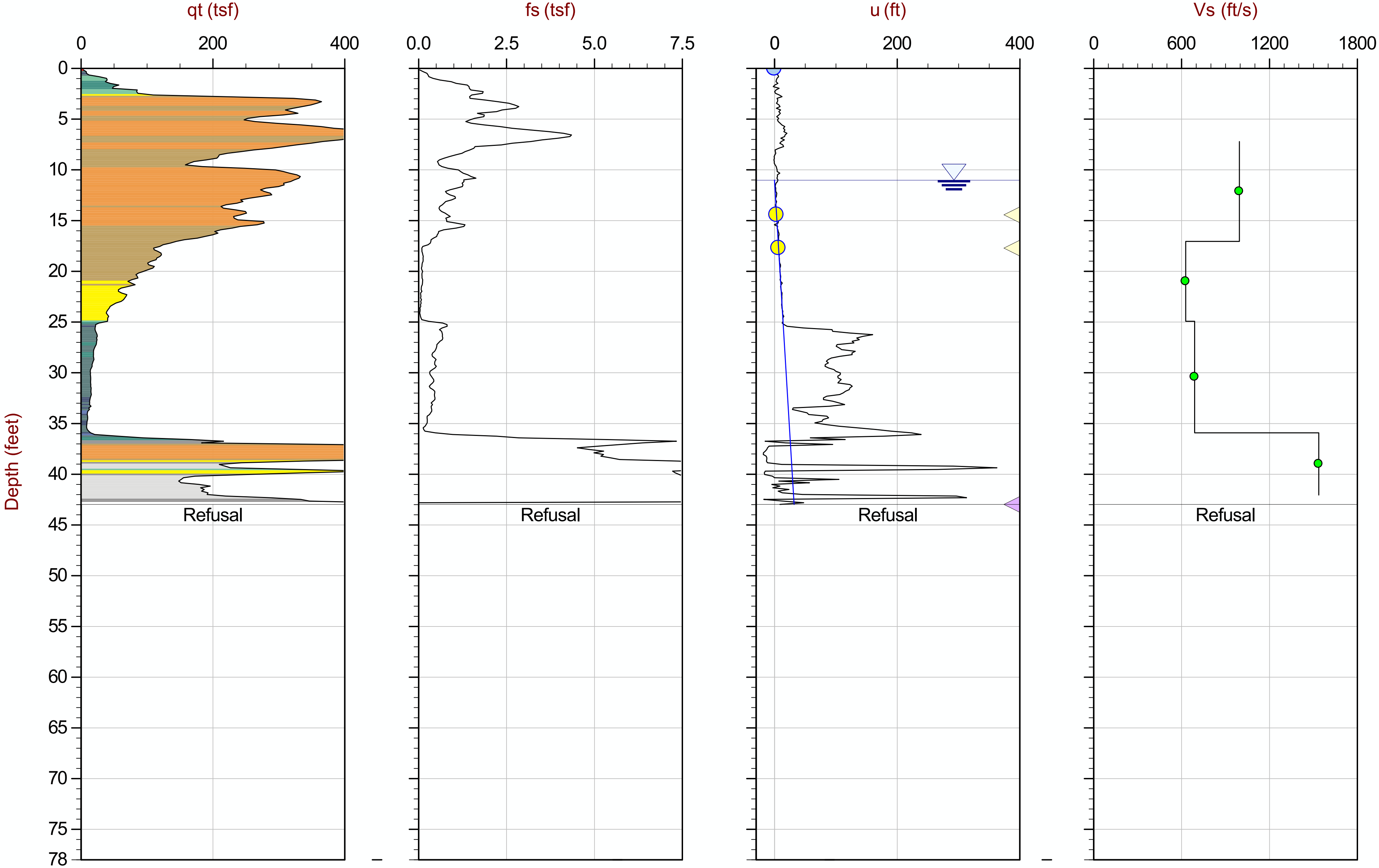
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:11:15 15:09
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C044
Cone: 374:T1500F15U500



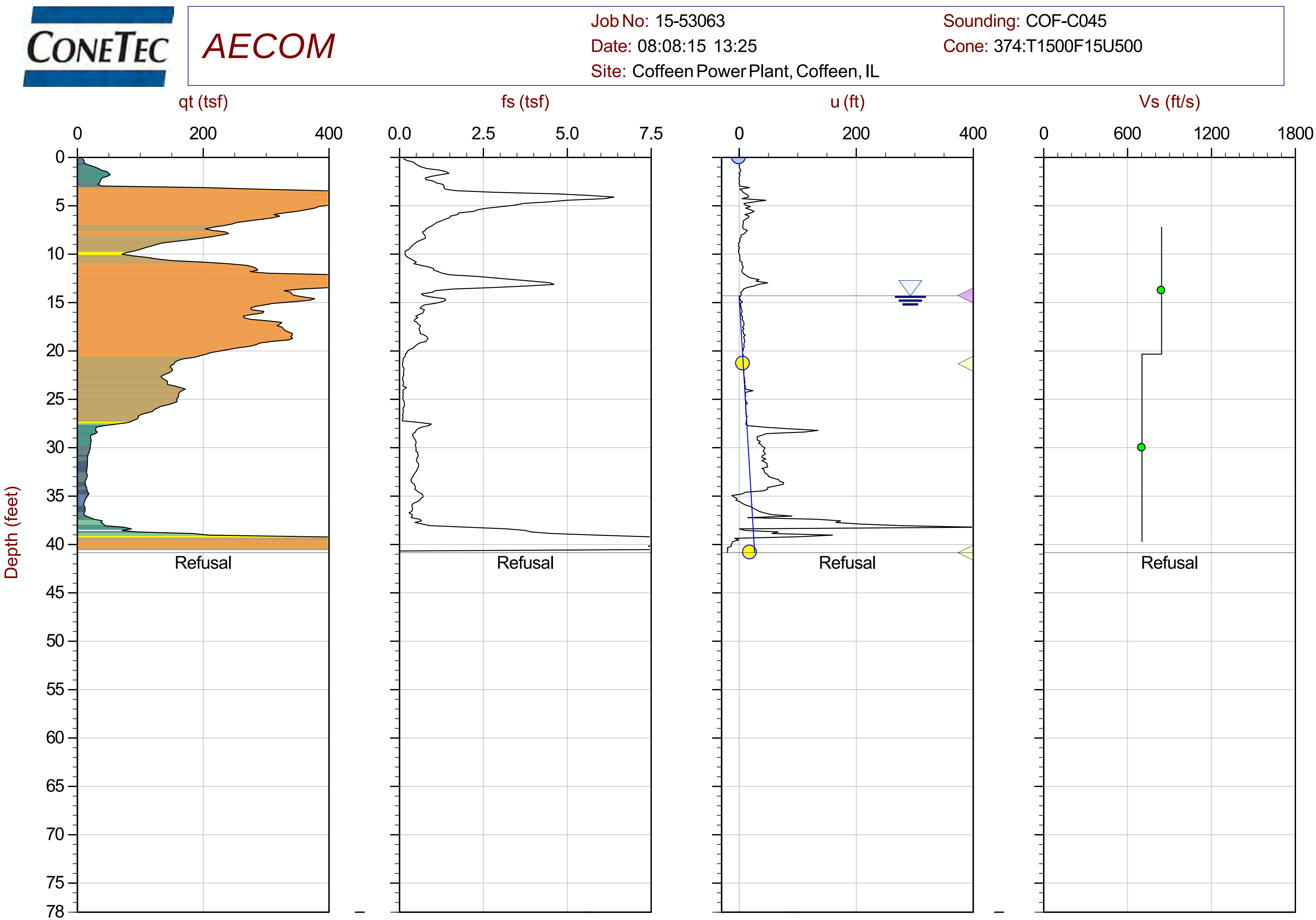
Max Depth: 13.100 m / 42.98 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP44.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326257m E: 292588m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.



Max Depth: 12.450 m / 40.85 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP45.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326563m E: 292609m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

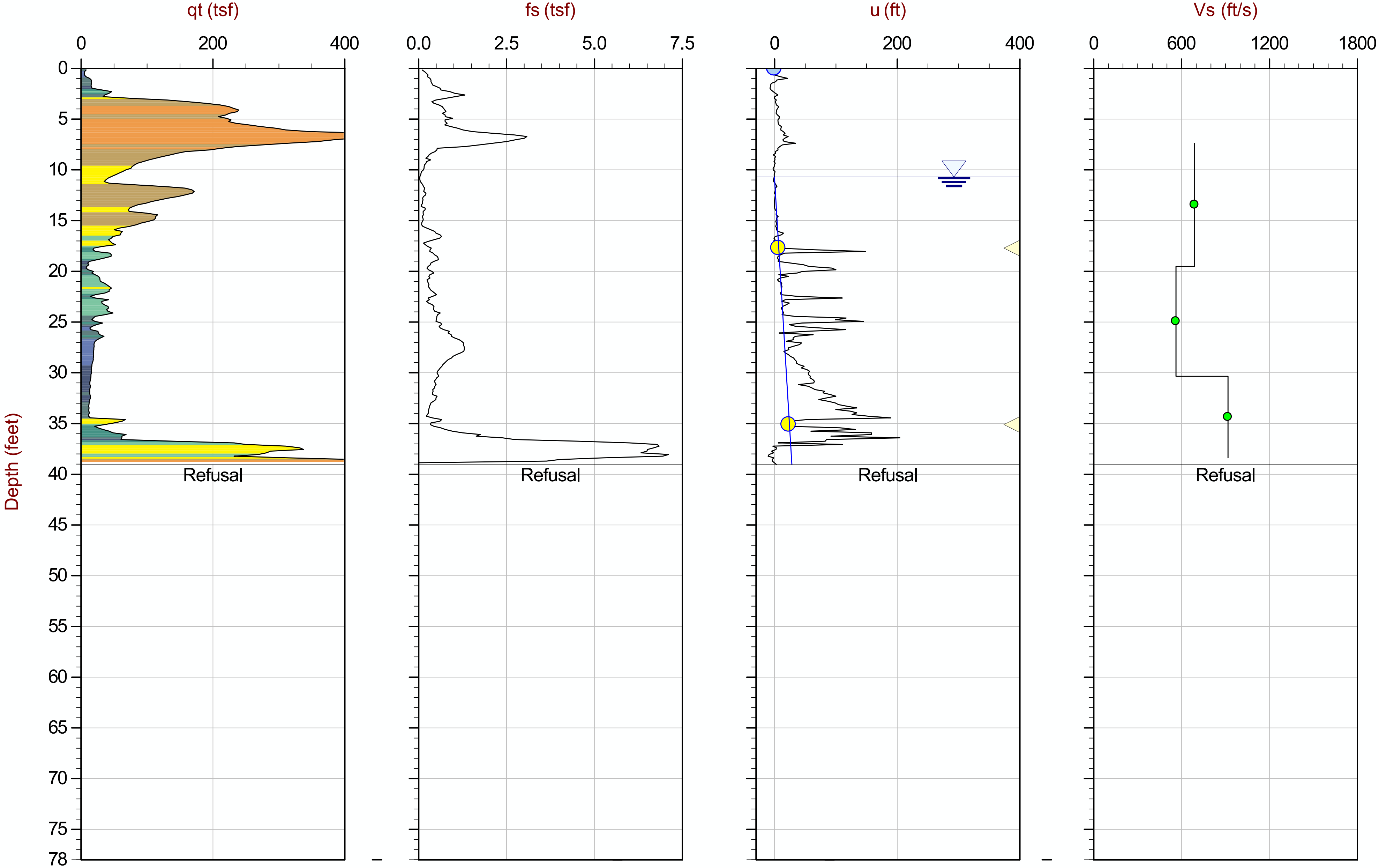
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 12:21
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C046
Cone: 374:T1500F15U500



Max Depth: 11.900 m / 39.04 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP46.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326548m E: 292890m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

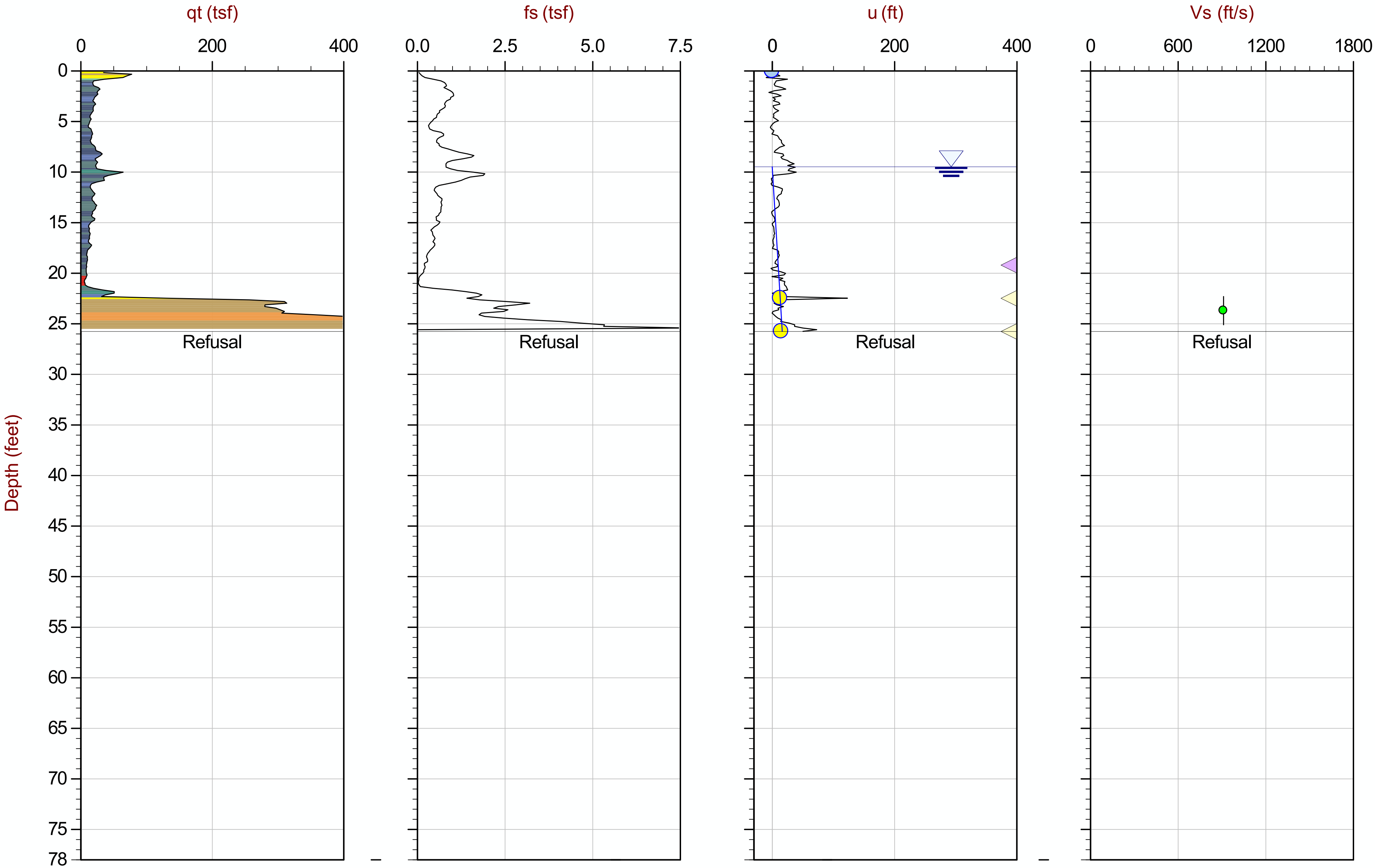
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 12:14
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335:T1500F15U500



Max Depth: 7.850 m / 25.75 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP49.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327443m E: 292710m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

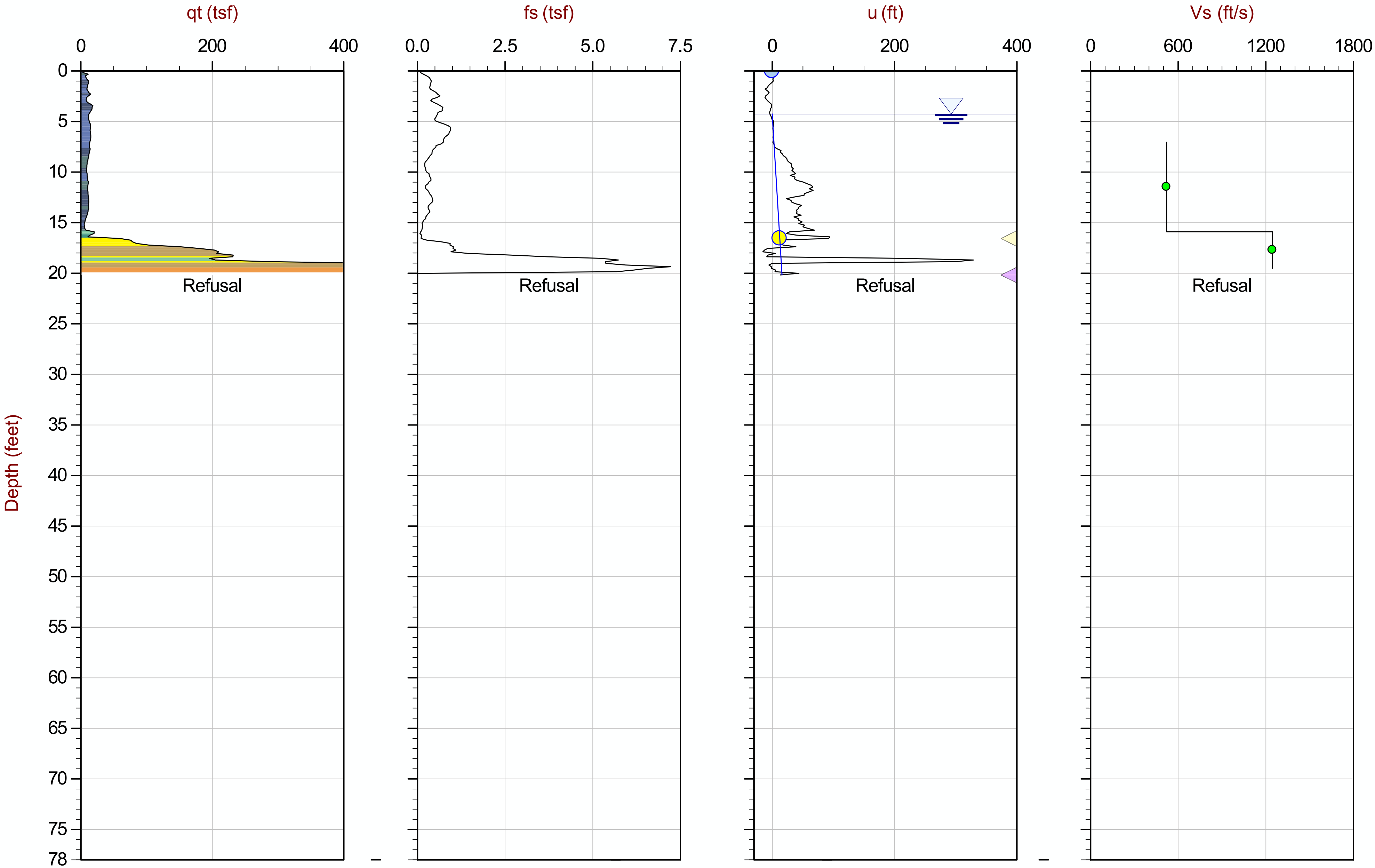
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:11:15 08:45
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C051
Cone: 374:T1500F15U500



Max Depth: 6.150 m / 20.18 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP51.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327193m E: 292459m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

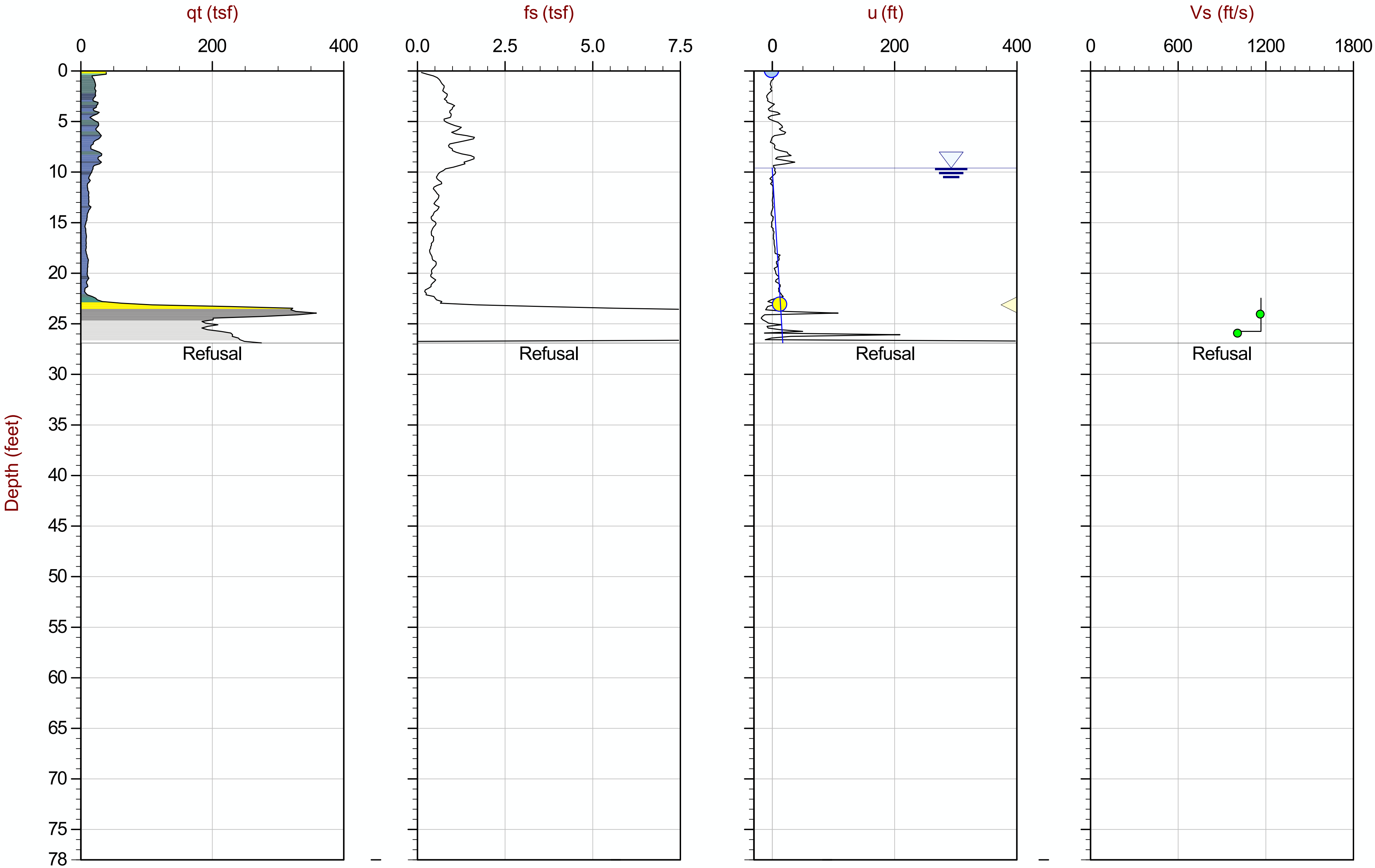
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 15:53
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C052
Cone: 335:T1500F15U500



Max Depth: 8.200 m / 26.90 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP52.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327045m E: 292612m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

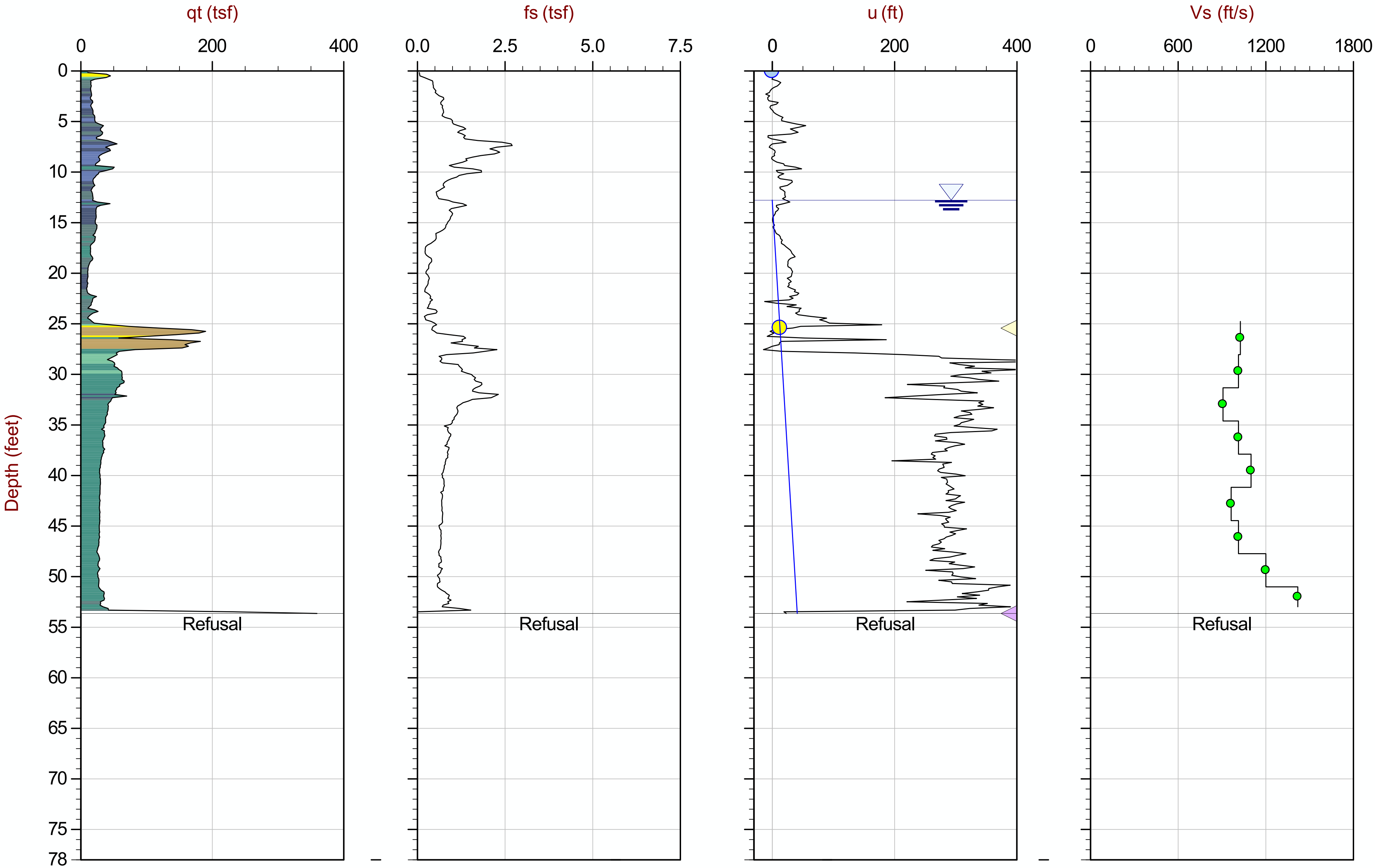
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:07:15 10:02
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C053
Cone: 335:T1500F15U500



Max Depth: 16.350 m / 53.64 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP53.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327306m E: 292894m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

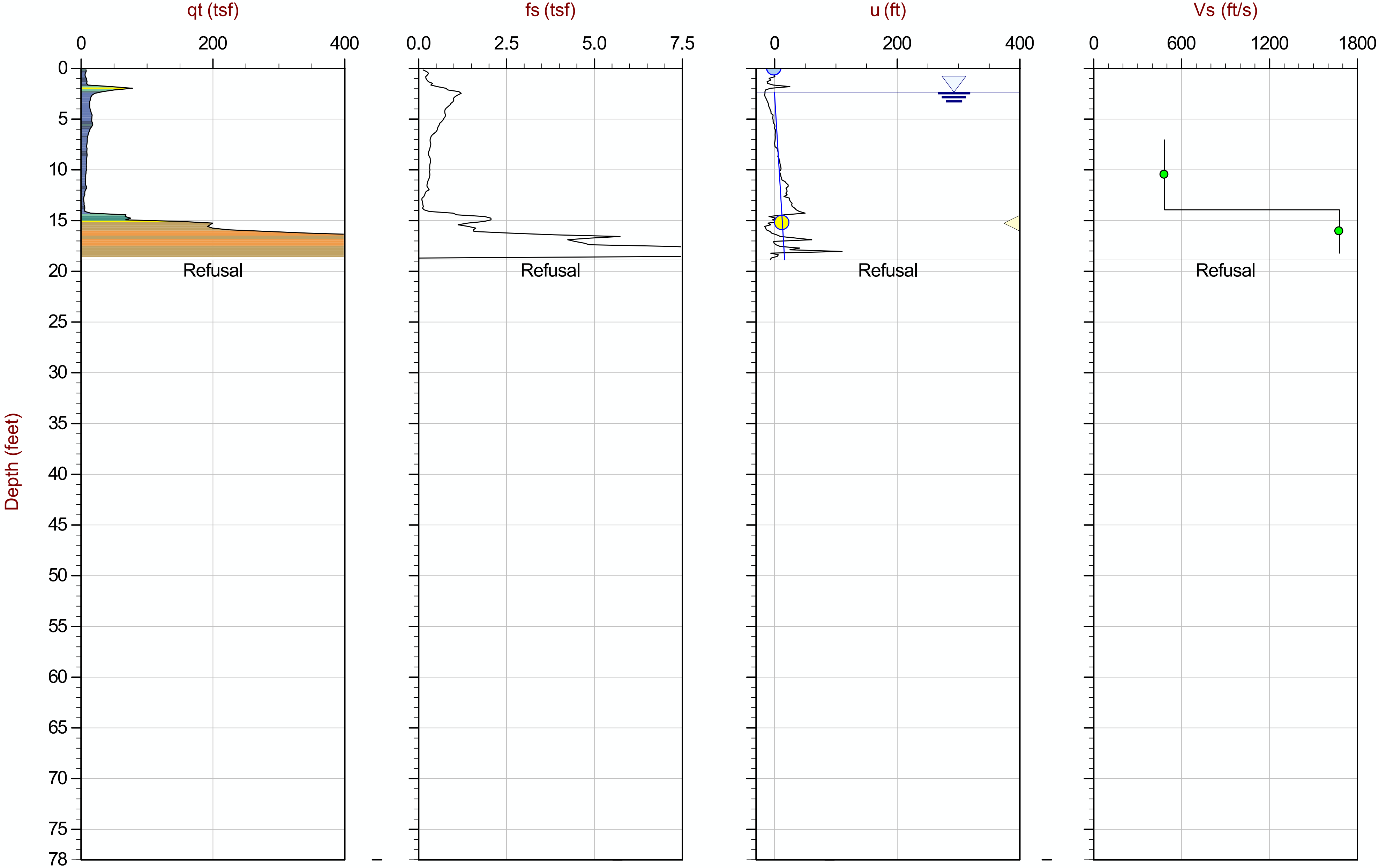
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:11:15 10:39
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C055
Cone: 374:T1500F15U500



Max Depth: 5.750 m / 18.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP55.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327459m E: 292712m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

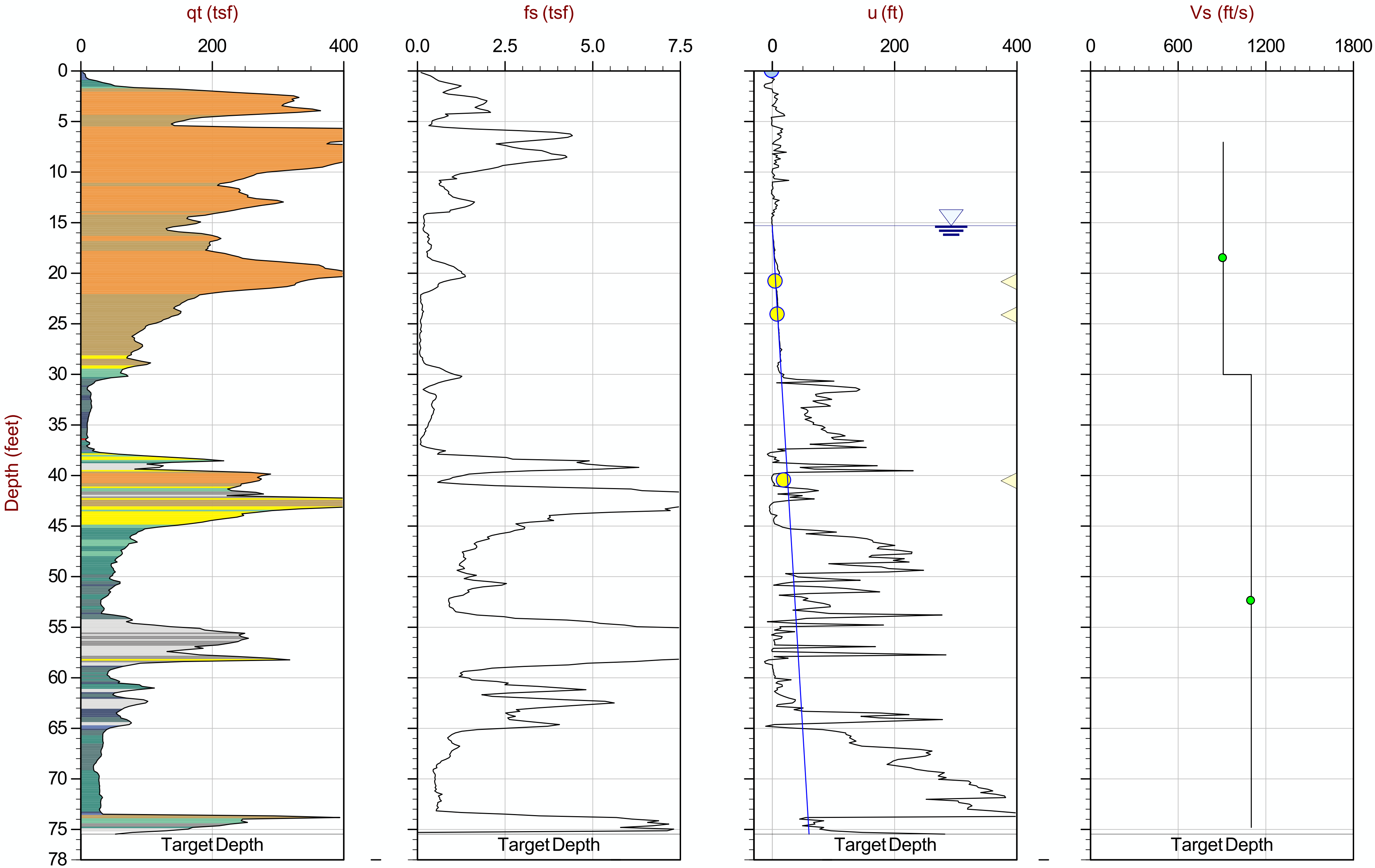
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:10:15 08:28
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C056
Cone: 374:T1500F15U500



Max Depth: 23.000 m / 75.46 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP56.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326494m E: 292684m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

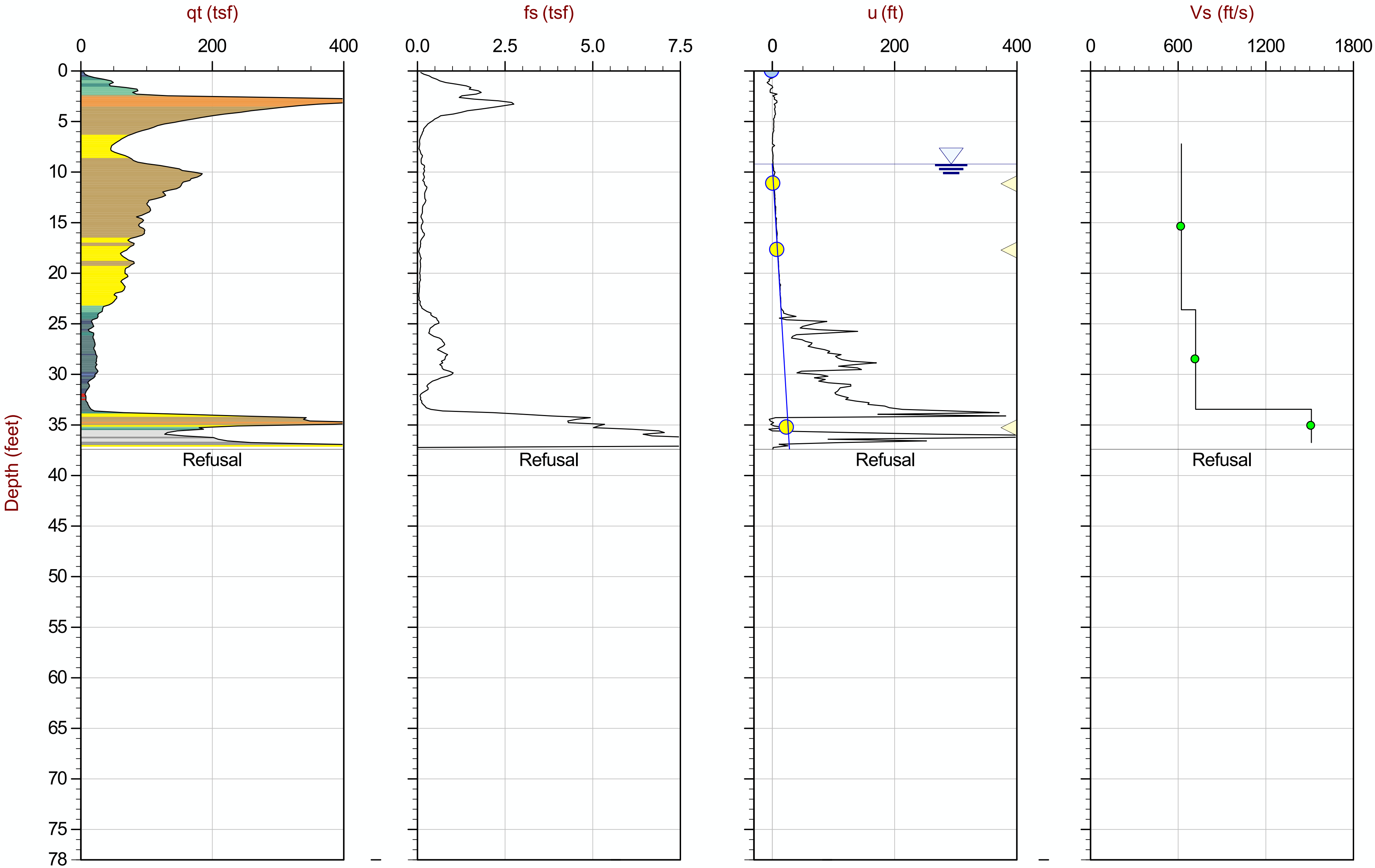
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:10:15 10:30
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C057
Cone: 374:T1500F15U500



Max Depth: 11.400 m / 37.40 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP57.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4326423m E: 292837m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Tabular Results (Vs)

CONETEC

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C001
Date: 05-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.23	5.58	5.78			
9.51	8.86	8.98	3.21	5.87	546
12.80	12.14	12.23	3.25	5.60	579
16.08	15.42	15.49	3.26	4.96	658
19.36	18.70	18.76	3.27	4.74	689
22.64	21.98	22.03	3.27	5.60	584
25.92	25.26	25.31	3.27	4.42	741
29.20	28.54	28.58	3.28	3.77	868
33.30	32.64	32.68	4.10	5.17	792

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C002
Date: 06-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.87	7.22	10.20			
24.28	23.62	24.70	14.50	19.09	759
32.81	32.15	32.95	8.25	8.97	920

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C004
Date: 06-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
31.50	30.84	30.88			
34.78	34.12	34.15	3.28	2.66	1232

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C005
Date: 07-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
9.35	8.69	8.82			
12.63	11.97	12.07	3.25	4.99	650
15.91	15.26	15.33	3.26	4.37	747
19.19	18.54	18.60	3.27	4.87	671
22.47	21.82	21.87	3.27	5.30	617
25.75	25.10	25.14	3.27	5.54	591
29.04	28.38	28.42	3.28	3.78	866
32.32	31.66	31.70	3.28	3.12	1051

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C006
Date: 04-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.07	5.41	5.62			
9.35	8.69	8.82	3.20	5.51	581
12.63	11.97	12.07	3.25	4.26	762

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station
Sounding ID:	COF-C007
Date:	07-Aug-2015

Seismic Source:	Beam
Source Offset (ft):	7.21
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
13.12	12.47	14.40			
21.00	20.34	21.58	7.18	12.02	597
30.84	30.18	31.03	9.45	12.65	747
34.61	33.96	34.71	3.68	2.55	1446

Job No:	15-53063	
Client:	AECOM	
Project:	Coffeen Power Station	
Sounding ID:	COF-C008	
Date:	05-Aug-2015	

Seismic Source:	Beam
Source Offset (ft):	1.50
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.23	5.58	5.78			
33.96	33.30	33.33	27.56	43.13	639

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C009
Date: 06-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
8.20	7.55	10.44			
13.12	12.47	14.40	3.97	5.49	723
17.55	16.90	18.37	3.97	3.28	1209

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station
Sounding ID:	COF-C010
Date:	07-Aug-2015

Seismic Source:	Beam
Source Offset (ft):	7.21
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.87	7.22	10.20			
12.14	11.48	13.56	3.36	6.45	521
21.00	20.34	21.58	8.02	12.41	646
30.84	30.18	31.03	9.45	11.72	806
32.81	32.15	32.95	1.92	1.06	1813

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station
Sounding ID:	COF-C011
Date:	05-Aug-2015

Seismic Source:	Beam
Source Offset (ft):	1.50
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.23	5.58	5.78			
16.08	15.42	15.49	9.72	17.11	568
31.99	31.33	31.37	15.88	22.85	695

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C012
Date: 04-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.23	5.58	5.78			
9.51	8.86	8.98	3.21	5.56	577
12.80	12.14	12.23	3.25	5.78	562
16.08	15.42	15.49	3.26	4.59	710
19.36	18.70	18.76	3.27	3.18	1028

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C013
Date: 05-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
16.08	15.42	15.49			
19.36	18.70	18.76	3.27	6.42	509
22.64	21.98	22.03	3.27	5.24	625
25.92	25.26	25.31	3.27	4.78	685
31.33	30.68	30.71	5.41	4.98	1086

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C014
Date: 04-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
5.91	5.25	5.46			
9.19	8.53	8.66	3.20	7.02	456
12.47	11.81	11.91	3.24	3.93	826
15.75	15.09	15.17	3.26	4.71	693
19.03	18.37	18.43	3.27	3.50	934
21.33	20.67	20.72	2.29	2.17	1056

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C018
Date: 05-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
5.74	5.09	5.30			
17.22	16.57	16.64	11.33	16.34	694

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station
Sounding ID:	COF-C020
Date:	06-Aug-2015

Seismic Source:	Beam
Source Offset (ft):	7.21
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.05	6.40	9.64			
15.45	14.80	16.46	6.82	5.87	1161

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C022
Date: 06-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.40	5.74	5.93			
9.68	9.02	9.15	3.21	4.39	731
12.96	12.30	12.39	3.25	4.93	659
16.24	15.58	15.66	3.26	4.63	704
19.52	18.86	18.92	3.27	3.99	820
22.80	22.15	22.20	3.27	6.03	542
26.08	25.43	25.47	3.27	4.42	741
29.36	28.71	28.75	3.28	3.88	844
35.92	35.27	35.30	6.55	4.82	1359
38.55	37.89	37.92	2.62	3.07	854

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C023
Date: 07-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.87	7.22	10.20			
11.15	10.50	12.74	2.53	3.03	838
14.44	13.78	15.55	2.82	4.26	662
17.72	17.06	18.52	2.97	2.99	993

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C025
Date: 10-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.23	5.58	5.78			
19.19	18.54	18.60	12.82	22.38	573
22.47	21.82	21.87	3.27	4.81	680
29.36	28.71	28.75	6.88	10.12	679
36.75	36.09	36.12	7.37	8.53	864

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station
Sounding ID:	COF-C028
Date:	10-Aug-2015

Seismic Source:	Beam
Source Offset (ft):	1.50
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
3.44	2.79	3.17			
19.85	19.19	19.25	16.09	22.34	720
23.13	22.47	22.52	3.27	4.68	699
29.69	29.04	29.07	6.55	10.95	598
32.97	32.32	32.35	3.28	5.27	621

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station
Sounding ID:	COF-C031
Date:	08-Aug-2015

Seismic Source:	Beam
Source Offset (ft):	7.21
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
4.26	3.61	8.06			
7.55	6.89	9.97	1.91	4.14	461
14.11	13.45	15.26	5.29	10.61	498
20.67	20.01	21.27	6.01	4.90	1226

CONETEC

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C032
Date: 11-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
9.19	8.53	8.66			
25.59	24.93	24.98	16.32	26.02	627
32.15	31.50	31.53	6.55	9.55	686

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C034
Date: 08-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.71	7.05	10.09			
10.01	9.35	11.81	1.72	2.59	665
14.60	13.94	15.70	3.89	6.22	625
18.04	17.39	18.82	3.13	3.34	936
26.25	25.59	26.59	7.76	6.62	1173
36.09	35.43	36.16	9.57	8.88	1079
50.36	49.70	50.22	14.07	13.28	1059
60.20	59.55	59.98	9.76	9.06	1076

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C037
Date: 08-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.87	7.22	10.20			
11.48	10.83	13.01	2.81	1.53	1839

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C038
Date: 11-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.97
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
5.74	5.09	5.45			
31.82	31.17	31.23	25.78	36.56	705

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C040
Date: 10-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
6.07	5.41	5.62			
12.30	11.65	11.74	6.13	9.20	666
20.83	20.18	20.23	8.49	20.51	414
39.99	39.34	39.37	19.13	27.74	690

Job No:	15-53063	
Client:	AECOM	
Project:	Coffeen Power Station	
Sounding ID:	COF-C041	
Date:	10-Aug-2015	

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
5.74	5.09	5.30			
9.02	8.37	8.50	3.20	8.53	375
12.30	11.65	11.74	3.24	5.92	548
15.58	14.93	15.00	3.26	5.85	558
19.03	18.37	18.43	3.43	5.64	608
22.15	21.49	21.54	3.11	4.68	664
25.43	24.77	24.82	3.27	4.54	721
28.71	28.05	28.09	3.28	5.23	627
31.99	31.33	31.37	3.28	4.88	671
35.10	34.45	34.48	3.11	4.47	696
38.55	37.89	37.92	3.44	4.81	715
41.83	41.17	41.20	3.28	5.57	588
45.11	44.46	44.48	3.28	3.58	917
48.39	47.74	47.76	3.28	3.51	935

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C043
Date: 10-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.71	7.05	10.09			
20.01	19.36	20.66	10.57	24.14	438
36.91	36.25	36.96	16.31	16.96	962

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C044
Date: 11-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.87	7.22	10.20			
17.72	17.06	18.52	8.32	8.36	995
25.59	24.93	25.96	7.43	11.84	628
36.58	35.92	36.64	10.69	15.51	689
42.72	42.06	42.67	6.03	3.92	1537

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C045
Date: 08-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.87	7.22	10.20			
21.00	20.34	21.58	11.38	13.50	843
40.35	39.70	40.35	18.77	26.69	703

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C046
Date: 10-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
8.04	7.38	10.32			
20.18	19.52	20.81	10.49	15.22	689
31.00	30.35	31.19	10.38	18.47	562
39.04	38.39	39.06	7.86	8.58	917

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C049
Date: 07-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
22.97	22.31	22.36			
25.75	25.10	25.14	2.78	3.05	911

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C051
Date: 11-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.71	7.05	10.09			
16.57	15.91	17.47	7.38	14.14	522
20.18	19.52	20.81	3.34	2.68	1246

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C052
Date: 07-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
23.13	22.47	22.52			
26.41	25.75	25.80	3.27	2.81	1167
26.90	26.25	26.29	0.49	0.49	1011

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C053
Date: 07-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
25.43	24.77	24.82			
28.71	28.05	28.09	3.28	3.19	1026
31.99	31.33	31.37	3.28	3.24	1013
35.27	34.61	34.65	3.28	3.61	907
38.55	37.89	37.92	3.28	3.24	1013
41.83	41.17	41.20	3.28	2.98	1099
45.11	44.46	44.48	3.28	3.40	963
48.39	47.74	47.76	3.28	3.24	1013
51.67	51.02	51.04	3.28	2.73	1201
53.64	52.99	53.01	1.97	1.39	1419

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C055
Date: 11-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.71	7.05	10.09			
14.60	13.94	15.70	5.61	11.58	484
18.86	18.21	19.58	3.89	2.32	1678

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station
Sounding ID:	COF-C056
Date:	10-Aug-2015

Seismic Source:	Beam
Source Offset (ft):	7.21
Source Depth (ft):	0.00
Geophone Offset (ft):	0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.71	7.05	10.09			
30.68	30.02	30.87	20.79	22.86	909
75.46	74.80	75.15	44.28	40.21	1101

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C057
Date: 10-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.87	7.22	10.20			
24.28	23.62	24.70	14.50	23.29	622
34.12	33.46	34.23	9.53	13.24	720
37.40	36.75	37.45	3.21	2.13	1512

Pore Pressure Dissipation Summary and

Pore Pressure Dissipation Plots

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station, Coffeen, IL
Start Date: 04-Aug-2015
End Date: 11-Aug-2015

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U_{eq} (ft)	Calculated Phreatic Surface (ft)	Estimated Phreatic Surface (ft)	t_{50} [a] (s)	Assumed Rigidity Index (I_r)	c_h [b] (cm^2/min)
COF-C001	15-53063_SP01	15	2220	32.48	18.59	13.89		117	100	5.98
COF-C002	15-53063_SP02	15	350	11.15						
COF-C004	15-53063_SP04	15	600	31.17	13.33	17.83		23	100	30.67
COF-C005	15-53063_SP05	15	545	30.35	15.47	14.88				
COF-C005	15-53063_SP05	15	660	33.46						
COF-C007	15-53063_SP07	15	1795	32.81						
COF-C008	15-53063_SP08	15	720	29.53	17.82	11.71				
COF-C009	15-53063_SP09	15	900	15.09	15.68	-0.59				
COF-C010	15-53063_SP10	15	300	11.15						
COF-C010	15-53063_SP10	15	300	17.72						
COF-C010	15-53063_SP10	15	400	29.53	16.24	13.29				
COF-C010	15-53063_SP10	15	2700	32.97						
COF-C011	15-53063_SP11	15	600	29.20	14.96	14.24				
COF-C012	15-53063_SP12	15	420	17.39	15.98	1.40				
COF-C013	15-53063_SP13	15	255	16.08	10.34	5.73				
COF-C013	15-53063_SP13	15	2165	29.20	23.08	6.12		41	100	17.09
COF-C014	15-53063_SP14	15	155	5.91	12.57	-6.66				
COF-C014	15-53063_SP14	15	480	15.91	12.39	3.52				
COF-C015	15-53063_CP15	15	180	32.32	16.41	15.91				
COF-C016	15-53063_CP16	15	1200	14.44	13.25	1.19				
COF-C016	15-53063_CP16	15	1800	30.84	14.53	16.31		90	100	7.77
COF-C017	15-53063_CP17	15	300	12.96						
COF-C018	15-53063_SP18	15	600	13.94	7.95	5.99				
COF-C018	15-53063_SP18	15	105	17.22	11.23		5.99	9	100	80.24
COF-C019	15-53063_CP19	15	1320	34.78						
COF-C020	15-53063_SP20	15	800	13.12	13.21	-0.08				
COF-C020	15-53063_SP20	15	600	15.58	0.64	14.94				
COF-C022	15-53063_SP22	15	320	15.09	0.64	14.45				
COF-C022	15-53063_SP22	15	275	26.74						
COF-C022	15-53063_SP22	15	425	35.43	12.84	22.59				
COF-C023	15-53063_SP23	15	600	16.40						
COF-C024	15-53063_CP24	15	3780	34.94						
COF-C025	15-53063_SP25	15	1030	22.47						
COF-C025	15-53063_SP25	15	900	32.15	9.83	22.32				
COF-C027	15-53063_CP27	15	300	10.99	1.78	9.21				
COF-C027	15-53063_CP27	15	900	31.82	14.10	17.72				
COF-C028	15-53063_SP28	15	300	32.97						
COF-C028	15-53063_SP28	15	75	32.97	12.05	20.92				
COF-C030	15-53063_CP30	15	1500	33.96	15.55	18.40				
COF-C031	15-53063_SP31	15	900	15.58	14.10	1.48				
COF-C031	15-53063_SP31	15	1100	22.80	2.57	20.24				
COF-C032	15-53063_SP32	15	600	31.17	14.49	16.68				
COF-C033	15-53063_CP33	15	300	31.00	13.93	17.07				
COF-C034	15-53063_SP34	15	1200	14.93	14.74	0.18				
COF-C034	15-53063_SP34	15	350	60.20						

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station, Coffeen, IL
Start Date: 04-Aug-2015
End Date: 11-Aug-2015

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U_{eq} (ft)	Calculated Phreatic Surface (ft)	Estimated Phreatic Surface (ft)	t_{50} [a] (s)	Assumed Rigidity Index (I_r)	c_h [b] (cm^2/min)
COF-C035	15-53063_CP35	15	600	32.64						
COF-C036	15-53063_CP36	15	420	30.84	14.02	16.82				
COF-C037	15-53063_SP37	15	300	11.15	0.00	11.15				
COF-C038	15-53063_SP38	15	430	25.26						
COF-C039	15-53063_CP39	15	300	7.71	2.35	5.36				
COF-C041	15-53063_SP41	15	500	34.78						
COF-C041	15-53063_SP41	15	120	34.78	12.22	22.56				
COF-C043	15-53063_SP43	15	600	14.76	6.75	8.01				
COF-C044	15-53063_SP44	15	600	14.44	3.42	11.02				
COF-C044	15-53063_SP44	15	300	17.72	6.67	11.05				
COF-C044	15-53063_SP44	15	110	42.98						
COF-C045	15-53063_SP45	15	300	14.27						
COF-C045	15-53063_SP45	15	300	21.33	6.84	14.49				
COF-C045	15-53063_SP45	15	1500	40.85	18.72	22.13				
COF-C046	15-53063_SP46	15	300	17.72	6.50	11.22				
COF-C046	15-53063_SP46	15	300	35.10	23.21	11.90				
COF-C049	15-53063_SP49	15	250	19.19						
COF-C049	15-53063_SP49	15	900	22.47	12.99	9.48				
COF-C049	15-53063_SP49	15	125	25.75	14.79	10.97				
COF-C050	15-53063_CP50	15	540	21.16	11.41	9.75		27	100	26.48
COF-C050	15-53063_CP50	15	260	23.95						
COF-C051	15-53063_SP51	15	1300	16.57	12.31	4.26				
COF-C051	15-53063_SP51	15	1200	20.18						
COF-C052	15-53063_SP52	15	730	23.13	13.27	9.86				
COF-C053	15-53063_SP53	15	720	25.43	12.65	12.78				
COF-C053	15-53063_SP53	15	65	25.43	12.74	12.69				
COF-C053	15-53063_SP53	15	465	53.64						
COF-C054	15-53063_CP54	15	300	17.22	14.87	2.35				
COF-C054	15-53063_CP54	15	300	65.62						
COF-C055	15-53063_SP55	15	300	15.26	12.91	2.35				
COF-C056	15-53063_SP56	15	300	20.83	5.64	15.19				
COF-C056	15-53063_SP56	15	300	24.11	8.97	15.14				
COF-C056	15-53063_SP56	15	300	40.52	19.53	20.99				
COF-C057	15-53063_SP57	15	300	11.15	1.87	9.28				
COF-C057	15-53063_SP57	15	300	17.72	8.55	9.17				
COF-C057	15-53063_SP57	15	900	35.27	24.14	11.13				
Totals	81 dissipations		902.7 min							

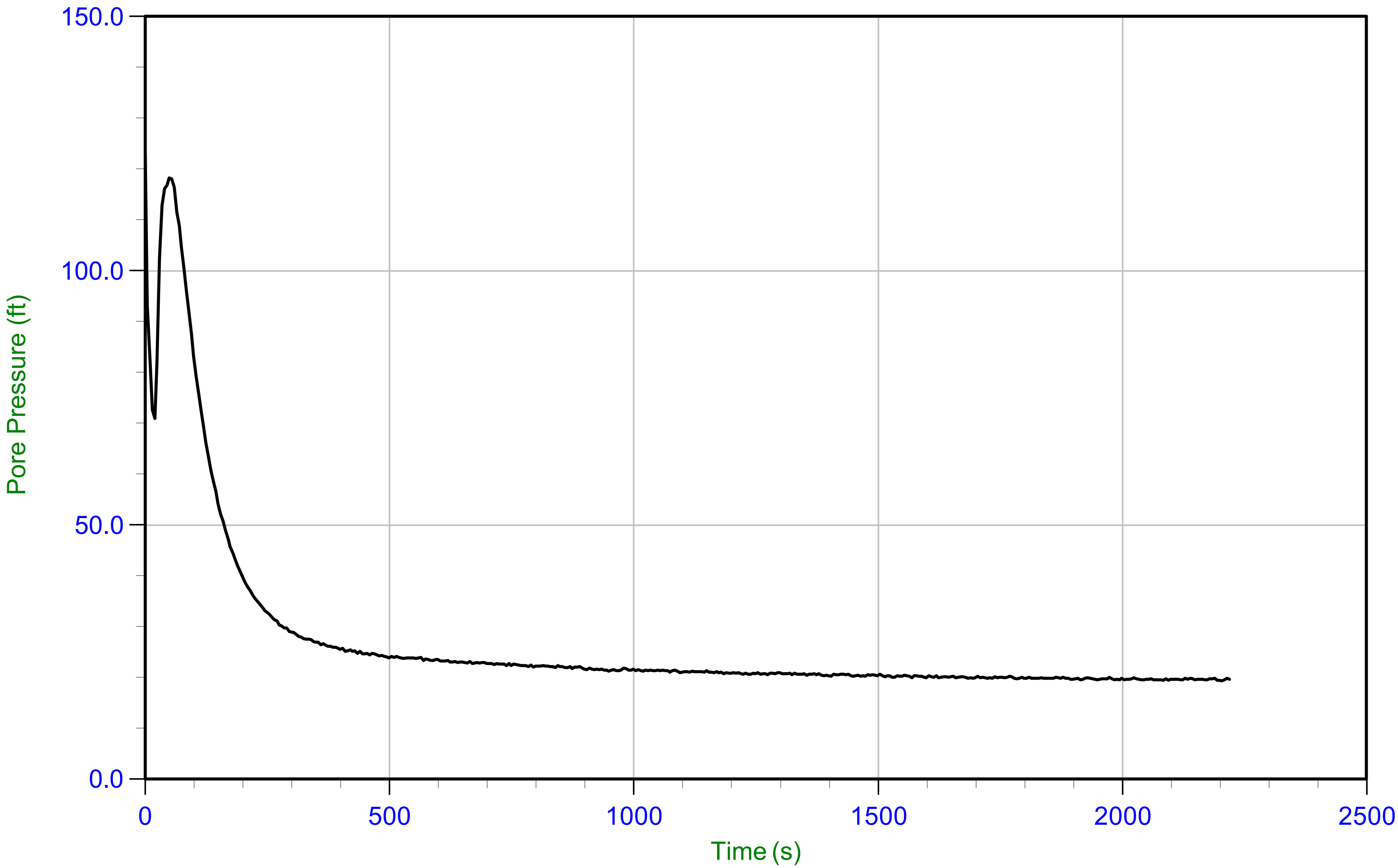
a. Time is relative to where umax occurred
b. Houlsby and Teh, 1991

CONETEC

AECOM

Job No: 15-53063
Date: 05-Aug-2015 11:25:27
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C001
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP01.PPD
Depth: 9.900 m / 32.480 ft
Duration: 2220.0 s

U Min: 19.4 ft
U Max: 123.0 ft

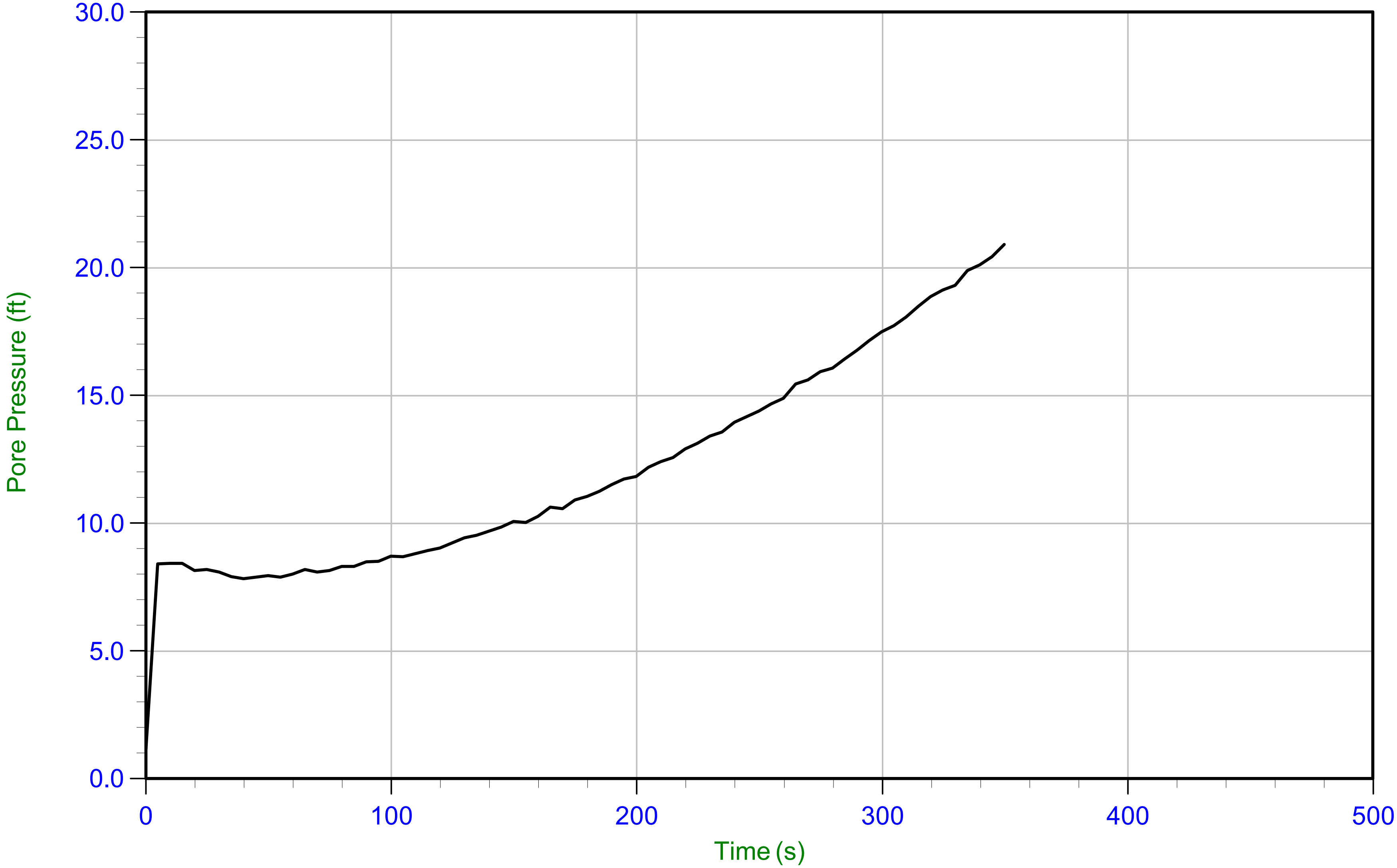
WT: 4.234 m / 13.891 ft
Ueq: 18.6 ft
U(50): 70.82 ft

T(50): 117.3 s
Ir: 100
Ch: 6.0 sq cm/min

AECOM

Job No: 15-53063
Date: 06-Aug-2015 13:40:38
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C002
Cone: 374
Cone Area: 15 sq cm

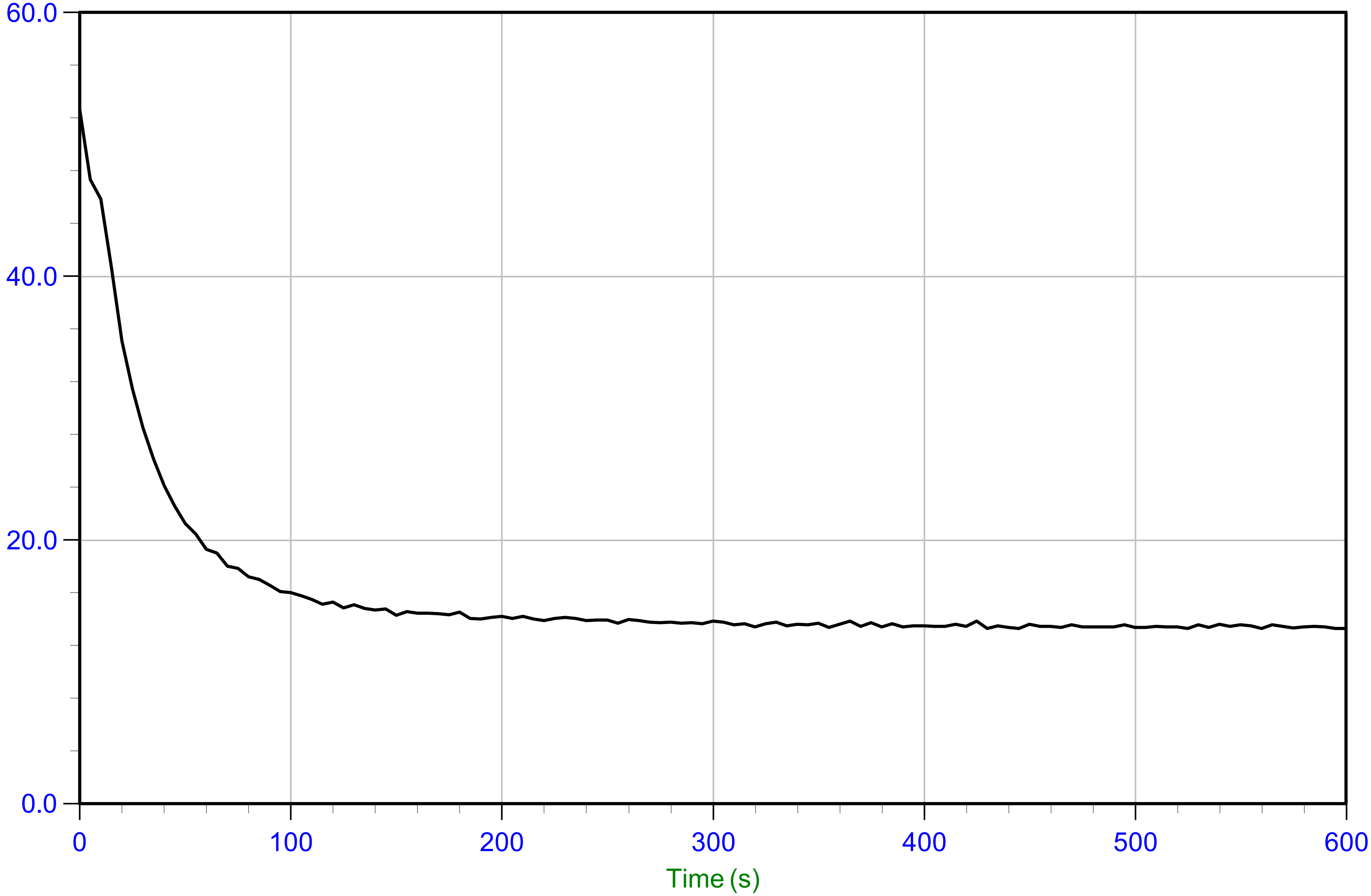


Trace Summary:

Filename: 15-53063_SP02.PPD
Depth: 3.400 m / 11.155 ft
Duration: 350.0 s

U Min: 1.1 ft
U Max: 20.9 ft

ConeTec	AECOM	Job No: 15-53063	Sounding: COF-C004
		Date: 06-Aug-2015 15:03:55	Cone: 335
		Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

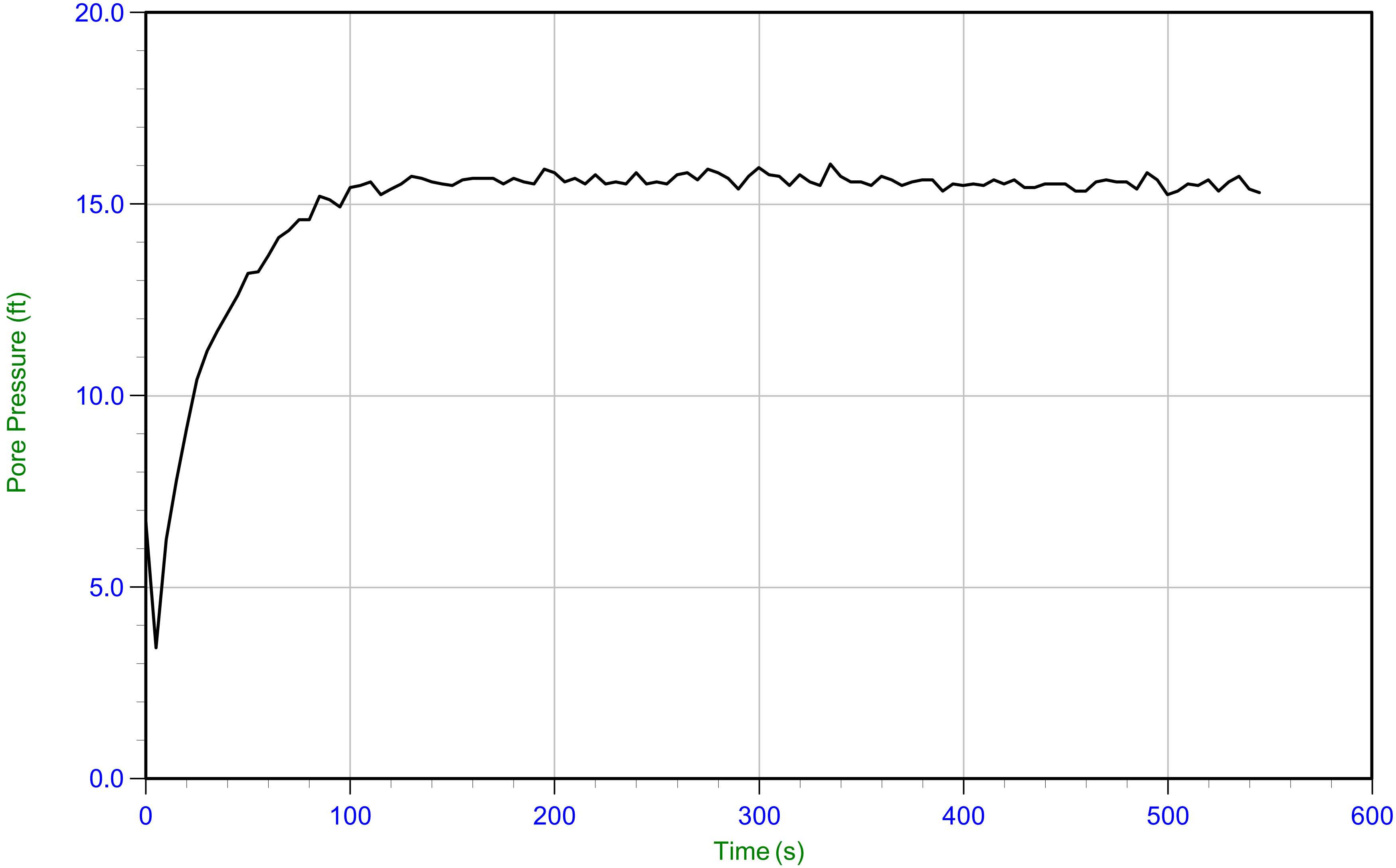
Filename: 15-53063_SP04.PPD	U Min: 13.3 ft	WT: 5.436 m / 17.834 ft	T(50): 22.9 s
Depth: 9.500 m / 31.168 ft	U Max: 52.7 ft	Ueq: 13.3 ft	Ir: 100
Duration: 600.0 s		U(50): 32.99 ft	Ch: 30.7 sq cm/min

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 07:21:31
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C005
Cone: 335
Cone Area: 15 sq cm



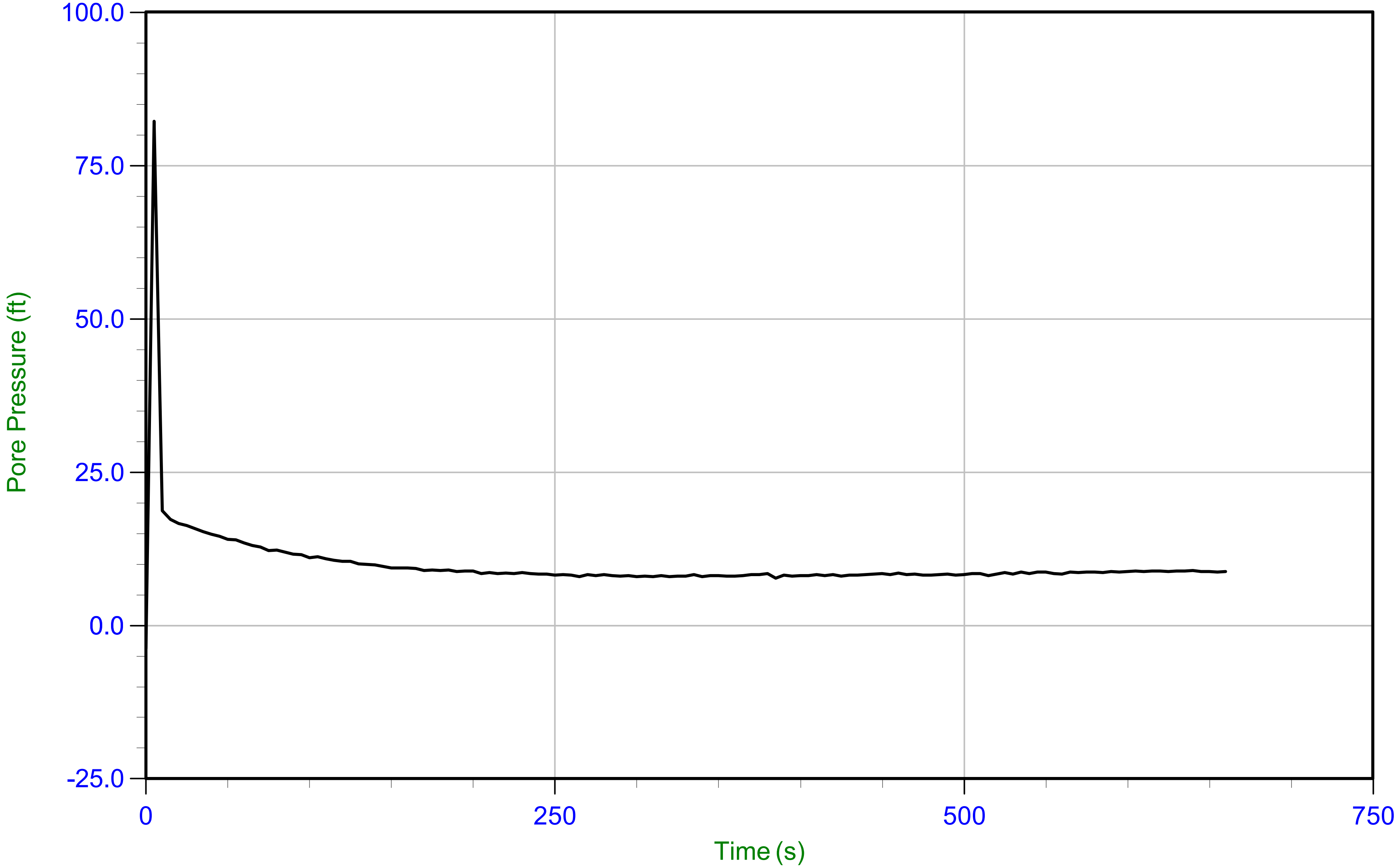
Trace Summary:

Filename: 15-53063_SP05.PPD
Depth: 9.250 m / 30.347 ft
Duration: 545.0 s

U Min: 3.4 ft
U Max: 16.1 ft

WT: 4.535 m / 14.878 ft
Ueq: 15.5 ft

AECOM	Job No: 15-53063 Date: 07-Aug-2015 07:21:31 Site: Coffeen Power Station, Coffeen, IL	Sounding: COF-C005 Cone: 335 Cone Area: 15 sq cm

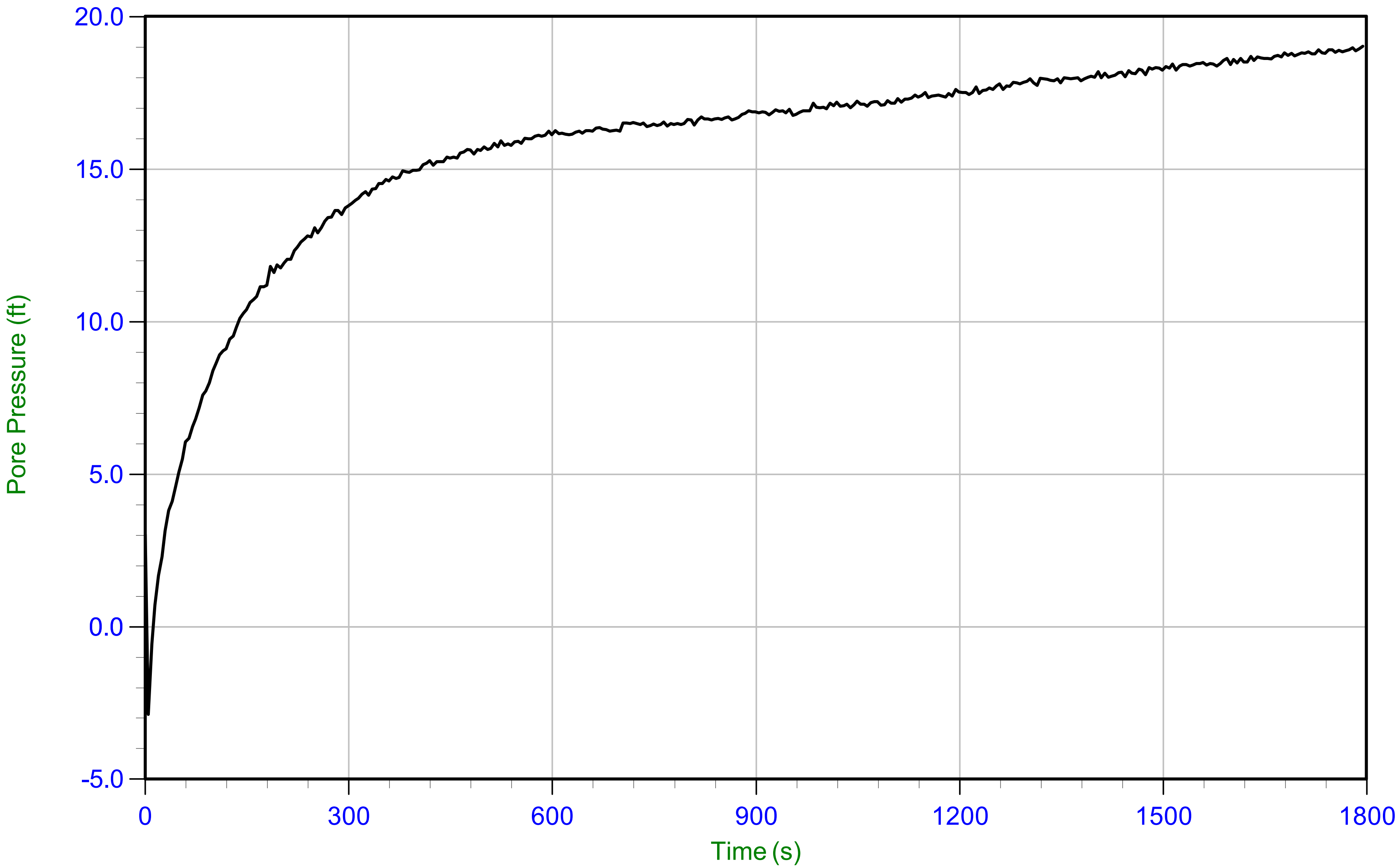


Trace Summary:

Filename: 15-53063_SP05.PPD
Depth: 10.200 m / 33.464 ft
Duration: 660.0 s

U Min: -3.8 ft
U Max: 82.2 ft

AECOM	Job No: 15-53063	Sounding: COF-C007
	Date: 07-Aug-2015 11:18:02	Cone: 374
	Site: Coffeen Power Plant, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

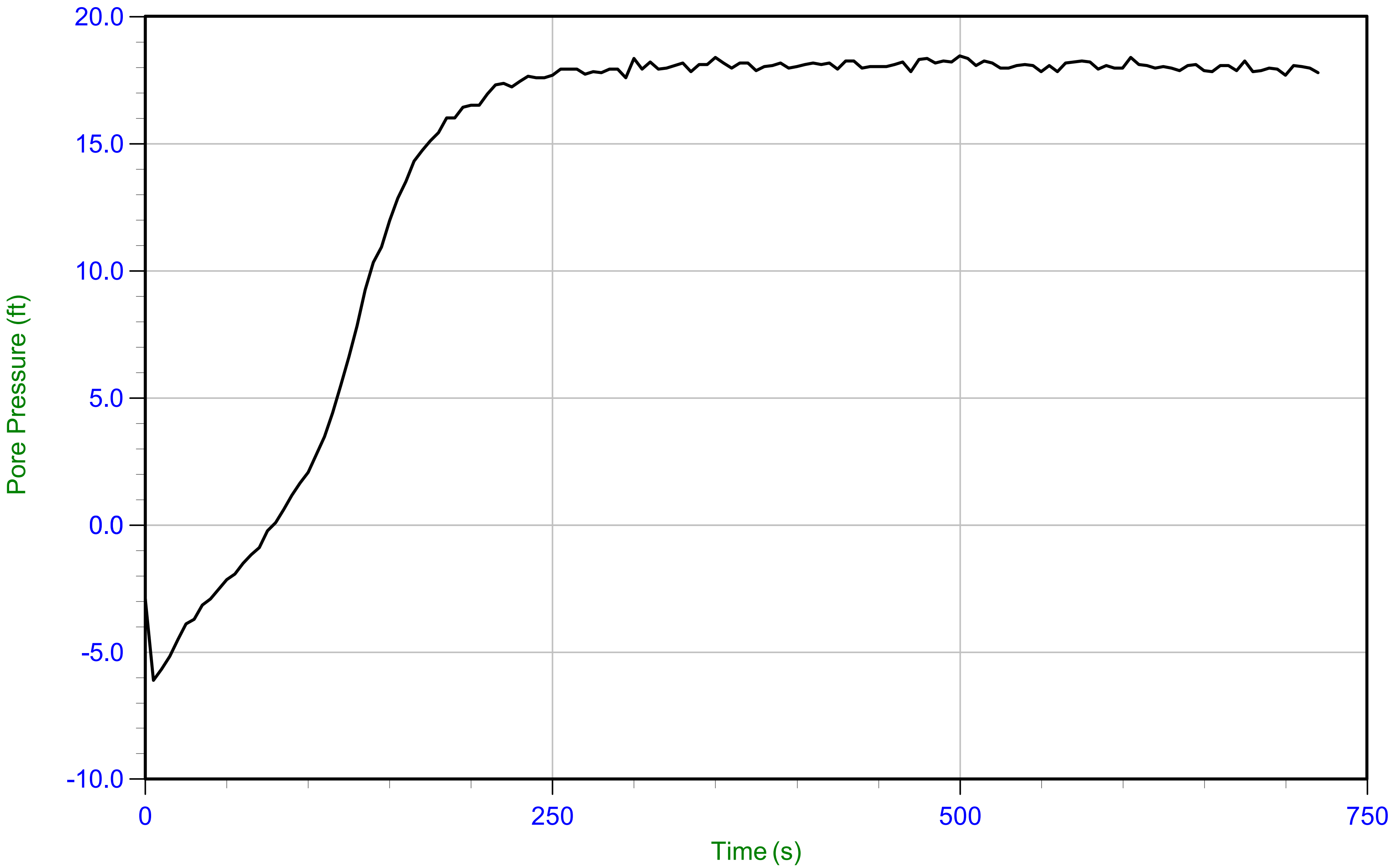
Filename: 15-53063_SP07.PPD
Depth: 10.000 m / 32.808 ft
Duration: 1795.0 s

U Min: -2.9 ft
U Max: 19.0 ft

AECOM

Job No: 15-53063
Date: 05-Aug-2015 09:57:19
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C008
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP08.PPD
Depth: 9.000 m / 29.527 ft
Duration: 720.0 s

U Min: -6.1 ft
U Max: 18.4 ft

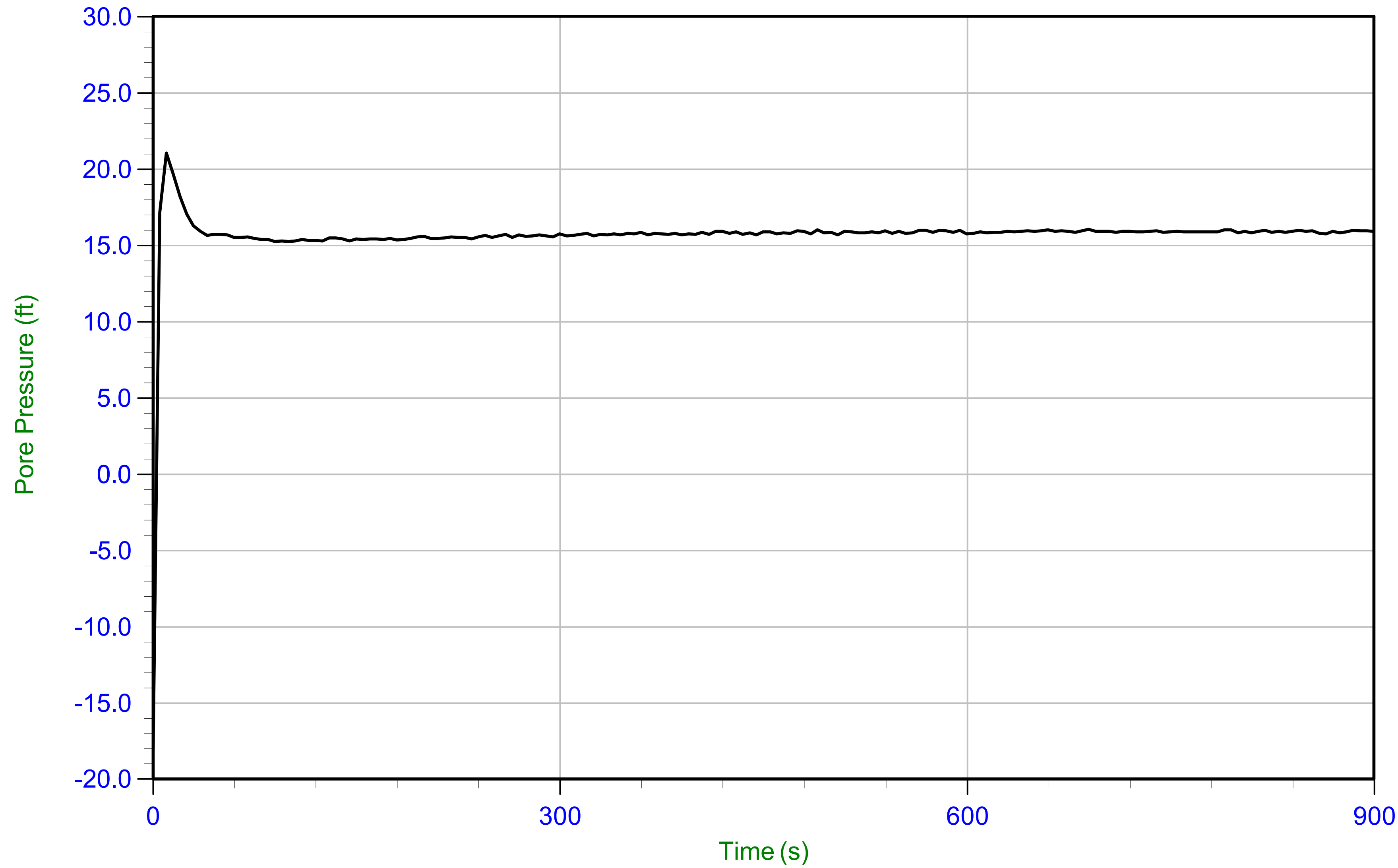
WT: 3.568 m / 11.706 ft
Ueq: 17.8 ft

ConeTec

AECOM

Job No: 15-53063
Date: 06-Aug-2015 16:06:02
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C009
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP09.PPD
Depth: 4.600 m / 15.092 ft
Duration: 900.0 s

U Min: -18.1 ft
U Max: 21.0 ft

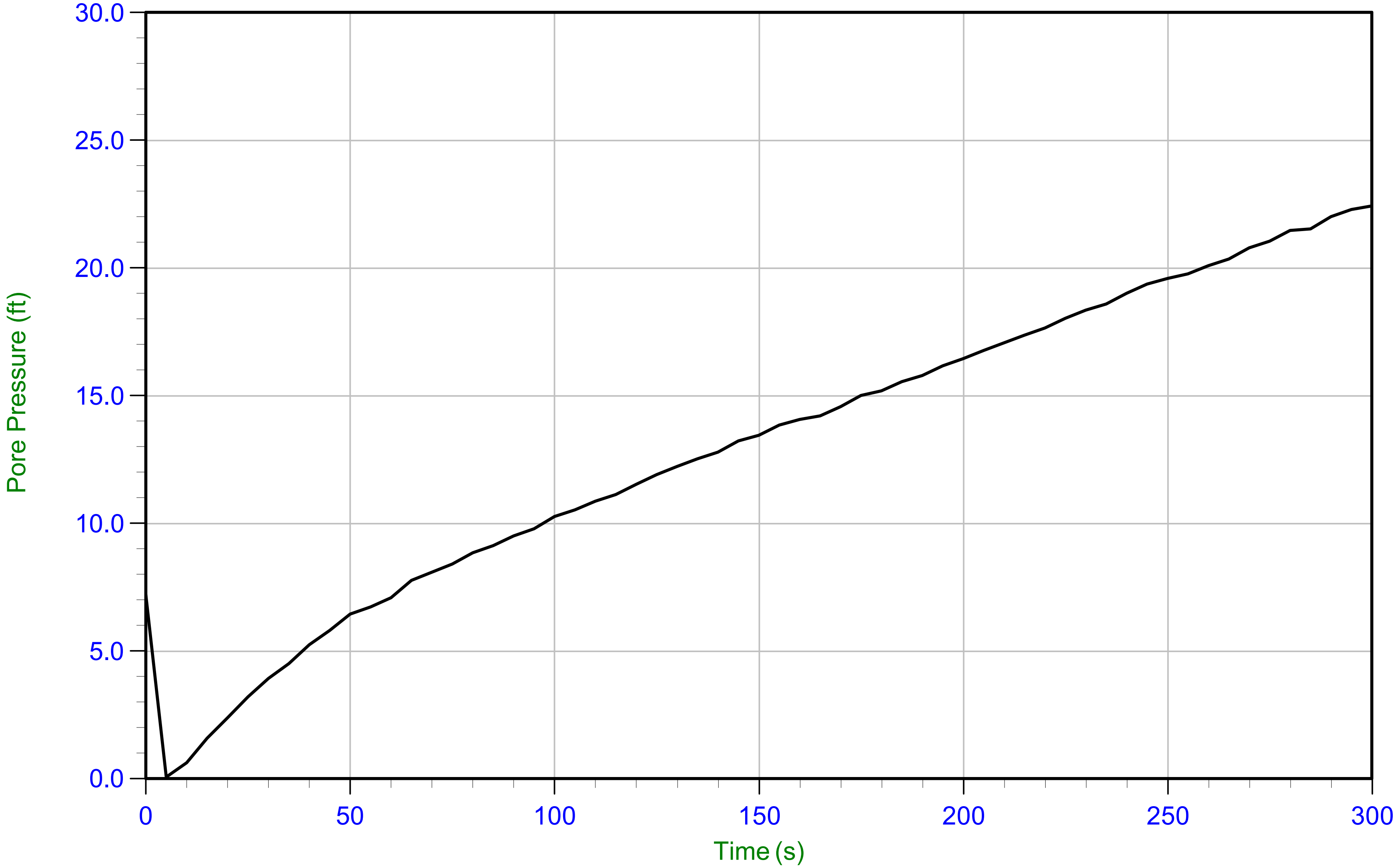
WT: -0.180 m / -0.591 ft
Ueq: 15.7 ft

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 09:01:18
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C010
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

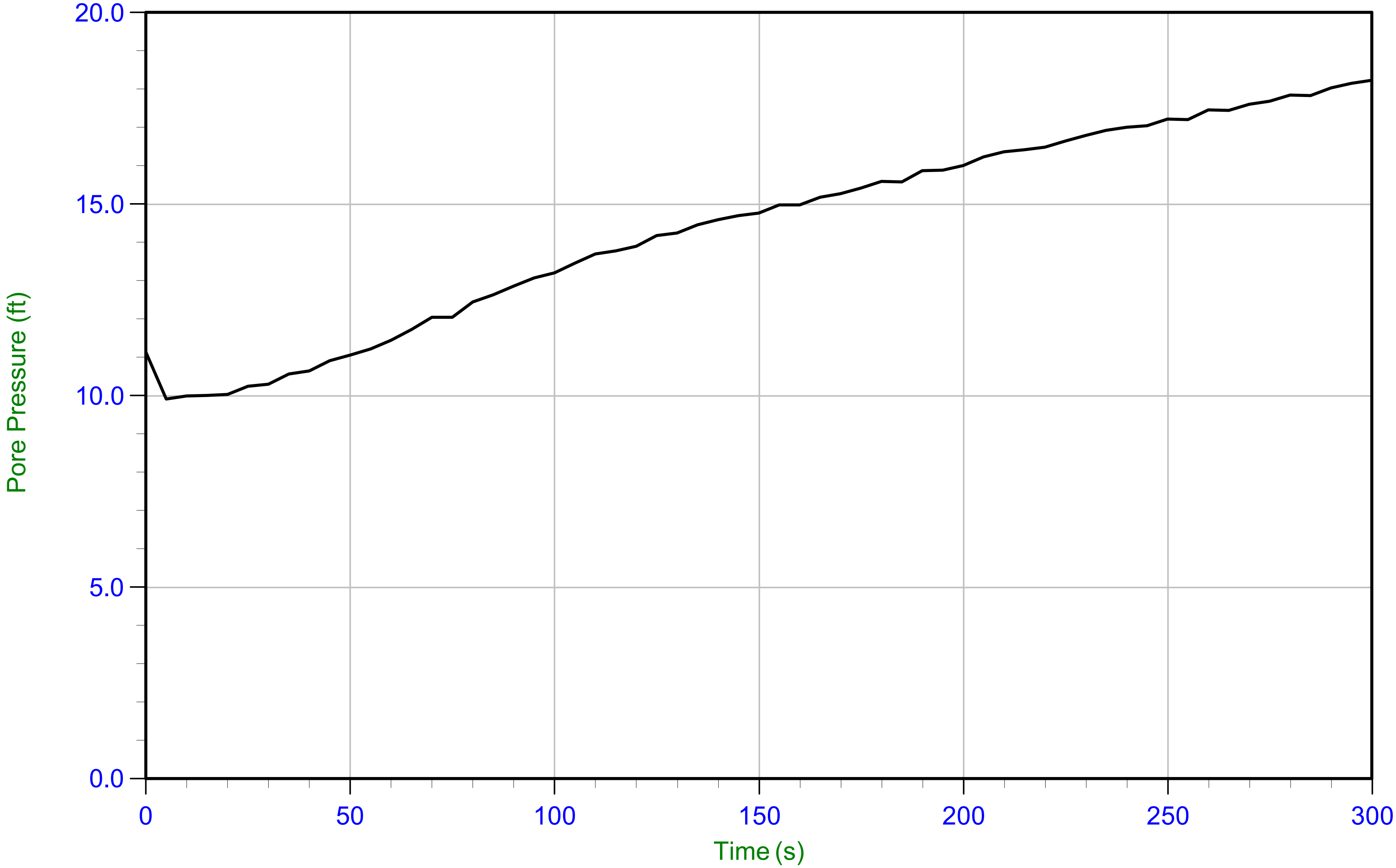
Filename: 15-53063_SP10.PPD
Depth: 3.400 m / 11.155 ft
Duration: 300.0 s

U Min: 0.1 ft
U Max: 22.4 ft

AECOM

Job No: 15-53063
Date: 07-Aug-2015 09:01:18
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C010
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

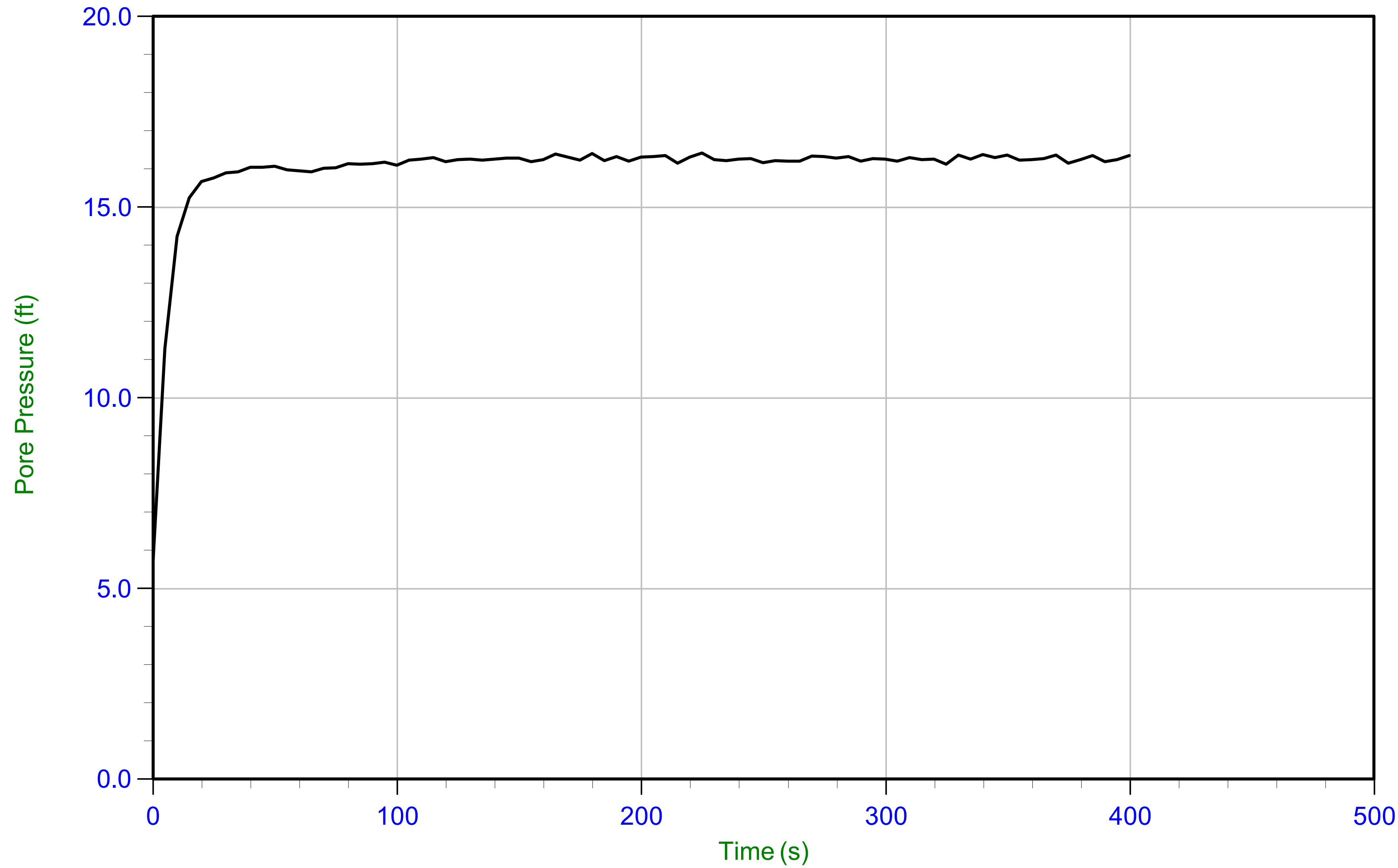
Filename: 15-53063_SP10.PPD
Depth: 5.400 m / 17.716 ft
Duration: 300.0 s

U Min: 9.9 ft
U Max: 18.2 ft

AECOM

Job No: 15-53063
Date: 07-Aug-2015 09:01:18
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C010
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP10.PPD
Depth: 9.000 m / 29.527 ft
Duration: 400.0 s

U Min: 5.7 ft
U Max: 16.4 ft

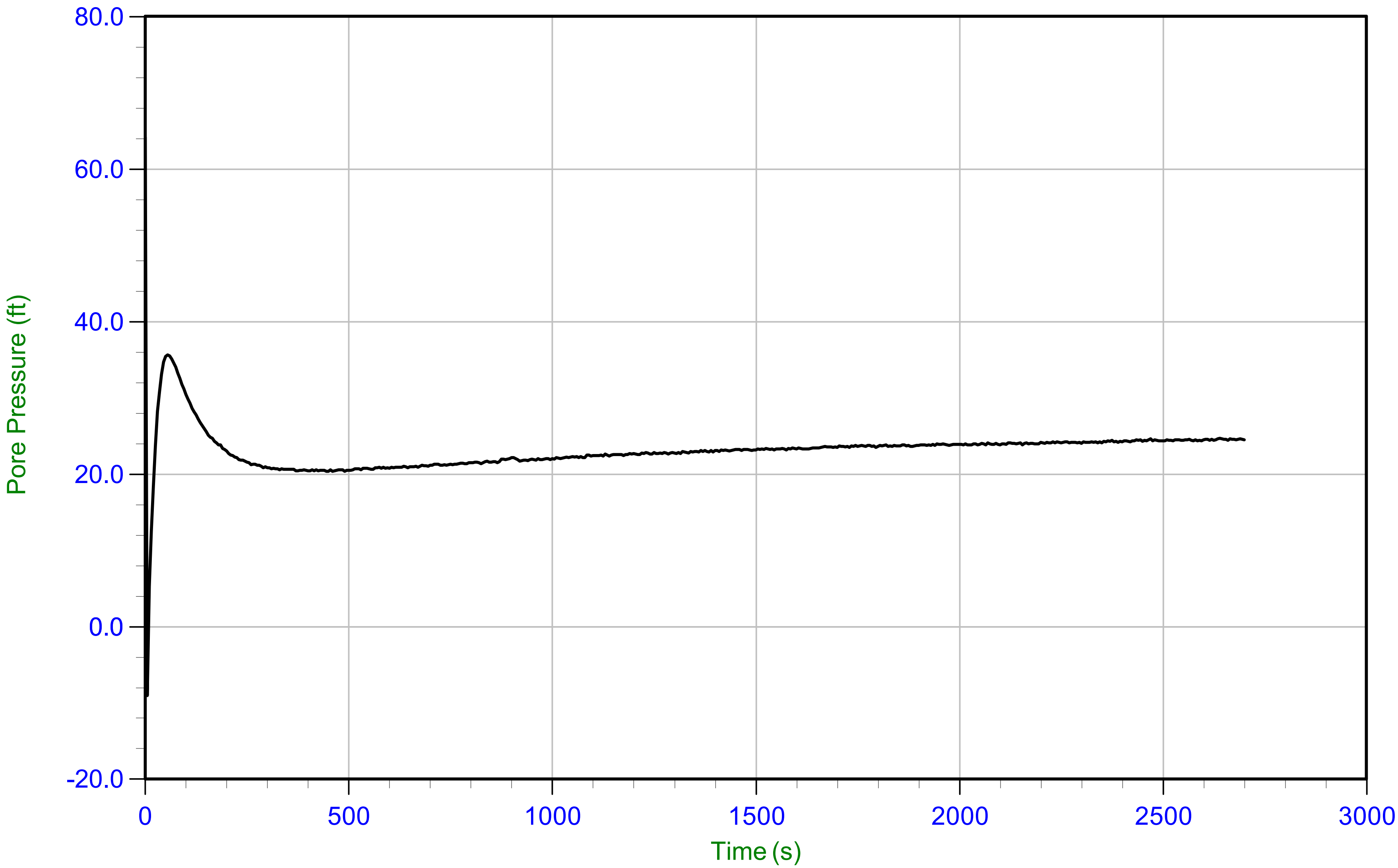
WT: 4.050 m / 13.287 ft
Ueq: 16.2 ft

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 09:01:18
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C010
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

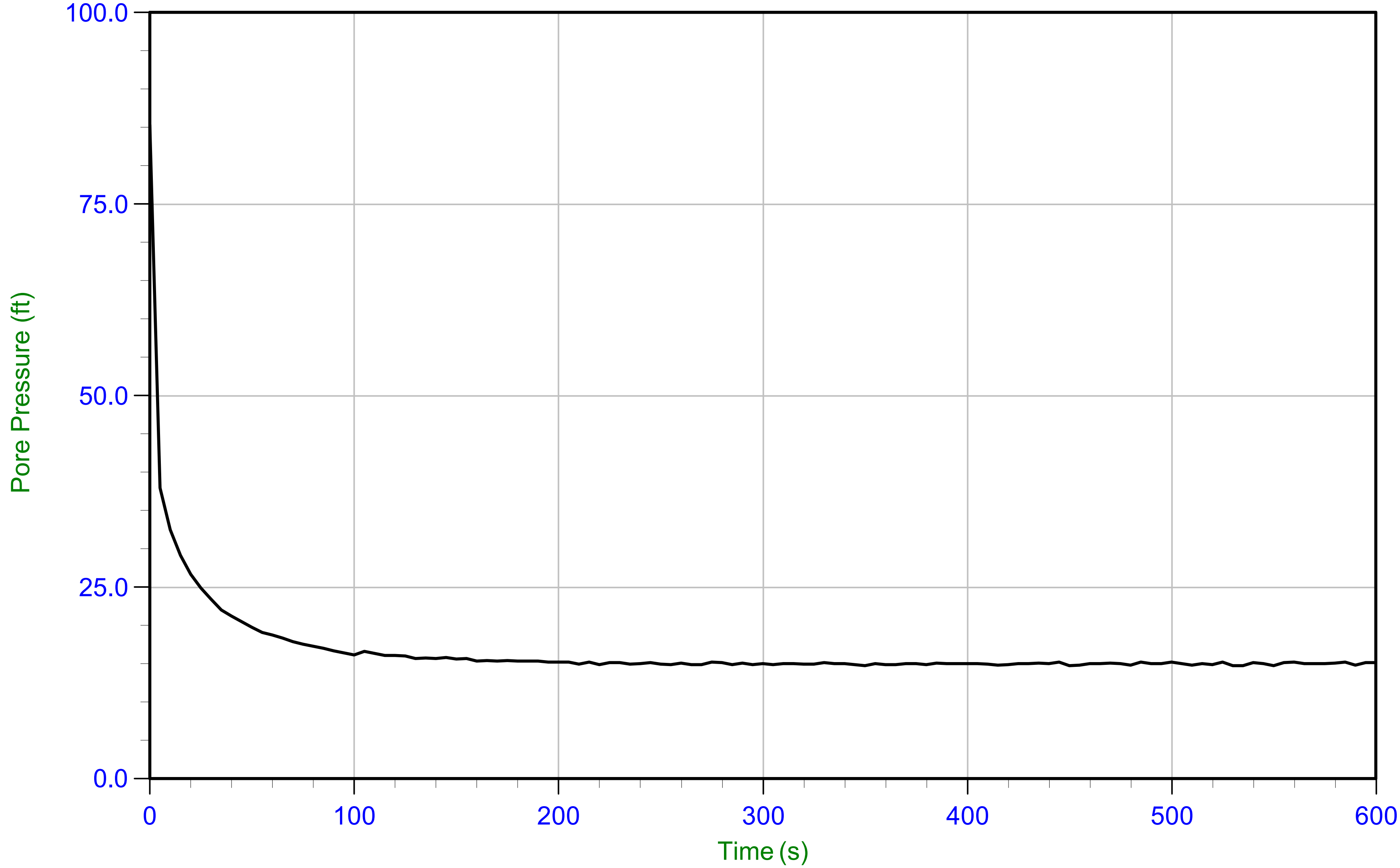
Filename: 15-53063_SP10.PPD
Depth: 10.050 m / 32.972 ft
Duration: 2700.0 s

U Min: -9.0 ft
U Max: 64.2 ft

AECOM

Job No: 15-53063
Date: 05-Aug-2015 08:38:16
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C011
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP11.PPD
Depth: 8.900 m / 29.199 ft
Duration: 600.0 s

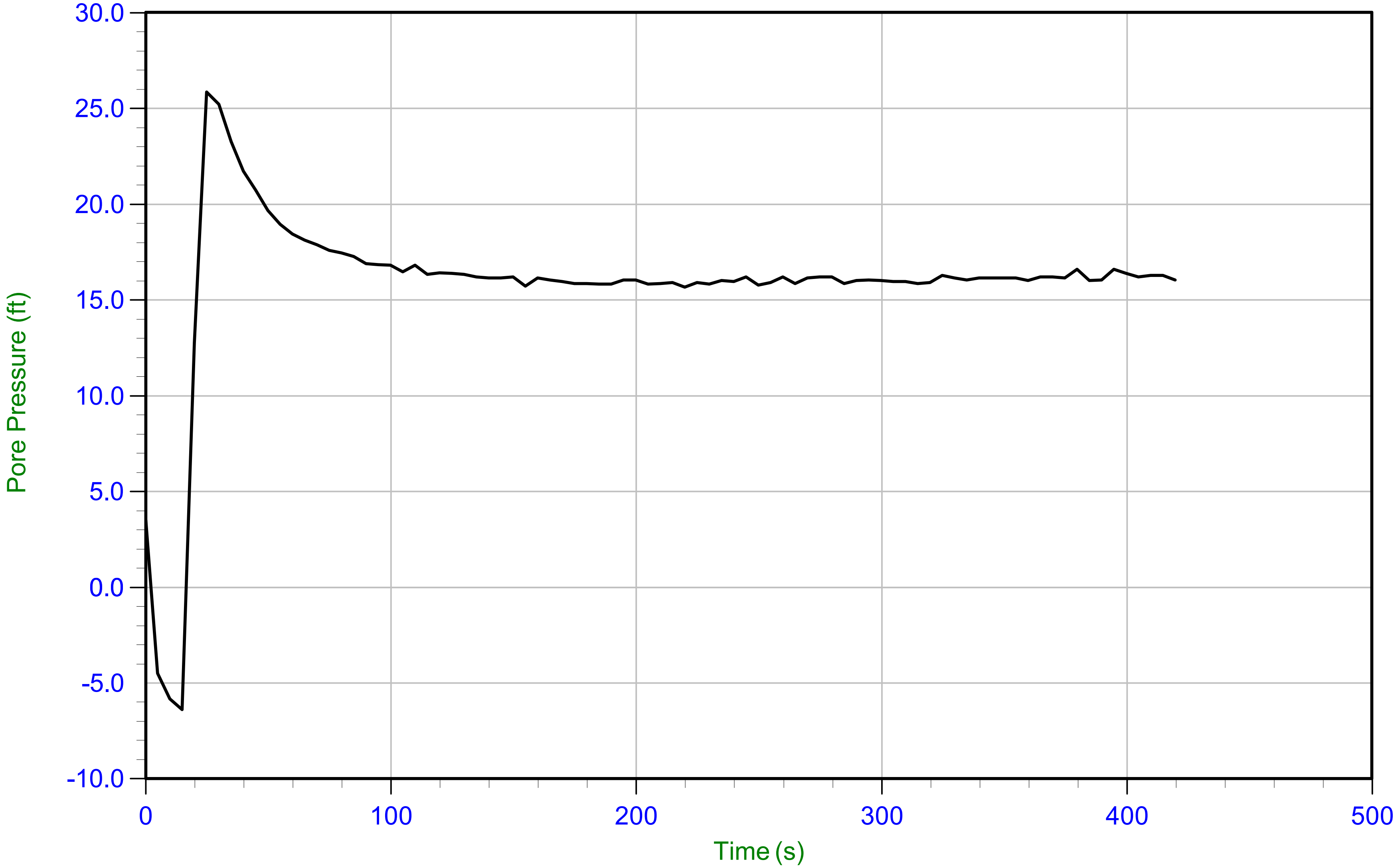
U Min: 14.7 ft
U Max: 85.4 ft

WT: 4.341 m / 14.242 ft
Ueq: 15.0 ft

AECOM

Job No: 15-53063
Date: 04-Aug-2015 12:36:19
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C012
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP12.PPD
Depth: 5.300 m / 17.388 ft
Duration: 420.0 s

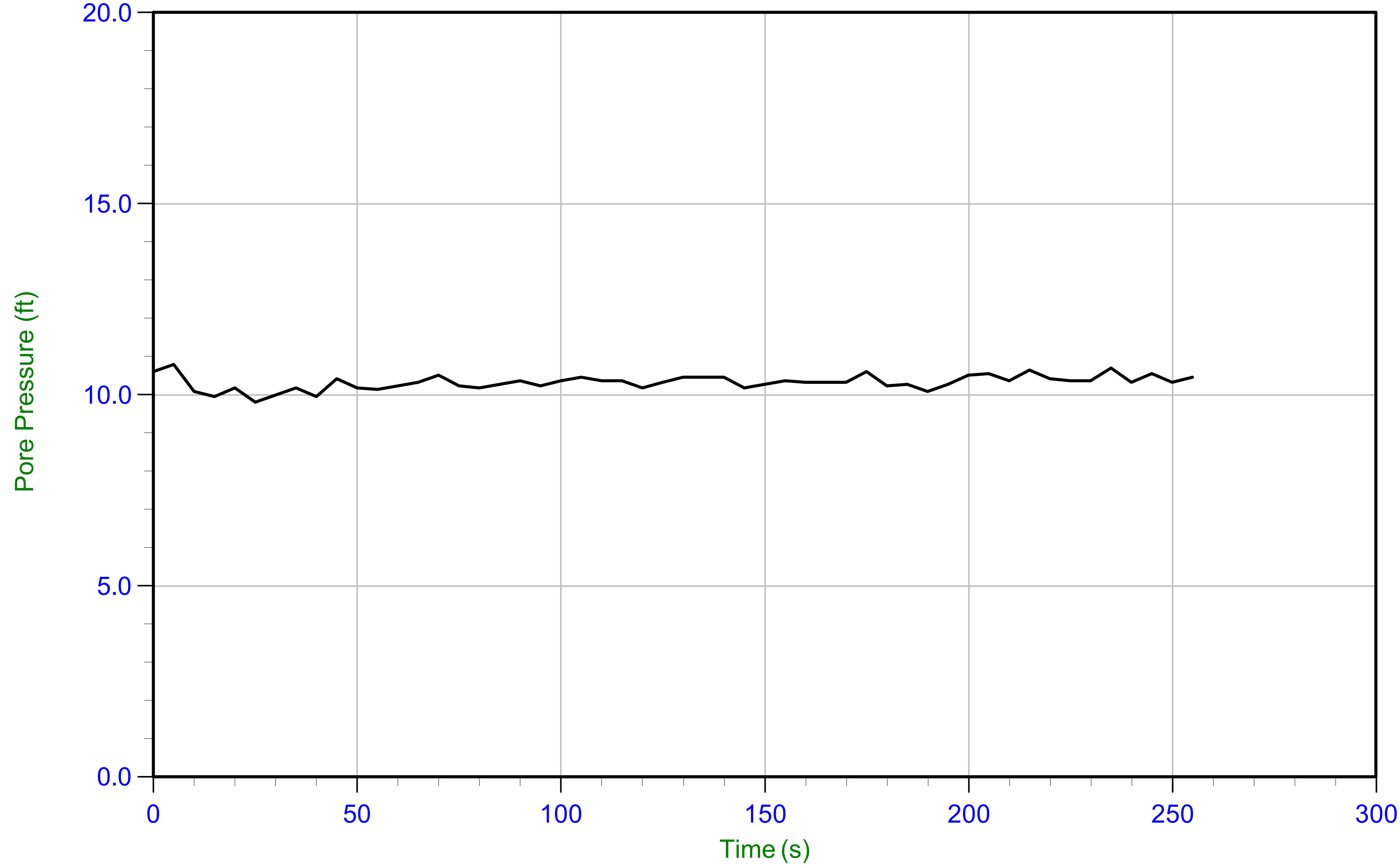
U Min: -6.4 ft
U Max: 25.9 ft

WT: 0.428 m / 1.404 ft
Ueq: 16.0 ft

AECOM

Job No: 15-53063
Date: 05-Aug-2015 15:50:23
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C013
Cone: 335
Cone Area: 15 sq cm

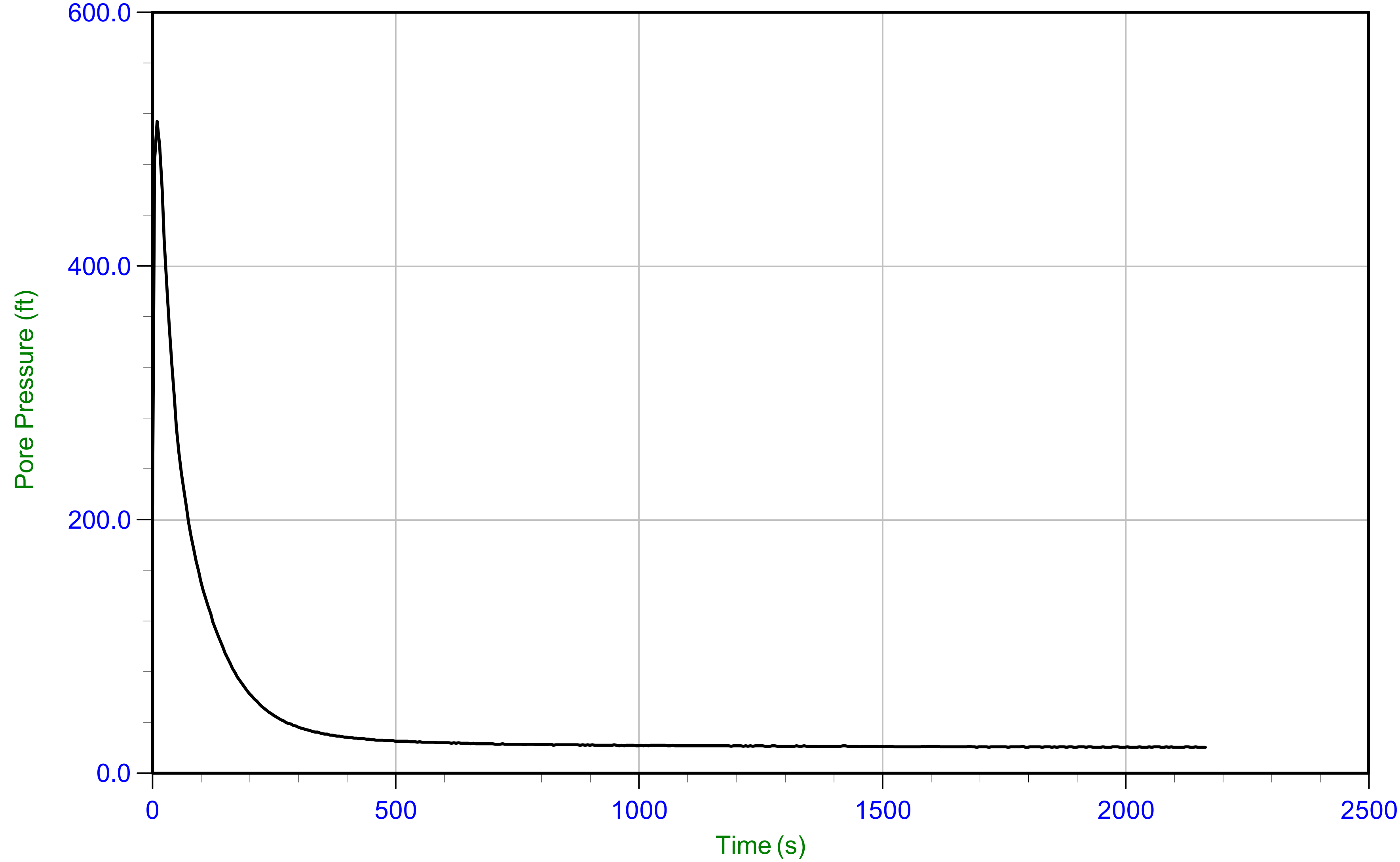


Trace Summary:
Filename: 15-53063_SP13.PPD
Depth: 4.900 m / 16.076 ft
Duration: 255.0 s
U Min: 9.8 ft
U Max: 10.8 ft
WT: 1.748 m / 5.735 ft
Ueq: 10.3 ft

AECOM

Job No: 15-53063
Date: 05-Aug-2015 15:50:23
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C013
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP13.PPD
Depth: 8.900 m / 29.199 ft
Duration: 2165.0 s

U Min: 20.5 ft
U Max: 514.2 ft

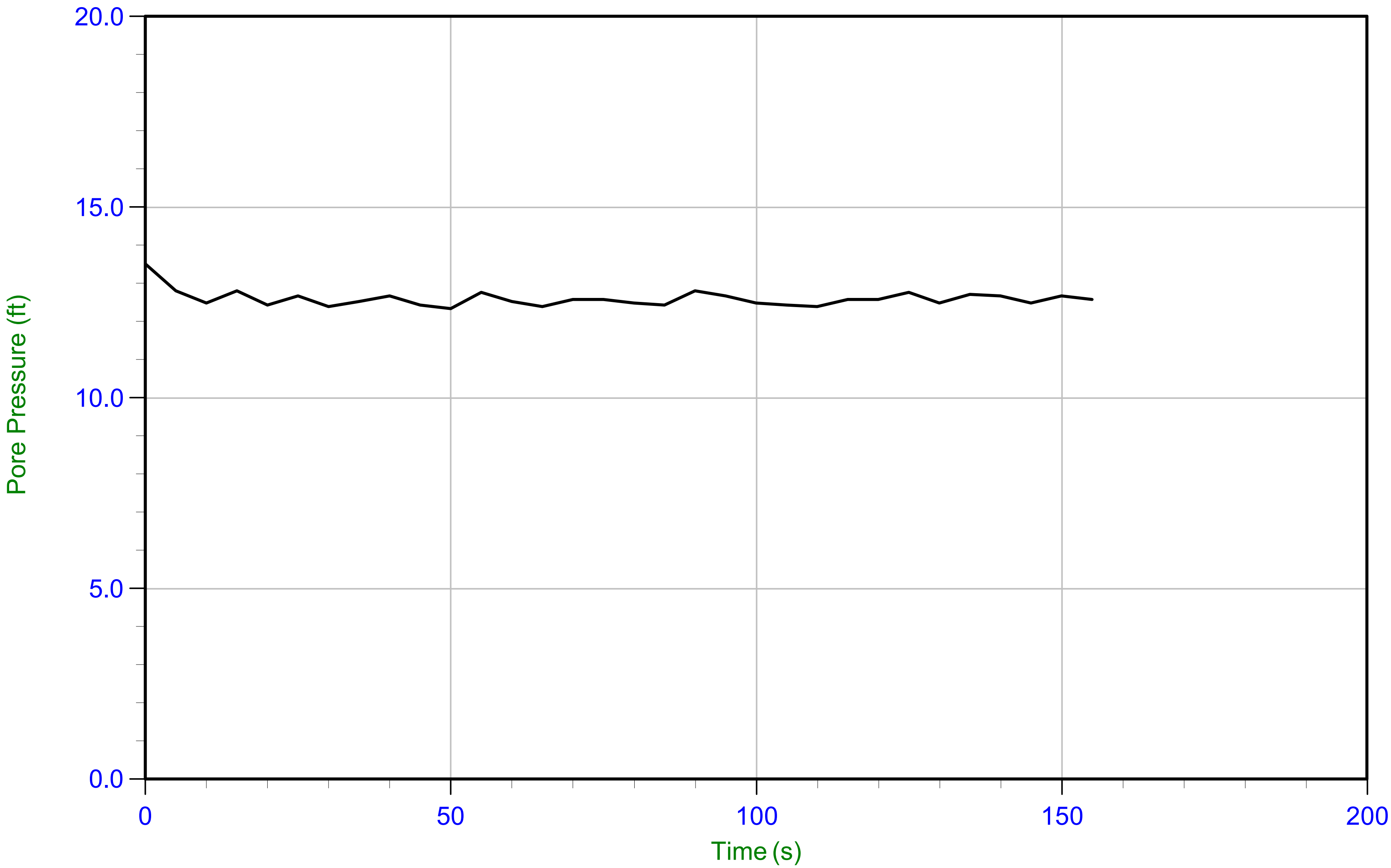
WT: 1.866 m / 6.122 ft
Ueq: 23.1 ft
U(50): 268.64 ft

T(50): 41.1 s
Ir: 100
Ch: 17.1 sq cm/min

AECOM

Job No: 15-53063
Date: 04-Aug-2015 10:48:26
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C014
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP14.PPD
Depth: 1.800 m / 5.905 ft
Duration: 155.0 s

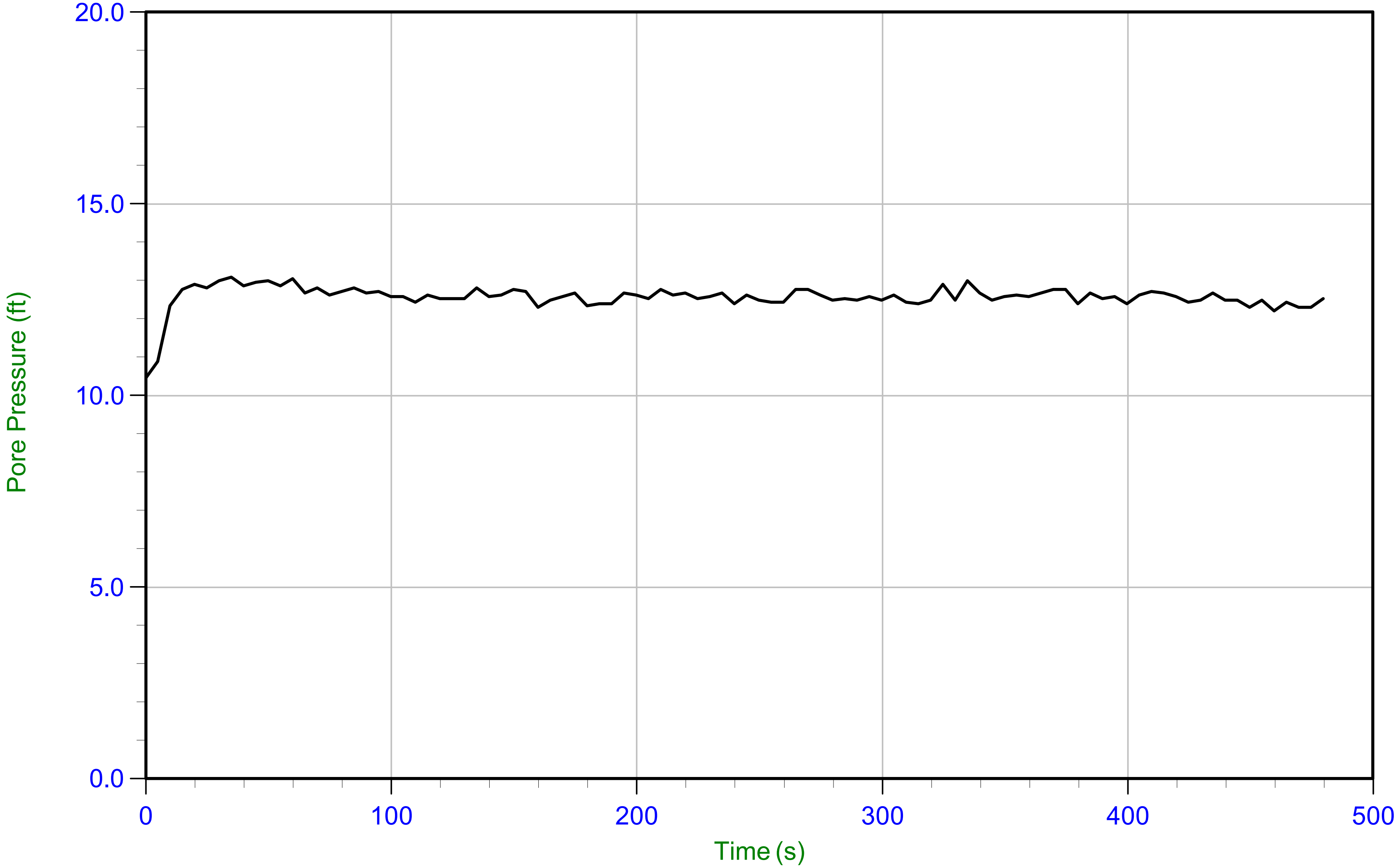
U Min: 12.3 ft
U Max: 13.5 ft

WT: -2.030 m / -6.660 ft
Ueq: 12.6 ft

AECOM

Job No: 15-53063
Date: 04-Aug-2015 10:48:26
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C014
Cone: 335
Cone Area: 15 sq cm



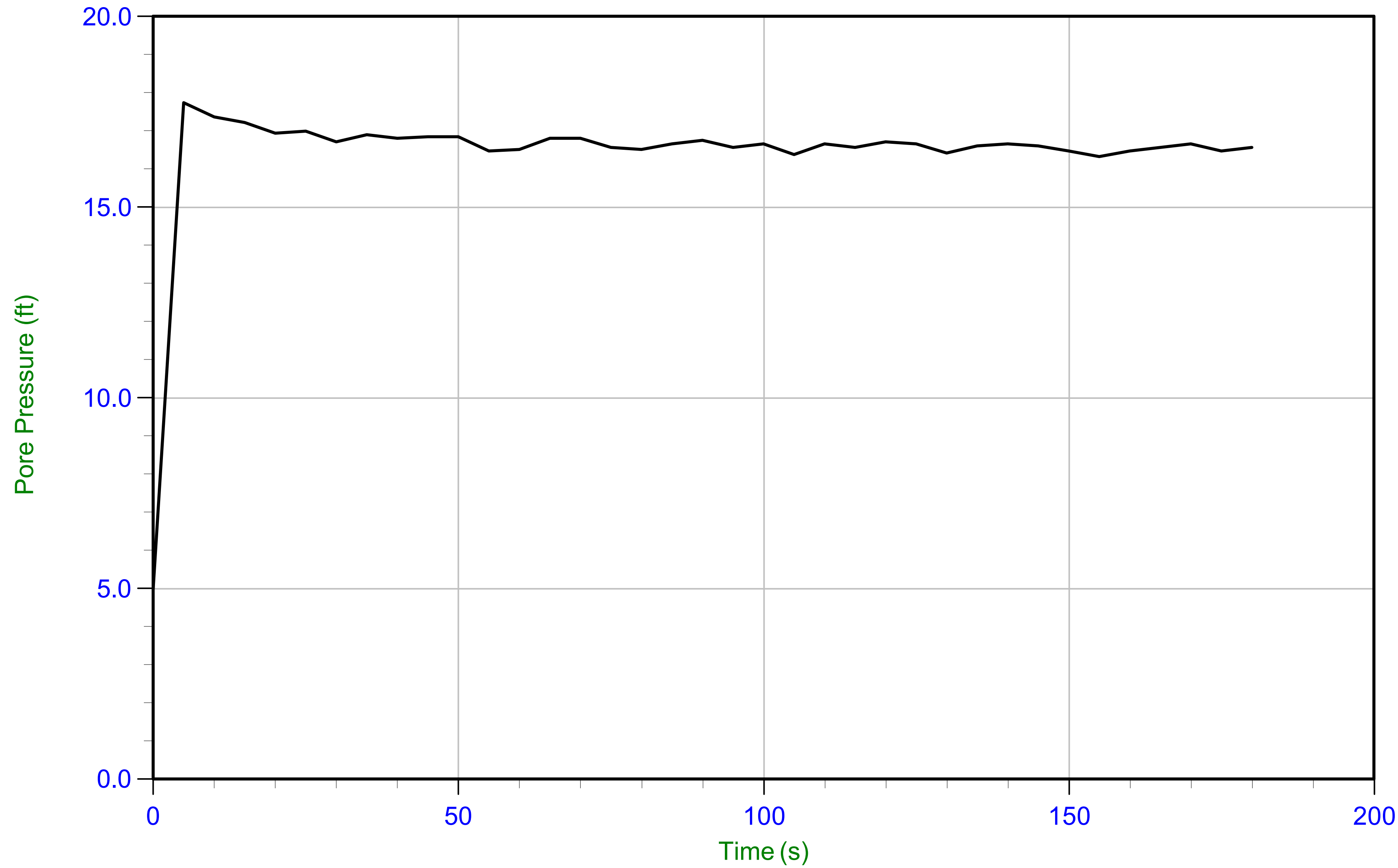
Trace Summary:

Filename: 15-53063_SP14.PPD
Depth: 4.850 m / 15.912 ft
Duration: 480.0 s

U Min: 10.5 ft
U Max: 13.1 ft

WT: 1.073 m / 3.520 ft
Ueq: 12.4 ft

AECOM	Job No: 15-53063	Sounding: COF-C015
	Date: 06-Aug-2015 09:31:56	Cone: 335
	Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

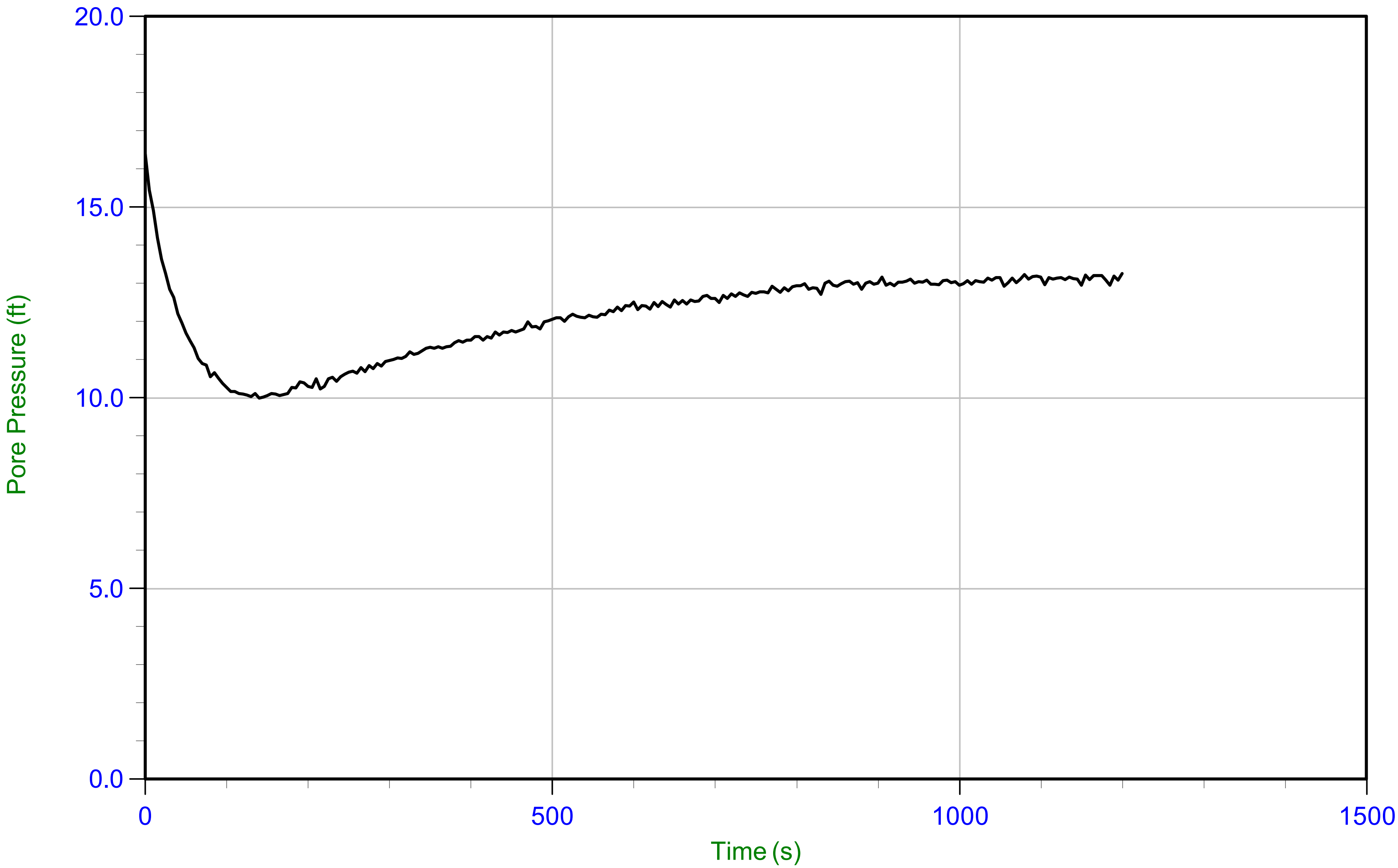
Filename: 15-53063_CP15.PPD	U Min: 5.0 ft	WT: 4.848 m / 15.905 ft
Depth: 9.850 m / 32.316 ft	U Max: 17.7 ft	Ueq: 16.4 ft
Duration: 180.0 s		

CONETEC

AECOM

Job No: 15-53063
Date: 06-Aug-2015 11:20:36
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C016
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP16.PPD
Depth: 4.400 m / 14.436 ft
Duration: 1200.0 s

U Min: 10.0 ft
U Max: 16.4 ft

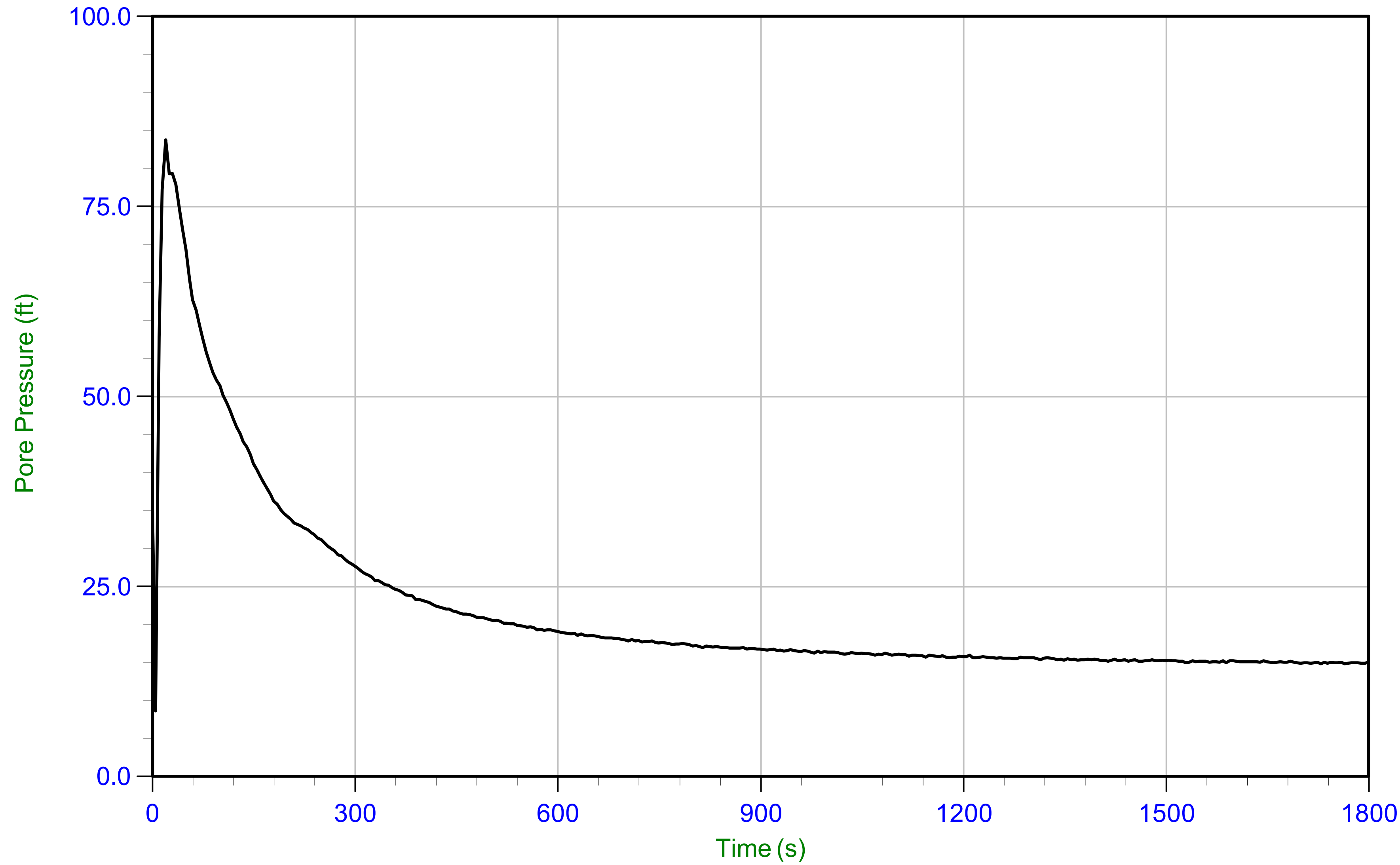
WT: 0.362 m / 1.188 ft
Ueq: 13.2 ft

CONETEC

AECOM

Job No: 15-53063
Date: 06-Aug-2015 11:20:36
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C016
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP16.PPD
Depth: 9.400 m / 30.840 ft
Duration: 1800.0 s

U Min: 8.6 ft
U Max: 83.8 ft

WT: 4.971 m / 16.309 ft
Ueq: 14.5 ft
U(50): 49.15 ft

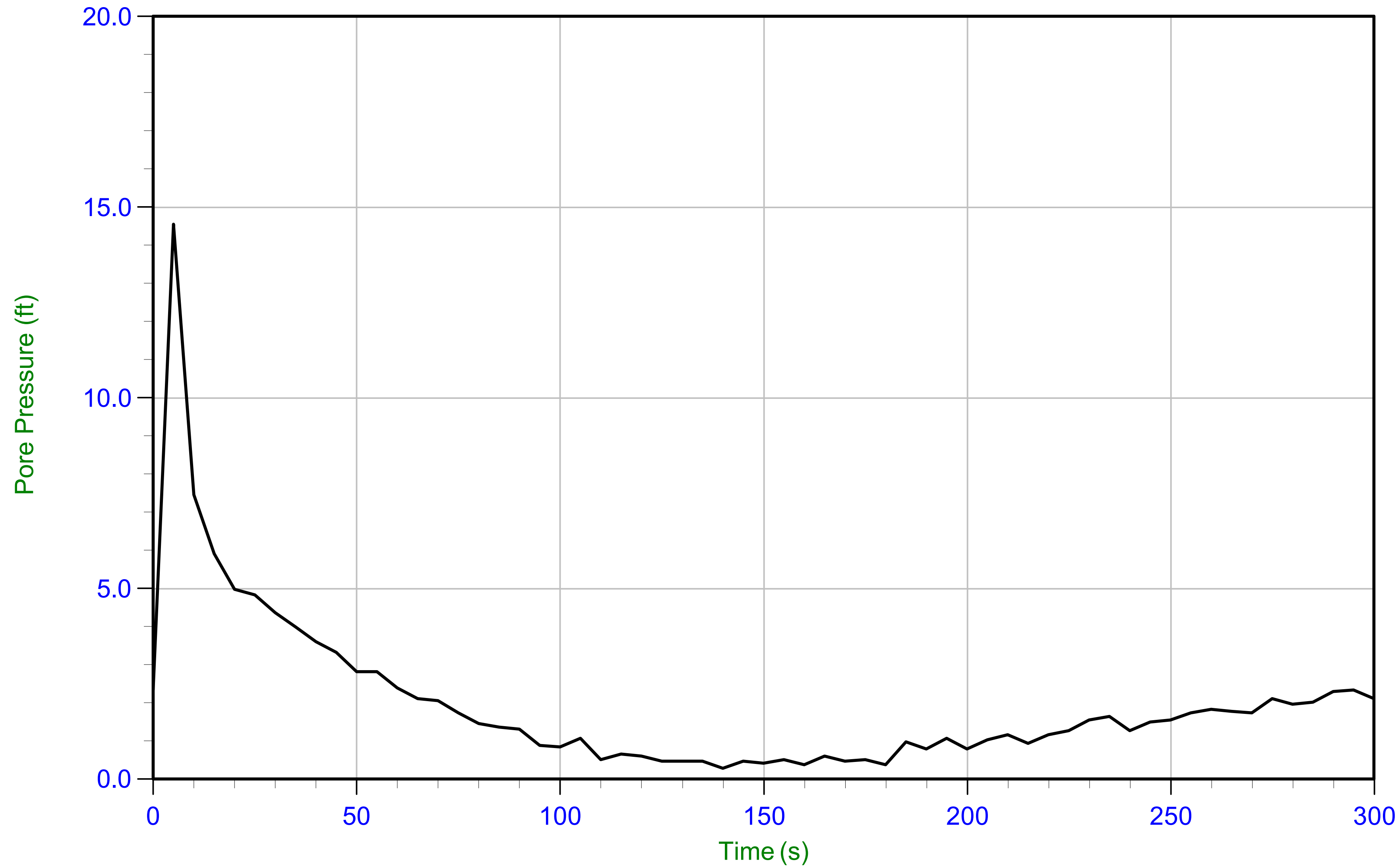
T(50): 90.3 s
Ir: 100
Ch: 7.8 sq cm/min

CONETEC

AECOM

Job No: 15-53063
Date: 04-Aug-2015 16:08:45
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C017
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

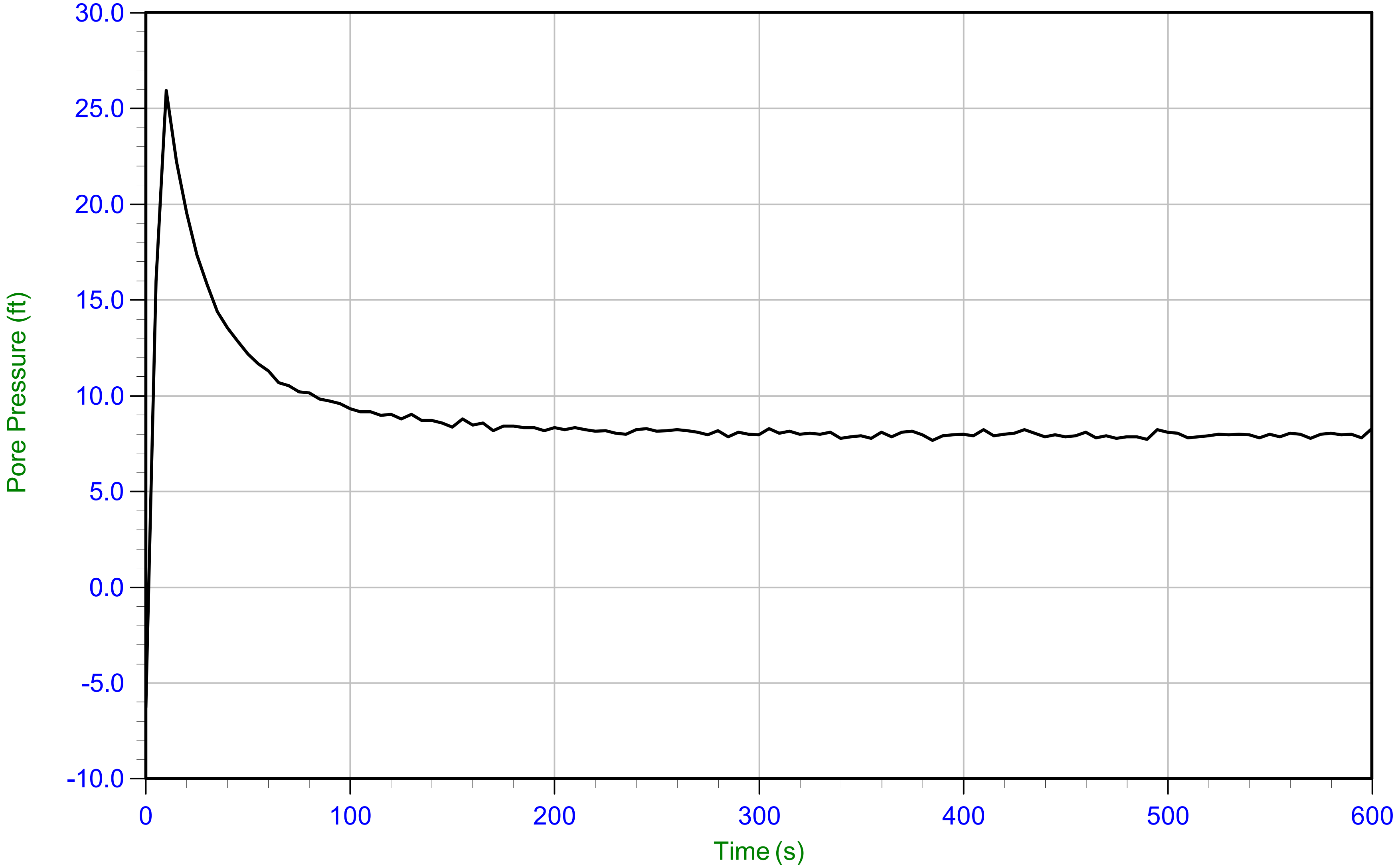
Filename: 15-53063_CP17.PPD
Depth: 3.950 m / 12.959 ft
Duration: 300.0 s

U Min: 0.3 ft
U Max: 14.5 ft

AECOM

Job No: 15-53063
Date: 05-Aug-2015 07:20:07
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C018
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP18.PPD
Depth: 4.250 m / 13.943 ft
Duration: 600.0 s

U Min: -6.3 ft
U Max: 25.9 ft

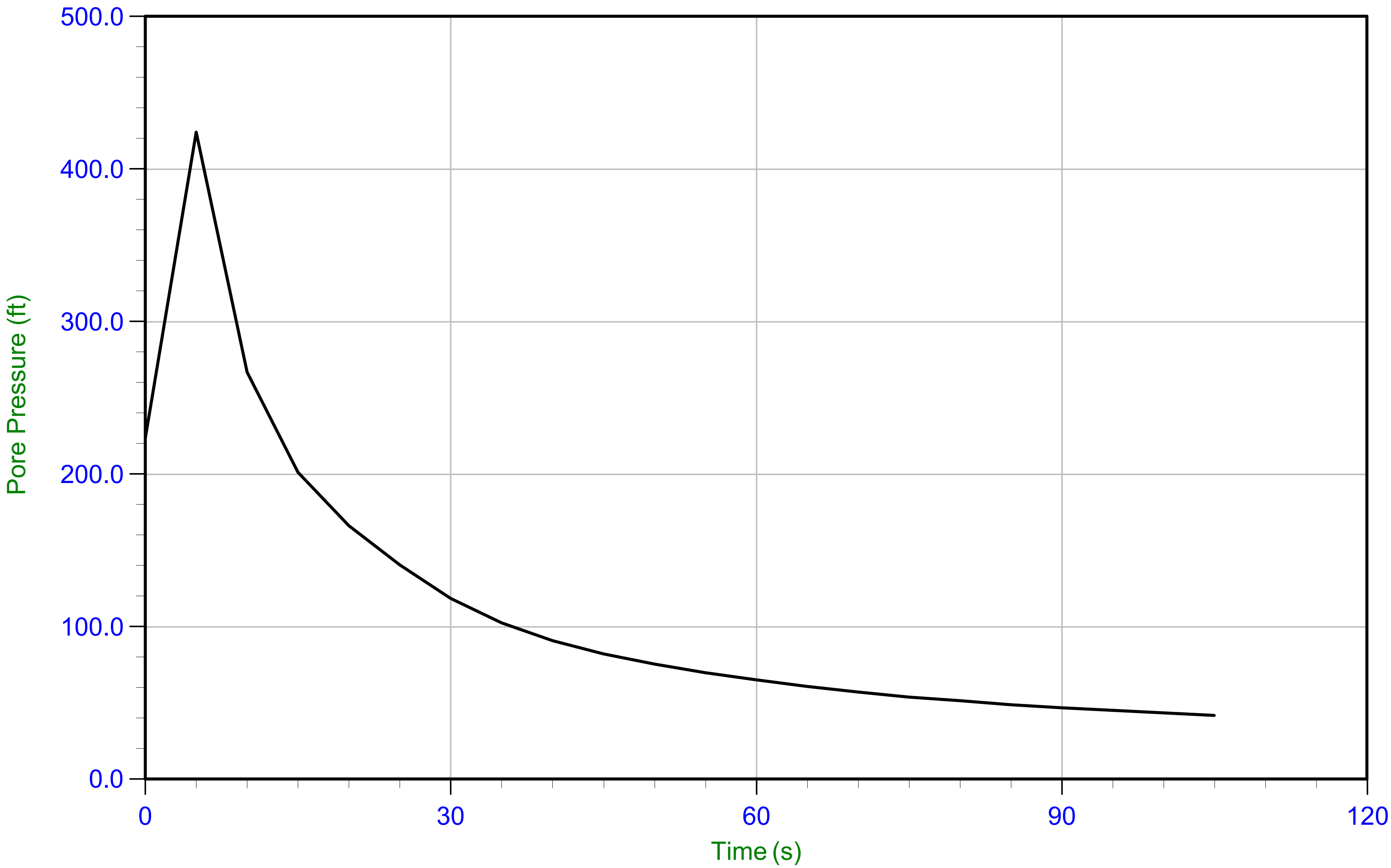
WT: 1.827 m / 5.994 ft
Ueq: 7.9 ft

ConeTec

AECOM

Job No: 15-53063
Date: 05-Aug-2015 07:20:07
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C018
Cone: 335
Cone Area: 15 sq cm

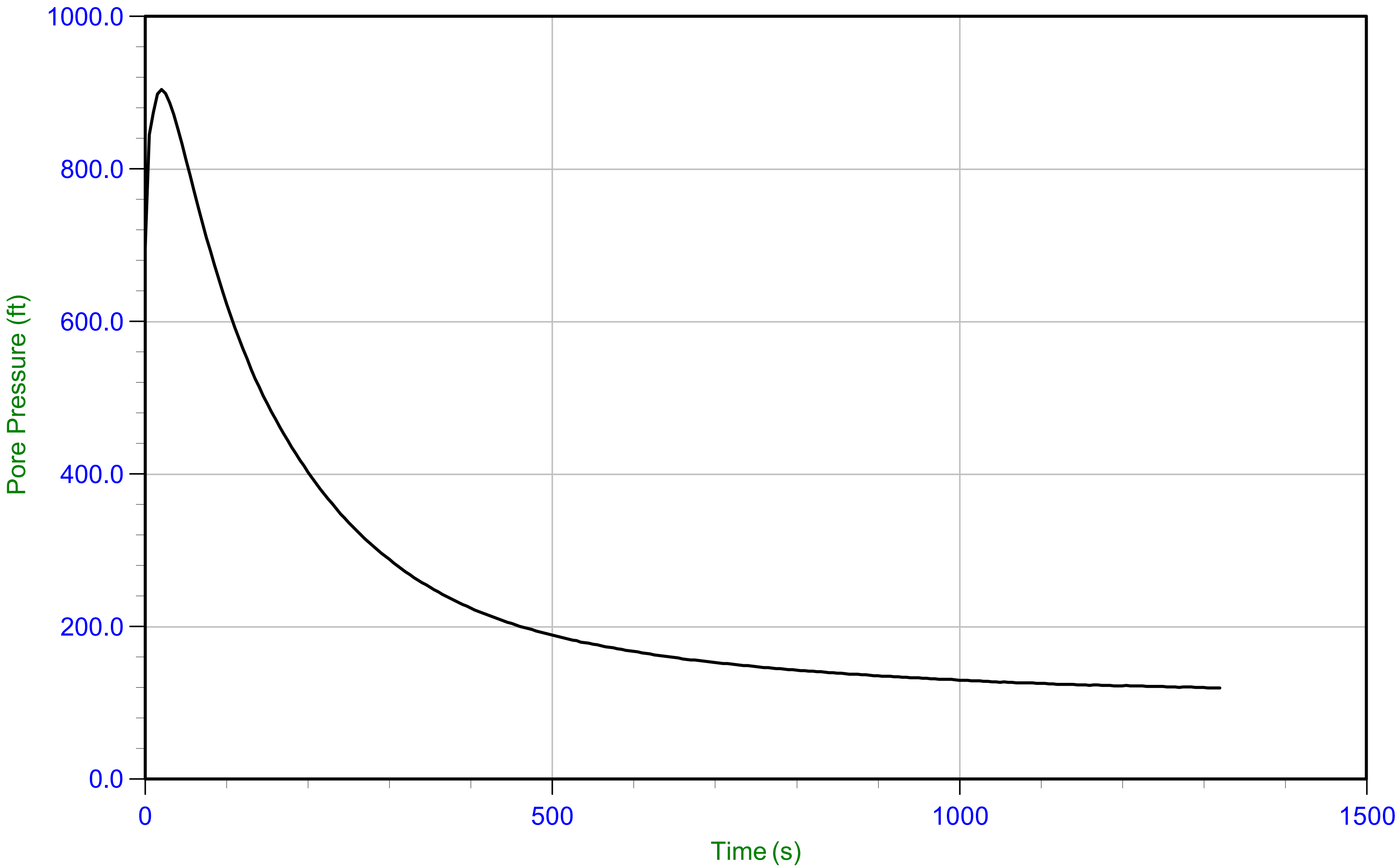


Trace Summary:	Filename: 15-53063_SP18.PPD	U Min: 41.9 ft	WT: 1.827 m / 5.994 ft	T(50): 8.7 s
	Depth: 5.250 m / 17.224 ft	U Max: 424.3 ft	Ueq: 11.2 ft	Ir: 100
	Duration: 105.0 s		U(50): 217.74 ft	Ch: 80.2 sq cm/min

AECOM

Job No: 15-53063
Date: 06-Aug-2015 11:35:31
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C019
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP19.PPD
Depth: 10.600 m / 34.776 ft
Duration: 1320.0 s

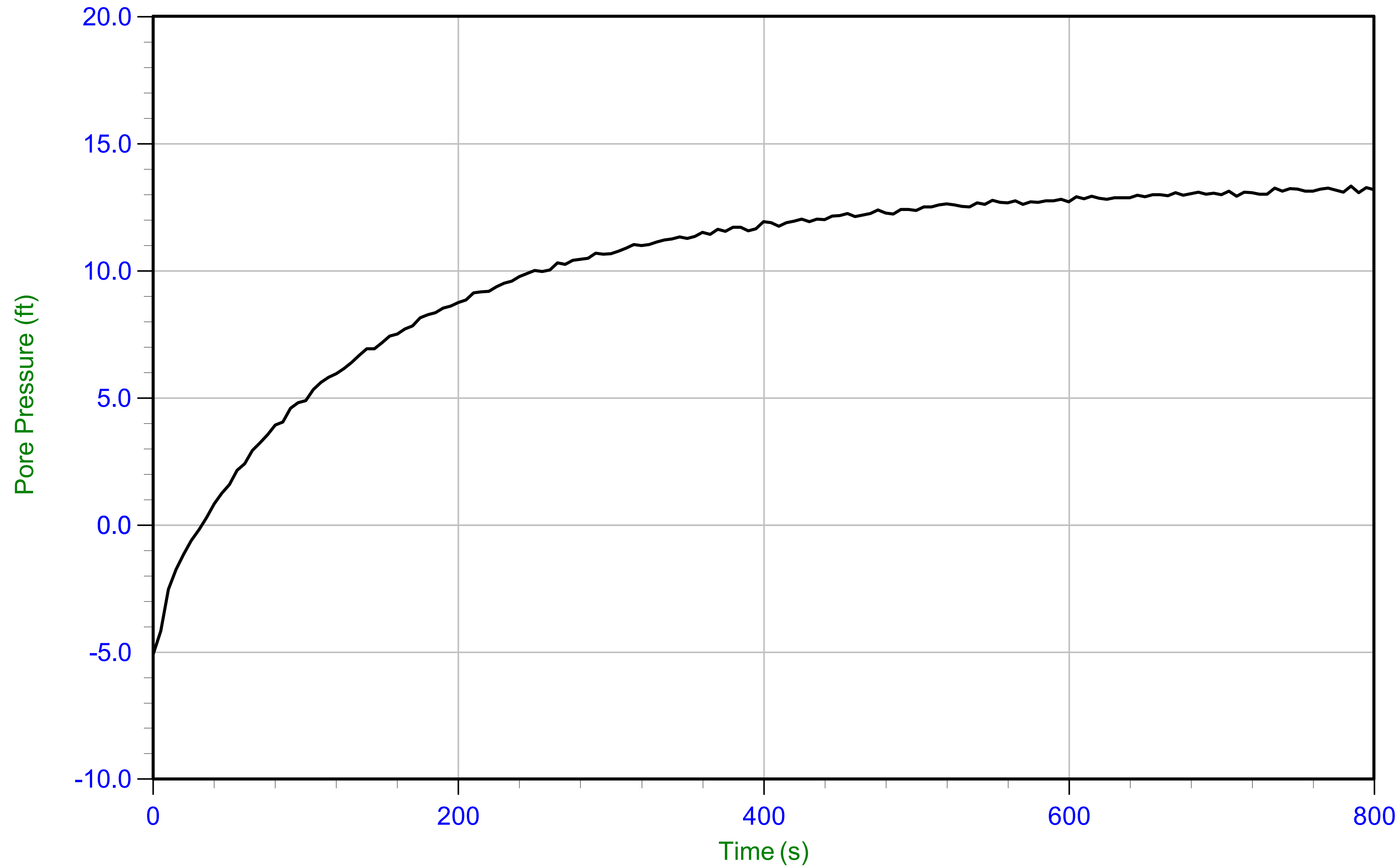
U Min: 119.3 ft
U Max: 904.4 ft

ConeTec

AECOM

Job No: 15-53063
Date: 06-Aug-2015 17:27:03
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C020
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP20.PPD
Depth: 4.000 m / 13.123 ft
Duration: 800.0 s

U Min: -5.1 ft
U Max: 13.3 ft

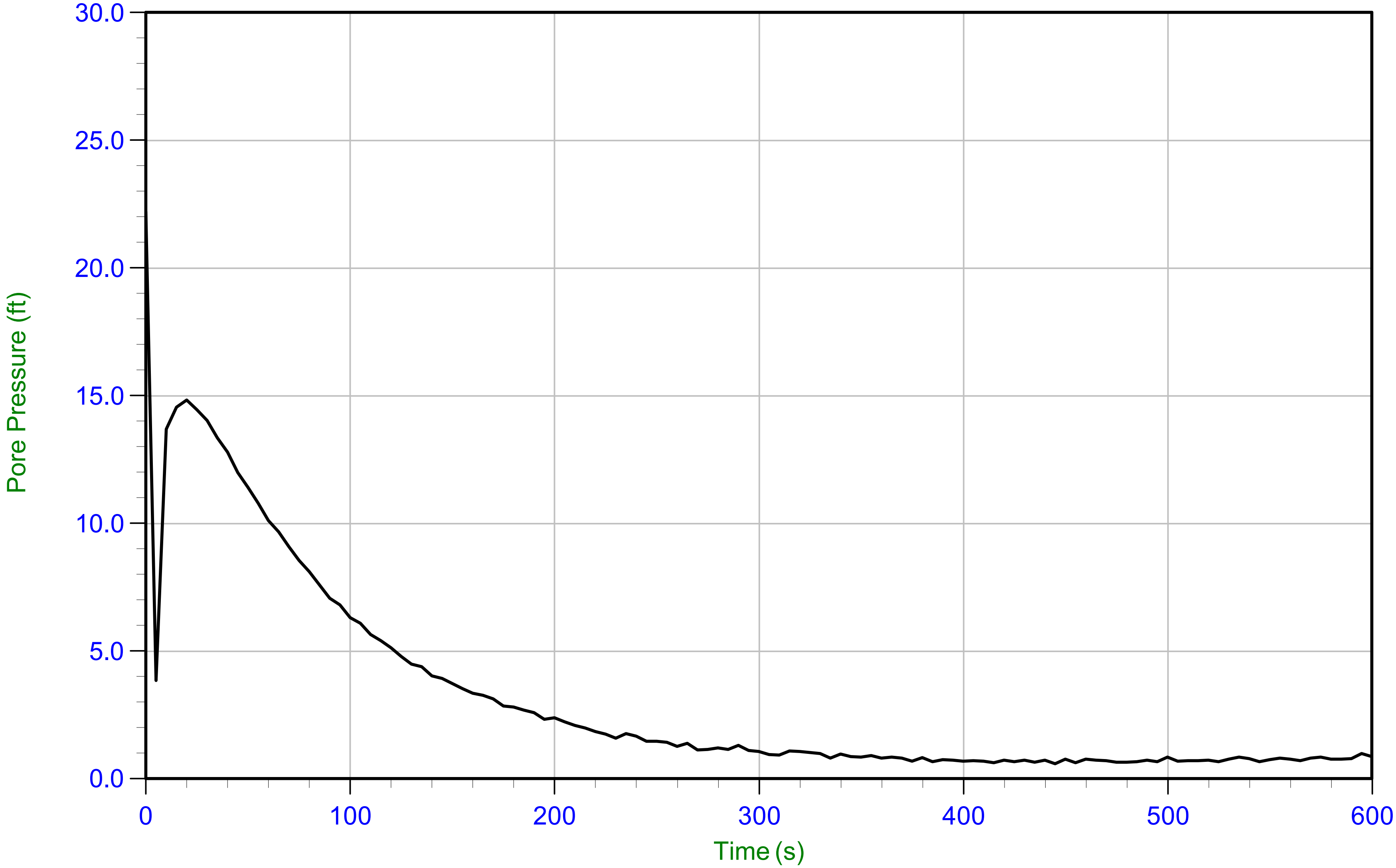
WT: -0.025 m / -0.082 ft
Ueq: 13.2 ft

CONETEC

AECOM

Job No: 15-53063
Date: 06-Aug-2015 17:27:03
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C020
Cone: 374
Cone Area: 15 sq cm



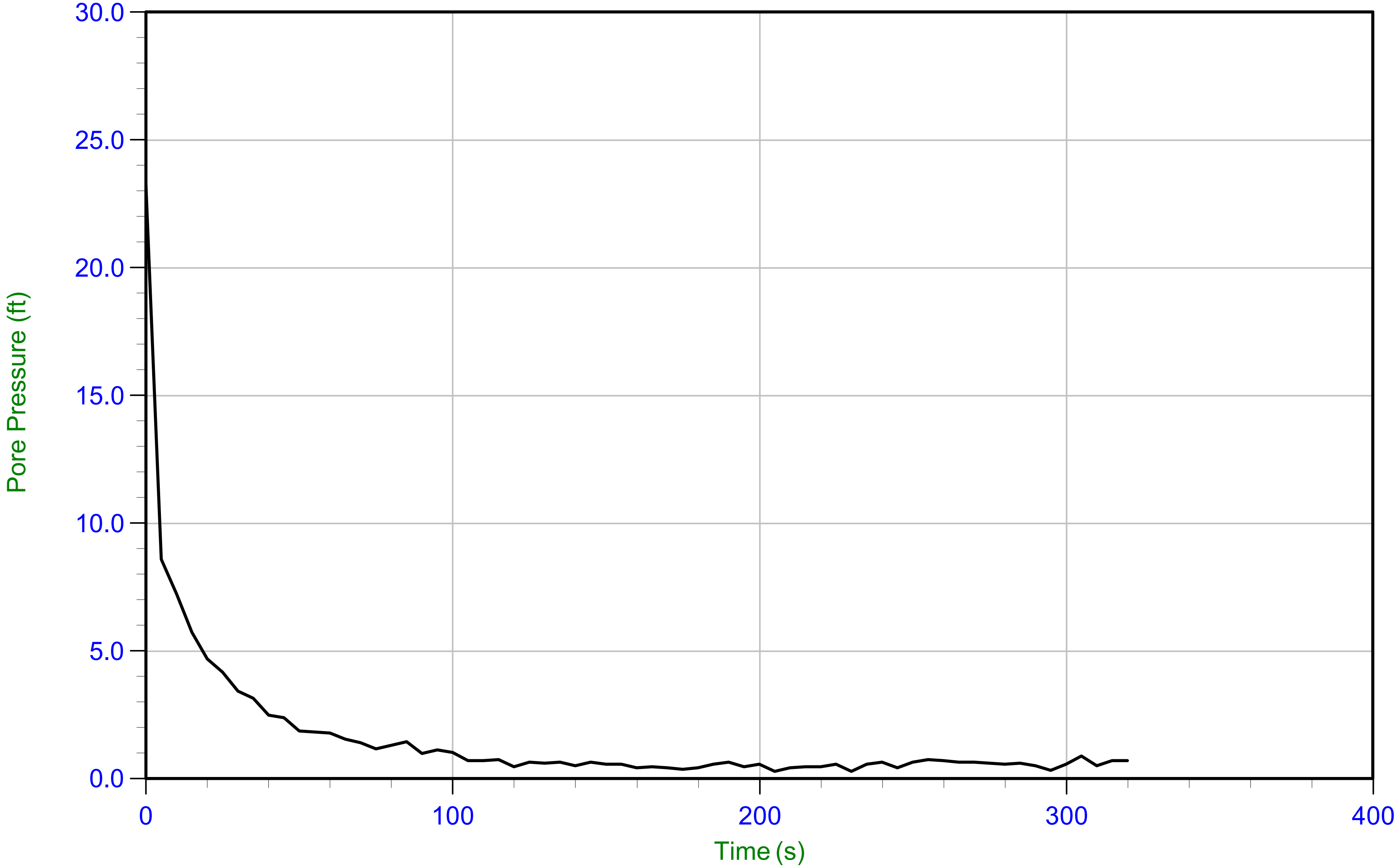
Trace Summary:

Filename: 15-53063_SP20.PPD
Depth: 4.750 m / 15.584 ft
Duration: 600.0 s

U Min: 0.6 ft
U Max: 22.2 ft

WT: 4.555 m / 14.944 ft
Ueq: 0.6 ft

AECOM	Job No: 15-53063	Sounding: COF-C022
	Date: 06-Aug-2015 13:10:59	Cone: 335
	Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP22.PPD
Depth: 4.600 m / 15.092 ft
Duration: 320.0 s

U Min: 0.3 ft
U Max: 23.2 ft

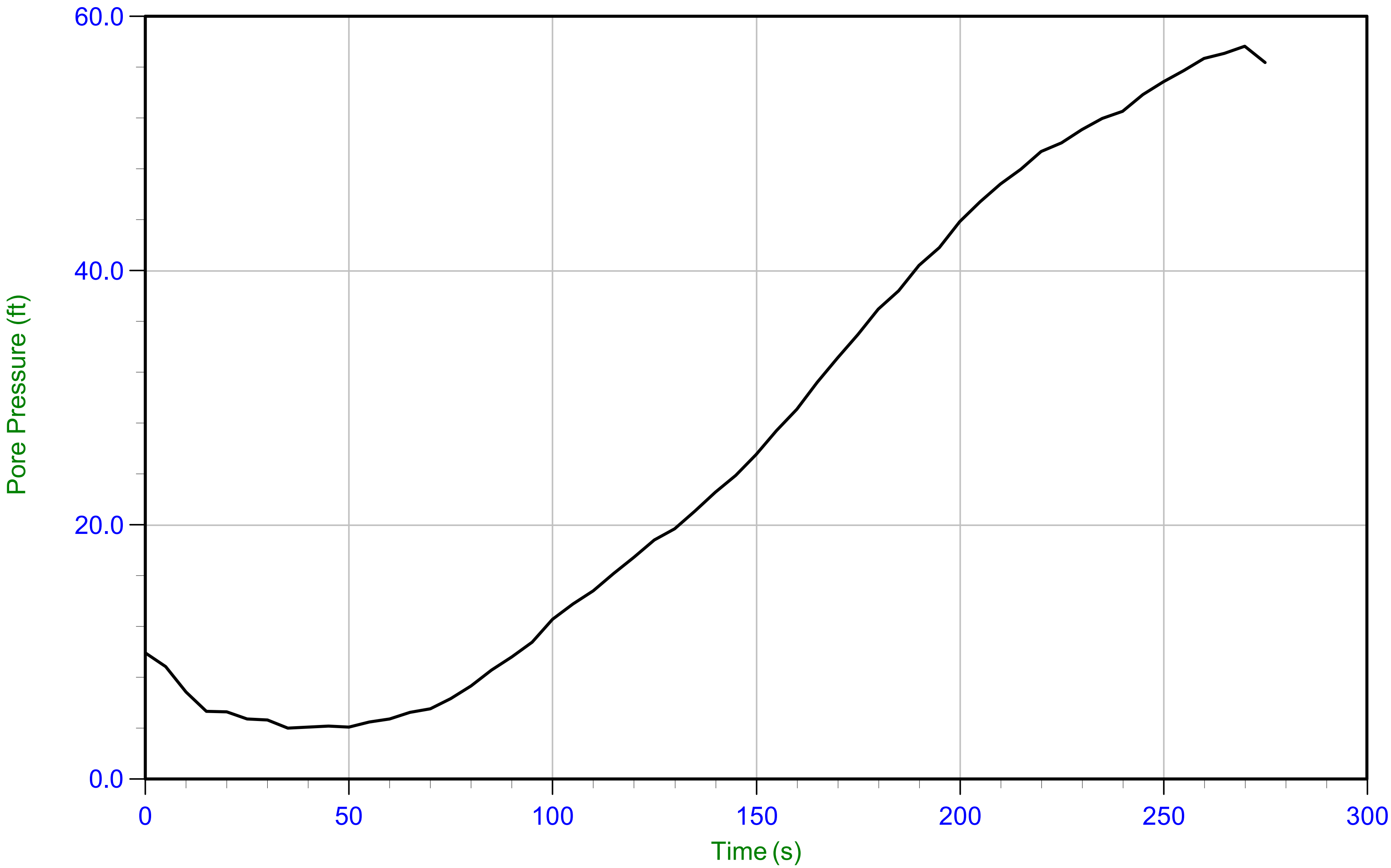
WT: 4.405 m / 14.452 ft
Ueq: 0.6 ft

CONETEC

AECOM

Job No: 15-53063
Date: 06-Aug-2015 13:10:59
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C022
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP22.PPD
Depth: 8.150 m / 26.739 ft
Duration: 275.0 s

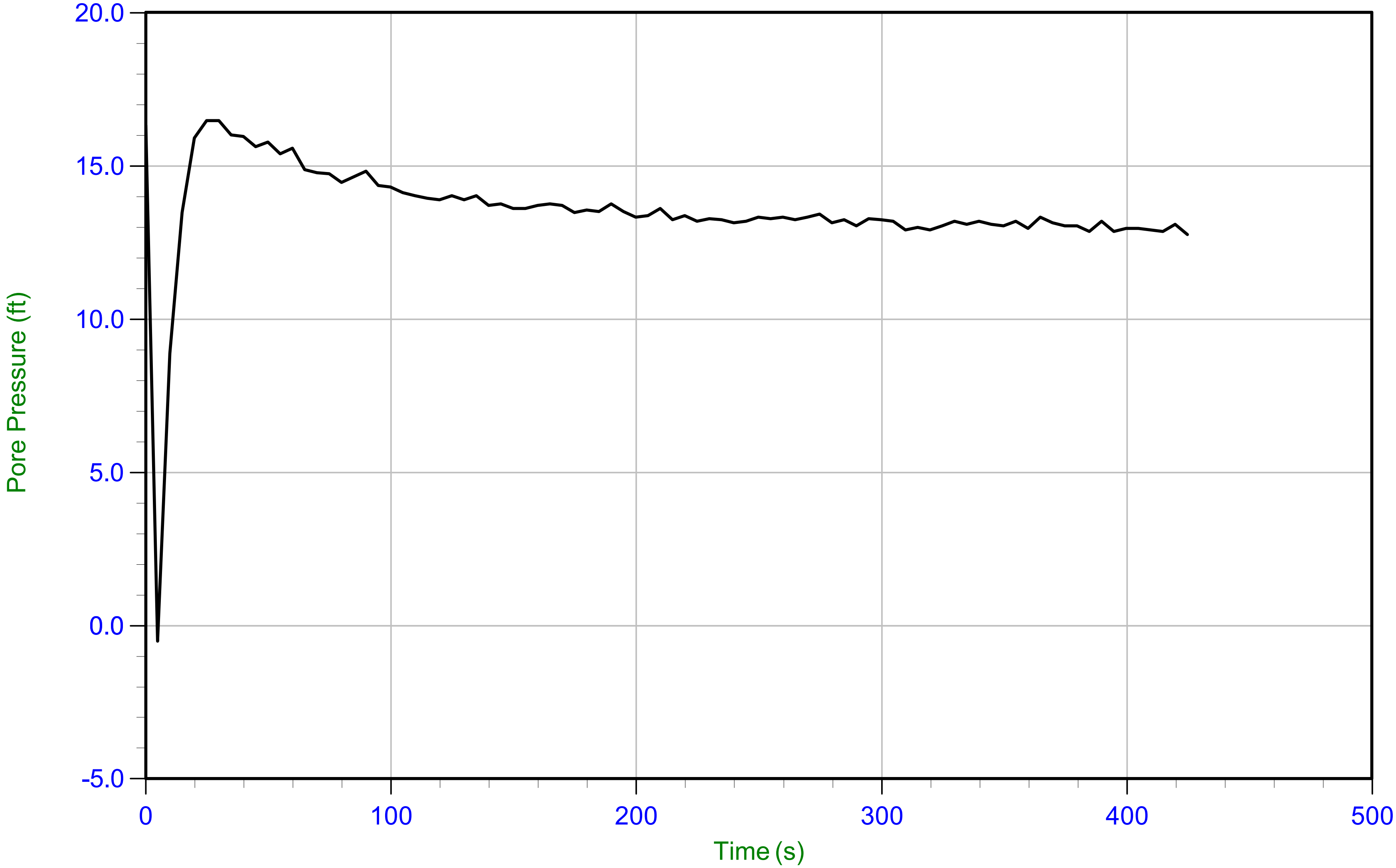
U Min: 4.0 ft
U Max: 57.7 ft

CONETEC

AECOM

Job No: 15-53063
Date: 06-Aug-2015 13:10:59
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C022
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP22.PPD
Depth: 10.800 m / 35.433 ft
Duration: 425.0 s

U Min: -0.5 ft
U Max: 16.5 ft

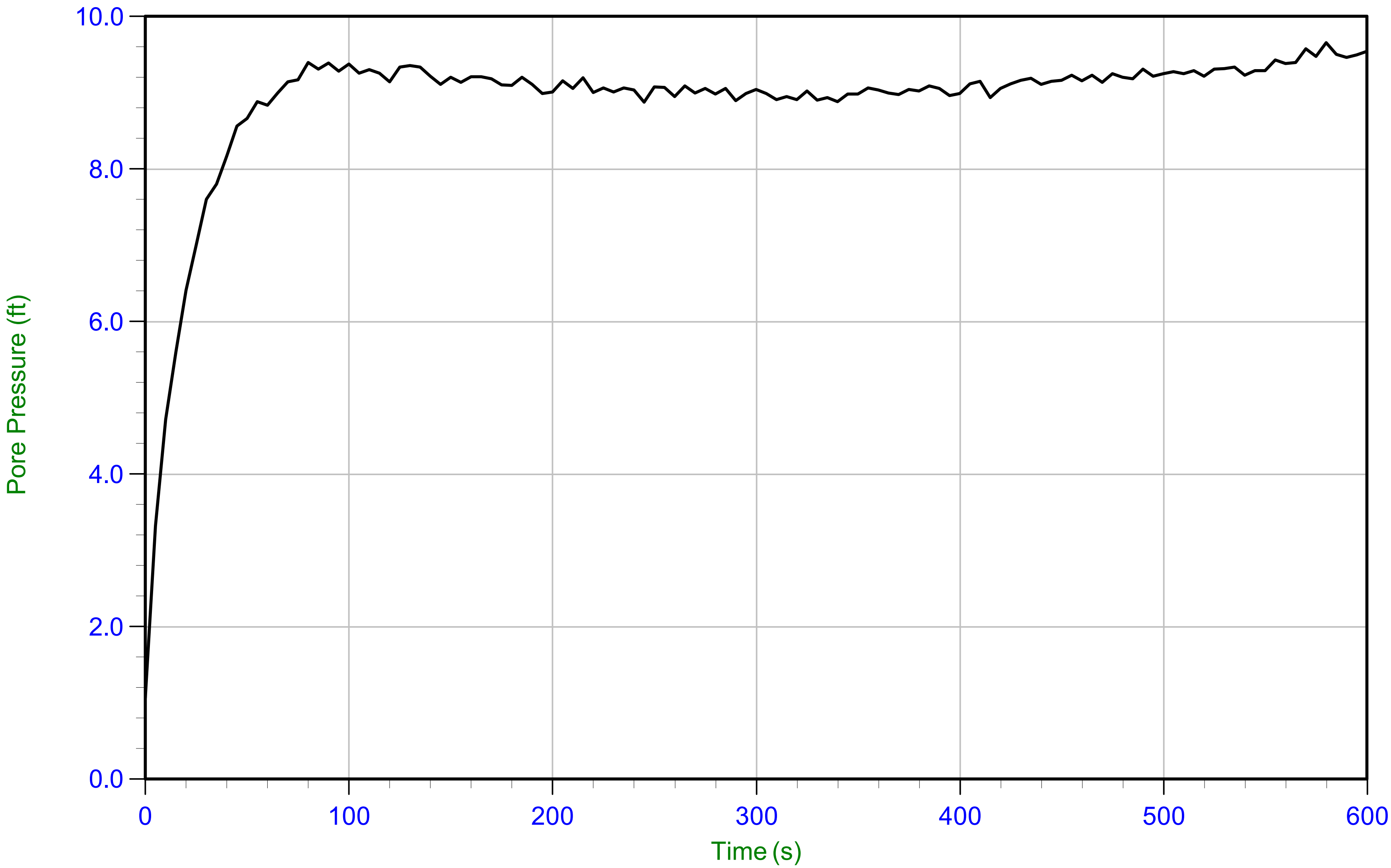
WT: 6.886 m / 22.592 ft
Ueq: 12.8 ft

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 13:15:40
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C023
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP23.PPD
Depth: 5.000 m / 16.404 ft
Duration: 600.0 s

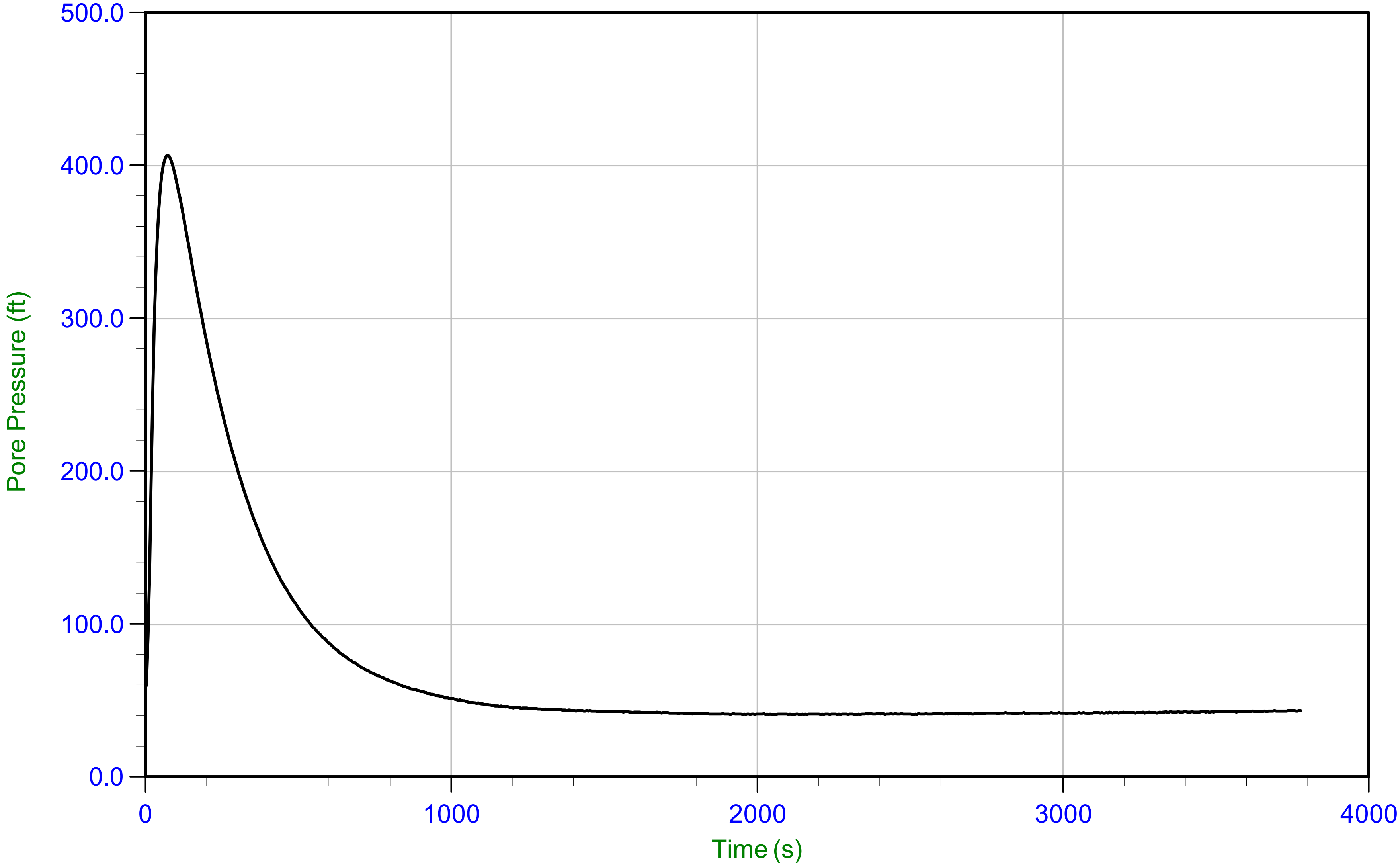
U Min: 1.1 ft
U Max: 9.7 ft

CONETEC

AECOM

Job No: 15-53063
Date: 05-Aug-2015 13:22:44
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C024
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP24.PPD
Depth: 10.650 m / 34.941 ft
Duration: 3780.0 s

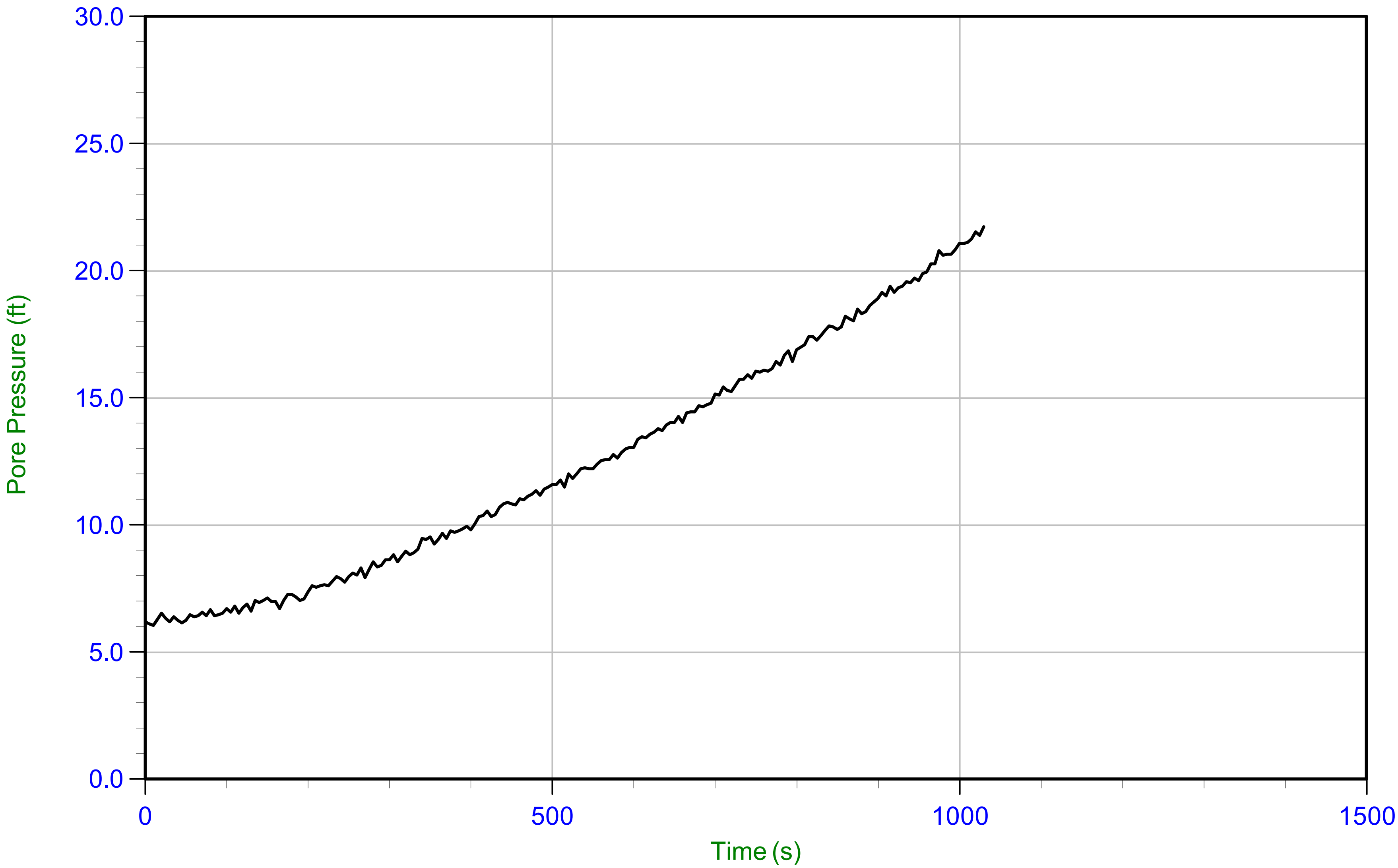
U Min: 40.7 ft
U Max: 406.5 ft

CONETEC

AECOM

Job No: 15-53063
Date: 10-Aug-2015 10:10:33
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C025
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP25.PPD
Depth: 6.850 m / 22.473 ft
Duration: 1030.0 s

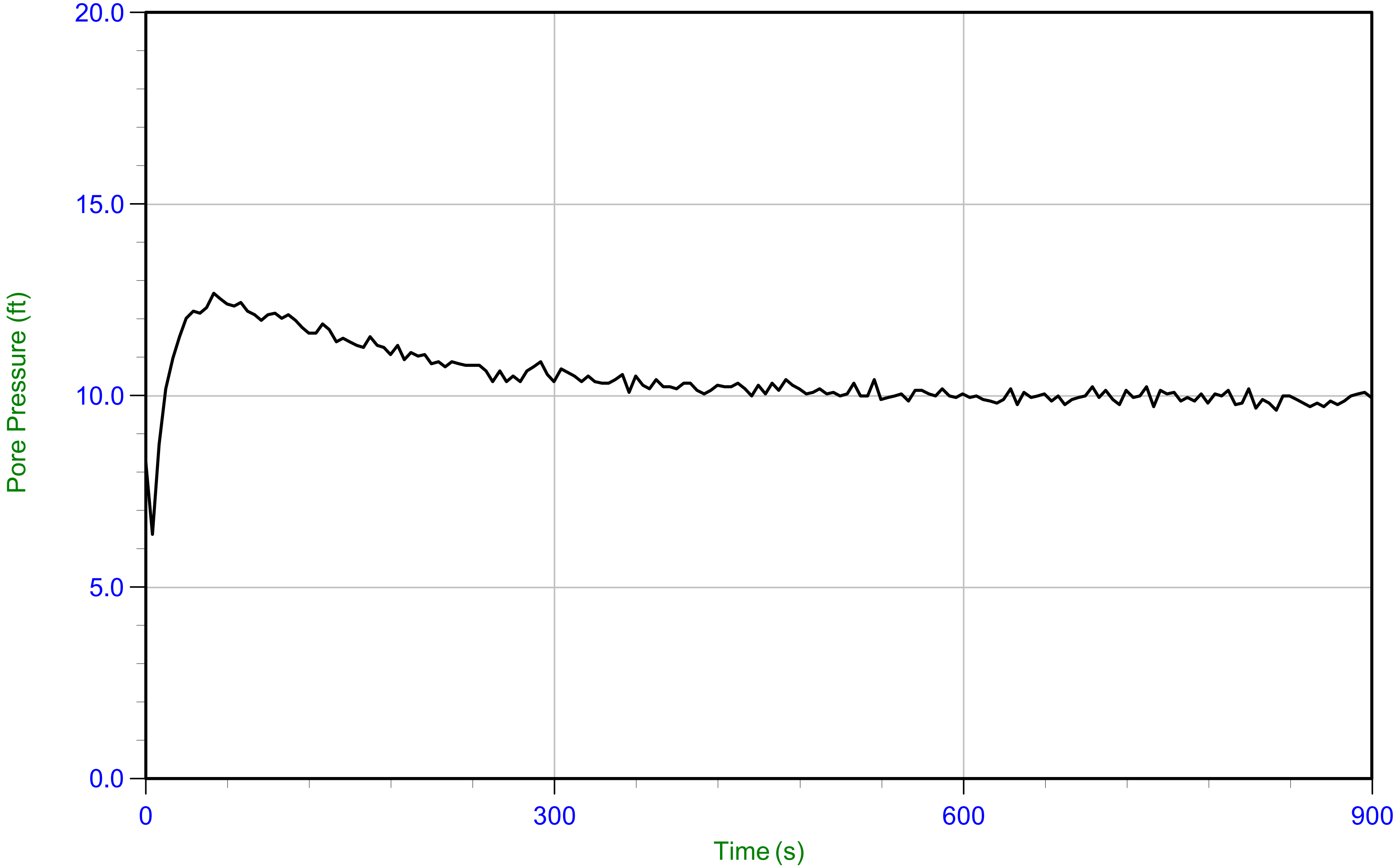
U Min: 6.1 ft
U Max: 21.7 ft

CONETEC

AECOM

Job No: 15-53063
Date: 10-Aug-2015 10:10:33
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C025
Cone: 335
Cone Area: 15 sq cm



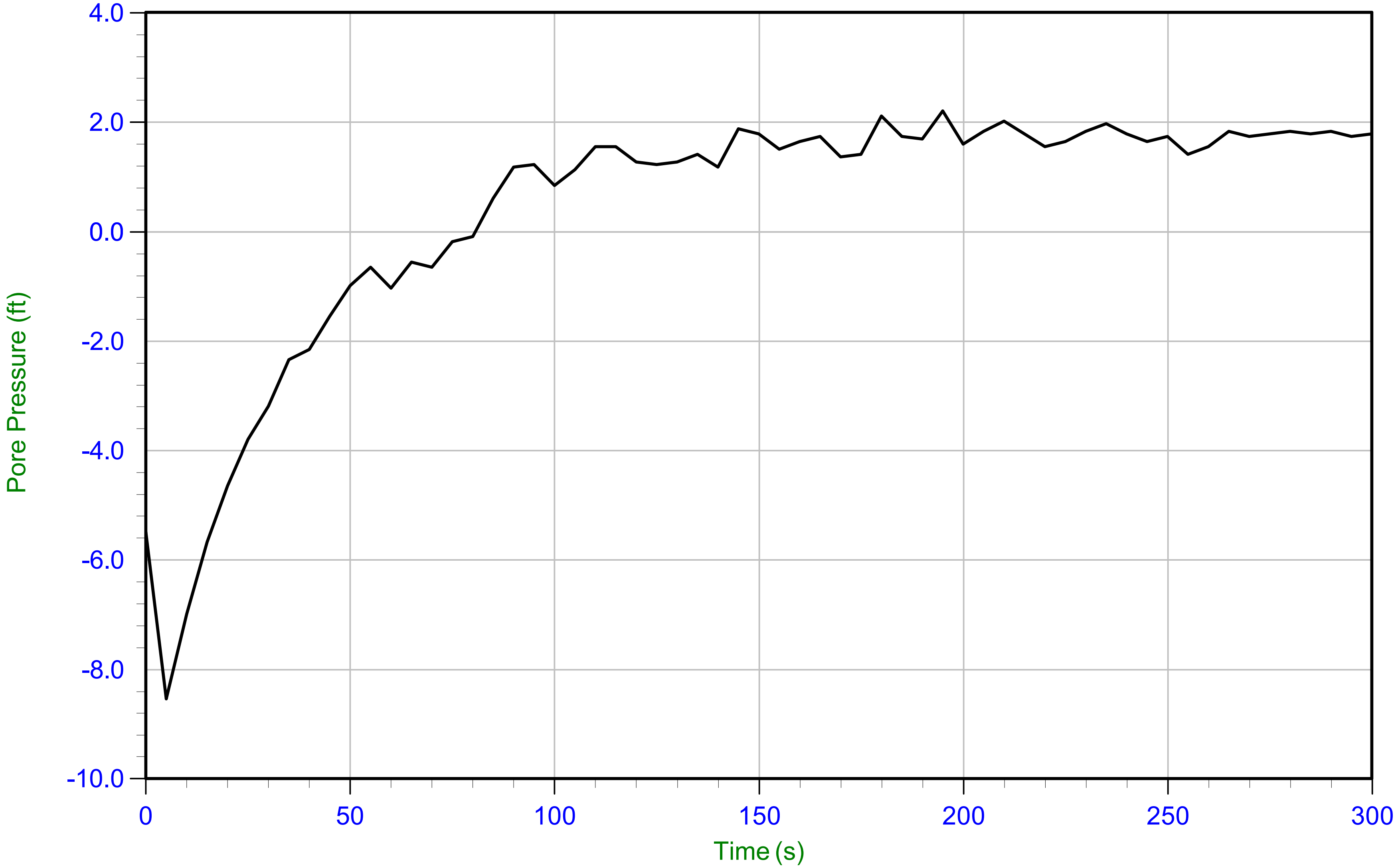
Trace Summary:

Filename: 15-53063_SP25.PPD
Depth: 9.800 m / 32.152 ft
Duration: 900.0 s

U Min: 6.4 ft
U Max: 12.7 ft

WT: 6.804 m / 22.323 ft
Ueq: 9.8 ft

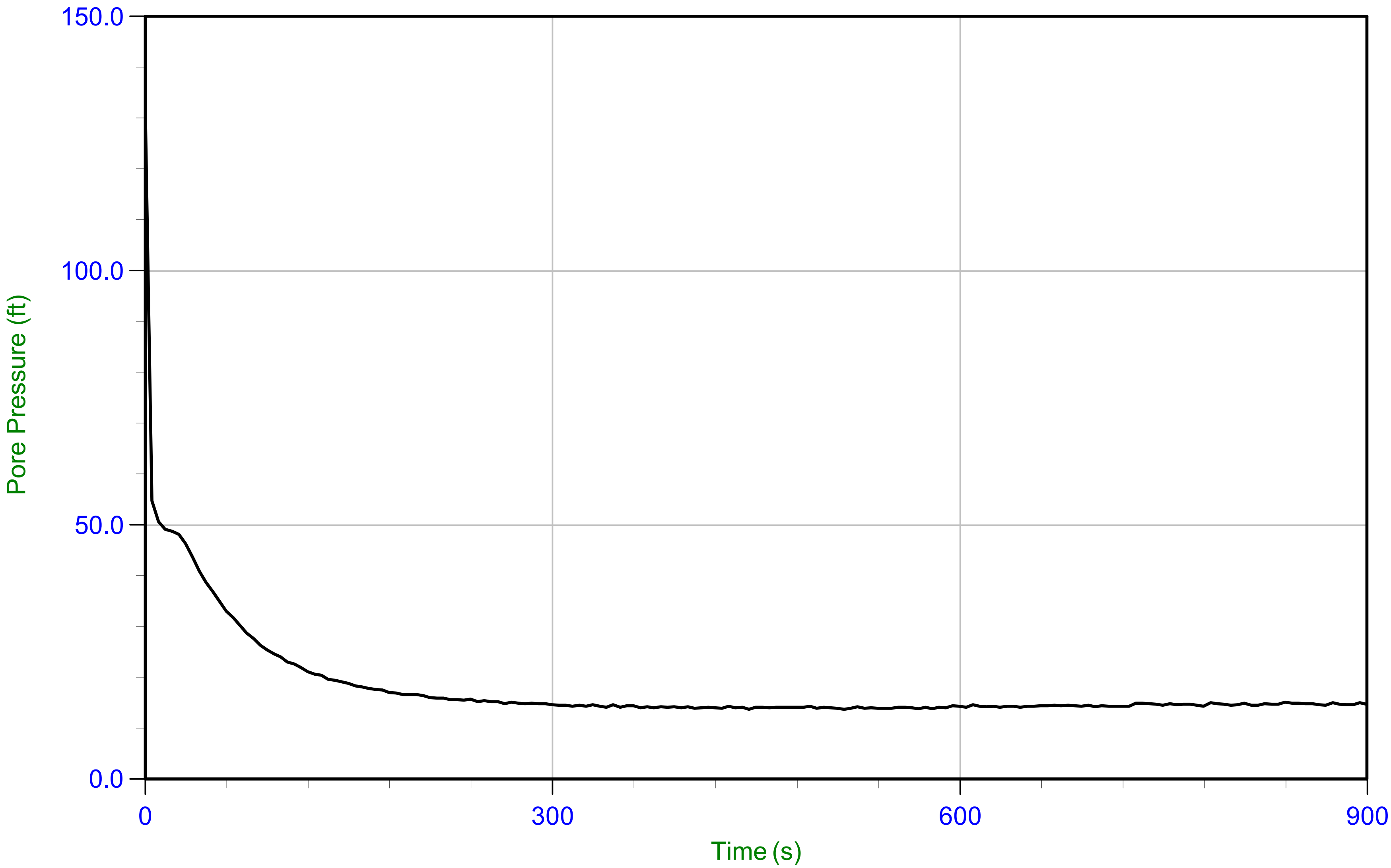
AECOM	Job No: 15-53063	Sounding: COF-C027
	Date: 08-Aug-2015 11:09:21	Cone: 335
	Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP27.PPD	U Min: -8.5 ft	WT: 2.806 m / 9.206 ft
Depth: 3.350 m / 10.991 ft	U Max: 2.2 ft	Ueq: 1.8 ft
Duration: 300.0 s		

AECOM	Job No: 15-53063 Date: 08-Aug-2015 11:09:21 Site: Coffeen Power Station, Coffeen, IL	Sounding: COF-C027 Cone: 335 Cone Area: 15 sq cm



Trace Summary:

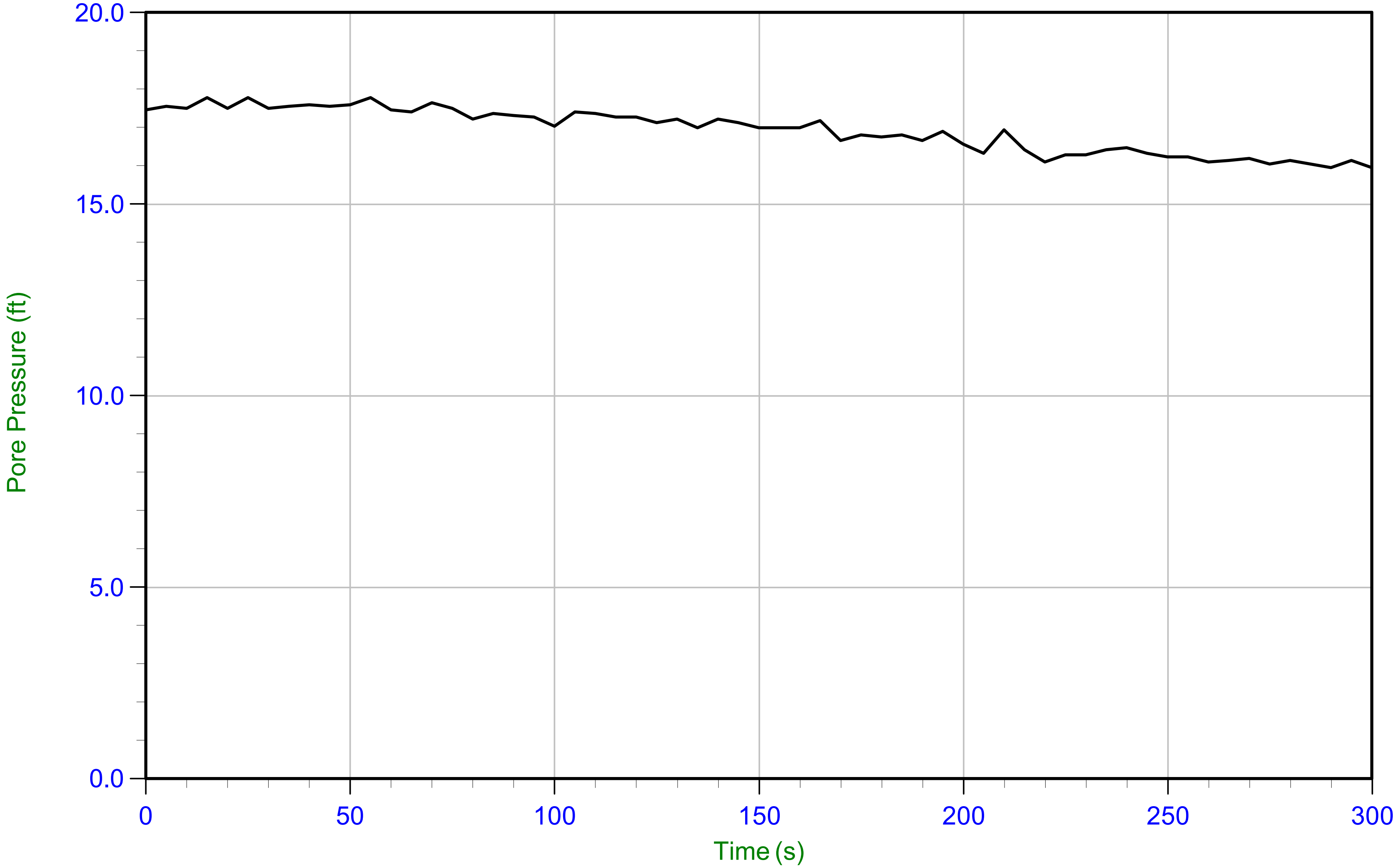
Filename: 15-53063_CP27.PPD	U Min: 13.7 ft	WT: 5.402 m / 17.723 ft
Depth: 9.700 m / 31.824 ft	U Max: 132.1 ft	Ueq: 14.1 ft
Duration: 900.0 s		

CONETEC

AECOM

Job No: 15-53063
Date: 10-Aug-2015 08:10:26
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C028
Cone: 335
Cone Area: 15 sq cm

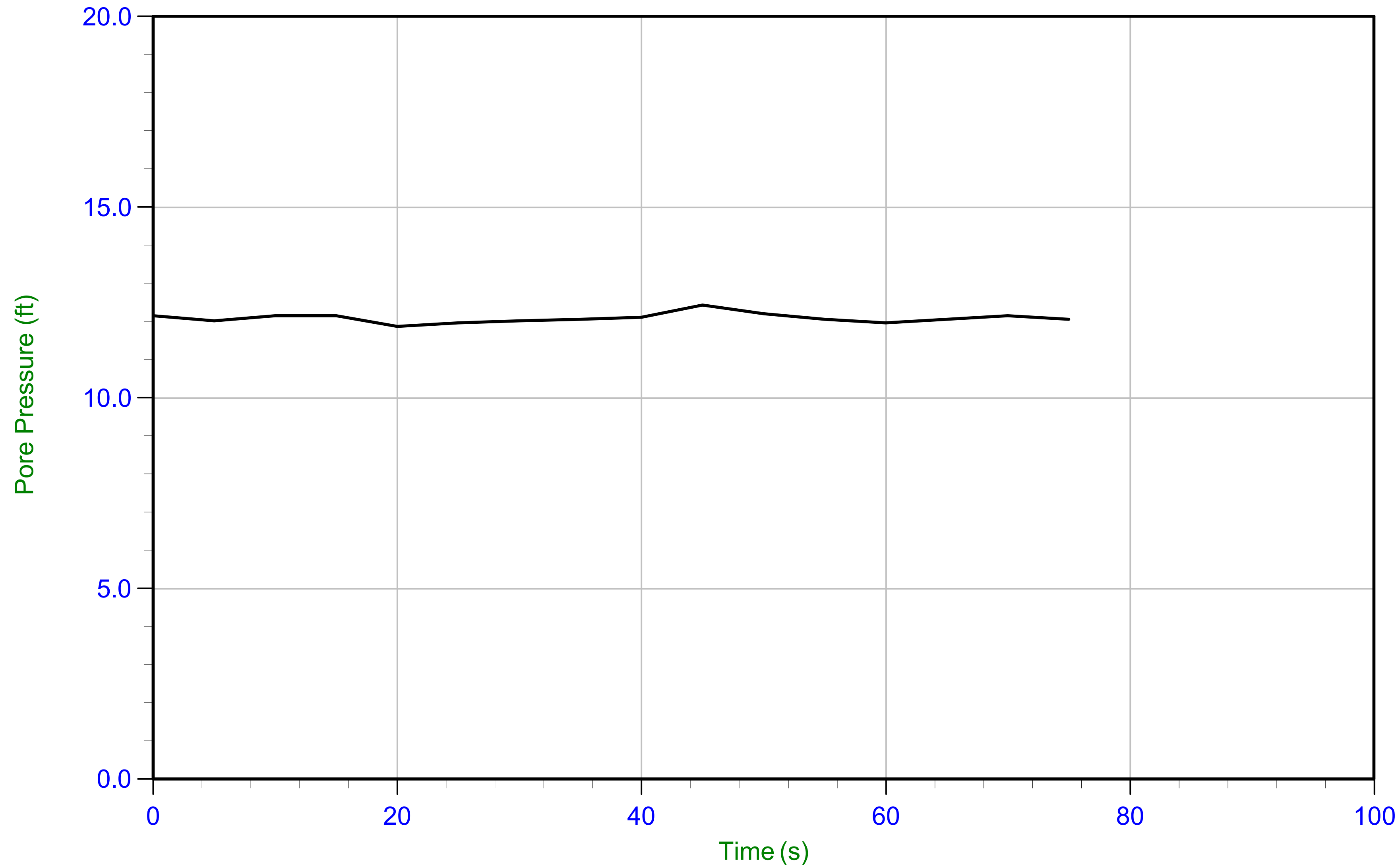


Trace Summary:

Filename: 15-53063_SP28.PPD
Depth: 10.050 m / 32.972 ft
Duration: 300.0 s

U Min: 16.0 ft
U Max: 17.8 ft

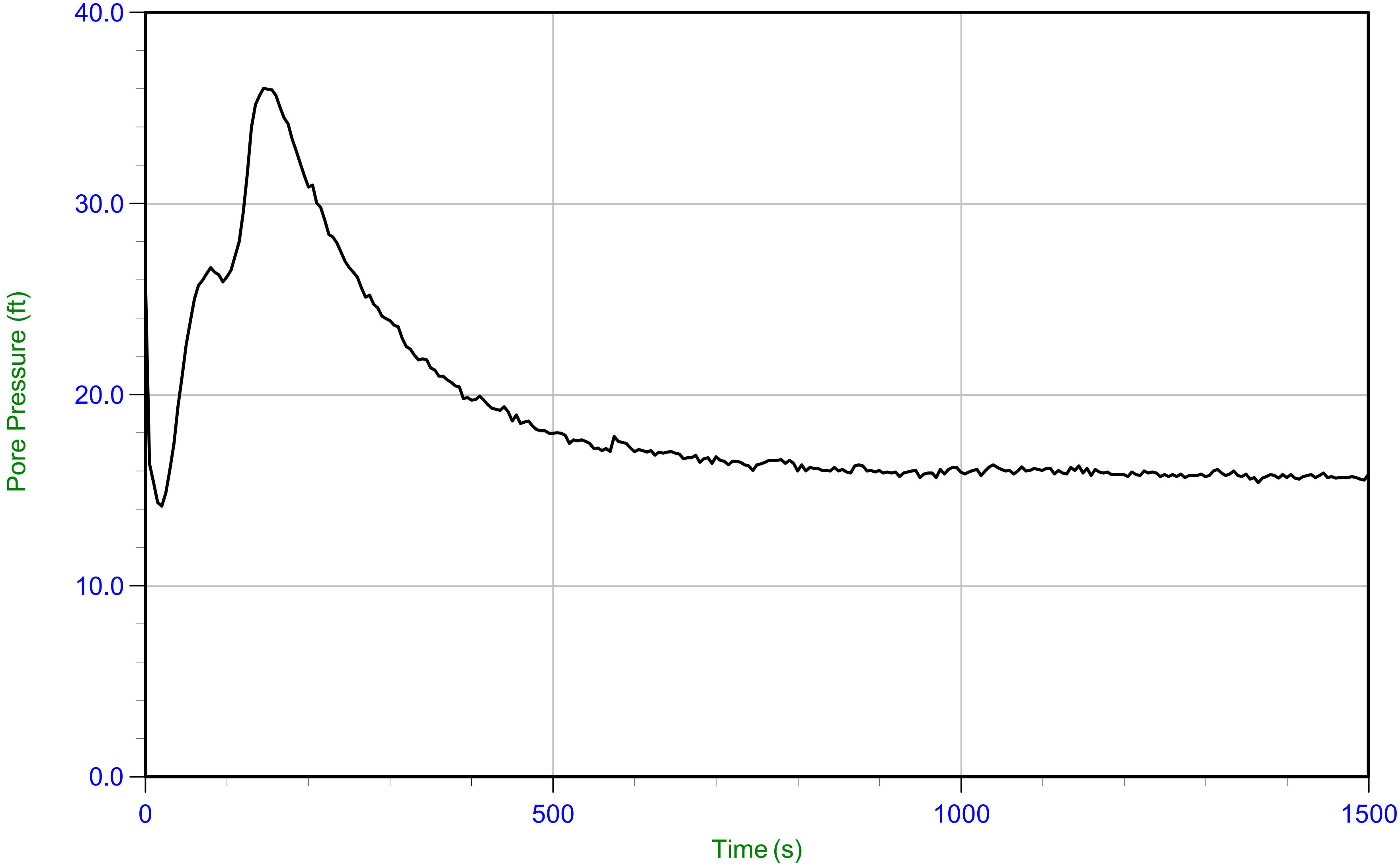
AECOM	Job No: 15-53063	Sounding: COF-C028
	Date: 10-Aug-2015 08:10:26	Cone: 335
	Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP28.PPD	U Min: 11.9 ft	WT: 6.377 m / 20.922 ft
Depth: 10.050 m / 32.972 ft	U Max: 12.4 ft	Ueq: 12.1 ft
Duration: 75.0 s		

AECOM	Job No: 15-53063 Date: 11-Aug-2015 11:19:37 Site: Coffeen Power Station, Coffeen, IL	Sounding: COF-C030 Cone: 335 Cone Area: 15 sq cm



Trace Summary:

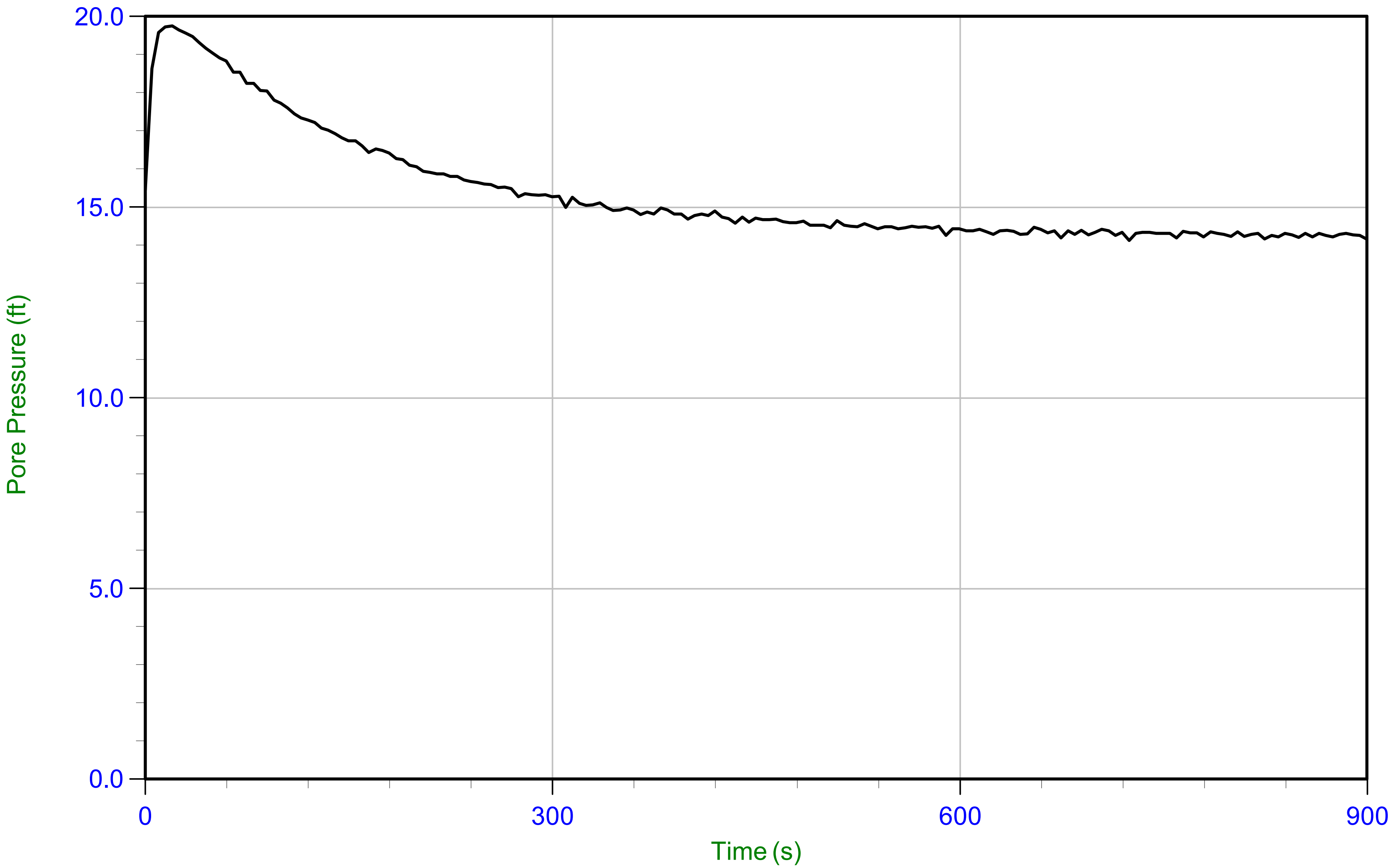
Filename: 15-53063_CP30.PPD	U Min: 14.2 ft	WT: 5.609 m / 18.402 ft
Depth: 10.350 m / 33.956 ft	U Max: 36.0 ft	Ueq: 15.6 ft
Duration: 1500.0 s		

CONETEC

AECOM

Job No: 15-53063
Date: 08-Aug-2015 08:19:29
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C031
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP31.PPD
Depth: 4.750 m / 15.584 ft
Duration: 900.0 s

U Min: 14.1 ft
U Max: 19.8 ft

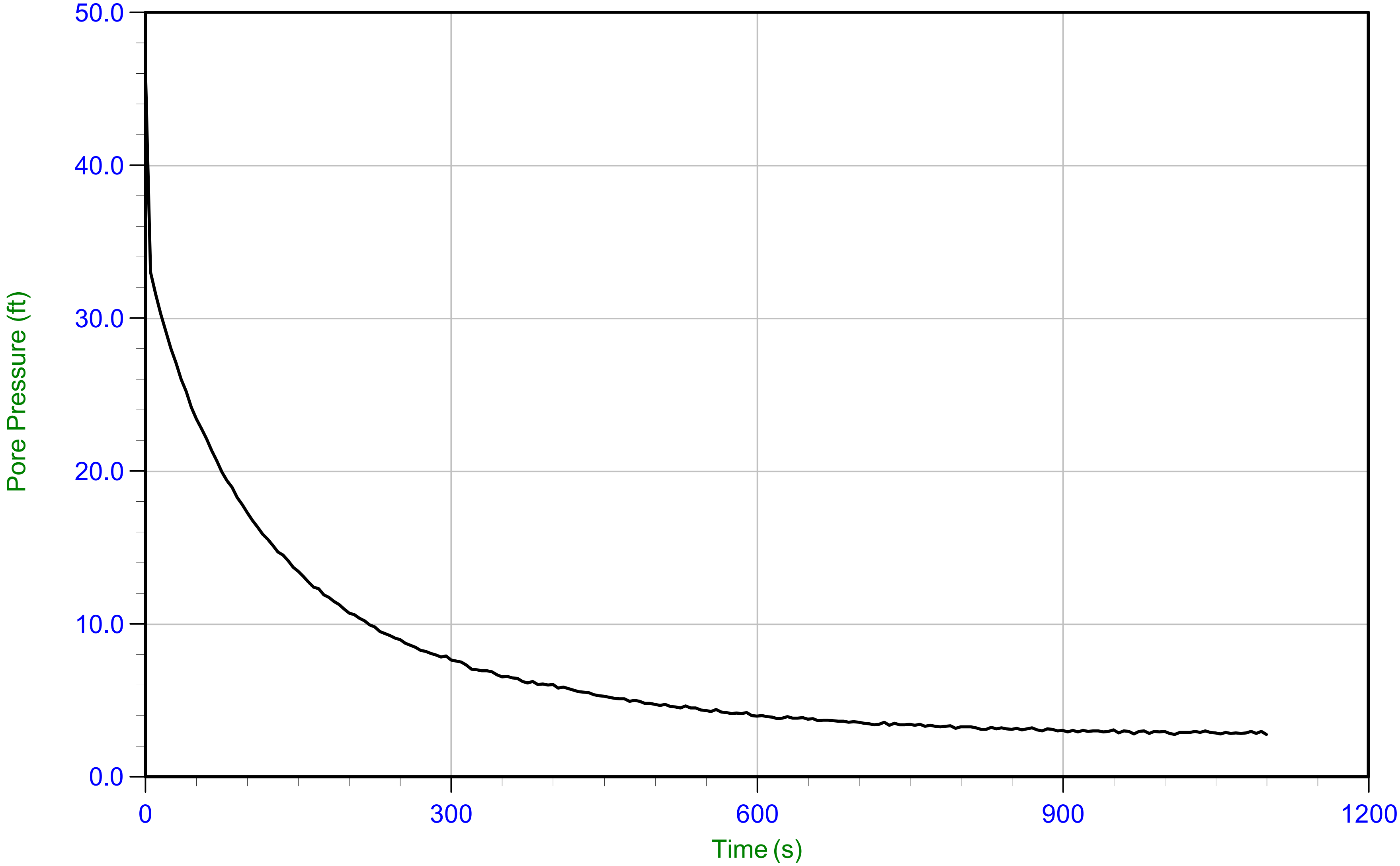
WT: 0.452 m / 1.483 ft
Ueq: 14.1 ft

ConeTec

AECOM

Job No: 15-53063
Date: 08-Aug-2015 08:19:29
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C031
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP31.PPD
Depth: 6.950 m / 22.802 ft
Duration: 1100.0 s

U Min: 2.8 ft
U Max: 46.2 ft

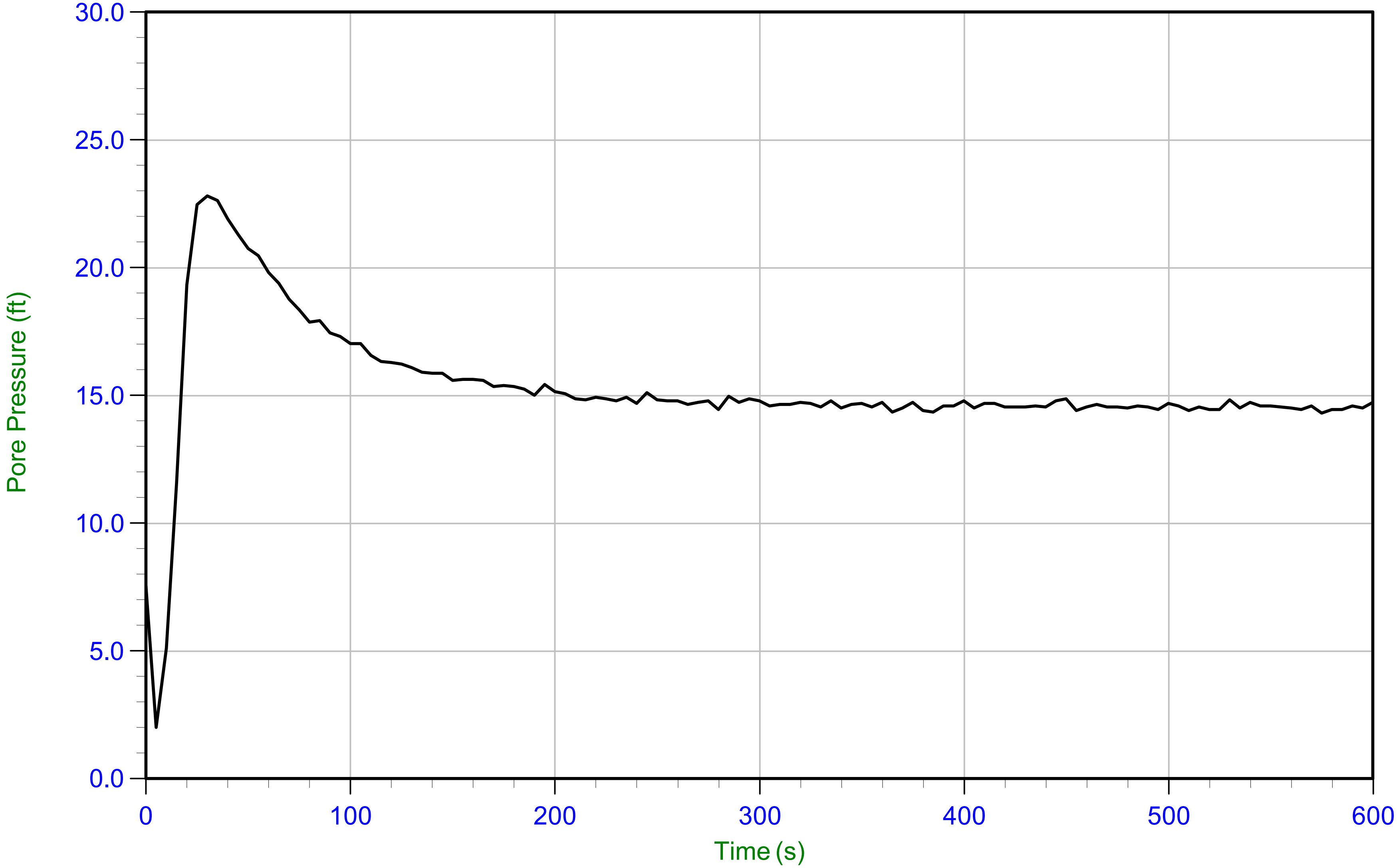
WT: 6.168 m / 20.236 ft
Ueq: 2.6 ft

ConeTec

AECOM

Job No: 15-53063
Date: 11-Aug-2015 13:07:44
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C032
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP32.PPD
Depth: 9.500 m / 31.168 ft
Duration: 600.0 s

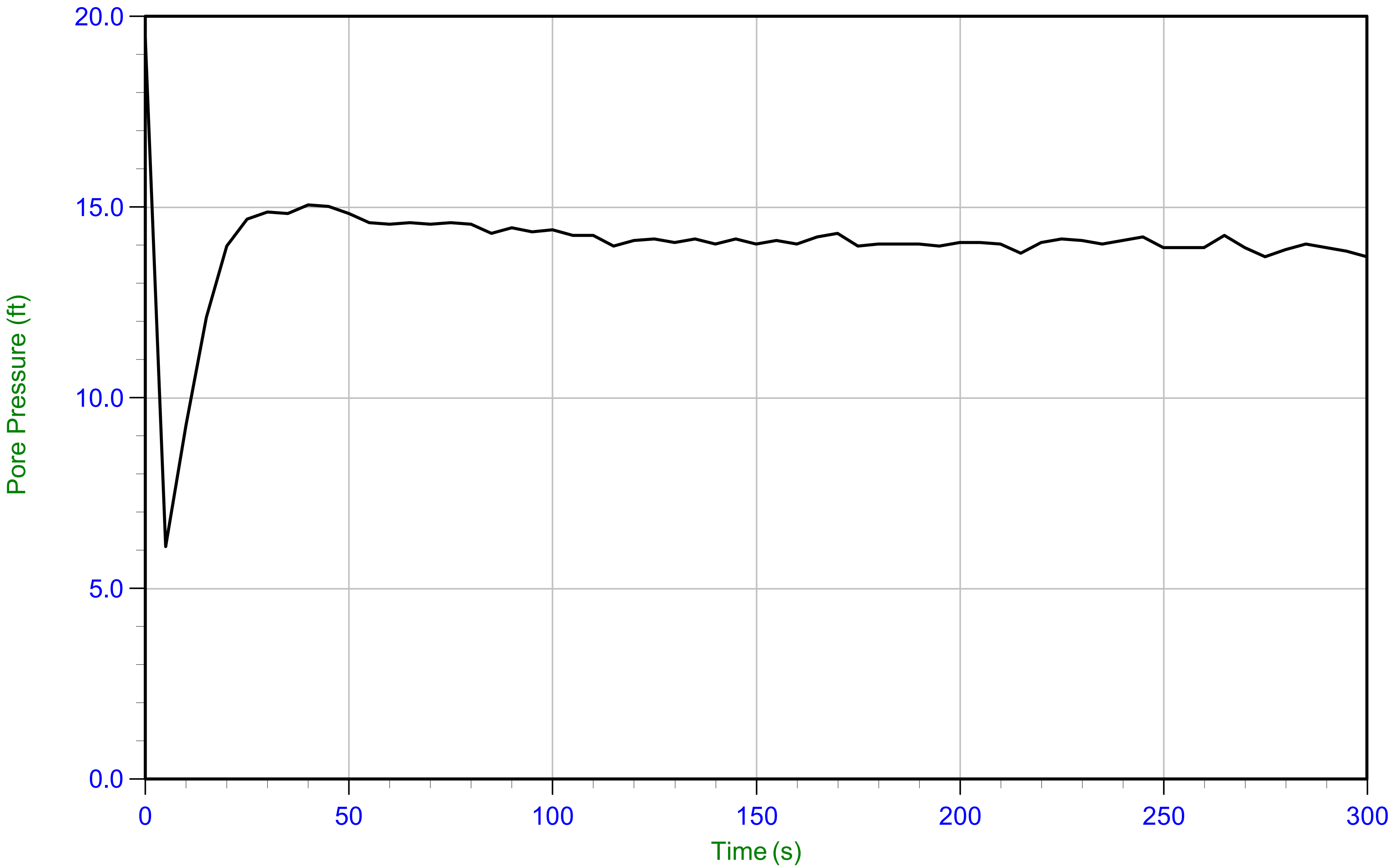
U Min: 2.0 ft
U Max: 22.8 ft

WT: 5.084 m / 16.680 ft
Ueq: 14.5 ft

AECOM

Job No: 15-53063
Date: 08-Aug-2015 07:49:00
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C033
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP33.PPD
Depth: 9.450 m / 31.004 ft
Duration: 300.0 s

U Min: 6.1 ft
U Max: 19.4 ft

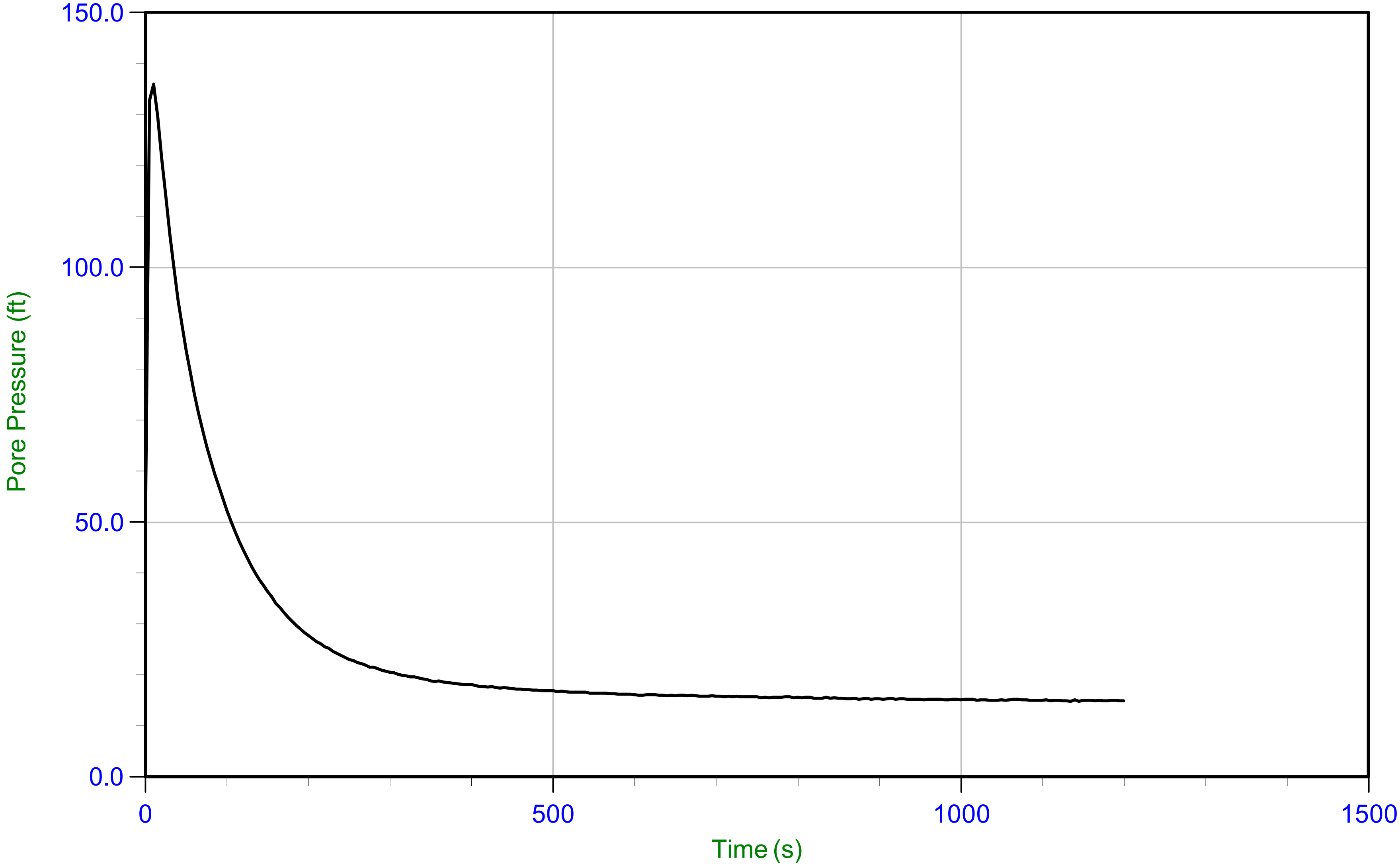
WT: 5.204 m / 17.073 ft
Ueq: 13.9 ft

CONETEC

AECOM

Job No: 15-53063
Date: 08-Aug-2015 10:03:03
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C034
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP34.PPD
Depth: 4.550 m / 14.928 ft
Duration: 1200.0 s

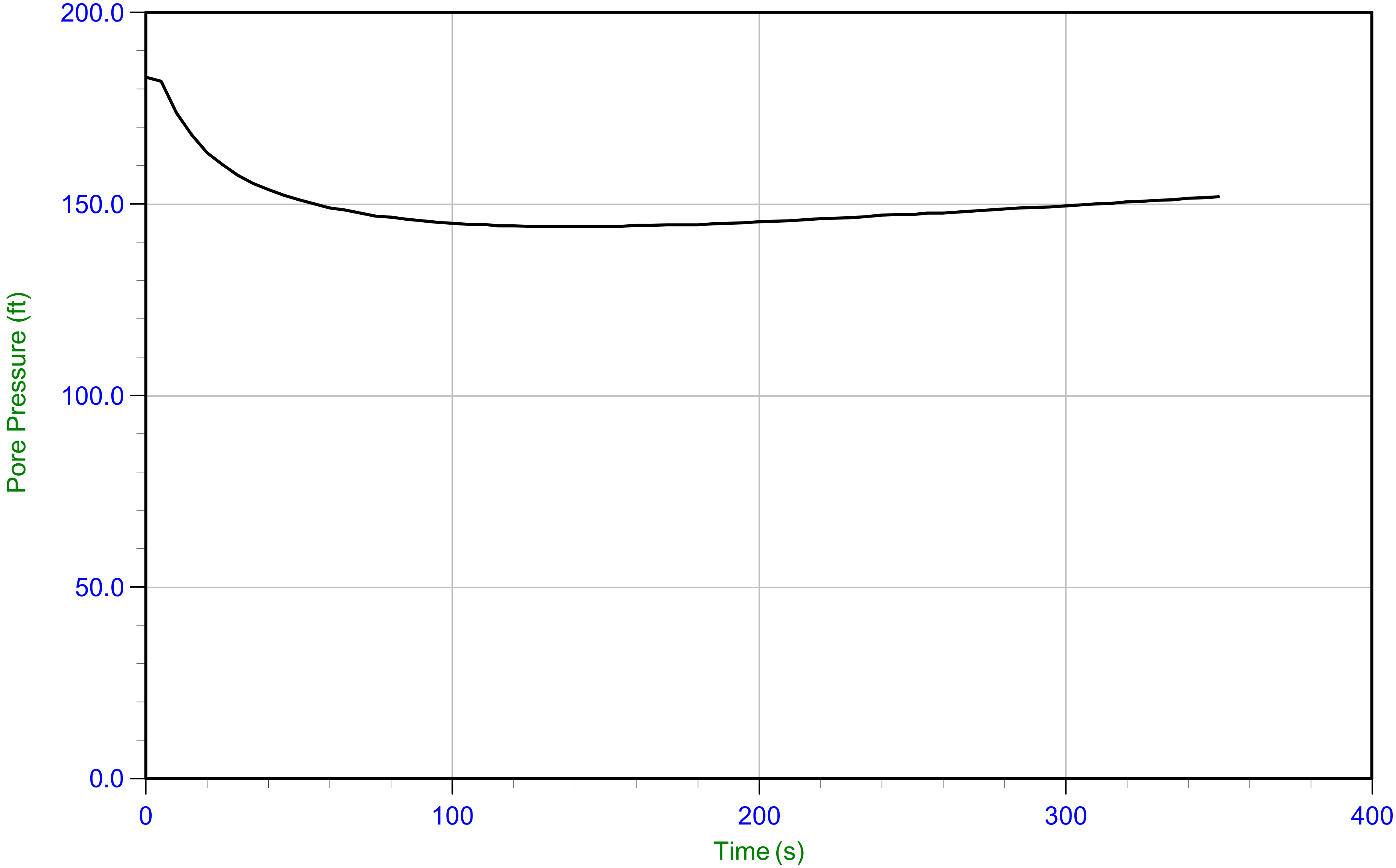
U Min: 14.9 ft
U Max: 136.0 ft

WT: 0.056 m / 0.184 ft
Ueq: 14.7 ft

AECOM

Job No: 15-53063
Date: 08-Aug-2015 10:03:03
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C034
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP34.PPD
Depth: 18.350 m / 60.203 ft
Duration: 350.0 s

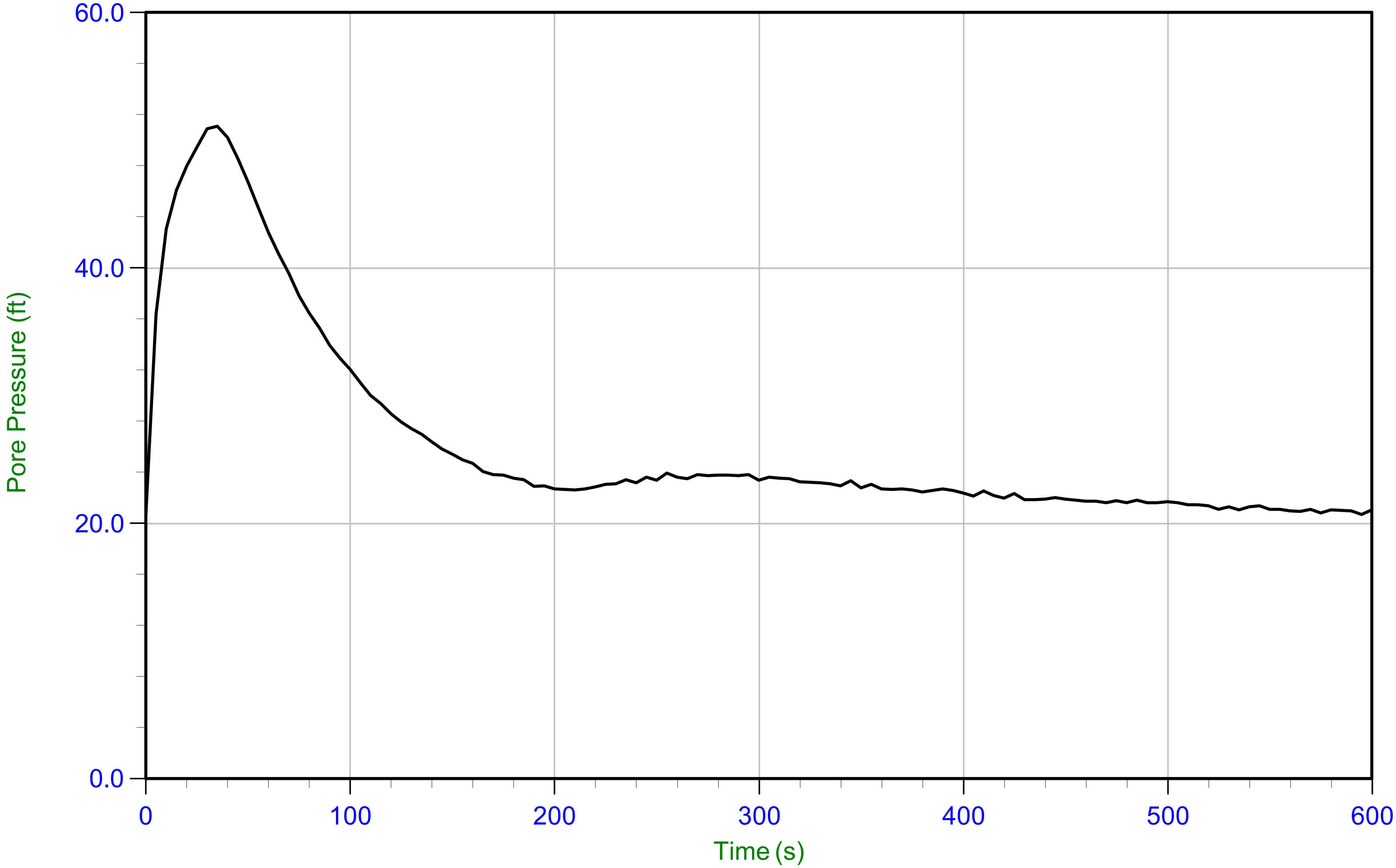
U Min: 144.2 ft
U Max: 183.2 ft

CONETEC

AECOM

Job No: 15-53063
Date: 08-Aug-2015 09:32:57
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C035
Cone: 335
Cone Area: 15 sq cm

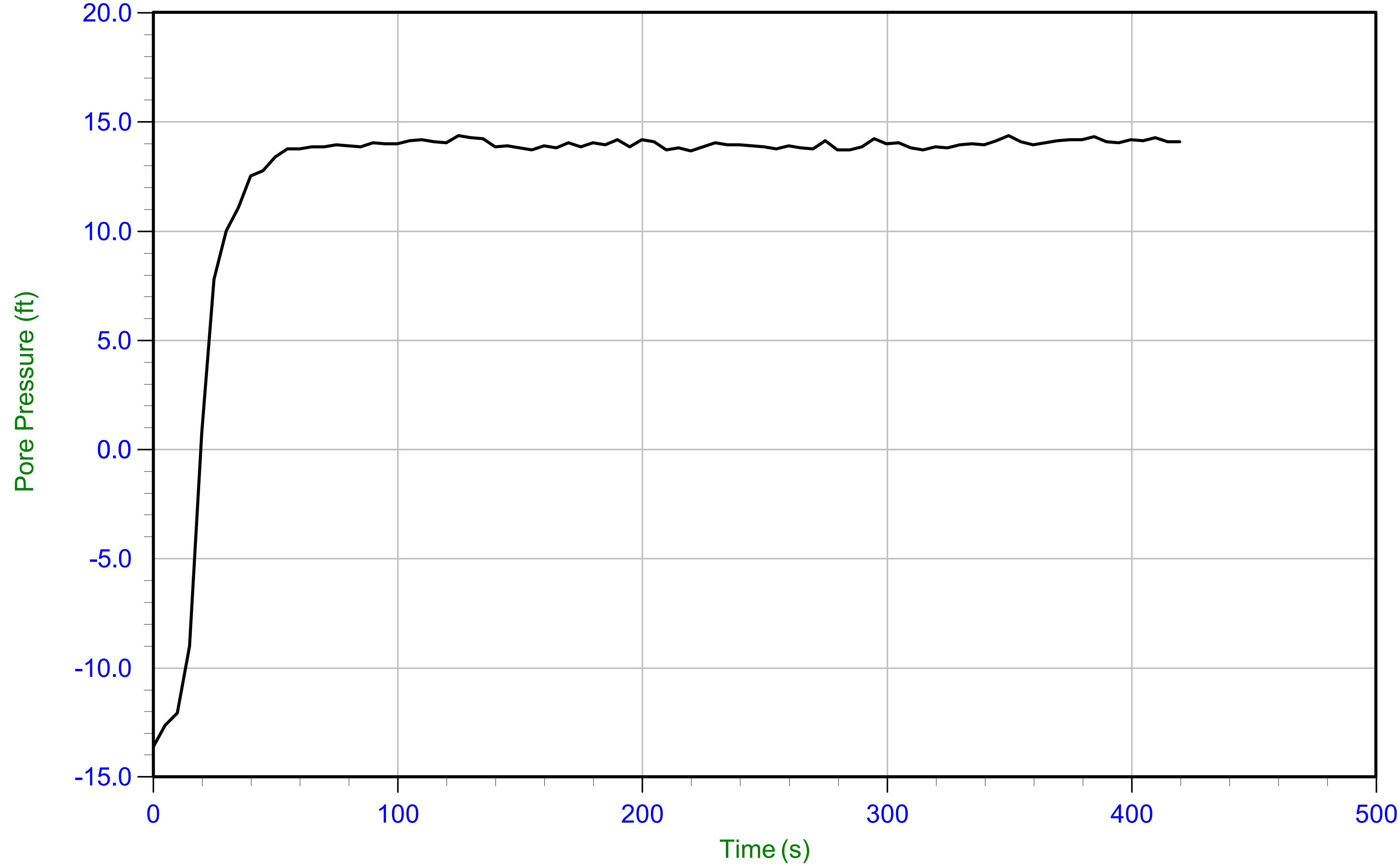


Trace Summary:

Filename: 15-53063_CP35.PPD
Depth: 9.950 m / 32.644 ft
Duration: 600.0 s

U Min: 20.6 ft
U Max: 51.1 ft

AECOM	Job No: 15-53063	Sounding: COF-C036
	Date: 08-Aug-2015 08:43:58	Cone: 335
	Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

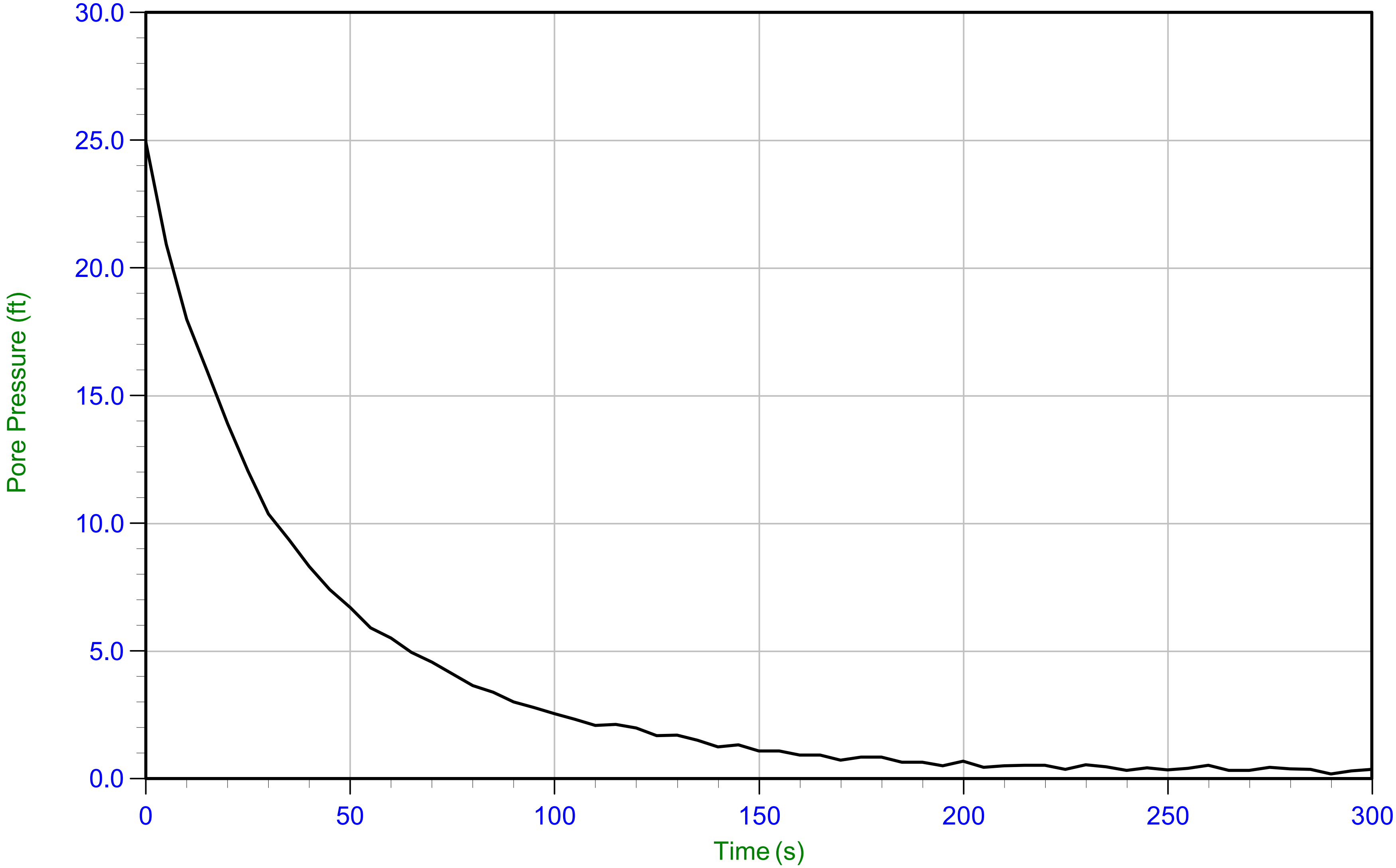
Filename: 15-53063_CP36.PPD	U Min: -13.6 ft	WT: 5.128 m / 16.824 ft
Depth: 9.400 m / 30.840 ft	U Max: 14.4 ft	Ueq: 14.0 ft
Duration: 420.0 s		

CONETEC

AECOM

Job No: 15-53063
Date: 08-Aug-2015 12:09:32
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C037
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP37.PPD
Depth: 3.400 m / 11.155 ft
Duration: 300.0 s

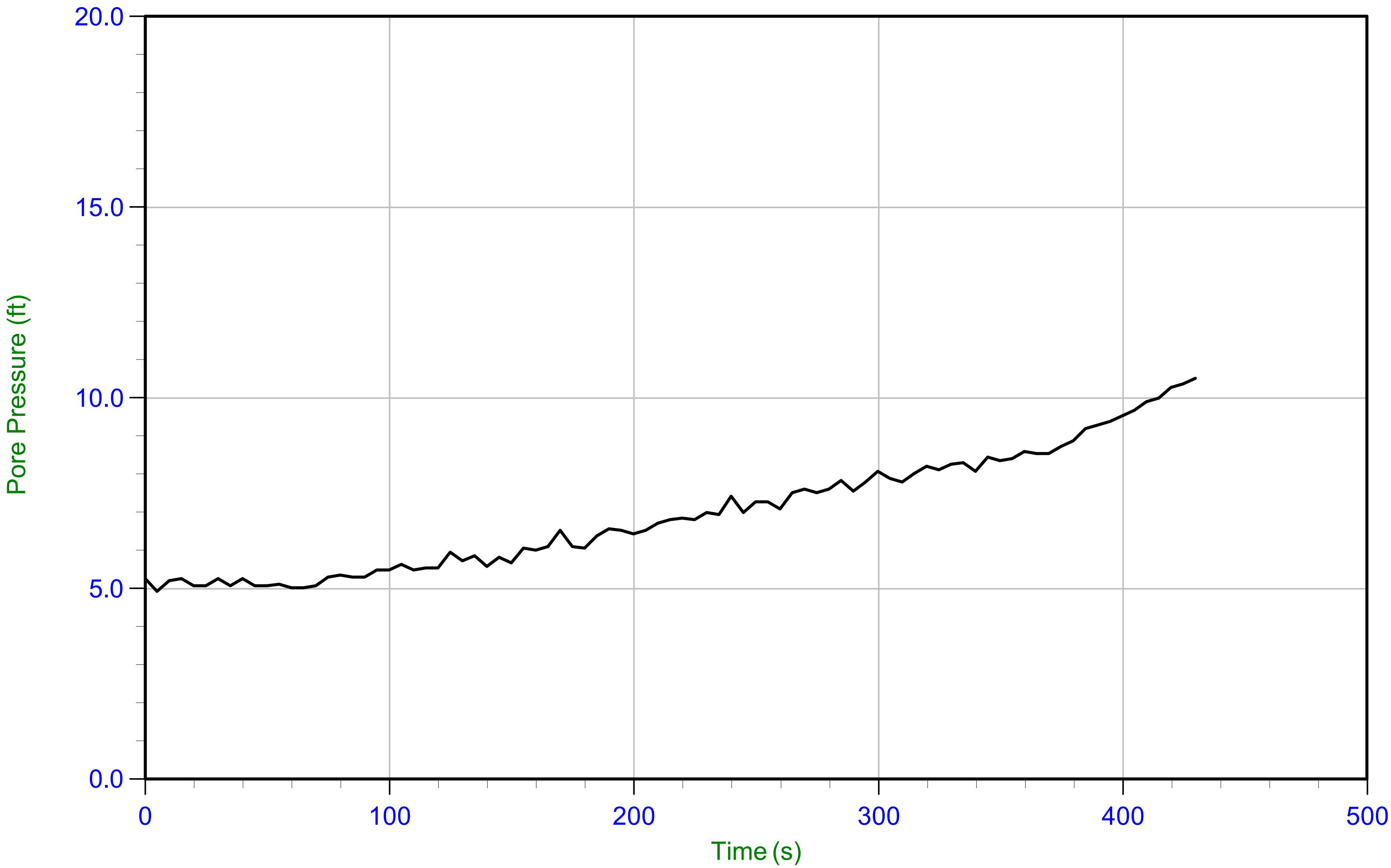
U Min: 0.2 ft
U Max: 24.9 ft

WT: 3.400 m / 11.155 ft
Ueq: 0.0 ft

AECOM

Job No: 15-53063
Date: 11-Aug-2015 08:38:42
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C038
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP38.PPD
Depth: 7.700 m / 25.262 ft
Duration: 430.0 s

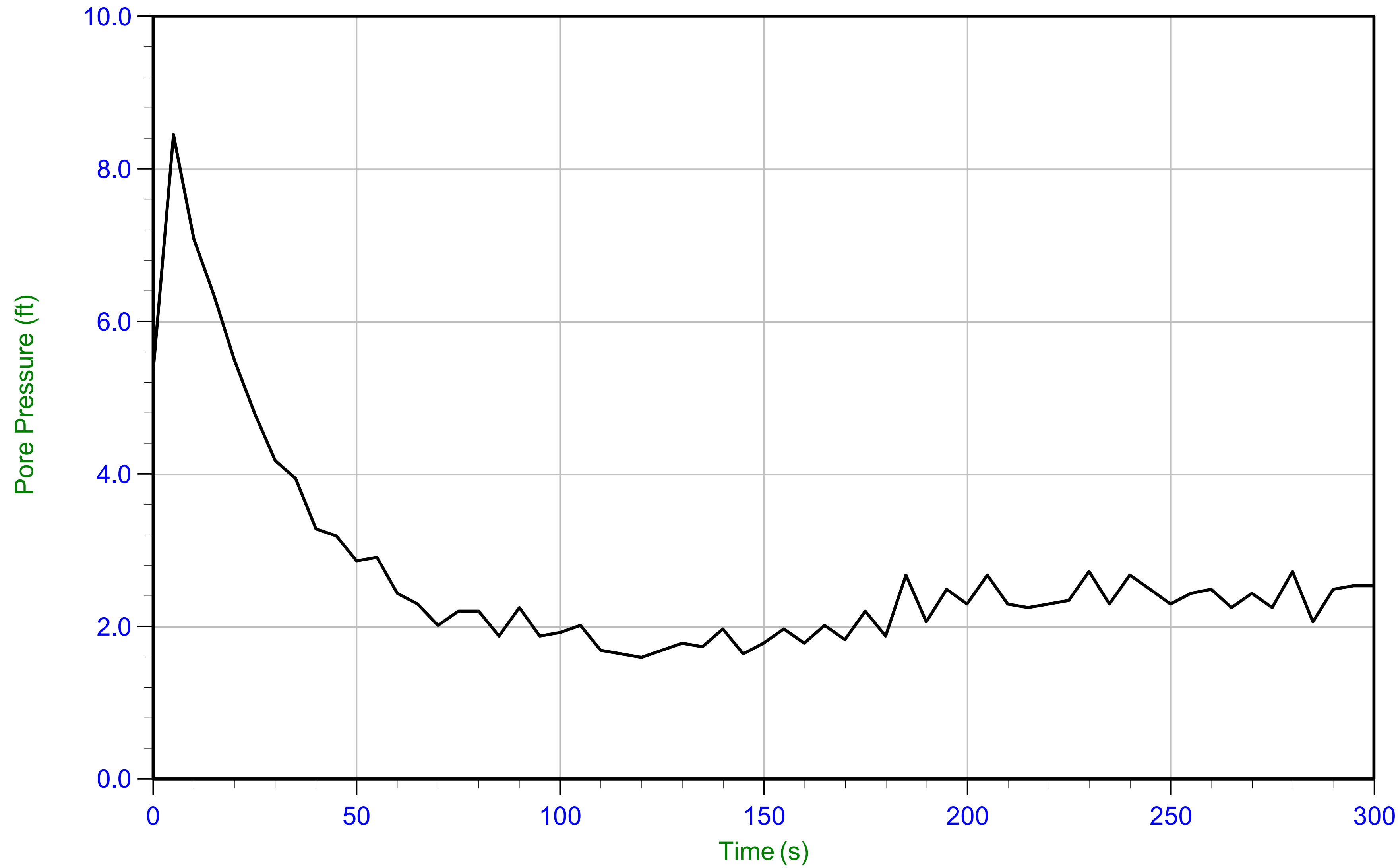
U Min: 4.9 ft
U Max: 10.5 ft

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 10:04:42
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C039
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP39.PPD
Depth: 2.350 m / 7.710 ft
Duration: 300.0 s

U Min: 1.6 ft
U Max: 8.4 ft

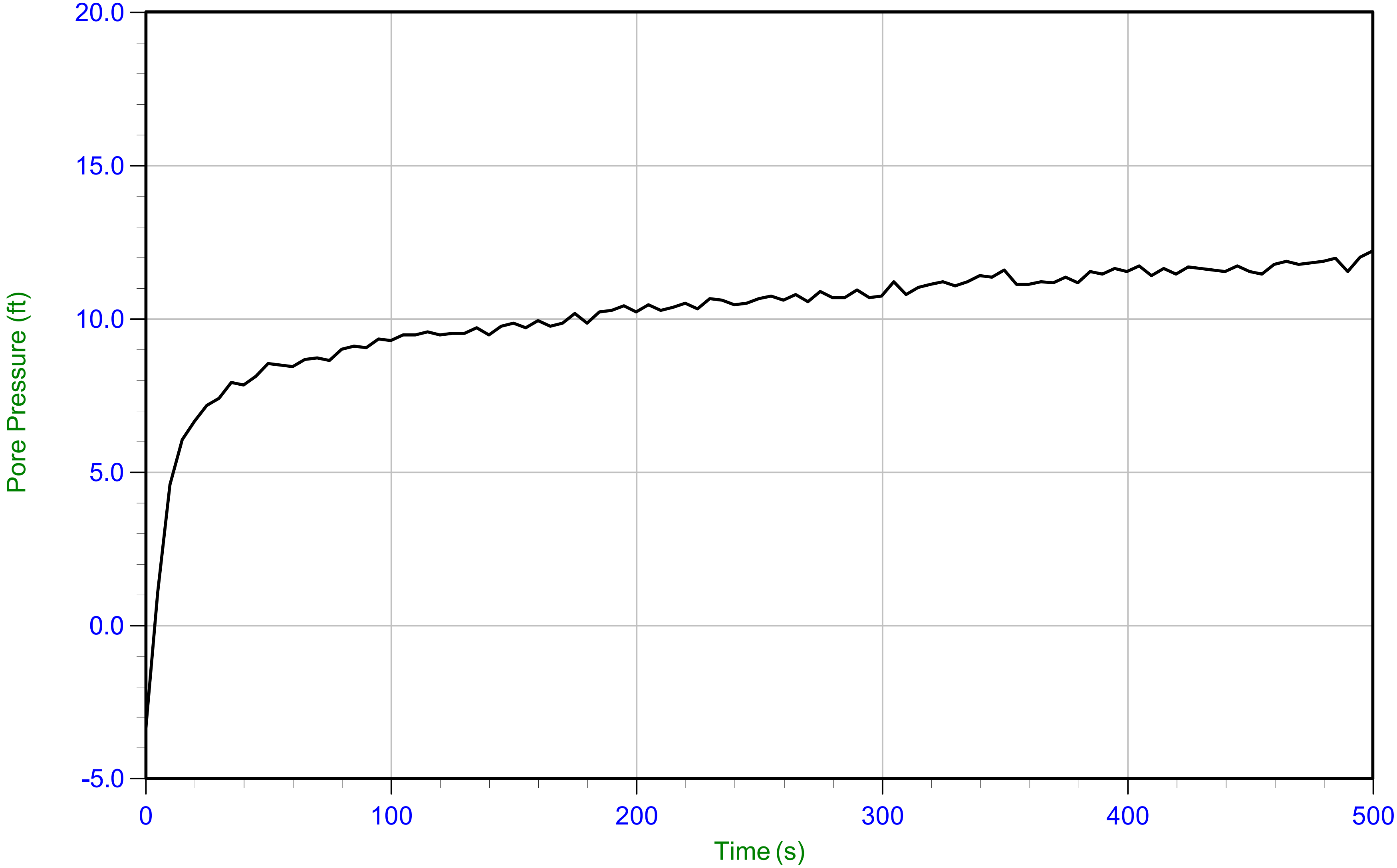
WT: 1.634 m / 5.361 ft
Ueq: 2.3 ft

ConeTec

AECOM

Job No: 15-53063
Date: 10-Aug-2015 13:52:24
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C041
Cone: 335
Cone Area: 15 sq cm

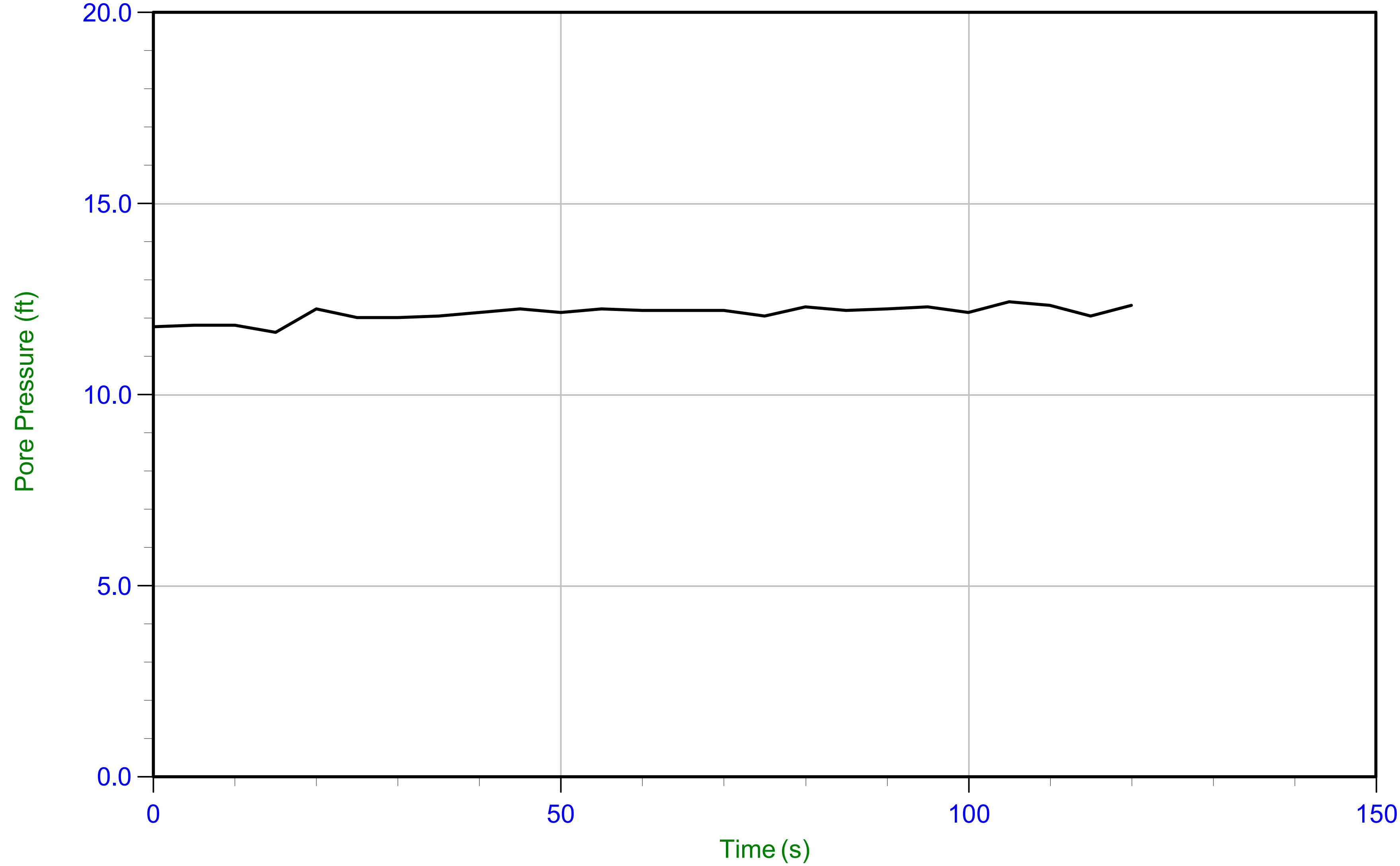


Trace Summary:

Filename: 15-53063_SP41.PPD
Depth: 10.600 m / 34.776 ft
Duration: 500.0 s

U Min: -3.3 ft
U Max: 12.2 ft

CONETEC	AECOM	Job No: 15-53063	Sounding: COF-C041
		Date: 10-Aug-2015 13:52:24	Cone: 335
		Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

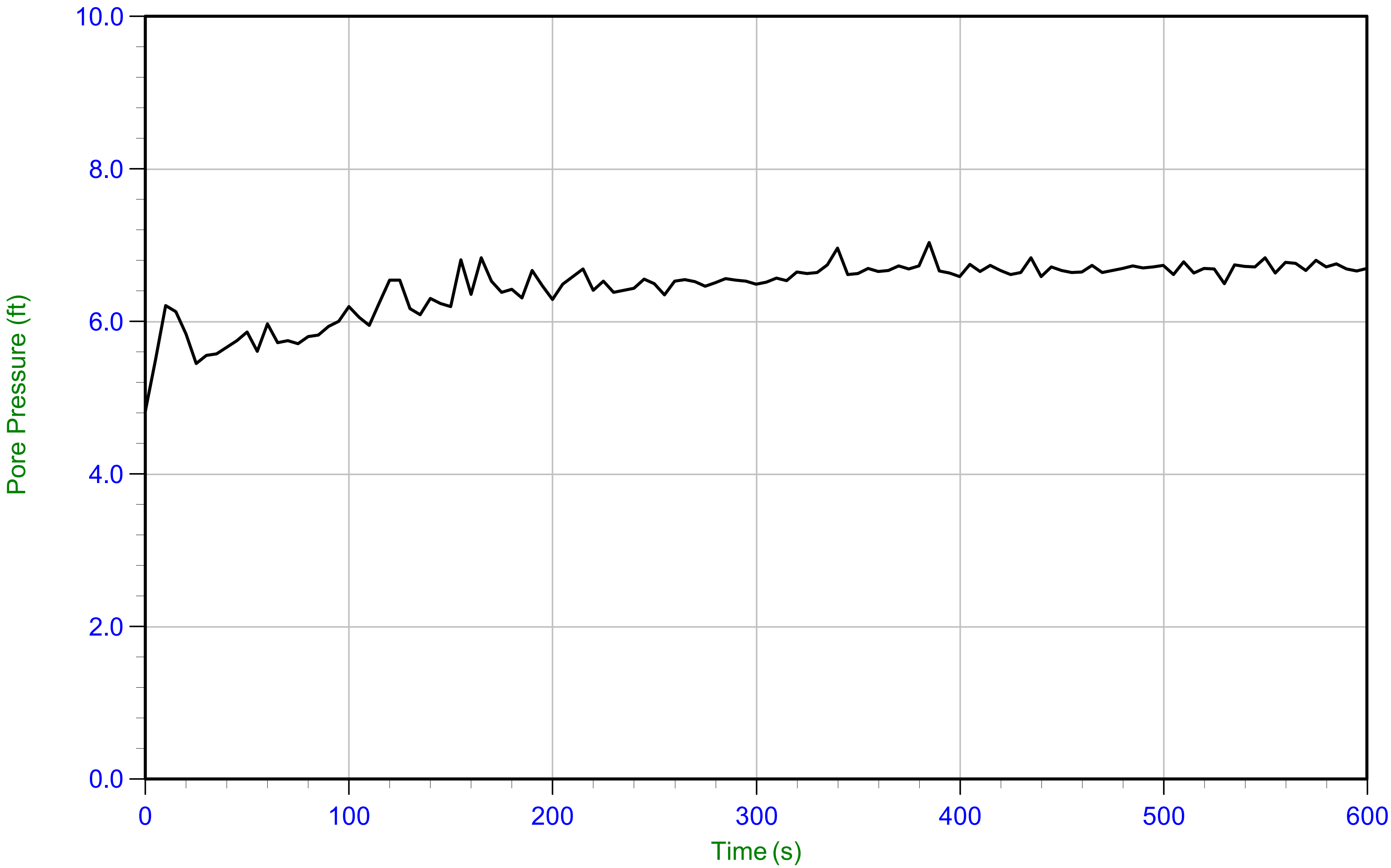
Filename: 15-53063_SP41.PPD	U Min: 11.6 ft	WT: 6.875 m / 22.556 ft
Depth: 10.600 m / 34.776 ft	U Max: 12.4 ft	Ueq: 12.2 ft
Duration: 120.0 s		

ConeTec

AECOM

Job No: 15-53063
Date: 10-Aug-2015 14:46:38
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C043
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP43.PPD
Depth: 4.500 m / 14.764 ft
Duration: 600.0 s

U Min: 4.8 ft
U Max: 7.0 ft

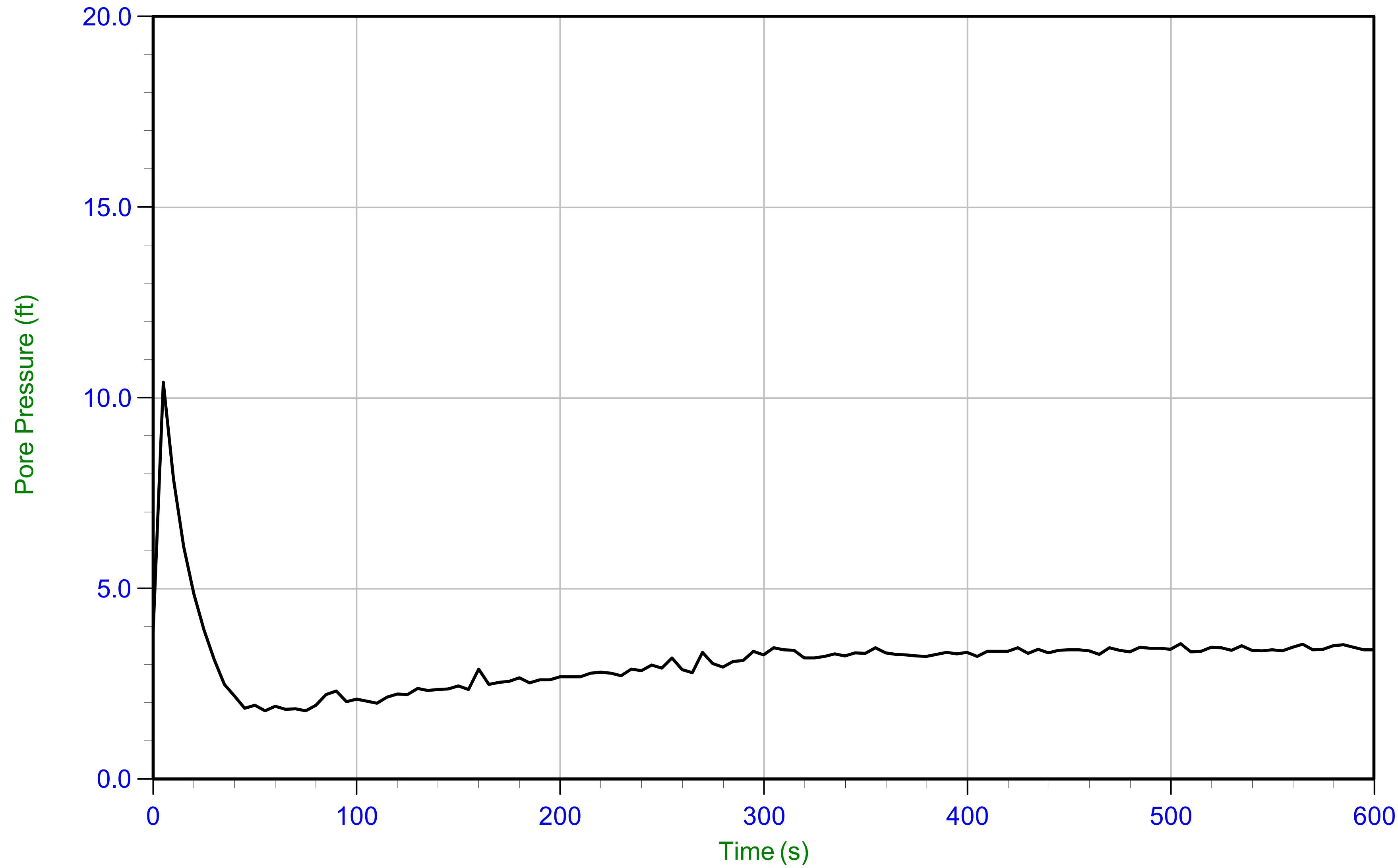
WT: 2.442 m / 8.012 ft
Ueq: 6.8 ft

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 15:09:57
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C044
Cone: 374
Cone Area: 15 sq cm



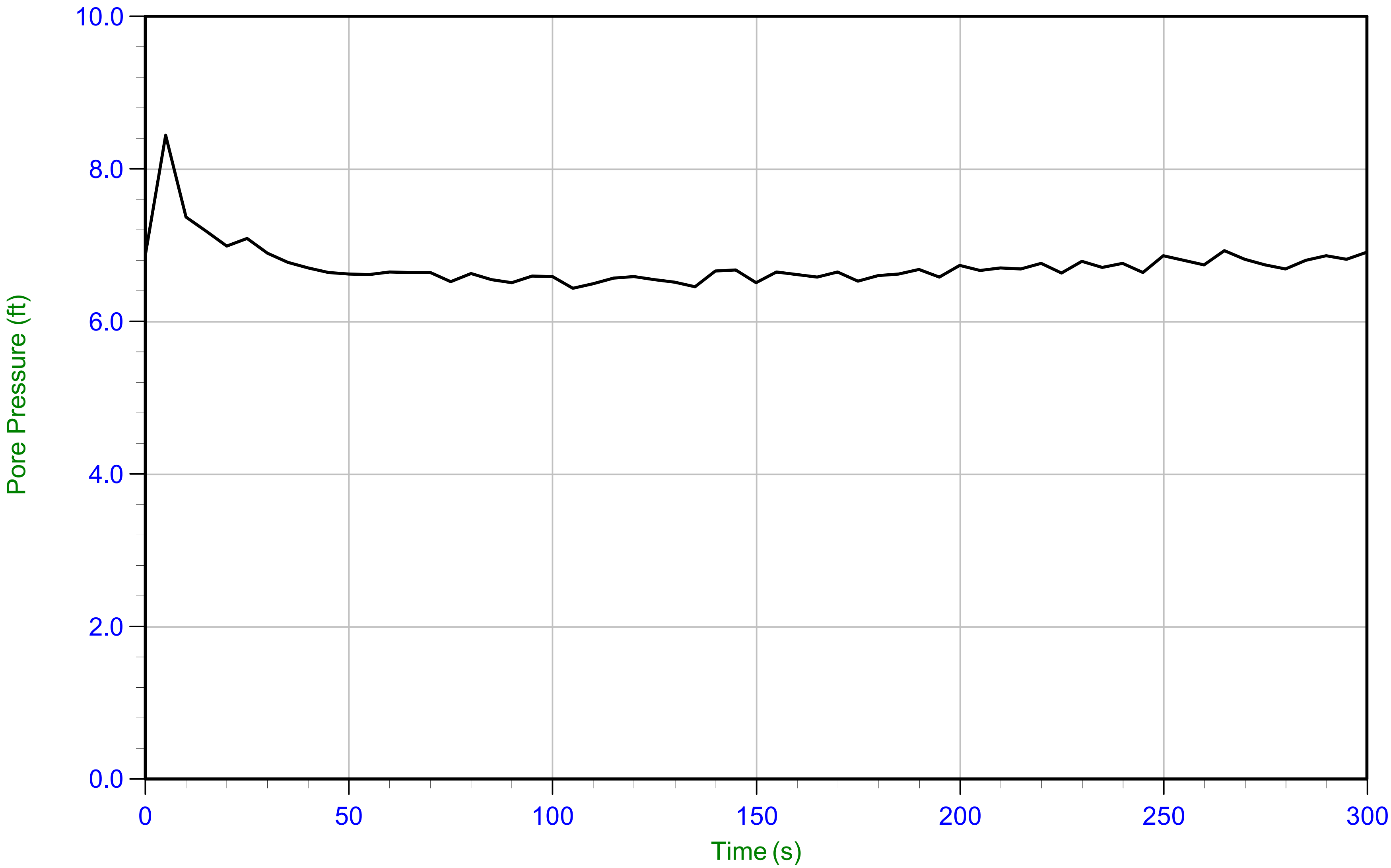
Trace Summary:

Filename: 15-53063_SP44.PPD
Depth: 4.400 m / 14.436 ft
Duration: 600.0 s

U Min: 1.8 ft
U Max: 10.4 ft

WT: 3.358 m / 11.017 ft
Ueq: 3.4 ft

AECOM	Job No: 15-53063 Date: 11-Aug-2015 15:09:57 Site: Coffeen Power Plant, Coffeen, IL	Sounding: COF-C044 Cone: 374 Cone Area: 15 sq cm



Trace Summary:

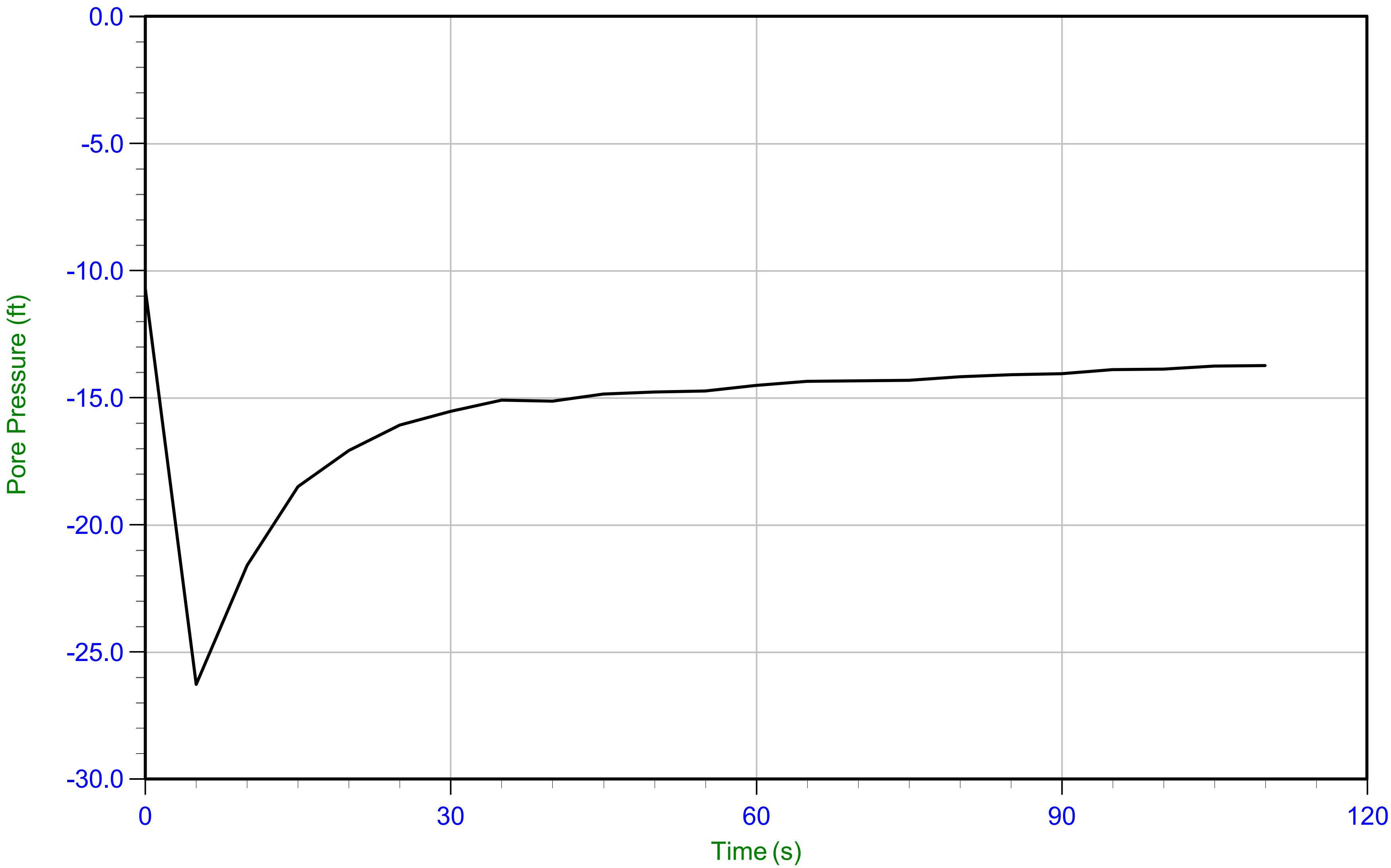
Filename: 15-53063_SP44.PPD	U Min: 6.4 ft	WT: 3.368 m / 11.050 ft
Depth: 5.400 m / 17.716 ft	U Max: 8.4 ft	Ueq: 6.7 ft
Duration: 300.0 s		

ConeTec

AECOM

Job No: 15-53063
Date: 11-Aug-2015 15:09:57
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C044
Cone: 374
Cone Area: 15 sq cm

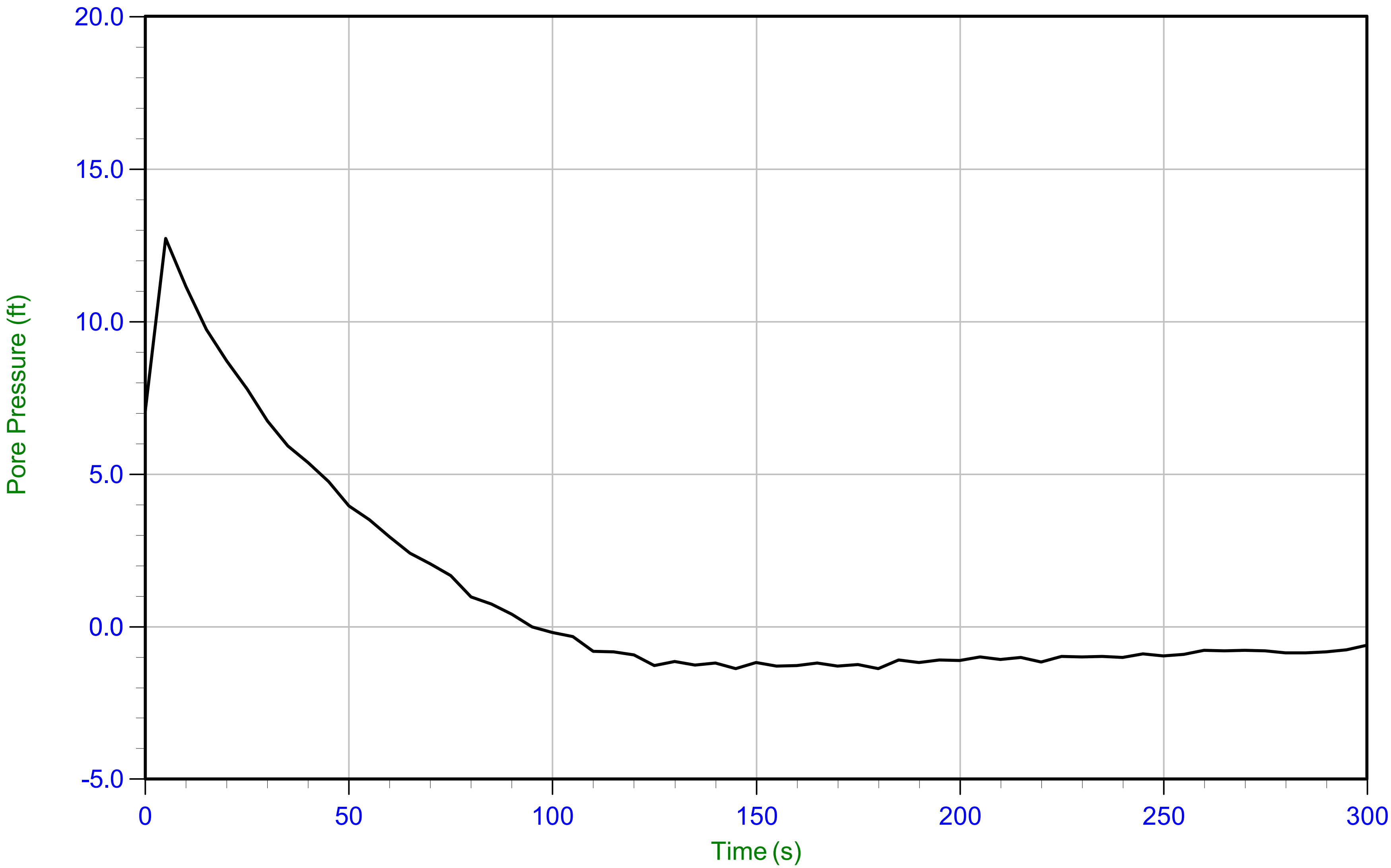


Trace Summary:

Filename: 15-53063_SP44.PPD
Depth: 13.100 m / 42.978 ft
Duration: 110.0 s

U Min: -26.3 ft
U Max: -10.7 ft

AECOM	Job No: 15-53063	Sounding: COF-C045
	Date: 08-Aug-2015 13:25:30	Cone: 374
	Site: Coffeen Power Plant, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP45.PPD
Depth: 4.350 m / 14.271 ft
Duration: 300.0 s

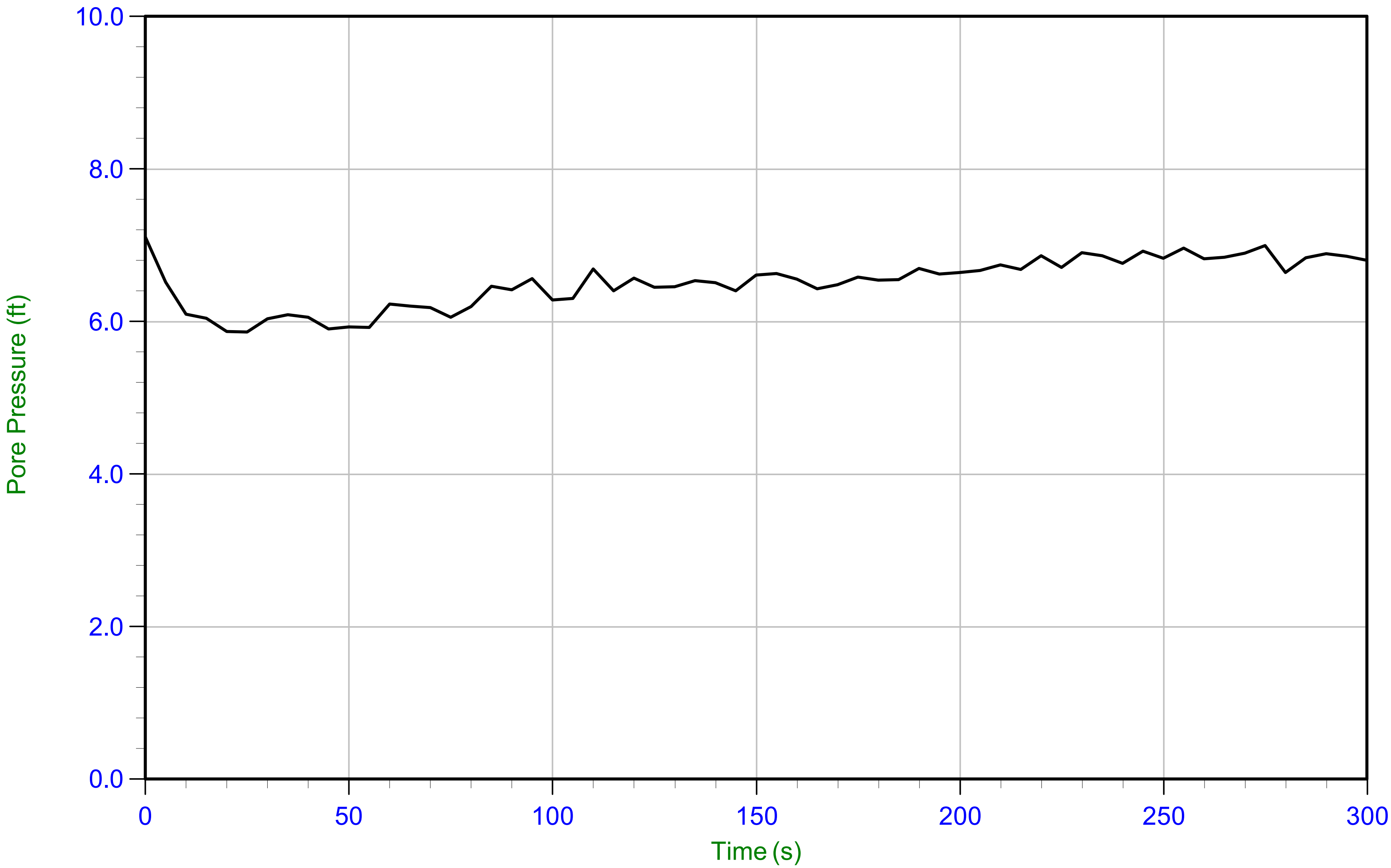
U Min: -1.4 ft
U Max: 12.7 ft

ConeTec

AECOM

Job No: 15-53063
Date: 08-Aug-2015 13:25:30
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C045
Cone: 374
Cone Area: 15 sq cm



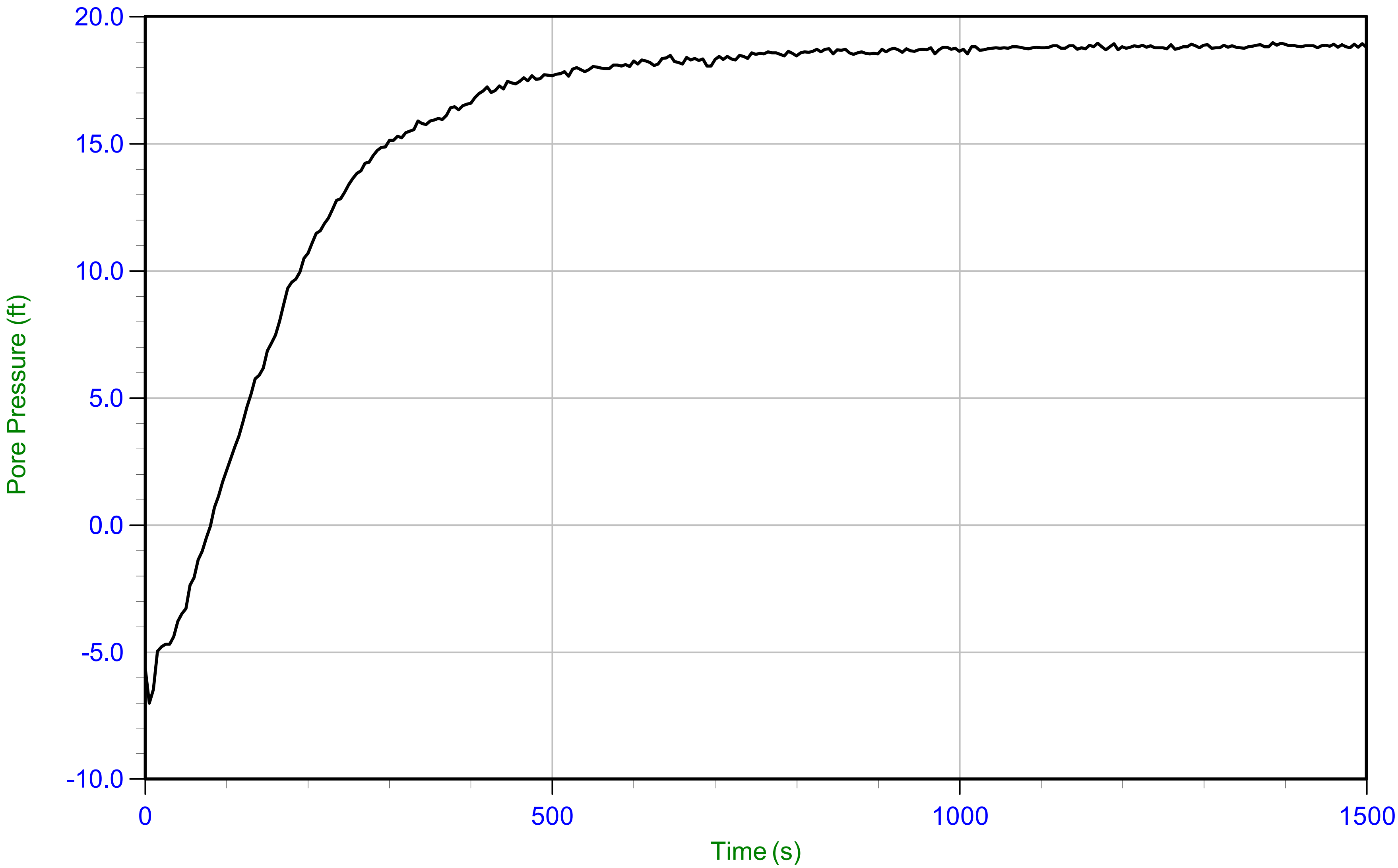
Trace Summary:

Filename: 15-53063_SP45.PPD
Depth: 6.500 m / 21.325 ft
Duration: 300.0 s

U Min: 5.9 ft
U Max: 7.1 ft

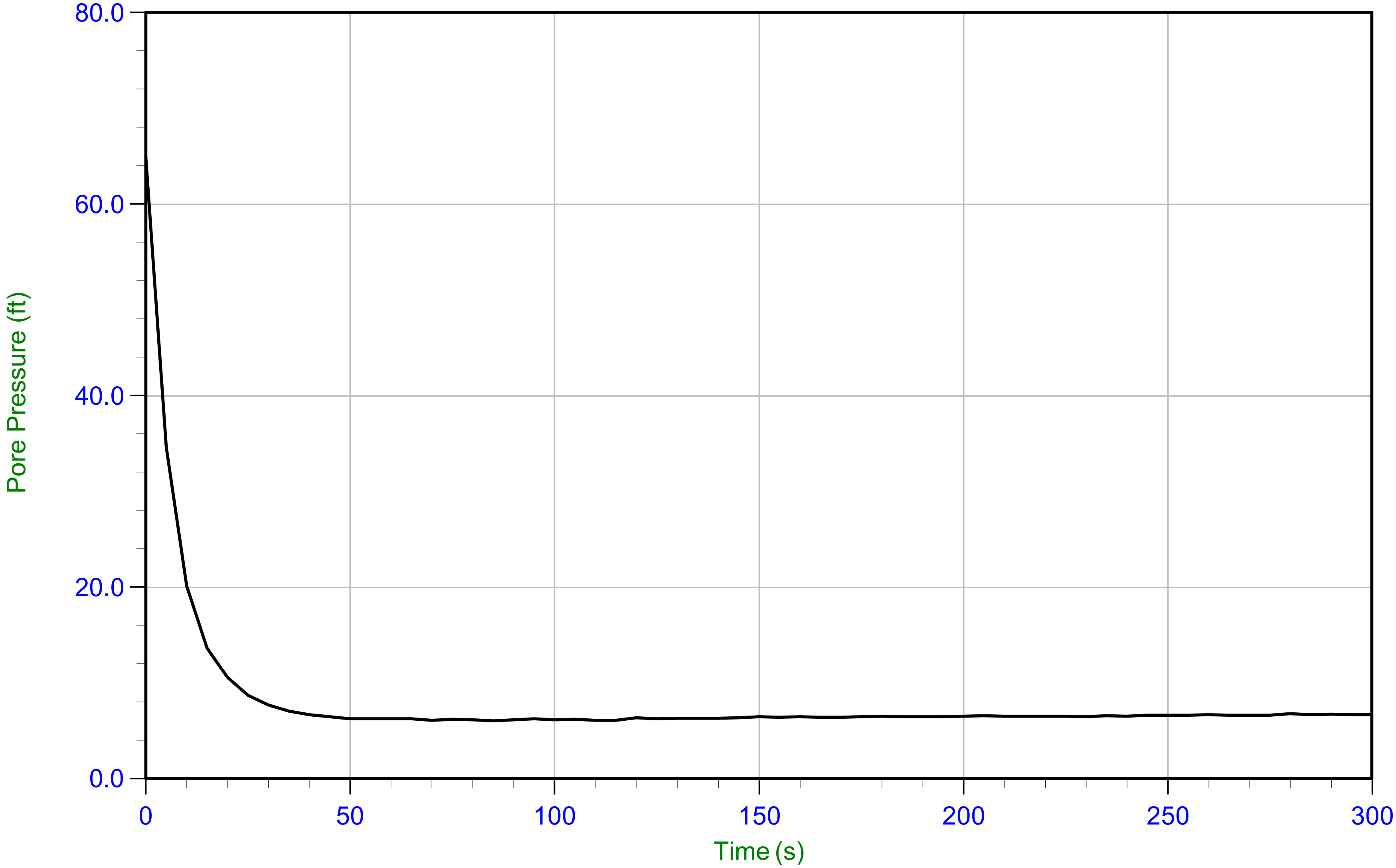
WT: 4.416 m / 14.488 ft
Ueq: 6.8 ft

AECOM	Job No: 15-53063	Sounding: COF-C045
	Date: 08-Aug-2015 13:25:30	Cone: 374
	Site: Coffeen Power Plant, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:	Filename: 15-53063_SP45.PPD	U Min: -7.0 ft	WT: 6.745 m / 22.129 ft
	Depth: 12.450 m / 40.846 ft	U Max: 19.0 ft	Ueq: 18.7 ft
	Duration: 1500.0 s		

AECOM	Job No: 15-53063	Sounding: COF-C046
	Date: 10-Aug-2015 12:21:18	Cone: 374
	Site: Coffeen Power Plant, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

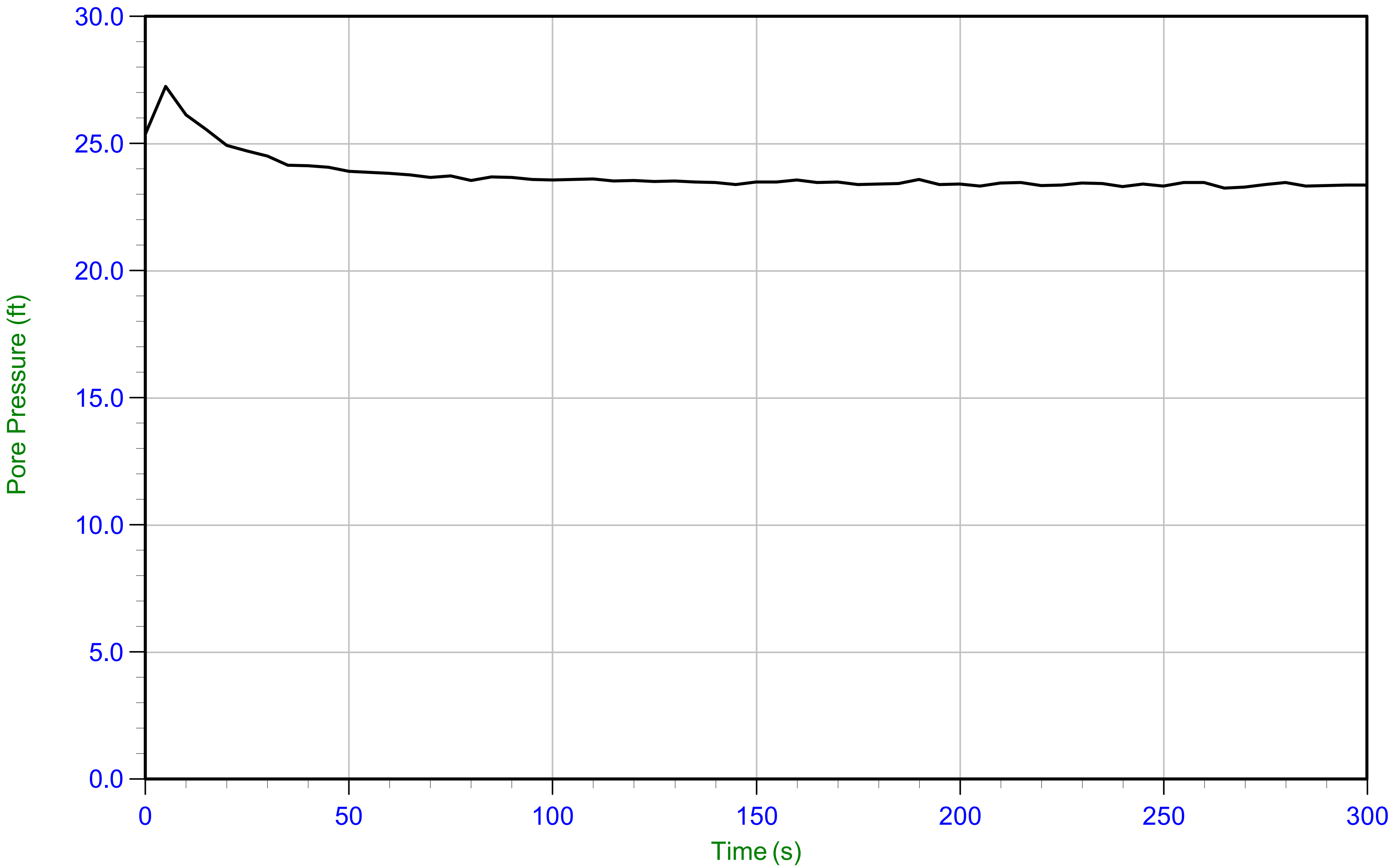
Filename: 15-53063_SP46.PPD	U Min: 6.1 ft	WT: 3.420 m / 11.220 ft
Depth: 5.400 m / 17.716 ft	U Max: 64.9 ft	Ueq: 6.5 ft
Duration: 300.0 s		

ConeTec

AECOM

Job No: 15-53063
Date: 10-Aug-2015 12:21:18
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C046
Cone: 374
Cone Area: 15 sq cm



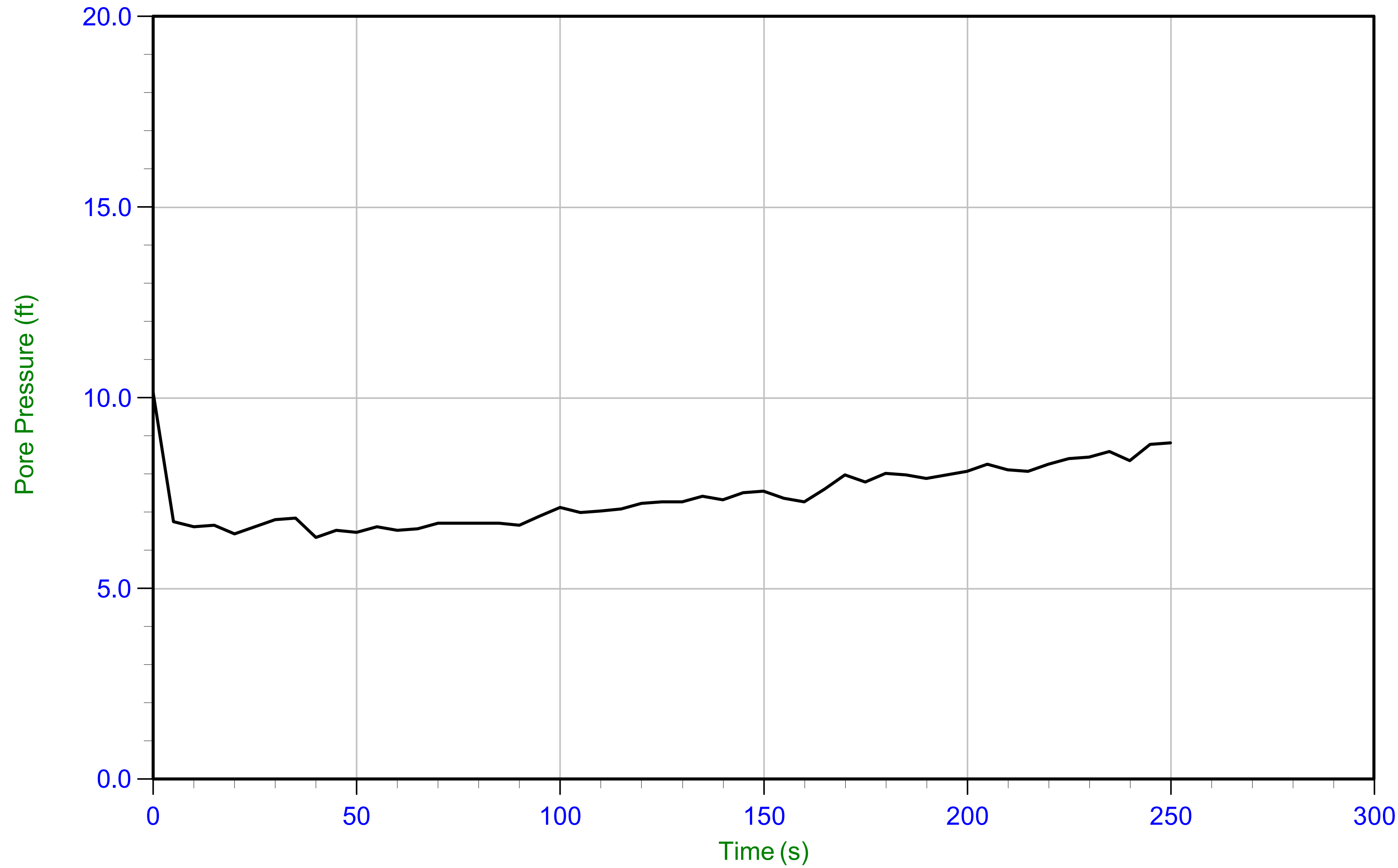
Trace Summary:

Filename: 15-53063_SP46.PPD
Depth: 10.700 m / 35.105 ft
Duration: 300.0 s

U Min: 23.2 ft
U Max: 27.3 ft

WT: 3.627 m / 11.899 ft
Ueq: 23.2 ft

AECOM	Job No: 15-53063	Sounding: COF-C049
	Date: 07-Aug-2015 12:14:53	Cone: 335
	Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP49.PPD
Depth: 5.850 m / 19.193 ft
Duration: 250.0 s

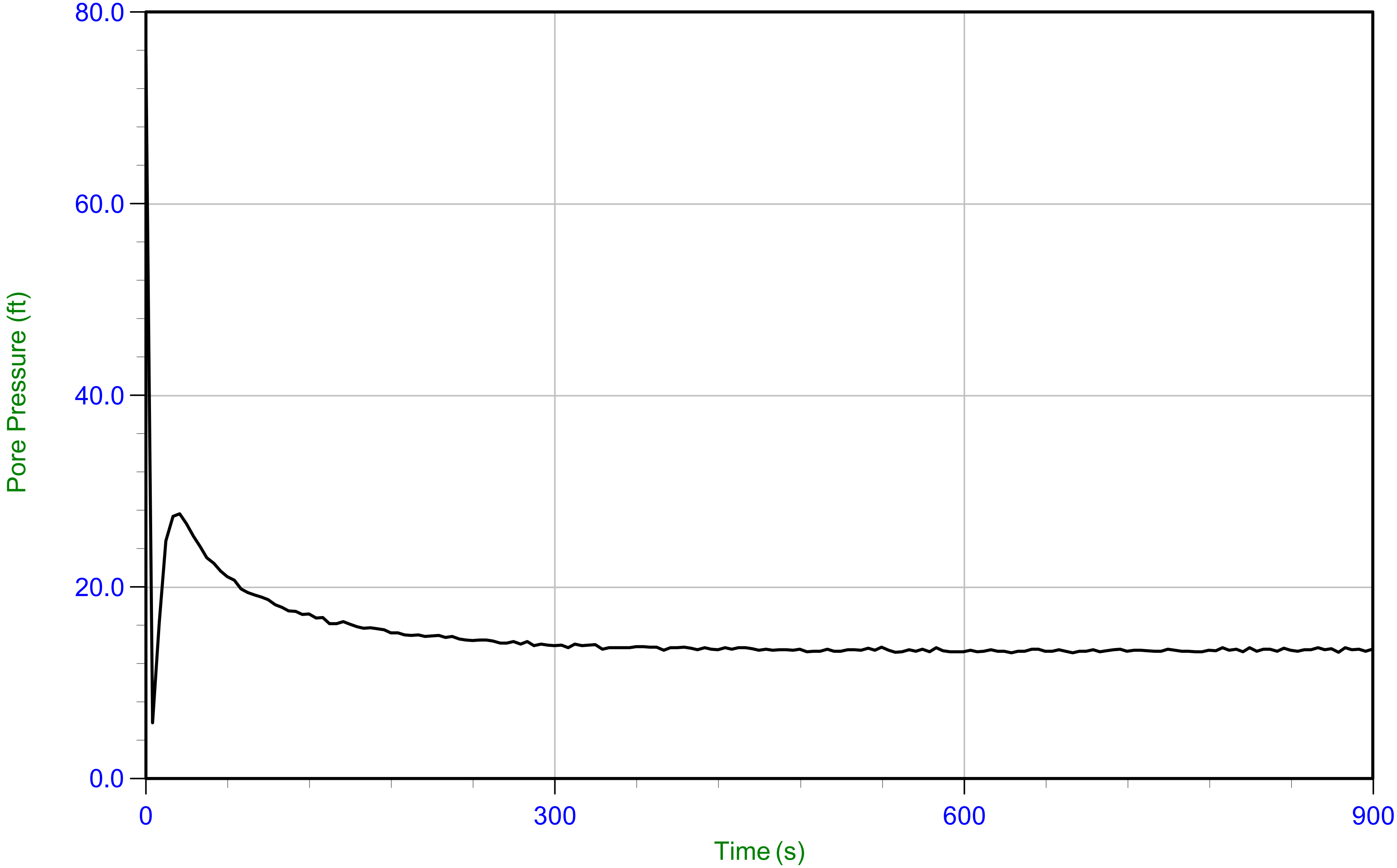
U Min: 6.3 ft
U Max: 10.1 ft

ConeTec

AECOM

Job No: 15-53063
Date: 07-Aug-2015 12:14:53
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP49.PPD
Depth: 6.850 m / 22.473 ft
Duration: 900.0 s

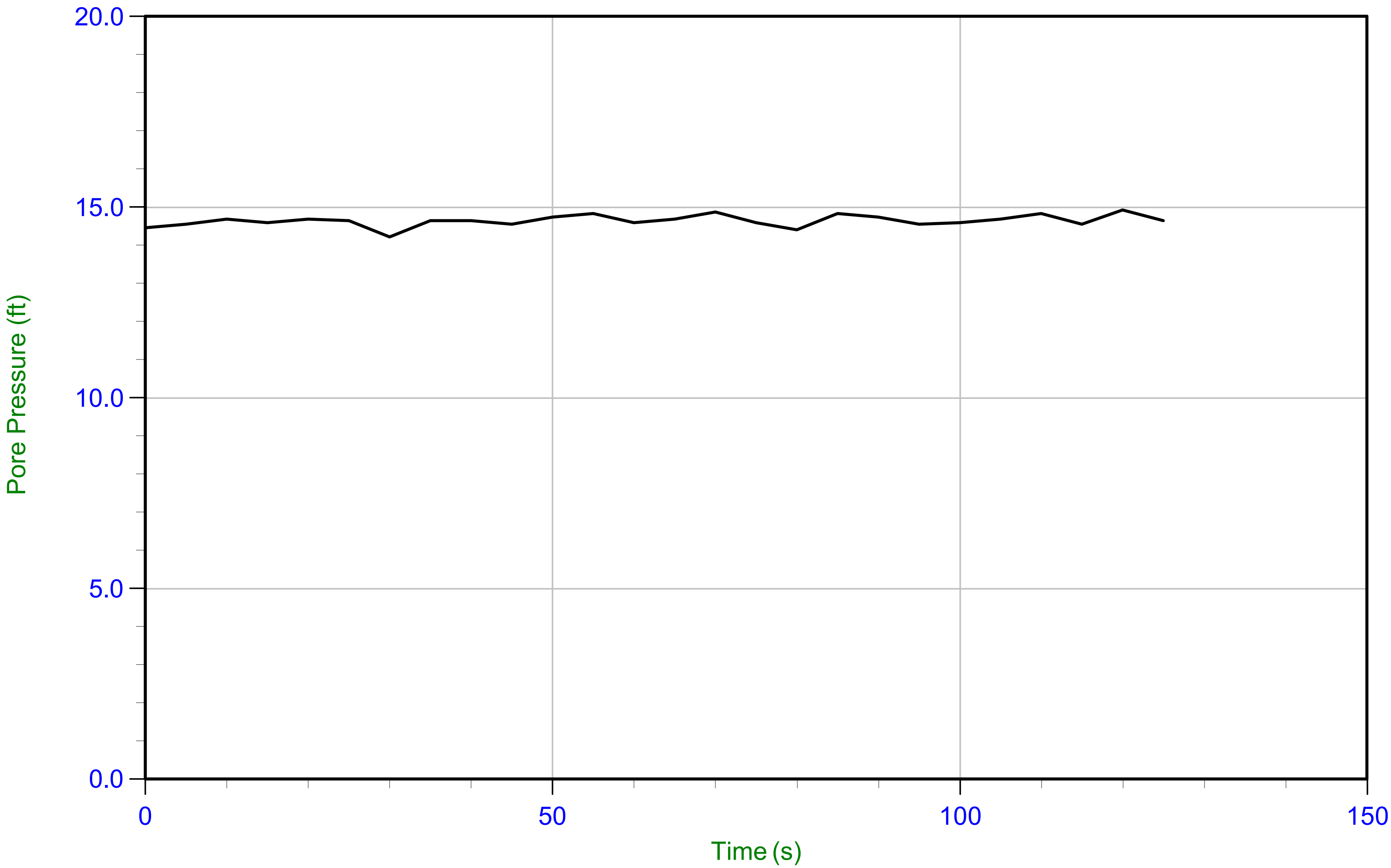
U Min: 5.9 ft
U Max: 75.6 ft

WT: 2.890 m / 9.482 ft
Ueq: 13.0 ft

AECOM

Job No: 15-53063
Date: 07-Aug-2015 12:14:53
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335
Cone Area: 15 sq cm



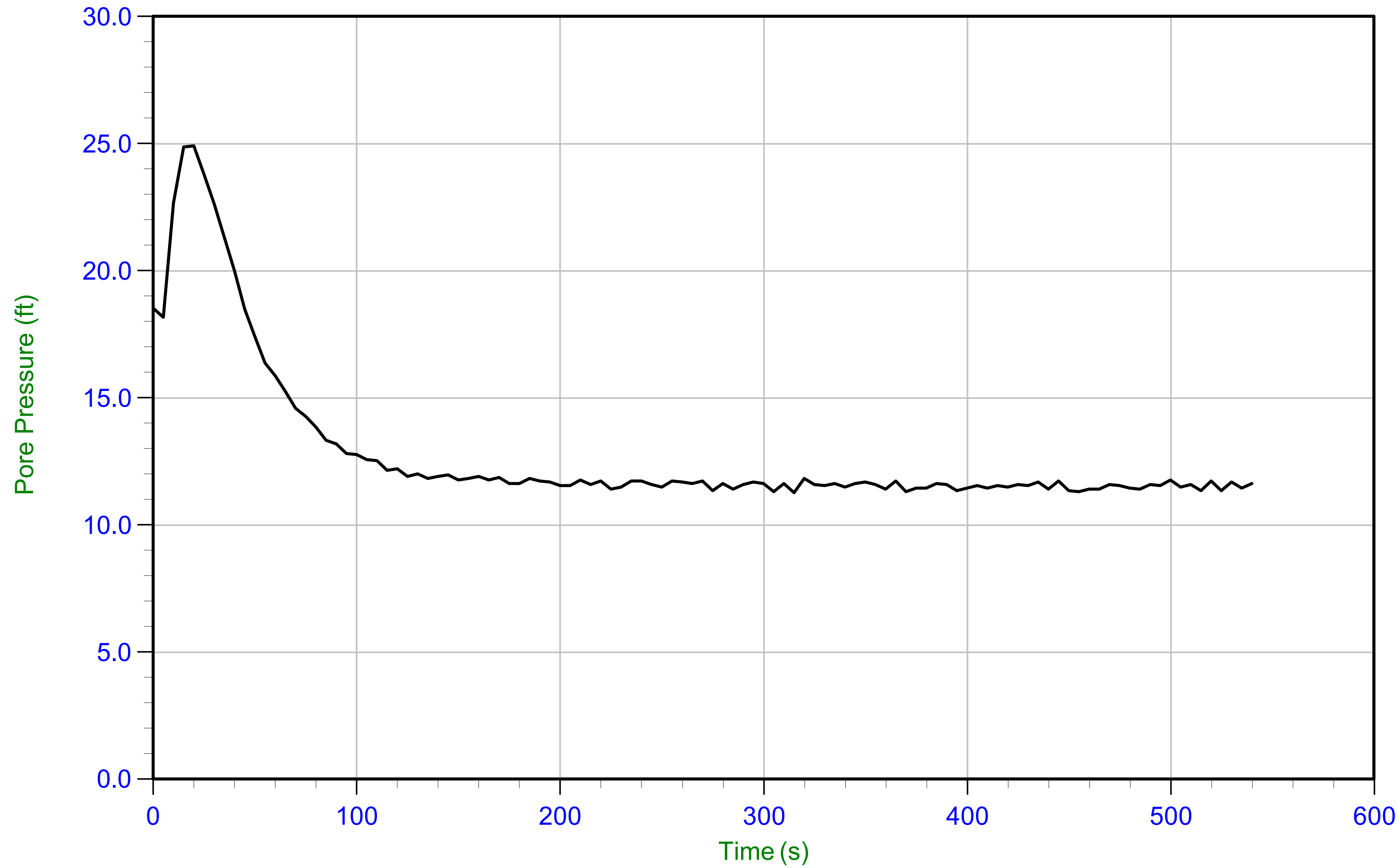
Trace Summary:

Filename: 15-53063_SP49.PPD
Depth: 7.850 m / 25.754 ft
Duration: 125.0 s

U Min: 14.2 ft
U Max: 14.9 ft

WT: 3.343 m / 10.968 ft
Ueq: 14.8 ft

AECOM	Job No: 15-53063	Sounding: COF-C050
	Date: 07-Aug-2015 13:50:57	Cone: 335
	Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm

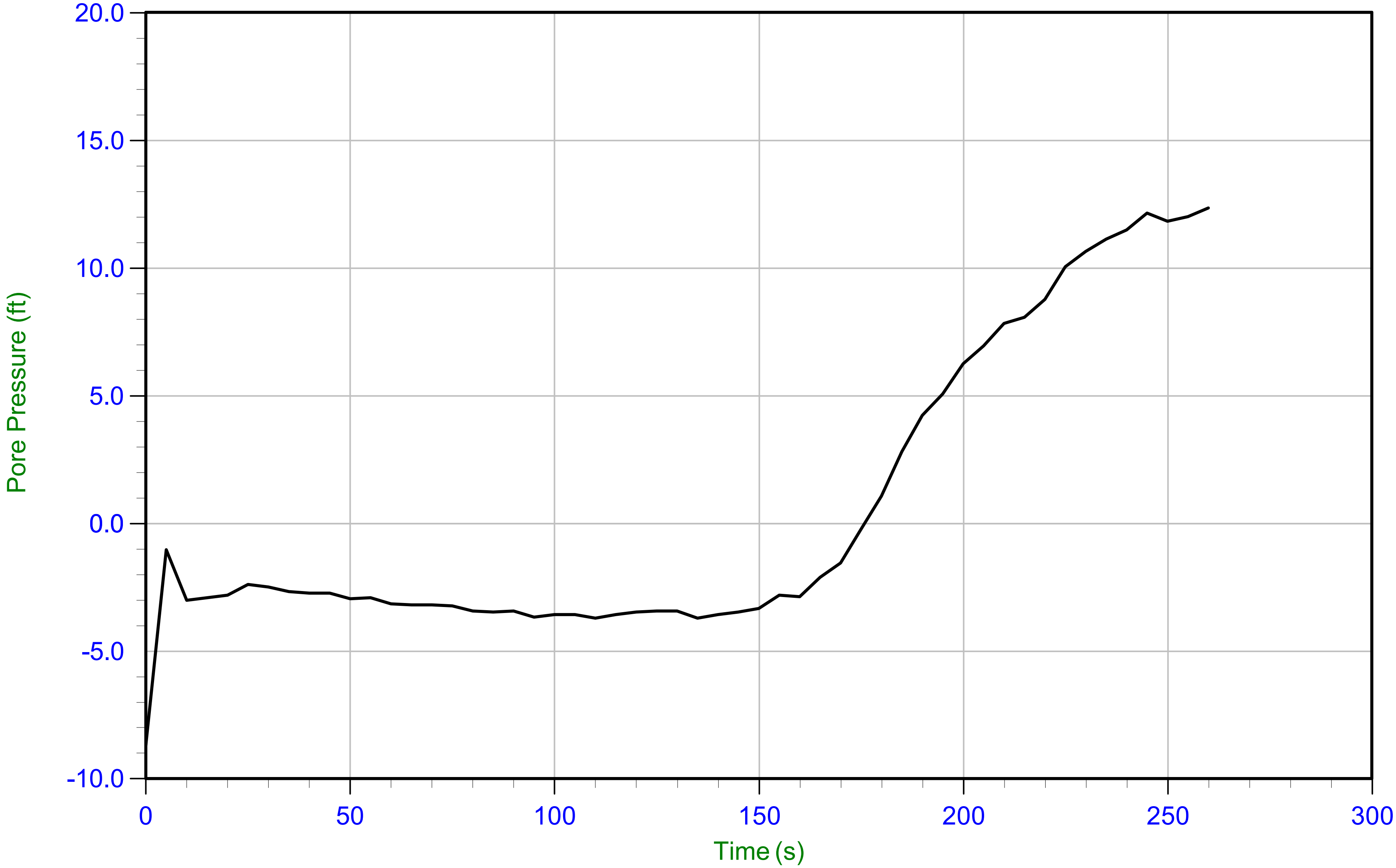


Trace Summary:

Filename: 15-53063_CP50.PPD	U Min: 11.3 ft	WT: 2.972 m / 9.751 ft	T(50): 26.5 s
Depth: 6.450 m / 21.161 ft	U Max: 24.9 ft	Ueq: 11.4 ft	Ir: 100
Duration: 540.0 s		U(50): 18.17 ft	Ch: 26.5 sq cm/min

Job No: 15-53063	Sounding: COF-C050
Date: 07-Aug-2015 13:50:57	Cone: 335
Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm

AECOM



Trace Summary:

Filename: 15-53063_CP50.PPD
Depth: 7.300 m / 23.950 ft
Duration: 260.0 s

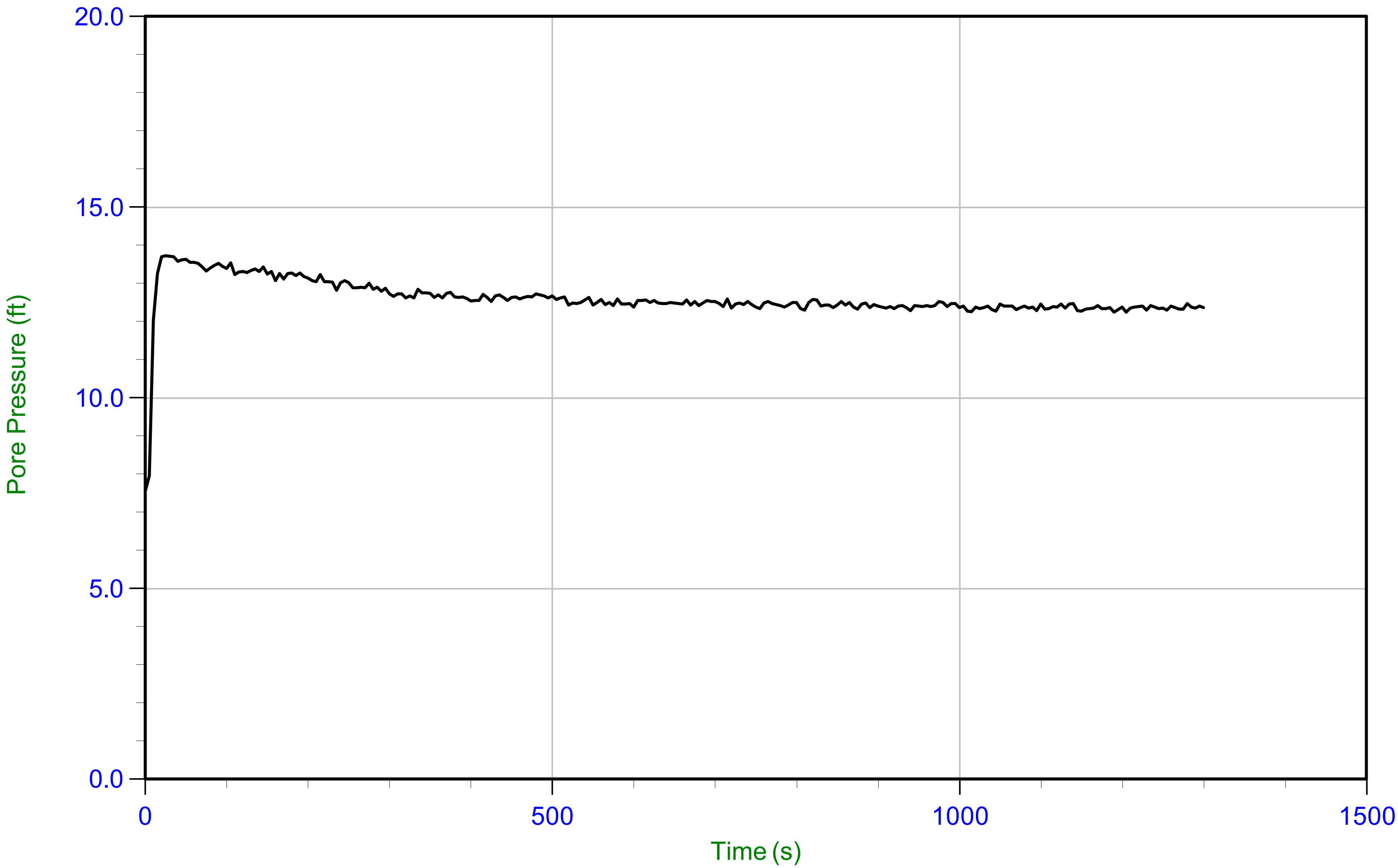
U Min: -8.7 ft
U Max: 12.3 ft

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 08:45:13
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C051
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP51.PPD
Depth: 5.050 m / 16.568 ft
Duration: 1300.0 s

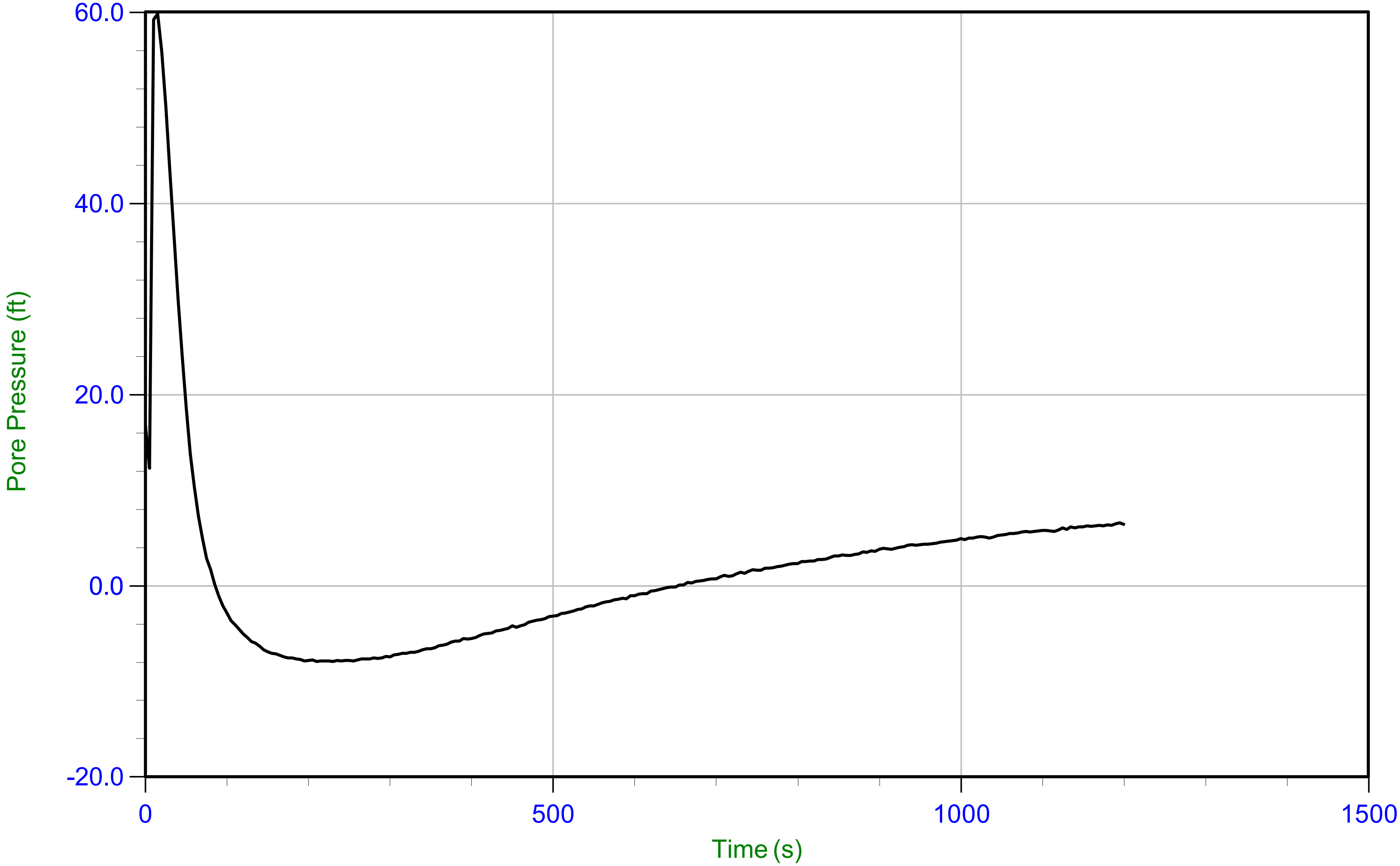
U Min: 7.6 ft
U Max: 13.7 ft

WT: 1.299 m / 4.262 ft
Ueq: 12.3 ft

AECOM

Job No: 15-53063
Date: 11-Aug-2015 08:45:13
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C051
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

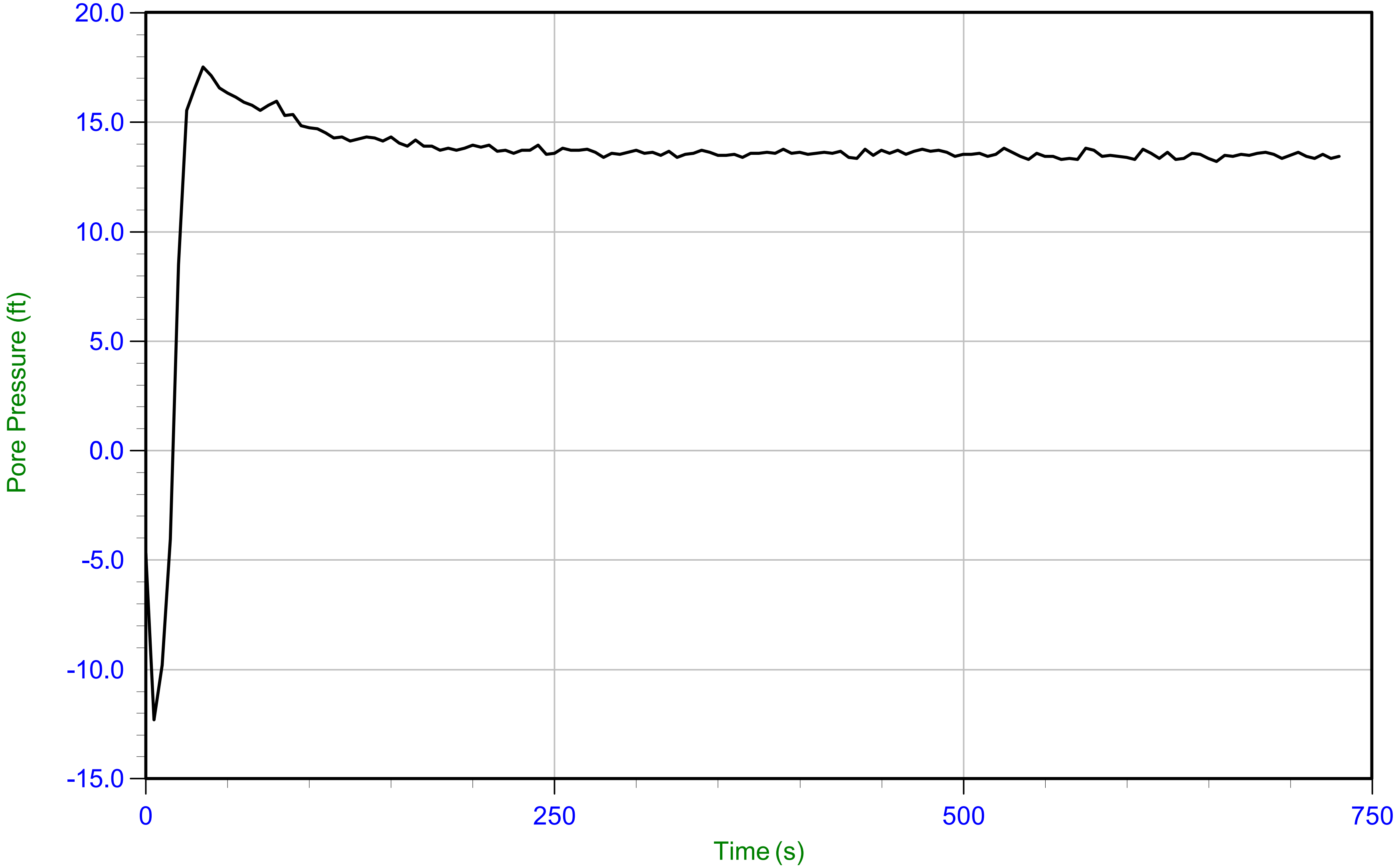
Filename: 15-53063_SP51.PPD
Depth: 6.150 m / 20.177 ft
Duration: 1200.0 s

U Min: -7.9 ft
U Max: 59.8 ft

AECOM

Job No: 15-53063
Date: 07-Aug-2015 15:53:40
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C052
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP52.PPD
Depth: 7.050 m / 23.130 ft
Duration: 730.0 s

U Min: -12.3 ft
U Max: 17.5 ft

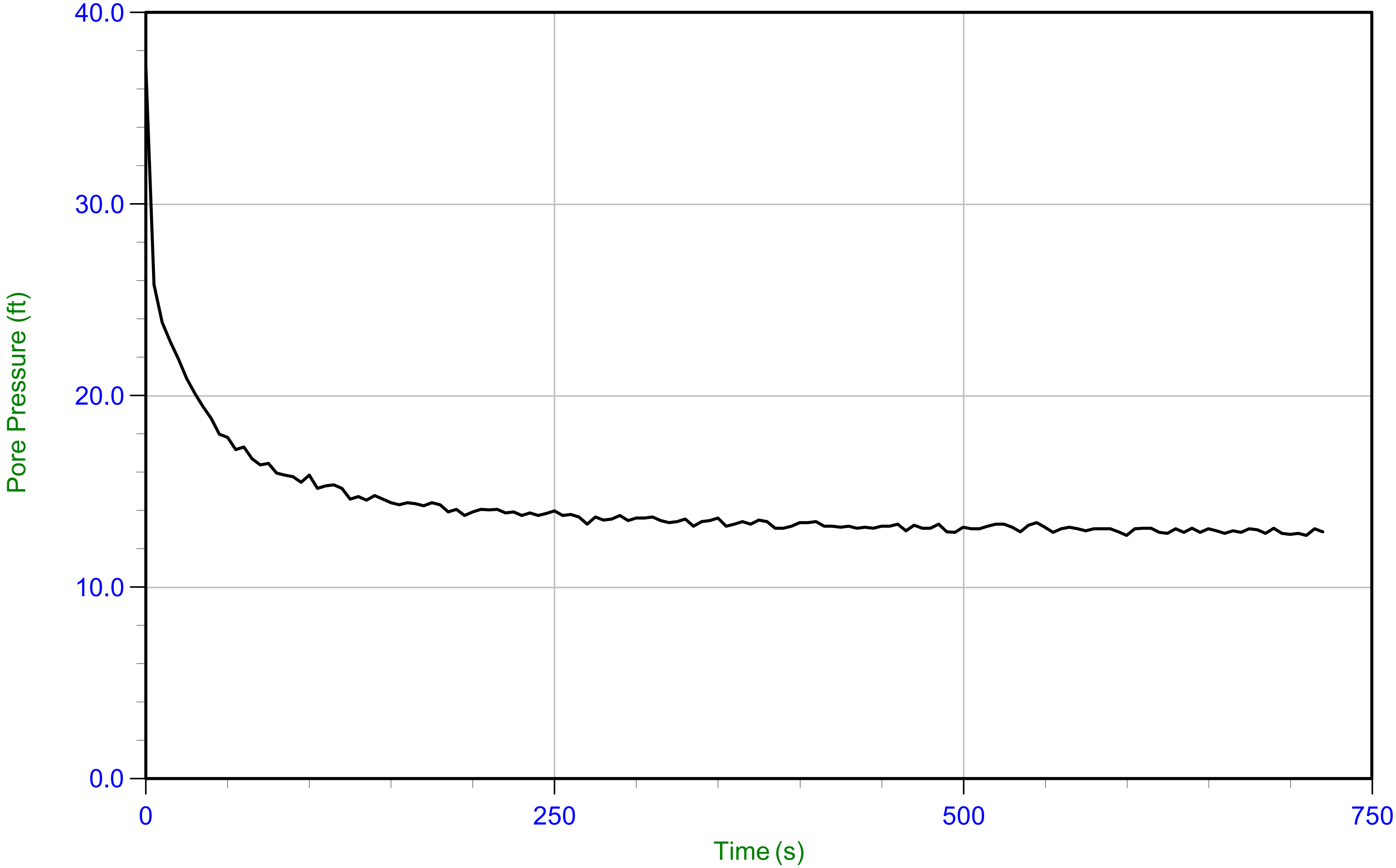
WT: 3.006 m / 9.862 ft
Ueq: 13.3 ft

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 10:02:11
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C053
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP53.PPD
Depth: 7.750 m / 25.426 ft
Duration: 720.0 s

U Min: 12.7 ft
U Max: 37.2 ft

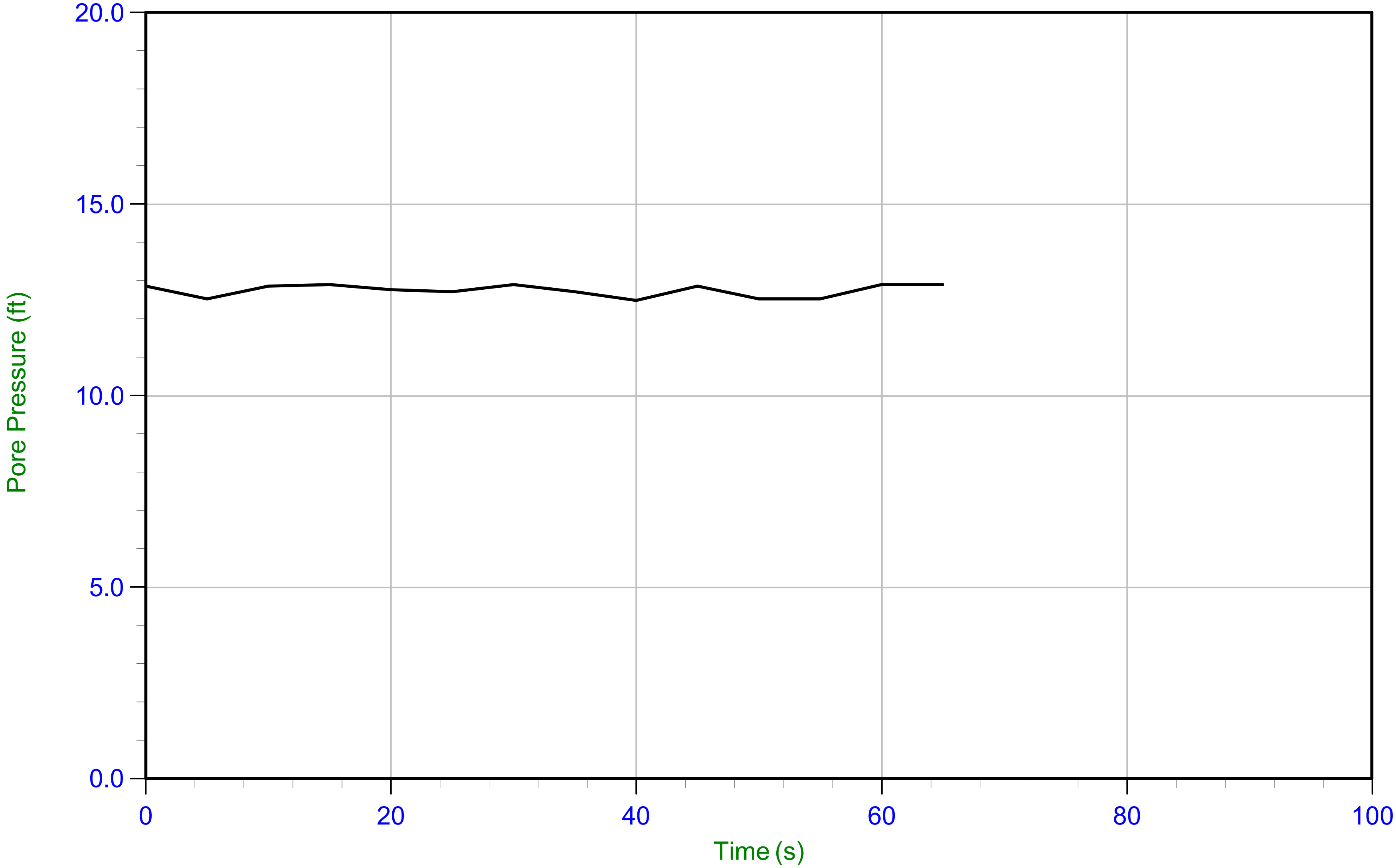
WT: 3.894 m / 12.775 ft
Ueq: 12.7 ft

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 10:02:11
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C053
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP53.PPD
Depth: 7.750 m / 25.426 ft
Duration: 65.0 s

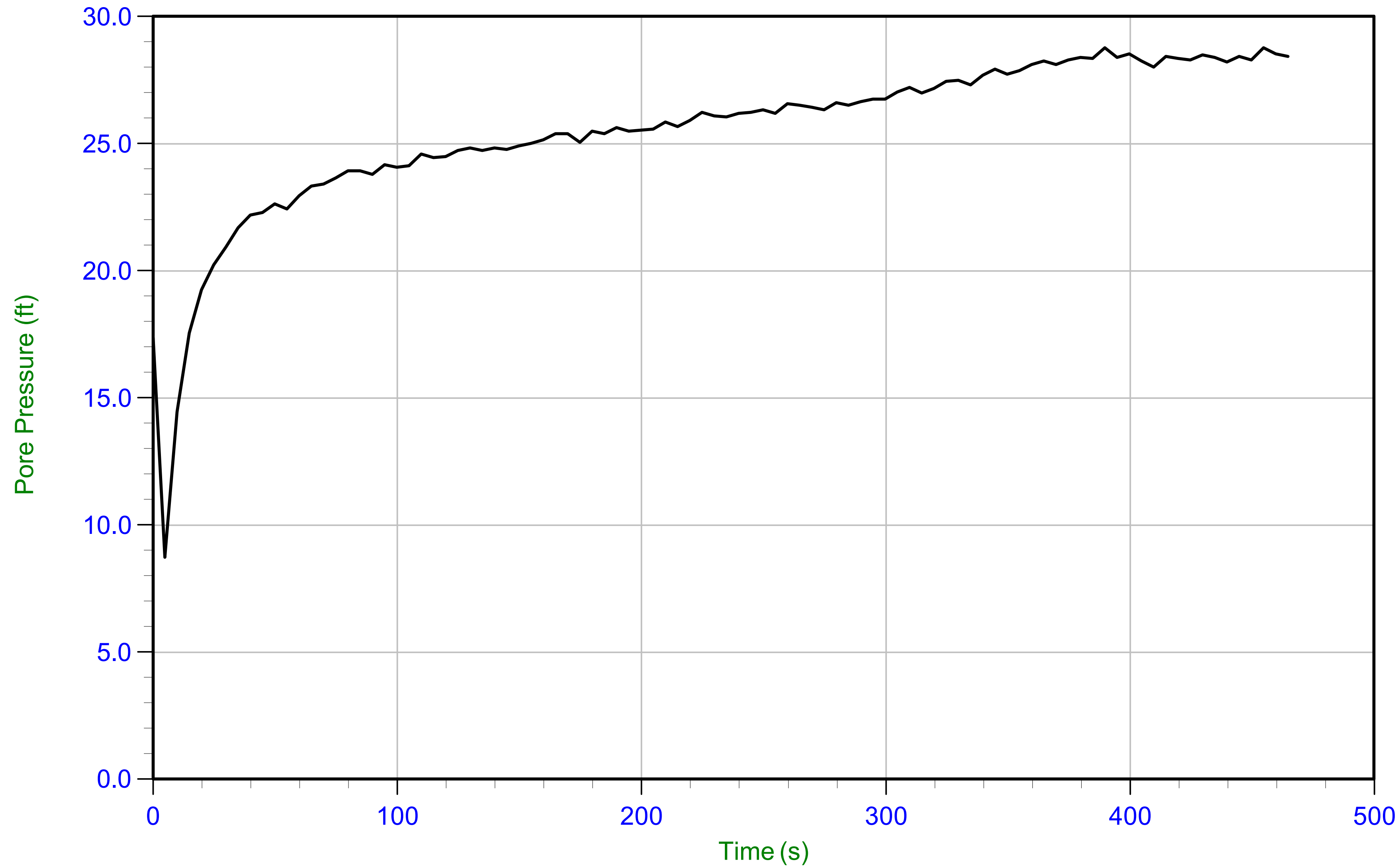
U Min: 12.5 ft
U Max: 12.9 ft

WT: 3.868 m / 12.690 ft
Ueq: 12.7 ft

AECOM

Job No: 15-53063
Date: 07-Aug-2015 10:02:11
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C053
Cone: 335
Cone Area: 15 sq cm

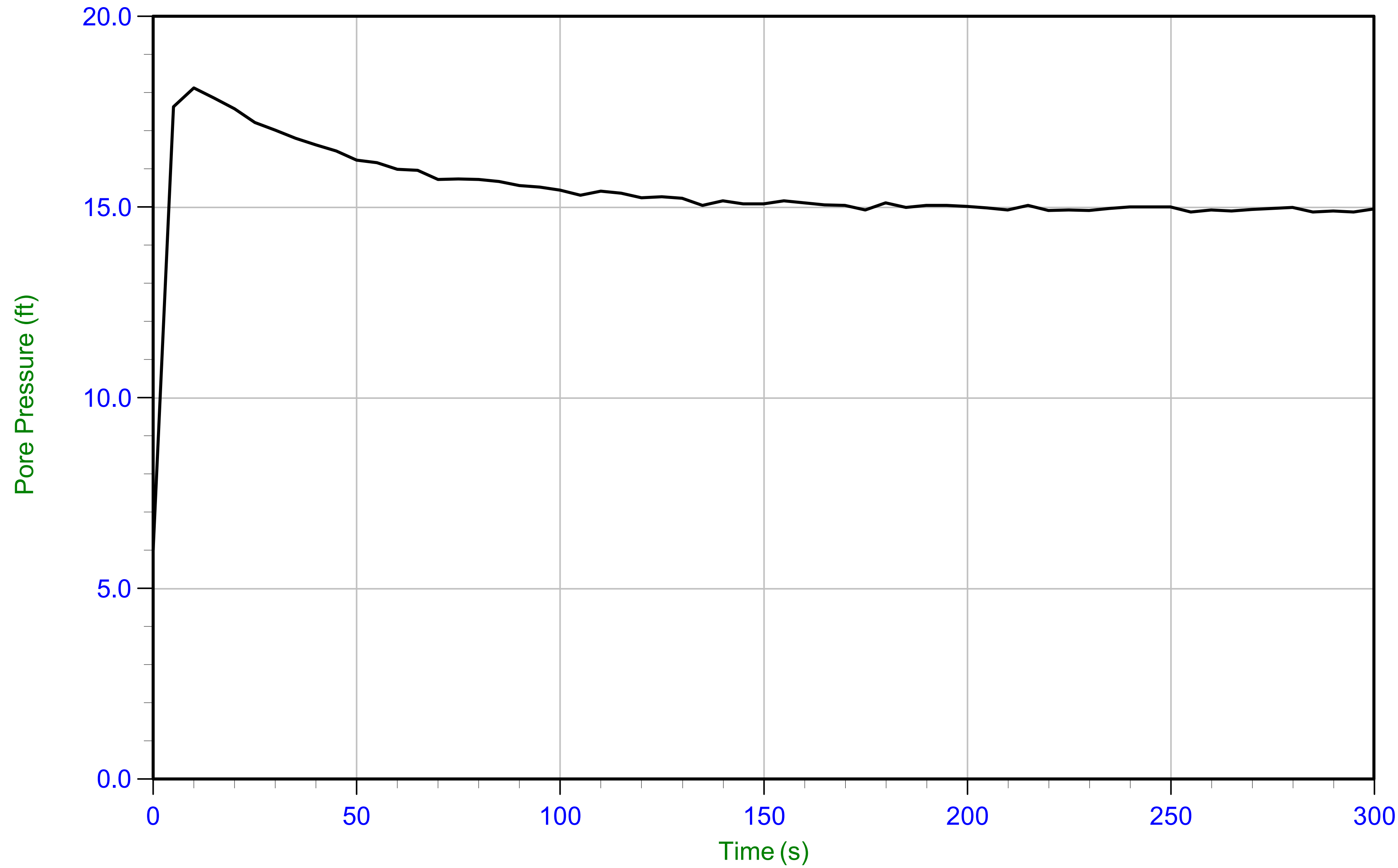


Trace Summary:

Filename: 15-53063_SP53.PPD
Depth: 16.350 m / 53.641 ft
Duration: 465.0 s

U Min: 8.7 ft
U Max: 28.8 ft

AECOM	Job No: 15-53063 Date: 11-Aug-2015 13:04:33 Site: Coffeen Power Plant, Coffeen, IL	Sounding: COF-C054 Cone: 374 Cone Area: 15 sq cm



Trace Summary:

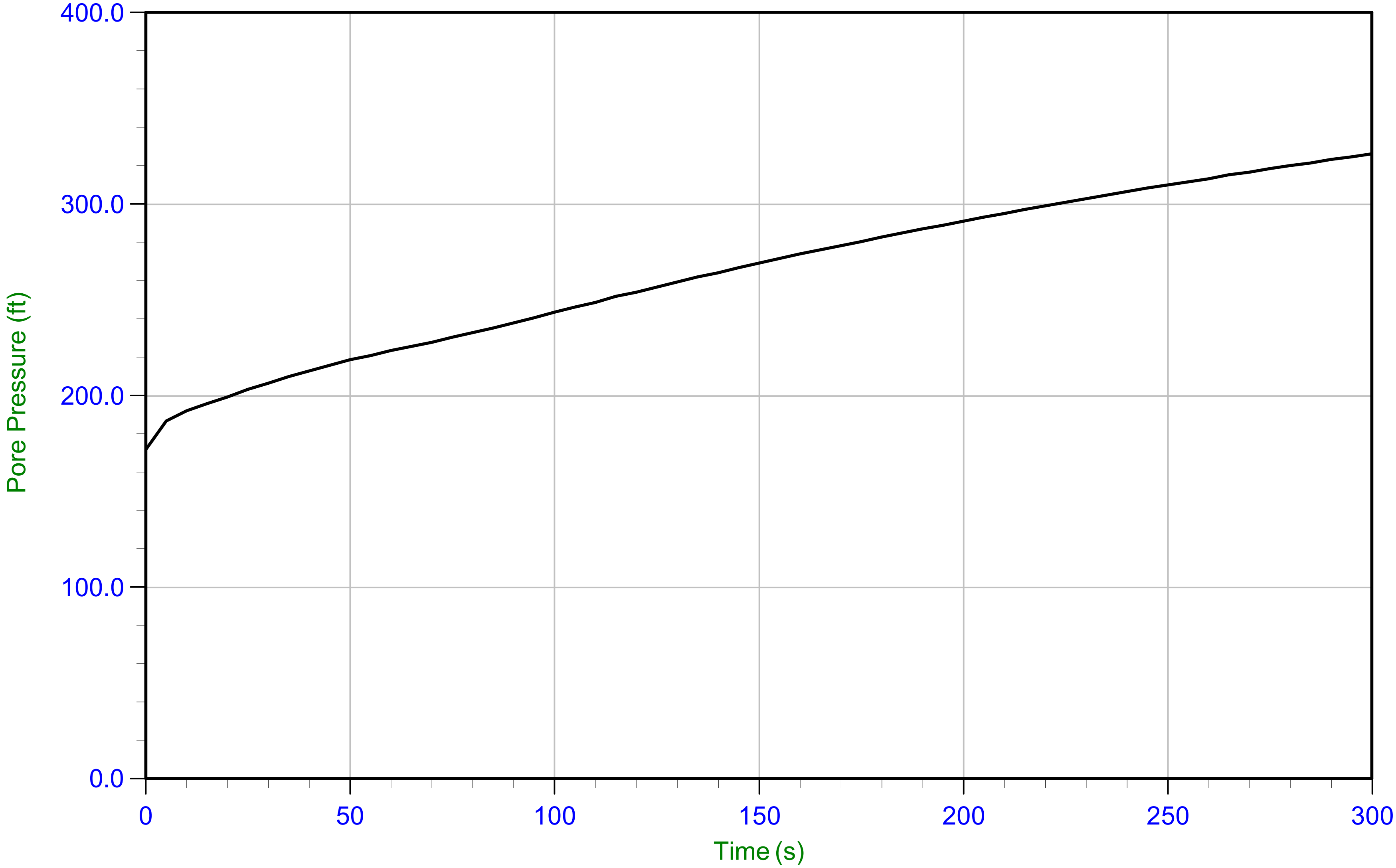
Filename: 15-53063_CP54.PPD	U Min: 6.0 ft	WT: 0.717 m / 2.352 ft
Depth: 5.250 m / 17.224 ft	U Max: 18.1 ft	Ueq: 14.9 ft
Duration: 300.0 s		

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 13:04:33
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C054
Cone: 374
Cone Area: 15 sq cm

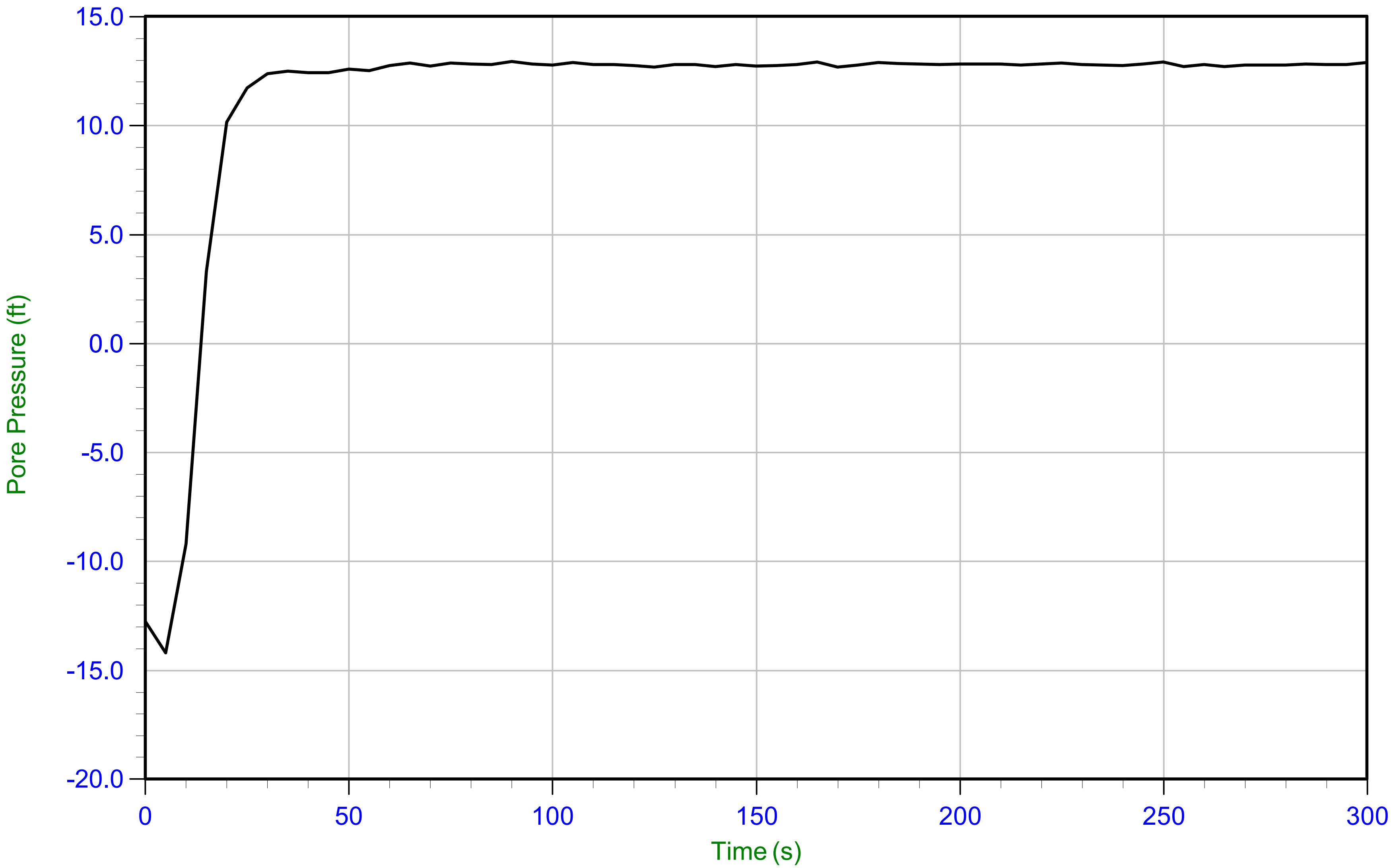


Trace Summary:

Filename: 15-53063_CP54.PPD
Depth: 20.000 m / 65.616 ft
Duration: 300.0 s

U Min: 171.9 ft
U Max: 326.2 ft

ConeTec	AECOM	Job No: 15-53063	Sounding: COF-C055
		Date: 11-Aug-2015 10:39:47	Cone: 374
		Site: Coffeen Power Plant, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP55.PPD
Depth: 4.650 m / 15.256 ft
Duration: 300.0 s

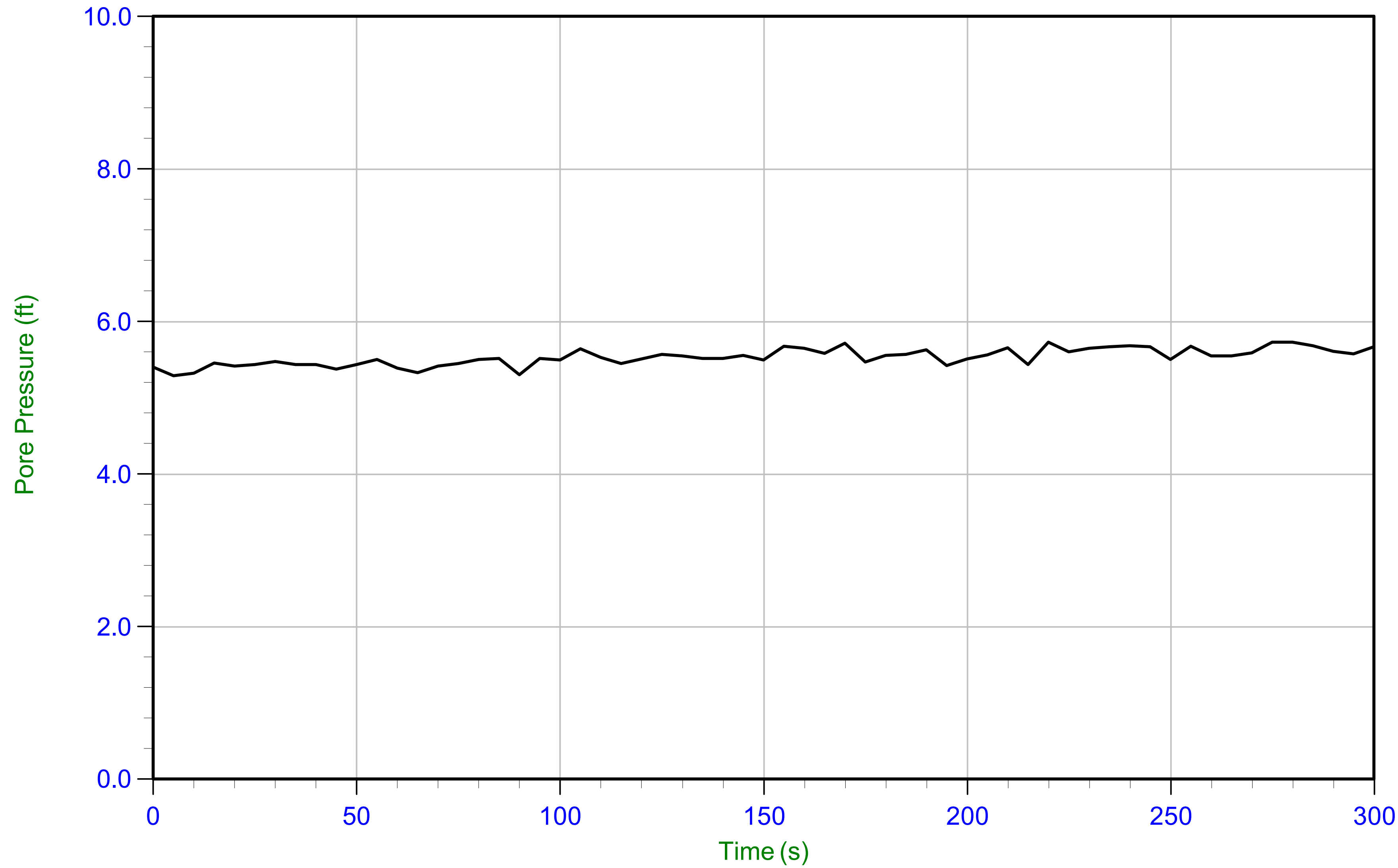
U Min: -14.2 ft
U Max: 12.9 ft

WT: 0.716 m / 2.349 ft
Ueq: 12.9 ft

AECOM

Job No: 15-53063
Date: 10-Aug-2015 08:28:32
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C056
Cone: 374
Cone Area: 15 sq cm



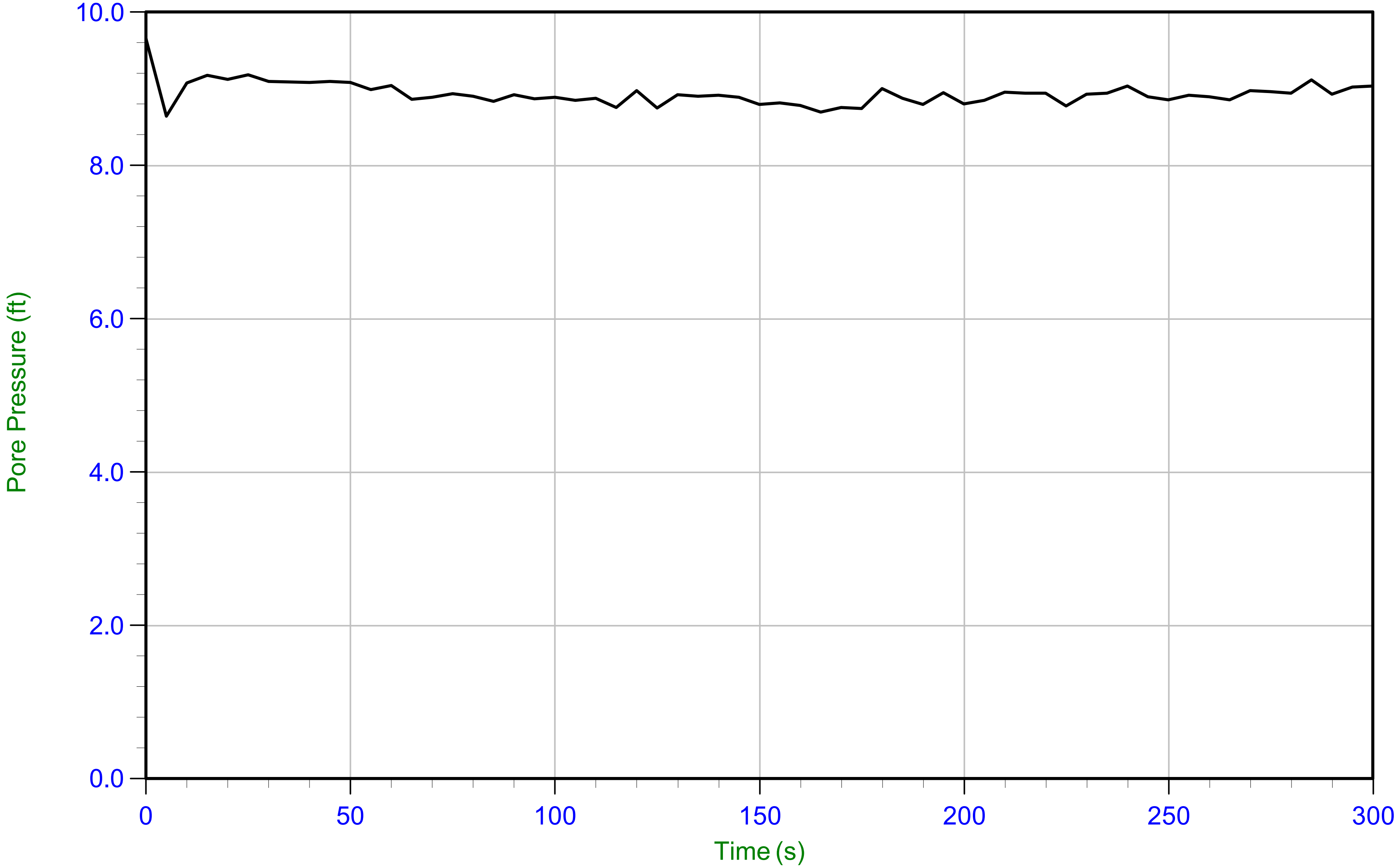
Trace Summary:

Filename: 15-53063_SP56.PPD
Depth: 6.350 m / 20.833 ft
Duration: 300.0 s

U Min: 5.3 ft
U Max: 5.7 ft

WT: 4.631 m / 15.193 ft
Ueq: 5.6 ft

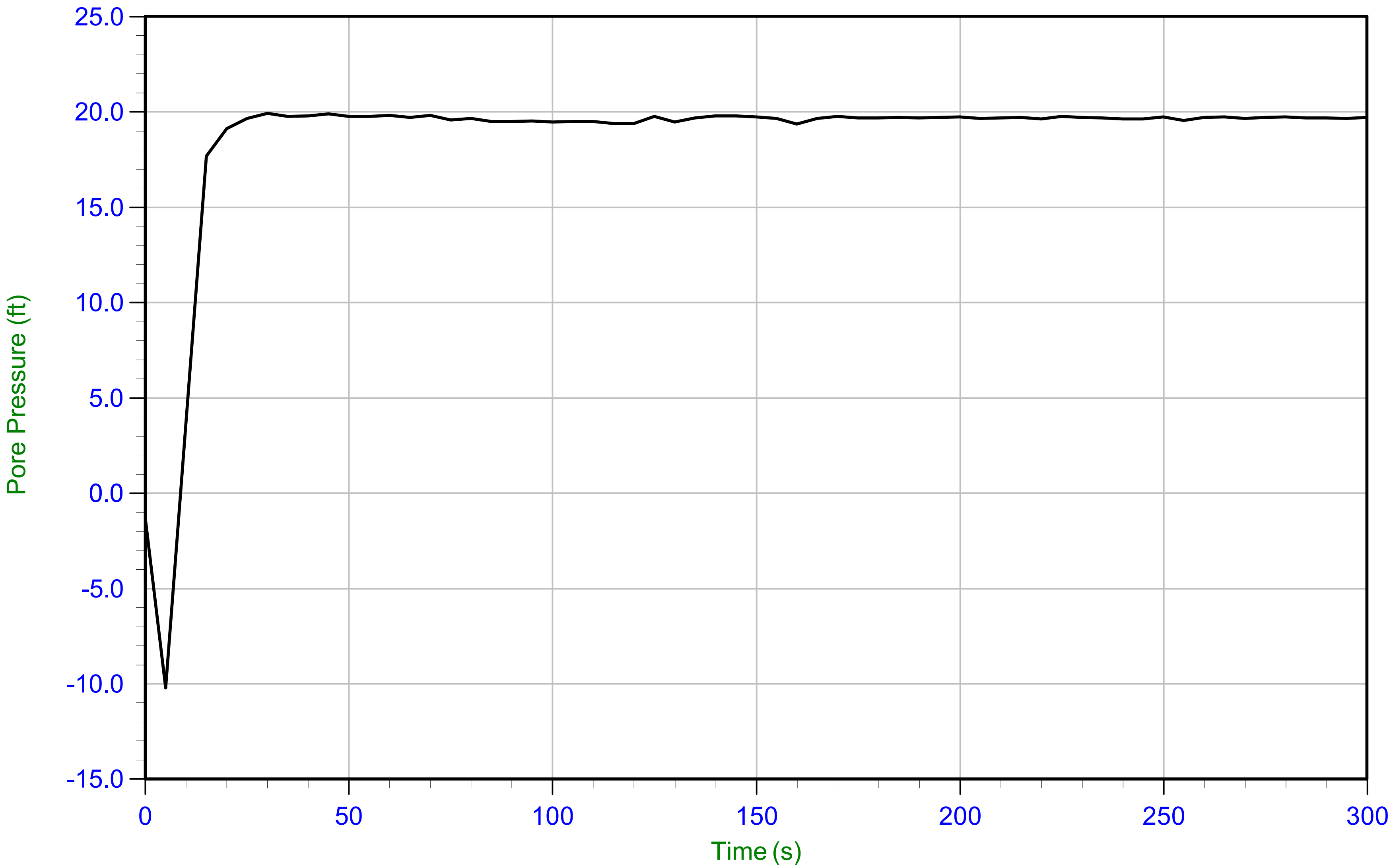
AECOM	Job No: 15-53063	Sounding: COF-C056
	Date: 10-Aug-2015 08:28:32	Cone: 374
	Site: Coffeen Power Plant, Coffeen, IL	Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP56.PPD	U Min: 8.6 ft	WT: 4.615 m / 15.141 ft
Depth: 7.350 m / 24.114 ft	U Max: 9.7 ft	Ueq: 9.0 ft
Duration: 300.0 s		

AECOM	Job No: 15-53063	Sounding: COF-C056
	Date: 10-Aug-2015 08:28:32	Cone: 374
	Site: Coffeen Power Plant, Coffeen, IL	Cone Area: 15 sq cm



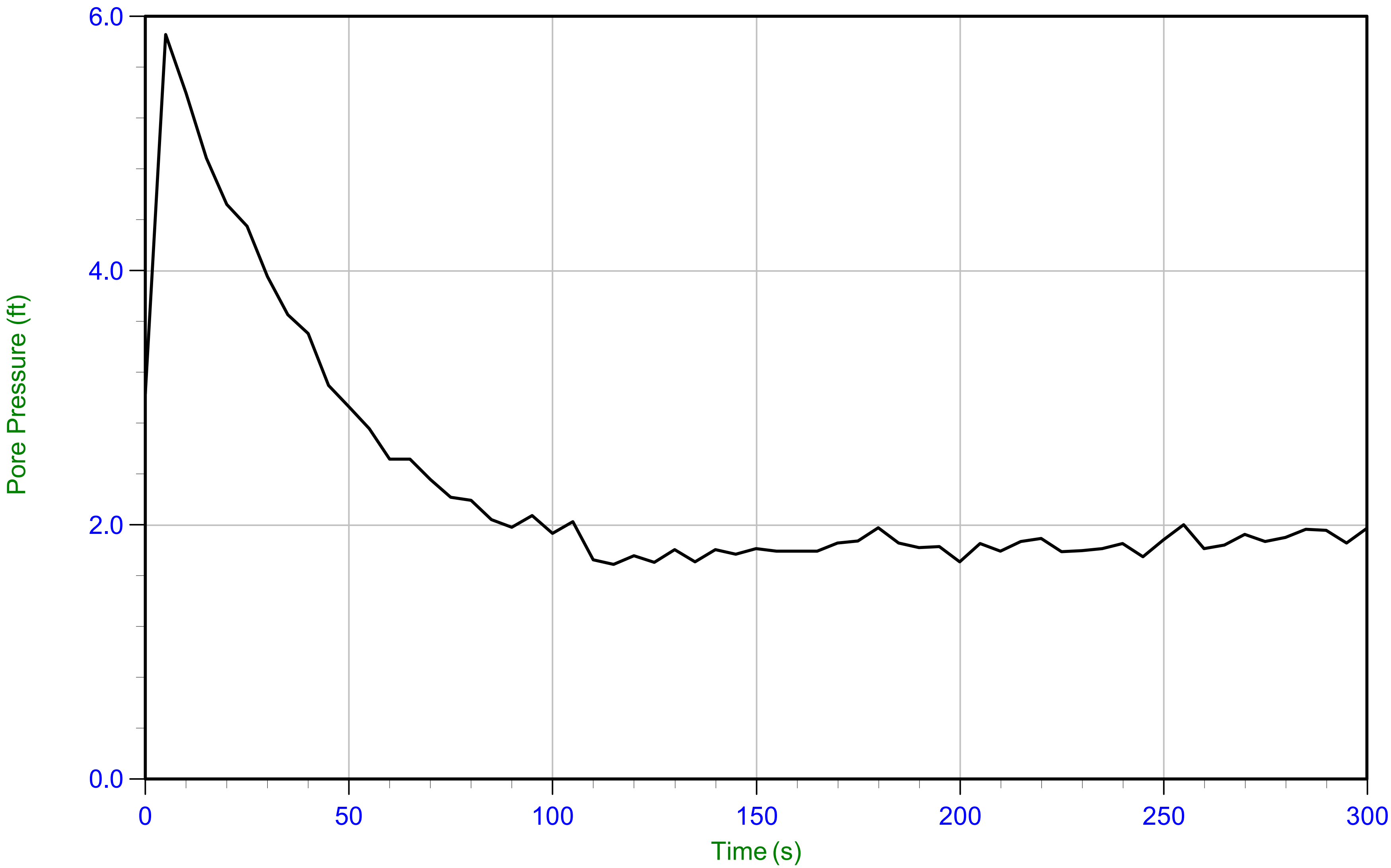
Trace Summary:

Filename: 15-53063_SP56.PPD	U Min: -10.2 ft	WT: 6.397 m / 20.987 ft
Depth: 12.350 m / 40.518 ft	U Max: 19.9 ft	Ueq: 19.5 ft
Duration: 300.0 s		

AECOM

Job No: 15-53063
Date: 10-Aug-2015 10:30:52
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C057
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP57.PPD
Depth: 3.400 m / 11.155 ft
Duration: 300.0 s

U Min: 1.7 ft
U Max: 5.9 ft

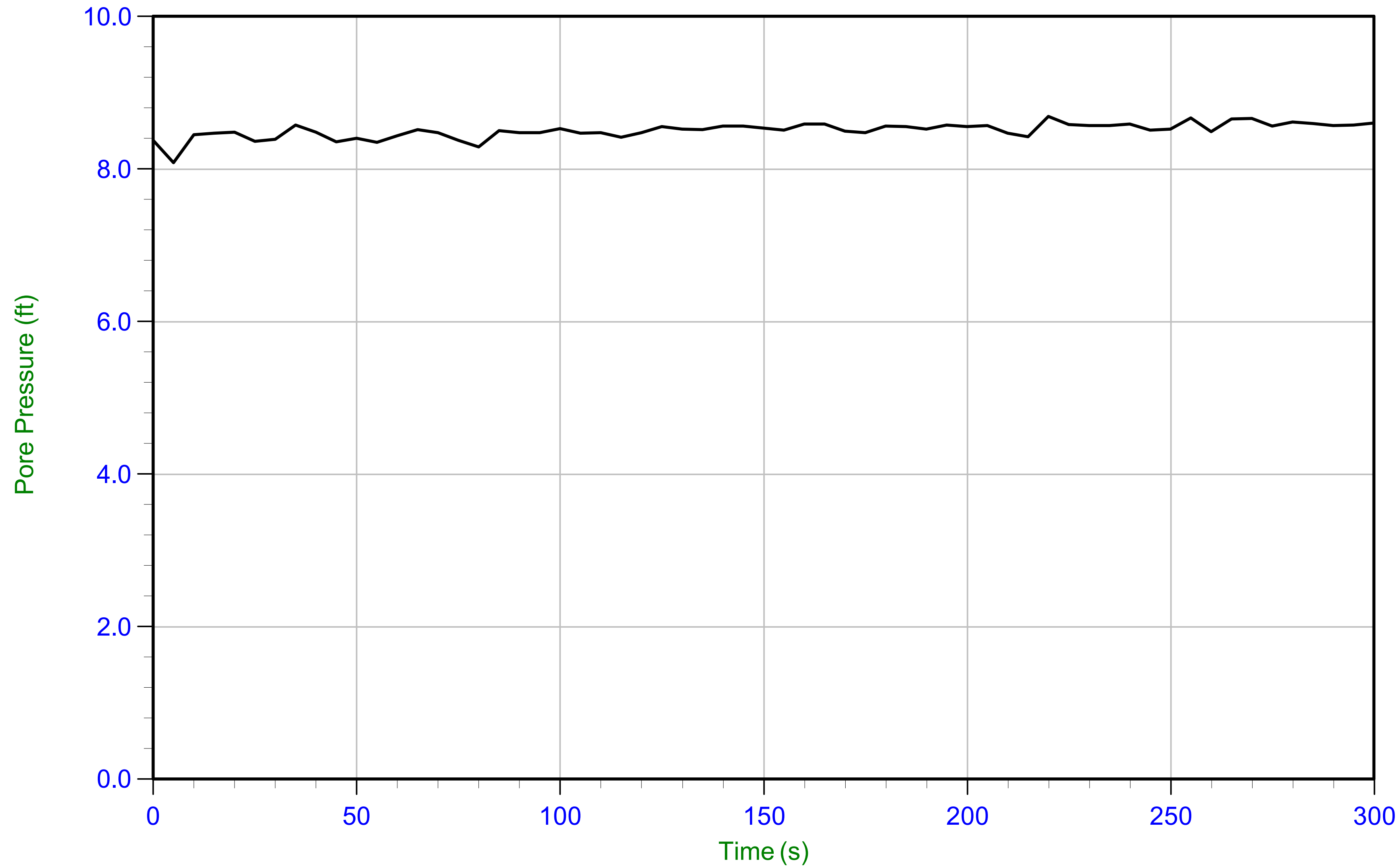
WT: 2.829 m / 9.281 ft
Ueq: 1.9 ft

CONETEC

AECOM

Job No: 15-53063
Date: 10-Aug-2015 10:30:52
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C057
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP57.PPD
Depth: 5.400 m / 17.716 ft
Duration: 300.0 s

U Min: 8.1 ft
U Max: 8.7 ft

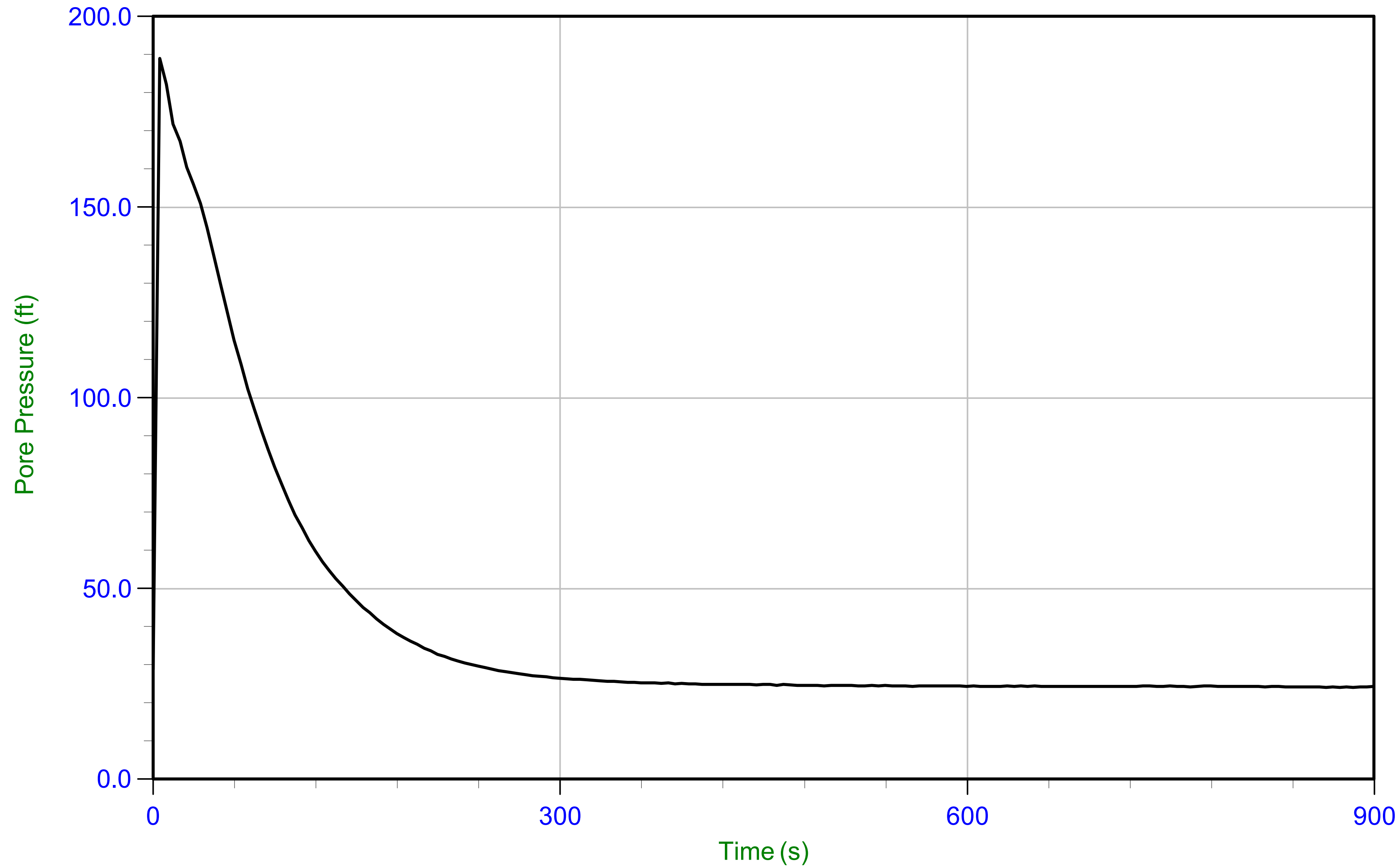
WT: 2.795 m / 9.170 ft
Ueq: 8.5 ft

CONETEC

AECOM

Job No: 15-53063
Date: 10-Aug-2015 10:30:52
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C057
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP57.PPD
Depth: 10.750 m / 35.269 ft
Duration: 900.0 s

U Min: 24.0 ft
U Max: 189.0 ft

WT: 3.391 m / 11.125 ft
Ueq: 24.1 ft

Vibrating Wire Piezometer Installation Summary

CONETEC

CONETEC

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Date: August 4 to 11, 2015
Coordinate Collection Method: TC-7 GPS Receiver (Handheld)
Coordinate Datum: NAD83

Where: P = CF (Li-Lc)

RST VIBRATING WIRE PIEZOMETER INSTALLATION SUMMARY

Location ID	Adjacent CPT	Installation Depth (ft)	Deployment Date	Deployment Time (hr)	Piezometer Serial No.	Cable Length (m)	Piezometer Baseline (Li)	Piezometer After Deployment (Lc)	Calibration Factor (CF)	Calculated Piezometric Surface (P; kPa)	Calculated Piezometric Surface (P; ft of head)	Comments
COF-P008	COF-C014	19.02	12-Aug-15	9:25	VW33848	19	8353.5	7866.9	0.10395	50.58	16.92	4.0 ft W of CPT
COF-P007	COF-C018	15.01	12-Aug-15	10:55	VW33845	13	8828.0	8693.6	0.11392	15.31	5.12	2.75 ft W of CPT
COF-P001	COF-006	11.99	12-Aug-15	12:45	VW33847	19	8909.0	8794.2	0.10804	12.40	4.15	4.25 ft N of CPT

Attachment E. Lab Test Data

DYNEGY - COFFEEN, ILLINOIS
15151122
9/9/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test Grade NOTE*	USCS Symbol
	S1	1.0	2.5	12.9														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S2	3.5	5.0	20.3		31	14	17			2.71							
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S3	6.0	7.5	15.4					NOTE*									
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Gravel					
	S4	8.5	10.0	16.1						24*						ND1	1	
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S5	13.5	15.5	14.7	116.7	35	15	20					NOTE*	NOTE*				
	Color		dark grayish brown with yellowish brown & dark gray							Visual Classification			Lean Clay with Sand					
COF-B001	S6	18.5	20.0	23.2														
	Color		brown & gray							Visual Classification			Silty Lean Clay trace Fine Sand & Organics					
	S7	21.0	23.0	23.4	101.8	66	22	44		22*		1.3E-08*			NOTE*	ND1	3	
	Color		gray with yellowish brown							Visual Classification			Fat Clay with Sand					
	S8	23.5	25.0	19.6		41	15	26			2.68							
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S9	28.5	30.0	16.8														
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S10	30.0	32.0															
	Color									Visual Classification								
	S11	33.5	35.0	11.7		30	13	17			2.73							
	Color		brown & gray							Visual Classification			Lean Clay trace Fine Gravel					

TESTED BY: KJL-JDM
APPROVED BY: RMS

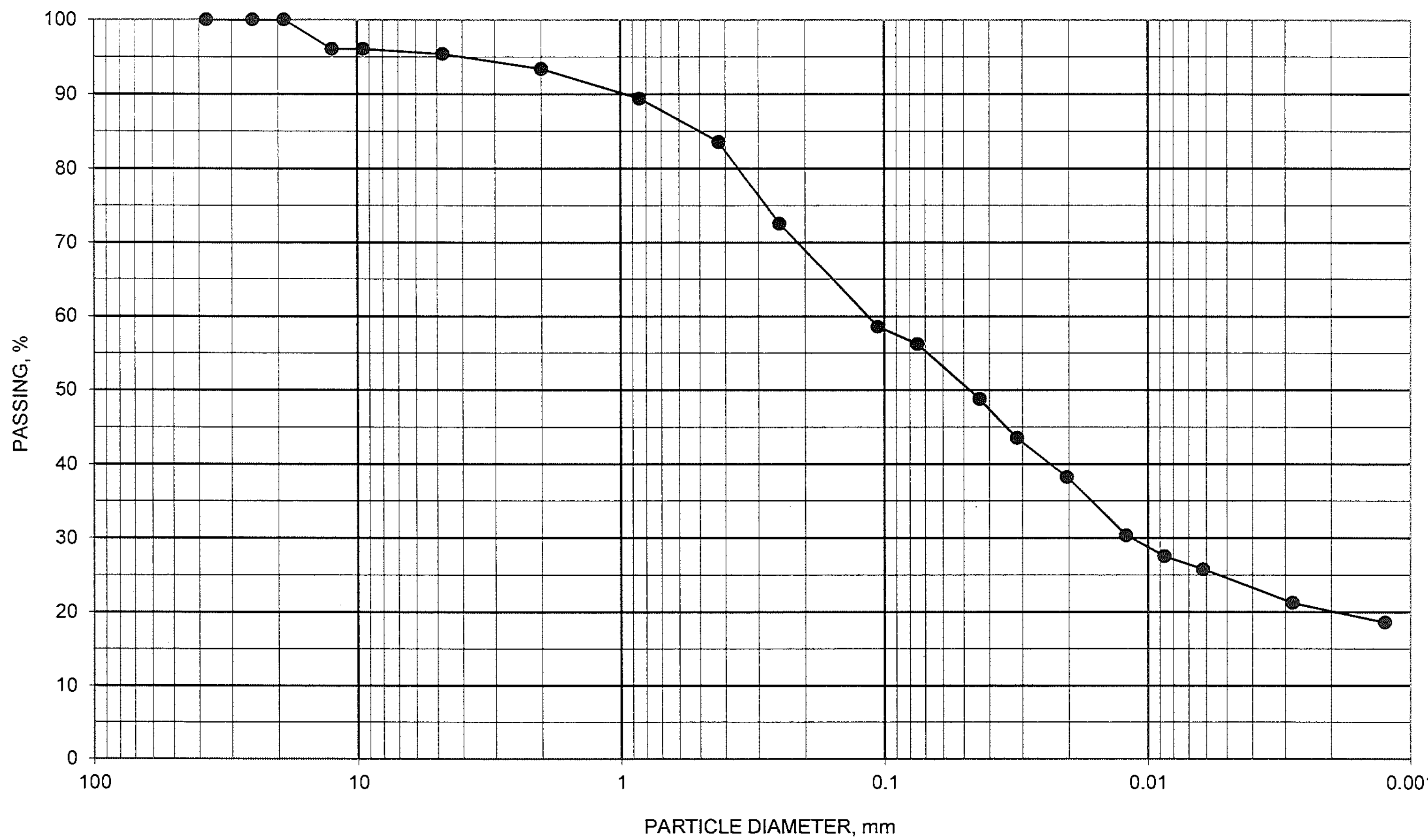
NOTE*: SEE ATTACHED DATA SHEETS.
NOT ASSIGNED, RUN WITH CU & DSS

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	96
3/8"	9.50	96
#4	4.75	95
#10	2.00	93
#20	0.850	89
#40	0.425	84
#60	0.250	73
#140	0.106	59
#200	0.075	56.2
	0.0436	48.8
	0.0315	43.5
	0.0204	38.3
	0.0121	30.4
	0.0087	27.5
	0.0062	25.8
	0.0028	21.2
	0.0013	18.6

D60	0.1155
D30	0.0116

SPECIFIC GRAVITY 2.68 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

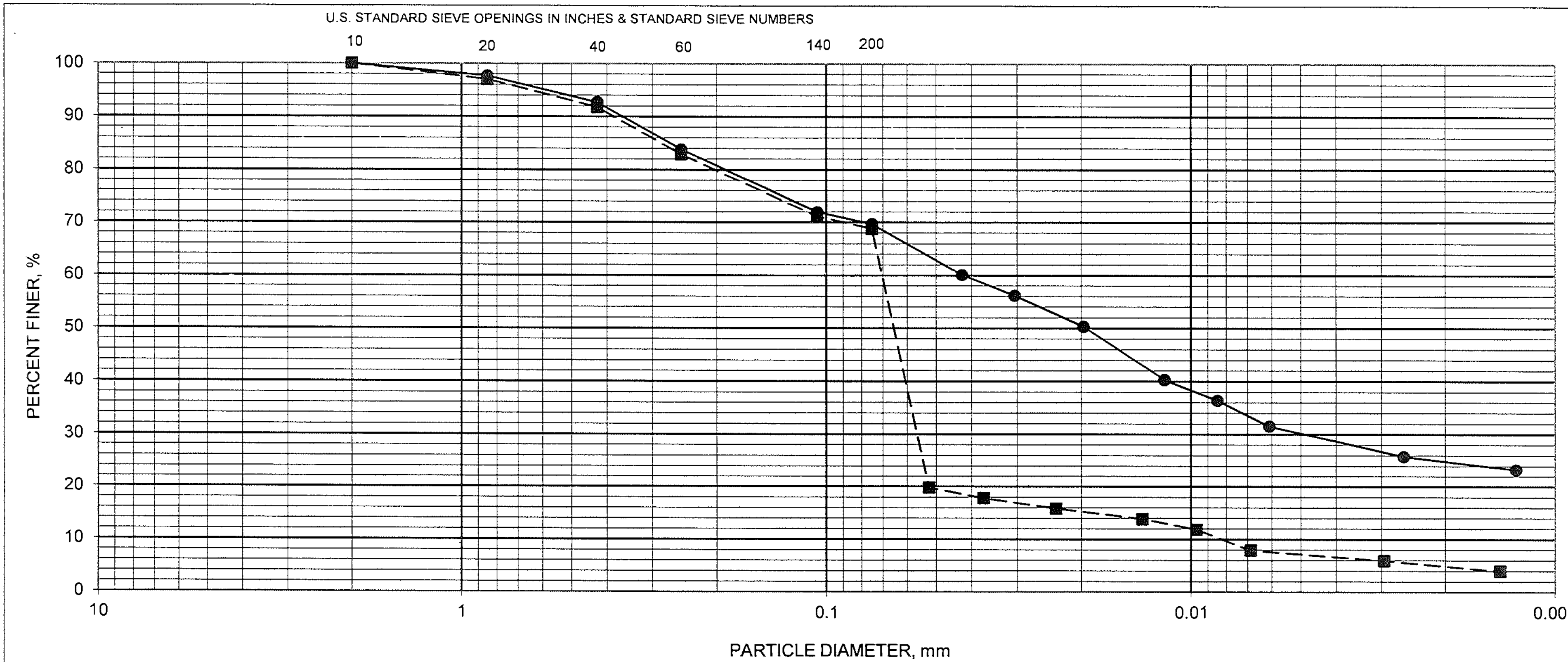
BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B001	S3	6 TO 7.5	SANDY LEAN CLAY TRACE GRAVEL BROWN & GRAY		15.4			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B001-S3-6.0.xlsx]ATTERBERG M%

Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	30.2	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	7.2	DISPERSION, %	24

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B001	S4	8.5 - 10.0	SANDY LEAN CLAY TRACE GRAVEL, BROWN & GRAY					

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/2/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B001-S4-8.5.xls]Double Hydrometer Data

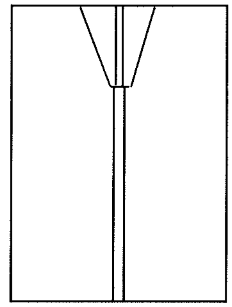
Terracon

DISPERSIVE CLAY SOILS BY THE PINHOLE TEST
ASTM D 4647, METHOD A
9/9/2015

PROJECT DYNEGY
JOB NO. COFFEEN, ILLINOIS
SAMPLE ID COF-B001, S4, 8.5 - 10.0 feet
COMPACTION CHARACTERISTICS UNDISTURBED
WATER CONTENT 15.1%
DISTILLED WATER ADDED ______ **YES** X **NO**
CURE TIME NATURAL MOSITURE, NO CURE
BY JDM
SAMPLE DESC. SANDY LEAN CLAY TRACE GRAVEL, BROWN & GRAY

FLOW STARTED ON 1ST **TRIAL**

FINAL HOLE
0.9 mm



TIME, min	HEAD, inch	FLOW, ml	FLOW, sec	FLOW RATE, ml/sec	TURBIDITY FROM SIDE: VERY DARK	DARK	MOD. DARK	SLIGHT DARK	BARELY VISIBLE	CLEAR	CLEAR FROM TOP	REMARKS
1	2	13.0	60	0.22						X	X	
2	2	12.5	60	0.21						X	X	
3	2	12.5	60	0.21						X	X	
4	2	12.0	60	0.20						X	X	
5	2	12.0	60	0.20						X	X	
6	2	11.0	60	0.18						X	X	
7	2	9.8	60	0.16						X	X	
8	2	11.0	60	0.18						X	X	
9	2	12.0	60	0.20						X	X	
10	2	12.0	60	0.20						X	X	
1	7	34.0	60	0.57						X		Barely Visible
2	7	34.0	60	0.57						X	X	
3	7	34.0	60	0.57						X	X	
4	7	33.5	60	0.56						X	X	
5	7	35.0	60	0.58						X	X	
1	15	60.0	60	1.00						X		Barely Visible
2	15	59.0	60	0.98						X		Barely Visible
3	15	59.0	60	0.98						X		Barely Visible
4	15	60.0	60	1.00						X		Barely Visible
5	15	59.0	60	0.98						X	X	
1	40	118.0	60	1.97						X		Barely Visible
2	40	120.0	60	2.00						X		Barely Visible
3	40	120.0	60	2.00						X	X	
4	40	120.0	60	2.00						X	X	
5	40	120.0	60	2.00						X	X	

CLASSIFICATION = ND1

Terracon

CRUMB TEST (ASTM D6572)

Project No.: 1515122 Project Name: DYNEGY Location: COFFEEN, IL

Boring No.: COF-B001 Sample No.: S4 Depth: 8.5-10.0 [X] ft [ ] m

Visual Classification: ______ Color: ______

Moisture Content of Sample:	[ ] as-received	[ ] in situ	[ ] air-dried	
Tare Number	Wet Mass + Tare (g)	Dry Mass+ Tare (g)	Tare Mass (g)	Water Content (%)
AL-79	63.28	57.75	21.00	15.0

Specimen Identification:		Specimen Identification:		Specimen Identification:	
Spec. Container Identification:	B	Spec. Container Identification:		Spec. Container Identification:	
Method:	[X] A (Natural) [ ] B (Remolded)	Method:	[ ] A (Natural) [ ] B (Remolded)	Method:	[ ] A (Natural) [ ] B (Remolded)
Water Type:	[X] Distilled [ ] Type IV	Water Type:	[ ] Distilled [ ] Type IV	Water Type:	[ ] Distilled [ ] Type IV
Initial Water Temp. (°C):	22.5	Initial Water Temp. (°C):		Initial Water Temp. (°C):	
Start Time (hh:mm:ss):	8:51:30	Start Time (hh:mm:ss):		Start Time (hh:mm:ss):	

Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	8:53:30	1	22.1	2 min ± 15 s				2 min ± 15 s			
1 h ± 8 min	9:52:00	1	20.9	1 h ± 8 min				1 h ± 8 min			
6 h ± 45 min	2:54:02	1	21.0	6 h ± 45 min				6 h ± 45 min			

Dispersive Classification:	Non-Dispersive	Dispersive Classification:		Dispersive Classification:	
Additional water added to remold the specimen (Method B):	[ ] Y [ ] N	Additional water added to remold the specimen (Method B):	[ ] Y [ ] N	Additional water added to remold the specimen (Method B):	[ ] Y [ ] N

Remarks: ______

Prepared By: John Martin Date: 9/1/15

Tested By: John Martin Date: 9/1/15

Input By: John Martin Date: 9/8/15

Reviewed By: ______ Date: ______

CRUMB TEST D6572

DYNEGY

COFFEEN, ILLINOIS

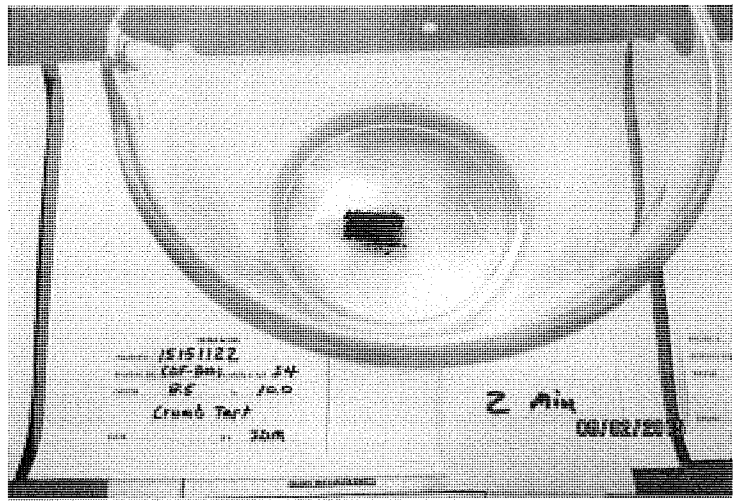
15151122

COF-B001 S4 8.5 - 10.0 feet

2 MIN

GRADE: 1

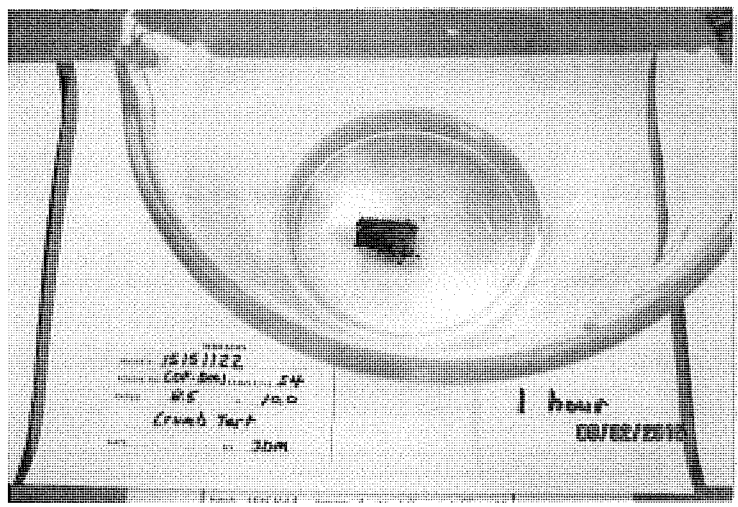
DISPERSIVE CALSSIFICATION: NONDISPERSIVE



1 HOUR

GRADE: 1

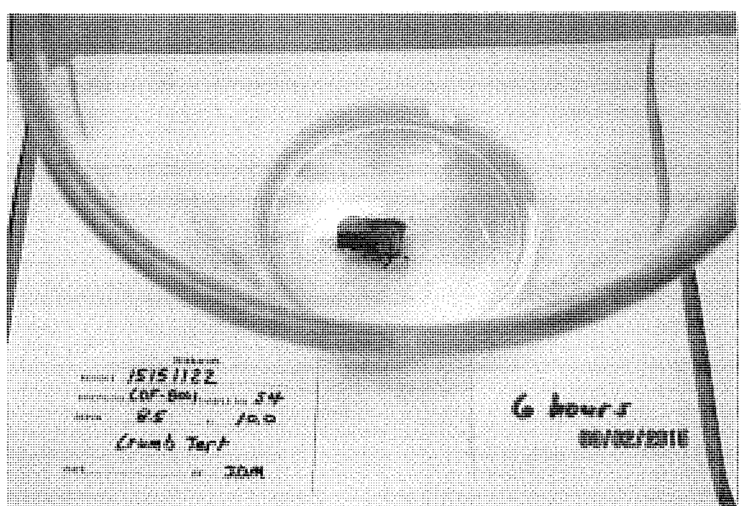
DISPERSIVE CALSSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 1

DISPERSIVE CALSSIFICATION: NONDISPERSIVE



Grade 1 - Nondipersive

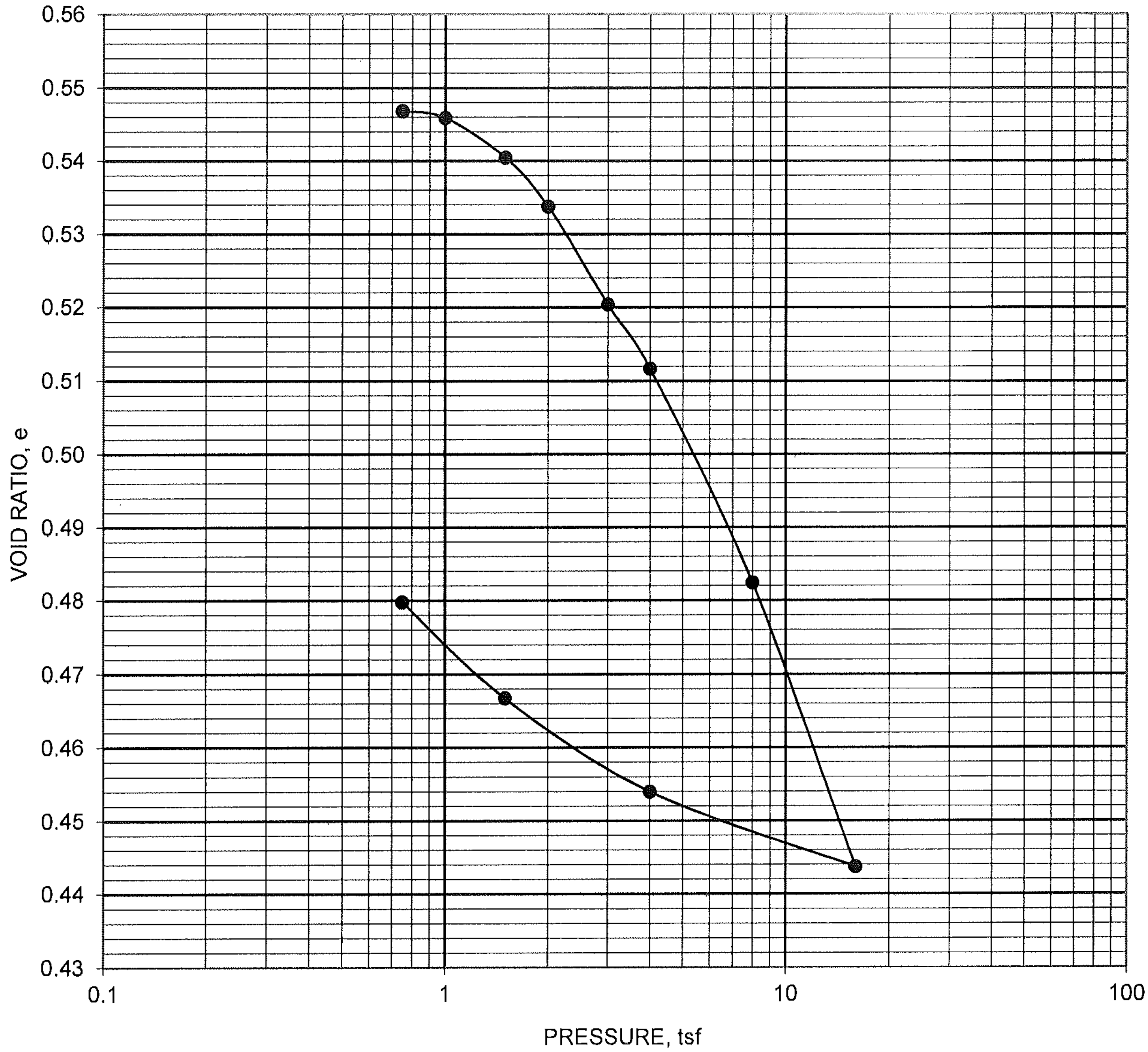
Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.54	HEIGHT, mm	25.26	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		0.94		MOISTURE, %		18.8	18.1
PRECONSOL. PRESSURE, tsf		3.00		DRY DENSITY, pcf		109.0	113.7
OVER CONSOLIDATION RATIO		3.2		SATURATION, %		93	102
COMPRESSION INDEX		0.13		VOID RATIO		0.547	0.479
REBOUND INDEX		0.036		SAMPLE TYPE		UNDISTURBED	
LIQUID LIMIT	35	PLASTIC LIMIT	15	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	LEAN CLAY WITH SAND, DARK GRAYISH BROWN WITH YELLOWISH BROWN & DARK GRAY						
BORING NO.	COF-B001	SAMPLE NO.	S5	DEPTH, feet	13.5 - 15.5		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

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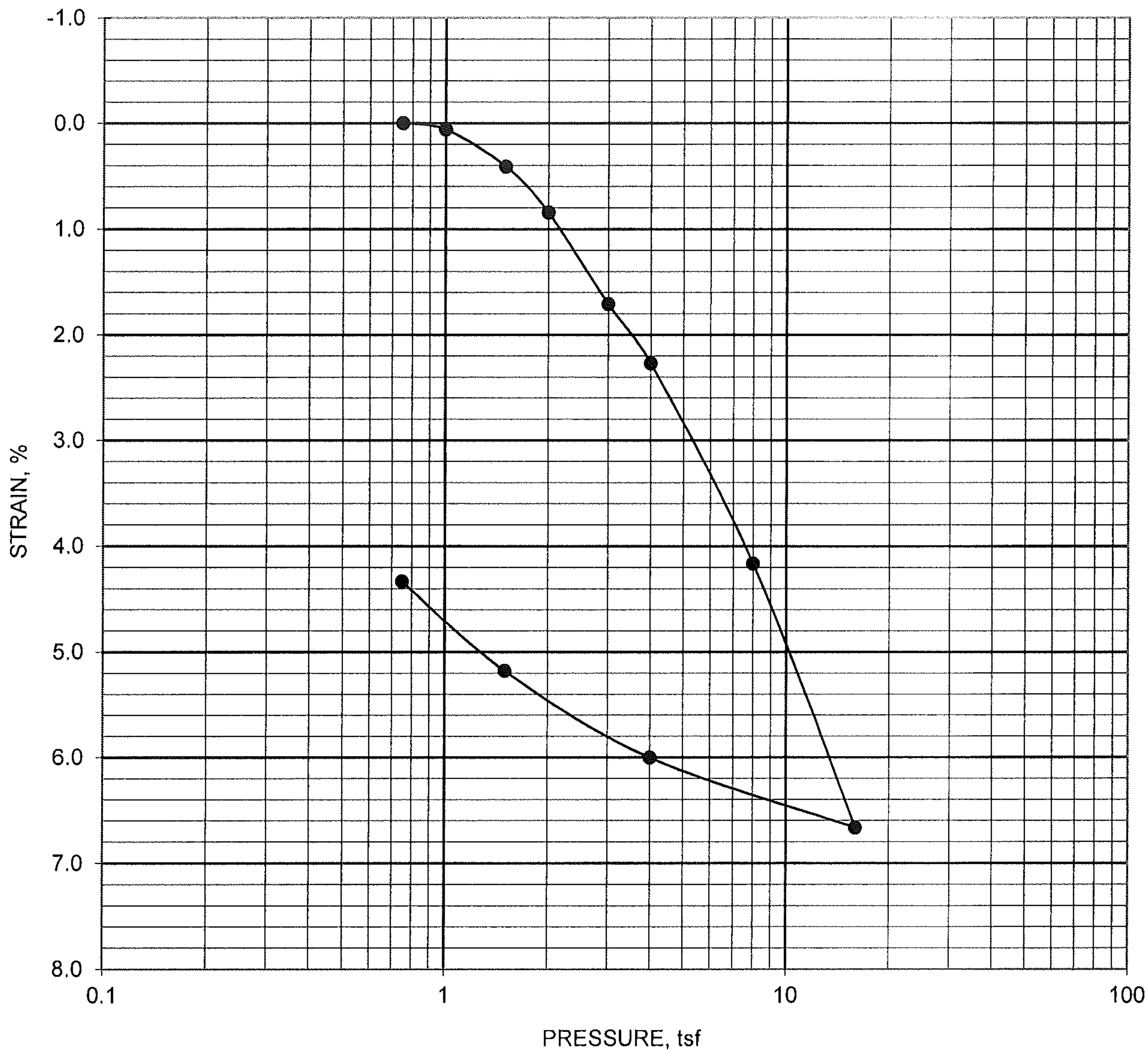
Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.54	HEIGHT, mm	25.26	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		0.94		MOISTURE, %		18.8	18.1
PRECONSOL. PRESSURE, tsf		3.00		DRY DENSITY, pcf		109.0	113.7
OVER CONSOLIDATION RATIO		3.2		SATURATION, %		93	102
COMPRESSION INDEX		0.13		VOID RATIO		0.547	0.479
REBOUND INDEX		0.036		SAMPLE TYPE		3" SHELBY TUBE	
LIQUID LIMIT	35	PLASTIC LIMIT	15	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	LEAN CLAY WITH SAND, DARK GRAYISH BROWN WITH YELLOWISH BROWN & DARK GRAY						
BORING NO.	COF-B001	SAMPLE NO.	S5	DEPTH, feet	13.5 - 15.5		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B001\[15151122 Consolidation COF-B001-S5

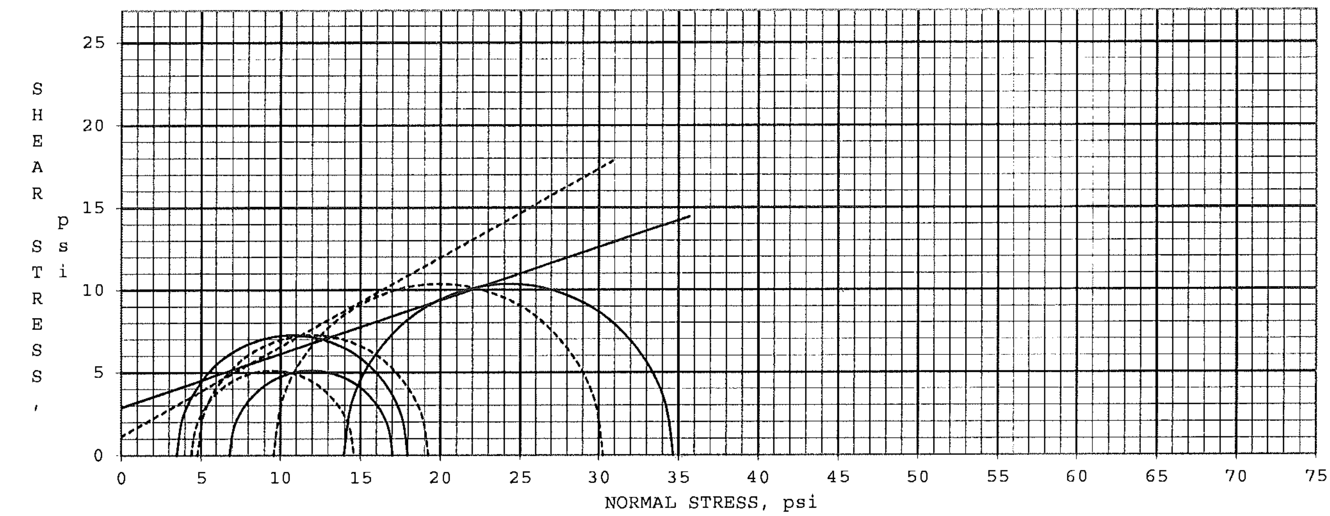
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

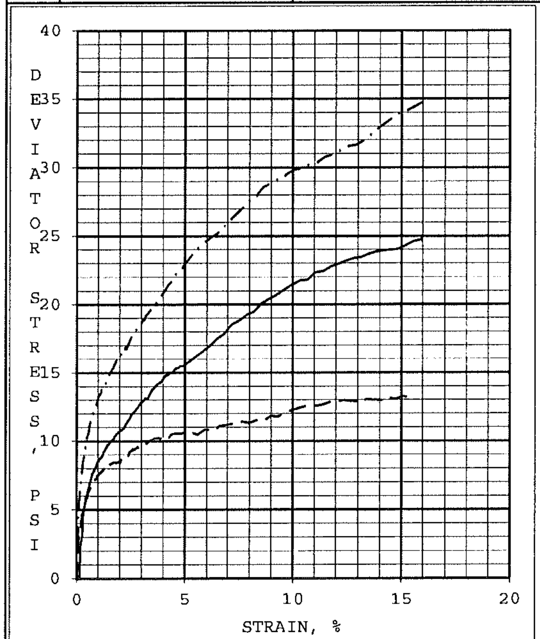
ADDITIONAL CONSOLIDATION DATA

COF-B001
S5
13.5 - 15.5

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.75					
1	1.87E-04	1.88E-04	3.81E-06	2.47E-06	4.61E-10
1.5	7.33E-04	7.38E-04	1.11E-05	7.20E-06	5.28E-09
2	4.30E-04	4.33E-04	1.37E-05	8.87E-06	3.82E-09
3	3.18E-04	3.20E-04	1.37E-05	8.91E-06	2.84E-09
4	1.86E-04	1.87E-04	8.90E-06	5.85E-06	1.09E-09
8	2.22E-04	2.23E-04	7.47E-06	4.94E-06	1.10E-09
16	1.55E-04	1.56E-04	4.95E-06	3.34E-06	5.18E-10
AVERAGE	3.19E-04	3.21E-04	9.08E-06	5.94E-06	2.16E-09



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	28.4	COHESION, psi	1.1
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	18.0	COHESION, psi	2.9



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	14.1	12.8	17.3
INITIAL	DRY DENSITY, pcf	118.3	116.1	115.6
INITIAL	SATURATION, %	89	77	102
INITIAL	VOID RATIO	0.42	0.45	0.46
BEFORE SHEAR	WATER CONTENT, %	15.6	16.1	15.9
BEFORE SHEAR	DRY DENSITY, pcf	118.5	117.4	117.9
BEFORE SHEAR	SATURATION (B PARAMETER)	0.96	0.96	0.95
BEFORE SHEAR	VOID RATIO	0.42	0.43	0.43
BEFORE SHEAR	FINAL BACK PRESSURE, psi	99.6	100.4	100.2
MINOR PRINCIPAL STRESS, psi		3.5	6.8	14.0
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		14.5	10.2	20.7
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		14.5	10.2	20.7
ULTIMATE DEVIATOR STRESS (15% STR), psi		24.1	13.1	34.0
TIME TO 50% PRIMARY CONSOLIDATION, min		23.00	1.60	7.20
STRAIN RATE, % / hour		0.76	2.23	2.34
INITIAL DIAMETER, inch		1.369	1.376	1.368
INITIAL HEIGHT, inch		2.795	2.865	2.757
AREA AFTER CONSOLIDATION, inch2		1.470	1.479	1.450

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, DARK GRAY WITH YELLOWISH BROWN & DARK GRAY

LL	PL	PI	Gs
35	15	20	2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B001

LABORATORY: TERRACON - LENEXA

SAMPLE #: S5

DATE: 9/8/2015

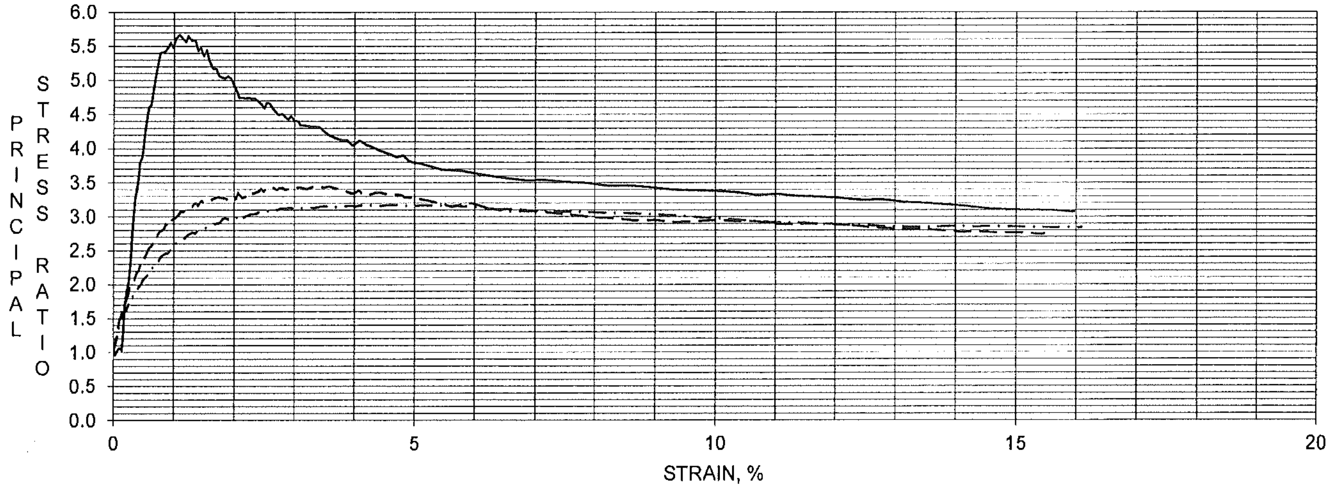
DEPTH, feet: 13.5 - 15.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

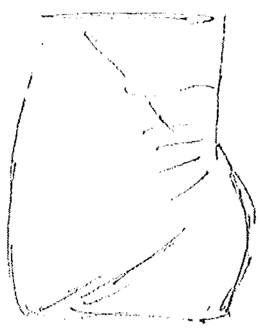
Terracon

DYNEGY

15151122 COF-B001 S5 13.5 - 15.5

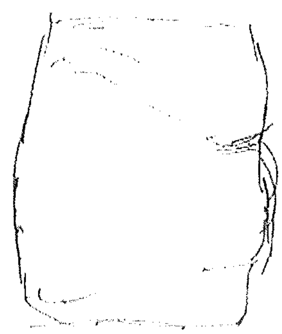


FAILURE SKETCH



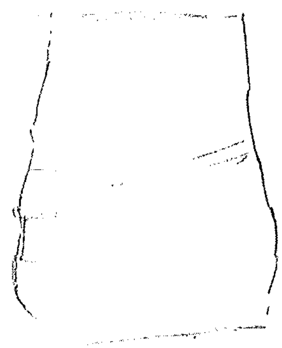
SPECIMEN A

FAILURE SKETCH



SPECIMEN B

FAILURE SKETCH



SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

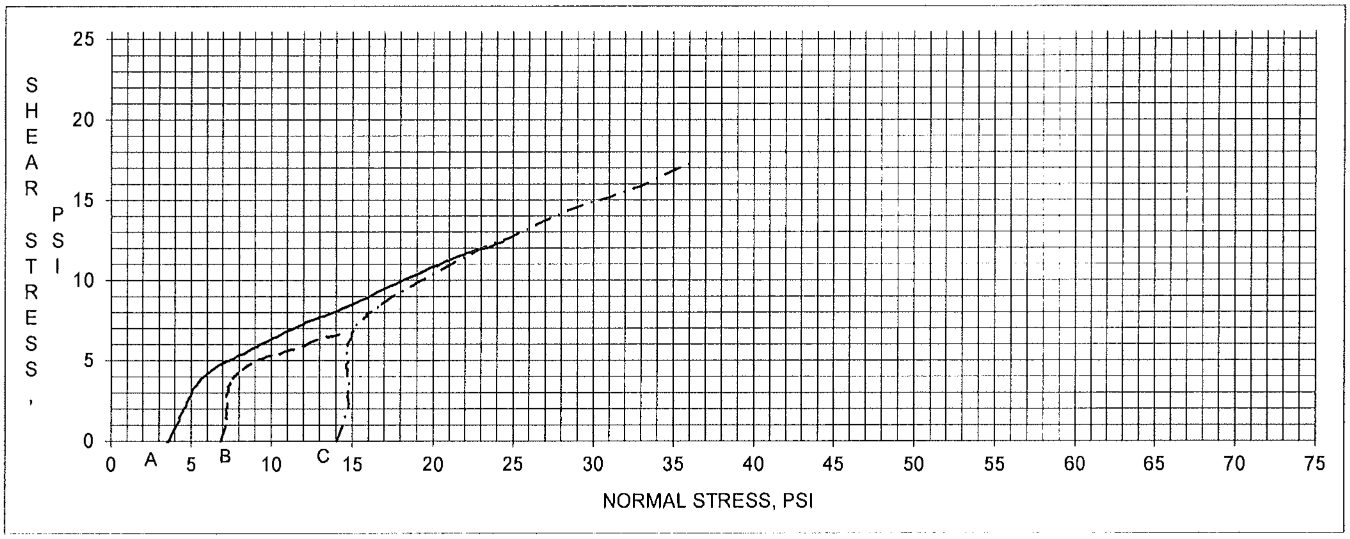
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

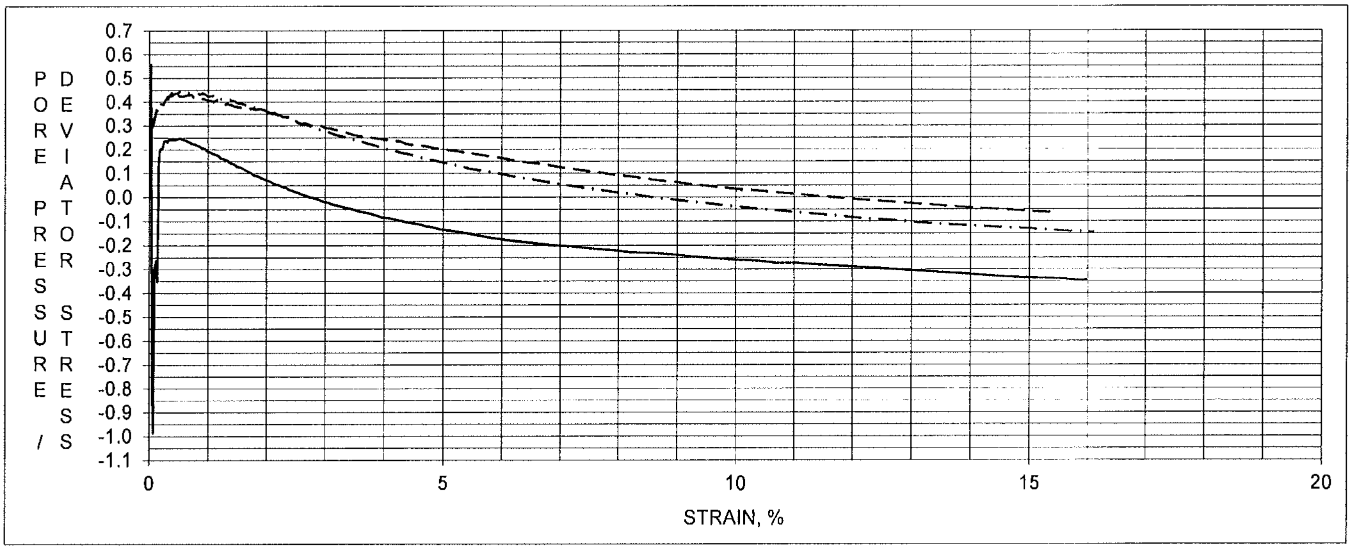
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

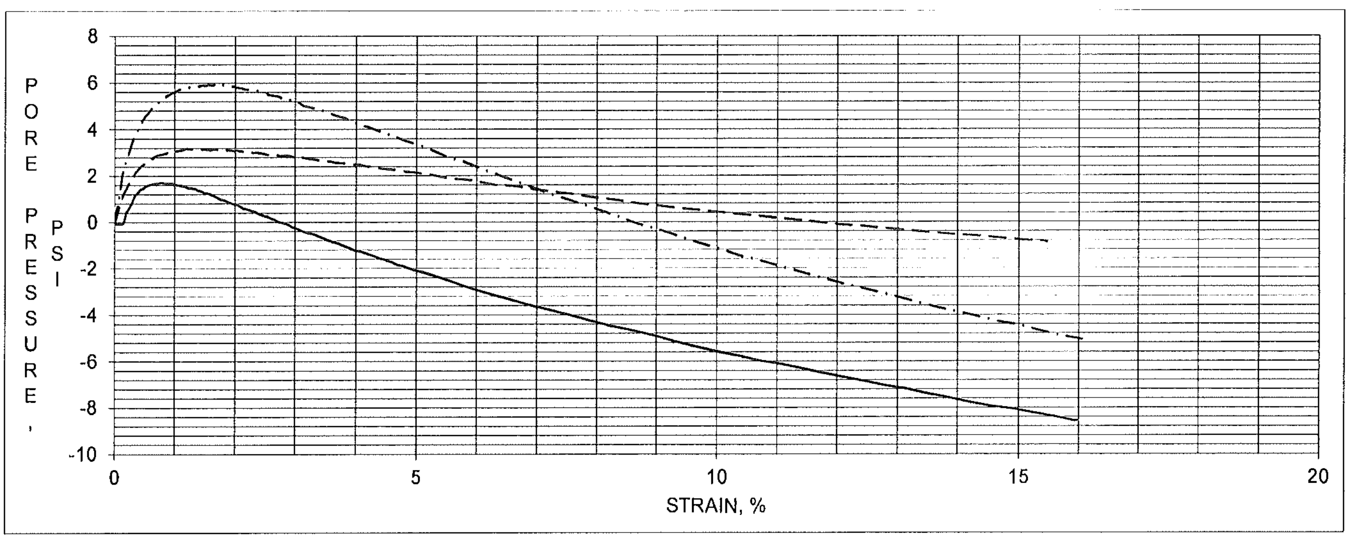
Terracon

DYNEGY

15151122 COF-B001 S5 13.5 - 15.5

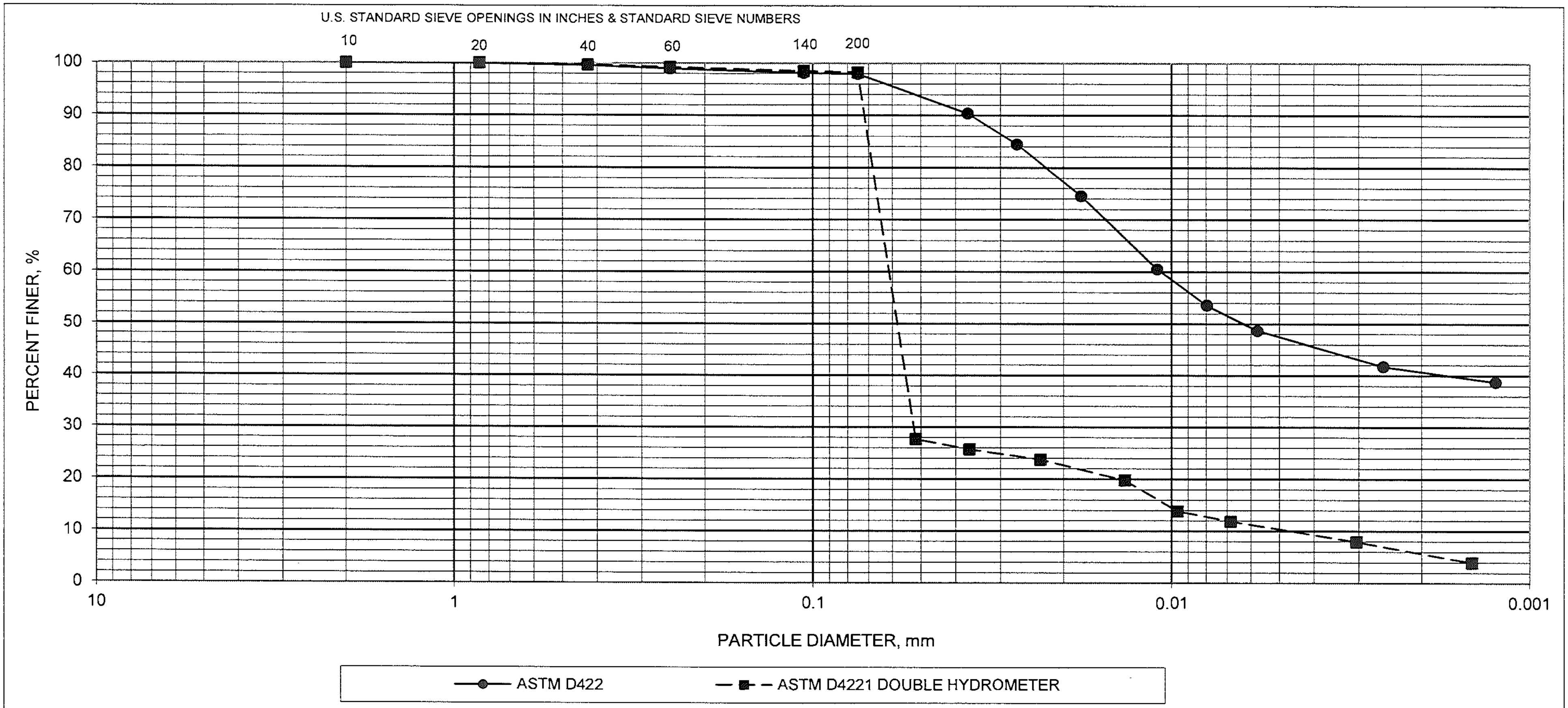






Terracon

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Triaxial CU COF-B001-S5-13.5.xlsx]REPORT



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	47.4	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	10.3	DISPERSION, %	22

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B001	S7	21.0 - 23.0						

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/2/2015

Terracon

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B001-S7-21.0.xls]Hydrometer Data

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 03 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N CaSO4

PROJECT NAME:	DYNEGY	PROJECT NUMBER:	15151122
LOCATION:	COFFEEN, ILLINOIS	DATE:	7/30/2015
		PANEL IDENTIFICATION:	Lenexa Perm Board
SAMPLE ID:	COF-B001 S7 21.0 - 23.0 feet	BURETTE AREA:	0.312 cm^2
SAMPLE DESCR.:	FAT CLAY WITH SAND, GRAY WITH YELLOWISH BROWN	BURETTE INCREMENT LENGTH:	1.000 cm
		VOLUME PER INCREMENT:	0.312 cm^3

INITIAL

MOISTURE%		DENSITY			
W & T, g	145.02	WET WT, g	475.6		
D & T, g	123.94	DIA, in	2.872	7.29	cm
T, g	33.98	HT, in	2.225	5.65	cm
		AREA		41.80	cm^2
MOIST-		DENSITY:	125.7	PCF WET	
URE, %	**23.4**	DENSITY:	**101.8**	PCF DRY	

ADDITIONAL DATA

SPECIFIC GRAVITY:	2.70	RECOMPACTED?:	NO
SPECIFIC GRAVITY:	ASSUMED	PROCTOR, pcf:	NA
POROSITY, %:	39.6	OPTIMUM, %:	NA
SATURATION, %:	96.6	COMPACTION, %:	NA
VOID RATIO:	0.66	OVER OPTIMUM, %:	NA

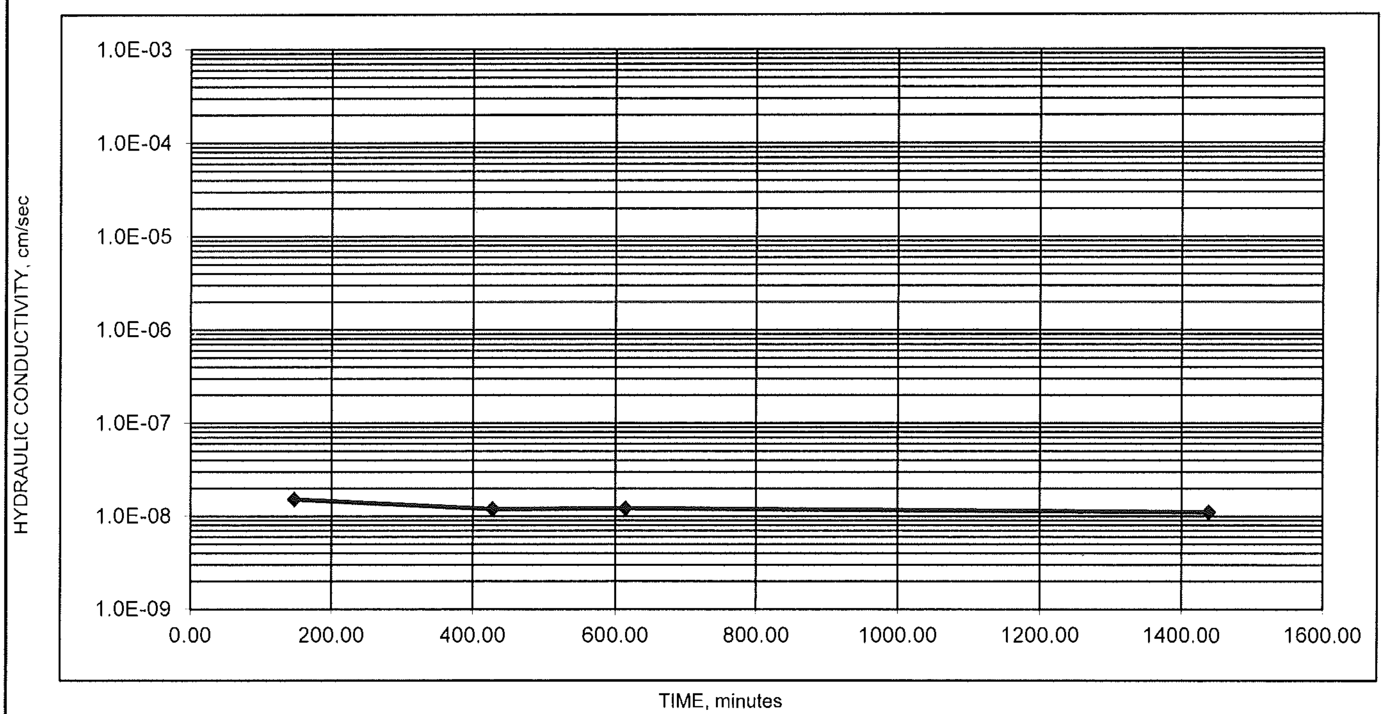
SATURATION: LATERAL PRESS.: 104.0 psi — BACK PRESSURE (=UPPER=LOWER): 100.0 psi

DURING TEST: LATERAL PRESS.: 104.0 psi — H2: 100.0 psi — H1: 100.0 psi — BIAS PRESSURE (=H1-H2) 0.0 psi

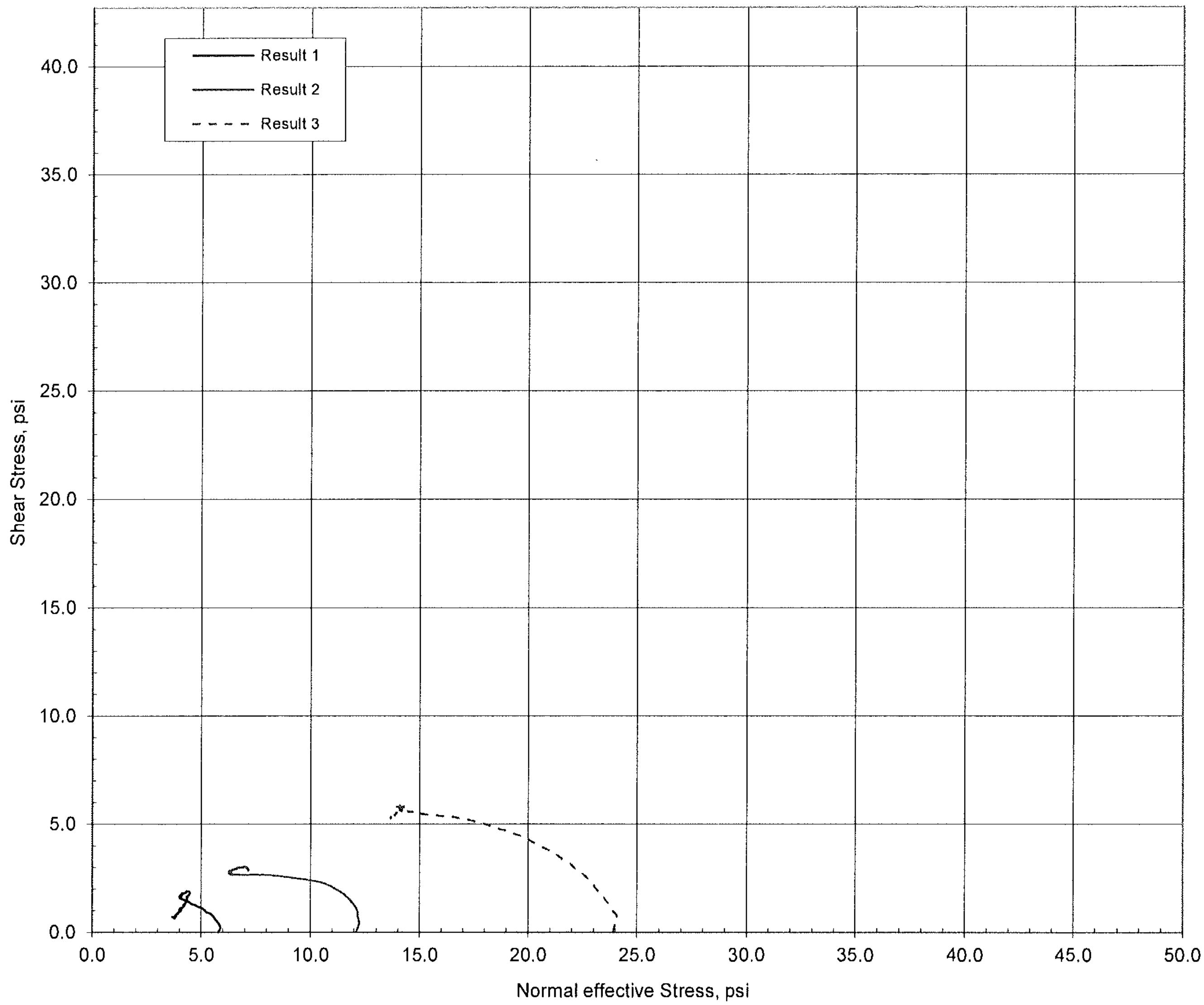
H1 VALUE	H2 VALUE	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
8.8	67.6	0.00	58.8									
9.0	67.4	147.00	58.4	0.006826	1.52E-08	0.06	0.06	1.00	10.3	21	23.0	0.931
9.3	67.1	428.00	57.8	0.010327	1.20E-08	0.09	0.09	1.00	10.2	5	23.3	0.925
9.5	66.9	614.00	57.4	0.006944	1.22E-08	0.06	0.06	1.00	10.2	3	23.2	0.927
10.3	66.1	1439.00	55.8	0.028270	1.11E-08	0.25	0.25	1.00	9.9	12	23.6	0.918

HYDRAULIC CONDUCTIVITY (k_{20}) = **AVERAGE 1.3E-08 cm/sec**

MAXIMUM HYDRAULIC GRADIENT	1.0E-03 TO 1.0E-04	2	0.75< RATIO <1.25	30 MAX HYDRAULIC GRADIENT ALLOWED — % < 25 AT > 1.0E-8 OR % < 50 AT < 1.0E-8
	1.0E-04 TO 1.0E-05	5		
	1.0E-05 TO 1.0E-06	10		
	1.0E-06 TO 1.0E-07	20		
	less than 1.0E-07	30		



CONSOLIDATED UNDRAINED DIRECT SIMPLE SHEAR TESTING OF COHESIVE SOILS
ASTM D6528



	RESULT 1	RESULT 2	RESULT 3		RESULT 1	RESULT 2	RESULT 3
INITIAL DATA				NORMAL EFF. STRESS, psi	5.8	12.1	23.9
AREA, inch2	5.371	5.371	5.379	PRESHEAR MOISTURE, %	30.8	30.6	29.5
HEIGHT, inch	0.704	0.701	0.701	PRESHEAR VOID RATIO	0.80	0.75	0.72
MOISTURE, %	28.2	28.5	29.3	FINAL MOISTURE, %	30.9	30.7	29.6
DRY DENSITY, pcf	92.3	93.5	93.1	FINAL VOID RATIO	0.81	0.77	0.76
SATURATION, %	92	96	98	SHEAR STRAIN RATE, %/min	0.086	0.087	0.090
VOID RATIO	0.83	0.80	0.81	t95 @ MAX STESS, min	0.82	1.58	3.23
LIQUID LIMIT	66		PLASTIC LIMIT	22	PLASTICITY INDEX		44
SAMPLE TYPE	UNDISTURBED			SPECIFIC GRAVITY	2.7 ESTIMATED		
SAMPLE DESCRIPTION	FAT CLAY WITH SAND, GRAY WITH YELLOWISH BROWN						

PROJECT NAME: DYNEGY

BORING NO. COF-B001

LOCATION: COFFEEN, ILLINOIS

SAMPLE NO. S7

JOB NO.: 15151122

DEPTH, feet 21.0 - 23.0

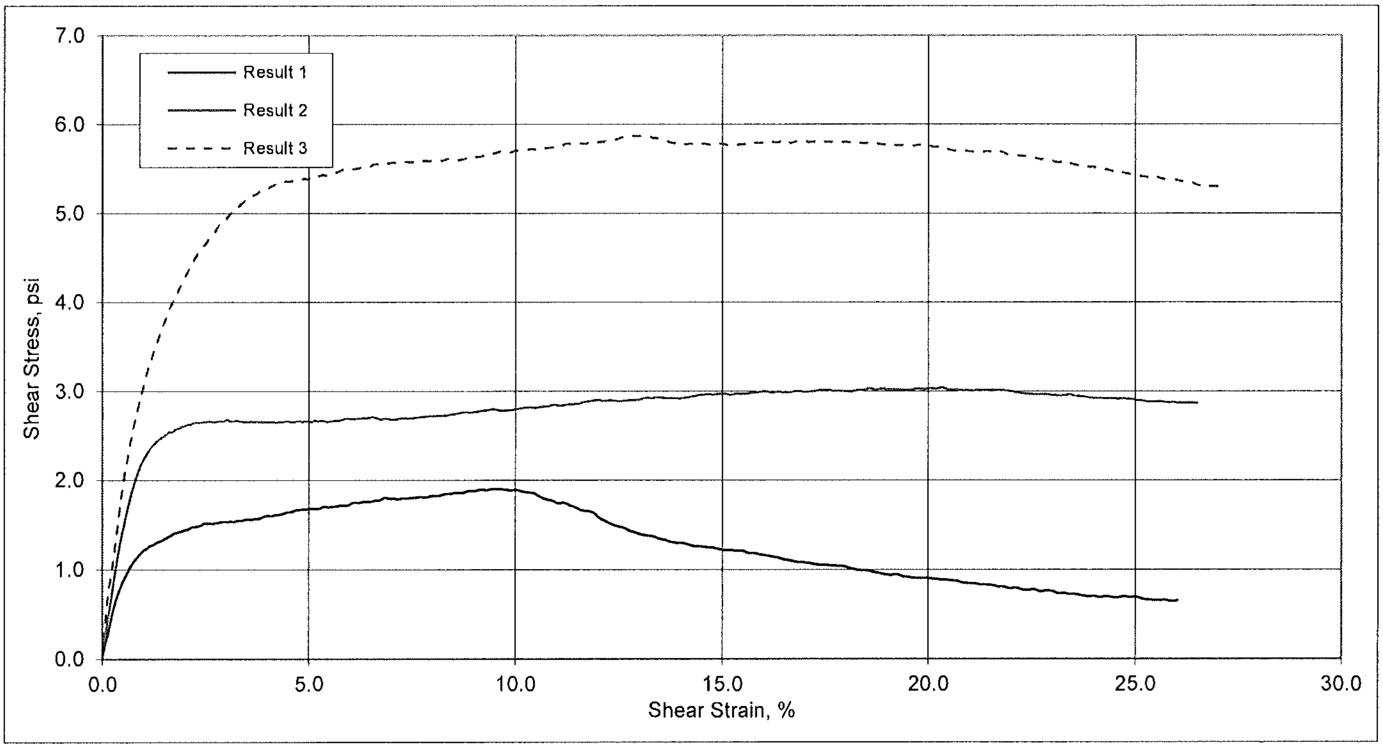
DATE: 9/9/2015

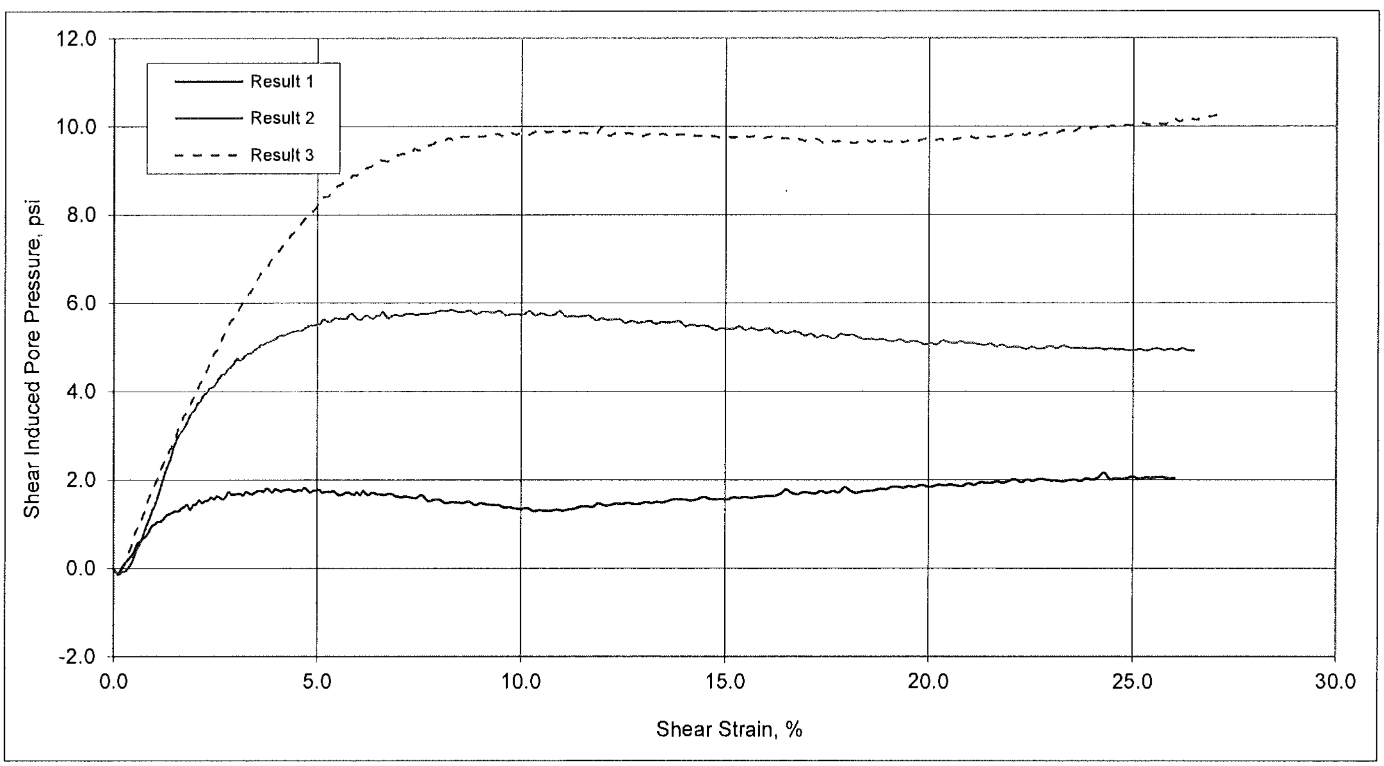
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 DirectSimpleShear COF-BC

Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/9/2015

BORING NO.	COF-B001
SAMPLE NO.	S7
DEPTH, feet	21.0 - 23.0

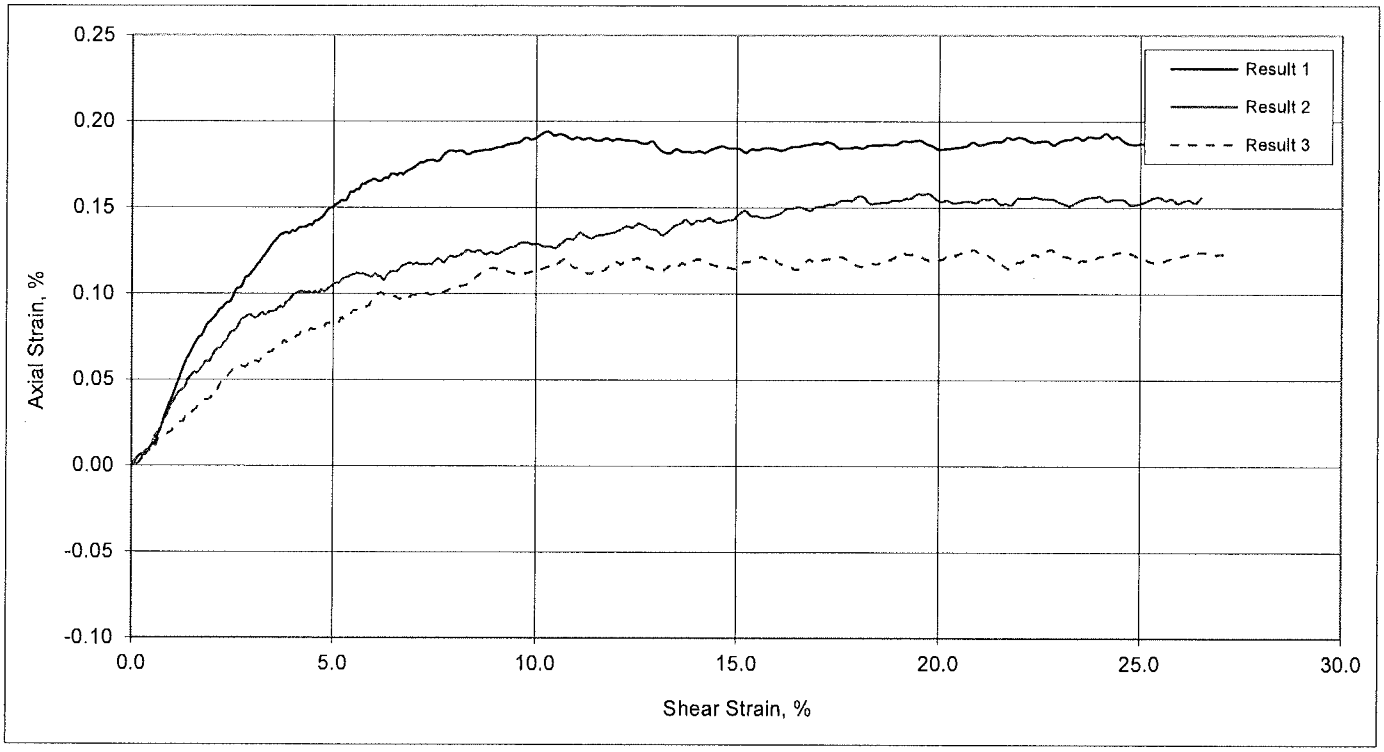


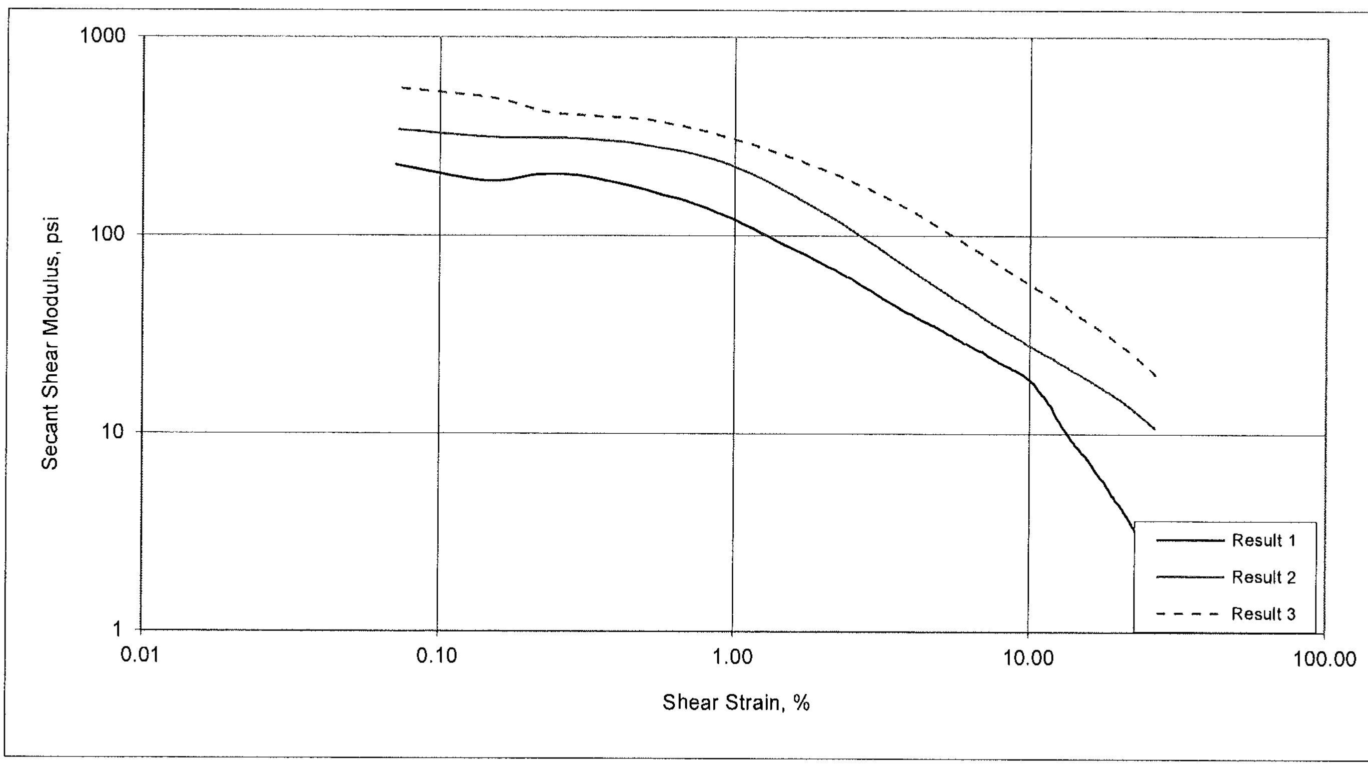


Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/9/2015

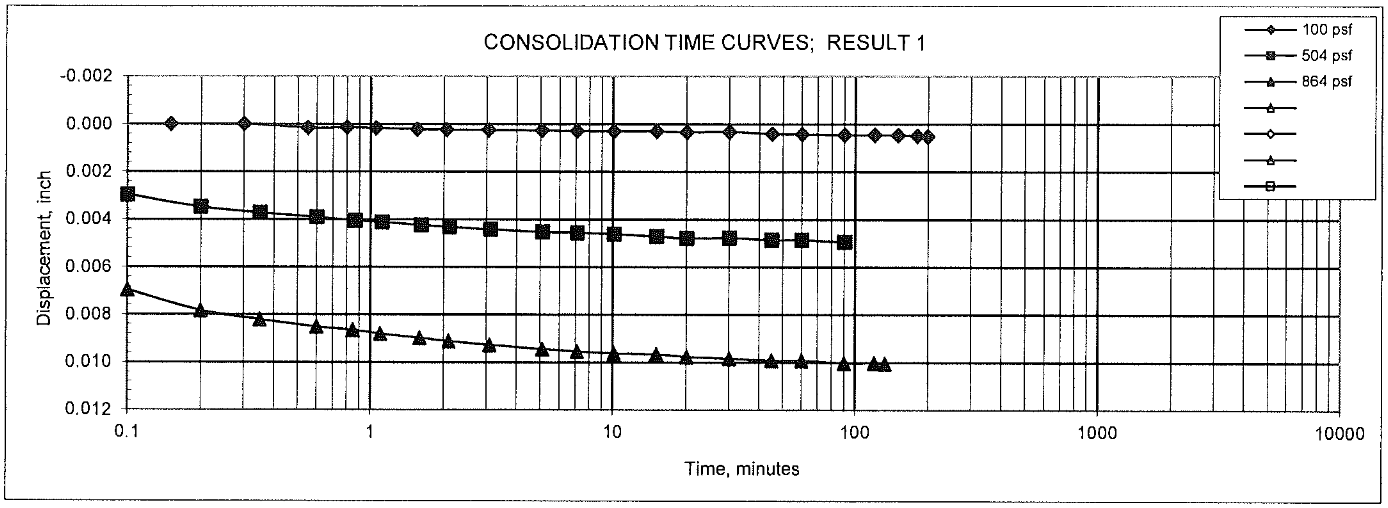
BORING NO.	COF-B001
SAMPLE NO.	S7
DEPTH, feet	21.0 - 23.0

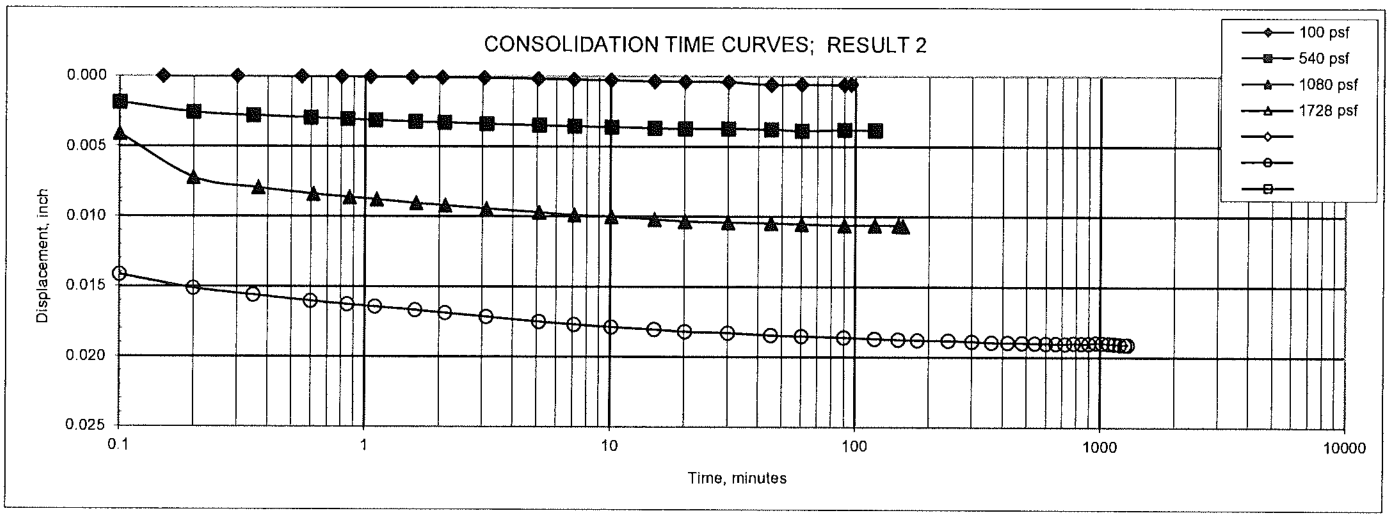


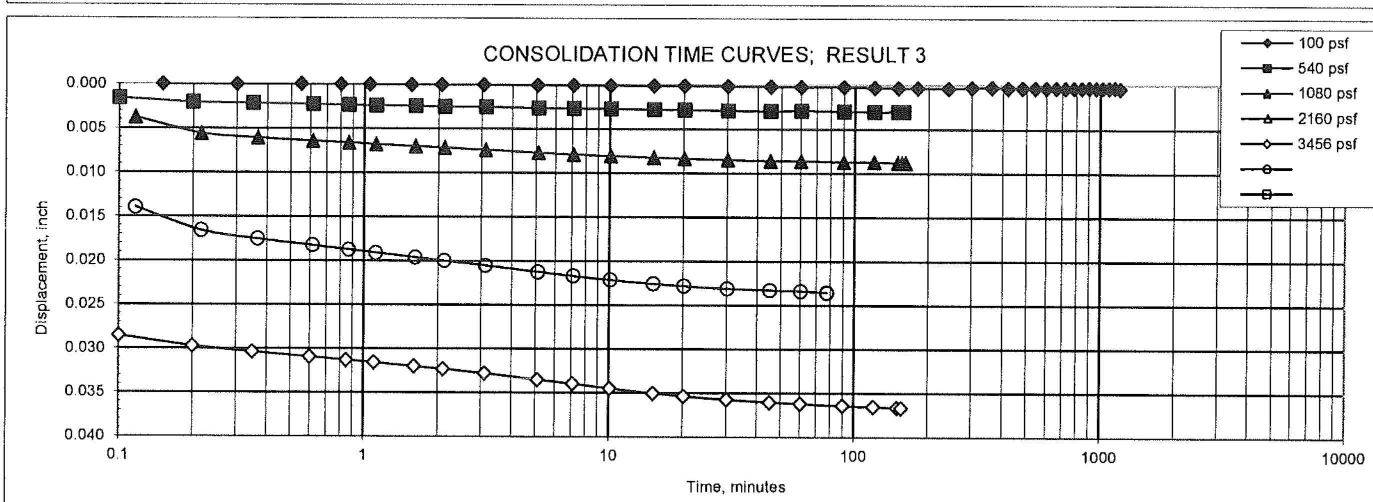


DYNEGY
COFFEEN, ILLINOIS
15151122
9/9/2015

BORING NO.	COF-B001
SAMPLE NO.	S7
DEPTH, feet	21.0 - 23.0





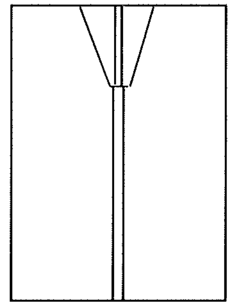


DISPERSIVE CLAY SOILS BY THE PINHOLE TEST
ASTM D 4647, METHOD A
9/9/2015

PROJECT DYNEGY
JOB NO. COFFEEN, ILLINOIS
SAMPLE ID COF-B001, S7, 21.0 - 23.0 feet
COMPACTION CHARACTERISTICS UNDISTURBED
WATER CONTENT 26.9%
DISTILLED WATER ADDED ____ **YES** X **NO**
CURE TIME NATURAL MOSITURE, NO CURE
BY JDM
SAMPLE DESC. FAT CLAY WITH SAND, GRAY WITH YELLOWISH BROWN

FLOW STARTED ON 1ST **TRIAL**

FINAL HOLE
1.0 mm



TIME, min	HEAD, inch	FLOW, ml	FLOW, sec	FLOW RATE, ml/sec	TURBIDITY FROM SIDE: VERY DARK	DARK	MOD. DARK	SLIGHT DARK	BARELY VISIBLE	CLEAR	CLEAR FROM TOP	REMARKS
1	2	15.5	60	0.26						X	X	
2	2	14.0	60	0.23						X	X	
3	2	13.5	60	0.23						X	X	
4	2	12.5	60	0.21						X	X	
5	2	12.3	60	0.20						X	X	
6	2	11.8	60	0.20						X	X	
7	2	11.0	60	0.18						X	X	
8	2	10.8	60	0.18						X	X	
9	2	10.8	60	0.18						X	X	
10	2	10.5	60	0.18						X	X	
1	7	28.5	60	0.48						X	X	
2	7	26.5	60	0.44						X	X	
3	7	26.0	60	0.43						X	X	
4	7	26.0	60	0.43						X	X	
5	7	26.0	60	0.43						X	X	
1	15	53.0	60	0.88						X		Barely Visible
2	15	54.0	60	0.90						X	X	
3	15	54.0	60	0.90						X		Barely Visible
4	15	53.5	60	0.89						X	X	
5	15	54.0	60	0.90						X		Barely Visible
1	40	81.0	60	1.35						X		Barely Visible
2	40	96.0	60	1.60						X		Barely Visible
3	40	96.0	60	1.60						X		Barely Visible
4	40	93.5	60	1.56						X	X	
5	40	96.0	60	1.60						X		Barely Visible

CLASSIFICATION = ND1

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CRUMB TEST (ASTM D6572)

Project No.: 15151122 Project Name: DYNEGY Location: COFFEEN, IL

Boring No.: COF-B001 Sample No.: S7 Depth: 21.0-23.0 [X] ft [ ] m

Visual Classification: ______ Color: ______

Moisture Content of Sample:	[ ] as-received	[ ] in situ	[ ] air-dried	
Tare Number	Wet Mass + Tare (g)	Dry Mass+ Tare (g)	Tare Mass (g)	Water Content (%)
AL-65	63.64	54.38	54.38	28.1

Specimen Identification:				Specimen Identification:				Specimen Identification:			
Spec. Container Identification:	4			Spec. Container Identification:				Spec. Container Identification:			
Method:	[X] A (Natural) [ ] B (Remolded)			Method:	[ ] A (Natural) [ ] B (Remolded)			Method:	[ ] A (Natural) [ ] B (Remolded)		
Water Type:	[X] Distilled [ ] Type IV			Water Type:	[ ] Distilled [ ] Type IV			Water Type:	[ ] Distilled [ ] Type IV		
Initial Water Temp. (°C):	22.5			Initial Water Temp. (°C):				Initial Water Temp. (°C):			
Start Time (hh:mm:ss):	8:48:30			Start Time (hh:mm:ss):				Start Time (hh:mm:ss):			
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	8:50:30	4	22.3	2 min ± 15 s				2 min ± 15 s			
1 h ± 8 min	9:48:50	3	21.4	1 h ± 8 min				1 h ± 8 min			
6 h ± 45 min	2:52:56	3	21.2	6 h ± 45 min				6 h ± 45 min			
Dispersive Classification:	Dispersive			Dispersive Classification:				Dispersive Classification:			
Additional water added to remold the specimen (Method B):	[ ] Y [ ] N			Additional water added to remold the specimen (Method B):	[ ] Y [ ] N			Additional water added to remold the specimen (Method B):	[ ] Y [ ] N		

Remarks: ______

Prepared By: John Martin Date: 9/1/15
Tested By: John Martin Date: 9/1/15
Input By: John Martin Date: 9/8/15
Reviewed By: ______ Date: ______

CRUMB TEST D6572

DYNEGY

COFFEEN, ILLINOIS

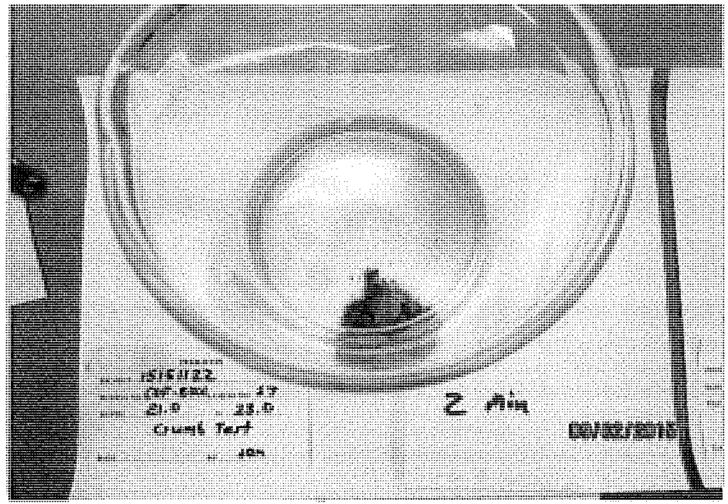
15151122

COF-B001 S7 21.0 - 23.0 feet

2 MIN

GRADE: 4

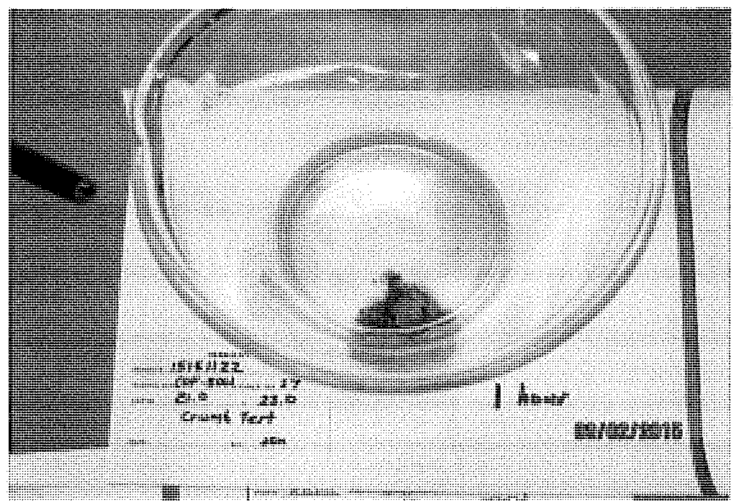
DISPERSIVE CALSSIFICATION: HIGHLY DISPERSIVE



1 HOUR

GRADE: 3

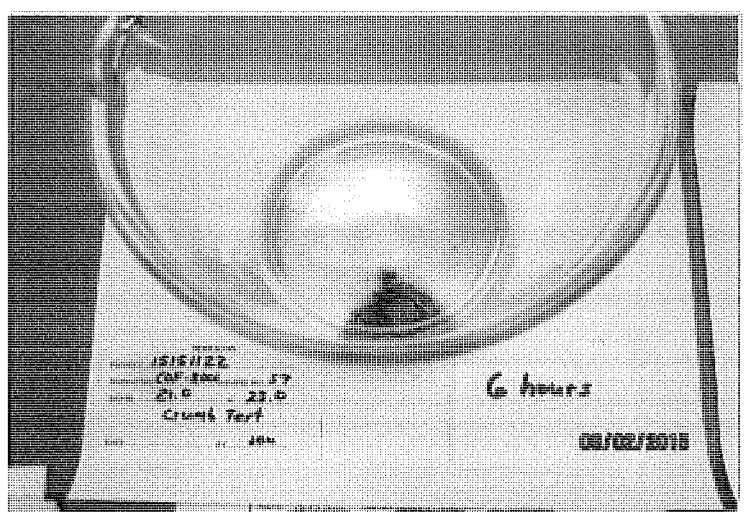
DISPERSIVE CALSSIFICATION: DISPERSIVE



6 HOUR

GRADE: 3

DISPERSIVE CALSSIFICATION: DISPERSIVE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

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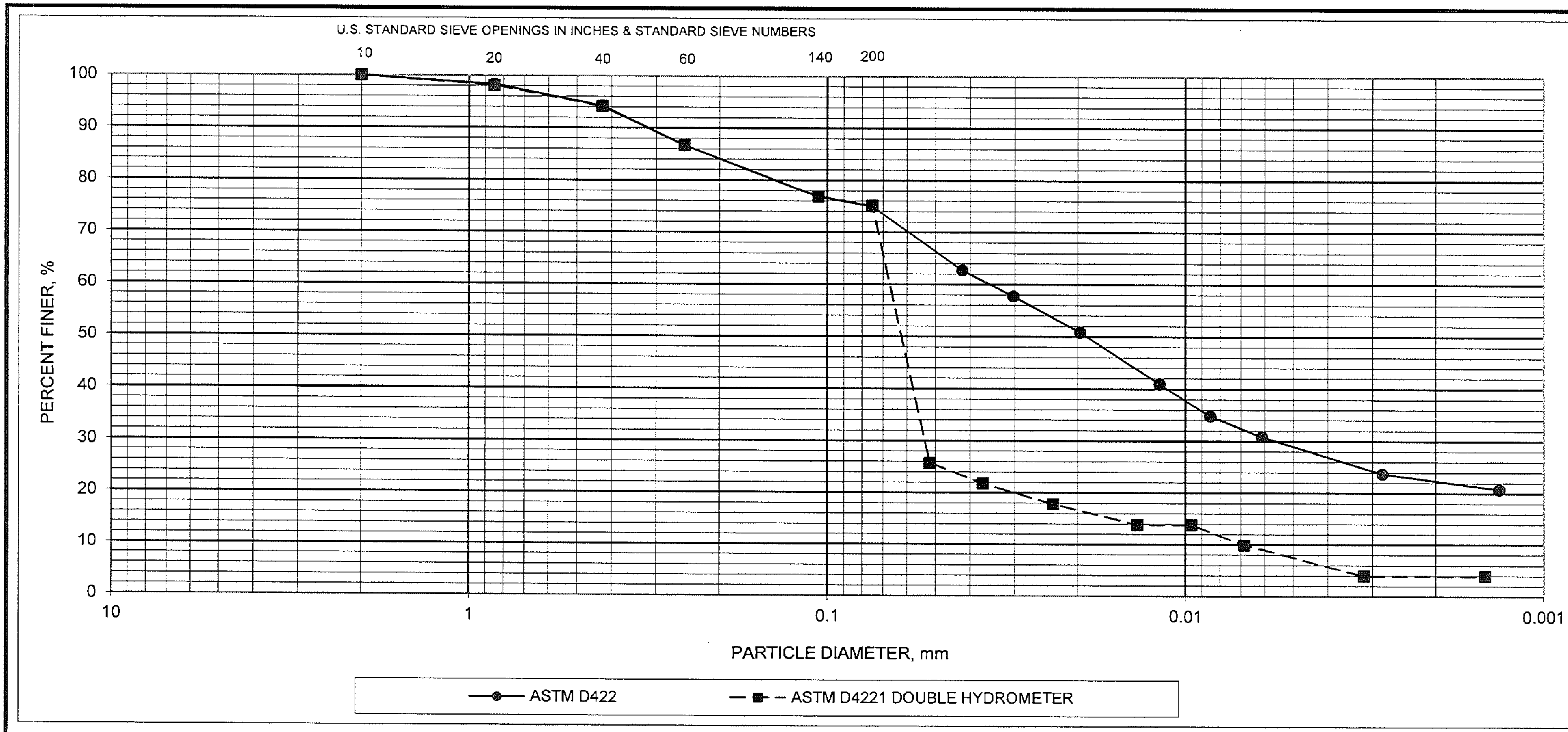
DYNEGY - COFFEEN, ILLINOIS
15151122
9/9/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B002	S1	1.0	2.5	25.4														
	Color			brown & gray							Visual Classification				Fill: Lean Clay trace Organics			
	S2	3.5	5.0	25.9		35	17	18										
	Color			brown & gray							Visual Classification				Fill: Sandy Lean Clay trace Fine Gravel			
	S3	6.0	7.5	25.9														
	Color			brown & gray							Visual Classification				Fill: Sandy Lean Clay trace Fine Gravel			
	S4	8.5	10.5	17.8	114.2	40	15	25		26*		4.1E-09*				ND1*	1*	
	Color			gray with yellowish brown							Visual Classification				Lean Clay with Sand			
	S5	13.5	15.0	23.3					NOTE*									
	Color			brown & gray							Visual Classification				Fill: Lean Clay with Sand trace Gravel			
	S6	15.0	17.0	26.7	94.9	25	18	7					NOTE*					
	Color			gray with brown							Visual Classification				Silty Clay			
	S7	18.5	20.0	25.4		47	18	29										
	Color			brown & gray							Visual Classification				Lean Clay trace Fine Sand			
	S8	23.5	25.0	18.9														
	Color			brown & gray							Visual Classification				Sandy Lean Clay trace Fine Gravel			
	S9	28.5	30.0	13.6					NOTE*									
	Color			brown							Visual Classification				Clayey Sand trace Gravel			
	S10	33.5	35.0	9.5		20	13	7										
	Color			brown							Visual Classification				Sandy, Silty Clay trace Fine Gravel			

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	29.0	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	7.5	DISPERSION, %	**26**

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B002	S-4	8.5 - 10.5	LEAN CLAY WITH SAND, GRAY WITH YELLOWISH BROWN					

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/2/2015

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MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 03 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N $CaSO_4$

PROJECT NAME:	DYNEGY	PROJECT NUMBER:	15151122
LOCATION:	COFFEEN, ILLINOIS	DATE:	7/30/2015
		PANEL IDENTIFICATION:	Lenexa Perm Board
SAMPLE ID:	COF-B002 S4 8.5 - 10.5 feet	BURETTE AREA:	0.312 cm^2
SAMPLE DESCR.:	LEAN CLAY WITH SAND, GRAY WITH YELLOWISH BROWN	BURETTE INCREMENT LENGTH:	1.000 cm
		VOLUME PER INCREMENT:	0.312 cm^3

INITIAL

MOISTURE%		DENSITY			
W & T, g	143.03	WET WT, g	495.1		
D & T, g	126.58	DIA, in	2.861	7.27	cm
T, g	33.92	HT, in	2.182	5.54	cm
		AREA		41.48	cm^2
MOIST-		DENSITY:	134.5	PCF WET	
URE, %	**17.8**	DENSITY:	**114.2**	PCF DRY	

ADDITIONAL DATA

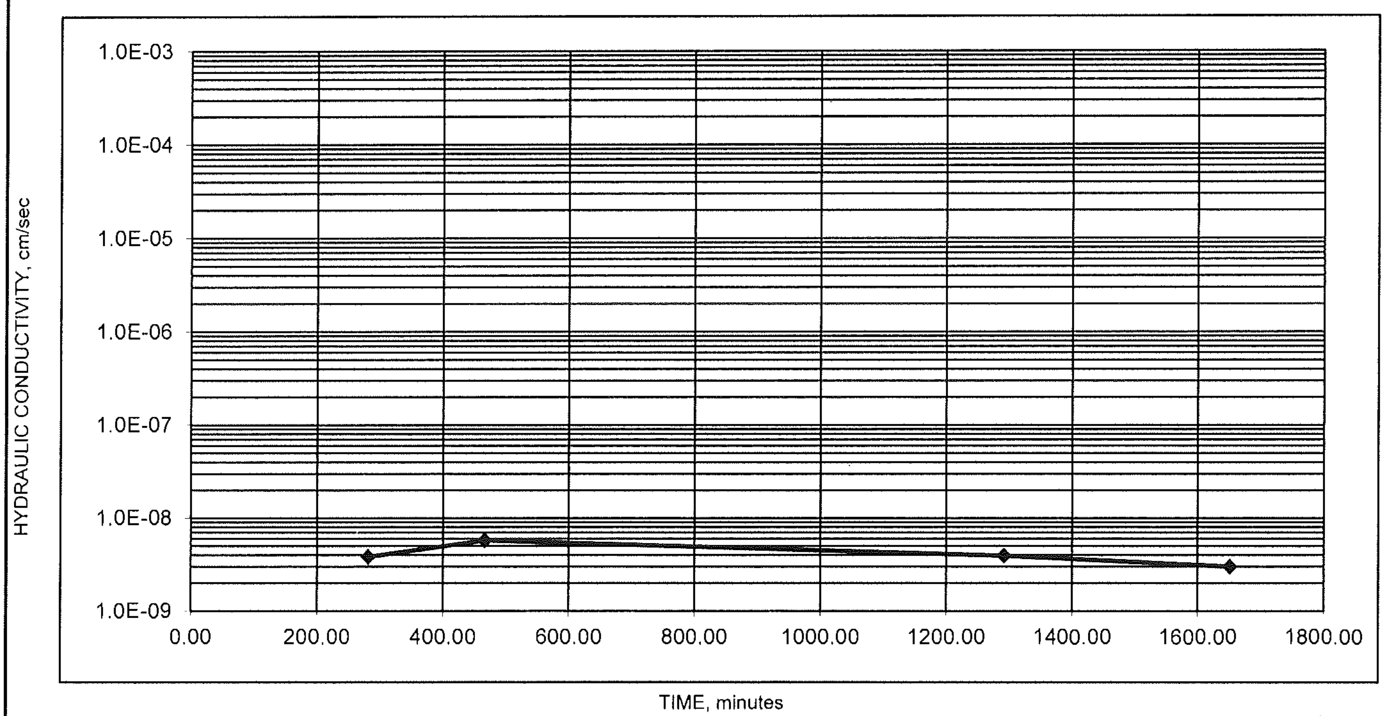
SPECIFIC GRAVITY:	2.70	RECOMPACTED?:	NO
SPECIFIC GRAVITY:	ASSUMED	PROCTOR, pcf:	NA
POROSITY, %:	32.3	OPTIMUM, %:	NA
SATURATION, %:	100.7	COMPACTION, %:	NA
VOID RATIO:	0.48	OVER OPTIMUM, %:	NA

SATURATION:	LATERAL PRESS.:	104.0	psi	BACK PRESSURE (=UPPER=LOWER):	100.0	psi		
DURING TEST:	LATERAL PRESS.:	104.0	psi	H2:	100.0 psi	H1:	100.0	psi
				BIAS PRESSURE (=H1-H2)	0.0	psi		

H1 VALUE	H2 VALUE	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
7.4	67.7	0.00	60.3									
7.5	67.6	281.00	60.1	0.003322	3.83E-09	0.03	0.03	1.00	10.8	7	23.0	0.931
7.6	67.5	467.00	59.9	0.003333	5.76E-09	0.03	0.03	1.00	10.8	39	23.3	0.925
7.9	67.2	1292.00	59.3	0.010067	3.93E-09	0.09	0.09	1.00	10.7	5	23.2	0.927
8.0	67.1	1651.00	59.1	0.003378	3.01E-09	0.03	0.03	1.00	10.7	27	23.6	0.918

HYDRAULIC CONDUCTIVITY (k_{20}) = AVERAGE 4.1E-09 cm/sec

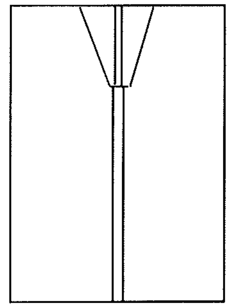
MAXIMUM	1.0E-03 TO 1.0E-04	2	0.75<	30	% < 25 AT
HYDRAULIC	1.0E-04 TO 1.0E-05	5	RATIO	MAX	> 1.0E-8
GRADIENT	1.0E-05 TO 1.0E-06	10	<1.25	HYDRAULIC	OR
	1.0E-06 TO 1.0E-07	20		GRADIENT	% < 50 AT
	less than 1.0E-07	30		ALLOWED	< 1.0E-8



DISPERSIVE CLAY SOILS BY THE PINHOLE TEST
ASTM D 4647, METHOD A
9/9/2015

PROJECT DYNEGY
JOB NO. COFFEEN, ILLINOIS
SAMPLE ID COF-B002, S4, 8.5 - 10.5 feet
COMPACTION CHARACTERISTICS UNDISTURBED
WATER CONTENT 11.5%
DISTILLED WATER ADDED ____ **YES** X **NO**
CURE TIME NATURAL MOISTURE, NO CURE
BY JDM
SAMPLE DESC. LEAN CLAY WITH SAND, GRAY WITH YELLOWISH BROWN

FINAL HOLE
1.1 mm



FLOW STARTED ON 1ST **TRIAL**

TIME, min	HEAD, inch	FLOW, ml	FLOW, sec	FLOW RATE, ml/sec	TURBIDITY FROM SIDE: VERY DARK	DARK	MOD. DARK	SLIGHT DARK	BARELY VISIBLE	CLEAR	CLEAR FROM TOP	REMARKS
1	2	18.5	60	0.31						X	X	
2	2	18.8	60	0.31						X	X	
3	2	18.3	60	0.30						X	X	
4	2	18.5	60	0.31						X	X	
5	2	18.8	60	0.31						X	X	
6	2	18.8	60	0.31						X	X	
7	2	19.5	60	0.33						X	X	
8	2	17.8	60	0.30						X	X	
9	2	19.0	60	0.32						X	X	
10	2	18.8	60	0.31						X	X	
1	7	50.0	60	0.83						X	X	
2	7	49.0	60	0.82						X	X	
3	7	50.0	60	0.83						X		Barely Visible
4	7	50.0	60	0.83						X	X	
5	7	49.0	60	0.82						X		Barely Visible
1	15	81.0	60	1.35						X		Barely Visible
2	15	82.0	60	1.37						X		Barely Visible
3	15	82.0	60	1.37						X		Barely Visible
4	15	80.0	60	1.33						X		Barely Visible
5	15	83.0	60	1.38						X		Barely Visible
1	40	151.0	60	2.52						X		Barely Visible
2	40	156.0	60	2.60						X		Barely Visible
3	40	154.0	60	2.57						X	X	
4	40	158.0	60	2.63						X	X	
5	40	158.0	60	2.63						X	X	

CLASSIFICATION = ND1

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Terracon

CRUMB TEST (ASTM D6572)

Project No.: 15151122 Project Name: DYNEGY Location: COFFEEN, IL

Boring No.: COF - B002 Sample No.: S4 Depth: 8.5-10.0 [X] ft [ ] m

Visual Classification: ______ Color: ______

Moisture Content of Sample:	[ ] as-received	[ ] in situ	[ ] air-dried	
Tare Number	Wet Mass + Tare (g)	Dry Mass+ Tare (g)	Tare Mass (g)	Water Content (%)
AL-297	77.37	71.84	20.90	10.9

Specimen Identification:		Specimen Identification:		Specimen Identification:	
Spec. Container Identification:	A	Spec. Container Identification:		Spec. Container Identification:	
Method:	[X] A (Natural) [ ] B (Remolded)	Method:	[ ] A (Natural) [ ] B (Remolded)	Method:	[ ] A (Natural) [ ] B (Remolded)
Water Type:	[X] Distilled [ ] Type IV	Water Type:	[ ] Distilled [ ] Type IV	Water Type:	[ ] Distilled [ ] Type IV
Initial Water Temp. (°C):	22.5	Initial Water Temp. (°C):		Initial Water Temp. (°C):	
Start Time (hh:mm:ss):	8:54:32	Start Time (hh:mm:ss):		Start Time (hh:mm:ss):	

Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	8:56:32	4	22.2	2 min ± 15 s				2 min ± 15 s			
1 h ± 8 min	9:55:37	2	20.9	1 h ± 8 min				1 h ± 8 min			
6 h ± 45 min	2:54:00	1	21.0	6 h ± 45 min				6 h ± 45 min			

Dispersive Classification:	NON-Dispersive	Dispersive Classification:		Dispersive Classification:	
Additional water added to remold the specimen (Method B):	[ ] Y [ ] N	Additional water added to remold the specimen (Method B):	[ ] Y [ ] N	Additional water added to remold the specimen (Method B):	[ ] Y [ ] N

Remarks: ______

Prepared By: John Martin Date: 9/1/15
Tested By: John Martin Date: 9/1/15
Input By: John Martin Date: 9/8/15
Reveiwed By: ______ Date: ______

CRUMB TEST D6572

DYNEGY

COFFEEN, ILLINOIS

15151122

COF-B002 S4 8.5 - 10.0 feet

2 MIN

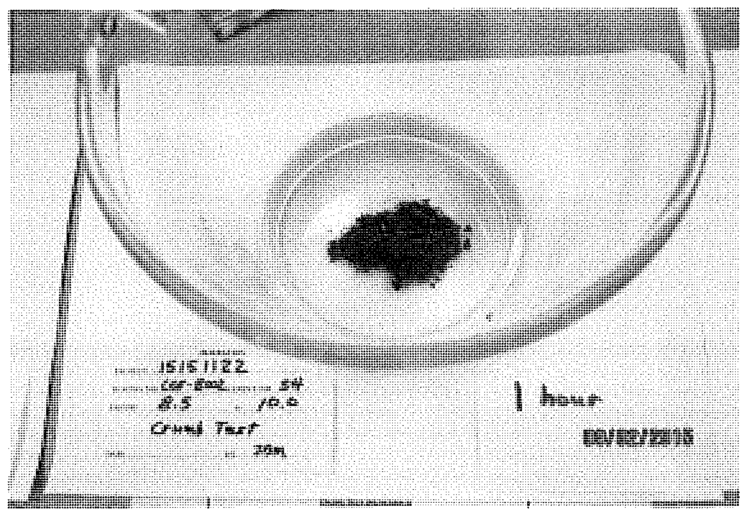
GRADE: 4

DISPERSIVE CALSSIFICATION: HIGHLY DISPERSIVE

1 HOUR

GRADE: 2

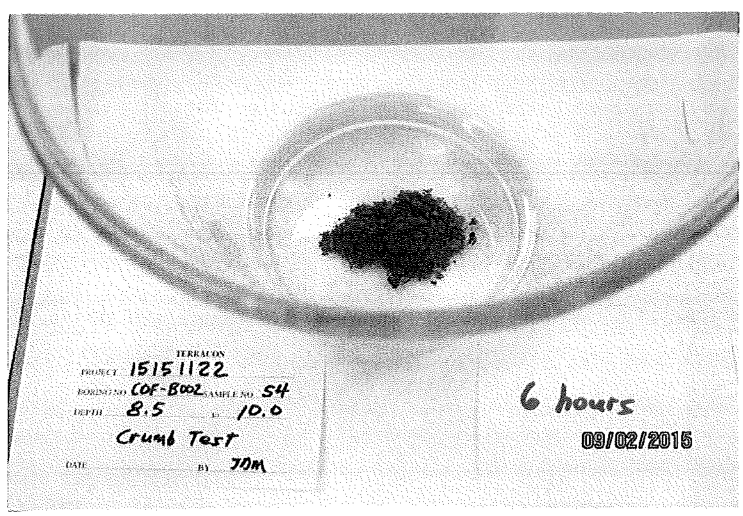
DISPERSIVE CALSSIFICATION: INTERMEDIATE



6 HOUR

GRADE: 1

DISPERSIVE CALSSIFICATION: NON DISPERSIVE



Grade 1 - Nondipersive

Grade 2 - Intermediate

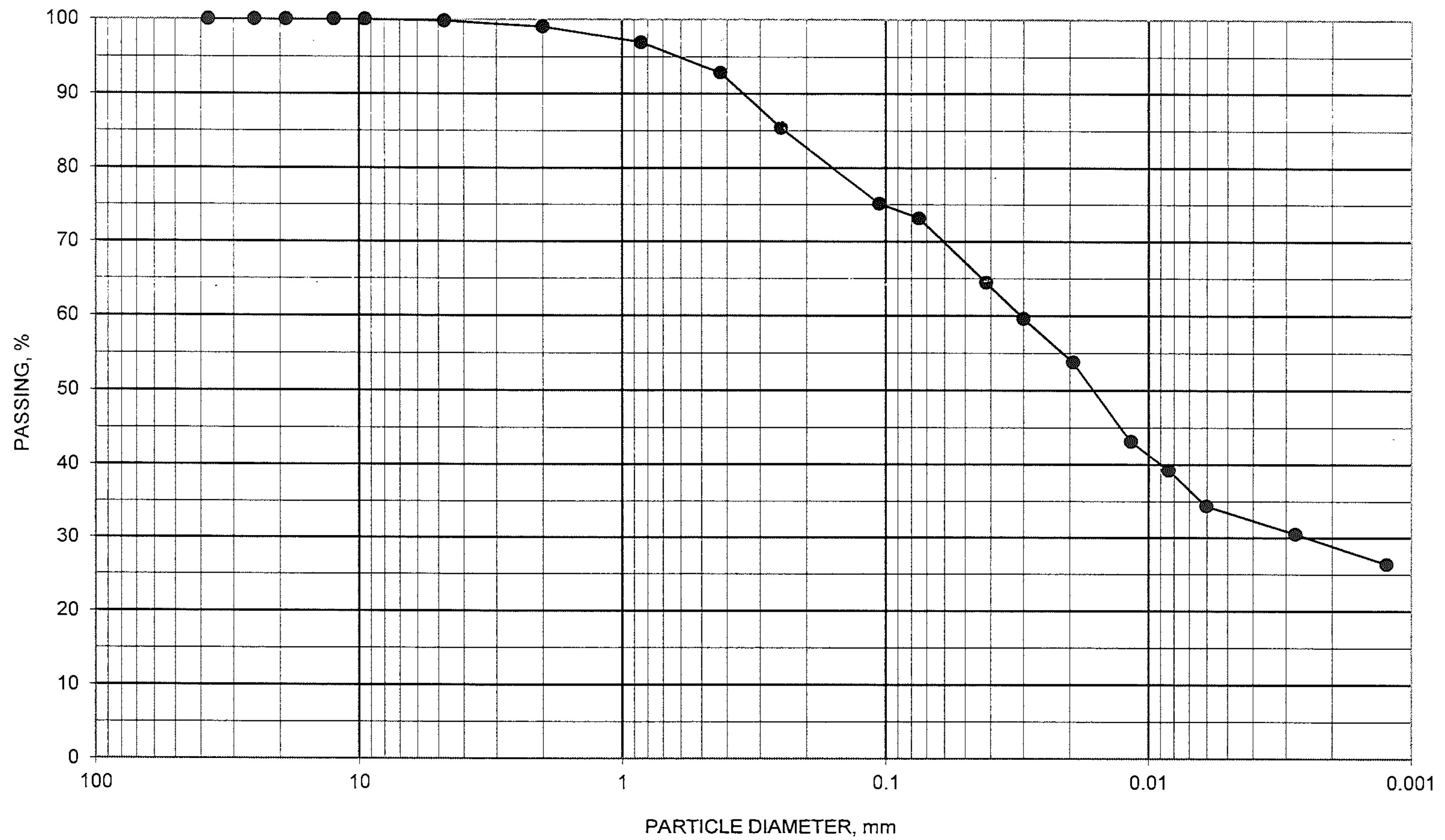
Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	99
#20	0.850	97
#40	0.425	93
#60	0.250	85
#140	0.106	75
#200	0.075	73.2
	0.0416	64.5
	0.0301	59.6
	0.0195	53.8
	0.0117	43.1
	0.0084	39.2
	0.0060	34.4
	0.0028	30.5
	0.0012	26.4
	D60	0.0308
	D30	0.0025

SPECIFIC GRAVITY 2.69 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B002	S-5	13.5 TO 15	LEAN CLAY WITH SAND TRACE GRAVEL BROWN & GRAY		23.3			

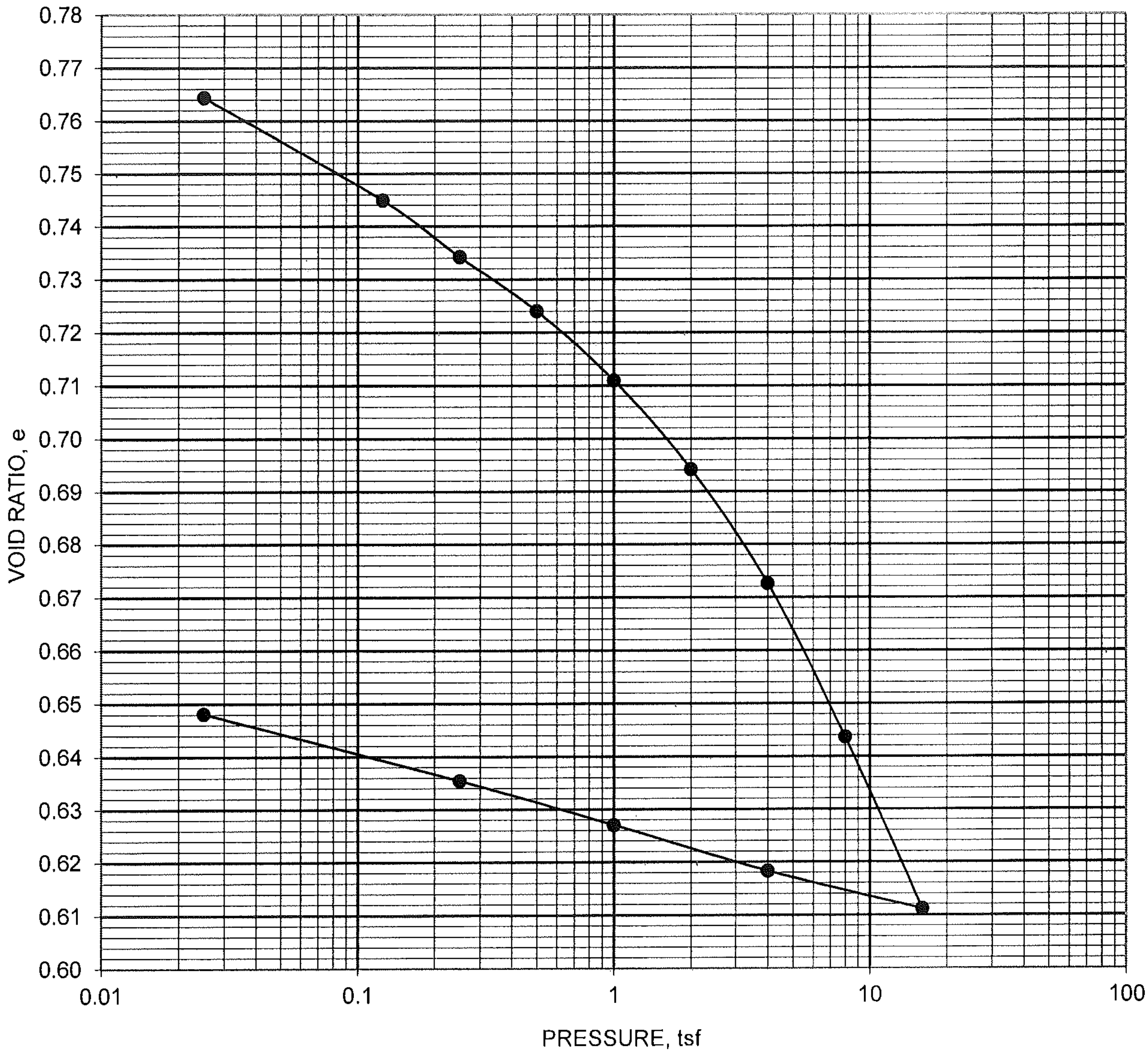
PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B002-S5-13.5.xlsx]ATTERBERG M%

Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.56	HEIGHT, mm	25.26	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		0.96		MOISTURE, %		26.7	23.5
PRECONSOL. PRESSURE, tsf		2.00		DRY DENSITY, pcf		94.9	100.9
OVER CONSOLIDATION RATIO		2.1		SATURATION, %		93	97
COMPRESSION INDEX		0.11		VOID RATIO		0.776	0.648
REBOUND INDEX		0.014		SAMPLE TYPE		UNDISTURBED	
LIQUID LIMIT 25	PLASTIC LIMIT	18	PLASTICITY INDEX	7	SPECIFIC GRAVITY	2.7 ESTIMATED	
SAMPLE DESCRIPTION	SILTY CLAY, GRAY WITH BROWN						
BORING NO.	COF-B002	SAMPLE NO.	S6	DEPTH, feet		15.0 - 17.0	

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

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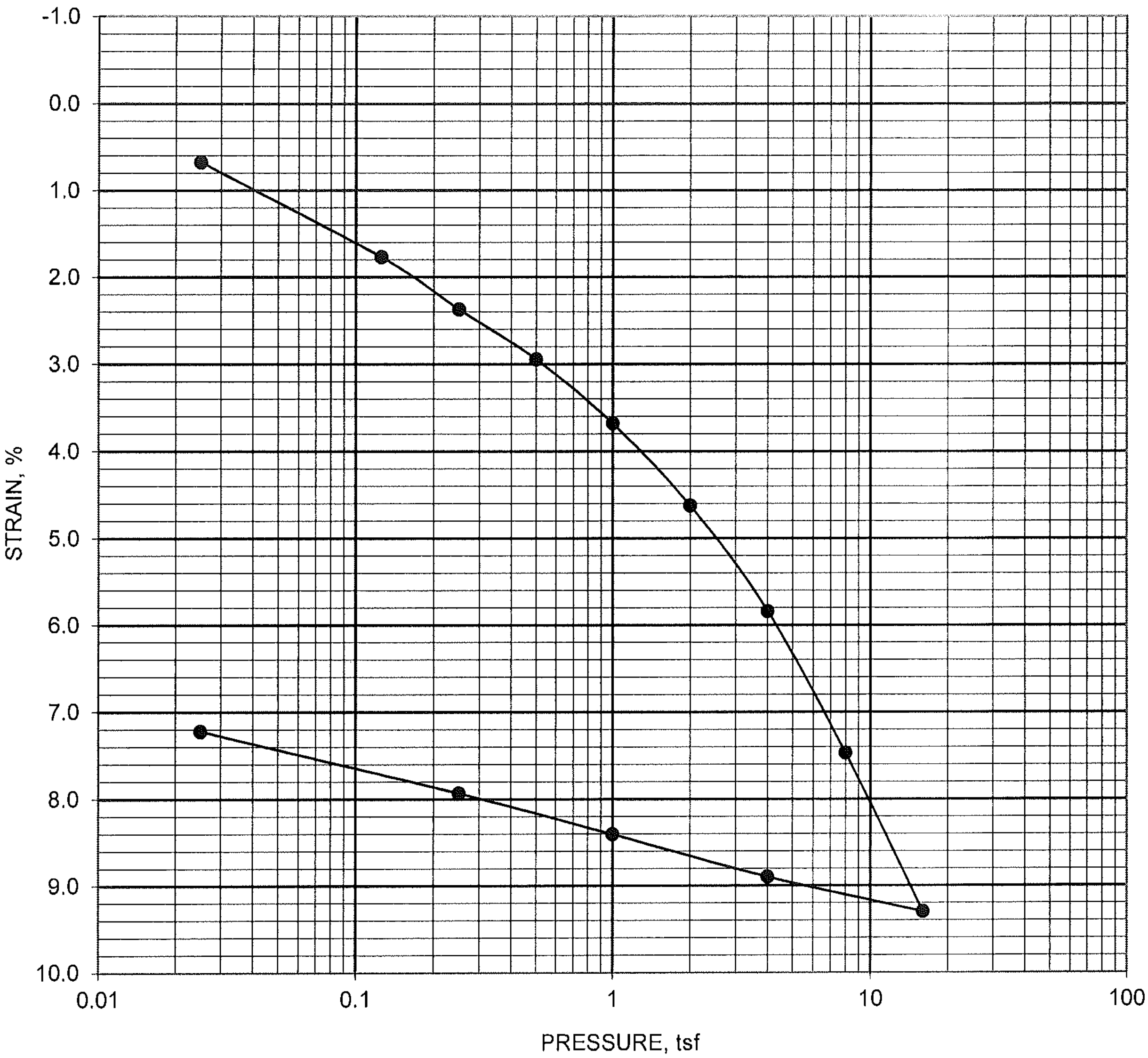
Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.56	HEIGHT, mm	25.26	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		0.96		MOISTURE, %		26.7	23.5
PRECONSOL. PRESSURE, tsf		2.00		DRY DENSITY, pcf		94.9	100.9
OVER CONSOLIDATION RATIO		2.1		SATURATION, %		93	97
COMPRESSION INDEX		0.11		VOID RATIO		0.776	0.648
REBOUND INDEX		0.014		SAMPLE TYPE		3" SHELBY TUBE	
LIQUID LIMIT	25	PLASTIC LIMIT	18	PLASTICITY INDEX	7	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	SILTY CLAY, GRAY WITH BROWN						
BORING NO.	COF-B002	SAMPLE NO.	S6	DEPTH, feet	15.0 - 17.0		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

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Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

ADDITIONAL CONSOLIDATION DATA

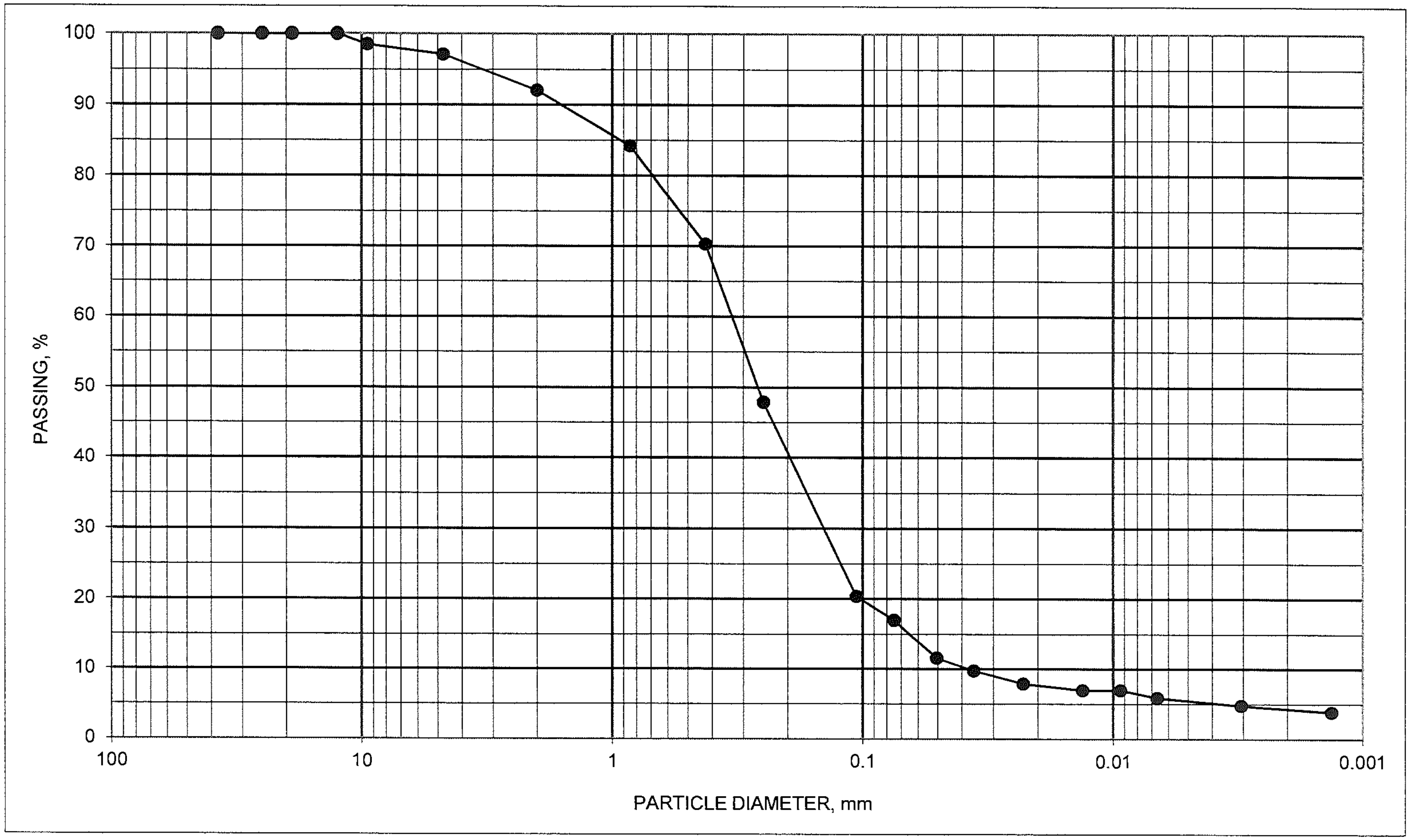
COF-B002
S6
15.0 - 17.0

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.025			4.89E-04	2.75E-04	
0.125	5.68E-04	5.71E-04	1.99E-04	1.13E-04	6.40E-08
0.25	1.07E-03	1.07E-03	8.76E-05	5.02E-05	5.36E-08
0.5	1.24E-03	1.25E-03	4.16E-05	2.40E-05	2.98E-08
1	1.88E-03	1.89E-03	2.66E-05	1.55E-05	2.91E-08
2	3.00E-03	3.02E-03	1.72E-05	1.00E-05	3.01E-08
4	5.10E-03	5.13E-03	1.10E-05	6.52E-06	3.32E-08
8	7.10E-03	7.14E-03	7.39E-06	4.42E-06	3.14E-08
16	3.97E-02	3.99E-02	4.15E-06	2.53E-06	1.00E-07
AVERAGE	7.46E-03	7.50E-03	9.82E-05	5.57E-05	4.64E-08

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	99
#4	4.75	97
#10	2.00	92
#20	0.850	84
#40	0.425	70
#60	0.250	48
#140	0.106	20
#200	0.075	17.0
	0.0506	11.6
	0.0360	9.7
	0.0229	7.9
	0.0133	7.0
	0.0094	7.0
	0.0067	5.9
	0.0031	4.8
	0.0013	3.9

D60	0.3331
D30	0.1432
D10	0.0379
Cu	8.8
Cc	1.6

SPECIFIC GRAVITY 2.65 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B002	S9	28.5 TO 30	CLAYEY SAND TRACE GRAVEL BROWN		13.6			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B002\[15151122 Hydrometer Plot COF-B002-S9-28.5.xlsx]ATTERBERG M%

Terracon

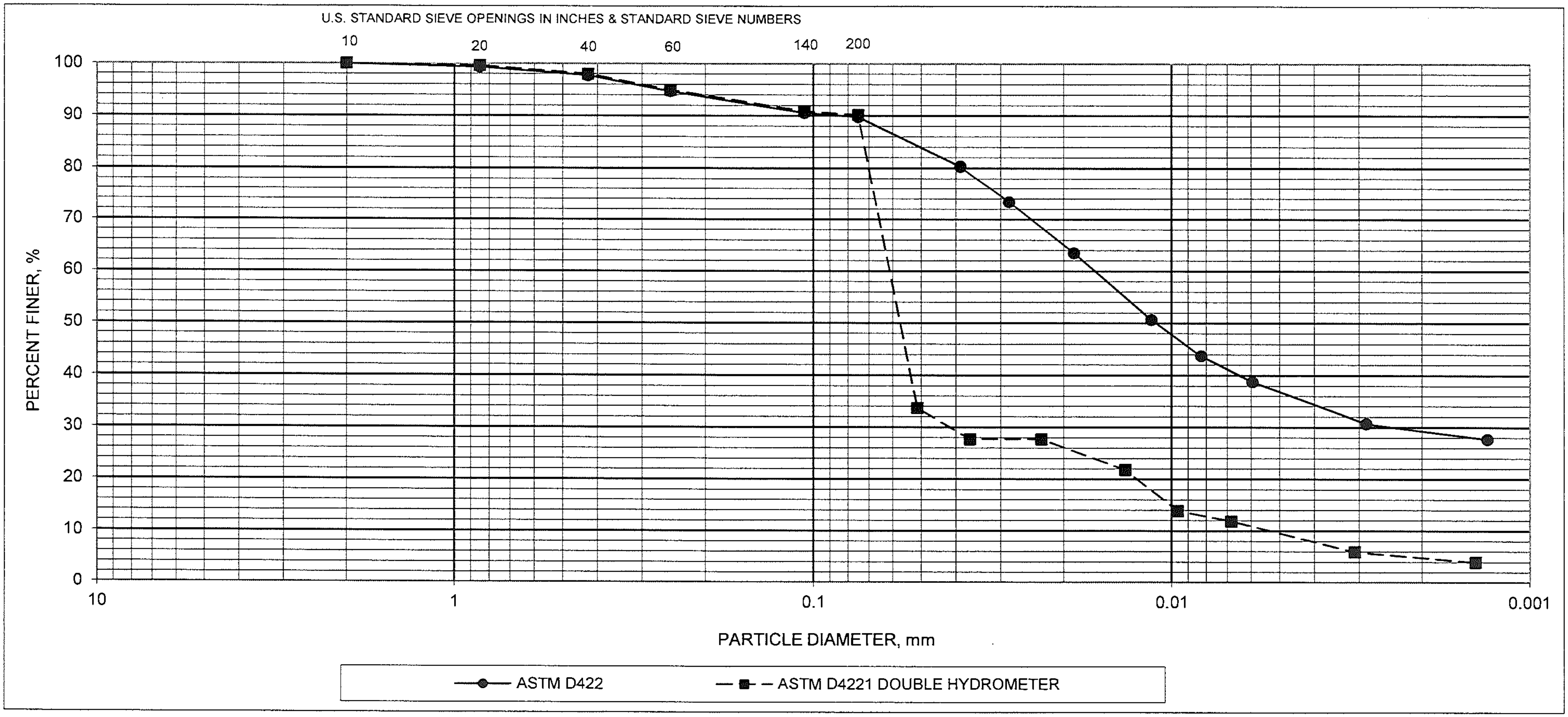
DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B003	S1	1.0	2.5	14.2														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace fine Gravel					
	S2	3.5	5.0	18.1		42	16	26										
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace fine Gravel					
	S3	6.0	7.5	15.0							2.70							
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace fine Gravel					
	S4	8.5	10.0	17.4														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace fine Gravel					
	S5	13.5	15.5	21.8	104.7	54	18	36		26*						ND1*	2*	
	Color		dark gray trace yellowish brown							Visual Classification			Fat Clay					
	S6	18.0	19.5	26.0														
	Color		brown & gray							Visual Classification			Fat Clay trace fine Sand					
	S7	23.5	25.0	20.8		50	16	34	NOTE*									CH
	Color		brown & gray							USCS Classification			Fat Clay with Sand					
	S8	28.5	30.0	12.5		21	15	6										
	Color		brown							Visual Classification			Sandy Silty Clay trace fine Gravel					
	S9	30.0	30.8	11.8	126.7				NOTE*			2.2E-07*						
	Color		dark yellowish brown with grayish brown							Visual Classification			Silty Sand trace Gravel					
	S10	33.5	35.0						** Sieve									SP
	Color		brown							USCA Classification			Poorly Graded Sand					
	S11	38.5	40.0	9.5					NOTE*									
	Color		brown							Visual Classification			Silty Sand trace Gravel					
	S12	43.5	45.0	9.9														
	Color		brown & gray							Visual Classification			Clayey Sand, fine to coarse trace fine Gravel					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	36.8	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	9.5	DISPERSION, %	**26**

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S5	13.5 - 15.5	FAT CLAY, DARK GRAY TRACE YELLOWISH BROWN					

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/2/2015

Terracon

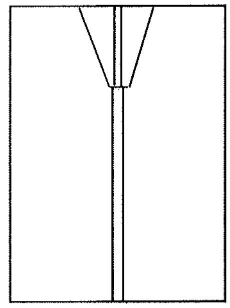
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B003-S5-13.5.xls]Double Hydrometer Da

DISPERSIVE CLAY SOILS BY THE PINHOLE TEST
ASTM D 4647, METHOD A
9/9/2015

PROJECT DYNEGY
JOB NO. COFFEEN, ILLINOIS
SAMPLE ID COF-B003, S5, 13.5 - 15.5 feet
COMPACTION CHARACTERISTICS UNDISTURBED
WATER CONTENT 14.7%
DISTILLED WATER ADDED ______ **YES** X **NO**
CURE TIME NATURAL MOISTURE, NO CURE
BY JDM
SAMPLE DESC. FAT CLAY, DARK GRAY TRACE YELLOWISH BROWN

FLOW STARTED ON 1ST **TRIAL**

FINAL HOLE
1.1 mm



TIME, min	HEAD, inch	FLOW, ml	FLOW, sec	FLOW RATE, ml/sec	TURBIDITY FROM SIDE: VERY DARK	DARK	MOD. DARK	SLIGHT DARK	BARELY VISIBLE	CLEAR	CLEAR FROM TOP	REMARKS
1	2	18.5	60	0.31						X	X	
2	2	18.5	60	0.31						X	X	
3	2	18.0	60	0.30						X	X	
4	2	18.0	60	0.30						X	X	
5	2	17.3	60	0.29						X	X	
6	2	18.0	60	0.30						X	X	
7	2	18.0	60	0.30						X	X	
8	2	17.8	60	0.30						X	X	
9	2	18.0	60	0.30						X	X	
10	2	17.5	60	0.29						X	X	
1	7	48.0	60	0.80						X	X	
2	7	49.0	60	0.82						X		Barely Visible
3	7	47.5	60	0.79						X	X	
4	7	49.0	60	0.82						X		Barely Visible
5	7	47.0	60	0.78						X	X	
1	15	79.0	60	1.32						X		Barely Visible
2	15	78.0	60	1.30						X		Barely Visible
3	15	78.0	60	1.30						X	X	
4	15	78.0	60	1.30						X		Barely Visible
5	15	78.0	60	1.30						X		Barely Visible
1	40	166.0	60	2.77						X		Barely Visible
2	40	174.0	60	2.90						X		Barely Visible
3	40	174.0	60	2.90						X		Barely Visible
4	40	173.0	60	2.88						X	X	
5	40	172.0	60	2.87						X	X	

CLASSIFICATION = ND1

CRUMB TEST (ASTM D6572)

Project No.: 15151122 Project Name: DYNEGY Location: COFFEEN, IL

Boring No.: COF-B003 Sample No.: S5 Depth: 13.5-15.5 [X] ft [ ] m

Visual Classification: ________ Color: ________

Moisture Content of Sample:	[ ] as-received	[ ] in situ	[ ] air-dried	
Tare Number	Wet Mass + Tare (g)	Dry Mass+ Tare (g)	Tare Mass (g)	Water Content (%)
AL-72	86.25	75.05	20.97	20.7

Specimen Identification:				Specimen Identification:				Specimen Identification:			
Spec. Container Identification:	3			Spec. Container Identification:				Spec. Container Identification:			
Method:	[X] A (Natural) [ ] B (Remolded)			Method:	[ ] A (Natural) [ ] B (Remolded)			Method:	[ ] A (Natural) [ ] B (Remolded)		
Water Type:	[X] Distilled [ ] Type IV			Water Type:	[ ] Distilled [ ] Type IV			Water Type:	[ ] Distilled [ ] Type IV		
Initial Water Temp. (°C): 22.5				Initial Water Temp. (°C):				Initial Water Temp. (°C):			
Start Time (hh:mm:ss): 8:56:45				Start Time (hh:mm:ss):				Start Time (hh:mm:ss):			
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	8:58:45	2	22.1	2 min ± 15 s				2 min ± 15 s			
1 h ± 8 min	9:56:58	2	20.9	1 h ± 8 min				1 h ± 8 min			
6 h ± 45 min	2:55:29	2	20.9	6 h ± 45 min				6 h ± 45 min			
Dispersive Classification:	Intermediate			Dispersive Classification:				Dispersive Classification:			
Additional water added to remold the specimen (Method B): [ ] Y [ ] N				Additional water added to remold the specimen (Method B): [ ] Y [ ] N				Additional water added to remold the specimen (Method B): [ ] Y [ ] N			

Remarks:

Prepared By: John Martin Date: 9/1/15

Tested By: John Martin Date 9/1/15

Input By: John Martin Date: 9/8/15

Reviewed By: ________ Date: ________

CRUMB TEST D6572

DYNEGY

COFFEEN, ILLINOIS

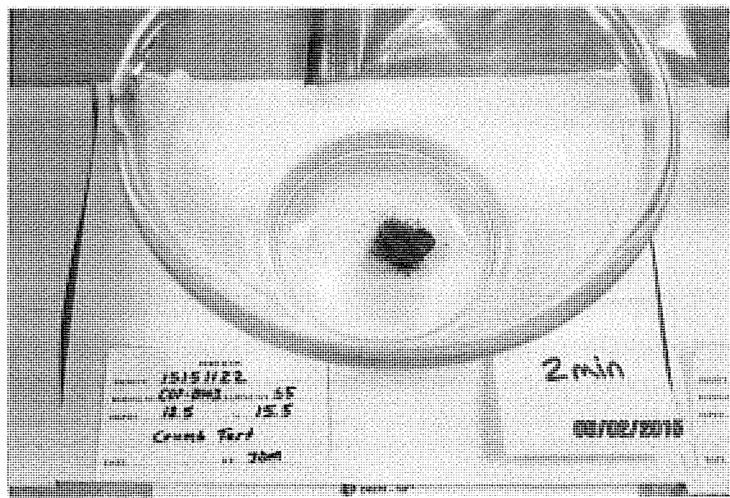
15151122

COF-B003 S5 13.5 - 15.5 feet

2 MIN

GRADE: 2

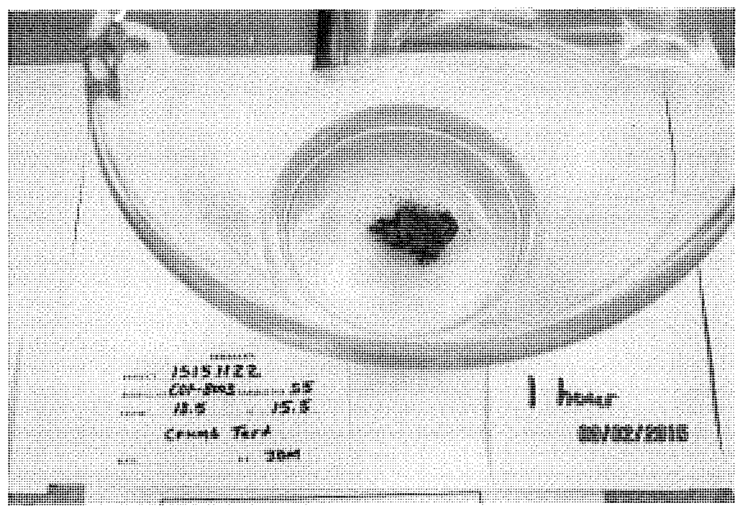
DISPERSIVE CALSSIFICATION: INTERMEDIATE



1 HOUR

GRADE: 2

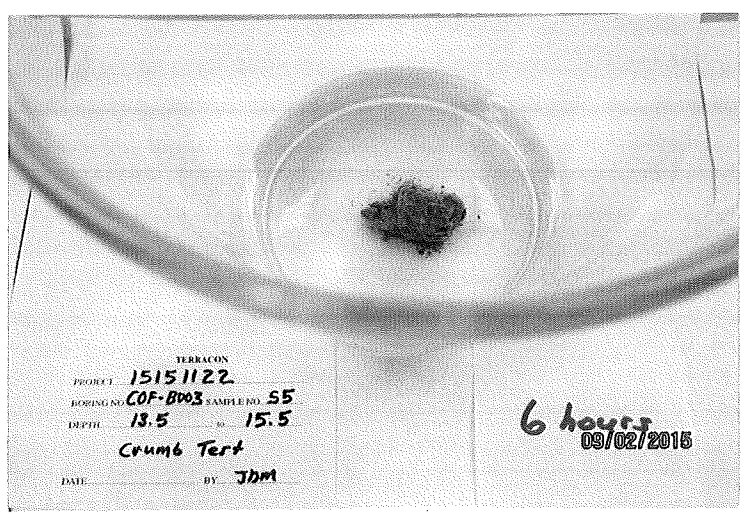
DISPERSIVE CALSSIFICATION: INTERMEDIATE



6 HOUR

GRADE: 2

DISPERSIVE CALSSIFICATION: INTERMEDIATE



Grade 1 - Nondispersive

Grade 2 - Intermediate

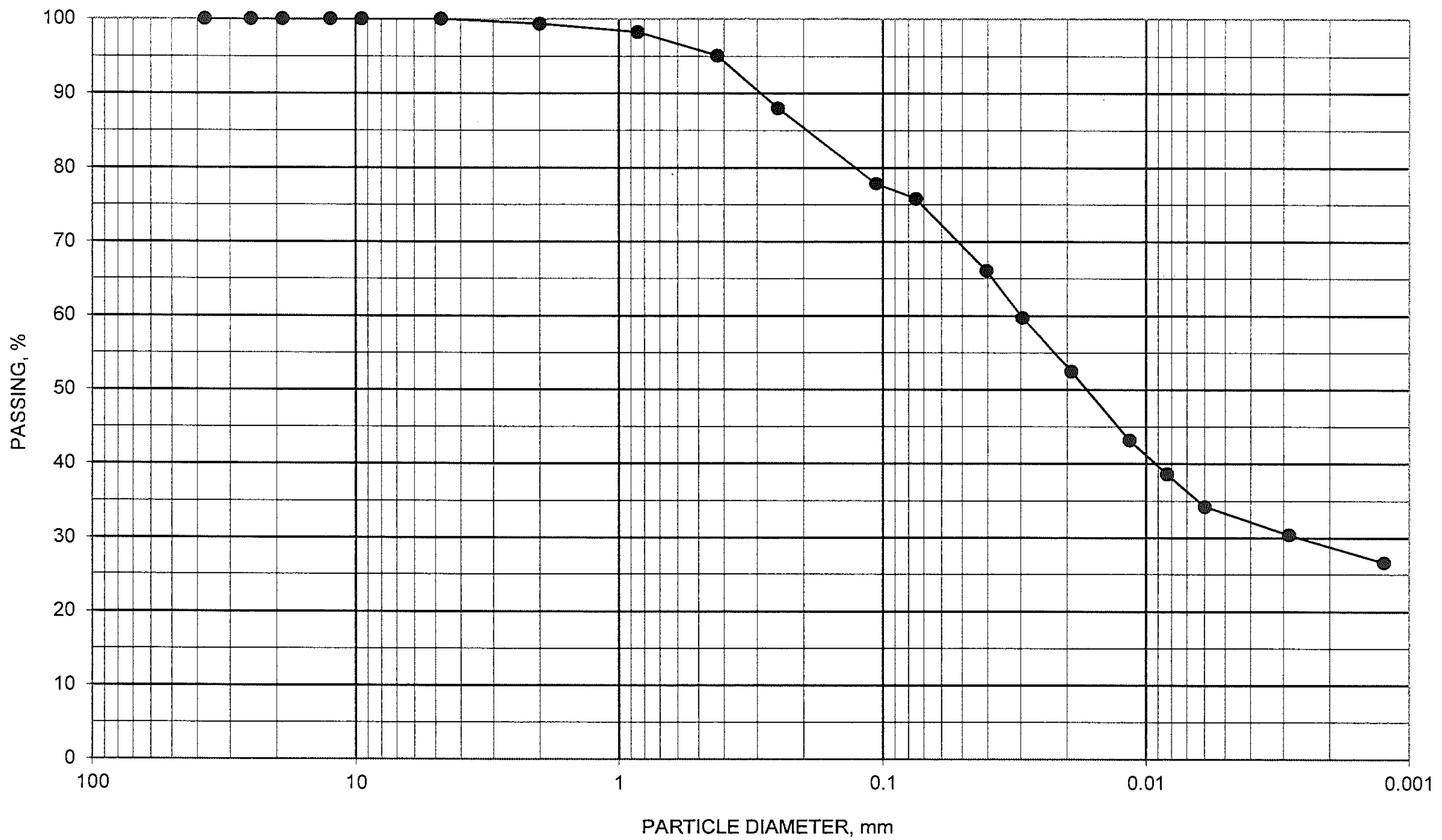
Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	99
#20	0.850	98
#40	0.425	95
#60	0.250	88
#140	0.106	78
#200	0.075	75.8
	0.0406	66.1
	0.0295	59.7
	0.0193	52.4
	0.0116	43.2
	0.0083	38.6
	0.0060	34.2
	0.0029	30.4
	0.0012	26.6
	D60	0.0299
	D30	0.0026

SPECIFIC GRAVITY 2.69 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S7	23.5 TO 25	FAT CLAY WITH SAND BROWN & GRAY	CH	20.8	50	16	34

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

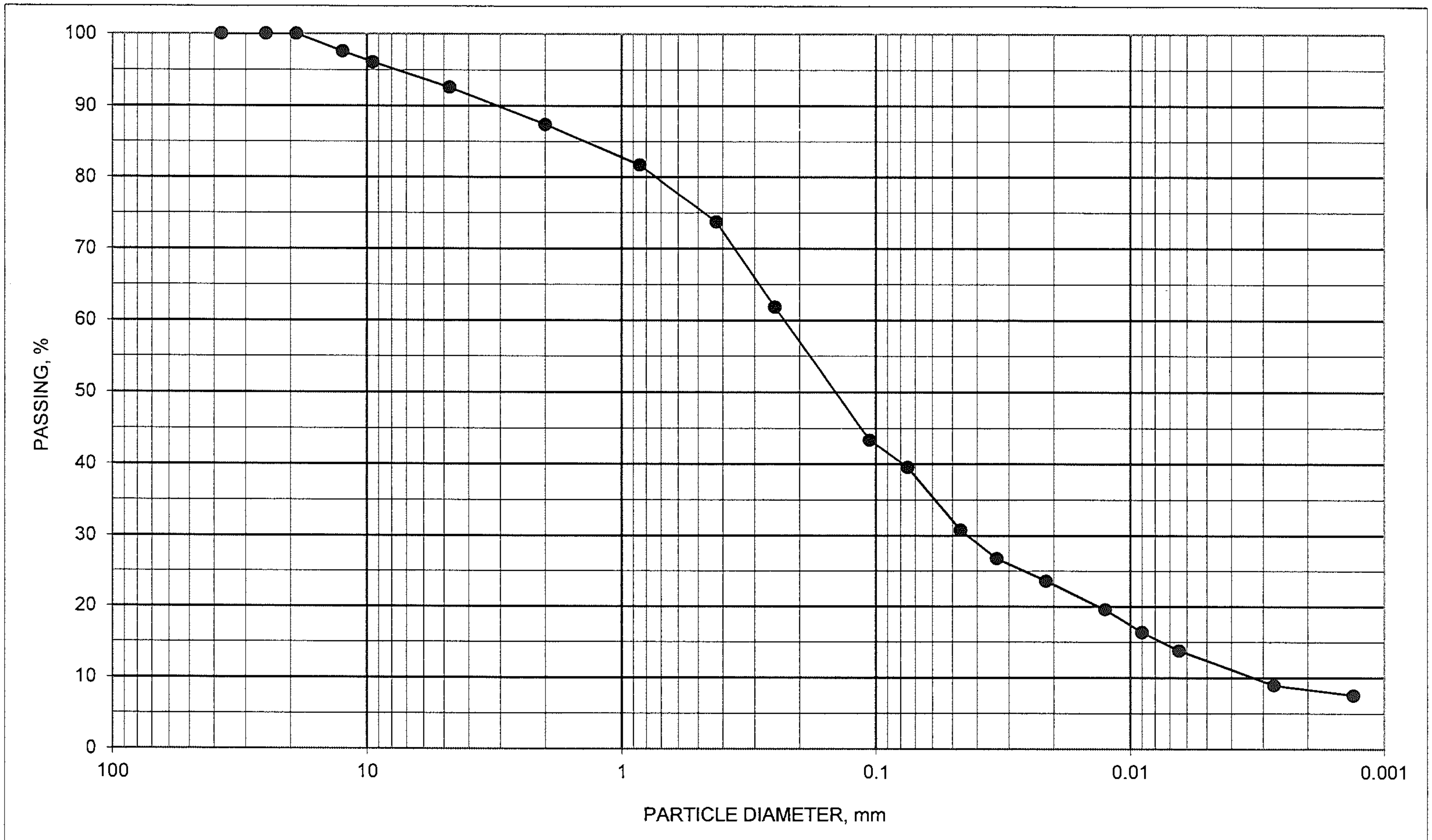
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B003-S7-23.5.xlsx]ATTERBERG M%

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	98
3/8"	9.50	96
#4	4.75	93
#10	2.00	87
#20	0.850	82
#40	0.425	74
#60	0.250	62
#140	0.106	43
#200	0.075	39.5
	0.0466	30.8
	0.0335	26.8
	0.0215	23.6
	0.0126	19.6
	0.0090	16.4
	0.0064	13.8
	0.0027	9.0
	0.0013	7.5

D60	0.2296
D30	0.0437
D10	0.0033
Cu	70.3
Cc	2.5

SPECIFIC GRAVITY 2.67 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S9	30 TO 30.8	SILTY SAND TRACE GRAVEL DARK YELLOWISH BROWN WITH GRAYISH BROWN		11.8			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B003-S9-30.0.xlsx]GRADATION

Terracon

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 03 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N $CaSO_4$

PROJECT NAME:	DYNEGY	PROJECT NUMBER:	15151122
LOCATION:	COFFEEN, ILLINOIS	DATE:	9/9/2015
		PANEL IDENTIFICATION:	Lenexa Perm Board
SAMPLE ID:	COF-B003 S9 30.0 - 30.0 feet	BURETTE AREA:	0.312 cm^2
SAMPLE DESCR.:	SILTY SAND, DARK YELLOWISH BROWN WITH GRAYISH BROWN	BURETTE INCREMENT LENGTH:	1.000 cm
		VOLUME PER INCREMENT:	0.312 cm^3

INITIAL

MOISTURE%		DENSITY			
W & T, g	170.46	WET WT, g	482.1		
D & T, g	155.96	DIA, in	2.858	7.26	cm
T, g	32.90	HT, in	2.022	5.14	cm
		AREA		41.39	cm^2
MOIST-		DENSITY:	141.6	PCF WET	
URE, %	**11.8**	DENSITY:	**126.7**	PCF DRY	

ADDITIONAL DATA

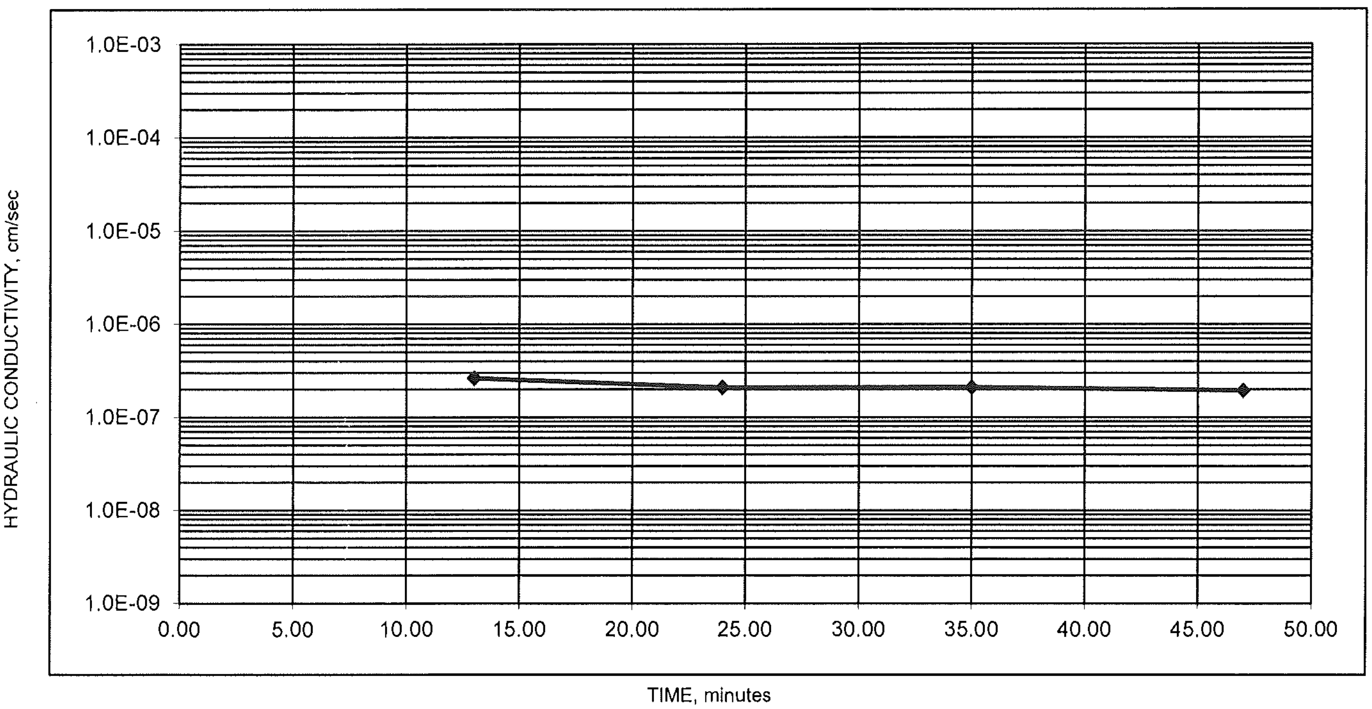
SPECIFIC GRAVITY:	2.70	RECOMPACTED?:	NO
SPECIFIC GRAVITY:	ASSUMED	PROCTOR, pcf:	NA
POROSITY, %:	24.9	OPTIMUM, %:	NA
SATURATION, %:	96.2	COMPACTION, %:	NA
VOID RATIO:	0.33	OVER OPTIMUM, %:	NA

SATURATION:	LATERAL PRESS.:	104.0	psi	BACK PRESSURE (=UPPER=LOWER):	100.0	psi		
DURING TEST:	LATERAL PRESS.:	104.0	psi	H2:	100.0 psi	H1:	100.0	psi
				BIAS PRESSURE (=H1-H2)	0.0	psi		

H1 VALUE	H2 VALUE	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
11.8	64.6	0.00	52.8									
12.1	64.3	13.00	52.2	0.011429	2.63E-07	0.09	0.09	1.00	10.2	20	23.3	0.925
12.3	64.1	24.00	51.8	0.007692	2.09E-07	0.06	0.06	1.00	10.1	5	23.3	0.925
12.5	63.9	35.00	51.4	0.007752	2.10E-07	0.06	0.06	1.00	10.0	4	23.3	0.925
12.7	63.7	47.00	51.0	0.007813	1.94E-07	0.06	0.06	1.00	9.9	11	23.3	0.925

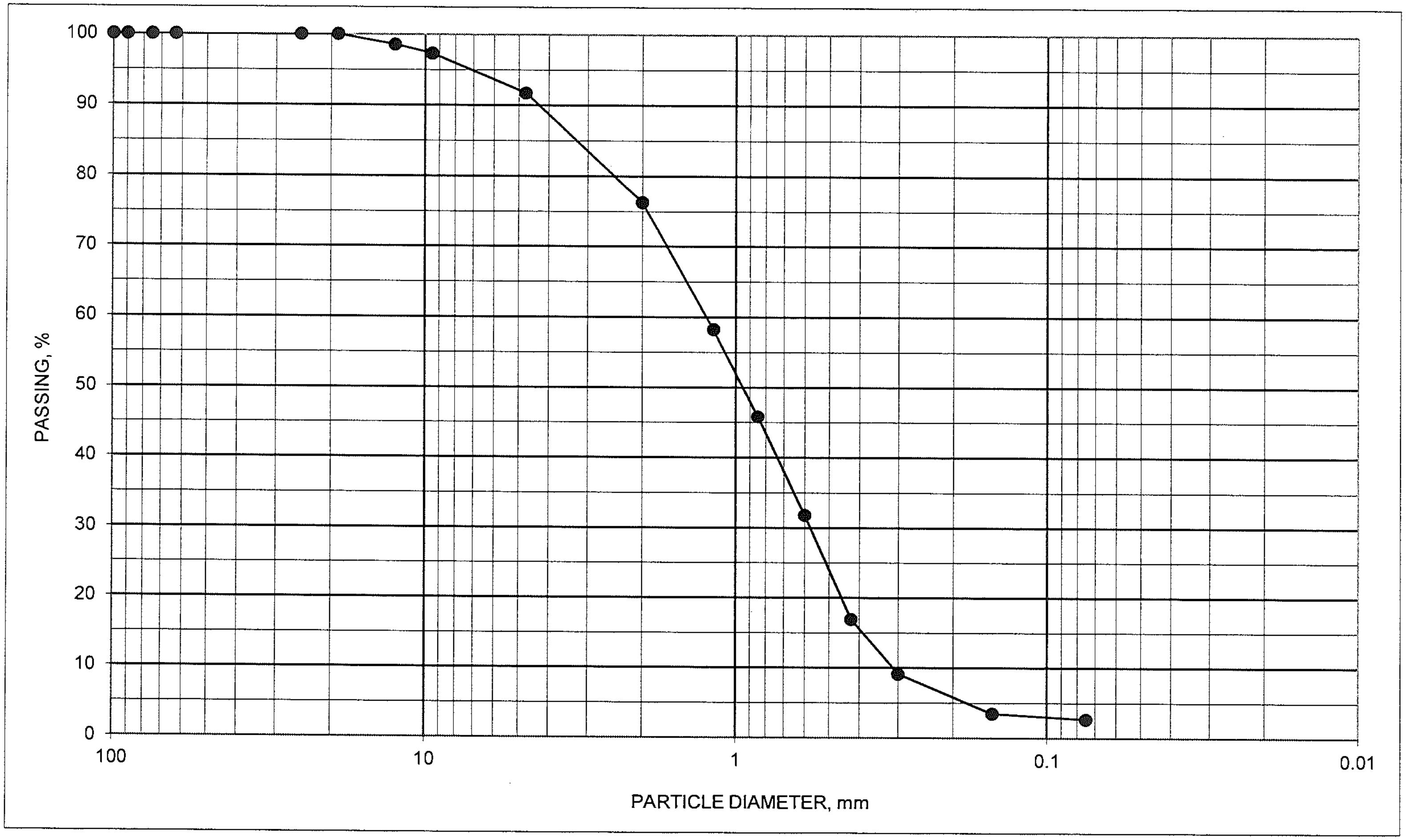
HYDRAULIC CONDUCTIVITY (k_{20}) = AVERAGE 2.2E-07 cm/sec

MAXIMUM HYDRAULIC GRADIENT			0.75< RATIO <1.25	20 MAX HYDRAULIC GRADIENT ALLOWED	% < 25 AT > 1.0E-8 OR % < 50 AT < 1.0E-8
	1.0E-03 TO 1.0E-04	2			
	1.0E-04 TO 1.0E-05	5			
	1.0E-05 TO 1.0E-06	10			
	1.0E-06 TO 1.0E-07	20			
	less than 1.0E-07	30			



SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	99
3/8"	9.5	97
#4	4.8	92
#10	2.00	76
#16	1.18	58
#20	0.85	46
#30	0.600	32
#40	0.425	17
#50	0.300	9
#100	0.150	3
#200	0.075	2.7

D60	1.2430
D30	0.5757
D10	0.3120
Cu	4.0
Cc	0.9



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S-10	33.5 TO 35	POORLY GRADED SAND BROWN	SP				

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

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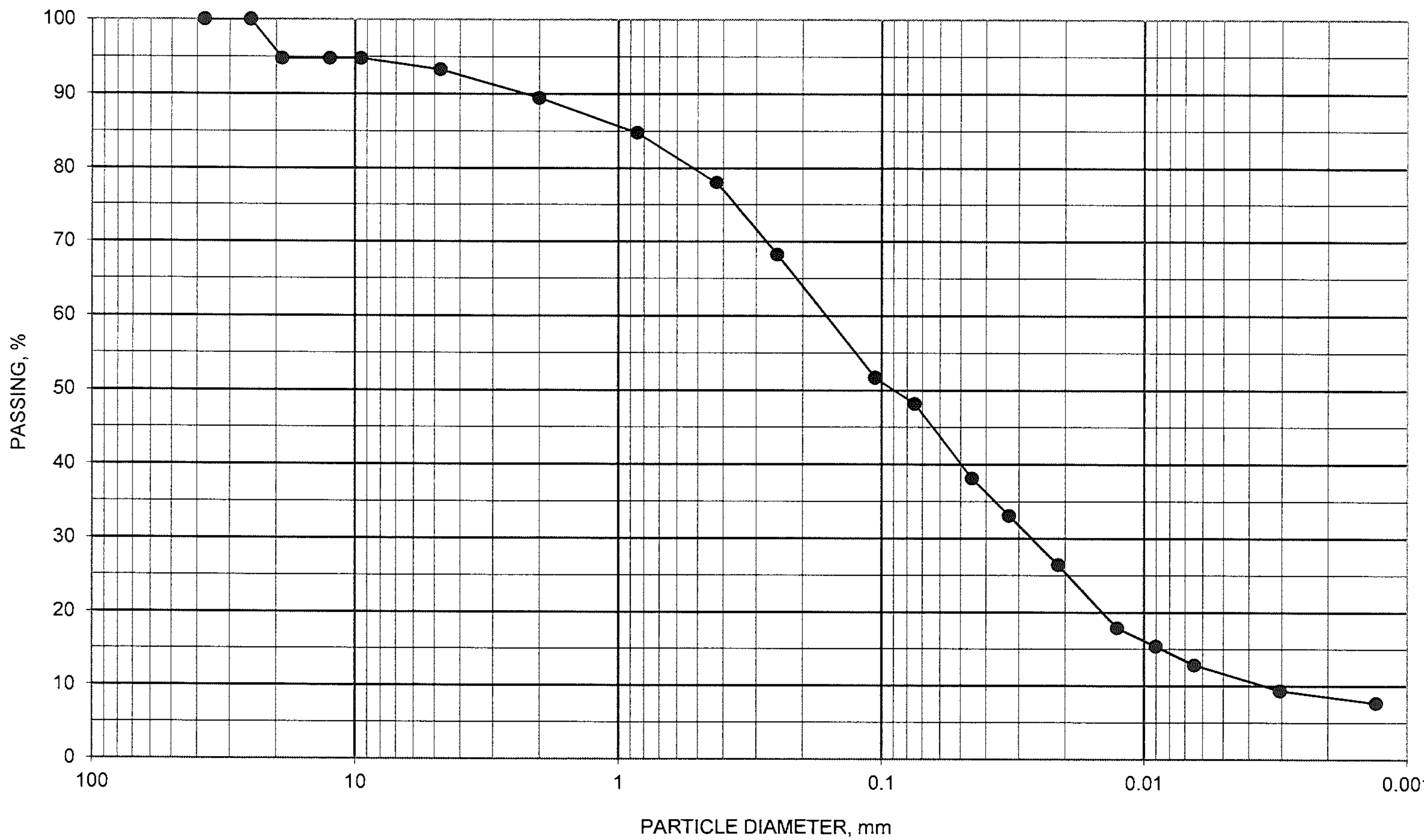
Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	95
1/2"	12.5	95
3/8"	9.50	95
#4	4.75	93
#10	2.00	89
#20	0.850	85
#40	0.425	78
#60	0.250	68
#140	0.106	52
#200	0.075	48.2
	0.0453	38.1
	0.0327	33.1
	0.0213	26.4
	0.0127	17.9
	0.0090	15.4
	0.0065	12.9
	0.0031	9.4
	0.0013	7.7

D60	0.1630
D30	0.0268
D10	0.0035
Cu	46.6
Cc	1.3

SPECIFIC GRAVITY 2.67 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S11	38.5 TO 40	SILTY SAND TRACE GRAVEL BROWN		9.5			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B003-S11-38.5.xlsx]GRADATION

Terracon

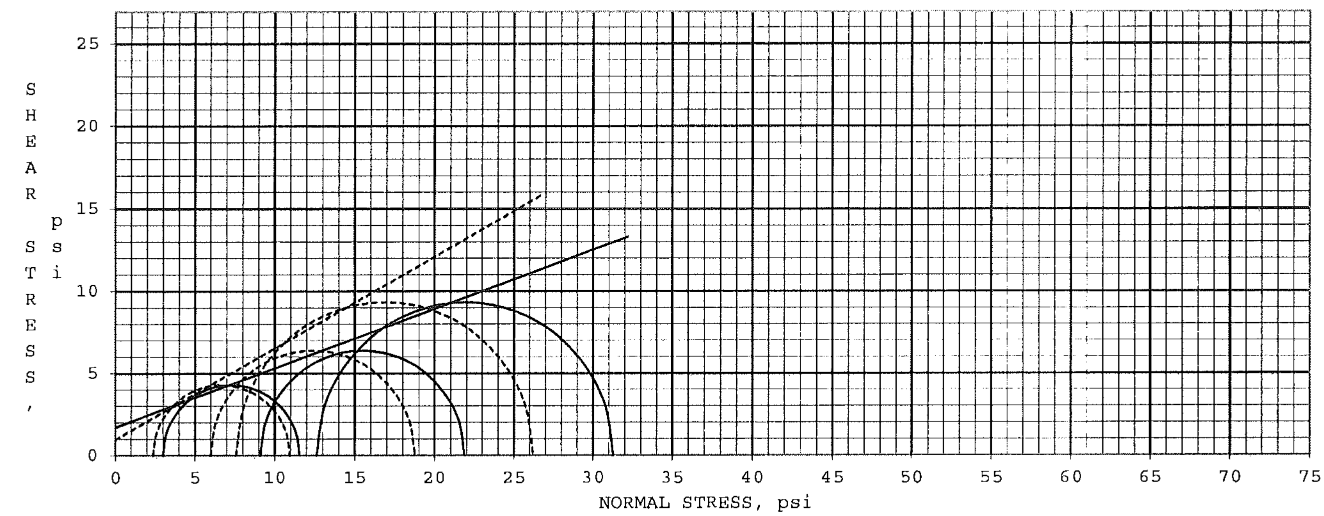
DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B004	S1	1.0	2.5	18.0														
	Color			brown						Visual Classification				Fill: Lean Clay with Fine Sand trace Fine Gravel				
	S2	3.5	5.0	10.9														
	Color			brown & gray						Visual Classification				Fill: Sandy Lean Clay trace Fine Gravel				
	S3	6.0	7.5	11.0														
	Color			brown & gray						Visual Classification				Fill: Sandy Lean Clay trace Fine Gravel				
	S4	8.5	10.5	12.8	121.4	39	15	24						NOTE*				
	Color			yellowish brown with gray						Visual Classification				Lean Clay with Sand				
	S5	13.5	15.0	13.1		26	14	12										
	Color			brown & gray						Visual Classification				Fill: Sandy Lean Clay trace Fine Gravel				
	S6	18.5	20.0	21.8														
	Color			brown & gray						Visual Classification				Sandy Lean Clay trace Fine Gravel				
	S7	23.5	25.5	20.6	107.4	51	17	34				5.0E-07*		NOTE*				
	Color			reddish brown with dark gray						Visual Classification								
	S8	28.5	30.0	24.2		43	16	27										
	Color			brown & gray						Visual Classification				Lean Clay with Fine to Med Sand				
	S9	33.5	35.0	8.4		21	13	8										
	Color			brown & gray						Visual Classification				Sandy Lean Clay trace Fine Gravel				
	S10	38.5	40.0	8.8							2.76							
	Color			brown & gray						Visual Classification				Sandy Silty Lean Clay trace Fine to Coarse Gravel				
	S11	43.5	45.0	14.8					NOTE*									
	Color			brown & gray						Visual Classification				Sandy Silty Clay trace Gravel				

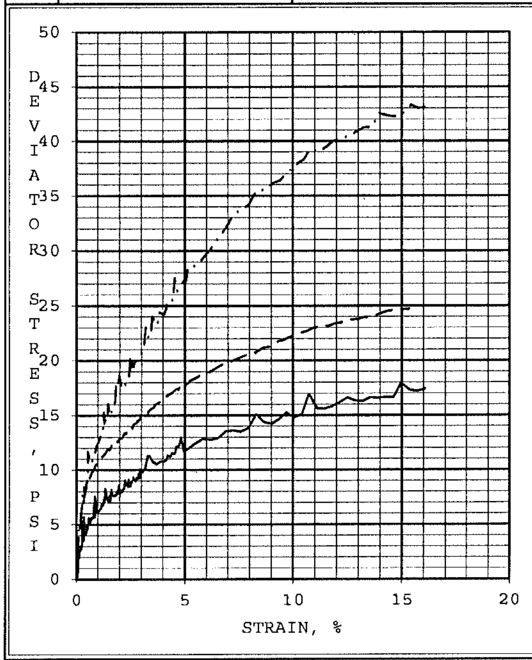
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	29.1	COHESION, psi	1.0
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	19.8	COHESION, psi	1.7



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	12.6	13.0	12.9
	DRY DENSITY, pcf	122.9	119.8	121.6
	SATURATION, %	91	86	90
	VOID RATIO	0.37	0.41	0.39
BEFORE SHEAR	WATER CONTENT, %	13.6	14.7	13.5
	DRY DENSITY, pcf	123.1	120.6	123.5
	SATURATION (B PARAMETER)	0.97	0.97	0.97
	VOID RATIO	0.37	0.40	0.36
	FINAL BACK PRESSURE, psi	100.6	99.8	101.1
MINOR PRINCIPAL STRESS, psi		3.0	9.1	12.6
EFFECTIVE STRESS PEAK AT % STRAIN		2.0	2.0	2.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		8.6	12.8	18.6
TOTAL STRESS PEAK AT % STRAIN		2.0	2.0	2.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		8.6	12.8	18.6
ULTIMATE DEVIATOR STRESS (15% STR), psi		17.9	24.7	42.7
TIME TO 50% PRIMARY CONSOLIDATION, min		23.00	9.00	4.00
STRAIN RATE, % / hour		0.80	1.95	3.98
INITIAL DIAMETER, inch		1.357	1.362	1.366
INITIAL HEIGHT, inch		2.874	2.885	2.831
AREA AFTER CONSOLIDATION, inch2		1.446	1.454	1.453

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, YELLOWISH BROWN WITH GRAY

LL	PL	PI	Gs
39	15	24	2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B004

LABORATORY: TERRACON - LENEXA

SAMPLE #: S4

DATE: 9/10/2015

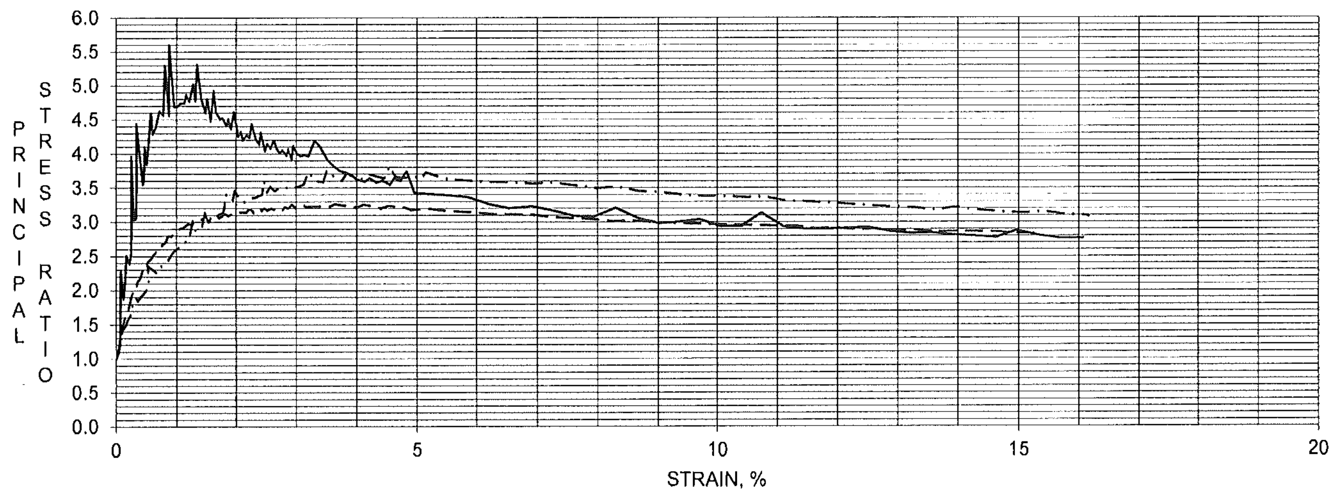
DEPTH, feet: 8.5 - 10.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

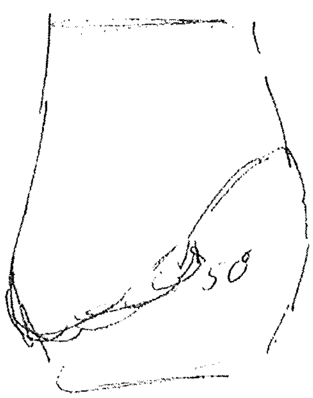
Terracon

DYNEGY

15151122 COF-B004 S4 8.5 - 10.5

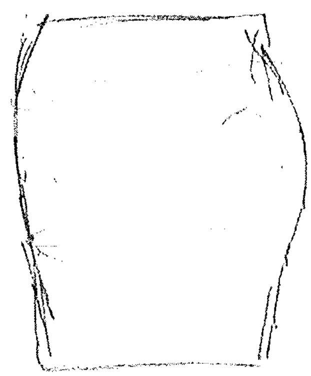


FAILURE SKETCH



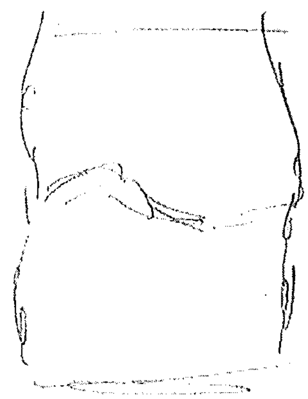
SPECIMEN A

FAILURE SKETCH



SPECIMEN B

FAILURE SKETCH



SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 2 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 2 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 2 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 2 % STRAIN.

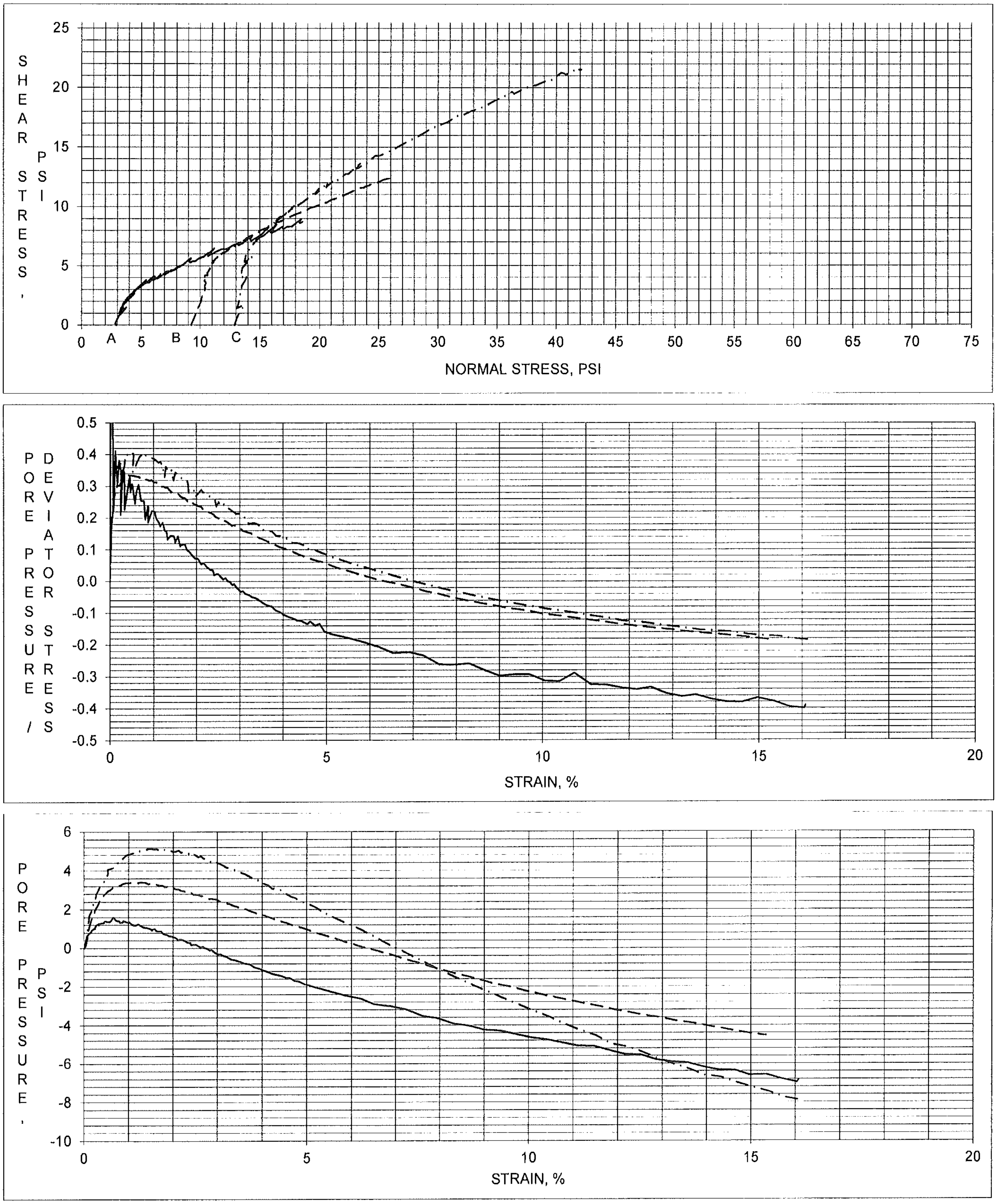
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

Terracon

DYNEGY

15151122 COF-B004 S4 8.5 - 10.5



Terracon

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MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 03 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N CaSO4

PROJECT NAME:	DYNEGY	PROJECT NUMBER:	15151122
LOCATION:	COFFEEN, ILLINOIS	DATE:	9/4/2015
		PANEL IDENTIFICATION:	Lenexa Perm Board
SAMPLE ID:	COF-B004 S7 23.5.0 - 25.5 feet	BURETTE AREA:	0.312 cm^2
SAMPLE DESCR.:	SANDY FAT CLAY, REDDISH BROWN WITH DARK GRAY	BURETTE INCREMENT LENGTH:	1.000 cm
		VOLUME PER INCREMENT:	0.312 cm^3

INITIAL

MOISTURE%		DENSITY			
W & T, g	140.98	WET WT, g	438.0		
D & T, g	122.69	DIA, in	2.857	7.26	cm
T, g	33.88	HT, in	2.010	5.11	cm
		AREA		41.36	cm^2
MOIST-		DENSITY:	129.5	PCF WET	
URE, %	**20.6**	DENSITY:	**107.4**	PCF DRY	

ADDITIONAL DATA

SPECIFIC GRAVITY:	2.70	RECOMPACTED?:	NO
SPECIFIC GRAVITY:	ASSUMED	PROCTOR, pcf:	NA
POROSITY, %:	36.3	OPTIMUM, %:	NA
SATURATION, %:	97.6	COMPACTION, %:	NA
VOID RATIO:	0.57	OVER OPTIMUM, %:	NA

SATURATION: LATERAL PRESS.: 104.0 psi | BACK PRESSURE (=UPPER=LOWER): 100.0 psi

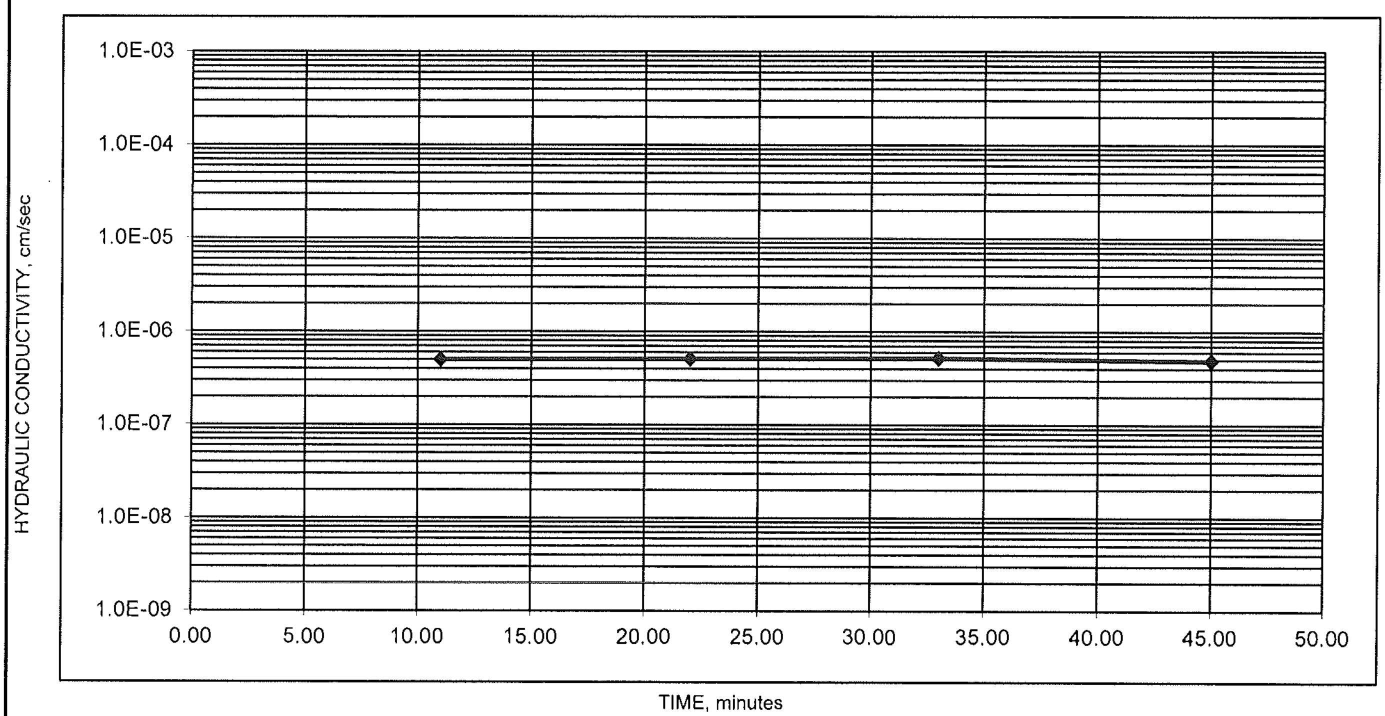
DURING TEST: LATERAL PRESS.: 104.0 psi | H2: 100.0 psi | H1: 100.0 psi

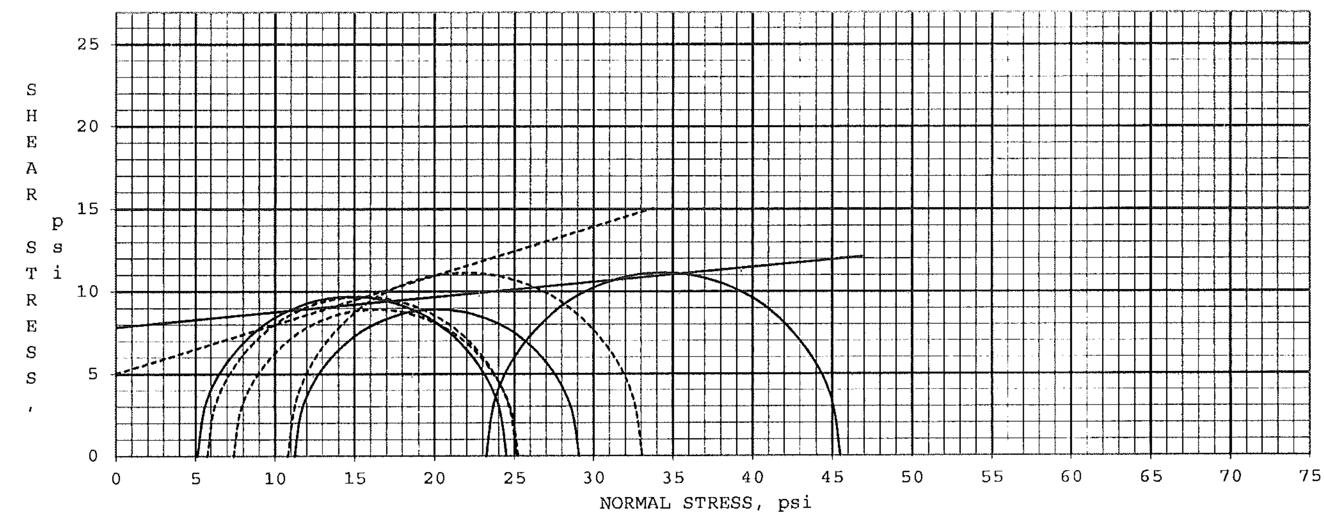
BIAS PRESSURE (=H1-H2) 0.0 psi

H1 VALUE	H2 VALUE	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
15.6	59.2	0.00	43.6									
16.0	58.8	11.00	42.8	0.018519	5.00E-07	0.12	0.12	1.00	8.4	1	23.3	0.925
16.4	58.4	22.00	42.0	0.018868	5.10E-07	0.12	0.12	1.00	8.2	1	23.3	0.925
16.8	58.0	33.00	41.2	0.019231	5.19E-07	0.12	0.12	1.00	8.1	3	23.3	0.925
17.2	57.6	45.00	40.4	0.019608	4.85E-07	0.12	0.12	1.00	7.9	4	23.3	0.925

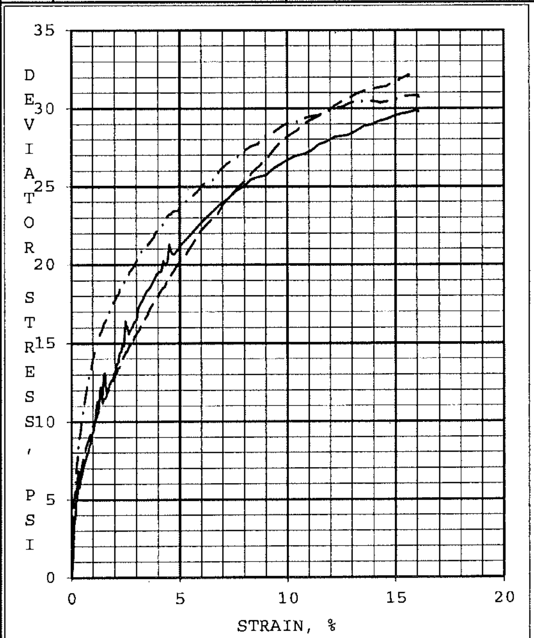
HYDRAULIC CONDUCTIVITY (k_{20}) = AVERAGE 5.0E-07 cm/sec

MAXIMUM	1.0E-03 TO 1.0E-04	2	0.75<	20	% < 25 AT
HYDRAULIC	1.0E-04 TO 1.0E-05	5	RATIO	MAX	> 1.0E-8
GRADIENT	1.0E-05 TO 1.0E-06	10	<1.25	HYDRAULIC	OR
	1.0E-06 TO 1.0E-07	20		GRADIENT	% < 50 AT
	less than 1.0E-07	30		ALLOWED	< 1.0E-8





EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**16.5**	COHESION, psi	**5.0**
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**5.2**	COHESION, psi	**7.8**



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	20.8	17.7	20.6
	DRY DENSITY, pcf	106.9	111.0	107.6
	SATURATION, %	97	92	98
	VOID RATIO	0.58	0.52	0.57
BEFORE SHEAR	WATER CONTENT, %	21.0	18.4	19.1
	DRY DENSITY, pcf	107.5	112.5	111.1
	SATURATION (B PARAMETER)	0.98	0.95	0.97
	VOID RATIO	0.57	0.50	0.52
	FINAL BACK PRESSURE, psi	100.8	100.7	100.6
MINOR PRINCIPAL STRESS, psi		5.1	11.2	23.2
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		19.4	17.8	22.3
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		19.4	17.8	22.3
ULTIMATE DEVIATOR STRESS (15% STR), psi		29.5	31.7	30.6
TIME TO 50% PRIMARY CONSOLIDATION, min		3.70	5.00	14.30
STRAIN RATE, % / hour		1.26	1.23	1.23
INITIAL DIAMETER, inch		1.368	1.366	1.360
INITIAL HEIGHT, inch		2.842	2.833	2.853
AREA AFTER CONSOLIDATION, inch2		1.464	1.455	1.421

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
SANDY FAT CLAY, REDDISH BROWN WITH DARK GRAY

LL 51	PL 17	PI 34	Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B004

LABORATORY: TERRACON - LENEXA

SAMPLE #: S7

DATE: 9/10/2015

DEPTH, feet: 23.5 - 25.5

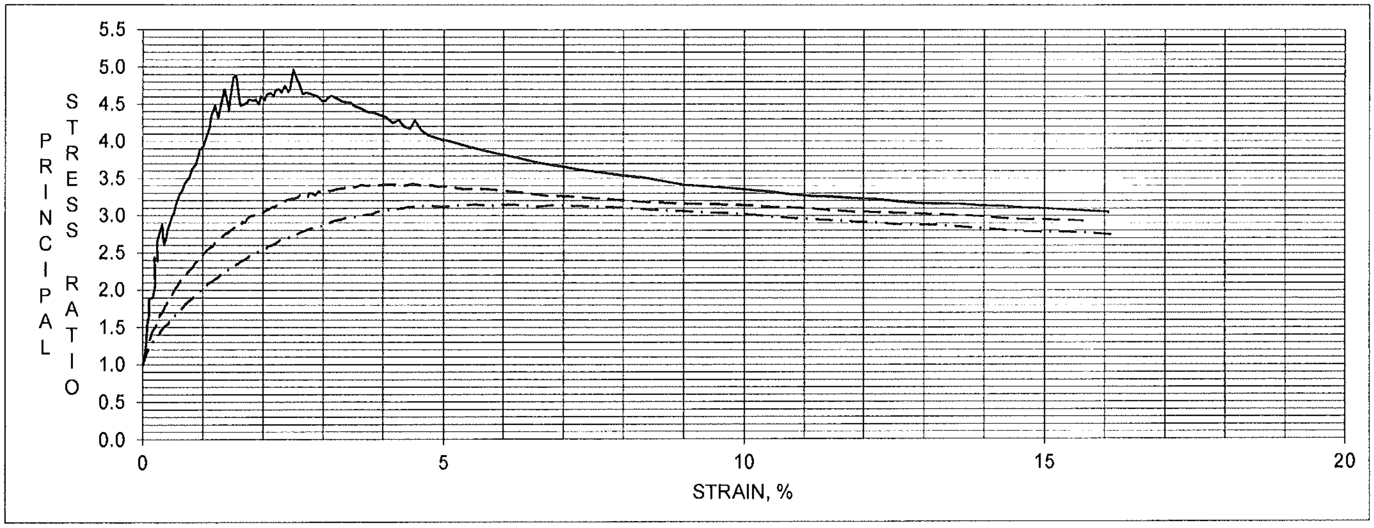
PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

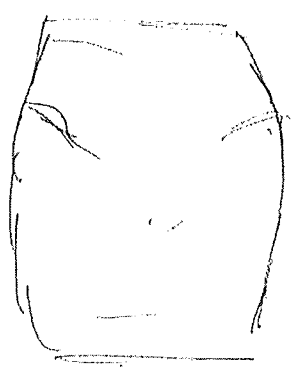
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B004\[15151122 Triaxial CU COF-B004-S7-23.5.xlsx]REPORT

DYNEGY

15151122 COF-B004 S7 23.5 - 25.5

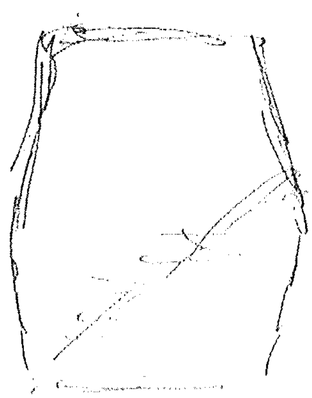


FAILURE SKETCH



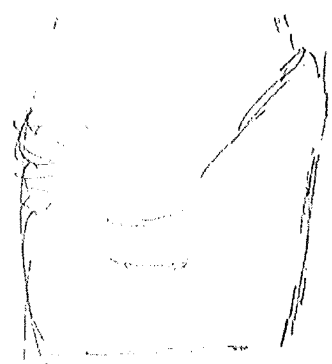
SPECIMEN A

FAILURE SKETCH



SPECIMEN B

FAILURE SKETCH



SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

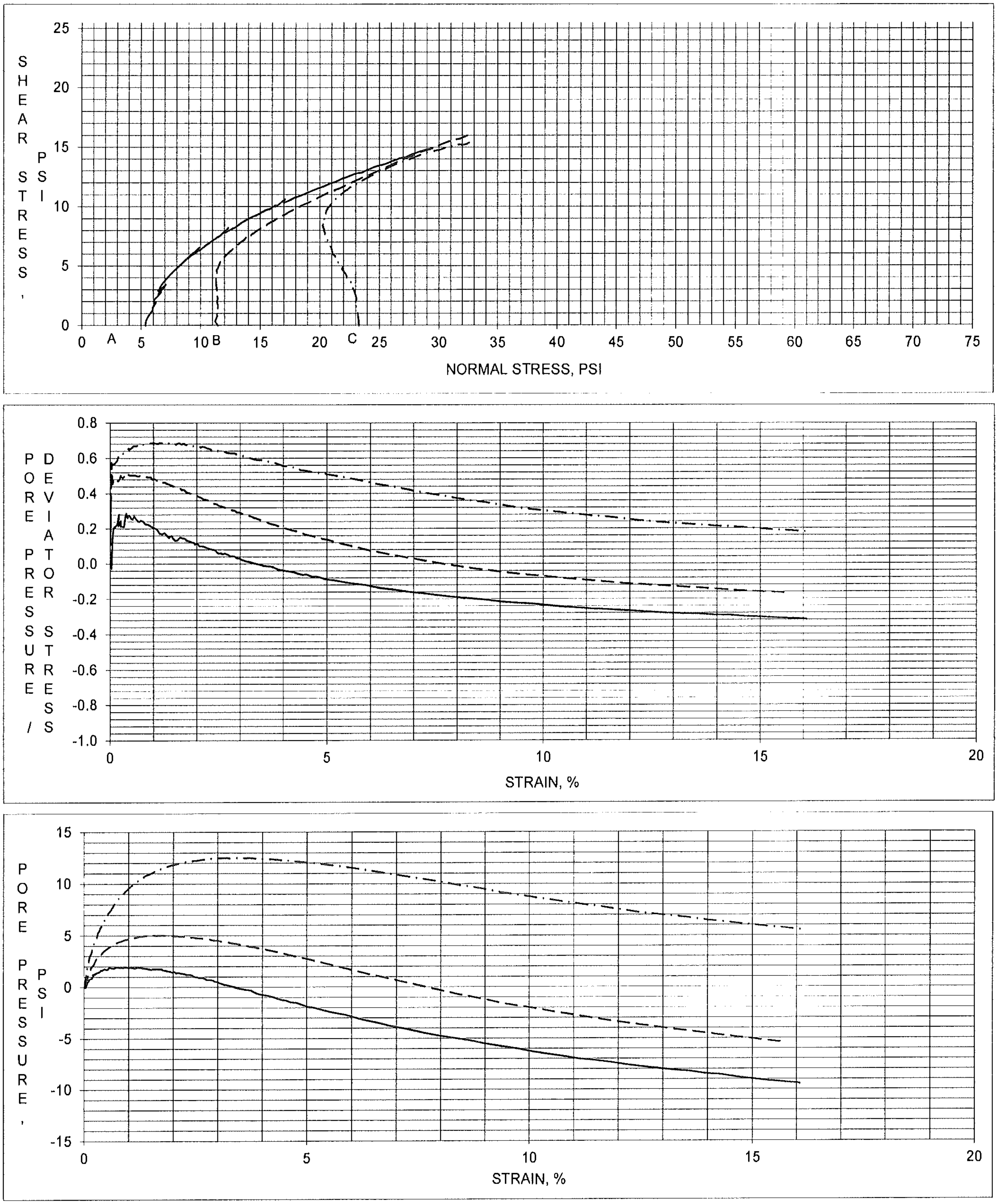
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

Terracon

DYNEGY

15151122 COF-B004 S7 23.5 - 25.5

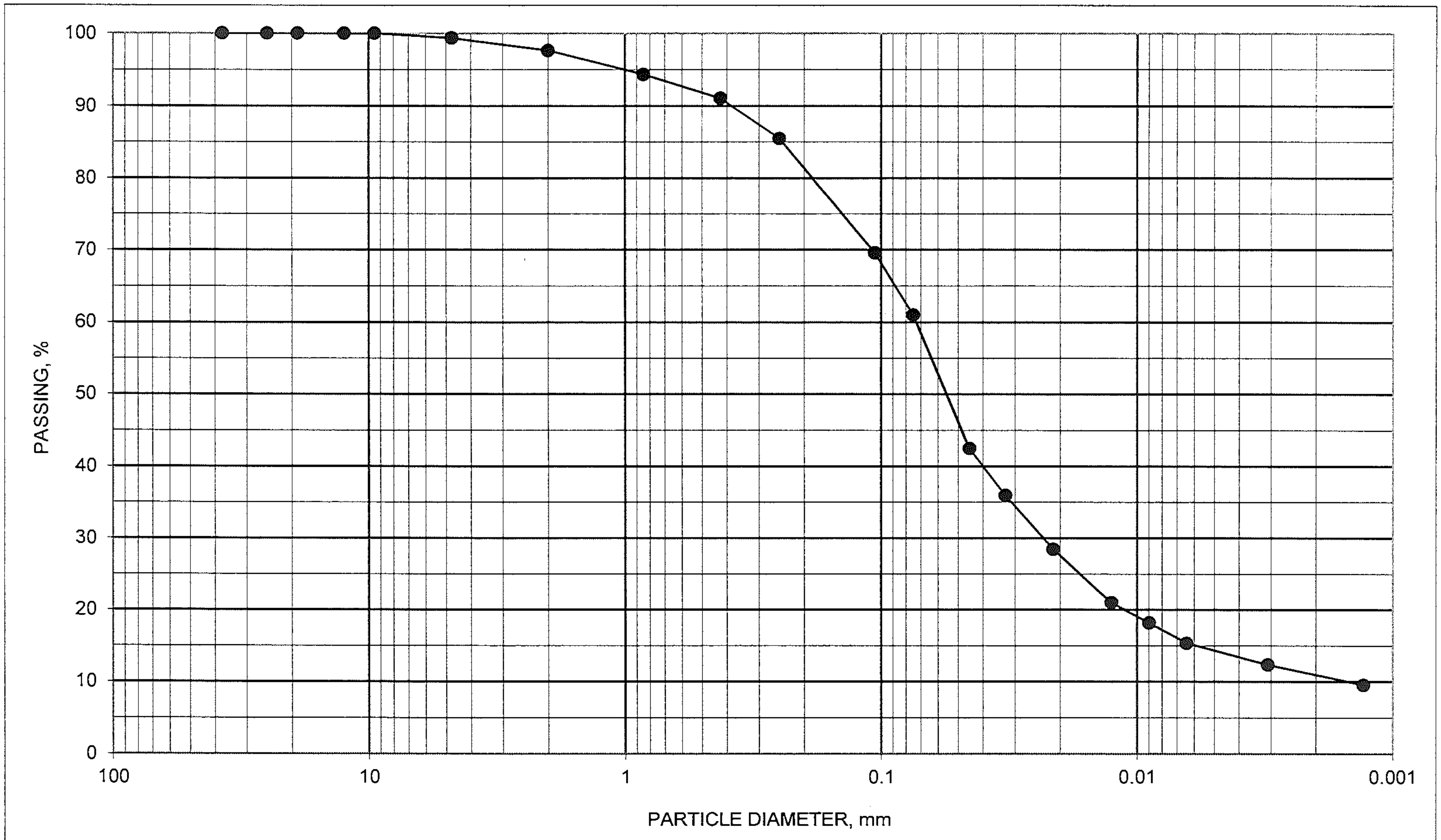


Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	99
#10	2.00	98
#20	0.850	94
#40	0.425	91
#60	0.250	85
#140	0.106	70
#200	0.075	61.0
	0.0453	42.5
	0.0328	36.0
	0.0213	28.5
	0.0126	21.0
	0.0090	18.2
	0.0064	15.4
	0.0031	12.4
	0.0013	9.6

D60	0.0730
D30	0.0232
D10	0.0015
Cu	48.7
Cc	4.9

SPECIFIC GRAVITY 2.68 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B004	S11	43.5 TO 45	SANDY SILTY CLAY TRACE GRAVEL BROWN & GRAY		14.8			

PROJECT DYNEGY

COFFEEN, ILLINOIS

JOB NO. 15151122 DATE 9/1/2015

DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B005	S1	1.0	2.5	21.1														
	Color			brown & gray						Visual Classification			Fill: Lean Clay					
	S2	3.5	5.5	8.0	126.5	22	13	9		58*		7.0E-07*				ND1*	2*	
	Color			brown						Visual Classification			Sandy Lean Clay					
	S3	6.0	7.5	13.1														
	Color			brown						Visual Classification			Fill: Sandy Lean Clay					
	S4	8.5	10.0	9.9		20	14	6										
	Color			brown						Visual Classification			Fill: Sandy, Silty Clay trace Fine Gravel					
	S5	13.5	15.0	10.3														
	Color			brown & gray						Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S6	18.5	20.0	9.4														
	Color			brown & gray						Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S7	23.5	25.5	18.7	110.7	37	17	20					NOTE*	NOTE*				
	Color			gray with grayish brown						Visual Classification			Lean Clay with Sand					
	S8	28.5	30.0	21.9														
	Color			brown & gray						Visual Classification			Fat Clay trace Fine Sand					
	S9	33.5	35.0	26.7		22	16	6	NOTE*									SC-SM
	Color			brown & gray						USCA Classification			Silty, Clayey Sand					
	S10	38.5	40.0	13.0 CL					** Sieve									
				11.6 SA														
	Color			brown & gray						Visual Classification			Clayey Sand trace Fine Gravel					
	S11	43.5	45.0	12.8		32	15	17	NOTE*									CL
	Color			brown & gray						USCA Classification			Sandy Lean Clay trace Gravel					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

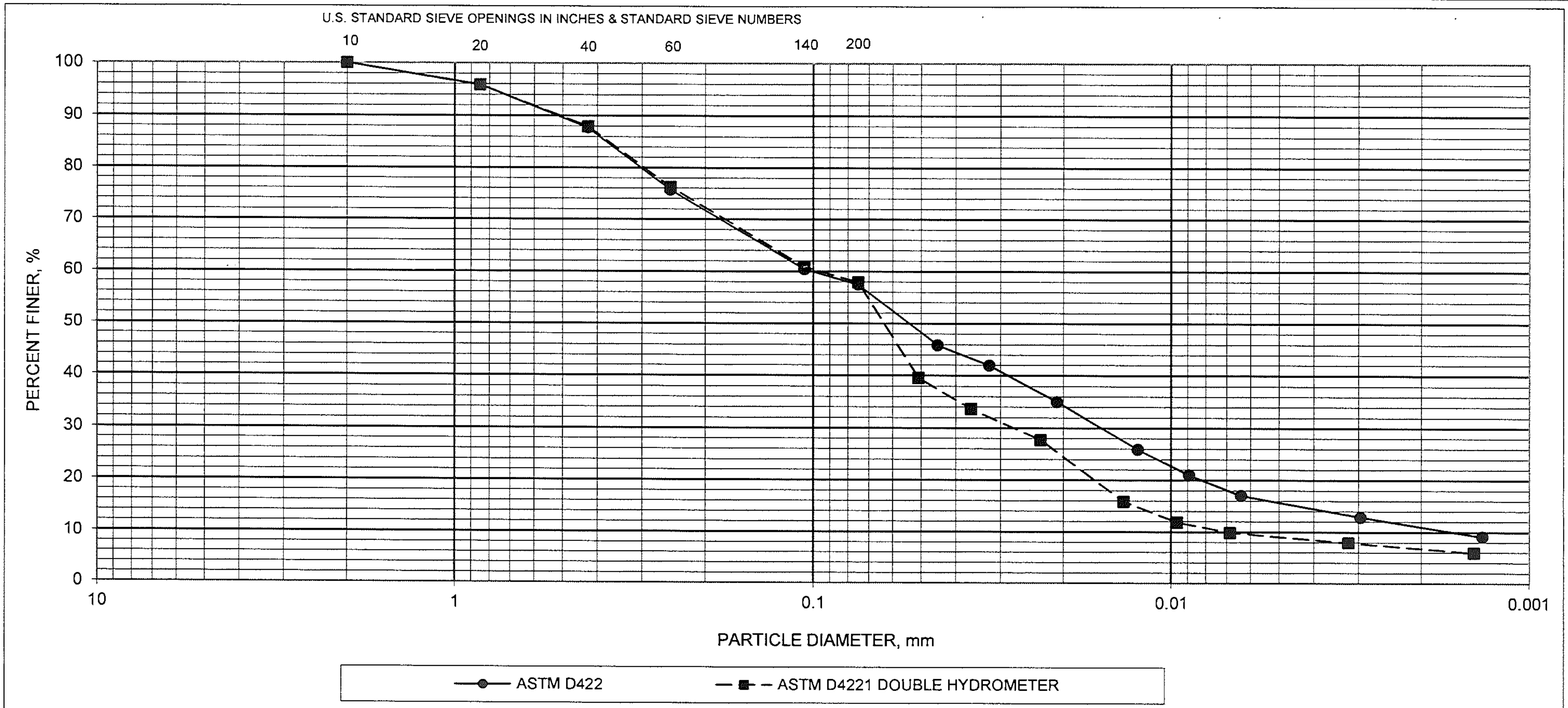
DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B005	S12	48.5	50.0	15.5		32	15	17										
	Color	brown & gray								**Visual Classification**			Sandy Lean Clay trace Fine Gravel					
	S13	53.5	55.0	23.2														
	Color	brown & gray								**Visual Classification**			Lean to Fat Clay trace Fine Sand					
	S14	58.5	60.0	23.3		47	17	30	NOTE*									CL
	Color	brown & gray								**USCA Classification**			Lean Clay with Sand					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	15.7	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	9.1	DISPERSION, %	**58**

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S2	3.5 - 5.5	SANDY LEAN CLAY, BROWN					

PROJECT DYNEGY

COFFEEN, ILLINOIS

JOB NO. 15151122 DATE 9/2/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B005-S2-3.5.xls]Hydrometer Data

Terracon

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 03 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N CaSO4

PROJECT NAME:	DYNEGY	PROJECT NUMBER:	15151122
LOCATION:	COFFEEN, ILLINOIS	DATE:	9/4/2015
		PANEL IDENTIFICATION:	Lenexa Perm Board
SAMPLE ID:	COF-B005 S2 3.5 - 5.5 feet	BURETTE AREA:	0.312 cm^2
SAMPLE DESCR.:	SANDY LEAN CLAY, BROWN	BURETTE INCREMENT LENGTH:	1.000 cm
		VOLUME PER INCREMENT:	0.312 cm^3

INITIAL

MOISTURE%		DENSITY			
W & T, g	177.91	WET WT, g	409.4		
D & T, g	167.15	DIA, in	2.882	7.32	cm
T, g	33.00	HT, in	1.750	4.45	cm
		AREA		42.09	cm^2
MOIST-		DENSITY:	136.6	PCF WET	
URE, %	**8.0**	DENSITY:	**126.5**	PCF DRY	

ADDITIONAL DATA

SPECIFIC GRAVITY:	2.70	RECOMPACTED?:	NO
SPECIFIC GRAVITY:	ASSUMED	PROCTOR, pcf:	NA
POROSITY, %:	25.0	OPTIMUM, %:	NA
SATURATION, %:	65.1	COMPACTION, %:	NA
VOID RATIO:	0.33	OVER OPTIMUM, %:	NA

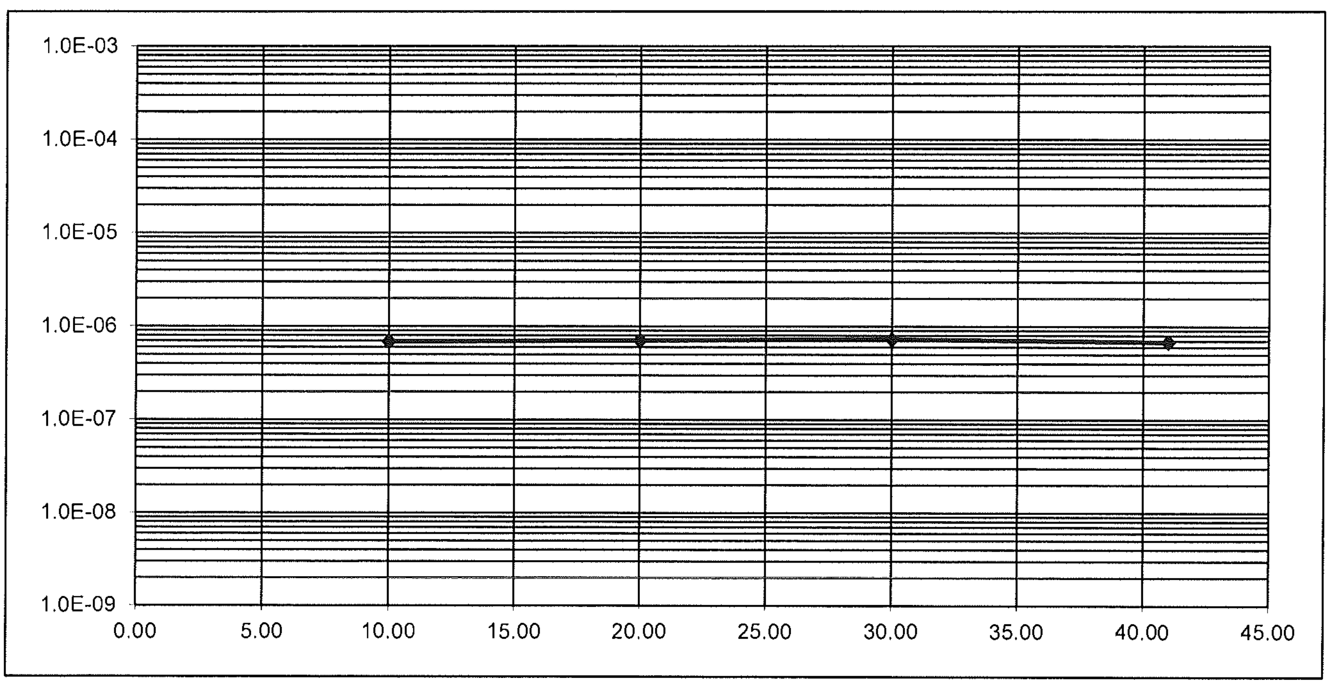
SATURATION:	LATERAL PRESS.: 104.0 psi	BACK PRESSURE (=UPPER=LOWER): 100.0 psi		
DURING TEST:	LATERAL PRESS.: 104.0 psi	H2: 100.0 psi	H1: 100.0 psi	
			BIAS PRESSURE (=H1-H2) 0.0 psi	

H1 VALUE	H2 VALUE	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
18.5	55.8	0.00	37.3									
19.0	55.3	10.00	36.3	0.027176	6.88E-07	0.16	0.16	1.00	8.2	2	23.5	0.920
19.5	54.8	20.00	35.3	0.027935	7.07E-07	0.16	0.16	1.00	7.9	1	23.5	0.920
20.0	54.3	30.00	34.3	0.028738	7.29E-07	0.16	0.16	1.00	7.7	4	23.4	0.923
20.5	53.8	41.00	33.3	0.029588	6.82E-07	0.16	0.16	1.00	7.5	3	23.4	0.923

HYDRAULIC CONDUCTIVITY (k_{20}) = **AVERAGE 7.0E-07 cm/sec**

MAXIMUM	1.0E-03 TO 1.0E-04	2	0.75<	20	% < 25 AT
HYDRAULIC	1.0E-04 TO 1.0E-05	5	RATIO	MAX	> 1.0E-8
GRADIENT	1.0E-05 TO 1.0E-06	10	<1.25	HYDRAULIC	OR
	1.0E-06 TO 1.0E-07	20		GRADIENT	% < 50 AT
	less than 1.0E-07	30		ALLOWED	< 1.0E-8

HYDRAULIC CONDUCTIVITY, cm/sec



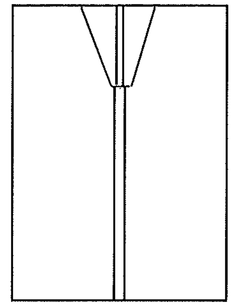
TIME, minutes

DISPERSIVE CLAY SOILS BY THE PINHOLE TEST
ASTM D 4647, METHOD A
9/9/2015

PROJECT DYNEGY
JOB NO. COFFEEN, ILLINOIS
SAMPLE ID COF-B005, S2, 3.5 - 5.5 feet
COMPACTION CHARACTERISTICS UNDISTURBED
WATER CONTENT 8.5%
DISTILLED WATER ADDED ____ **YES** X **NO**
CURE TIME NATURAL MOSITURE, NO CURE
BY JDM
SAMPLE DESC. SANDY LEAN CLAY, BROWN

FLOW STARTED ON 1ST **TRIAL**

FINAL HOLE
0.9 mm



TIME, min	HEAD, inch	FLOW, ml	FLOW, sec	FLOW RATE, ml/sec	TURBIDITY FROM SIDE: VERY DARK	DARK	MOD. DARK	SLIGHT DARK	BARELY VISIBLE	CLEAR	CLEAR FROM TOP	REMARKS
1	2	15.0	60	0.25						X	X	
2	2	14.0	60	0.23						X	X	
3	2	14.8	60	0.25						X	X	
4	2	14.5	60	0.24						X	X	
5	2	14.5	60	0.24						X	X	
6	2	14.5	60	0.24						X	X	
7	2	15.5	64	0.24						X	X	
8	2	13.0	56	0.23						X	X	
9	2	14.5	60	0.24						X	X	
10	2	14.0	60	0.23						X	X	
1	7	51.0	60	0.85						X	X	
2	7	57.0	64	0.89						X	X	
3	7	46.0	56	0.82						X		Barely Visible
4	7	51.5	60	0.86						X	X	
5	7	43.5	60	0.73						X		Barely Visible
1	15	92.0	60	1.53						X		Barely Visible
2	15	93.0	60	1.55						X		Barely Visible
3	15	91.5	60	1.53						X		Barely Visible
4	15	93.0	60	1.55						X	X	
5	15	93.0	60	1.55						X		Barely Visible
1	40	170.0	60	2.83						X		Barely Visible
2	40	172.0	60	2.87						X		Barely Visible
3	40	172.0	60	2.87						X		Barely Visible
4	40	172.0	60	2.87						X	X	
5	40	172.0	60	2.87						X	X	

CLASSIFICATION = ND1

Terracon

CRUMB TEST (ASTM D6572)

Project No.: 15151122 Project Name: DYNEGY Location: COFFEEN, IL

Boring No.: COF-B005 Sample No.: S2 Depth: 3.5 - 5.5 [X] ft [ ] m

Visual Classification: ______ Color: ______

Moisture Content of Sample:	[ ] as-received	[ ] in situ	[ ] air-dried	
Tare Number	Wet Mass + Tare (g)	Dry Mass+ Tare (g)	Tare Mass (g)	Water Content (%)
AL-88	81.07	70.95	21.06	20.3

Specimen Identification:		Specimen Identification:		Specimen Identification:	
Spec. Container Identification:	1	Spec. Container Identification:		Spec. Container Identification:	
Method:	[X] A (Natural) [ ] B (Remolded)	Method:	[ ] A (Natural) [ ] B (Remolded)	Method:	[ ] A (Natural) [ ] B (Remolded)
Water Type:	[X] Distilled [ ] Type IV	Water Type:	[ ] Distilled [ ] Type IV	Water Type:	[ ] Distilled [ ] Type IV
Initial Water Temp. (°C):	22.5	Initial Water Temp. (°C):		Initial Water Temp. (°C):	
Start Time (hh:mm:ss):	8:59:02	Start Time (hh:mm:ss):		Start Time (hh:mm:ss):	

Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	9:01:02	1	22.0	2 min ± 15 s				2 min ± 15 s			
1 h ± 8 min	9:58:44	1	21.0	1 h ± 8 min				1 h ± 8 min			
6 h ± 45 min	2:56:05	2	21.0	6 h ± 45 min				6 h ± 45 min			

Dispersive Classification:	Intermediate	Dispersive Classification:		Dispersive Classification:	
Additional water added to remold the specimen (Method B):	[ ] Y [ ] N	Additional water added to remold the specimen (Method B):	[ ] Y [ ] N	Additional water added to remold the specimen (Method B):	[ ] Y [ ] N

Remarks: ______

Prepared By: John Martin Date: 9/1/15
Tested By: John Martin Date: 9/1/15
Input By: John Martin Date: 9/8/15
Reviewed By: ______ Date: ______

CRUMB TEST D6572

DYNEGY

COFFEEN, ILLINOIS

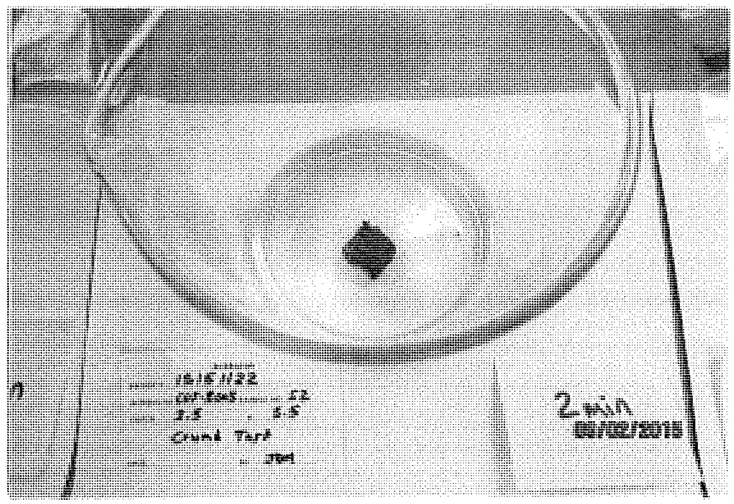
15151122

COF-B005 S2 3.5 - 5.5 feet

2 MIN

GRADE: 1

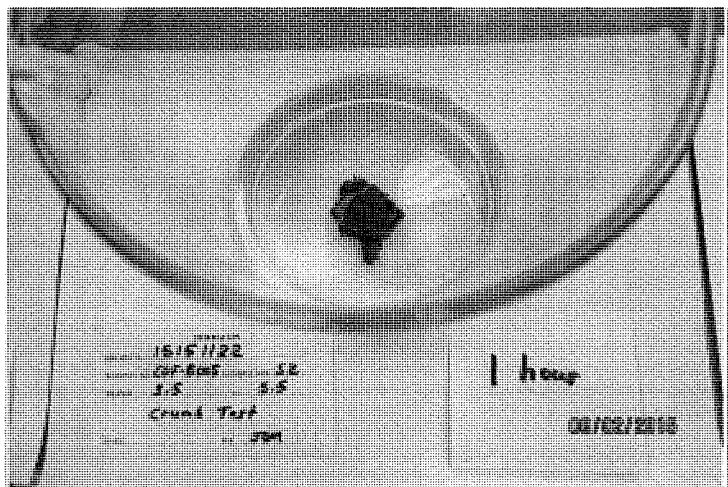
DISPERSIVE CALSSIFICATION: NONDISPERSIVE



1 HOUR

GRADE: 1

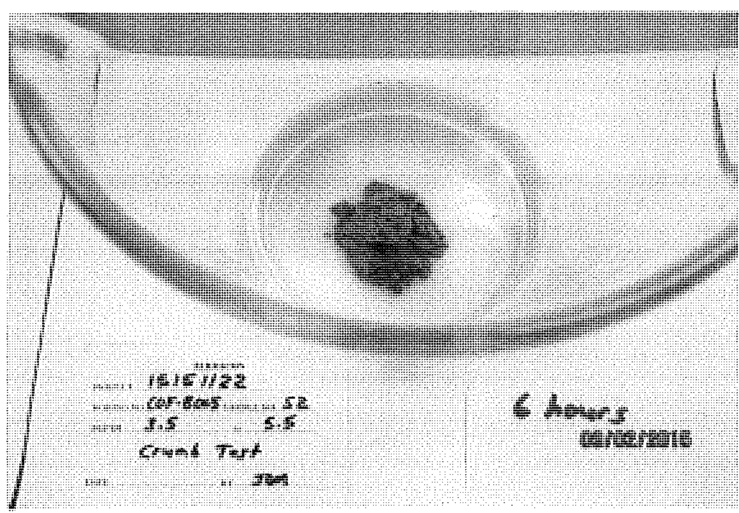
DISPERSIVE CALSSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 2

DISPERSIVE CALSSIFICATION: INTERMEDIATE



Grade 1 - Nondispersive

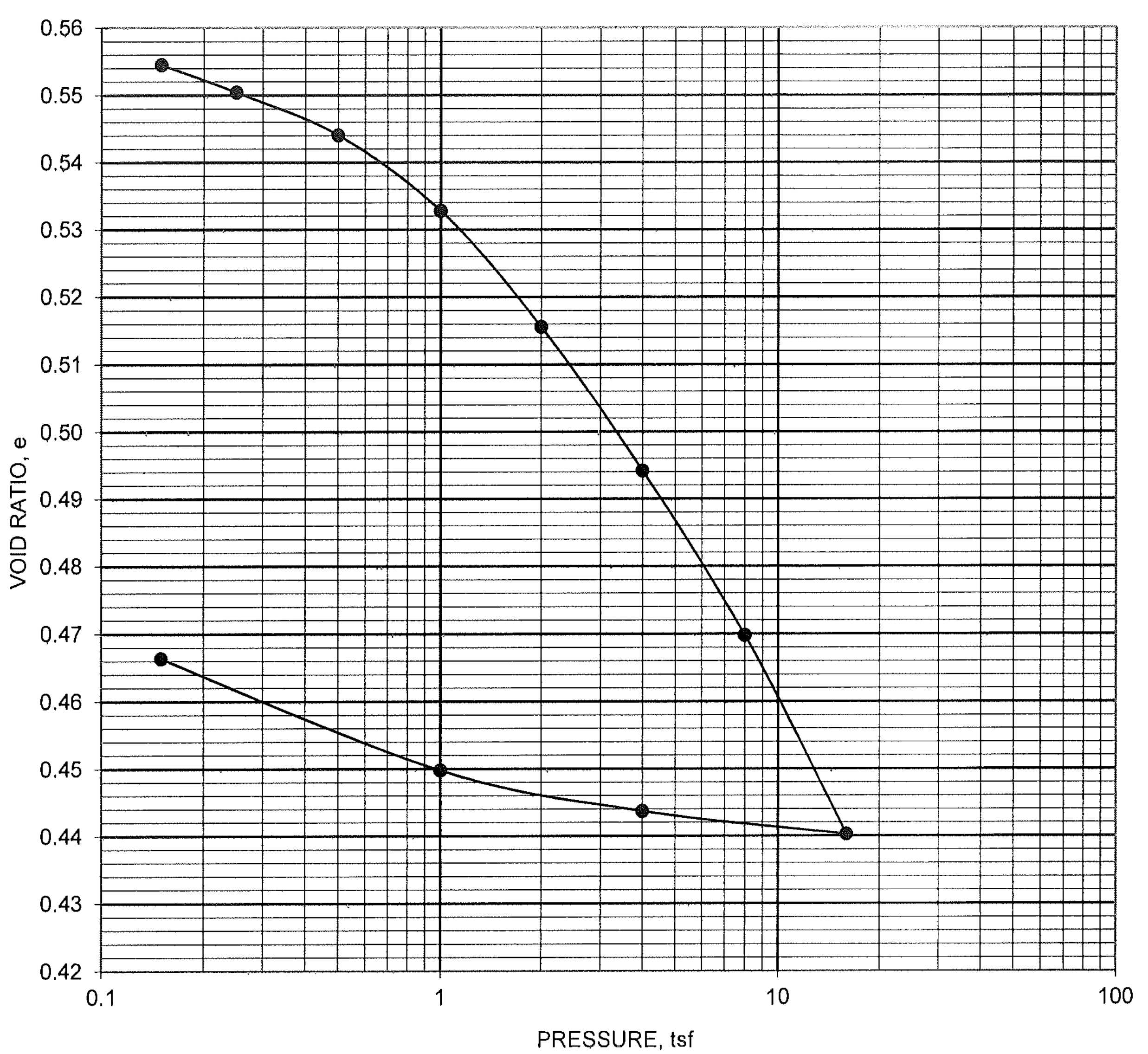
Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.56	HEIGHT, mm	25.30	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		1.03		MOISTURE, %		18.3	15.4
PRECONSOL. PRESSURE, tsf		2.12		DRY DENSITY, pcf		108.3	116.0
OVER CONSOLIDATION RATIO		2.1		SATURATION, %		89	90
COMPRESSION INDEX		0.10		VOID RATIO		0.556	0.466
REBOUND INDEX		0.016		SAMPLE TYPE		UNDISTURBED	
LIQUID LIMIT	37	PLASTIC LIMIT	17	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	LEAN CLAY WITH SAND, GRAY WITH GRAYISH BROWN						
BORING NO.	COF-B005	SAMPLE NO.	S7	DEPTH, feet		23.5 - 25.5	

DYNEGY
COFFEEN, ILLINOIS
15151122
9/8/2015

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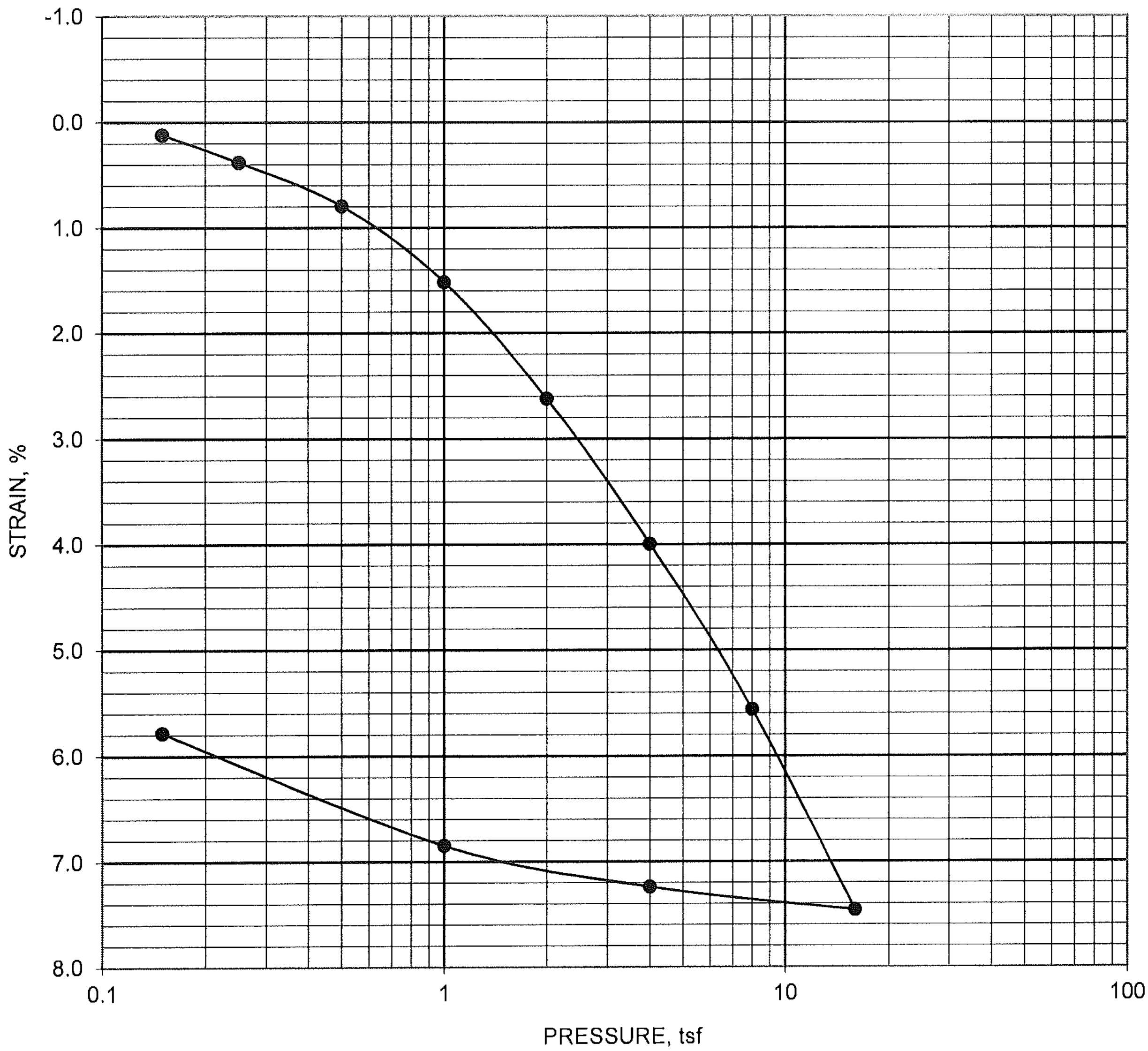
Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.56	HEIGHT, mm	25.30	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		1.03		MOISTURE, %	18.3	15.4
PRECONSOL. PRESSURE, tsf		2.12		DRY DENSITY, pcf	108.3	116.0
OVER CONSOLIDATION RATIO		2.1		SATURATION, %	89	90
COMPRESSION INDEX		0.10		VOID RATIO	0.556	0.466
REBOUND INDEX		0.016		SAMPLE TYPE	3" SHELBY TUBE	

LIQUID LIMIT	37	PLASTIC LIMIT	17	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	LEAN CLAY WITH SAND, GRAY WITH GRAYISH BROWN						
BORING NO.	COF-B005	SAMPLE NO.	S7	DEPTH, feet	23.5 - 25.5		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/8/2015

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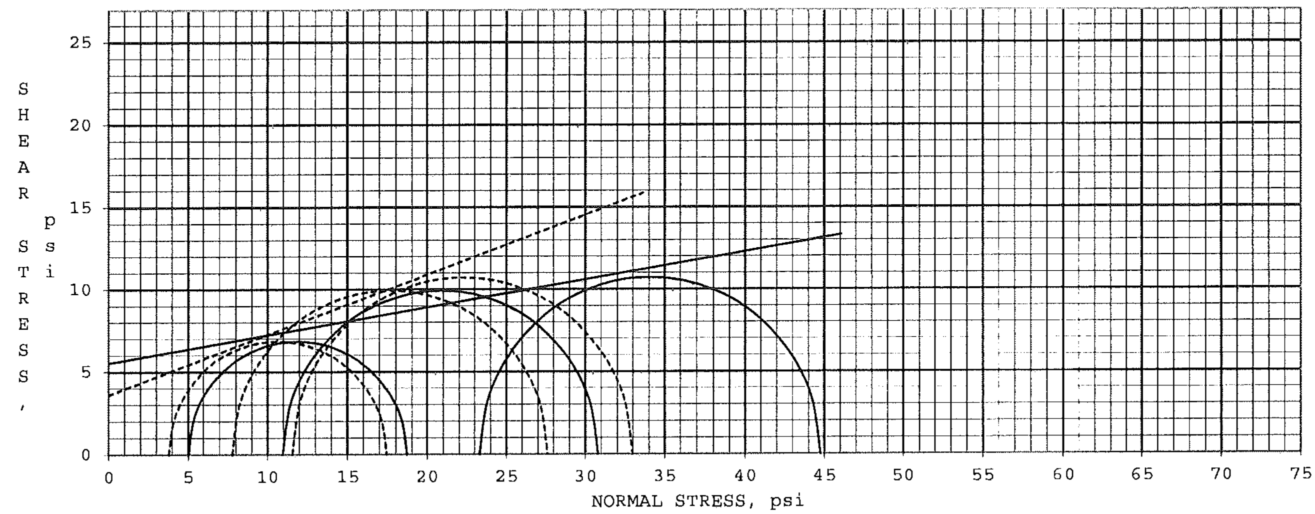
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/8/2015

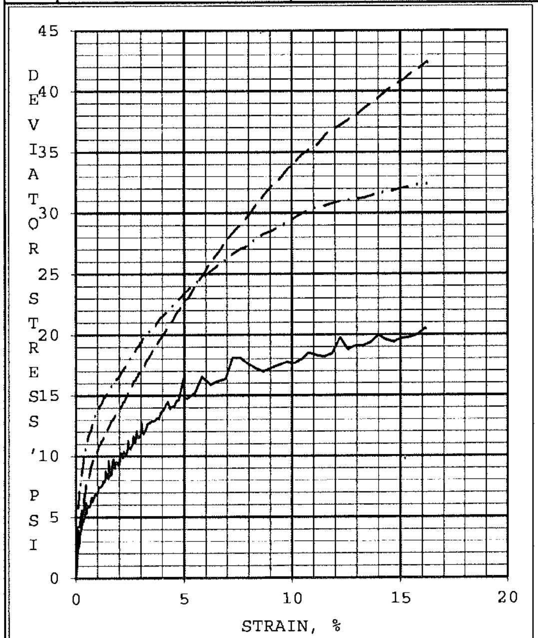
ADDITIONAL CONSOLIDATION DATA

COF-B005
S7
23.5 - 25.5

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.15			1.28E-05	8.21E-06	
0.25	1.58E-03	1.59E-03	4.15E-05	2.67E-05	4.23E-08
0.5	7.63E-04	7.67E-04	2.62E-05	1.69E-05	1.29E-08
1	1.71E-03	1.72E-03	2.30E-05	1.49E-05	2.54E-08
2	3.87E-03	3.89E-03	1.76E-05	1.15E-05	4.43E-08
4	5.26E-03	5.29E-03	1.09E-05	7.22E-06	3.80E-08
8	3.39E-03	3.41E-03	6.23E-06	4.17E-06	1.41E-08
16	2.40E-03	2.41E-03	3.77E-06	2.57E-06	6.16E-09
AVERAGE	2.71E-03	2.73E-03	1.77E-05	1.15E-05	2.62E-08



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	20.0	COHESION, psi	3.6
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	9.6	COHESION, psi	5.5



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	21.1	14.7	20.6
INITIAL	DRY DENSITY, pcf	107.5	119.5	107.6
INITIAL	SATURATION, %	100	97	98
INITIAL	VOID RATIO	0.57	0.41	0.57
BEFORE SHEAR	WATER CONTENT, %	20.4	14.2	23.4
BEFORE SHEAR	DRY DENSITY, pcf	108.6	121.7	103.3
BEFORE SHEAR	SATURATION (B PARAMETER)	0.98	0.99	0.98
BEFORE SHEAR	VOID RATIO	0.55	0.38	0.63
BEFORE SHEAR	FINAL BACK PRESSURE, psi	100.8	101.0	100.6
MINOR PRINCIPAL STRESS, psi		5.0	11.0	23.3
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		13.7	19.8	21.4
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		13.7	19.8	21.4
ULTIMATE DEVIATOR STRESS (15% STR), psi		19.6	40.8	32.0
TIME TO 50% PRIMARY CONSOLIDATION, min		3.70	0.84	3.40
STRAIN RATE, % / hour		4.09	4.09	4.09
INITIAL DIAMETER, inch		1.358	1.363	1.360
INITIAL HEIGHT, inch		2.867	2.739	2.848
AREA AFTER CONSOLIDATION, inch2		1.439	1.446	1.534

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, GRAY WITH GRAYISH BROWN

LL 37	PL 17	PI 20	Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B005

LABORATORY: TERRACON - LENEXA

SAMPLE #: S7

DATE: 9/8/2015

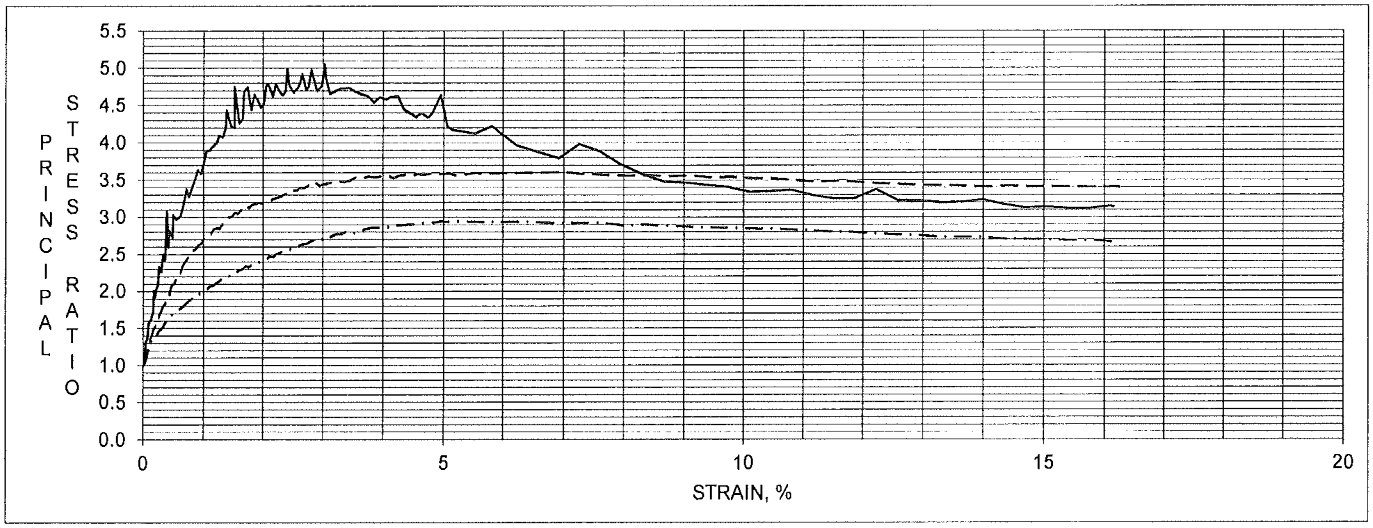
DEPTH, feet: 23.5 - 25.5

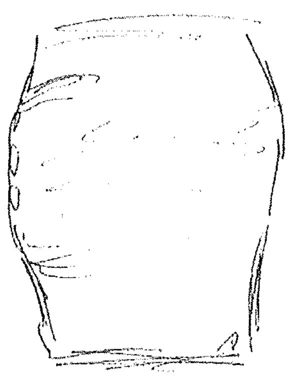
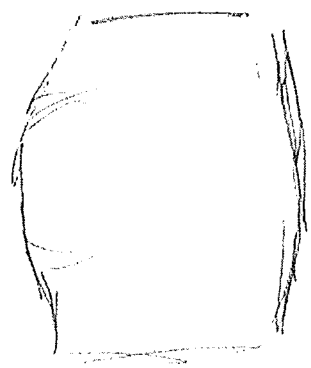
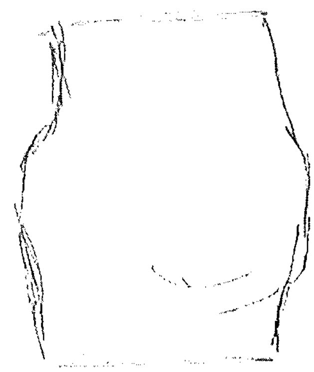
PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

DYNEGY

15151122 COF-B005 S7 23.5 - 25.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

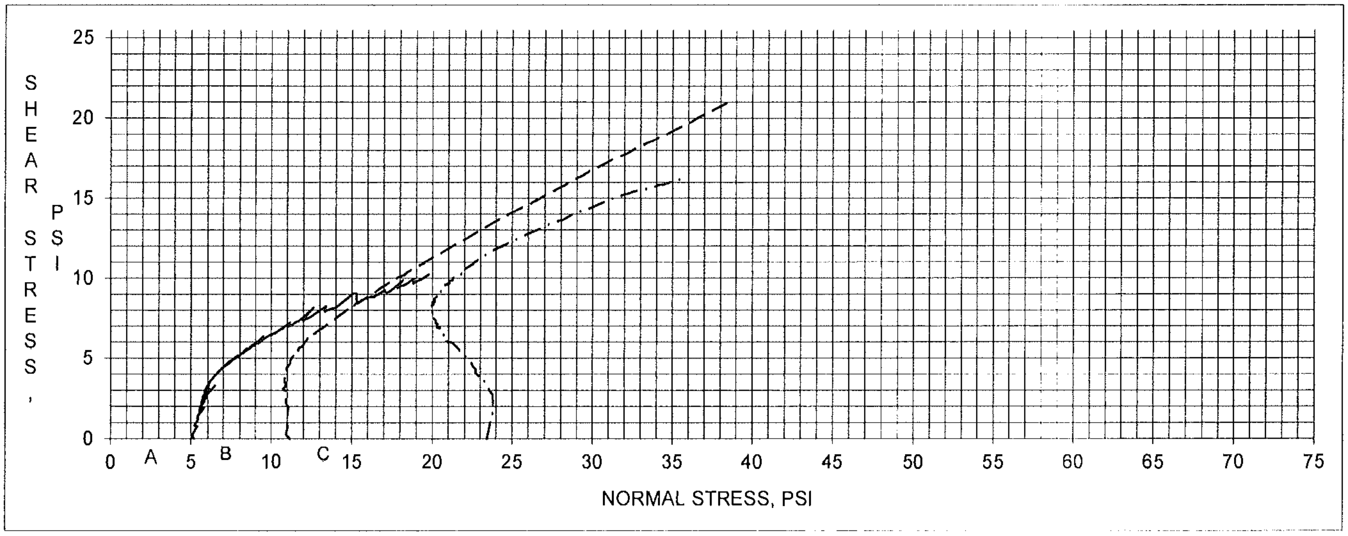
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

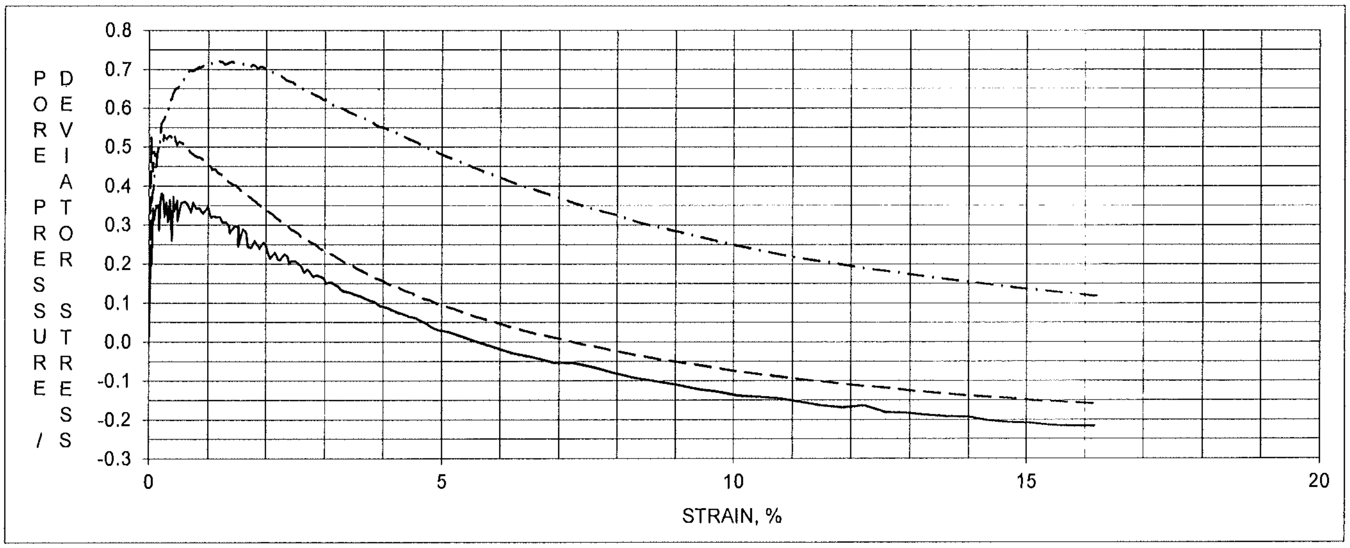
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

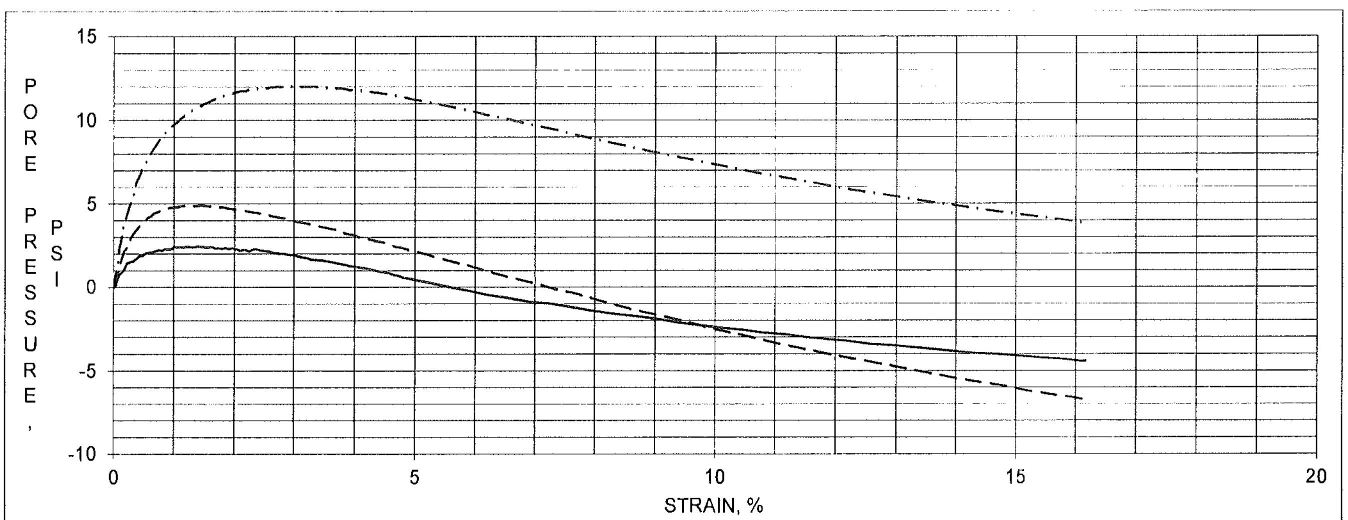
Terracon

DYNEGY

15151122 COF-B005 S7 23.5 - 25.5





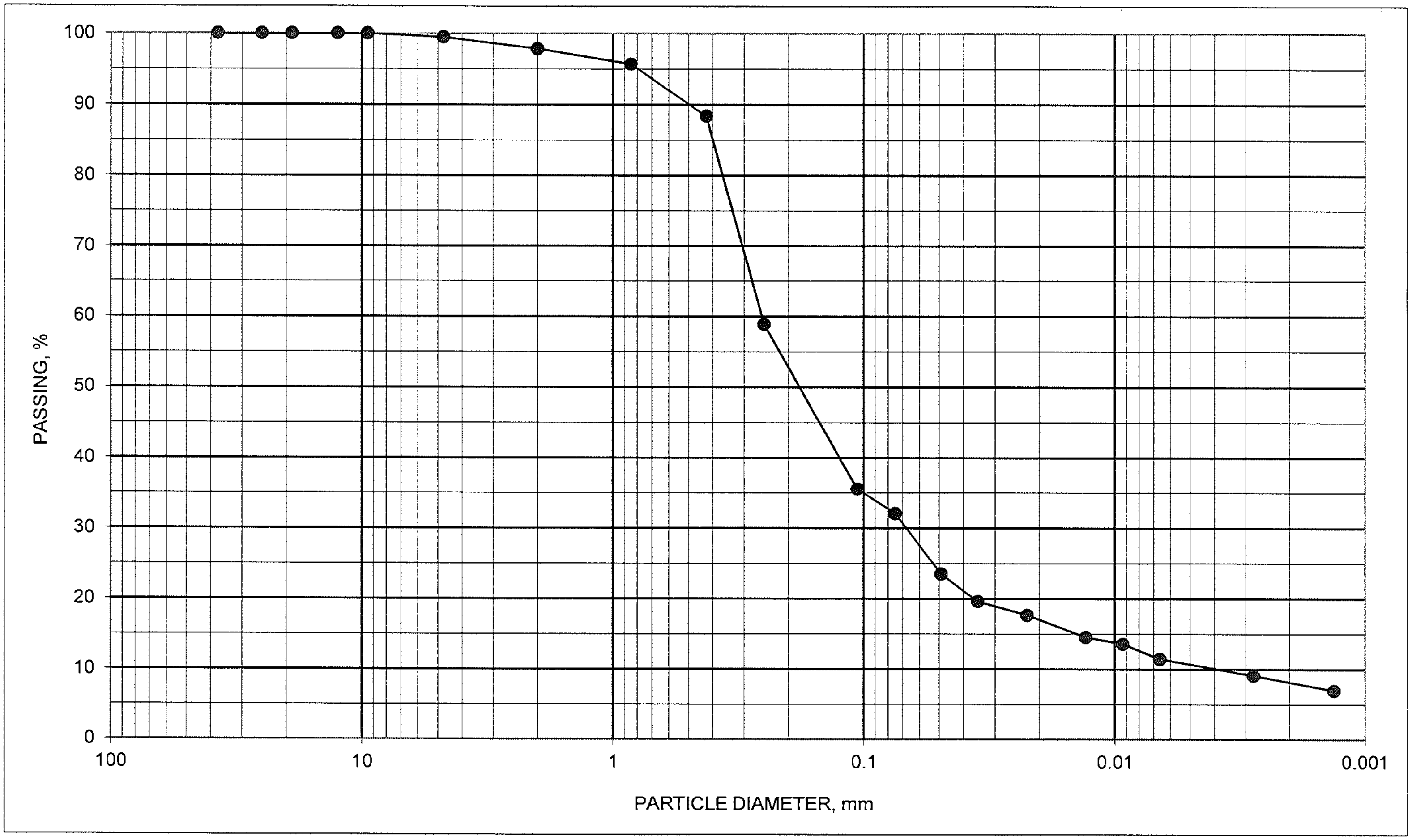


Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	99
#10	2.00	98
#20	0.850	96
#40	0.425	88
#60	0.250	59
#140	0.106	36
#200	0.075	32.1
	0.0492	23.5
	0.0352	19.6
	0.0224	17.7
	0.0131	14.6
	0.0093	13.6
	0.0066	11.5
	0.0028	9.1
	0.0013	7.0

D60	0.2550
D30	0.0677
D10	0.0039
Cu	66.1
Cc	4.7

SPECIFIC GRAVITY 2.65 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S9	33.5 TO 35	SILTY, CLAYEY SAND BROWN & GRAY	SC-SM	26.7	22	16	6

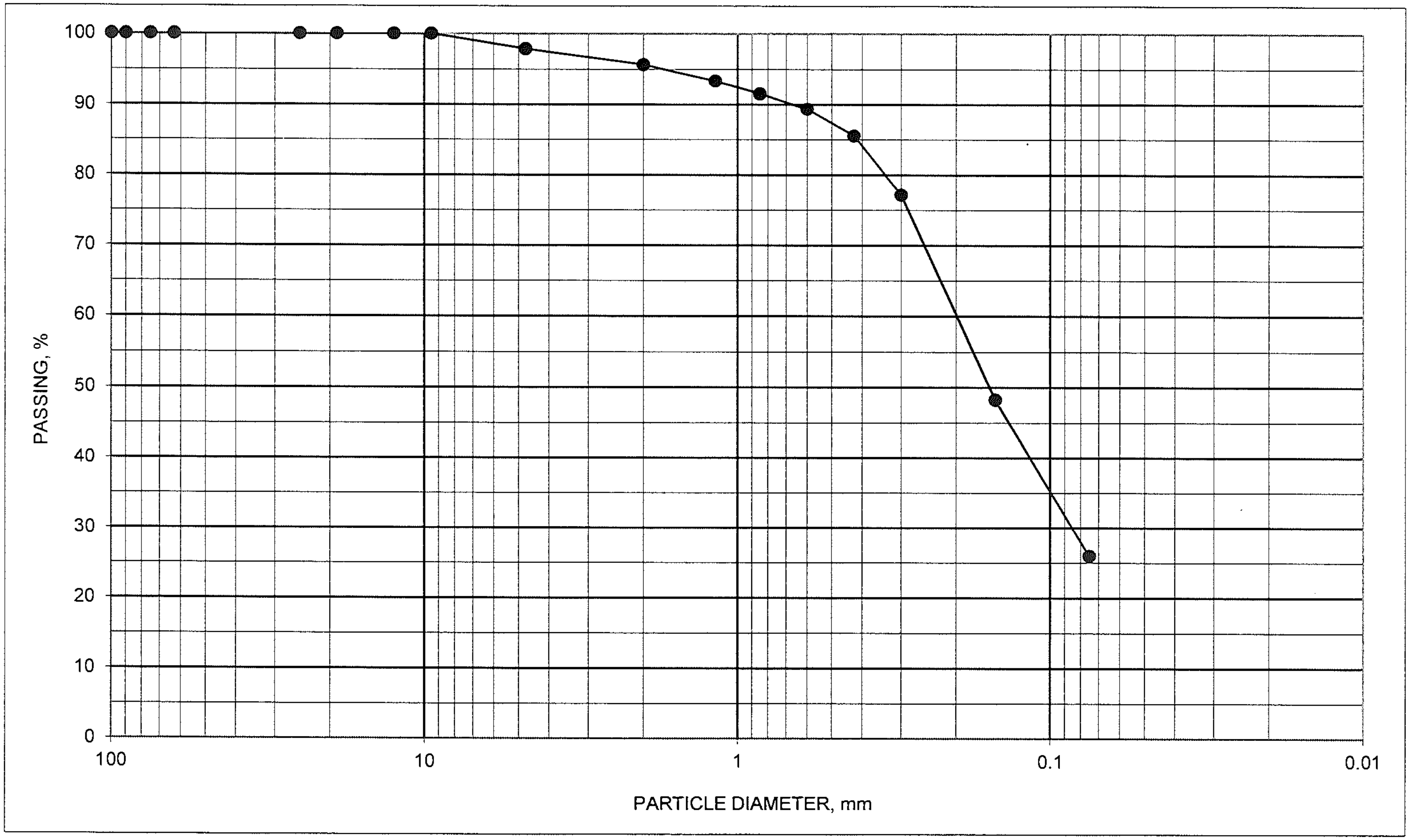
PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B005-S9-33.5.xlsx]ATTERBERG M%

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.5	100
#4	4.8	98
#10	2.00	96
#16	1.18	93
#20	0.85	92
#30	0.600	89
#40	0.425	86
#50	0.300	77
#100	0.150	48
#200	0.075	26.0
	D60	0.1988
	D30	0.0850



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S10	38.5 TO 40	CLAYEY SAND TRACE FINE GRAVEL BROWN & GRAY					

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

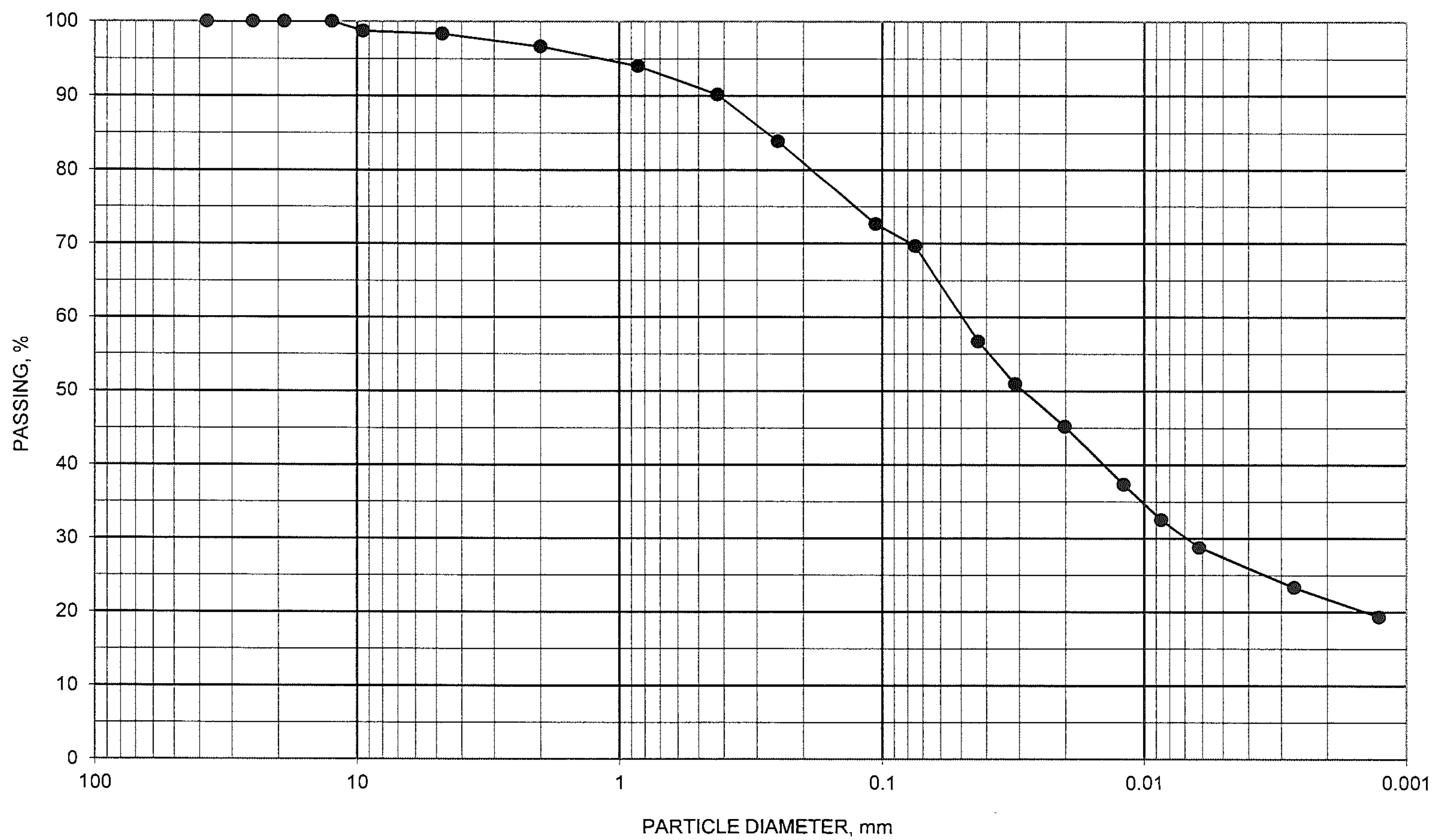
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B005-S10-38.5.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	99
#4	4.75	98
#10	2.00	97
#20	0.850	94
#40	0.425	90
#60	0.250	84
#140	0.106	73
#200	0.075	69.7
	0.0431	56.7
	0.0312	51.0
	0.0202	45.2
	0.0120	37.4
	0.0086	32.6
	0.0062	28.7
	0.0027	23.4
	0.0013	19.3

D60 0.0496
D30 0.0069

SPECIFIC GRAVITY 2.69
ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S11	43.5 TO 45	SANDY LEAN CLAY BROWN & GRAY	CL	12.8	32	15	17

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

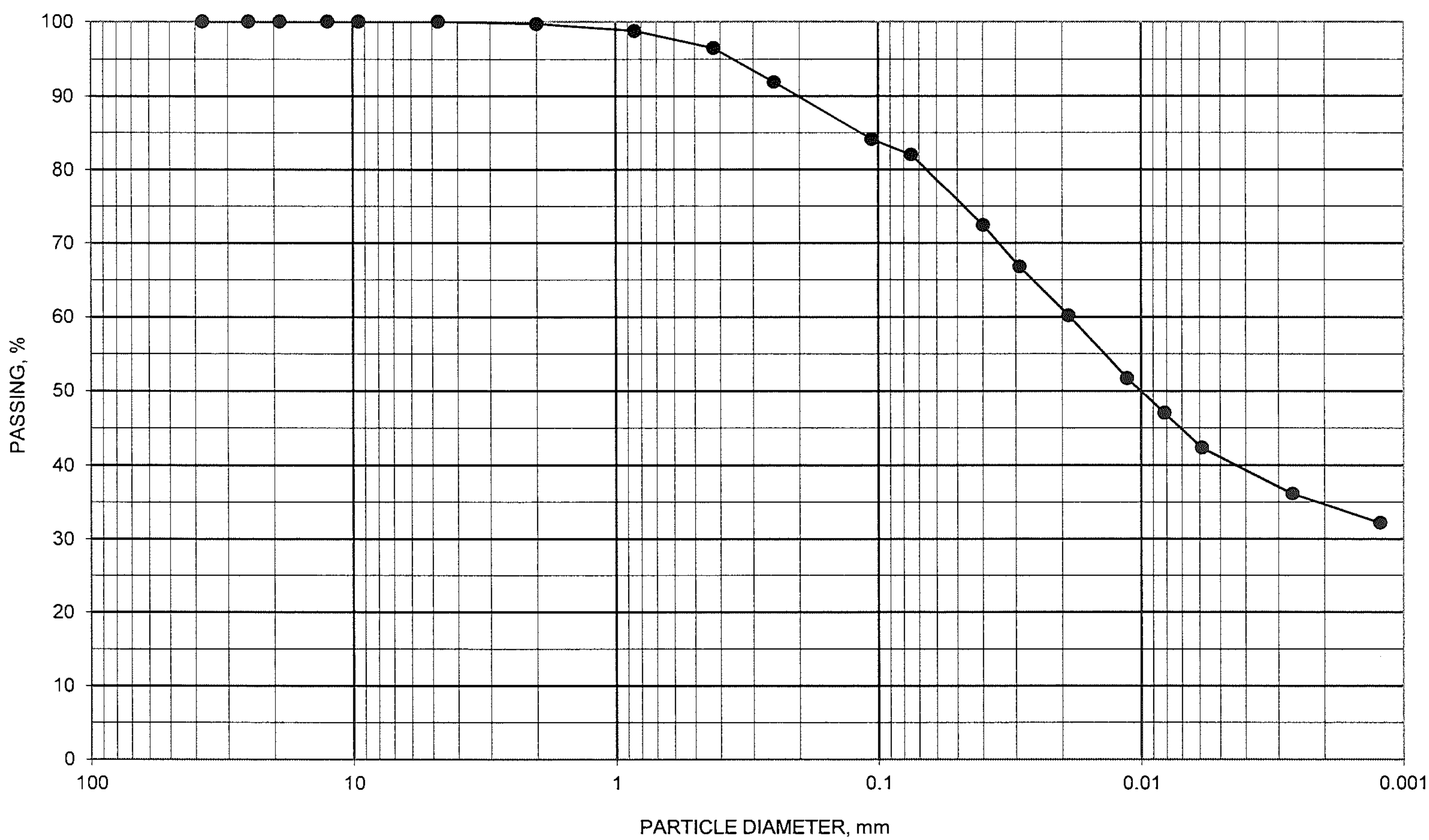
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B005-S11-43.5.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	99
#40	0.425	97
#60	0.250	92
#140	0.106	84
#200	0.075	82.0
	0.0400	72.5
	0.0290	66.8
	0.0189	60.2
	0.0113	51.8
	0.0082	47.0
	0.0059	42.3
	0.0027	36.1
	0.0012	32.2

D60 0.0187

SPECIFIC GRAVITY 2.69 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S14	58.5 TO 60	LEAN CLAY WITH SAND BROWN & GRAY	CL	23.3	47	17	30

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B005-S14-58.5.xlsx]GRADATION

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B006	S1	1.0	2.5	6.6					** Sieve									
	Color		black							Visual Classification		Fill: Cinders; Well-Graded Sand with Silt trace Fine Gravel						
	S2	3.5	5.0	48.3							2.54							
	Color		black							Visual Classification		Fill: Cinders with Clay						
	S3	6.0	8.0	22.2					** Sieve									
	Color		black							Visual Classification		Fill: Cinders; Well Graded Sand with Clay						
	S4	8.5	10.0	16.7														
	Color		black							Visual Classification		Fill: Cinders						
	S5	13.5	15.0	24.4		57	20	37										
	Color		brown & gray							Visual Classification		Fat Clay frace Fine Sand						
	S6	18.5	20.0	21.9														
	Color		brown & gray							Visual Classification		Lean to Fat Clay						
	S7	23.5	25.0	19.8		23	14	9										
	Color		brown							Visual Classification		Sandy Lean Clay						
	S8	28.5	30.0	16.1														
	Color		brown & gray							Visual Classification		Sandy Lean CLay						
	S9	32.0	33.5	8.1		25	13	12										
	Color		brown & gray							Visual Classification		Sandy Lean Clay trace Fine Gravel						

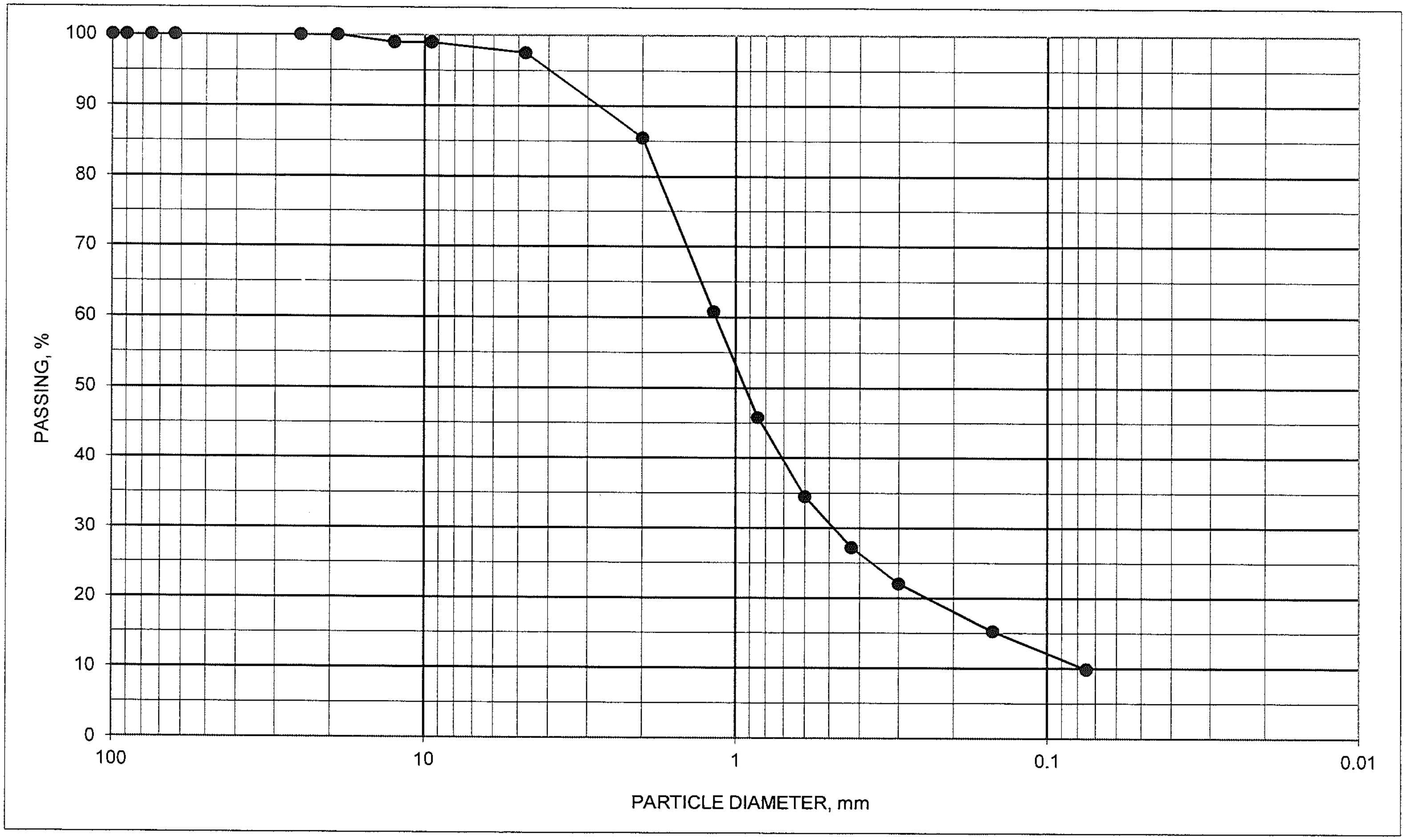
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	99
3/8"	9.5	99
#4	4.8	98
#10	2.00	85
#16	1.18	61
#20	0.85	46
#30	0.600	35
#40	0.425	27
#50	0.300	22
#100	0.150	15
#200	0.075	9.9

D60	1.1603
D30	0.4849
D10	0.0763
Cu	15.2
Cc	2.7



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B006	S-1	1 TO 2.5	CINDERS; WELL-GRADED SAND WITH SILT TRACE FINE GRAVEL BLACK					

PROJECT DYNEGY

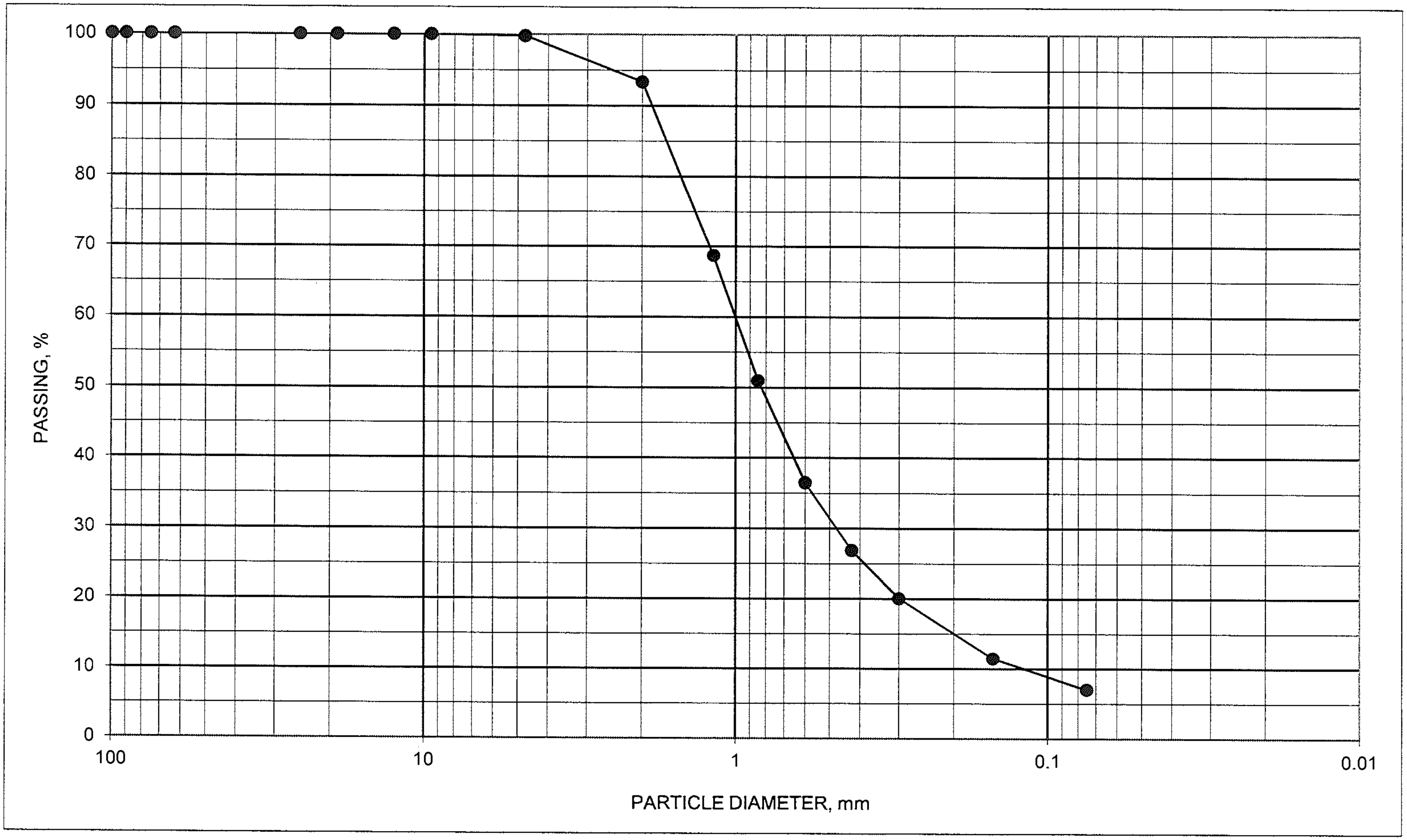
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B006-S1-1.0.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.5	100
#4	4.8	100
#10	2.00	93
#16	1.18	69
#20	0.85	51
#30	0.600	36
#40	0.425	27
#50	0.300	20
#100	0.150	11
#200	0.075	7.0

D60	1.0042
D30	0.4757
D10	0.1188
Cu	8.5
Cc	1.9



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B006	S3	6 TO 8	CINDERS: WELL-GRADED SAND WITH CLAY BLACK					

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B006-S3-6.0.xlsx]GRADATION

Terracon

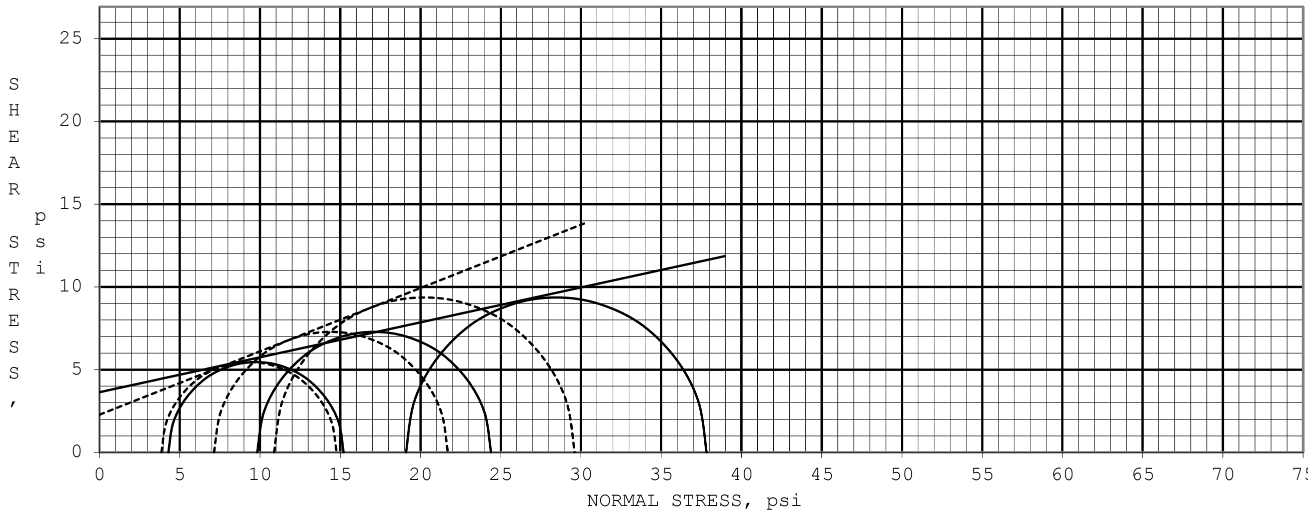
DYNEGY - COFFEEN, ILLINOIS
15151122
9/25/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B007	S1	1.0	2.5	21.4														
	Color		brown							Visual Classification			Fill: Sand, Cinders & Clay					
	S2	3.5	5.5	23.2	102.9	46	19	27										
	Color									Visual Classification								
	S3	5.5	7.5	21.7	107.6	43	17	26						NOTE*				
	Color		gray trace yellowish brown							Visual Classification			Lean Clay with Sand					
	S4	8.5	10.0	25.3					NOTE*									
	Color		brown & gray							Visual Classification			Lean Clay trace Fine Sand					
	S5	13.5	15.0	21.6		47	19	28										
	Color		brown & gray							Visual Classification			Lean Clay trace Fine Sand & Gravel					
	S6	18.5	20.0	24.5														
	Color		brown & gray							Visual Classification			Lean to Fat Clay trace Fine to Coarse Sand					
	S7	20.0	22.0	22.5	103.7	52	17	35					NOTE*	NOTE*				
	Color		yellowish brown with dark gray							Visual Classification			Fat Clay with Sand trace Gravel					
	S8	22.0	24.0	18.3	108.6	43	16	27		20*		7.0E-08*			NOTE*	ND1*	1*	
	Color		yellowish brown							Visual Classification			Sandy Lean Clay					
	S9	28.5	30.0	20.3					NOTE*									
	Color		brown & gray							Visual Classification			Sandy Lean Clay					
	S10	34.0	35.5	11.0		34	15	19										
	Color		gray							Visual Classification			Sandy Lean Clay					
	S11	36.0	37.5	13.6					NOTE*									
	Color		gray							Visual Classification			Lean Clay with Sand					

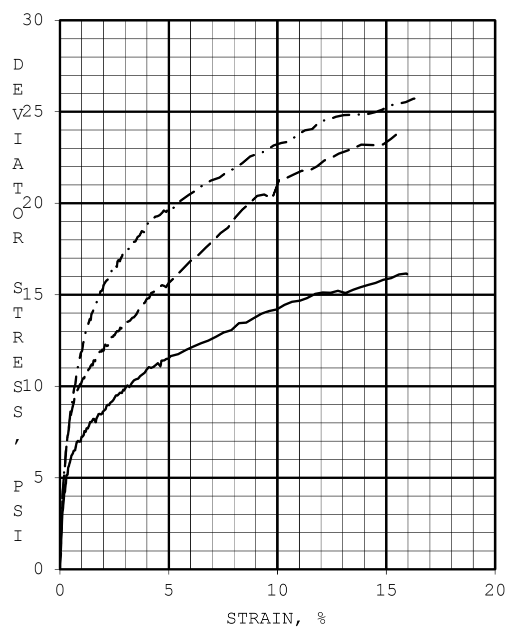
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**20.9**	COHESION, psi	**2.3**
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**11.9**	COHESION, psi	**3.6**



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	23.2	19.6	22.2
	DRY DENSITY, pcf	106.4	109.7	106.7
	SATURATION, %	107	99	104
	VOID RATIO	0.58	0.54	0.58
BEFORE SHEAR	WATER CONTENT, %	21.4	19.2	19.8
	DRY DENSITY, pcf	106.8	111.0	109.7
	SATURATION (B PARAMETER)	0.95	1.00	0.95
	VOID RATIO	0.58	0.52	0.54
	FINAL BACK PRESSURE, psi	100.3	99.6	100.6
MINOR PRINCIPAL STRESS, psi		4.3	9.8	19.1
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		10.9	14.6	18.7
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		10.9	14.6	18.7
ULTIMATE DEVIATOR STRESS (15% STR), psi		15.9	23.3	25.2
TIME TO 50% PRIMARY CONSOLIDATION, min		13.00	60.00	21.00
STRAIN RATE, % / hour		0.84	0.27	0.86
INITIAL DIAMETER, inch		1.358	1.368	1.371
INITIAL HEIGHT, inch		2.883	2.834	2.833
AREA AFTER CONSOLIDATION, inch2		1.446	1.457	1.443

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, GRAY TRACE YELLOWISH BROWN

LL	PL	PI	Gs
43	17	26	2.7 EST.

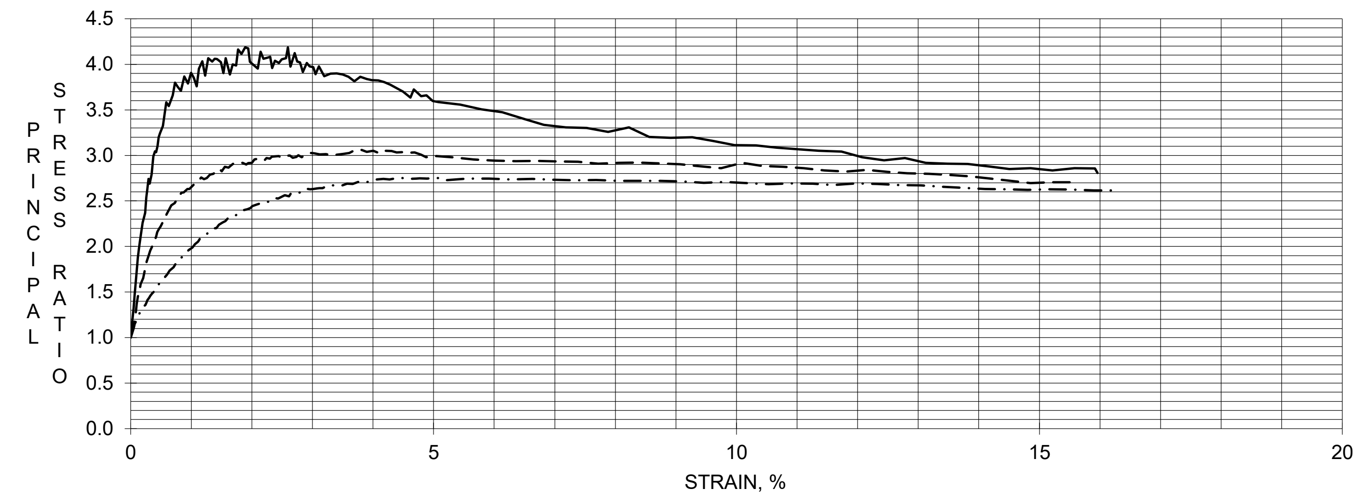
PROJECT NO. 15151122	PROJECT: DYNEGY COFFEEN, ILLINOIS
	BORING #: COF-B007
LABORATORY: TERRACON - LENEXA	SAMPLE #: S3
DATE: 9/24/2015	DEPTH, feet: 5.5 - 7.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

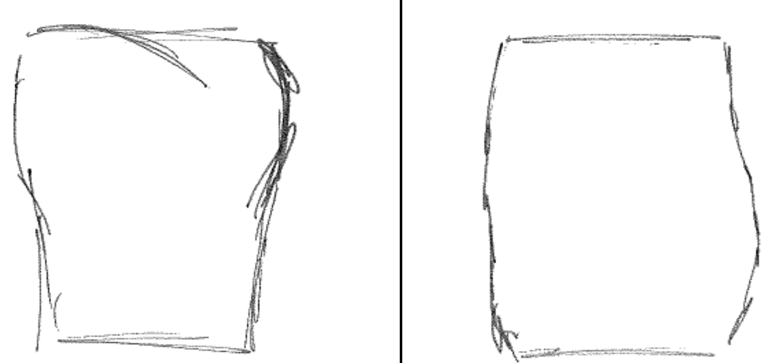
Terracon

DYNEGY

15151122 COF-B007 S3 5.5 - 7.5



FAILURE SKETCH | FAILURE SKETCH | FAILURE SKETCH



SPECIMEN A | SPECIMEN B | SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

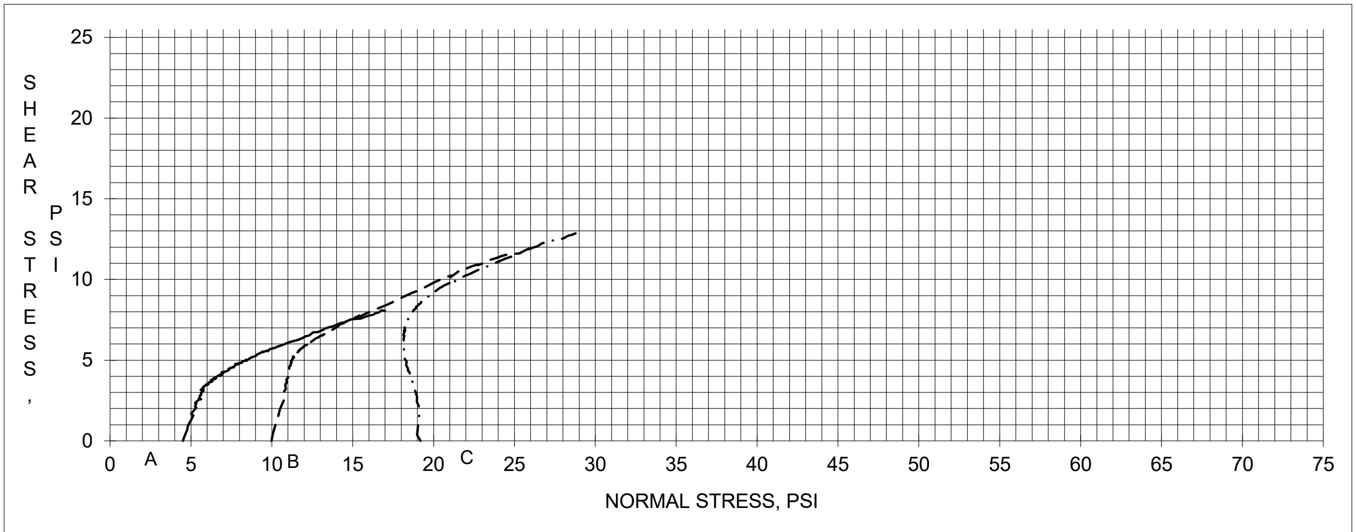
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

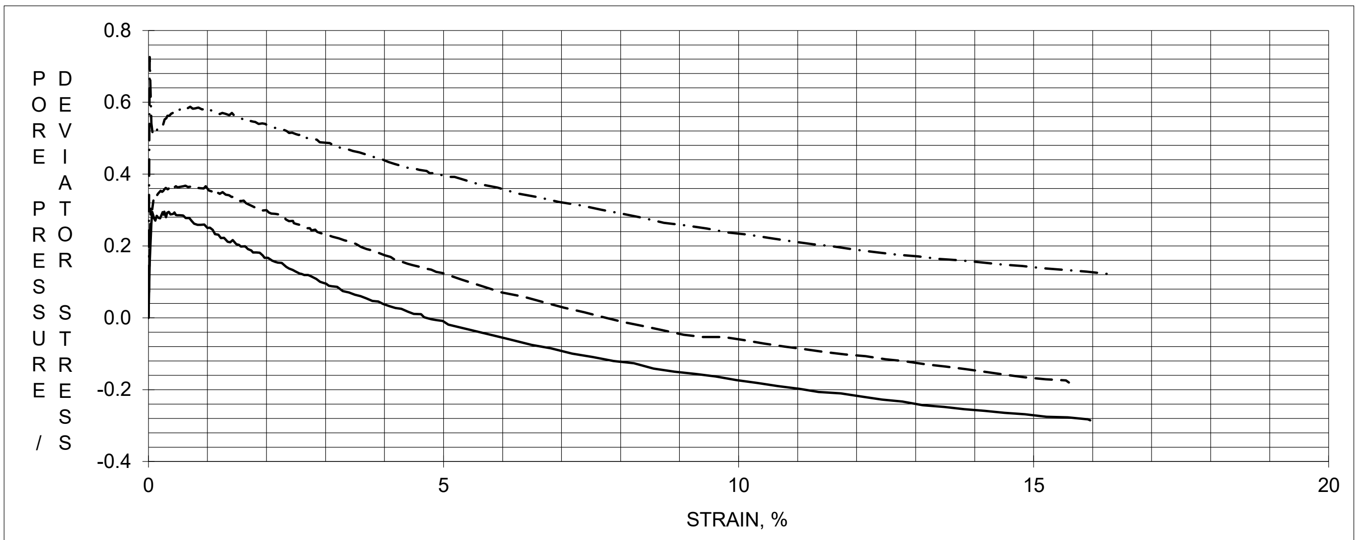
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

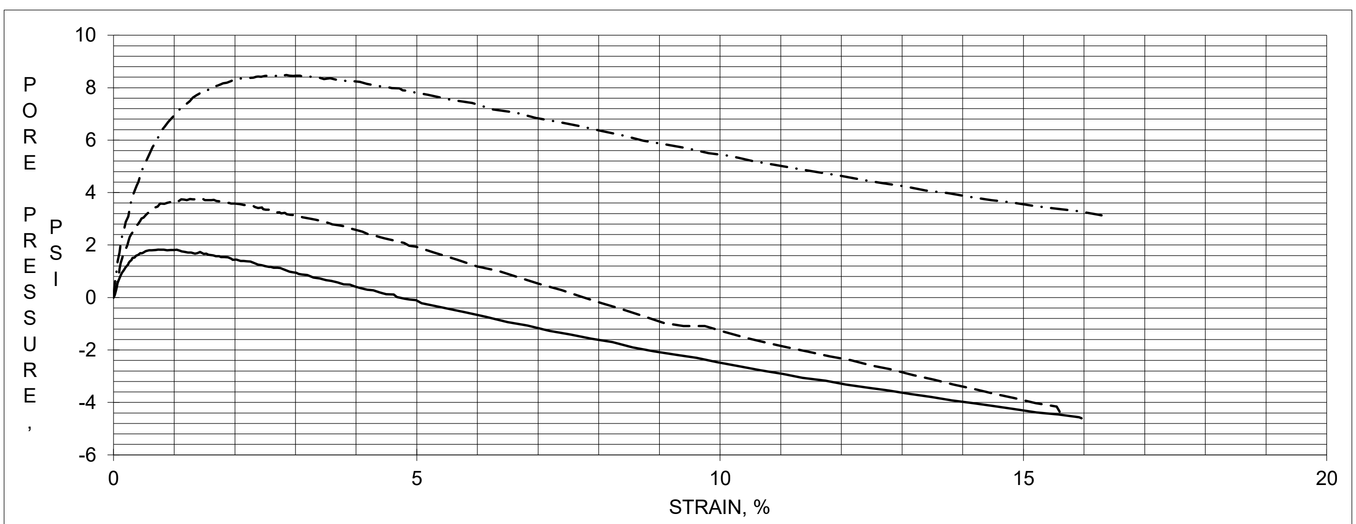
Terracon

DYNEGY

15151122 COF-B007 S3 5.5 - 7.5



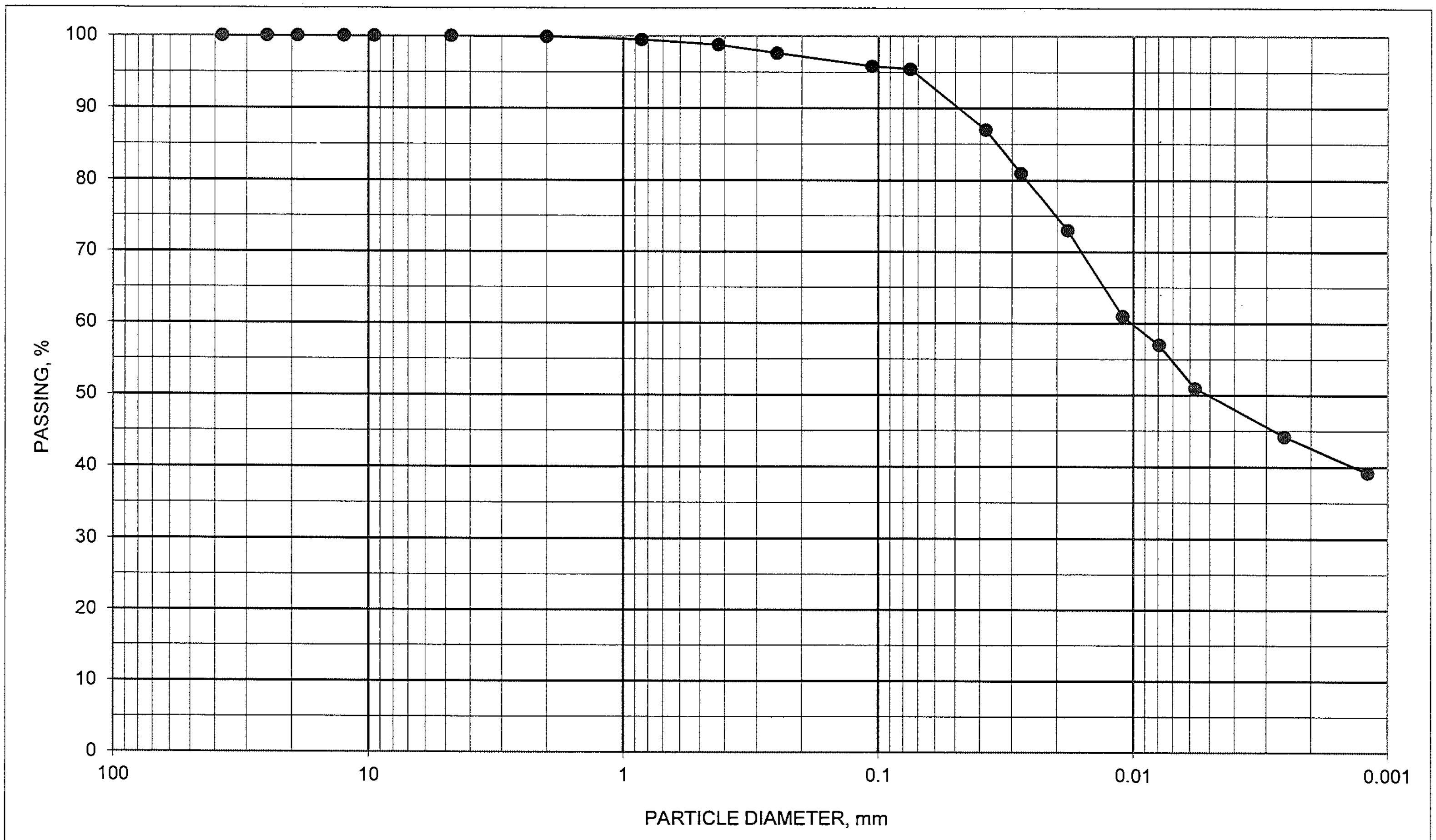




Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	99
#60	0.250	98
#140	0.106	96
#200	0.075	95.4
	0.0380	87.0
	0.0277	81.0
	0.0182	73.0
	0.0110	61.0
	0.0079	57.0
	0.0057	51.0
	0.0026	44.2
	0.0012	39.2
	D60	0.0102

SPECIFIC GRAVITY 2.70 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B007	S4	8.5 TO 10	LEAN CLAY, TRACE SAND BROWN & GRAY		25.3			

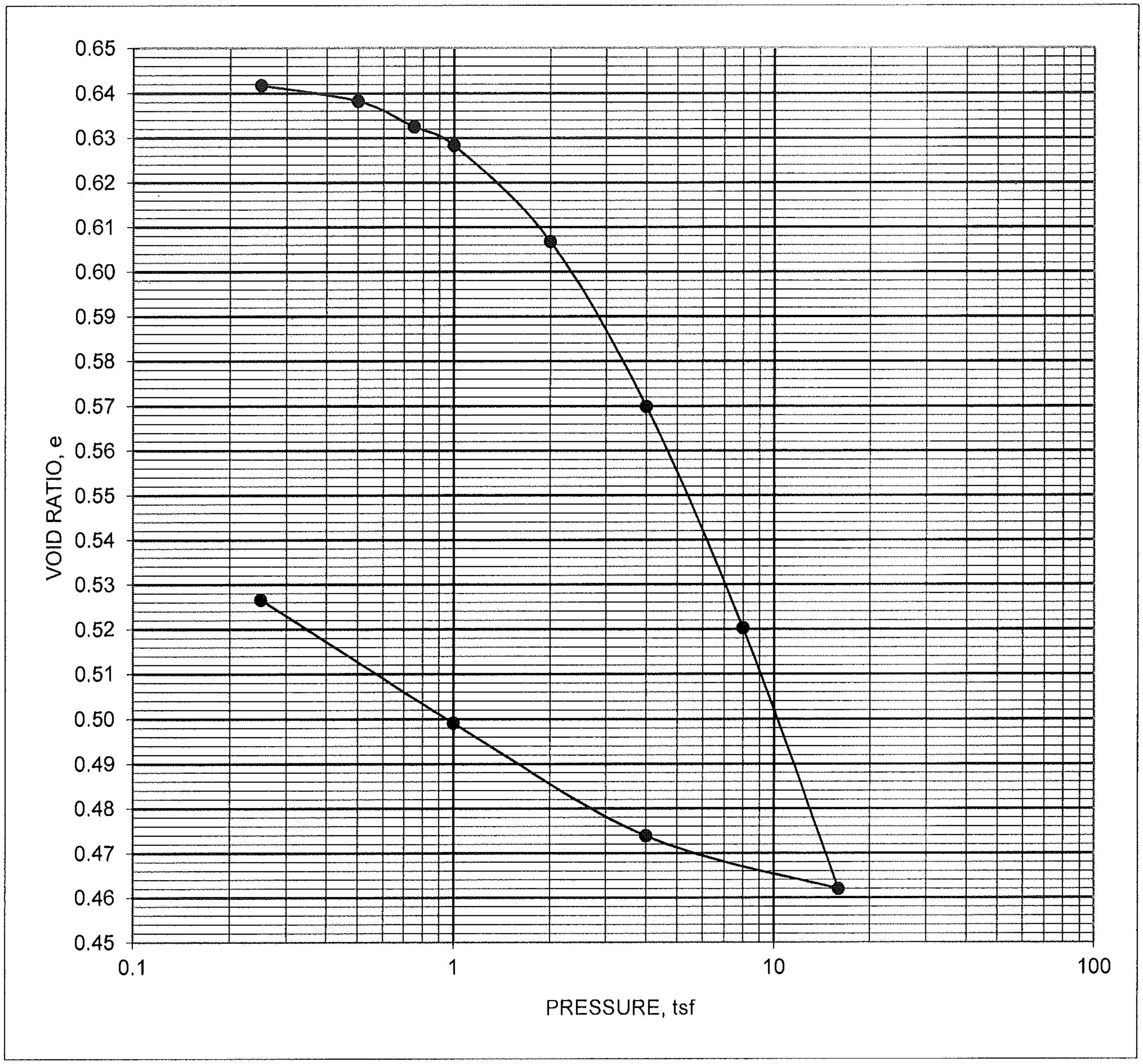
PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B007-S4-8.5.xlsx]REPORT

Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.57	HEIGHT, mm	18.98	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		1.32		MOISTURE, %	22.5	19.6
PRECONSOL. PRESSURE, tsf		2.31		DRY DENSITY, pcf	102.6	110.2
OVER CONSOLIDATION RATIO		1.8		SATURATION, %	94	100
COMPRESSION INDEX		0.19		VOID RATIO	0.642	0.526
REBOUND INDEX		0.044		SAMPLE TYPE	UNDISTURBED	

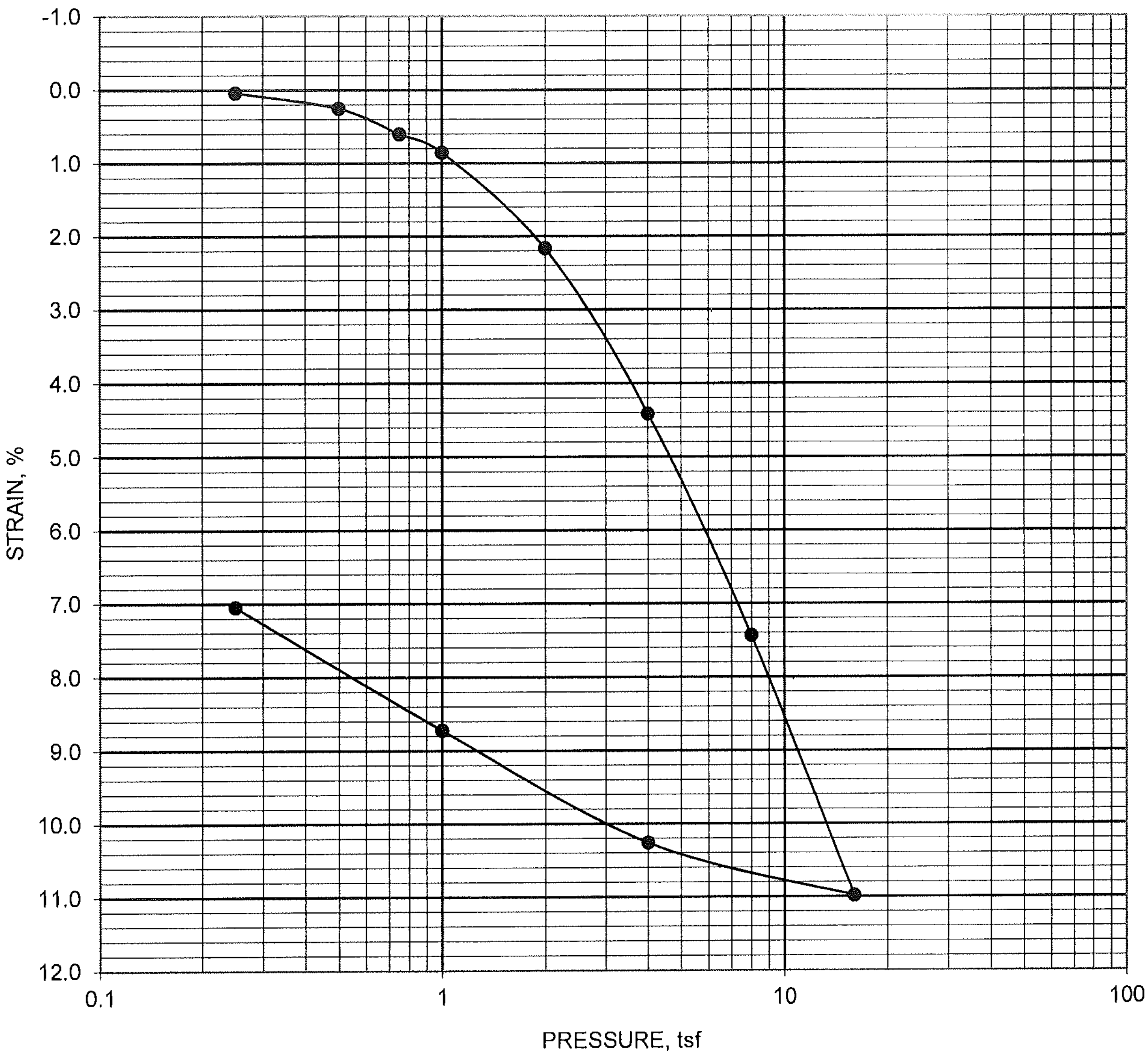
LIQUID LIMIT	52	PLASTIC LIMIT	17	PLASTICITY INDEX	35	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	FAT CLAY WITH SAND TRACE GRAVEL, YELLOWISH BROWN WITH DARK GRAY						
BORING NO.	COF-B007	SAMPLE NO.	S7	DEPTH, feet	20.0 - 22.0		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B007\[15151122 Consolidation COF-B007-S7

Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.57	HEIGHT, mm	18.98	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		1.32		MOISTURE, %		22.5	19.6
PRECONSOL. PRESSURE, tsf		2.31		DRY DENSITY, pcf		102.6	110.2
OVER CONSOLIDATION RATIO		1.8		SATURATION, %		94	100
COMPRESSION INDEX		0.19		VOID RATIO		0.642	0.526
REBOUND INDEX		0.044		SAMPLE TYPE		3" SHELBY TUBE	
LIQUID LIMIT	52	PLASTIC LIMIT	17	PLASTICITY INDEX	35	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	FAT CLAY WITH SAND TRACE GRAVEL, YELLOWISH BROWN WITH DARK GRAY						
BORING NO.	COF-B007	SAMPLE NO.	S7	DEPTH, feet	20.0 - 22.0		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B007\[15151122 Consolidation COF-B007-S7

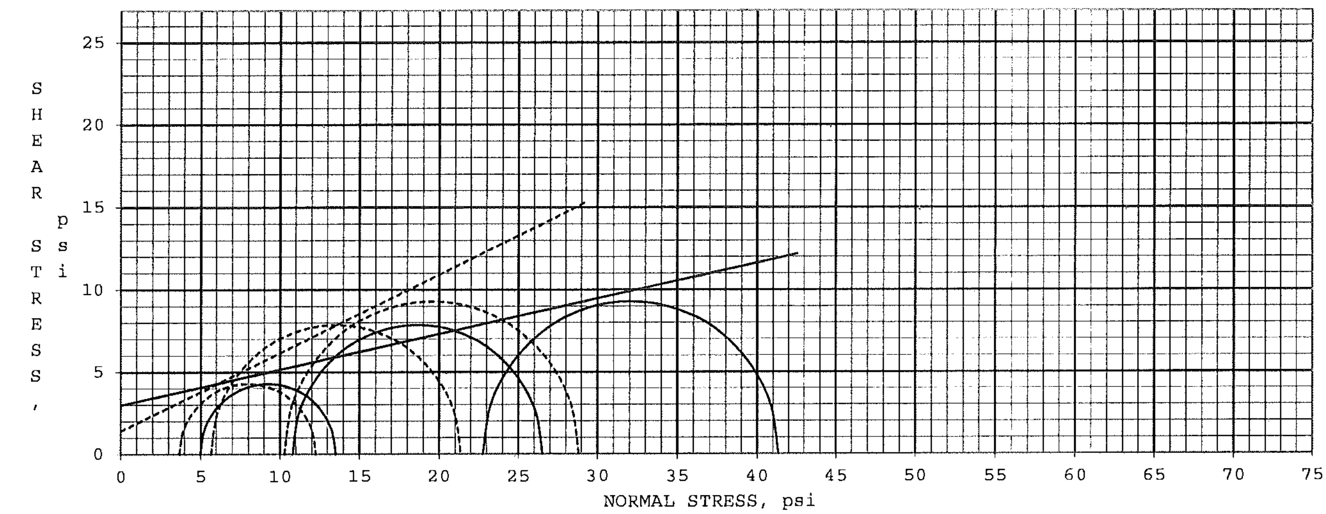
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

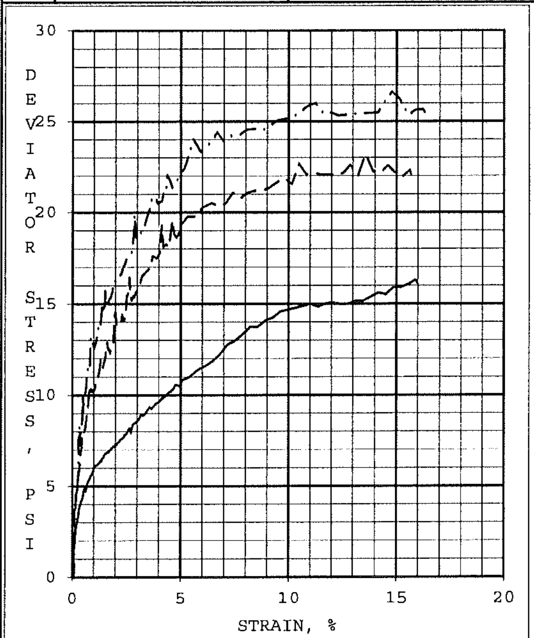
ADDITIONAL CONSOLIDATION DATA

COF-B007
S7
20.0 - 22.0

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.25			2.69E-06	1.64E-06	
0.5	1.09E-03	1.10E-03	1.44E-05	8.75E-06	9.55E-09
0.75	4.88E-04	4.91E-04	2.34E-05	1.43E-05	6.96E-09
1	2.24E-04	2.25E-04	1.71E-05	1.05E-05	2.34E-09
2	1.14E-03	1.15E-03	2.20E-05	1.35E-05	1.55E-08
4	6.72E-04	6.76E-04	1.89E-05	1.17E-05	7.89E-09
8	4.26E-04	4.29E-04	1.27E-05	8.08E-06	3.45E-09
16	2.98E-04	3.00E-04	7.44E-06	4.89E-06	1.46E-09
AVERAGE	6.21E-04	6.24E-04	1.48E-05	9.17E-06	6.73E-09



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**25.4**	COHESION, psi	**1.4**
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**12.2**	COHESION, psi	**3.0**



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	21.1	23.8	22.7
INITIAL	DRY DENSITY, pcf	105.7	102.5	103.0
INITIAL	SATURATION, %	96	100	96
INITIAL	VOID RATIO	0.60	0.64	0.64
BEFORE SHEAR	WATER CONTENT, %	21.5	22.8	21.2
BEFORE SHEAR	DRY DENSITY, pcf	106.6	104.2	107.1
BEFORE SHEAR	SATURATION (B PARAMETER)	0.98	0.98	0.97
BEFORE SHEAR	VOID RATIO	0.58	0.62	0.57
BEFORE SHEAR	FINAL BACK PRESSURE, psi	100.7	100.5	100.5
MINOR PRINCIPAL STRESS, psi		5.0	10.8	22.8
EFFECTIVE STRESS PEAK AT % STRAIN		3.0	3.0	3.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		8.6	15.7	18.6
TOTAL STRESS PEAK AT % STRAIN		3.0	3.0	3.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		8.6	15.7	18.6
ULTIMATE DEVIATOR STRESS (15% STR), psi		15.9	22.1	26.4
TIME TO 50% PRIMARY CONSOLIDATION, min		3.10	4.00	5.00
STRAIN RATE, % / hour		3.19	3.14	3.30
INITIAL DIAMETER, inch		1.369	1.363	1.370
INITIAL HEIGHT, inch		2.914	2.832	2.841
AREA AFTER CONSOLIDATION, inch2		1.461	1.444	1.435

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
FAT CLAY WITH SAND TRACE GRAVEL, YELLOWISH BROWN WITH DARK GRAY

LL 52	PL 17	PI 35	Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B007

LABORATORY: TERRACON - LENEXA

SAMPLE #: S7

DATE: 9/8/2015

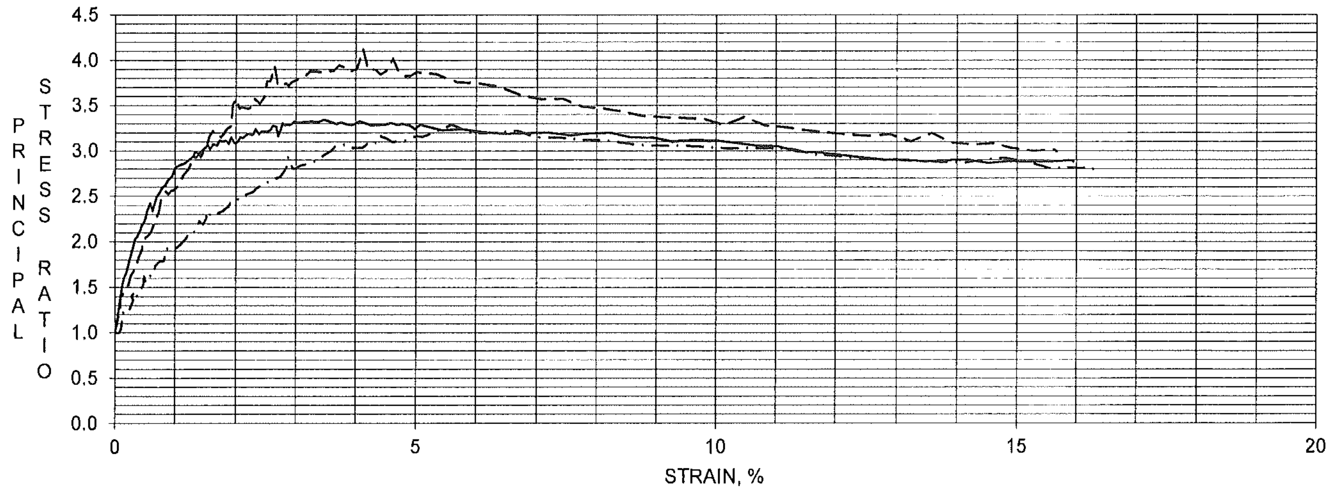
DEPTH, feet: 20.0 - 22.0

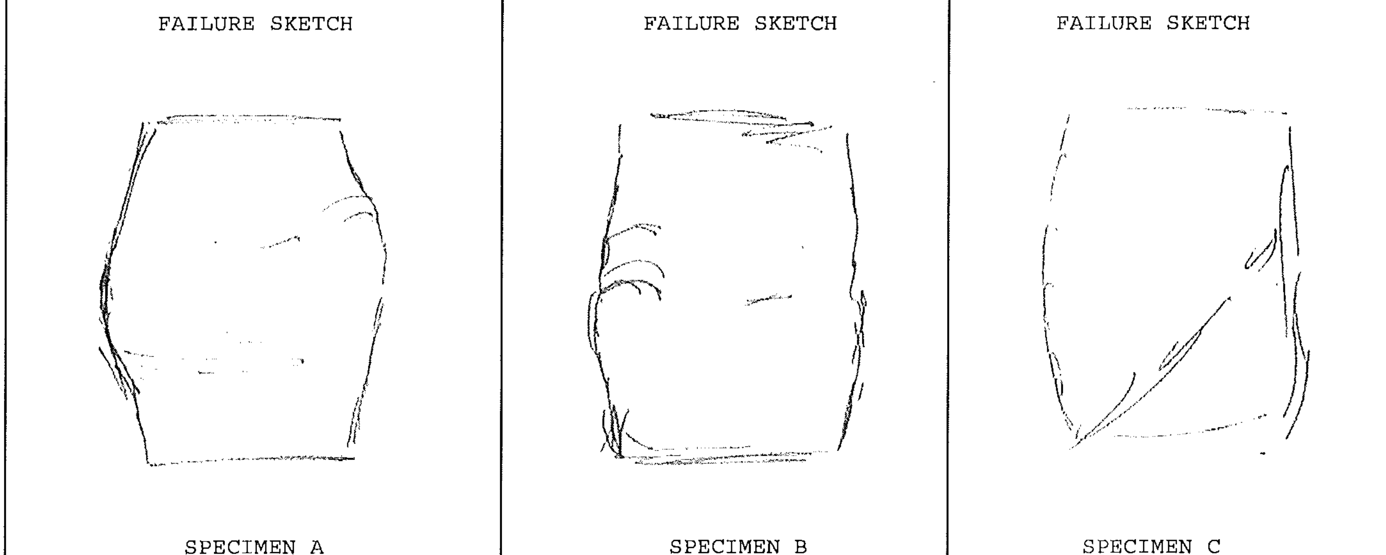
PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

DYNEGY

15151122 COF-B007 S7 20.0 - 22.0





REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 3 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 3 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 3 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 3 % STRAIN.

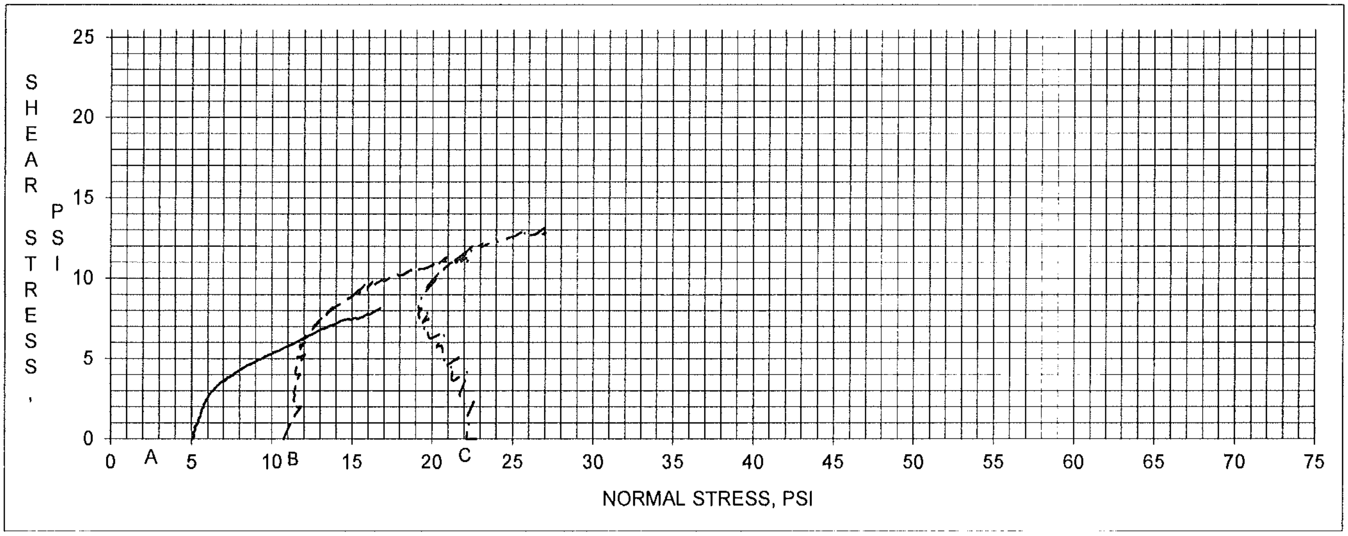
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

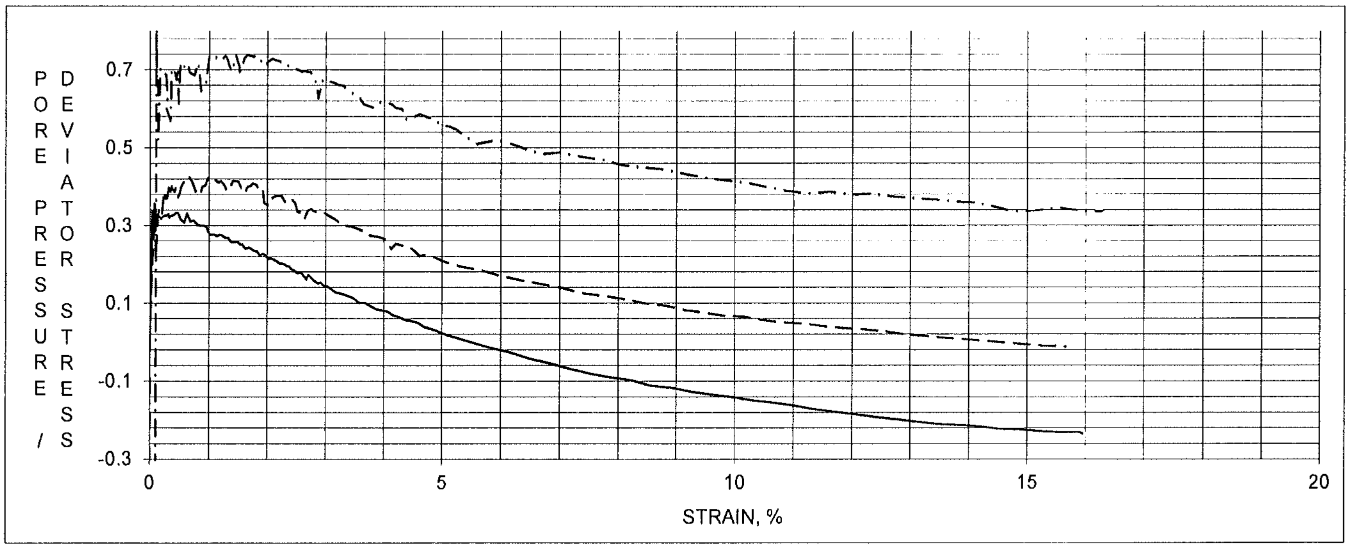
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

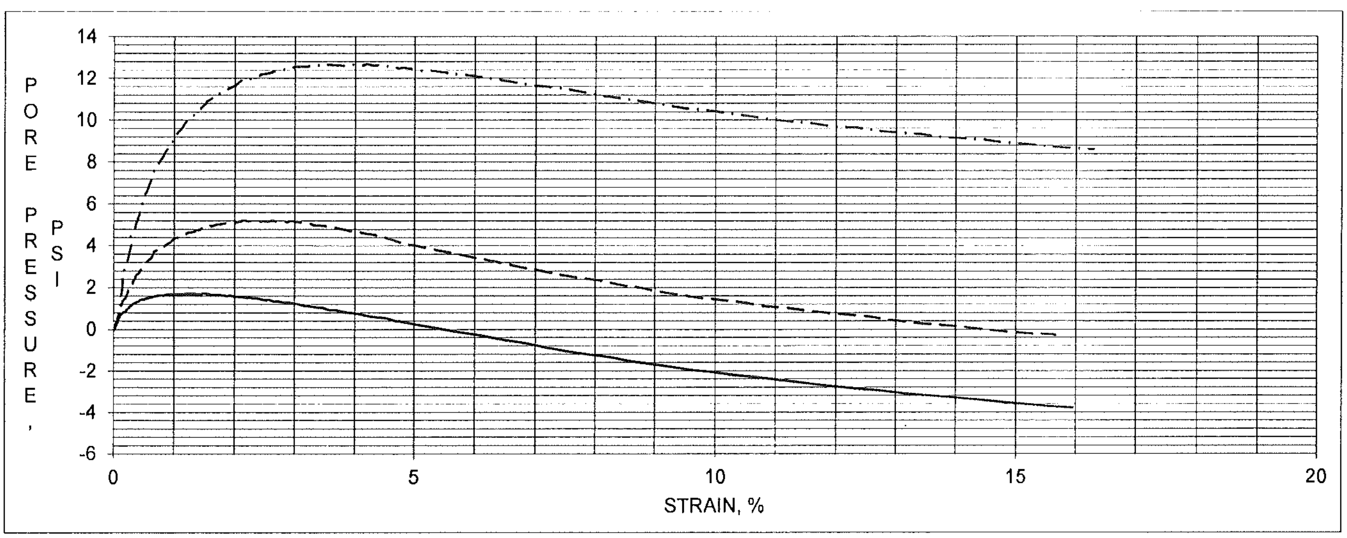
Terracon

DYNEGY

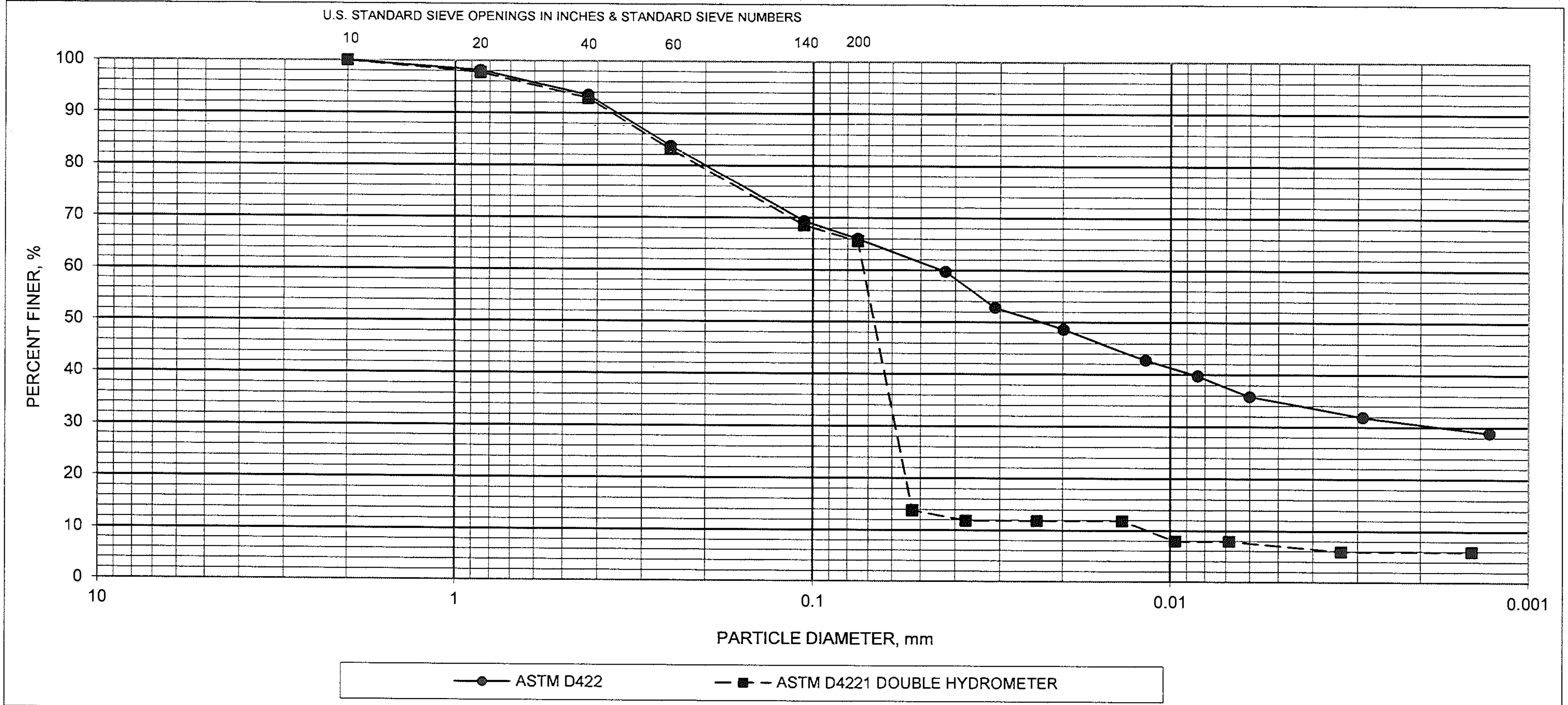
15151122 COF-B007 S7 20.0 - 22.0







Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	34.8	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	7.0	DISPERSION, %	**20**

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B007	S8	22.0 - 24.0						

PROJECT DYNEGY

COFFEEN, ILLINOIS

JOB NO. 15151122 DATE 9/2/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B007-S8-22.0.xls]Double Hydrometer Da

Terracon

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 03 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N CaSO4

PROJECT NAME:	DYNEGY	PROJECT NUMBER:	15151122
LOCATION:	COFFEEN, ILLINOIS	DATE:	7/30/2015
		PANEL IDENTIFICATION:	Lenexa Perm Board
SAMPLE ID:	COF-B007 S8 22.0 - 24.0 feet	BURETTE AREA:	0.312 cm^2
SAMPLE DESCR.:	SANDY LEAN CLAY, YELLOWISH BROWN	BURETTE INCREMENT LENGTH:	1.000 cm
		VOLUME PER INCREMENT:	0.312 cm^3

INITIAL

MOISTURE%		DENSITY			
W & T, g	142.44	WET WT, g	432.7		
D & T, g	125.52	DIA, in	2.863	7.27	cm
T, g	33.26	HT, in	1.992	5.06	cm
		AREA		41.53	cm^2
MOIST-		DENSITY:	128.5	PCF WET	
URE, %	**18.3**	DENSITY:	**108.6**	PCF DRY	

ADDITIONAL DATA

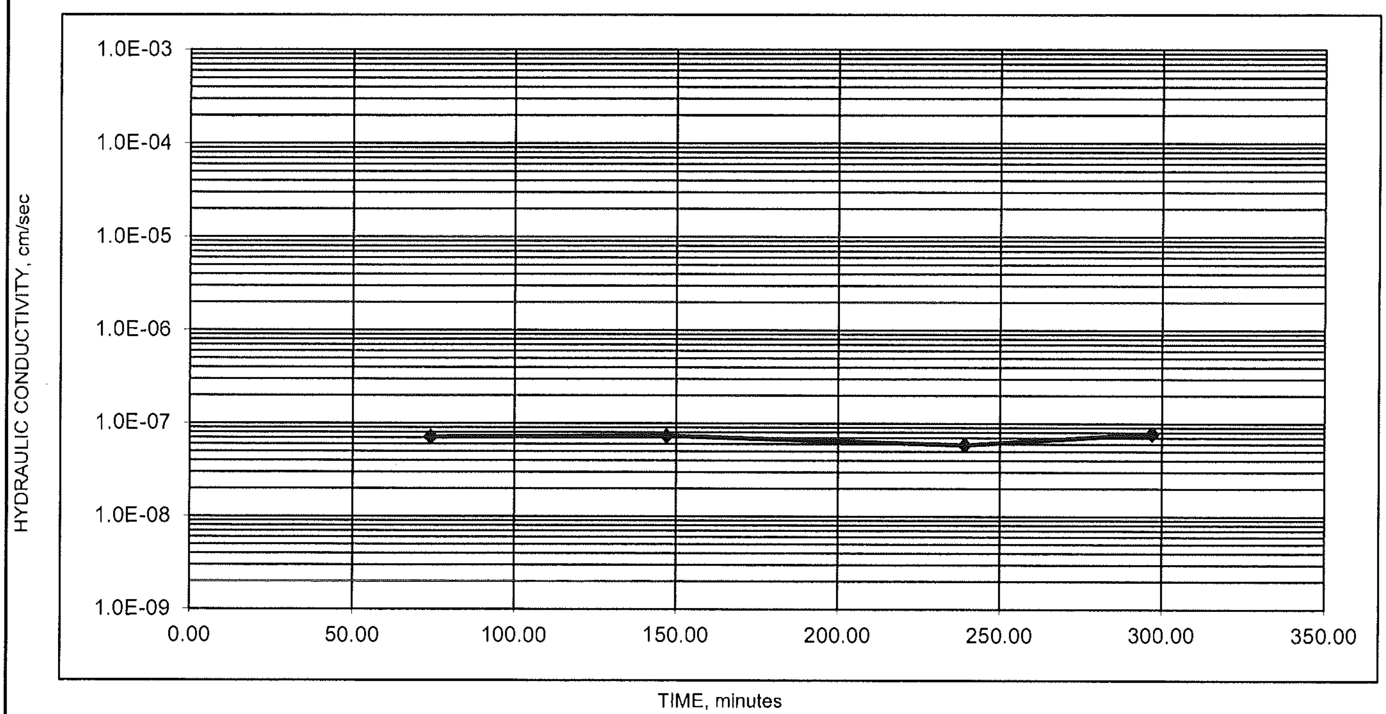
SPECIFIC GRAVITY:	2.70	RECOMPACTED?:	NO
SPECIFIC GRAVITY:	ASSUMED	PROCTOR, pcf:	NA
POROSITY, %:	35.6	OPTIMUM, %:	NA
SATURATION, %:	89.7	COMPACTION, %:	NA
VOID RATIO:	0.55	OVER OPTIMUM, %:	NA

SATURATION:	LATERAL PRESS.: 104.0 psi	BACK PRESSURE (=UPPER=LOWER): 100.0 psi
DURING TEST:	LATERAL PRESS.: 104.0 psi	H2: 100.0 psi; H1: 100.0 psi
		BIAS PRESSURE (=H1-H2) 0.0 psi

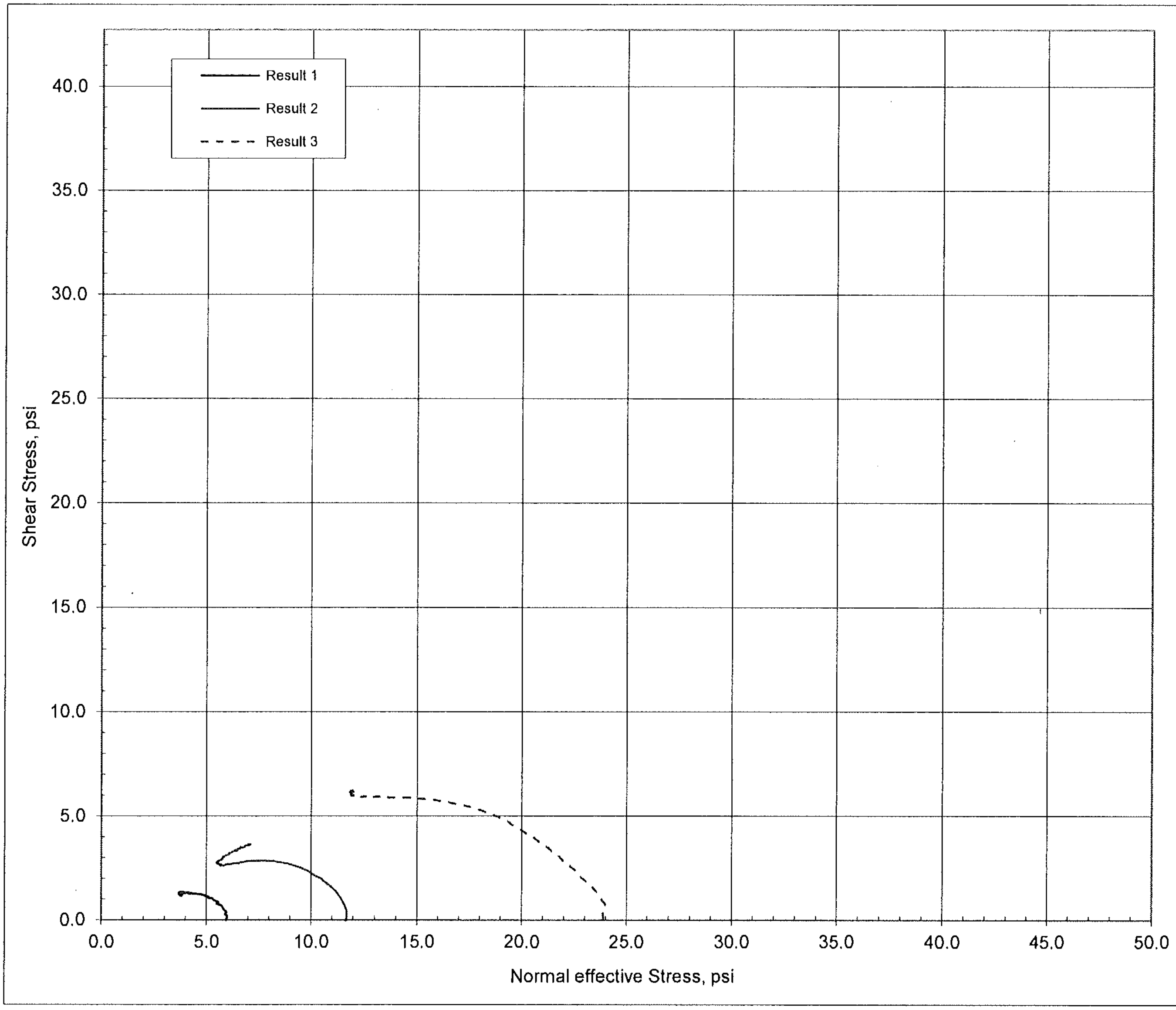
H1 VALUE	H2 VALUE	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
9.2	64.7	0.00	55.5									
9.7	64.2	74.00	54.5	0.018182	7.14E-08	0.16	0.16	1.00	10.8	2	23.7	0.916
10.2	63.7	147.00	53.5	0.018519	7.32E-08	0.16	0.16	1.00	10.6	4	24.0	0.910
10.7	63.2	239.00	52.5	0.018868	5.88E-08	0.16	0.16	1.00	10.4	16	24.3	0.904
11.1	62.8	297.00	51.7	0.015355	7.76E-08	0.12	0.12	1.00	10.2	11	23.3	0.925

HYDRAULIC CONDUCTIVITY (k_{20}) = AVERAGE 7.0E-08 cm/sec

MAXIMUM	1.0E-03 TO 1.0E-04	2	0.75<	30	% < 25 AT
HYDRAULIC	1.0E-04 TO 1.0E-05	5	RATIO	MAX	> 1.0E-8
GRADIENT	1.0E-05 TO 1.0E-06	10	<1.25	HYDRAULIC	OR
	1.0E-06 TO 1.0E-07	20		GRADIENT	% < 50 AT
	less than 1.0E-07	30		ALLOWED	< 1.0E-8



CONSOLIDATED UNDRAINED DIRECT SIMPLE SHEAR TESTING OF COHESIVE SOILS
ASTM D6528



	RESULT 1	RESULT 2	RESULT 3		RESULT 1	RESULT 2	RESULT 3
INITIAL DATA				NORMAL EFF. STRESS, psi	6.0	11.7	23.9
AREA, inch2	5.391	5.383	5.383	PRESHEAR MOISTURE, %	22.6	22.6	22.2
HEIGHT, inch	0.708	0.702	0.703	PRESHEAR VOID RATIO	0.64	0.59	0.58
MOISTURE, %	20.3	20.1	20.5	FINAL MOISTURE, %	22.7	22.6	22.3
DRY DENSITY, pcf	101.4	103.3	101.3	FINAL VOID RATIO	0.66	0.61	0.61
SATURATION, %	83	86	83	SHEAR STRAIN RATE, %/min	0.085	0.087	0.089
VOID RATIO	0.66	0.63	0.66	t95 @ MAX STESS, min	0.59	0.25	0.70
LIQUID LIMIT	43		PLASTIC LIMIT	16	PLASTICITY INDEX		27
SAMPLE TYPE	UNDISTURBED			SPECIFIC GRAVITY	2.7 ESTIMATED		
SAMPLE DESCRIPTION	SANDY LEAN CLAY, YELLOWISH BROWN						

PROJECT NAME: DYNEGY

BORING NO. COF-B007

LOCATION: COFFEEN, ILLINOIS

SAMPLE NO. S8

JOB NO.: 15151122

DEPTH, feet 22.0 - 24.0

DATE: 9/10/2015

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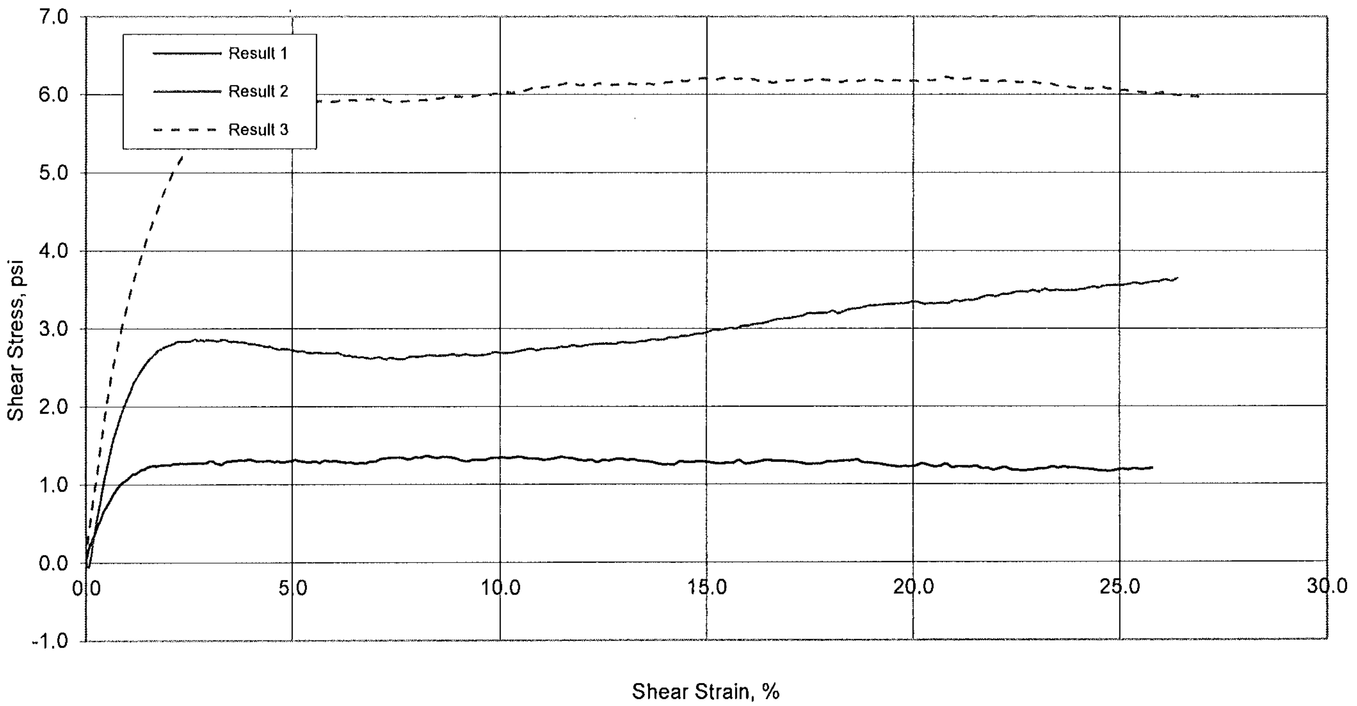
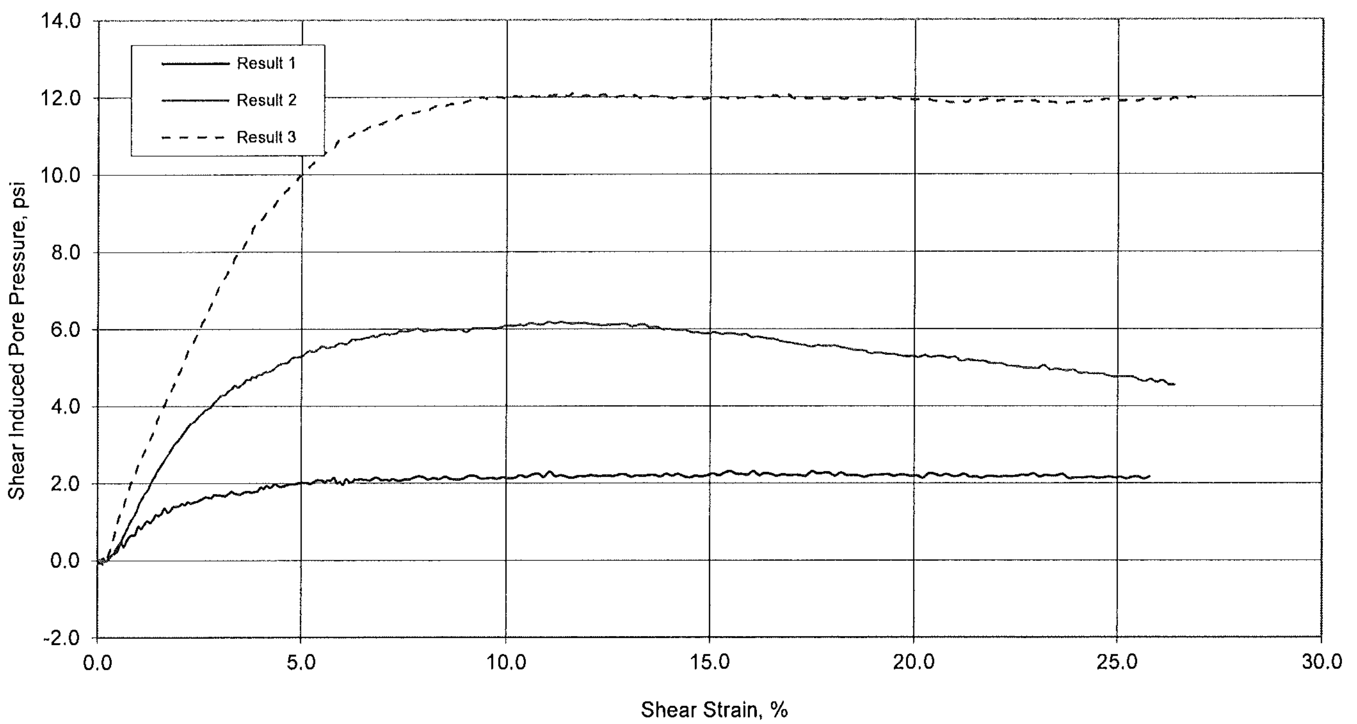
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

BORING NO.	COF-B007
SAMPLE NO.	S8
DEPTH, feet	22.0 - 24.0





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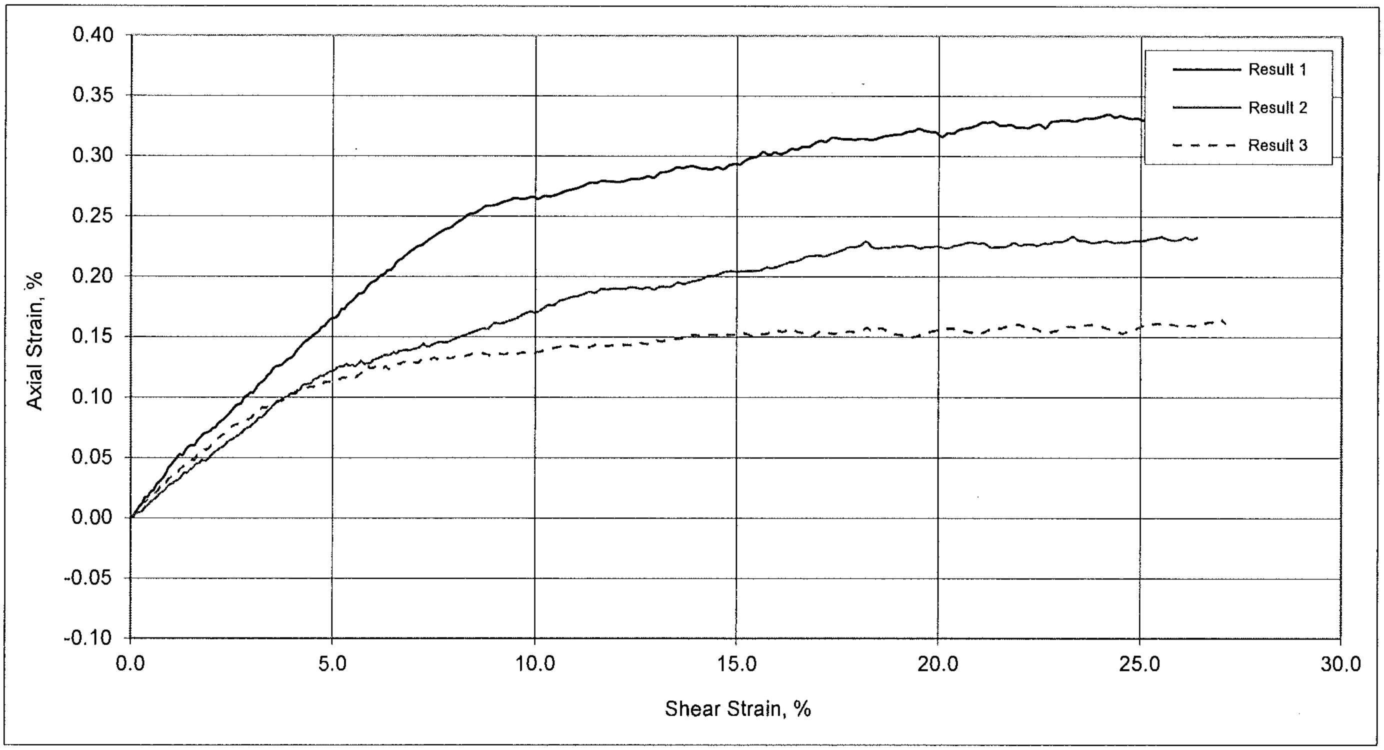
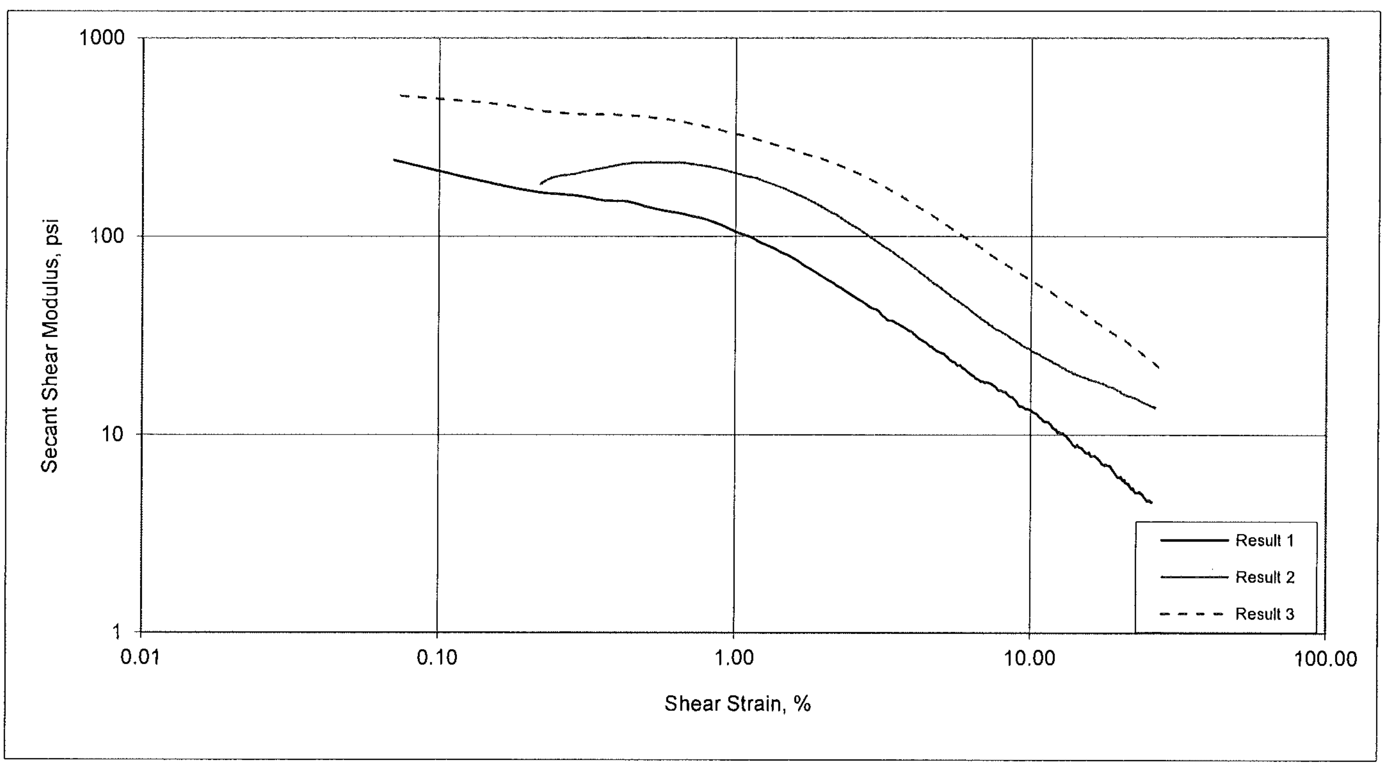
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

BORING NO.	COF-B007
SAMPLE NO.	S8
DEPTH, feet	22.0 - 24.0





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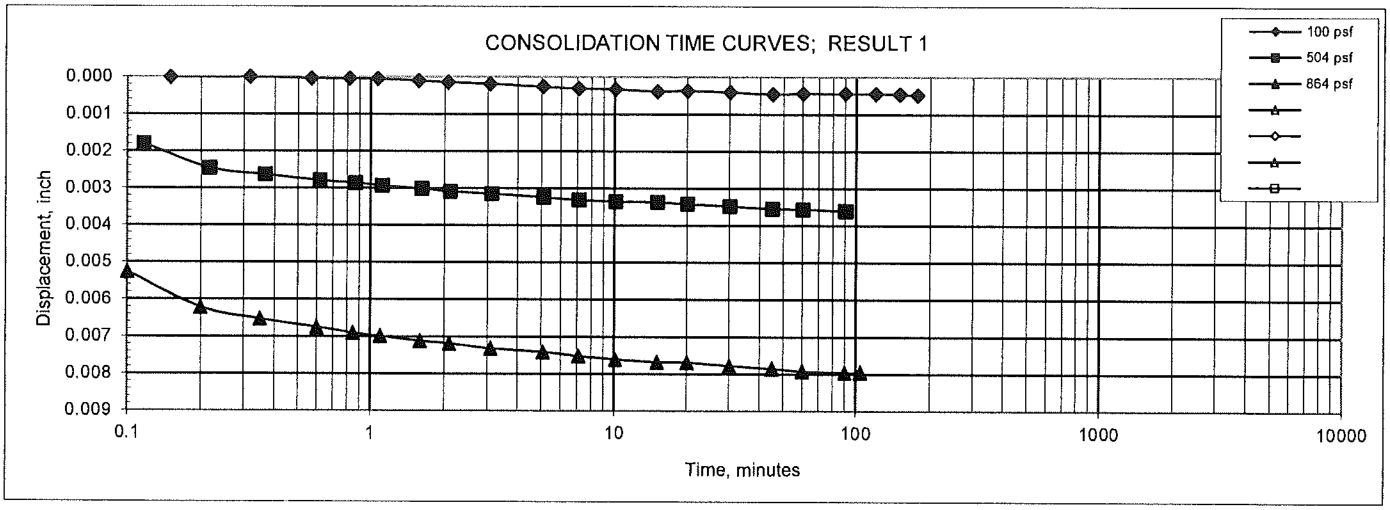
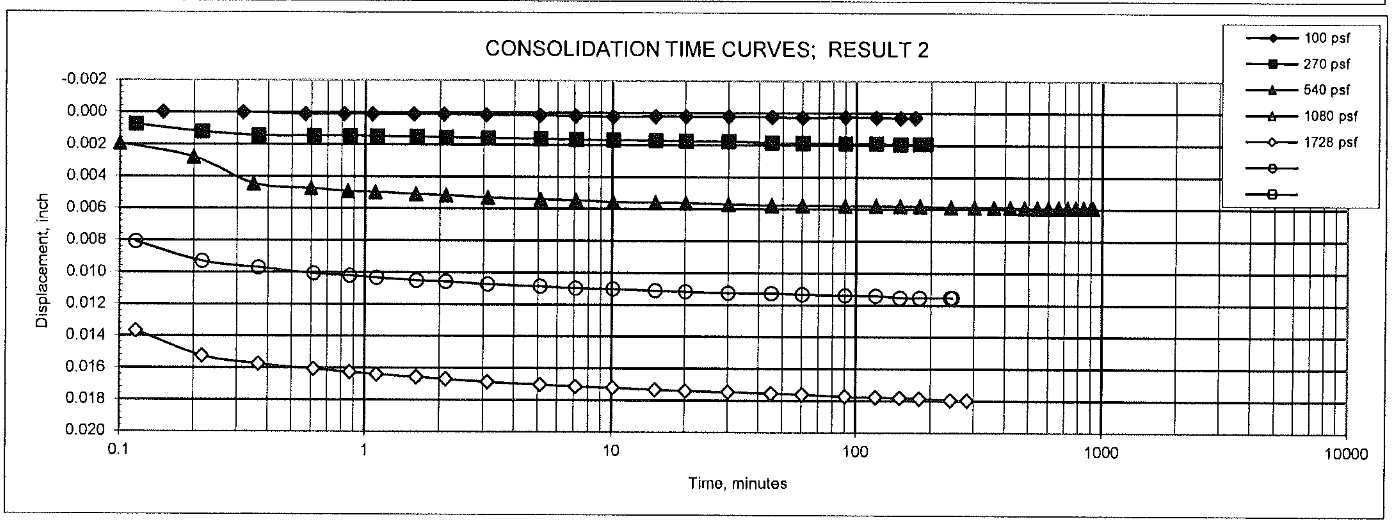
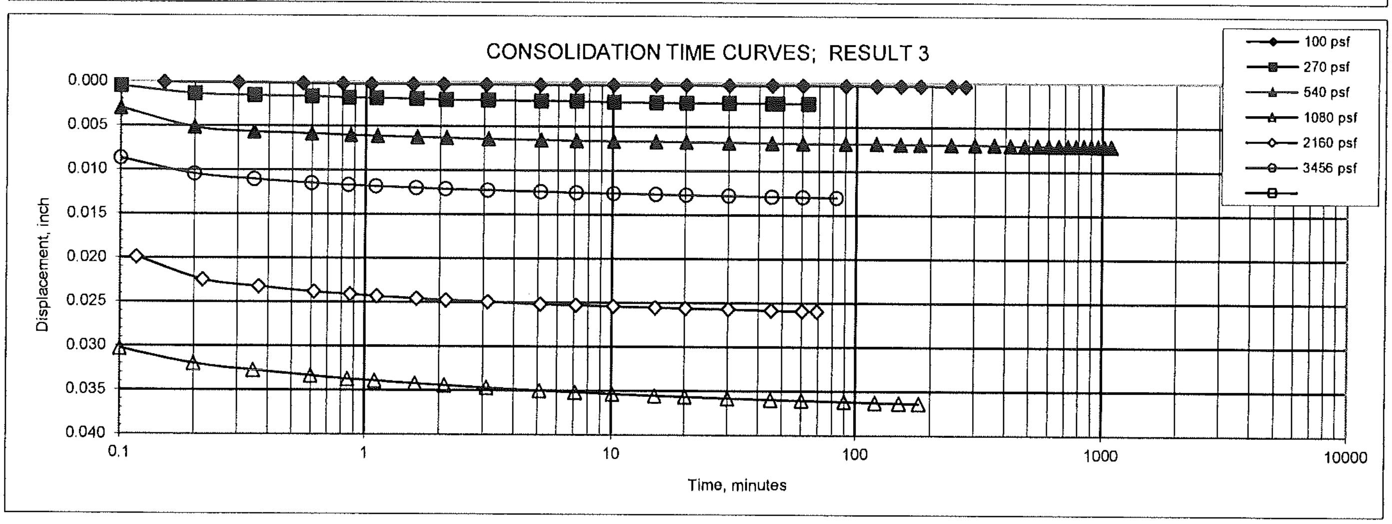
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

BORING NO.	COF-B007
SAMPLE NO.	S8
DEPTH, feet	22.0 - 24.0







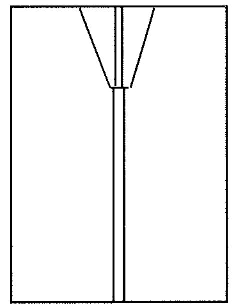
Terracon

DISPERSIVE CLAY SOILS BY THE PINHOLE TEST
ASTM D 4647, METHOD A
9/9/2015

PROJECT DYNEGY
JOB NO. COFFEEN, ILLINOIS
SAMPLE ID COF-B007, S8, 22.0 - 24.0 feet
COMPACTION CHARACTERISTICS UNDISTURBED
WATER CONTENT 21.8 %
DISTILLED WATER ADDED ____ **YES** X **NO**
CURE TIME NATURAL MOISTURE, NO CURE
BY JDM
SAMPLE DESC. SANDY LEAN CLAY, YELLOWISH BROWN

FLOW STARTED ON 1ST **TRIAL**

FINAL HOLE
1.0 mm



TIME, min	HEAD, inch	FLOW, ml	sec	FLOW RATE, ml/sec	TURBIDITY FROM SIDE: VERY DARK	DARK	MOD. DARK	SLIGHT DARK	BARELY VISIBLE	CLEAR	CLEAR FROM TOP	REMARKS
1	2	12.8	60	0.21						X	X	
2	2	12.3	60	0.20						X	X	
3	2	12.3	60	0.20						X	X	
4	2	12.0	60	0.20						X	X	
5	2	12.3	60	0.20						X	X	
6	2	12.0	60	0.20						X	X	
7	2	11.8	60	0.20						X	X	
8	2	12.0	60	0.20						X	X	
9	2	12.0	60	0.20						X	X	
10	2	11.8	60	0.20						X	X	
1	7	34.0	60	0.57						X	X	
2	7	34.0	60	0.57						X	X	
3	7	34.0	60	0.57						X	X	
4	7	35.0	60	0.58						X	X	
5	7	34.0	60	0.57						X	X	
1	15	57.0	60	0.95						X	X	
2	15	57.0	60	0.95						X		Barely Visible
3	15	527.5	60	8.79						X		Barely Visible
4	15	58.0	60	0.97						X		Barely Visible
5	15	57.0	60	0.95						X		Barely Visible
1	40	108.0	60	1.80						X		Barely Visible
2	40	105.0	60	1.75						X		Barely Visible
3	40	107.0	60	1.78						X	X	
4	40	105.0	60	1.75						X	X	
5	40	106.0	60	1.77						X	X	

CLASSIFICATION = **ND1**

Terracon

CRUMB TEST (ASTM D6572)

Project No.: 15151122 Project Name: DYNEGY Location: COFFEEN, IL

Boring No.: COF-B007 Sample No.: S8 Depth: 22.0-24.0 [X] ft [ ] m

Visual Classification: ____ Color: ____

Moisture Content of Sample:	[ ] as-received	[ ] in situ	[ ] air-dried	
Tare Number	Wet Mass + Tare (g)	Dry Mass+ Tare (g)	Tare Mass (g)	Water Content (%)
AL-211	86.77	74.59	21.06	22.8

Specimen Identification:				Specimen Identification:				Specimen Identification:			
Spec. Container Identification:	5			Spec. Container Identification:				Spec. Container Identification:			
Method:	[X] A (Natural) [ ] B (Remolded)			Method:	[ ] A (Natural) [ ] B (Remolded)			Method:	[ ] A (Natural) [ ] B (Remolded)		
Water Type:	[X] Distilled [ ] Type IV			Water Type:	[ ] Distilled [ ] Type IV			Water Type:	[ ] Distilled [ ] Type IV		
Initial Water Temp. (°C):	22.5			Initial Water Temp. (°C):				Initial Water Temp. (°C):			
Start Time (hh:mm:ss):	9:01:27			Start Time (hh:mm:ss):				Start Time (hh:mm:ss):			
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	9:03:27	1	22.0	2 min ± 15 s				2 min ± 15 s			
1 h ± 8 min	10:01:55	1	21.1	1 h ± 8 min				1 h ± 8 min			
6 h ± 45 min	2:56:22	1	21.1	6 h ± 45 min				6 h ± 45 min			
Dispersive Classification:	Non-Dispersive			Dispersive Classification:				Dispersive Classification:			
Additional water added to remold the specimen (Method B):	[ ] Y [ ] N			Additional water added to remold the specimen (Method B):	[ ] Y [ ] N			Additional water added to remold the specimen (Method B):	[ ] Y [ ] N		

Remarks:

Prepared By: John Martin Date: 9/1/15 Tested By: John Martin Date: 9/1/15 Input By: John Martin Date: 9/8/15 Reviewed By: ____ Date: ____

CRUMB TEST D6572

DYNEGY

COFFEEN, ILLINOIS

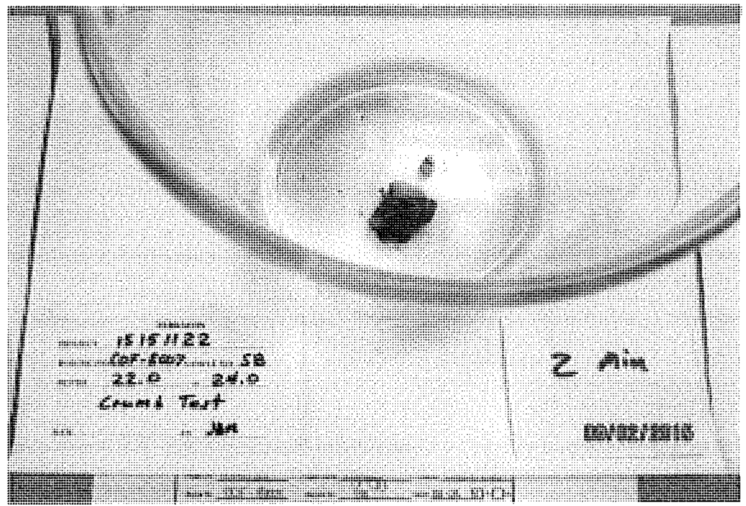
15151122

COF-B007 S8 22.0 - 24.0 feet

2 MIN

GRADE: 1

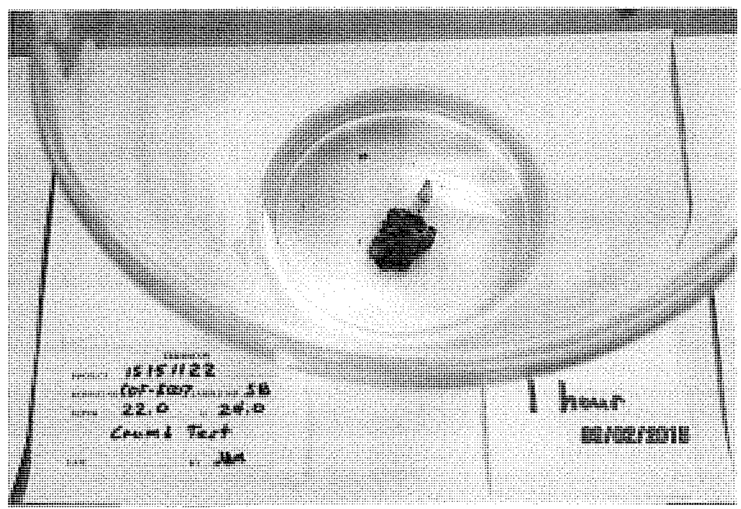
DISPERSIVE CALSSIFICATION: NONDISPERSIVE



1 HOUR

GRADE: 1

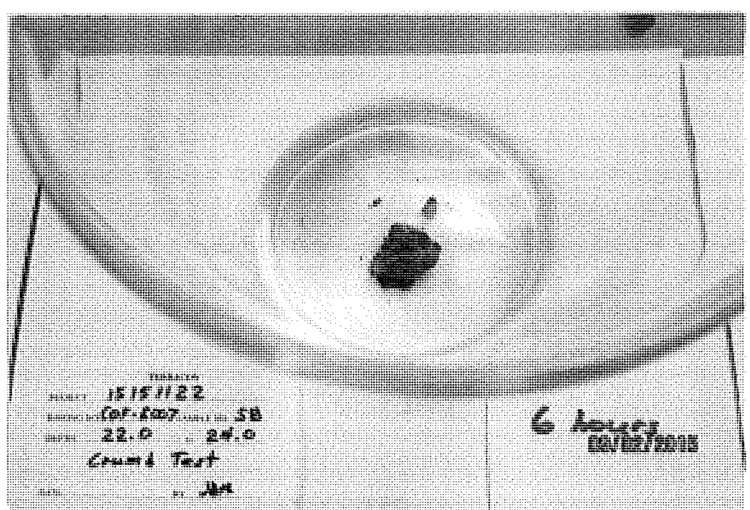
DISPERSIVE CALSSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 1

DISPERSIVE CALSSIFICATION: NONDISPERSIVE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

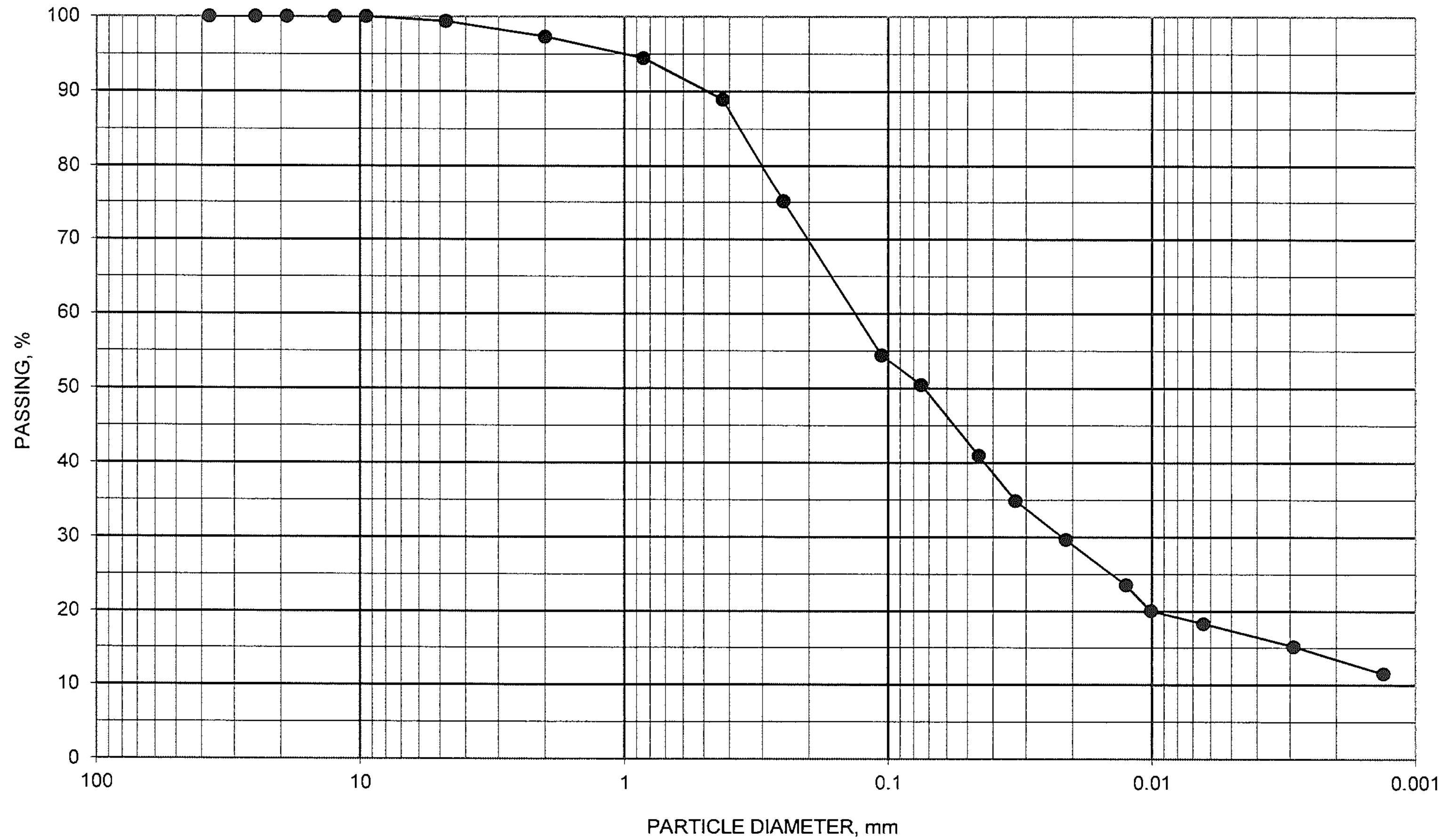
Grade 4 - Highly Dispersive

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	99
#10	2.00	97
#20	0.850	94
#40	0.425	89
#60	0.250	75
#140	0.106	54
#200	0.075	50.5
	0.0454	41.0
	0.0329	34.9
	0.0212	29.6
	0.0125	23.5
	0.0101	20.1
	0.0064	18.3
	0.0029	15.2
	0.0013	11.5

D60 0.1337
D30 0.0219

SPECIFIC GRAVITY 2.67 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B007	S9	28.5 TO 30	SANDY LEAN CLAY BROWN & GRAY		20.3			

PROJECT DYNEGY

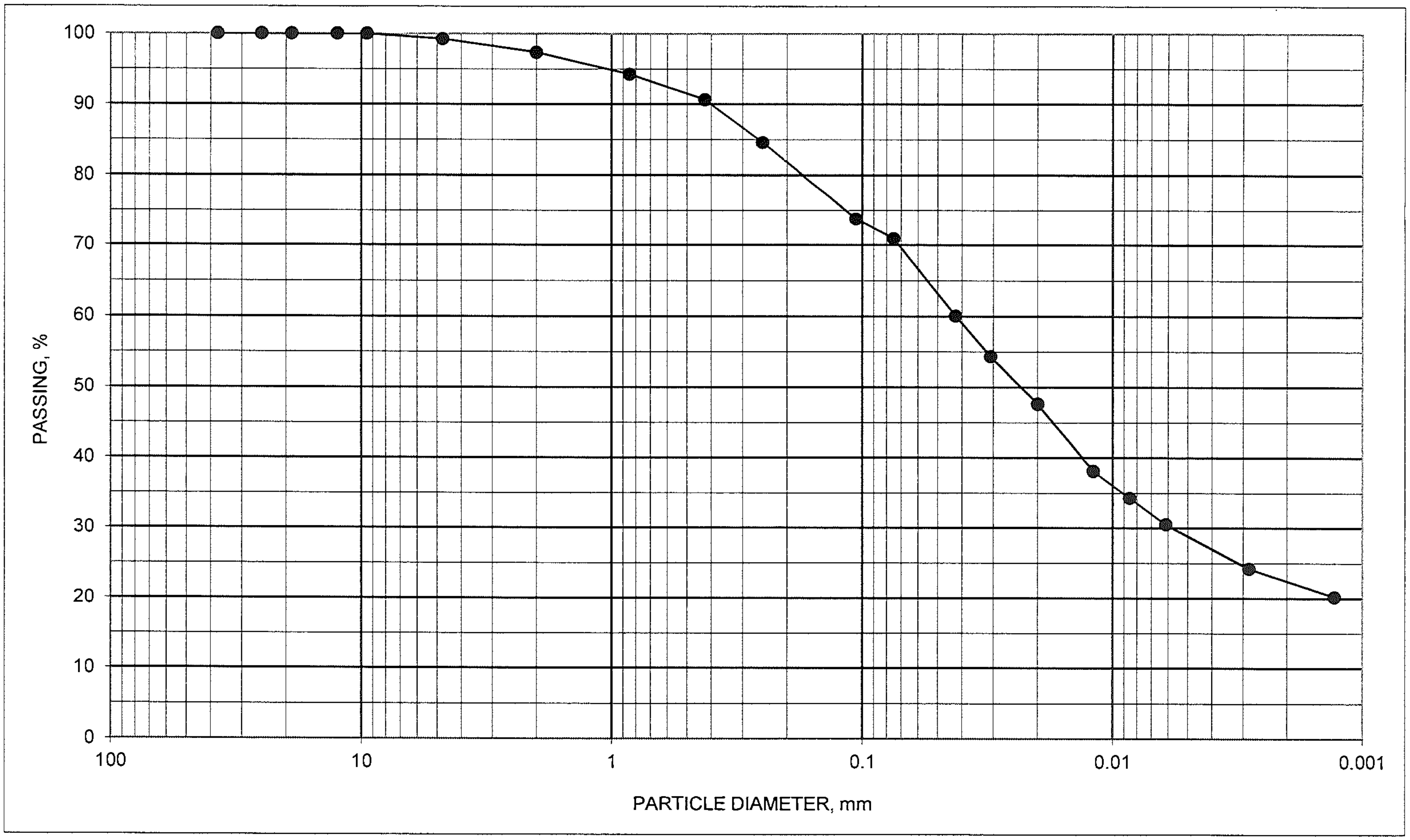
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B007-S9-28.5.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	99
#10	2.00	97
#20	0.850	94
#40	0.425	91
#60	0.250	85
#140	0.106	74
#200	0.075	70.9
	0.0425	60.0
	0.0307	54.3
	0.0200	47.6
	0.0120	38.1
	0.0086	34.3
	0.0061	30.5
	0.0028	24.2
	0.0013	20.2
	D60	0.0424
	D30	0.0058

SPECIFIC GRAVITY 2.69
ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B007	S11	36 TO 37.5	LEAN CLAY WITH SAND BROWN & GRAY		13.6			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B007-S11-36.0.xlsx]GRADATION

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/16/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B008	S1	1.0	2.5	19.7														
	Color	brown & gray								Visual Classification			Fill: Lean Clay trace Sand					
	S2	3.5	5.0	16.3		46	17	29	NOTE*									CL
	Color	brown								USCS Classification			Lean Clay					
	S3	6.0	7.5	21.7														
	Color	brown & gray								Visual Classification			Fill: Fat Clay trace Sand					
	S4	9.5	11.0	21.6		54	18	36										
	Color	brown & gray								Visual Classification			Fill: Fat Clay trace Sand					
	S5	11.0	13.0	16.6	112.8	43	16	27				7.9E-09*						
	Color	dark gray with gray trace grayish brown								Visual Classification			Lean Clay with Sand					
	S6	13.0	15.0	13.9	120.5	35	15	20						NOTE*		ND1	4*	
	Color	light yellowish brown with light gray								Visual Classification			Lean Clay with Sand					
	S7	20.0	21.5	20.5						14*								
	Color	brown & gray								Visual Classification			Fill: Fat Clay trace Sand					
	S8	25.0	26.5	16.4														
	Color	brown & gray								Visual Classification			Fat Clay with Sand					
	S9	28.0	30.0	Tube to Fugro														
	Color									Visual Classification								
	S10	30.0	30.5	no recovery														
	Color									Visual Classification								
	S11	33.5	35.0	5.8														
	Color	brown & gray								Visual Classification			Sandy Lean Clay trace Fine Gravel					

TESTED BY: KJL-JDM
APPROVED BY: RMS

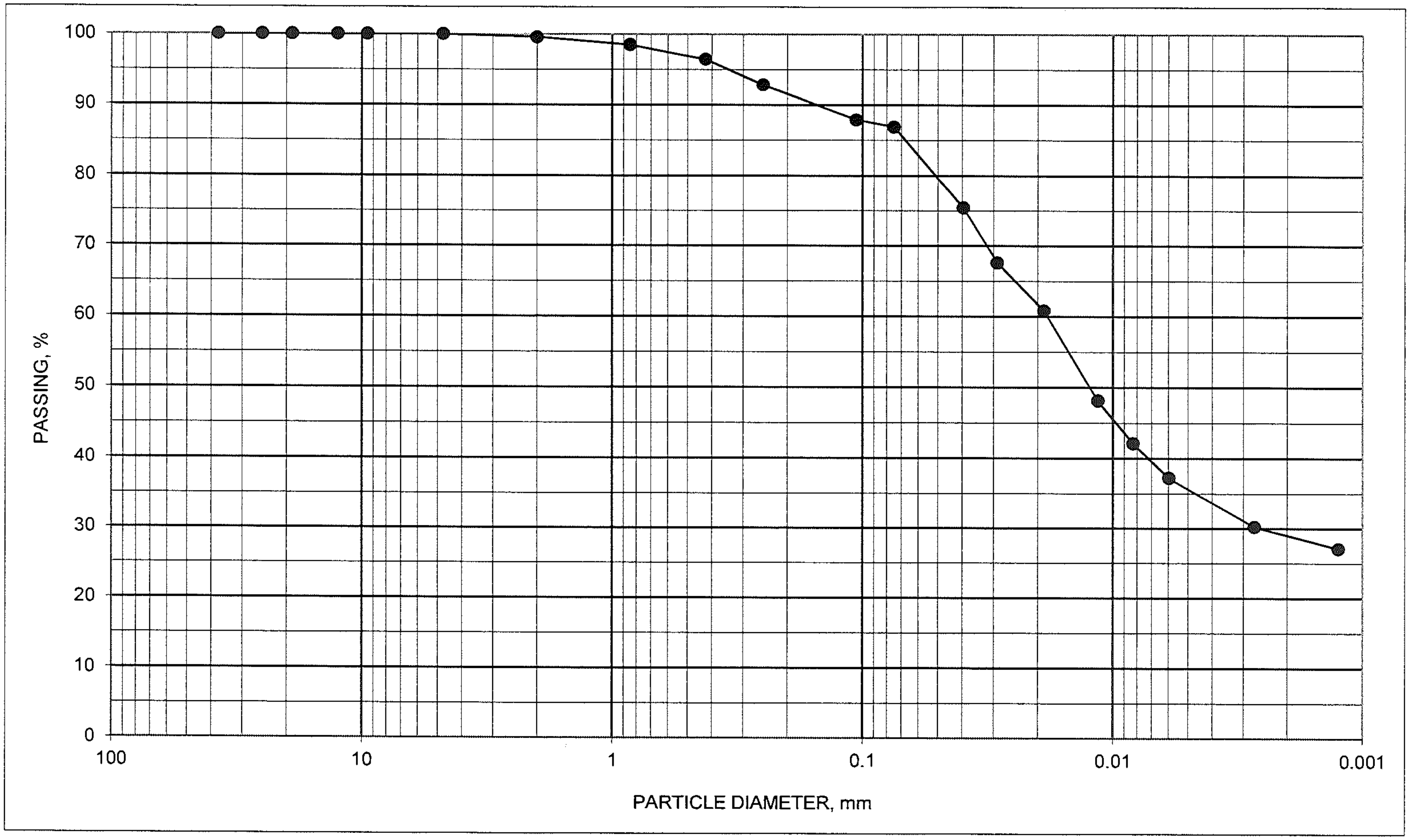
NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	99
#40	0.425	96
#60	0.250	93
#140	0.106	88
#200	0.075	86.9
	0.0396	75.4
	0.0290	67.6
	0.0189	60.8
	0.0115	48.1
	0.0083	42.1
	0.0060	37.2
	0.0027	30.2
	0.0013	27.1

D60 0.0183
D30 0.0026

SPECIFIC GRAVITY 2.70 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B008	S2	3.5 TO 5	LEAN CLAY BROWN	CL	16.3	46	17	29

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B008-S2-3.5.xlsx]GRADATION

Terracon

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 03 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N CaSO4

PROJECT NAME:	DYNEGY	PROJECT NUMBER:	15151122
LOCATION:	COFFEEN, ILLINOIS	DATE:	9/10/2015
		PANEL IDENTIFICATION:	Lenexa Perm Board
SAMPLE ID:	COF-B008 S5 11.0 - 13.0 feet	BURETTE AREA:	0.312 cm^2
SAMPLE DESCR.:	LEAN CLAY WITH SAND, DARK GRAY WITH GRAY TRACE GRAYISH BROWN	BURETTE INCREMENT LENGTH:	1.000 cm
		VOLUME PER INCREMENT:	0.312 cm^3

INITIAL

MOISTURE%		DENSITY			
W & T, g	125.65	WET WT, g	468.5		
D & T, g	112.54	DIA, in	2.865	7.28	cm
T, g	33.72	HT, in	2.105	5.35	cm
		AREA		41.59	cm^2
MOIST-		DENSITY:	131.5	PCF WET	
URE, %	**16.6**	DENSITY:	**112.8**	PCF DRY	

ADDITIONAL DATA

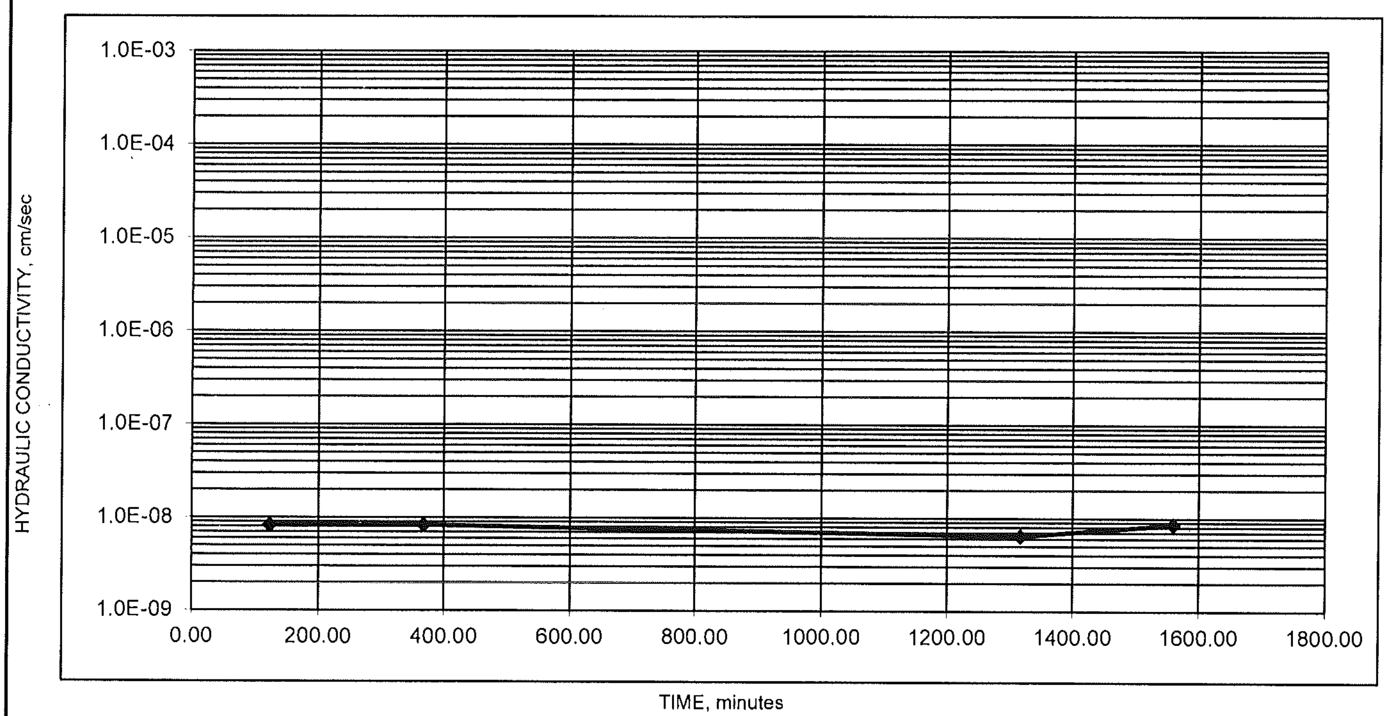
SPECIFIC GRAVITY:	2.70	RECOMPACTED?:	NO
SPECIFIC GRAVITY:	ASSUMED	PROCTOR, pcf:	NA
POROSITY, %:	33.1	OPTIMUM, %:	NA
SATURATION, %:	90.8	COMPACTION, %:	NA
VOID RATIO:	0.49	OVER OPTIMUM, %:	NA

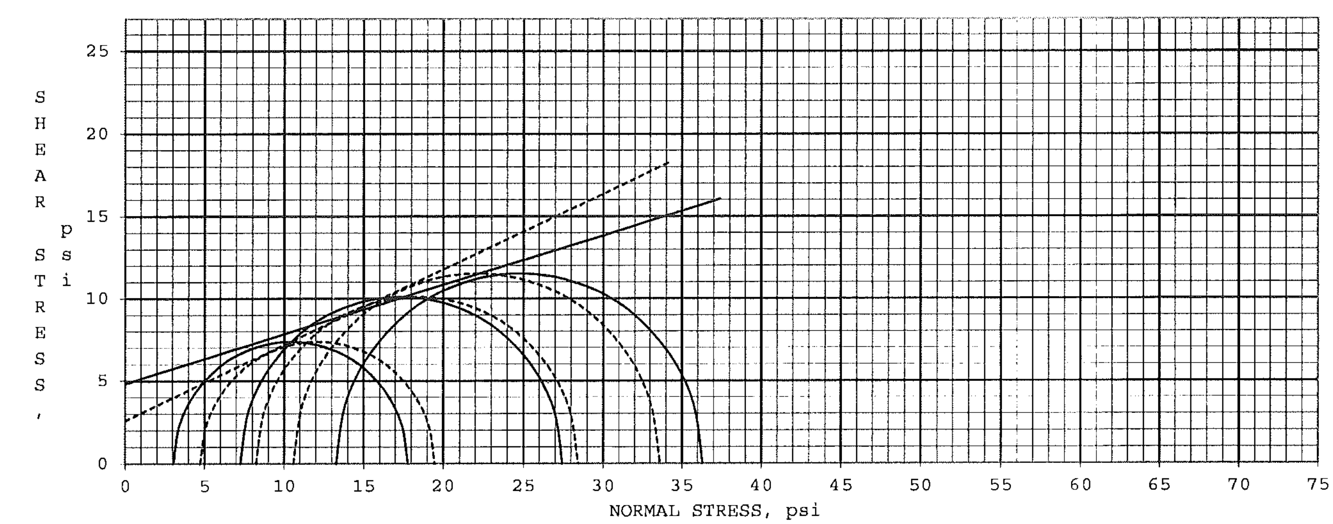
SATURATION:	LATERAL PRESS.: 104.0 psi	BACK PRESSURE (=UPPER=LOWER): 100.0 psi	
DURING TEST:	LATERAL PRESS.: 104.0 psi	H2: 100.0 psi	H1: 100.0 psi
			BIAS PRESSURE (=H1-H2) 0.0 psi

H1 VALUE	H2 VALUE	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
7.4	69.0	0.00	61.6									
7.5	68.9	123.00	61.4	0.003252	8.22E-09	0.03	0.03	1.00	11.5	4	23.1	0.929
7.7	68.7	368.00	61.0	0.006536	8.29E-09	0.06	0.06	1.00	11.4	5	23.1	0.929
8.3	68.1	1317.00	59.8	0.019868	6.43E-09	0.19	0.19	1.00	11.2	18	23.6	0.918
8.5	67.9	1560.00	59.4	0.006711	8.55E-09	0.06	0.06	1.00	11.1	9	23.3	0.925

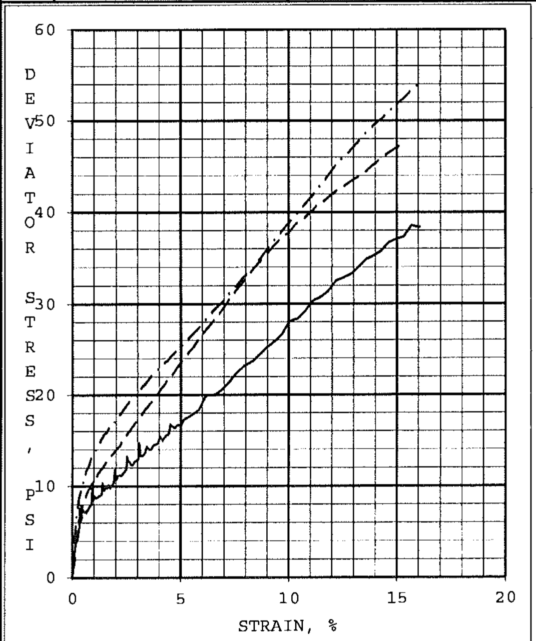
HYDRAULIC CONDUCTIVITY (k_{20}) = AVERAGE 7.9E-09 cm/sec

MAXIMUM	1.0E-03 TO 1.0E-04	2	0.75<	30	% < 25 AT
HYDRAULIC	1.0E-04 TO 1.0E-05	5	RATIO	MAX	> 1.0E-8
GRADIENT	1.0E-05 TO 1.0E-06	10	<1.25	HYDRAULIC	OR
	1.0E-06 TO 1.0E-07	20		GRADIENT	% < 50 AT
	less than 1.0E-07	30		ALLOWED	< 1.0E-8





EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**24.6**	COHESION, psi	**2.6**
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**16.7**	COHESION, psi	**4.8**



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	14.9	12.7	14.2
	DRY DENSITY, pcf	119.3	121.2	121.0
	SATURATION, %	98	88	98
	VOID RATIO	0.41	0.39	0.39
BEFORE SHEAR	WATER CONTENT, %	15.2	14.1	13.9
	DRY DENSITY, pcf	119.5	122.0	122.6
	SATURATION (B PARAMETER)	0.98	0.96	0.97
	VOID RATIO	0.41	0.38	0.37
	FINAL BACK PRESSURE, psi	100.0	100.3	100.6
MINOR PRINCIPAL STRESS, psi		3.1	7.3	13.3
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		14.7	20.2	23.0
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		14.7	20.2	23.0
ULTIMATE DEVIATOR STRESS (15% STR), psi		37.1	47.1	51.8
TIME TO 50% PRIMARY CONSOLIDATION, min		5.30	12.00	9.50
STRAIN RATE, % / hour		1.82	1.41	1.78
INITIAL DIAMETER, inch		1.364	1.366	1.362
INITIAL HEIGHT, inch		2.832	2.857	2.836
AREA AFTER CONSOLIDATION, inch2		1.460	1.457	1.445

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, LIGHT YELLOWISH BROWN WITH LIGHT GRAY

LL 35	PL 15	PI 20	Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B008

LABORATORY: TERRACON - LENEXA

SAMPLE #: S6

DATE: 9/15/2015

DEPTH, feet: 13.0 - 15.0

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

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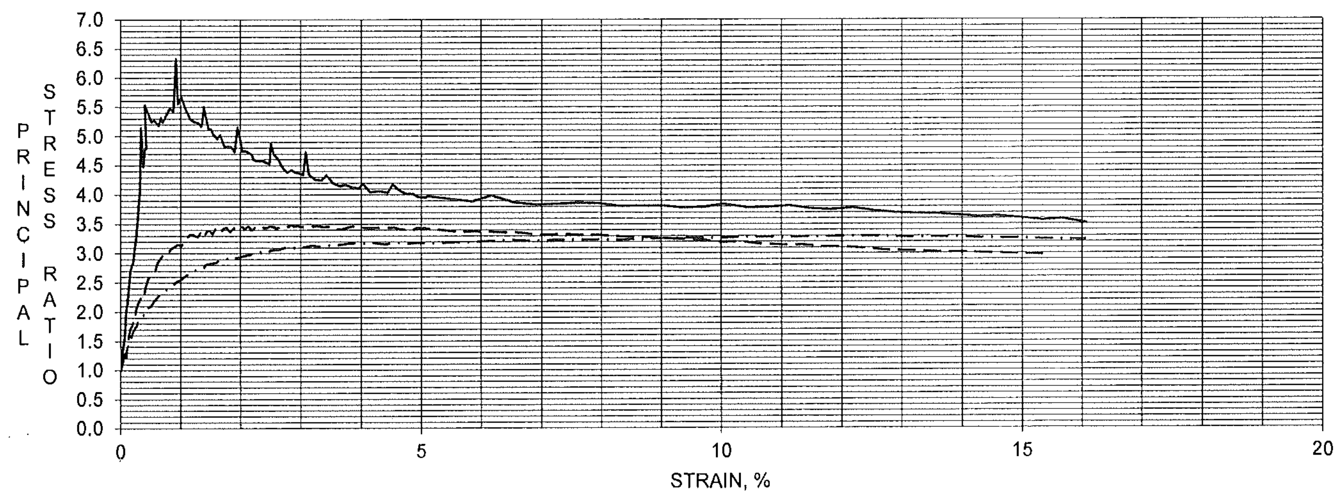
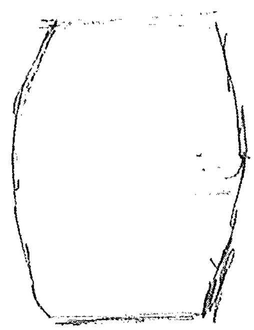
DYNEGY

15151122 COF-B008 S6 13.0 - 15.0

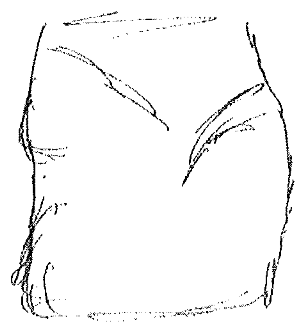


FAILURE SKETCH



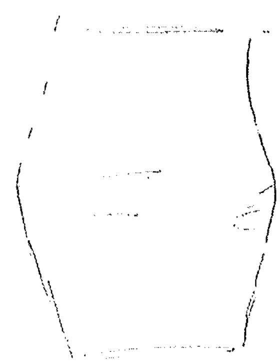
SPECIMEN A

FAILURE SKETCH



SPECIMEN B

FAILURE SKETCH



SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

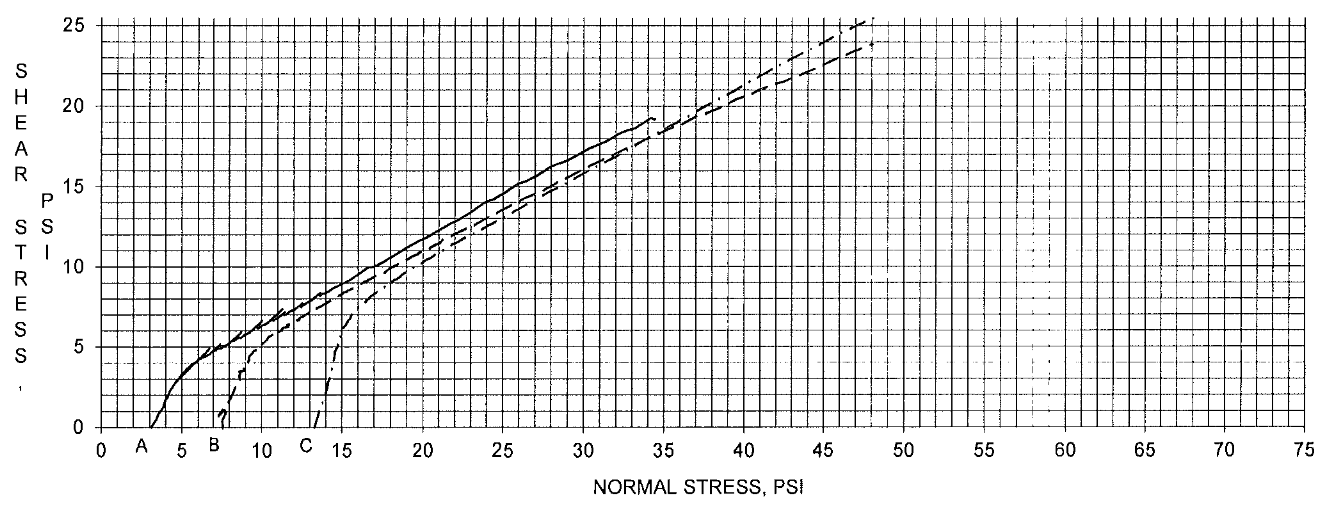
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

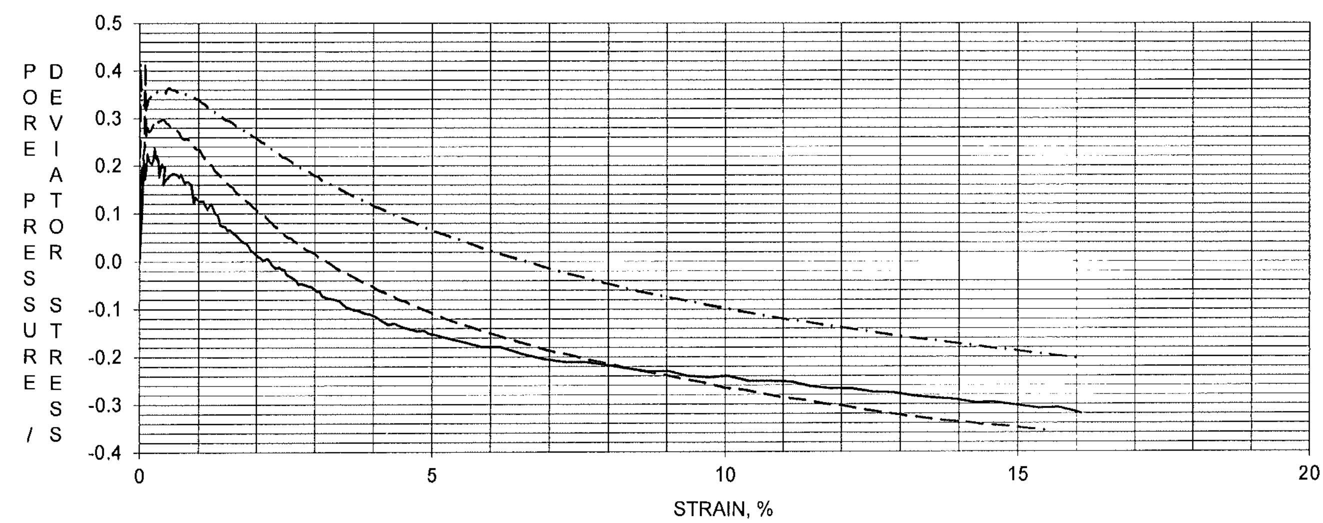
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

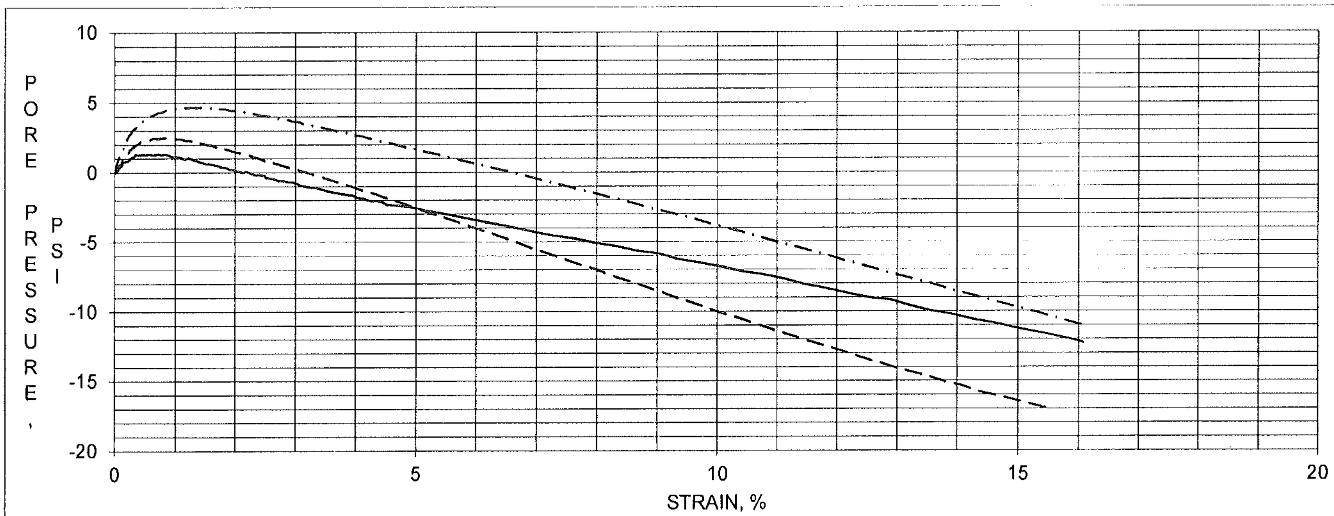
Terracon

DYNEGY

15151122 COF-B008 S6 13.0 - 15.0







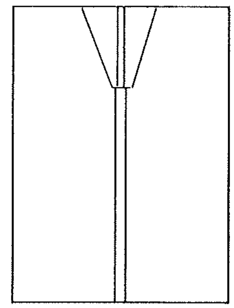
Terracon

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B008\[15151122 Triaxial CU COF-B008-S6-13.0.xlsx]REPORT

DISPERSIVE CLAY SOILS BY THE PINHOLE TEST
ASTM D 4647, METHOD A
9/10/2015

PROJECT DYNEGY
JOB NO. COFFEEN, ILLINOIS
SAMPLE ID COF-B008, S6, 13.0 - 15.0 feet
COMPACTION CHARACTERISTICS UNDISTURBED
WATER CONTENT 13.9%
DISTILLED WATER ADDED ____ **YES** X **NO**
CURE TIME NATURAL MOISTURE, NO CURE
BY JDM
SAMPLE DESC. LEAN CLAY WITH SAND, LIGHT YELLOWISH BROWN WITH LIGHT GRAY
FLOW STARTED ON 1ST **TRIAL**

FINAL HOLE
1.1 mm



TIME, min	HEAD, inch	FLOW, ml	FLOW, sec	FLOW RATE, ml/sec	TURBIDITY FROM SIDE: VERY DARK	DARK	MOD. DARK	SLIGHT DARK	BARELY VISIBLE	CLEAR	CLEAR FROM TOP	REMARKS
1	2	9.3	60	0.15						X	X	
2	2	8.3	60	0.14						X	X	
3	2	7.5	60	0.13						X	X	
4	2	6.8	60	0.11						X	X	
5	2	5.0	60	0.08						X	X	
6	2	4.0	60	0.07						X	X	
7	2	3.5	64	0.05						X	X	
8	2	3.3	56	0.06						X	X	
9	2	4.8	60	0.08						X	X	
10	2	5.3	60	0.09						X	X	
1	7	18.0	60	0.30						X	X	
2	7	17.0	64	0.27						X	X	
3	7	17.0	56	0.30						X	X	
4	7	16.3	60	0.27						X	X	
5	7	15.8	60	0.26						X	X	
1	15	40.5	60	0.68						X	X	
2	15	42.0	60	0.70						X	X	
3	15	43.5	60	0.73						X	X	
4	15	44.0	60	0.73						X	X	
5	15	43.0	60	0.72						X	X	
1	40	124.0	60	2.07						X		Barely Visible
2	40	129.0	60	2.15						X		Barely Visible
3	40	131.0	60	2.18						X		Barely Visible
4	40	137.0	60	2.28						X		Barely Visible
5	40	136.0	60	2.27						X		Barely Visible

CLASSIFICATION = ND1

CRUMB TEST (ASTM D6572)

Project No.: 15151122 Project Name: DYNEGY Location: COFFEEN, IL

Boring No.: COF-B008 Sample No.: S6 Depth: 13.0-15.0 [X] ft [ ] m

Visual Classification: ______ Color: ______

Moisture Content of Sample:	[ ] as-received	[ ] in situ	[ ] air-dried	
Tare Number	Wet Mass + Tare (g)	Dry Mass+ Tare (g)	Tare Mass (g)	Water Content (%)
1017	77.81	70.51	27.90	17.1

Specimen Identification:		Specimen Identification:		Specimen Identification:	
Spec. Container Identification:	5	Spec. Container Identification:		Spec. Container Identification:	
Method:	[X] A (Natural) [ ] B (Remolded)	Method:	[ ] A (Natural) [ ] B (Remolded)	Method:	[ ] A (Natural) [ ] B (Remolded)
Water Type:	[X] Distilled [ ] Type IV	Water Type:	[ ] Distilled [ ] Type IV	Water Type:	[ ] Distilled [ ] Type IV
Initial Water Temp. (°C):	21.4	Initial Water Temp. (°C):		Initial Water Temp. (°C):	
Start Time (hh:mm:ss):	8:10:00	Start Time (hh:mm:ss):		Start Time (hh:mm:ss):	

Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	8:12:00	2	21.1	2 min ± 15 s				2 min ± 15 s			
1 h ± 8 min	9:10:00	3	20.9	1 h ± 8 min				1 h ± 8 min			
6 h ± 45 min	2:17:58	4	20.8	6 h ± 45 min				6 h ± 45 min			

Dispersive Classification:	Highly-Dispersive	Dispersive Classification:		Dispersive Classification:	
Additional water added to remold the specimen (Method B):	[ ] Y [ ] N	Additional water added to remold the specimen (Method B):	[ ] Y [ ] N	Additional water added to remold the specimen (Method B):	[ ] Y [ ] N

Remarks:

Prepared By: John Martin Date: 9/8/15

Tested By: John Martin Date: 9/8/15

Input By: John Martin Date: ______

Reviewed By: ______ Date: ______

CRUMB TEST D6572

DYNEGY

COFFEEN, ILLINOIS

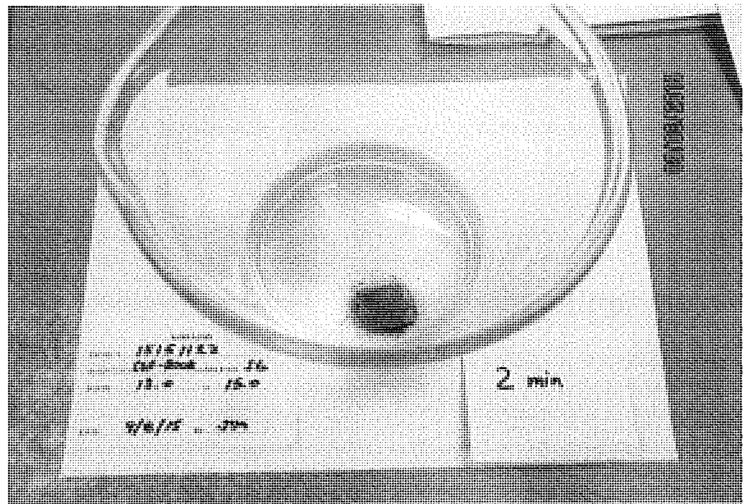
15151122

COF-B008 S6 13.0 - 15.0 feet

2 MIN

GRADE: 2

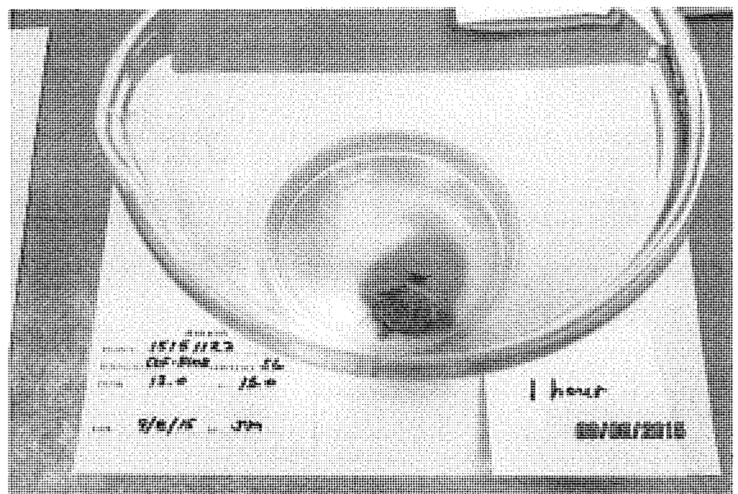
DISPERSIVE CALSSIFICATION: INTERMEDIATE



1 HOUR

GRADE: 3

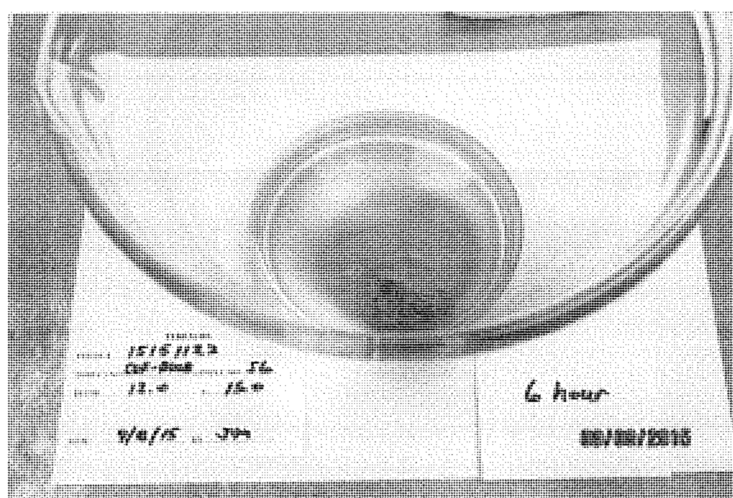
DISPERSIVE CALSSIFICATION: DISPERSIVE



6 HOUR

GRADE: 4

DISPERSIVE CALSSIFICATION: HIGHLY DISPERSIVE

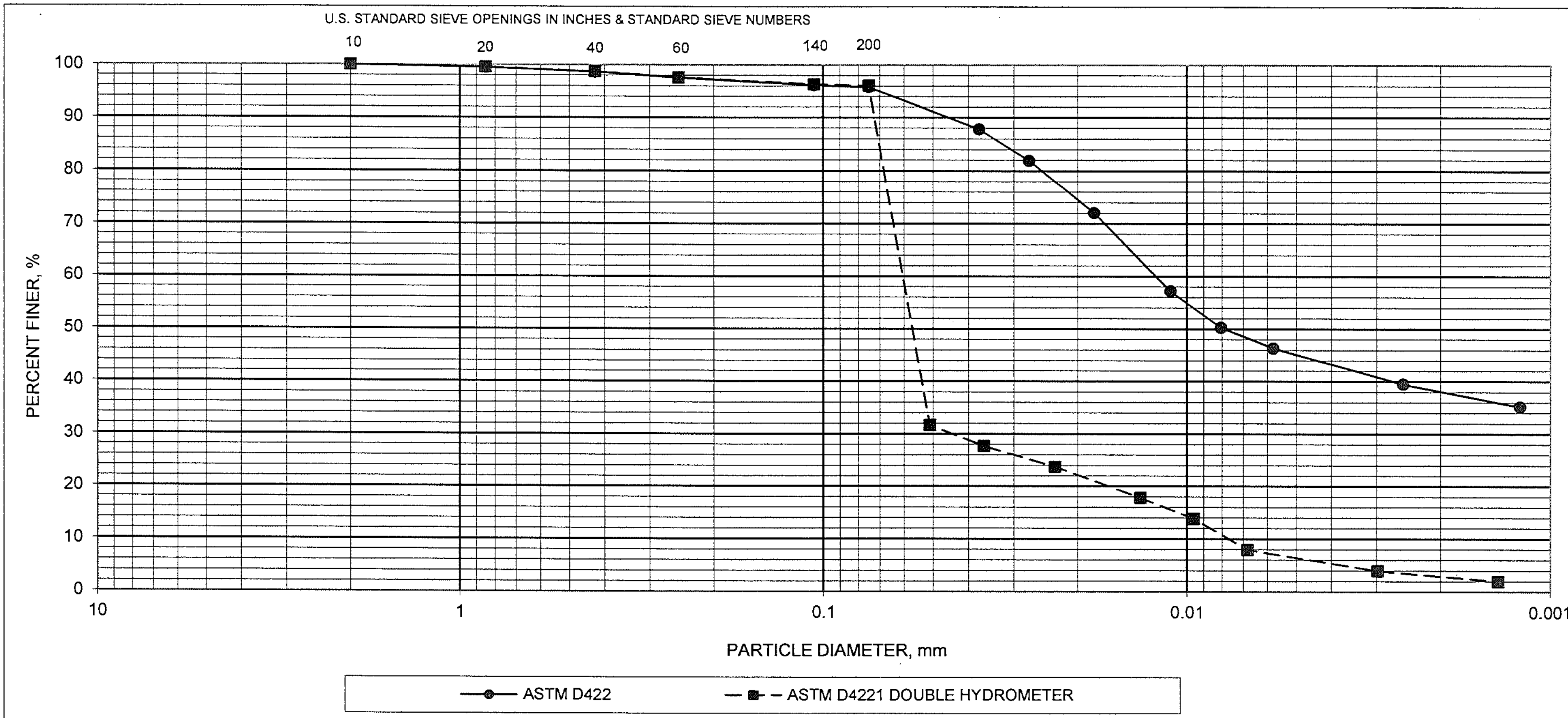


Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	45.1	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	6.4	DISPERSION, %	14

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B008	S7	20.0 - 21.5	FILL; FAT CLAY TRACE SAND, DARK GRAYISH BROWN & BROWN					

PROJECT DYNEGY

COFFEEN, ILLINOIS

JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B008-S7-20.0.xls]Hydrometer Data

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/18/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B009	S1	1.0	2.5	2.6														
	Color		black							Visual Classification			Fill: Cinders					
	S2	3.5	5.0	26.1														
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S3	6.0	7.5	17.1		58	18	40	NOTE*									CH
	Color		dark grayish brown							USCS Classification			Fat Clay					
	S4	8.5	10.0	22.4														
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S5	13.5	15.5	18.4	111.1	50	15	35					NOTE*	NOTE*				
	Color		olive gray & grayish brown							Visual Classification			Fat Clay with Sand					
	S6	15.5	17.5	23.3	104.2													
	Color		brown & gray							Visual Classification			Lean to Fat Clay					
	S7	18.5	20.0	29.3														
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S8	23.5	25.0	23.1		48	18	30										
	Color		brown & gray							Visual Classification			Lean Clay trace Sand					
	S9	28.5	30.5	24.9	100.0	62	22	40										
	Color		brown & gray							Visual Classification			Fat Clay					
	S10	33.5	35.0	20.1														
	Color		brown & gray							Visual Classification			Fat Clay trace Sand					
	S11	38.5	40.0	21.6		49	17	32	NOTE*									CL
	Color		brown & gray							USCS Classification			Lean Clay					

TESTED BY: KJL-JDM
APPROVED BY: RMS

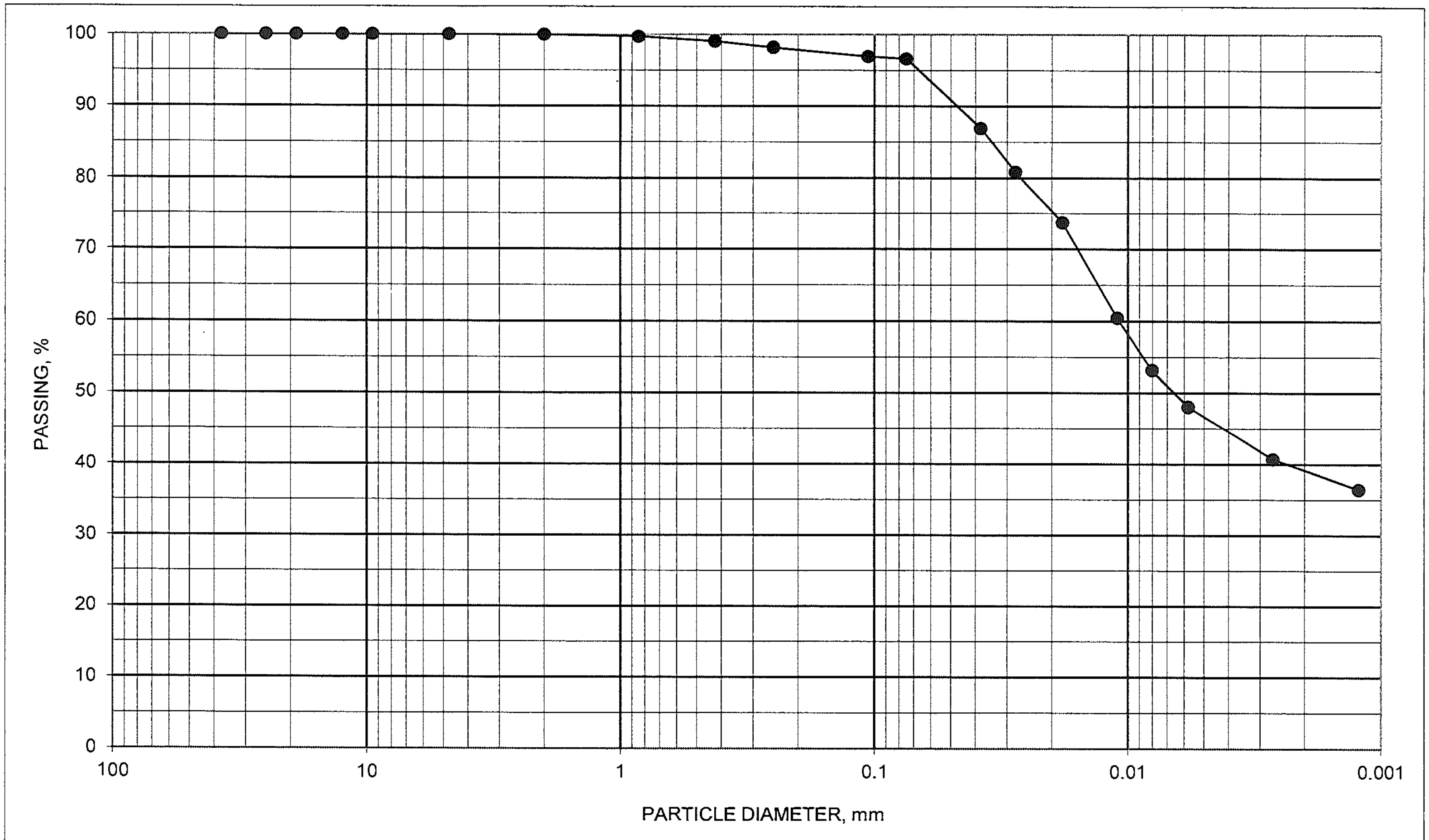
NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	99
#60	0.250	98
#140	0.106	97
#200	0.075	96.6
	0.0382	86.9
	0.0278	80.8
	0.0181	73.7
	0.0110	60.5
	0.0080	53.1
	0.0058	48.0
	0.0027	40.7
	0.0012	36.4

D60 0.0108

SPECIFIC GRAVITY 2.70
ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B009	S3	6 TO 7.5	FAT CLAY DARK GRAYISH BROWN	CH	17.1	58	18	40

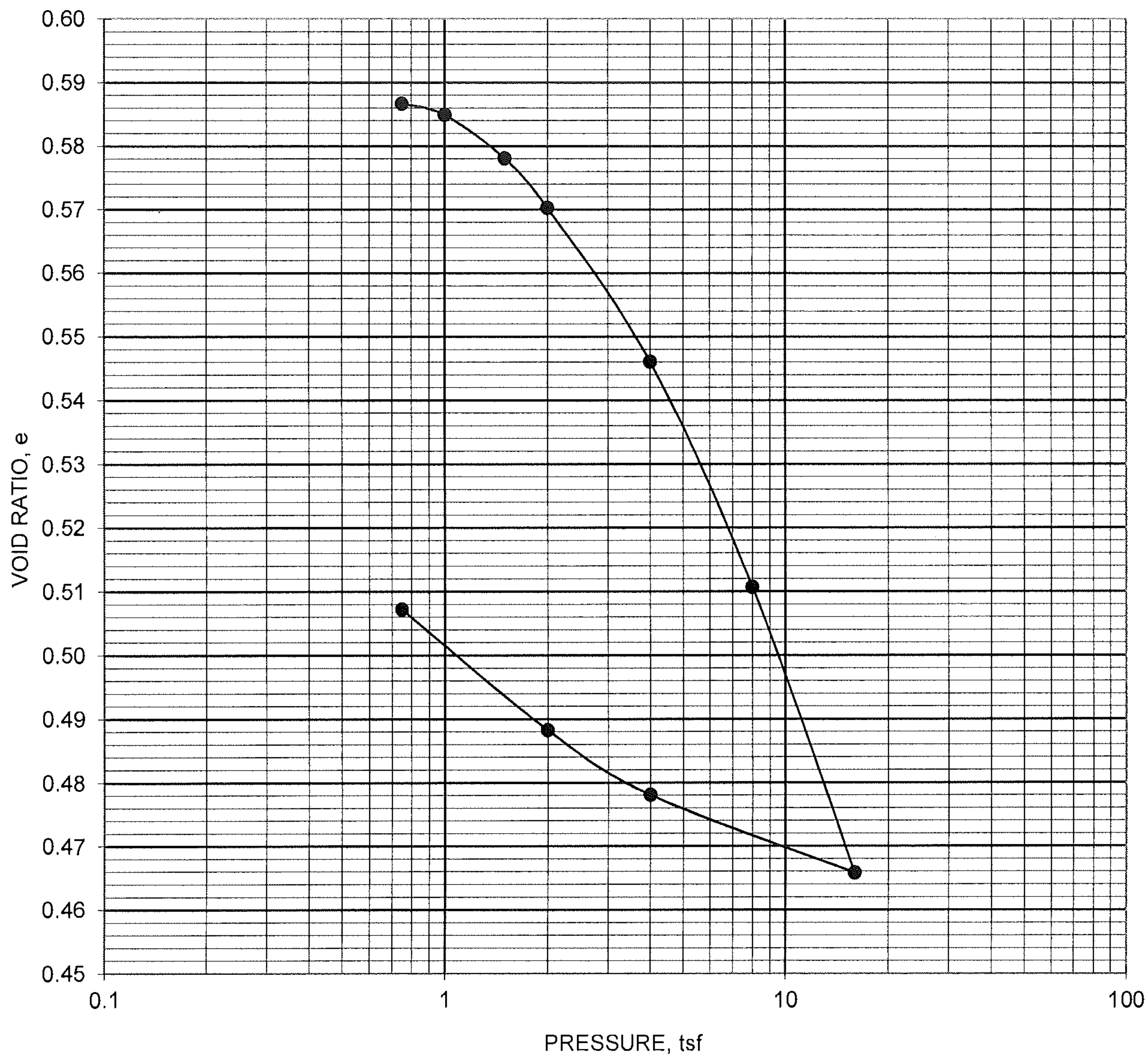
PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B009-S3-6.0.xlsx]GRADATION

Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.57	HEIGHT, mm	25.31	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf			0.92	MOISTURE, %		19.9	19.3
PRECONSOL. PRESSURE, tsf			2.61	DRY DENSITY, pcf		106.2	109.7
OVER CONSOLIDATION RATIO			2.8	SATURATION, %		92	99
COMPRESSION INDEX			0.14	VOID RATIO		0.587	0.522
REBOUND INDEX			0.040	SAMPLE TYPE		UNDISTURBED	
LIQUID LIMIT	50	PLASTIC LIMIT	15	PLASTICITY INDEX	35	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	FAT CLAY WITH SAND, OLIVE GRAY WITH GRAYISH BROWN						
BORING NO.	COF-B009	SAMPLE NO.	S5	DEPTH, feet		13.5 - 15.5	

DYNEGY
COFFEEN, ILLINOIS
15151122
9/18/2015

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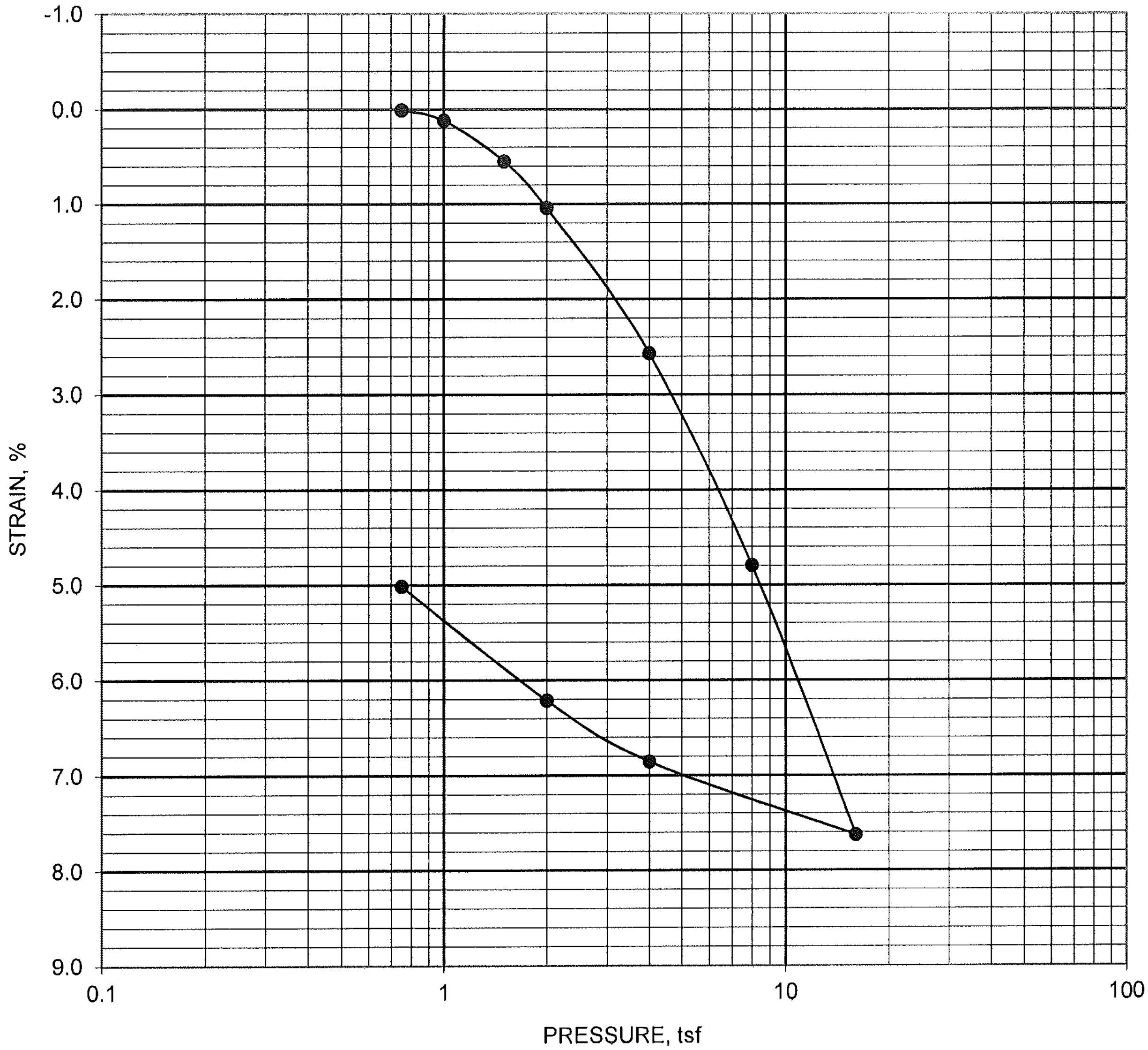
Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.57	HEIGHT, mm	25.31	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		0.92		MOISTURE, %	19.9	19.3
PRECONSOL. PRESSURE, tsf		2.61		DRY DENSITY, pcf	106.2	109.7
OVER CONSOLIDATION RATIO		2.8		SATURATION, %	92	99
COMPRESSION INDEX		0.14		VOID RATIO	0.587	0.522
REBOUND INDEX		0.040		SAMPLE TYPE	3" SHELBY TUBE	

LIQUID LIMIT	50	PLASTIC LIMIT	15	PLASTICITY INDEX	35	SPECIFIC GRAVITY	2.7 ESTIMATED

SAMPLE DESCRIPTION FAT CLAY WITH SAND, OLIVE GRAY WITH GRAYISH BROWN

BORING NO.	COF-B009	SAMPLE NO.	S5	DEPTH, feet	13.5 - 15.5

DYNEGY
COFFEEN, ILLINOIS
15151122
9/18/2015

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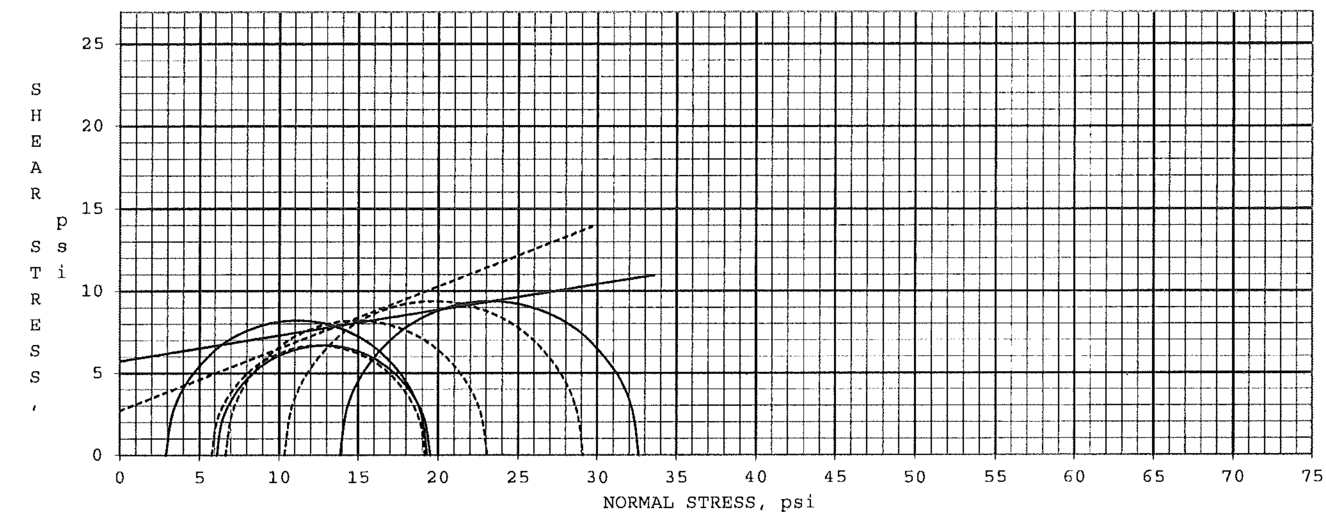
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/18/2015

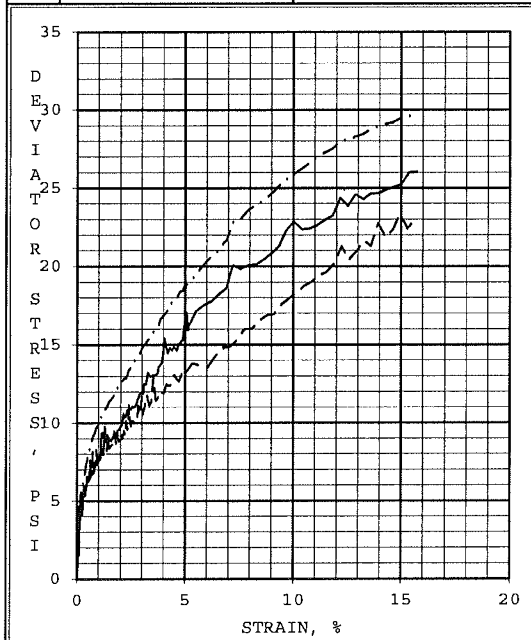
ADDITIONAL CONSOLIDATION DATA

COF-B009
S5
13.5 - 15.5

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.75			2.17E-07	1.37E-07	
1	6.10E-04	6.13E-04	7.16E-06	4.51E-06	2.75E-09
1.5	4.35E-04	4.37E-04	1.40E-05	8.83E-06	3.84E-09
2	1.67E-04	1.68E-04	1.59E-05	1.01E-05	1.68E-09
4	1.53E-04	1.54E-04	1.24E-05	7.88E-06	1.21E-09
8	1.01E-04	1.02E-04	9.03E-06	5.84E-06	5.91E-10
16	9.99E-05	1.00E-04	5.74E-06	3.80E-06	3.79E-10
AVERAGE	2.61E-04	2.62E-04	9.21E-06	5.87E-06	1.74E-09



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**20.7**	COHESION, psi	**2.7**
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**8.9**	COHESION, psi	**5.7**



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	17.9	17.8	17.9
INITIAL	DRY DENSITY, pcf	114.0	111.8	112.5
INITIAL	SATURATION, %	101	95	97
INITIAL	VOID RATIO	0.48	0.51	0.50
BEFORE SHEAR	WATER CONTENT, %	17.7	18.3	17.3
BEFORE SHEAR	DRY DENSITY, pcf	114.1	112.8	114.9
BEFORE SHEAR	SATURATION (B PARAMETER)	0.96	0.96	0.96
BEFORE SHEAR	VOID RATIO	0.48	0.49	0.47
BEFORE SHEAR	FINAL BACK PRESSURE, psi	100.3	101.2	100.0
MINOR PRINCIPAL STRESS, psi		2.9	6.1	13.9
EFFECTIVE STRESS PEAK AT % STRAIN		5.0	5.0	5.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		16.4	13.4	18.8
TOTAL STRESS PEAK AT % STRAIN		5.0	5.0	5.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		16.4	13.4	18.8
ULTIMATE DEVIATOR STRESS (15% STR), psi		25.5	23.2	29.4
TIME TO 50% PRIMARY CONSOLIDATION, min		5.60	38.00	62.00
STRAIN RATE, % / hour		0.29	0.48	0.29
INITIAL DIAMETER, inch		1.363	1.367	1.367
INITIAL HEIGHT, inch		2.836	2.822	2.837
AREA AFTER CONSOLIDATION, inch2		1.457	1.460	1.443

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
FAT CLAY WITH SAND, OLIVE GRAY & GRAYISH BROWN

LL 50	PL 15	PI 35	Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B009

LABORATORY: TERRACON - LENEXA

SAMPLE #: S5

DATE: 9/18/2015

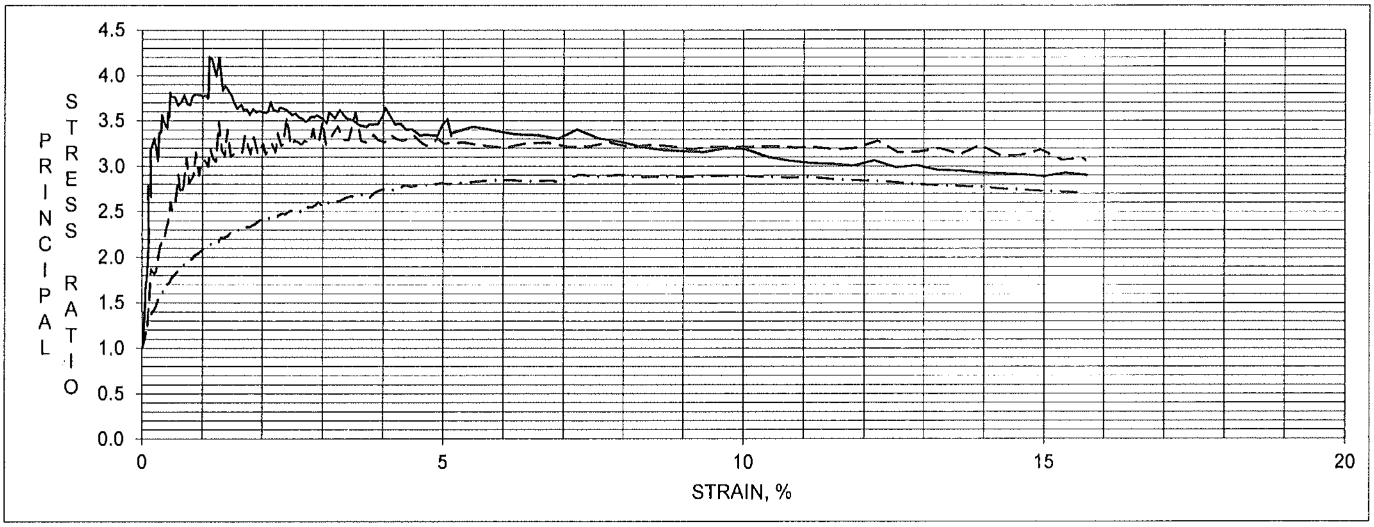
DEPTH, feet: 13.5 - 15.5

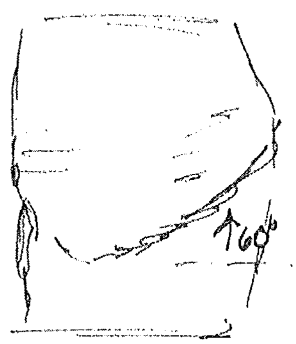
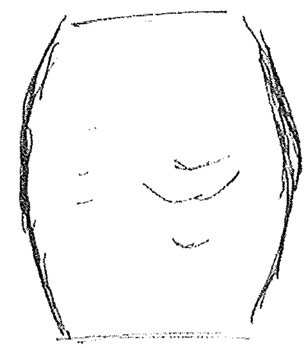
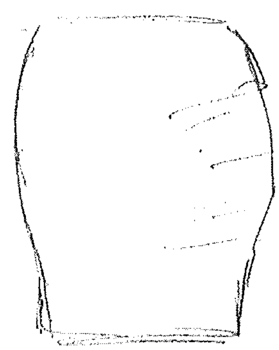
PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

DYNEGY

15151122 | COF-B009 | S5 | 13.5 - 15.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 5 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 5 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 5 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 5 % STRAIN.

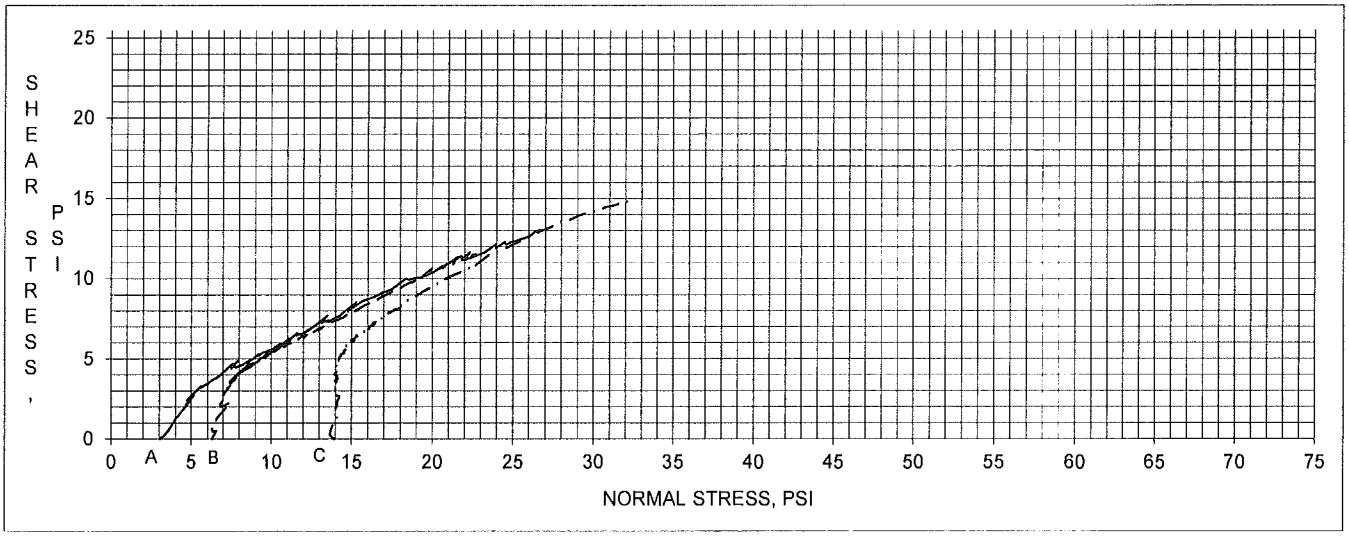
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

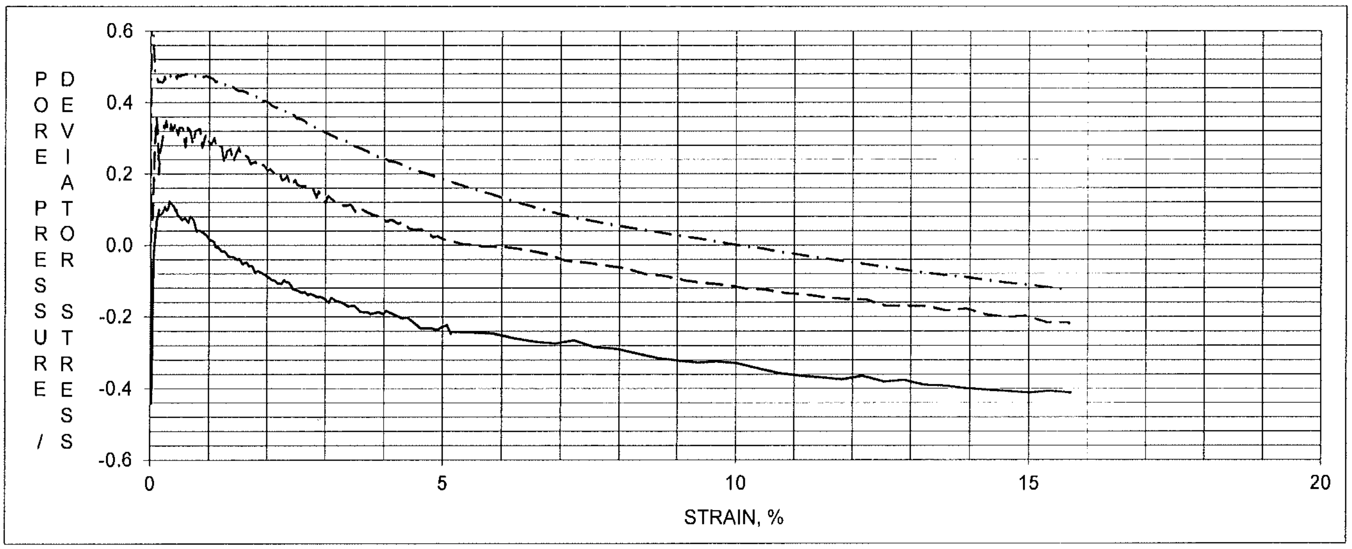
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

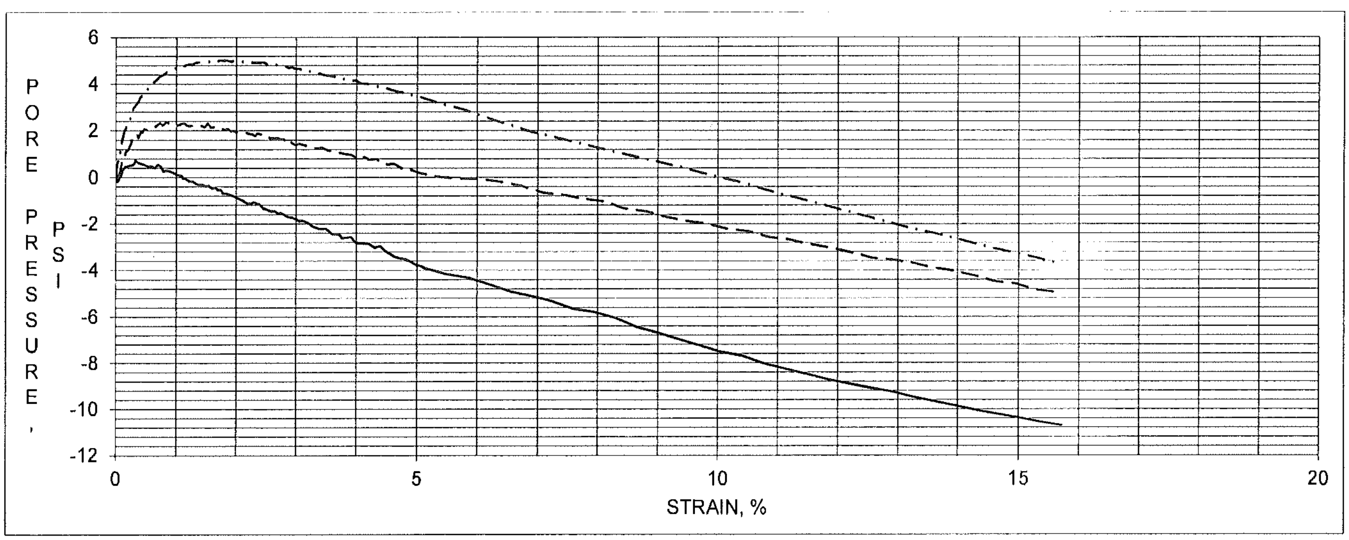
Terracon

DYNEGY

15151122 COF-B009 S5 13.5 - 15.5



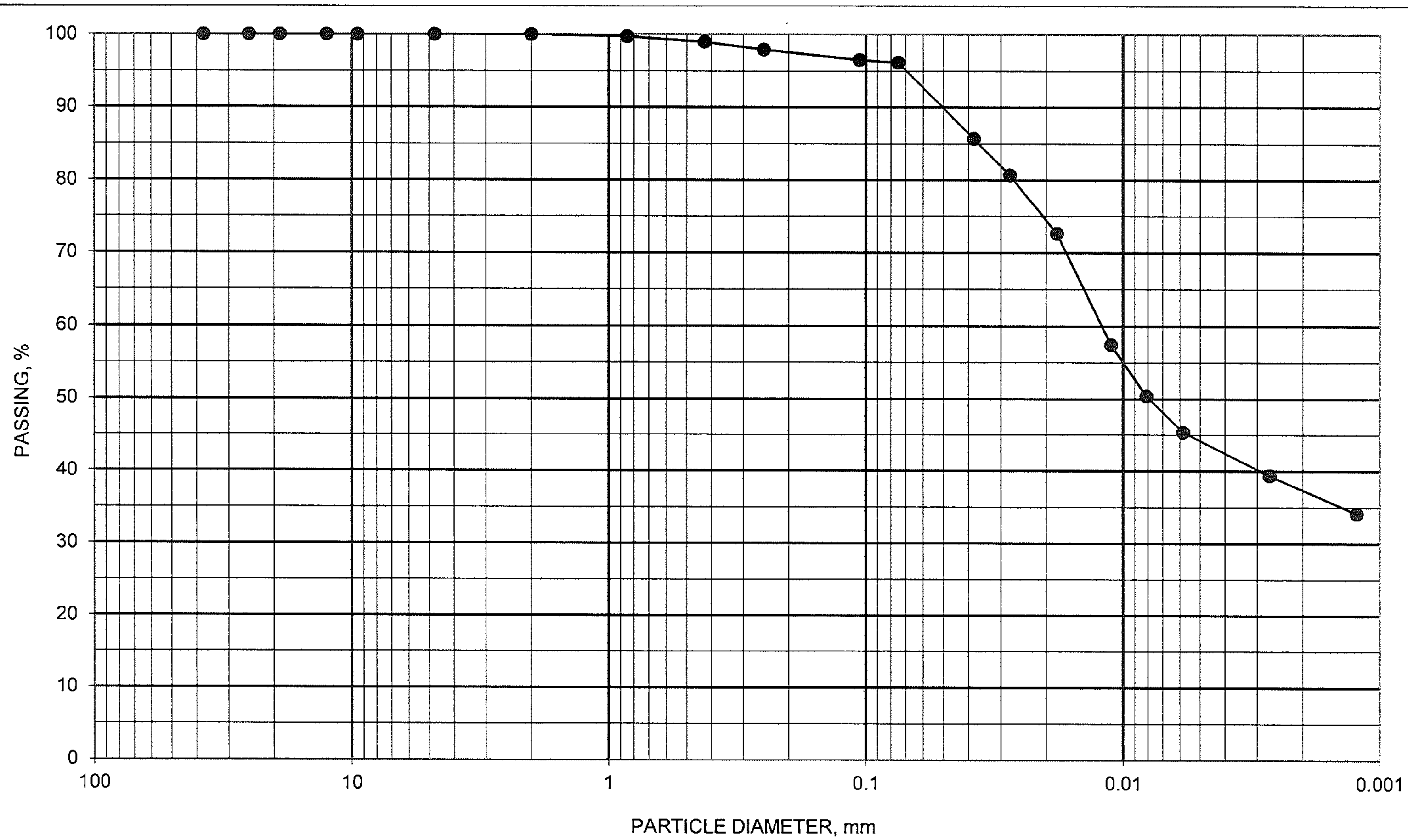




Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	99
#60	0.250	98
#140	0.106	97
#200	0.075	96.2
	0.0382	85.7
	0.0277	80.7
	0.0181	72.7
	0.0111	57.4
	0.0081	50.4
	0.0058	45.4
	0.0027	39.3
	0.0012	34.1
	D60	0.0121

SPECIFIC GRAVITY 2.70 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B009	S11	38.5 TO 40	LEAN CLAY BROWN & GRAY	CL	21.6	49	17	32

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B009\[15151122 Hydrometer Plot COF-B009-S11-38.5.xlsx]ATTERBERG M%

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B010	S1	1.0	2.5	15.1														
	Color				brown & gray					Visual Classification					Fill: Lean Clay trace fine Gravel			
	S2	3.5	5.0	5.8					**Sieve									
	Color				black					Visual Classification					Fill: Cinders; Well-Graded Sand with Clay trace Gravel			
	S3	6.0	7.5	3.8														
	Color				black					Visual Classification					Fill: Cinders			
	S4	8.5	10.0	9.6					**Sieve		2.70							
	Color				black					Visual Classification					Fill: Cinders; Well-Graded Sand with Clay trace Gravel			
	S5	13.5	15.0	14.2														
	Color				black					Visual Classification					Fill: Cinders			
	S6	18.5	20.0	14.8		NP	NP	NP	**Sieve									SW-SM
	Color				black					Visual Classification					Fill: Cinders; Well-Graded Sand with Clay trace Gravel			
	S7	23.5	25.0	24.1														
			Cinders	13.9														
	Color				Cinders: black - Clay: brown & gray					Visual Classification					Fill: Cinders & Fat Clay trace fine Sand			
	S8	28.5	30.0	21.9		48	17	31	NOTE*									CL
	Color				brown & gray					USCS Classification					Sandy Lean Clay			
	S9	33.5	35.0	18.6														
	Color				brown & gray					Visual Classification					Sandy Lean Clay trace fine Gravel			
	S10	38.5	40.0	9.1		47	19	28	NOTE*									CL
	Color				gray					USCS Classification					Sandy Lean Clay			
	S11	42.5	44.0	9.6														
	Color				gray					Visual Classification					Sandy Silty Lean Clay trace fine Gravel			

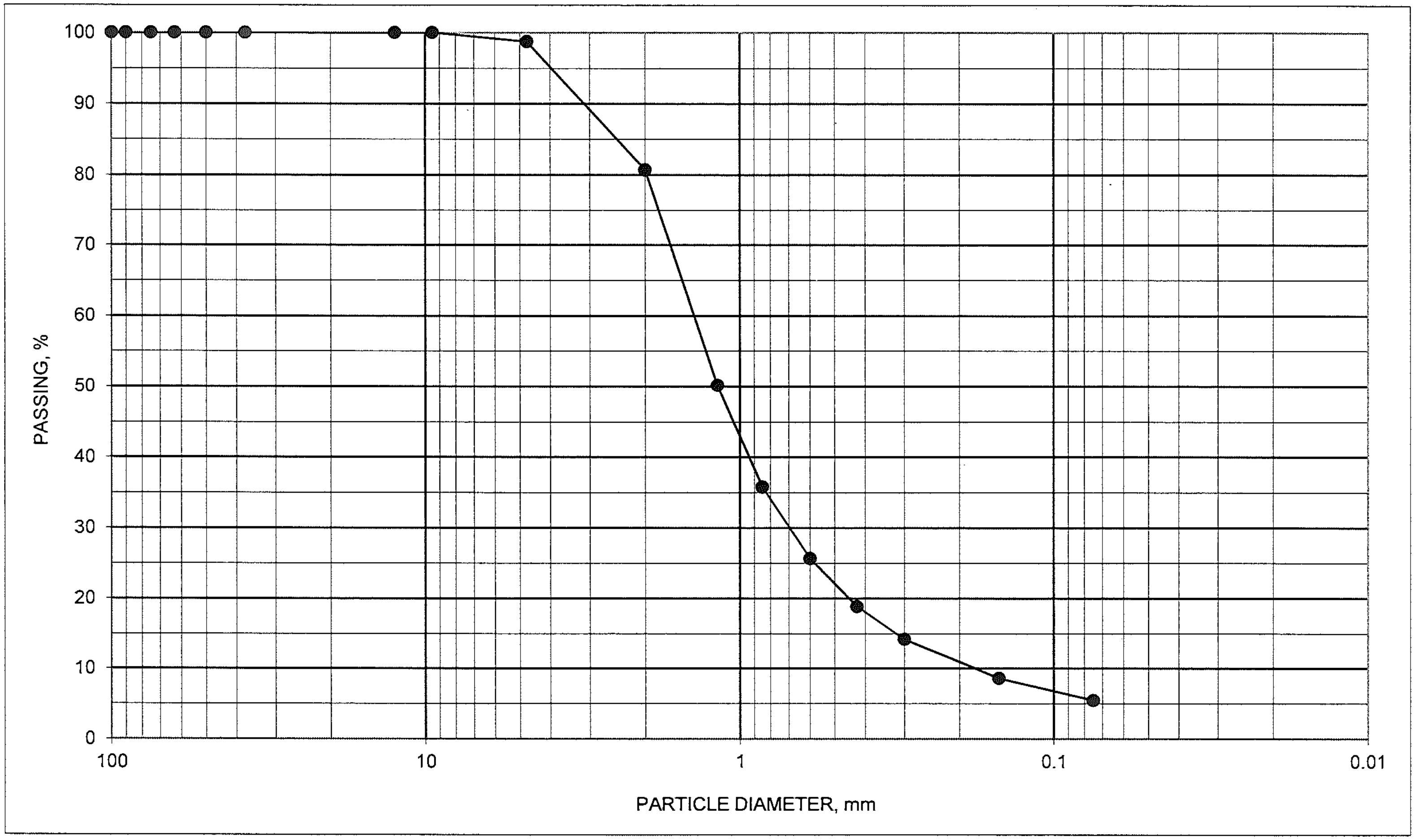
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
2"	50.0	100
1.5"	37.5	100
1/2"	12.5	100
3/8"	9.5	100
#4	4.8	99
#10	2.00	81
#16	1.18	50
#20	0.85	36
#30	0.600	26
#40	0.425	19
#50	0.300	14
#100	0.150	9
#200	0.075	5.5

D60	1.3982
D30	0.6966
D10	0.1781
Cu	7.9
Cc	1.9



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B010	S2	3.5 TO 5	CINDERS; WELL-GRADED SAND WITH CLAY TRSACE GRAVEL BLACK					

PROJECT DYNEGY

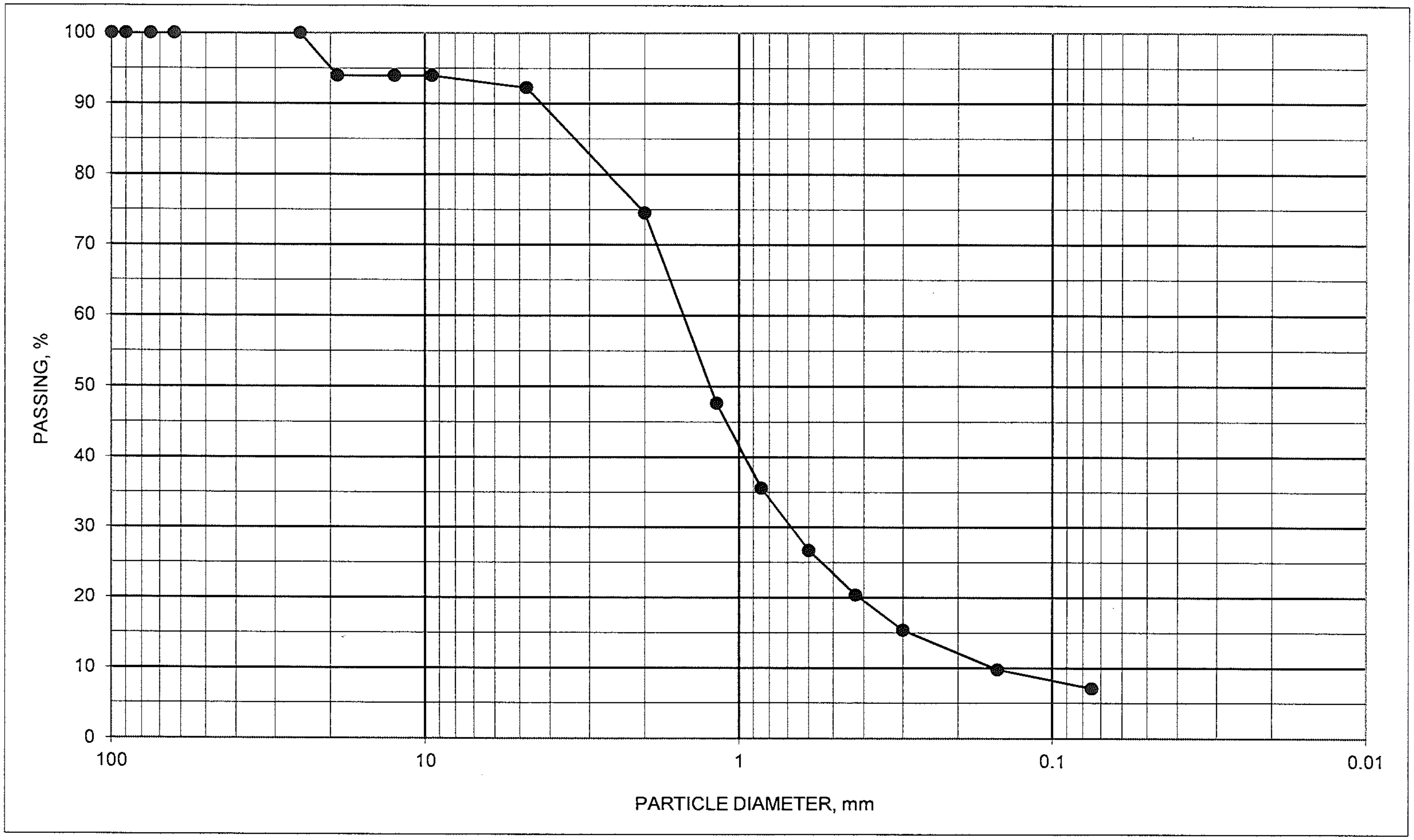
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B10-S2-3.5 .xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	94
1/2"	12.5	94
3/8"	9.5	94
#4	4.8	92
#10	2.00	75
#16	1.18	48
#20	0.85	36
#30	0.600	27
#40	0.425	20
#50	0.300	15
#100	0.150	10
#200	0.075	7.1

D60	1.5037
D30	0.6823
D10	0.1536
Cu	9.8
Cc	2.0



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B010	S4	8.5 TO 10	CINDERS; WELL=GRADED SAND WITH CLAY TRACE GRAVEL BLACK					

PROJECT DYNEGY

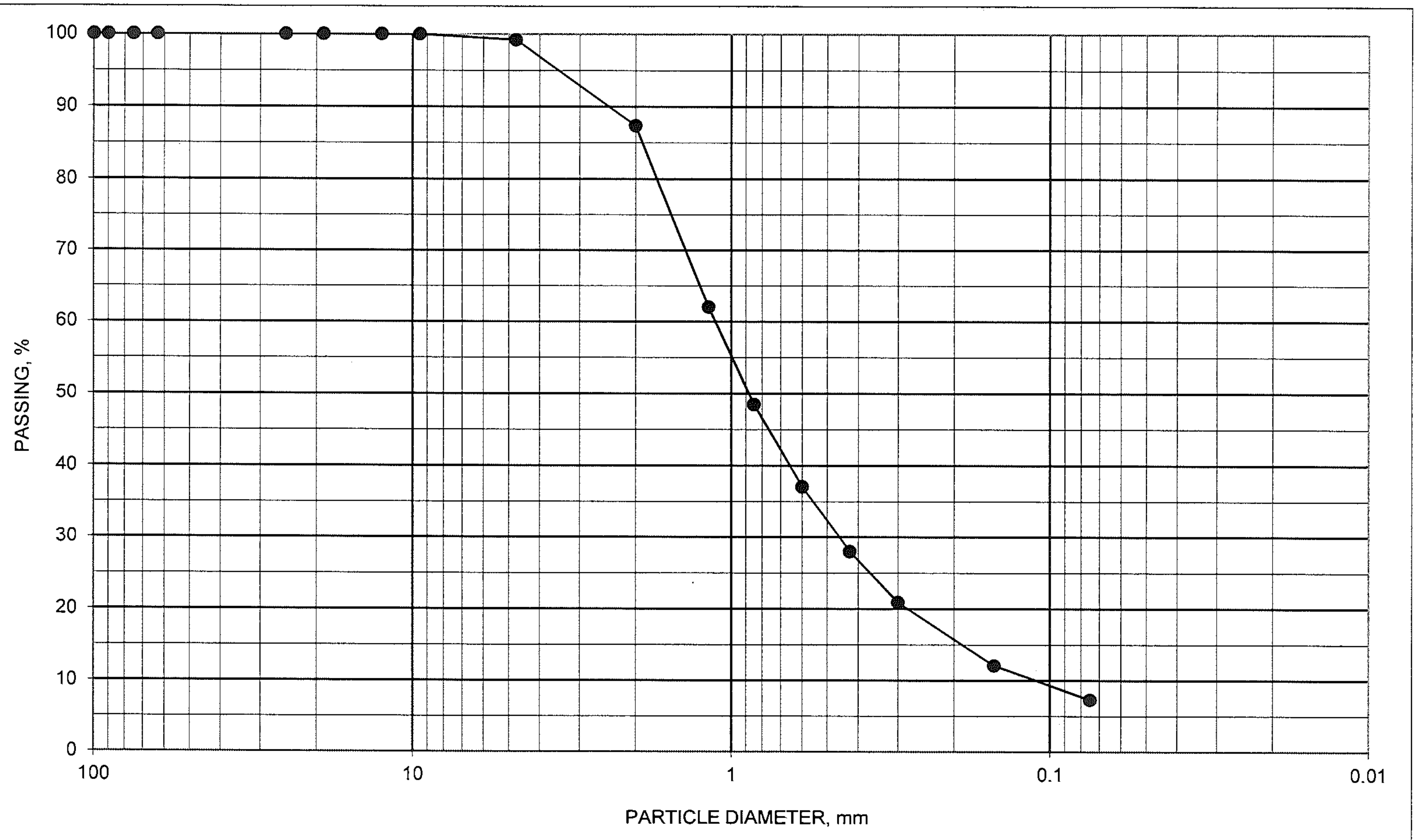
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B010-S48.5.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.5	100
#4	4.8	99
#10	2.00	87
#16	1.18	62
#20	0.85	48
#30	0.600	37
#40	0.425	28
#50	0.300	21
#100	0.150	12
#200	0.075	7.3

D60	1.1233
D30	0.4582
D10	0.1105
Cu	10.2
Cc	1.7



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B010	S6	18.5 TO 20	CINDERS; WELL-GRADED SAND WITH SILT TRACE GRAVEL BLACK	SW-SM		NP	NP	NP

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

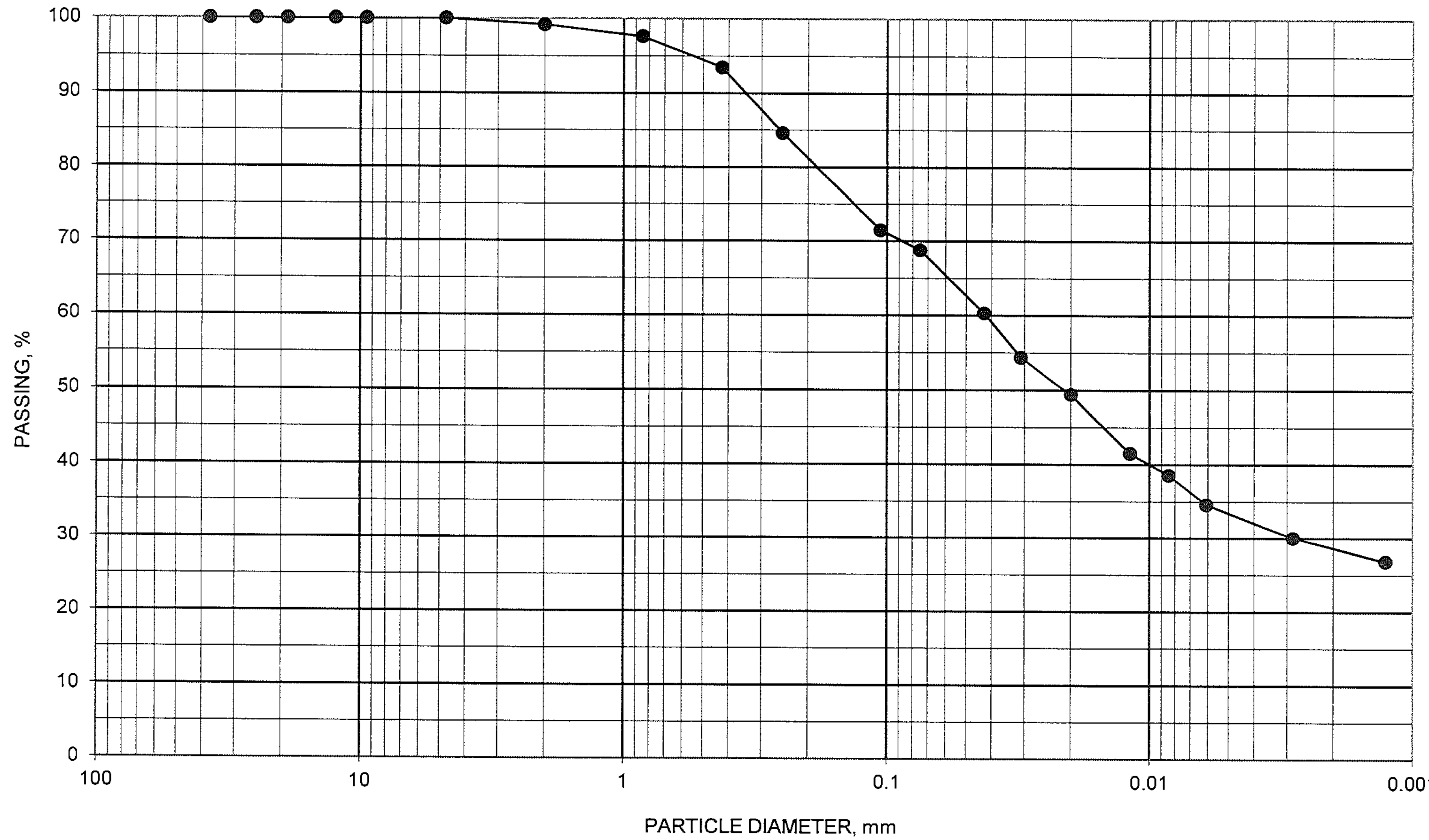
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B010-S6-18.5.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	99
#20	0.850	98
#40	0.425	93
#60	0.250	85
#140	0.106	71
#200	0.075	68.8
	0.0428	60.3
	0.0310	54.3
	0.0200	49.4
	0.0119	41.5
	0.0085	38.5
	0.0061	34.6
	0.0029	30.0
	0.0013	26.9

D60 0.0422
D30 0.0028

SPECIFIC GRAVITY 2.69
ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B010	S8	28.5 TO 30	SANDY LEAN CLAY BROWN & GRAY	CL	21.9	48	17	31

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/3/2015

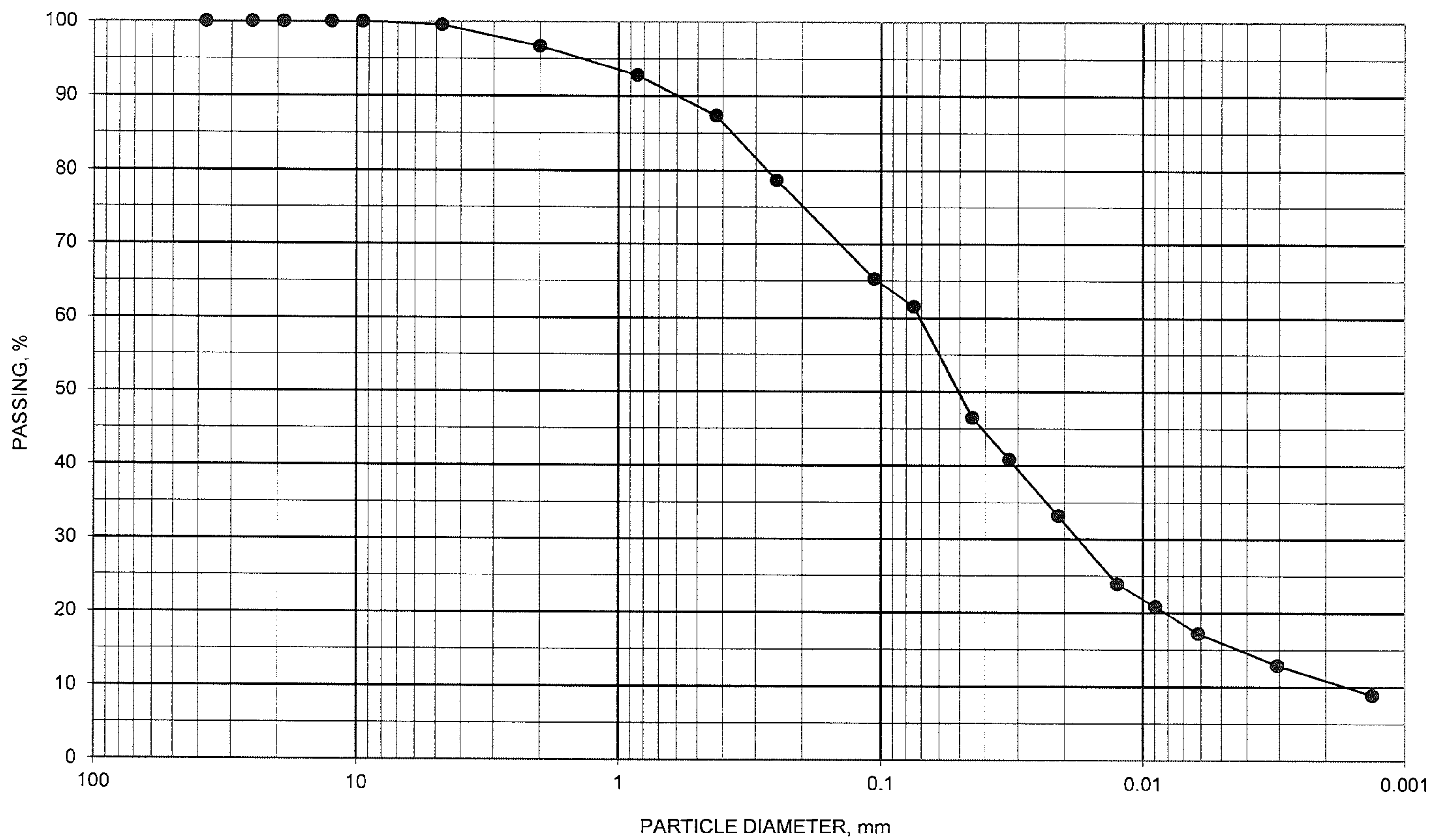
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B010-S8-28.5.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	97
#20	0.850	93
#40	0.425	87
#60	0.250	79
#140	0.106	65
#200	0.075	61.6
	0.0449	46.5
	0.0325	40.8
	0.0211	33.2
	0.0126	23.9
	0.0090	20.9
	0.0062	17.3
	0.0031	12.9
	0.0013	8.9

D60	0.0711
D30	0.0176
D10	0.0017
Cu	42.6
Cc	2.6

SPECIFIC GRAVITY 2.68 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B010	S10	38.5 TO 40	SANDY LEAN CLAY GRAY	CL	9.1	47	19	28

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/3/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B010-S10-38.5.xlsx]GRADATION

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B011	S1	1.0	2.5	23.9														
	Color		brown & gray							Visual Classification			Fill: Lean to Fat Clay with fine to medium Sand					
	S2	3.5	5.0	23.5	***	67	20	47										
	Color		brown & gray							Visual Classification			Fill: Fat Clay					
	S3	6.0	7.5	26.1														
	Color		brown & gray							Visual Classification			Fill: Lean Clay trace fine Sand					
	S4	8.0	8.2	21.8														
	Color		brown & gray							Visual Classification			Fill: Lean Clay trace fine Sand					
	S5	8.5	10.0	10.9		32	14	18										
	Color		brown & gray							Visual Classification			Fill: Sandy Elan Clay trace fine Gravel					
	S6	13.5	15.5	11.5	125.0	34	14	20				2.7E-06*						
	Color		yellowish brown with grayish brown							Visual Classification			Sandy Lean Clay					
	S7	16.0	18.0	12.0	119.7	30	14	16		32*			NOTE*	***		ND1*	1*	
	Color		yellowish brown trace gray							Visual Classification			Sandy Lean Clay trace Gravel					
	S8	18.5	20.0	27.3														
	Color		brown & gray							Visual Classification			Lean to Fat Clay					
	S9	23.5	25.0	19.4	106.7													
	Color		brown & gray							Visual Classification			Lean Clay trace fine to medium Sand					
	S10	28.5	30.0	17.3		32	15	17										
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace fine Gravel					
	S11	30.0	32.0	Sent to Fugro														
	Color									Visual Classification								
	S12	32.0	33.0	8.9	***													
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace fine Gravel					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.
*** Testing Not Possible

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B011	S13	33.5	35.0	9.3					NOTE*									
	Color		gray							Visual Classification		Silty, Clayey Sand trace Gravel						
	S14	38.5	40.0	9.8	***													
	Color		gray							Visual Classification		Sandy Silty Lean Clay trace fine Gravel						

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.
*** Testing Not Possible

Terracon

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS
USING A FLEXIBLE WALL PERMEAMETER
ASTM D 5084 - 03 METHOD C TEST WITH INCREASING TAILWATER LEVEL
FLUID: DEAIRED TAP WATER WITH 0.005 N CaSO4

PROJECT NAME:	DYNEGY	PROJECT NUMBER:	15151122
LOCATION:	COFFEEN, ILLINOIS	DATE:	9/4/2015
		PANEL IDENTIFICATION:	Lenexa Perm Board
SAMPLE ID:	COF-B011 S6 13.5 - 15.5 feet	BURETTE AREA:	0.312 cm^2
SAMPLE DESCR.:	SANDY LEAN CLAY, YELLOWISH BROWN WITH GRAYISH BROWN	BURETTE INCREMENT LENGTH:	1.000 cm
		VOLUME PER INCREMENT:	0.312 cm^3

INITIAL

MOISTURE%		DENSITY			
W & T, g	151.23	WET WT, g	464.3		
D & T, g	139.17	DIA, in	2.861	7.27	cm
T, g	33.87	HT, in	1.975	5.02	cm
		AREA		41.48	cm^2
MOIST-		DENSITY:	139.3	PCF WET	
URE, %	**11.5**	DENSITY:	**125.0**	PCF DRY	

ADDITIONAL DATA

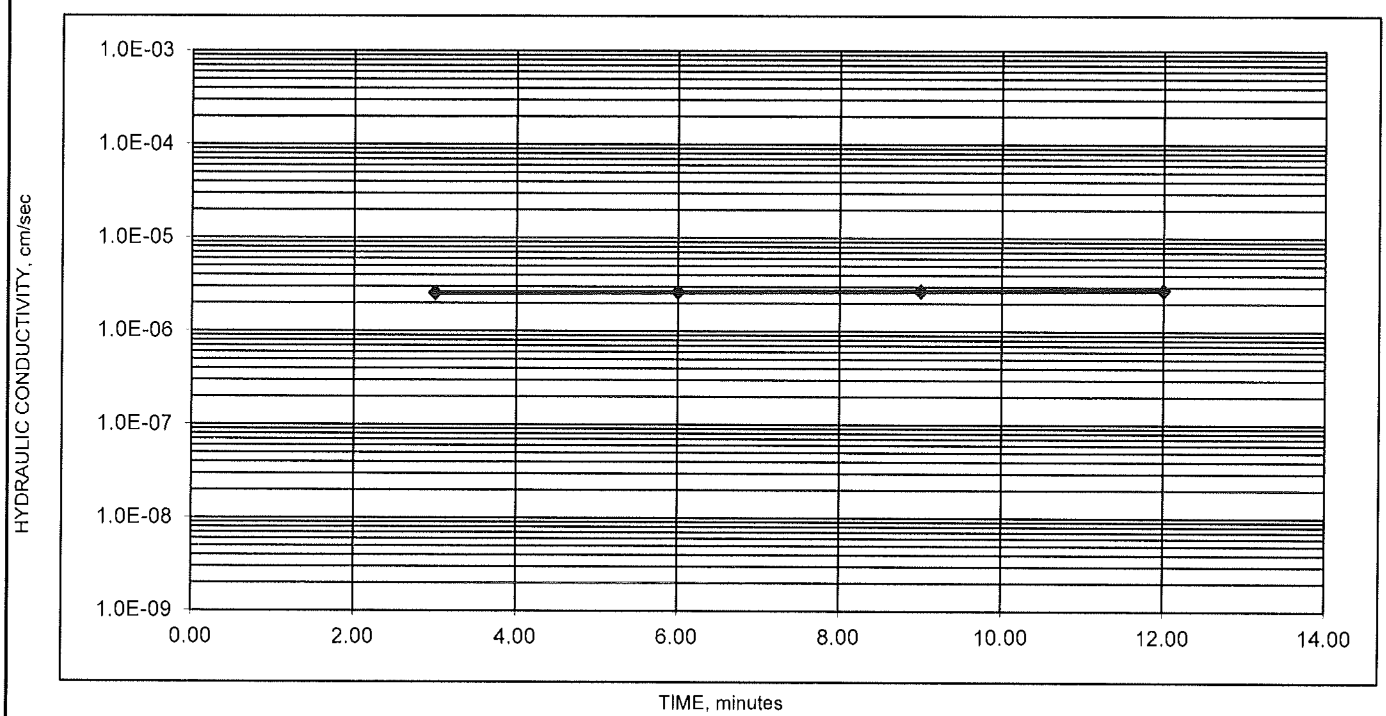
SPECIFIC GRAVITY:	2.70	RECOMPACTED?:	NO
SPECIFIC GRAVITY:	ASSUMED	PROCTOR, pcf:	NA
POROSITY, %:	25.8	OPTIMUM, %:	NA
SATURATION, %:	88.7	COMPACTION, %:	NA
VOID RATIO:	0.35	OVER OPTIMUM, %:	NA

SATURATION:	LATERAL PRESS.: 104.0 psi	BACK PRESSURE (=UPPER=LOWER): 100.0 psi	
DURING TEST:	LATERAL PRESS.: 104.0 psi	H2: 100.0 psi	H1: 100.0 psi
			BIAS PRESSURE (=H1-H2) 0.0 psi

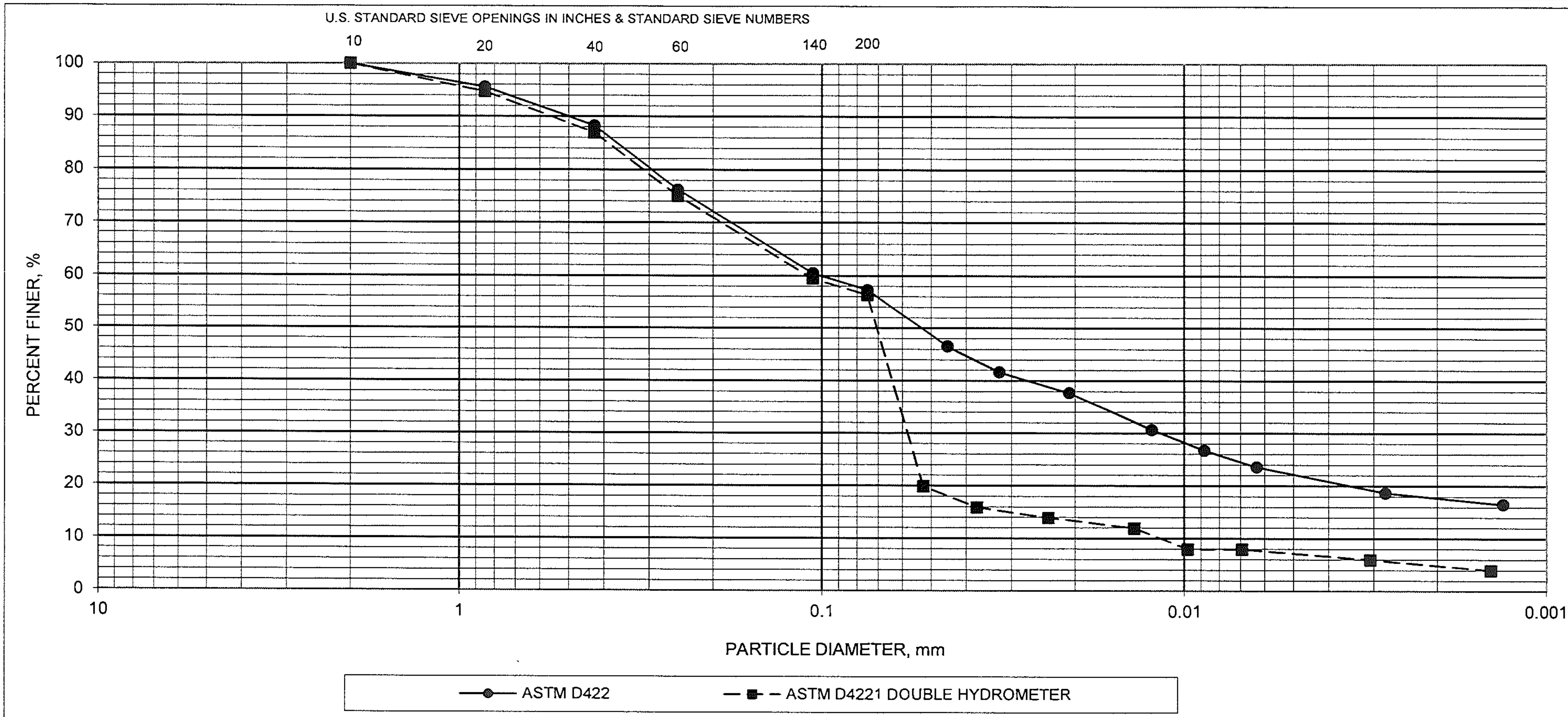
H1 VALUE	H2 VALUE	ELAPSED TIME, min	DELTA H cm	Ln H1/H2	HYD CON k, cm/sec	OUT FLOW cm^3	IN FLOW cm^3	OUT/IN RATIO	HYD GRAD	% FROM MEAN k	TEMP.: C	TEMP. CORR.:
8.5	23.9	0.00	15.4									
8.7	23.7	3.00	15.0	0.026317	2.55E-06	0.06	0.06	1.00	3.0	4	23.4	0.923
8.9	23.5	6.00	14.6	0.027029	2.62E-06	0.06	0.06	1.00	2.9	1	23.4	0.923
9.1	23.3	9.00	14.2	0.027780	2.69E-06	0.06	0.06	1.00	2.8	1	23.4	0.923
9.3	23.1	12.00	13.8	0.028573	2.77E-06	0.06	0.06	1.00	2.8	4	23.4	0.923

HYDRAULIC CONDUCTIVITY (k_{20}) = **AVERAGE 2.7E-06 cm/sec**

MAXIMUM	1.0E-03 TO 1.0E-04	2	0.75<	10	% < 25 AT
HYDRAULIC	1.0E-04 TO 1.0E-05	5	RATIO	MAX	> 1.0E-8
GRADIENT	1.0E-05 TO 1.0E-06	10	<1.25	HYDRAULIC	OR
	1.0E-06 TO 1.0E-07	20		GRADIENT	% < 50 AT
	less than 1.0E-07	30		ALLOWED	< 1.0E-8



Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	22.2	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	7.2	DISPERSION, %	**32**

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B011	S7	16.0 - 18.0	SANDY LEAN CLAY TRACE GRAVEL, YELLOWISH BROWN TRACE GRAY					

PROJECT DYNEGY

COFFEEN, ILLINOIS

JOB NO. 15151122 DATE 9/2/2015

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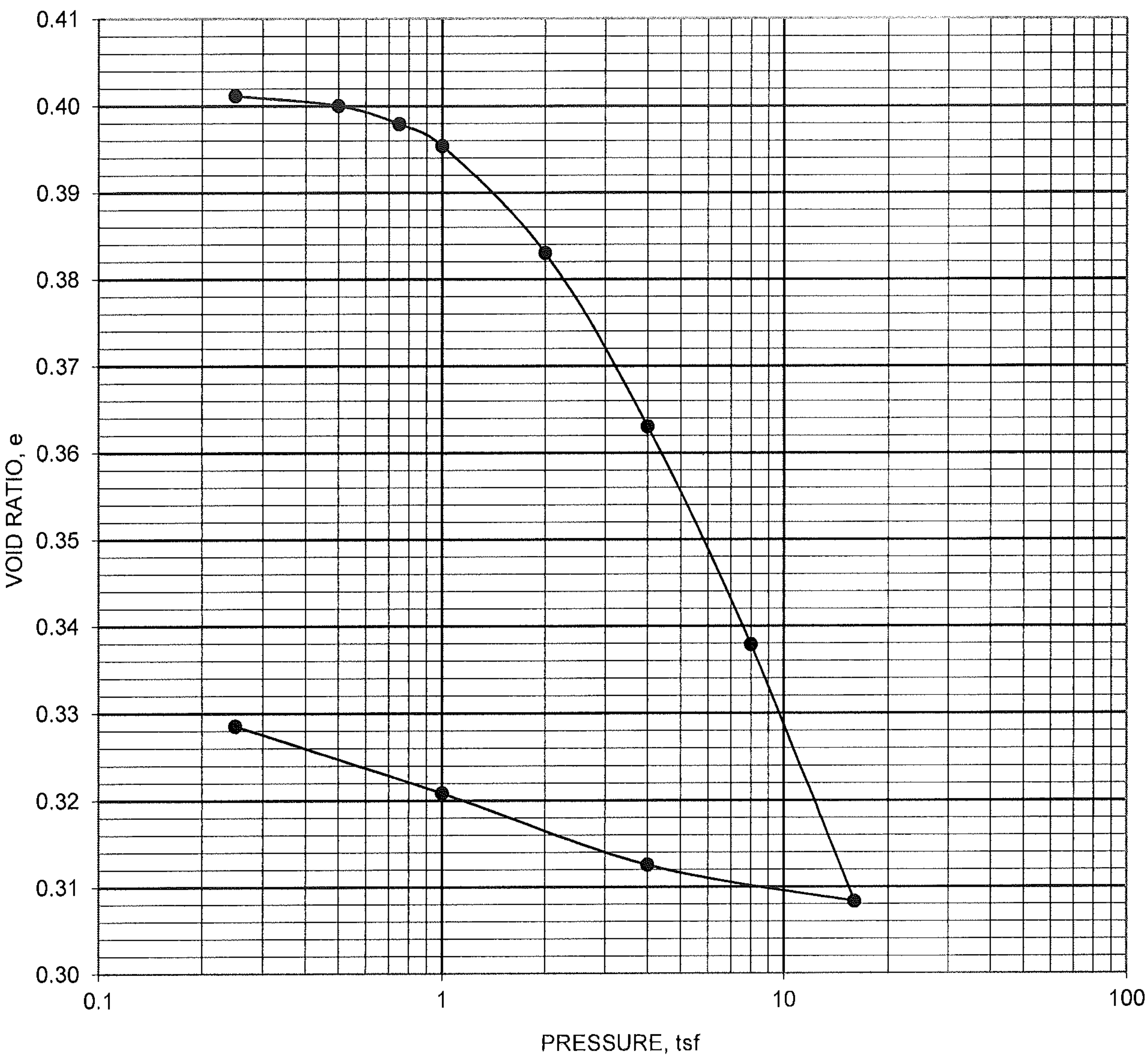
Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.54	HEIGHT, mm	25.30	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		1.14		MOISTURE, %		12.0	12.4
PRECONSOL. PRESSURE, tsf		2.17		DRY DENSITY, pcf		120.3	125.2
OVER CONSOLIDATION RATIO		1.9		SATURATION, %		80	101
COMPRESSION INDEX		0.10		VOID RATIO		0.401	0.328
REBOUND INDEX		0.013		SAMPLE TYPE		UNDISTURBED	
LIQUID LIMIT	30	PLASTIC LIMIT	14	PLASTICITY INDEX	16	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	SANDY LEAN CLAY TRACE GRAVEL, YELLOWISH BROWN TRACE GRAY						
BORING NO.	COF-B011	SAMPLE NO.	S7	DEPTH, feet	16.0 - 18.0		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

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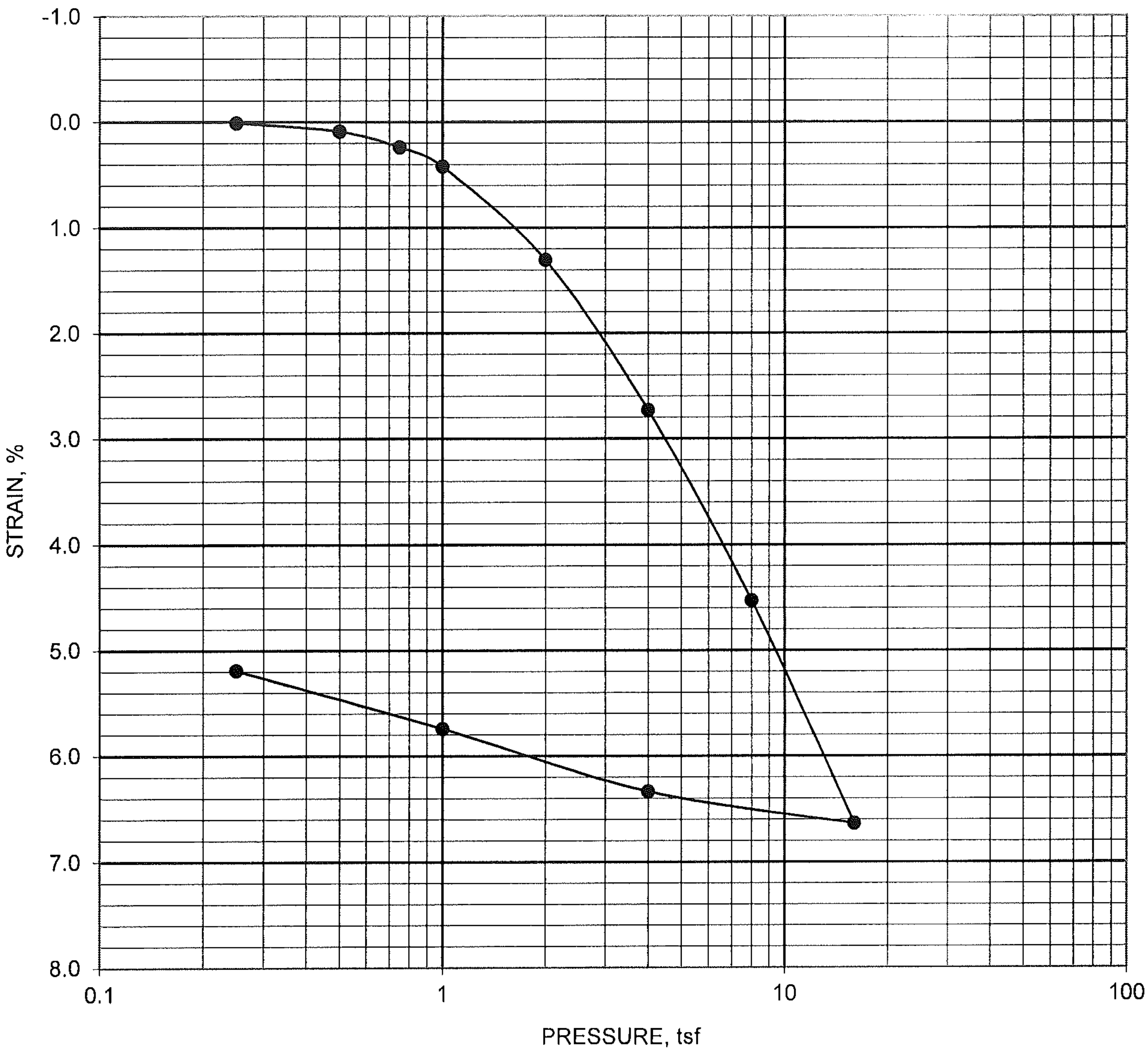
Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.54	HEIGHT, mm	25.30	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		1.14		MOISTURE, %	12.0	12.4
PRECONSOL. PRESSURE, tsf		2.17		DRY DENSITY, pcf	120.3	125.2
OVER CONSOLIDATION RATIO		1.9		SATURATION, %	80	101
COMPRESSION INDEX		0.10		VOID RATIO	0.401	0.328
REBOUND INDEX		0.013		SAMPLE TYPE	3" SHELBY TUBE	

LIQUID LIMIT	30	PLASTIC LIMIT	14	PLASTICITY INDEX	16	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	SANDY LEAN CLAY TRACE GRAVEL, YELLOWISH BROWN TRACE GRAY						
BORING NO.	COF-B011	SAMPLE NO.	S7	DEPTH, feet	16.0 - 18.0		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

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Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

ADDITIONAL CONSOLIDATION DATA

COF-B011
S7
16.0 - 18.0

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.25			5.75E-07	4.10E-07	
0.5	1.64E-03	1.65E-03	4.60E-06	3.28E-06	5.38E-09
0.75	3.27E-04	3.29E-04	8.62E-06	6.16E-06	2.01E-09
1	4.01E-04	4.03E-04	1.03E-05	7.40E-06	2.97E-09
2	1.66E-03	1.67E-03	1.26E-05	9.06E-06	1.51E-08
4	1.62E-03	1.63E-03	1.02E-05	7.38E-06	1.20E-08
8	1.52E-03	1.53E-03	6.43E-06	4.72E-06	7.16E-09
16	6.95E-04	6.99E-04	3.77E-06	2.82E-06	1.96E-09
AVERAGE	1.12E-03	1.13E-03	7.15E-06	5.16E-06	6.65E-09

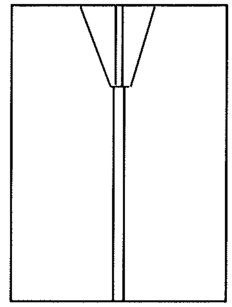
Terracon

DISPERSIVE CLAY SOILS BY THE PINHOLE TEST
ASTM D 4647, METHOD A
9/9/2015

PROJECT DYNEGY
JOB NO. COFFEEN, ILLINOIS
SAMPLE ID COF-B011, S7, 16.0 - 18.0 feet
COMPACTION CHARACTERISTICS UNDISTURBED
WATER CONTENT 12.7%
DISTILLED WATER ADDED ____ **YES** X **NO**
CURE TIME NATURAL MOISTURE, NO CURE
BY JDM
SAMPLE DESC. SANDY LEAN CLAY TRACE GRAVEL, YELLOWISH BROWN TR GRAY

FLOW STARTED ON 1ST **TRIAL**

FINAL HOLE
1.0 mm



TIME, min	HEAD, inch	FLOW, ml	FLOW, sec	FLOW RATE, ml/sec	TURBIDITY FROM SIDE: VERY DARK	DARK	MOD. DARK	SLIGHT DARK	BARELY VISIBLE	CLEAR	CLEAR FROM TOP	REMARKS
1	2	18.0	60	0.30						X	X	
2	2	17.0	60	0.28						X	X	
3	2	17.0	60	0.28						X	X	
4	2	17.0	60	0.28						X	X	
5	2	17.0	60	0.28						X	X	
6	2	16.3	60	0.27						X	X	
7	2	16.5	60	0.28						X	X	
8	2	16.0	60	0.27						X	X	
9	2	16.0	60	0.27						X	X	
10	2	16.0	60	0.27						X	X	
1	7	40.0	60	0.67						X	X	
2	7	40.0	60	0.67						X	X	
3	7	40.5	60	0.68						X	X	
4	7	40.5	60	0.68						X	X	
5	7	40.0	60	0.67						X	X	
1	15	64.5	60	1.08						X	X	
2	15	65.0	60	1.08						X		Barely Visible
3	15	65.5	60	1.09						X		Barely Visible
4	15	65.0	60	1.08						X	X	
5	15	65.0	60	1.08						X		Barely Visible
1	40	122.0	60	2.03						X	X	
2	40	126.0	60	2.10						X	X	
3	40	123.0	60	2.05						X	X	
4	40	122.0	60	2.03						X	X	
5	40	124.0	60	2.07						X		Barely Visible

CLASSIFICATION = **ND1**

CRUMB TEST (ASTM D6572)

Project No.: 15151122 Project Name: DYNEGY Location: COFFEEN, IL

Boring No.: COF-B011 Sample No.: S7 Depth: 16.0 - 18.0 [x] ft [ ] m

Visual Classification: ______ Color: ______

Moisture Content of Sample:	[ ] as-received	[ ] in situ	[ ] air-dried	
Tare Number	Wet Mass + Tare (g)	Dry Mass+ Tare (g)	Tare Mass (g)	Water Content (%)
AL-71	63.77	59.32	21.16	11.7

Specimen Identification:				Specimen Identification:				Specimen Identification:			
Spec. Container Identification:	E			Spec. Container Identification:				Spec. Container Identification:			
Method:	[x] A (Natural) [ ] B (Remolded)			Method:	[ ] A (Natural) [ ] B (Remolded)			Method:	[ ] A (Natural) [ ] B (Remolded)		
Water Type:	[x] Distilled [ ] Type IV			Water Type:	[ ] Distilled [ ] Type IV			Water Type:	[ ] Distilled [ ] Type IV		
Initial Water Temp. (°C):	22.5			Initial Water Temp. (°C):				Initial Water Temp. (°C):			
Start Time (hh:mm:ss):	9:03:31			Start Time (hh:mm:ss):				Start Time (hh:mm:ss):			
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	9:05:31	3	21.6	2 min ± 15 s				2 min ± 15 s			
1 h ± 8 min	10:03:40	1	21.2	1 h ± 8 min				1 h ± 8 min			
6 h ± 45 min	2:56:43	1	21.1	6 h ± 45 min				6 h ± 45 min			
Dispersive Classification:	Non-Dispersive			Dispersive Classification:				Dispersive Classification:			
Additional water added to remold the specimen (Method B):	[ ] Y [ ] N			Additional water added to remold the specimen (Method B):	[ ] Y [ ] N			Additional water added to remold the specimen (Method B):	[ ] Y [ ] N		

Remarks: ______

Prepared By: John Martin Date: 9/1/15 Tested By: John Martin Date: 9/1/15 Input By: John Martin Date: 9/8/15 Reviewed By: ______ Date: ______

CRUMB TEST D6572

DYNEGY

COFFEEN, ILLINOIS

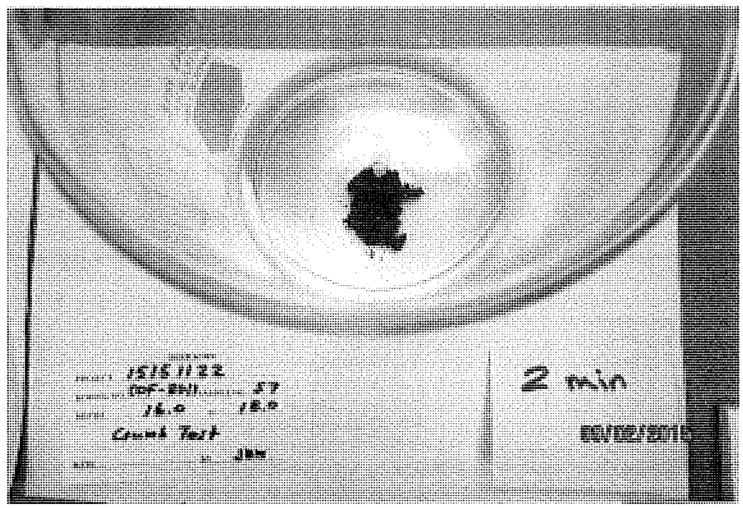
15151122

COF-B011 S7 16.0 - 18.0 feet

2 MIN

GRADE: 3

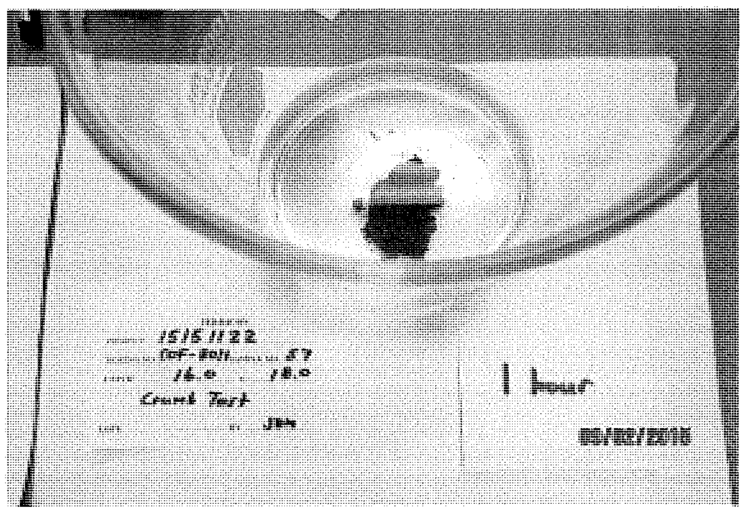
DISPERSIVE CALSSIFICATION: DISPERSIVE



1 HOUR

GRADE: 1

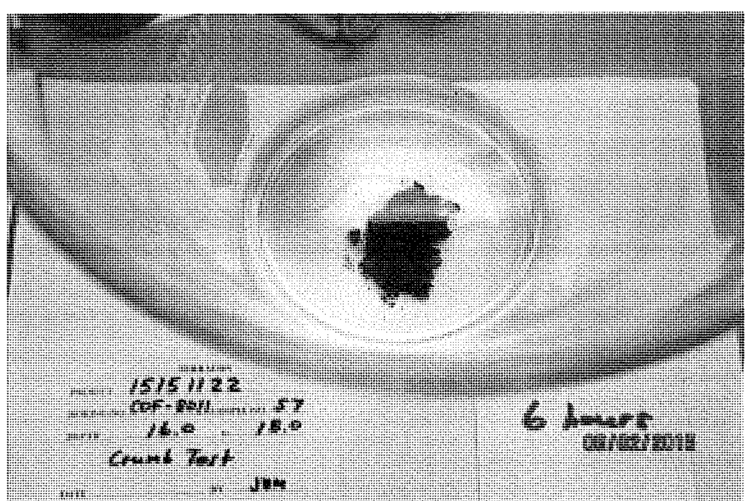
DISPERSIVE CALSSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 1

DISPERSIVE CALSSIFICATION: NONDISPERSIVE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

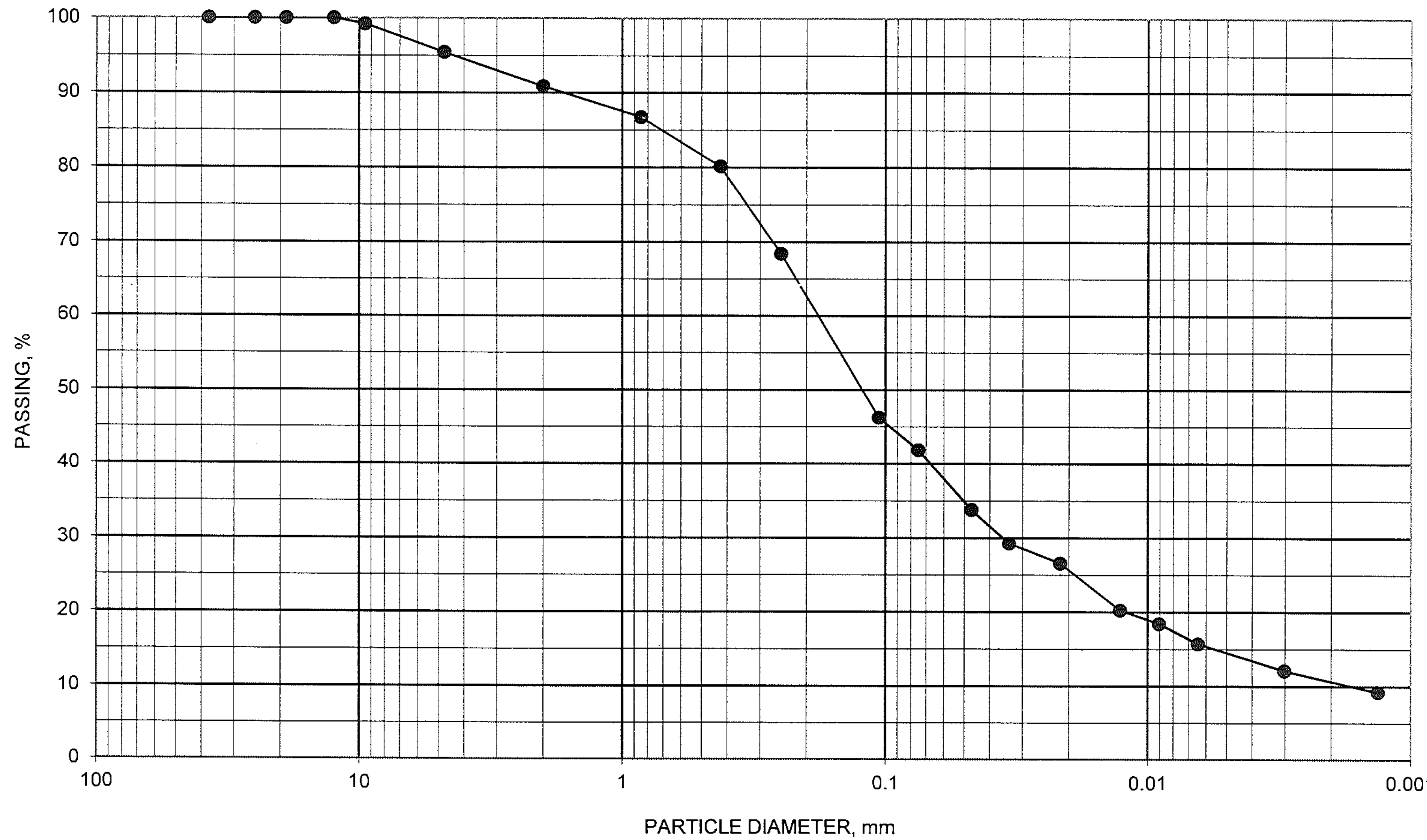
Grade 4 - Highly Dispersive

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	99
#4	4.75	95
#10	2.00	91
#20	0.850	87
#40	0.425	80
#60	0.250	68
#140	0.106	46
#200	0.075	41.8
	0.0470	33.8
	0.0338	29.3
	0.0216	26.6
	0.0127	20.2
	0.0091	18.4
	0.0065	15.7
	0.0030	12.1
	0.0013	9.2

D60	0.1806
D30	0.0357
D10	0.0017
Cu	108.6
Cc	4.2

SPECIFIC GRAVITY 2.65 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B011	S13	33.5 TO 35	SILTY, CLAYEY SAND TRACE GRAVEL GRAY		9.3			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B011-S13-33.5.xlsx]GRADATION

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/16/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-HA-1	S1	0.0	1.0	12.9														
	Color		brown							Visual Classification			Lean Clay					
	S2	1.0	2.0	13.3		35	21	14										
	Color		brown							Visual Classification			Lean Clay					
	S3	2.0	3.0	21.7														
	Color		brown & gray							Visual Classification			Fat Clay					
	S4	3.0	4.0	19.0														
	Color		brown & gray							Visual Classification			Fat Clay trace Sand					
	S5	4.0	5.0	18.1														
	Color		brown & gray							Visual Classification			Fat Clay with Sand					
	S6	5.0	6.0	18.0														
	Color		brown & gray							Visual Classification			Lean Clay with Sand					
	S7	6.0	7.0	16.0		35	14	21										
	Color		brown & gray							Visual Classification			Sandy Lean Clay					
	S8	7.0	8.0	22.9														
	Color		brown & gray							Visual Classification			Sandy Lean Clay					

TESTED BY: JLB
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

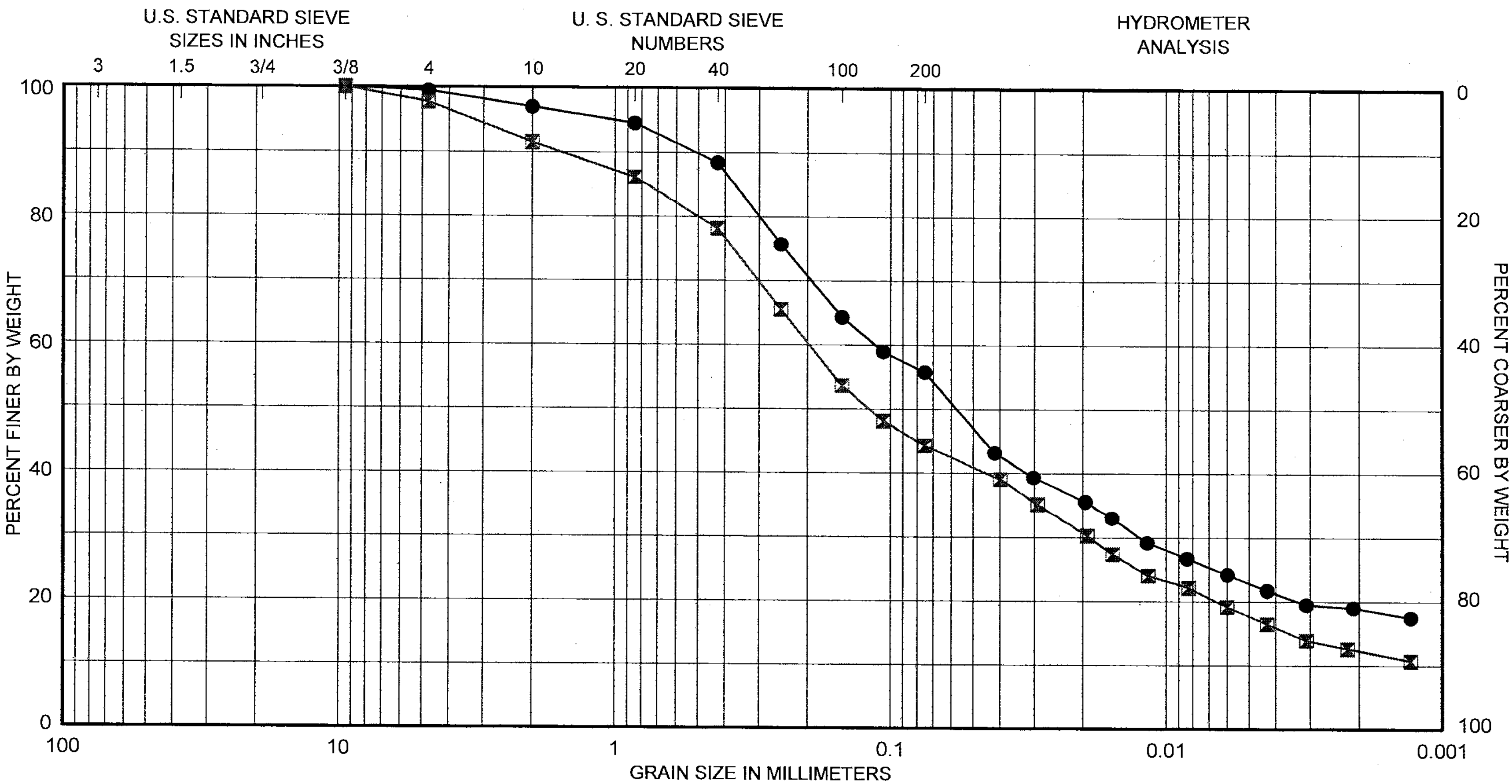
DYNEGY - COFFEEN, ILLINOIS
15151122
9/16/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-HA-2	S1	0.0	1.0	18.6		51	26	25										
	Color		dark brown							Visual Classification			Fat Clay with Sand, Cinders and Organics					
	S2	1.0	2.0	20.9		47	20	27										
	Color		brown							Visual Classification			Lean Clay					
	S3	2.0	3.0	22.8														
	Color		brown							Visual Classification			Lean Clay					
	S4	3.0	4.0	15.8														
	Color		brown							Visual Classification			Lean Clay trace Sand					
	S5	4.0	5.0	13.4		43	16	27										
	Color		brown							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S6	5.0	6.0	11.4														
	Color		brown							Visual Classification			Sandy Lean Clay trace Fine Gravel					

TESTED BY: JLB
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

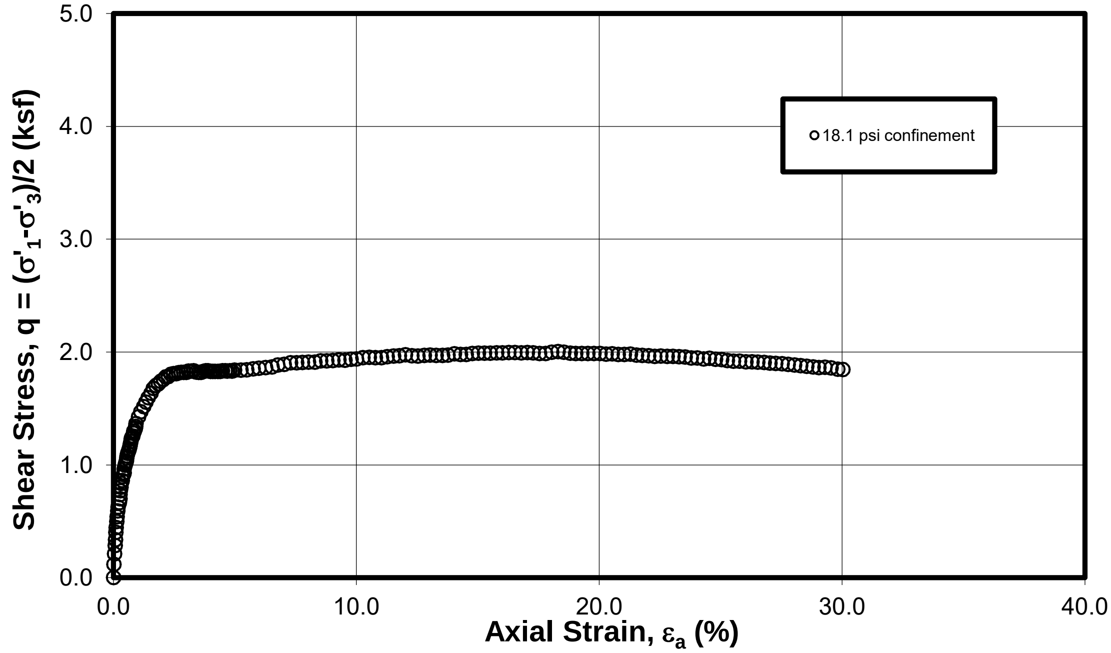
Terracon

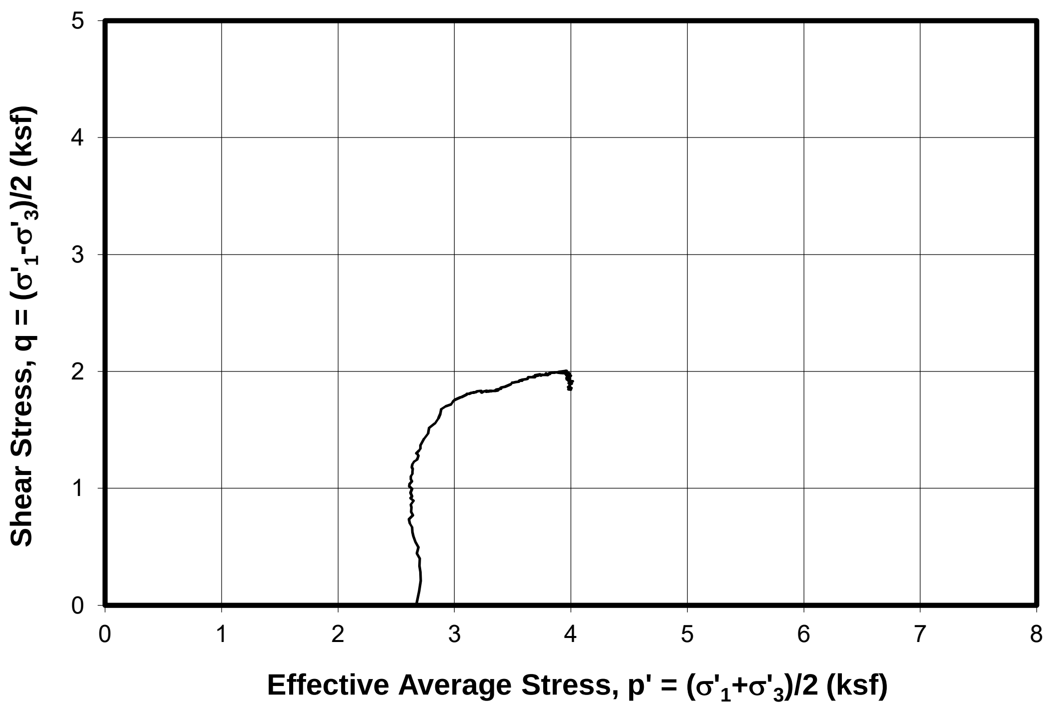


GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

SYMBOL	BORING	DEPTH, FT	C_c	C_u	D_{50}	D_{90}	CLASSIFICATION
●	COF-B008	29.5			0.06	0.51	Sandy Clay, gray, with ferrous stains, gravel, and carbonate nodules
⧗	COF-B011	32			0.12	1.58	Sandy Clay, gray, with sand and gravel
✳							
⊗							

GRAIN SIZE CURVE



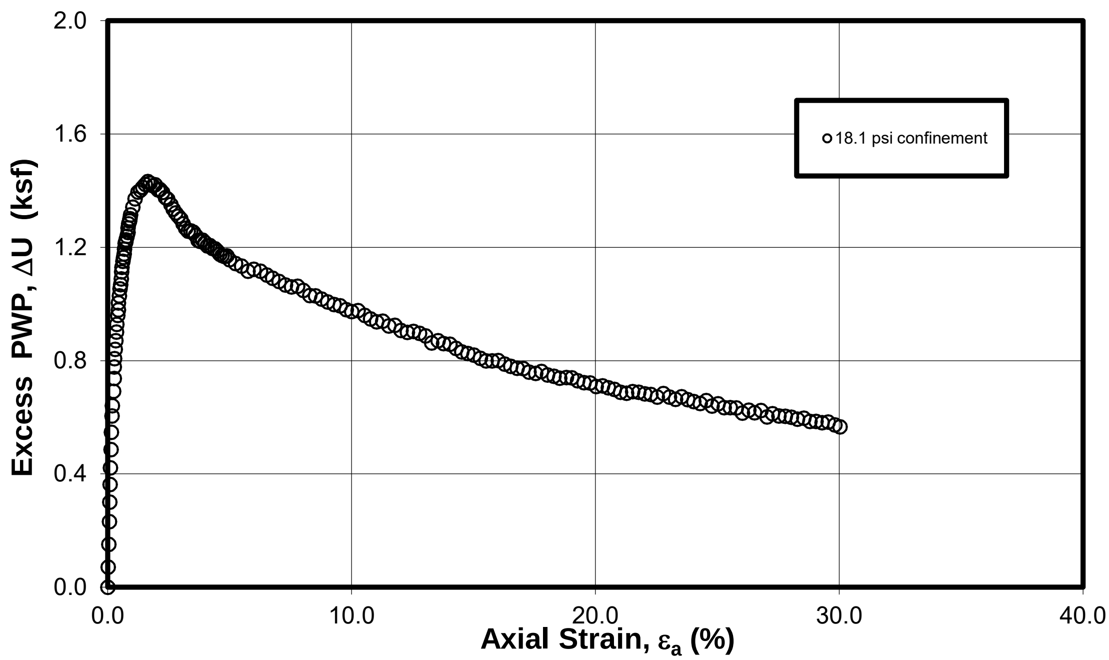


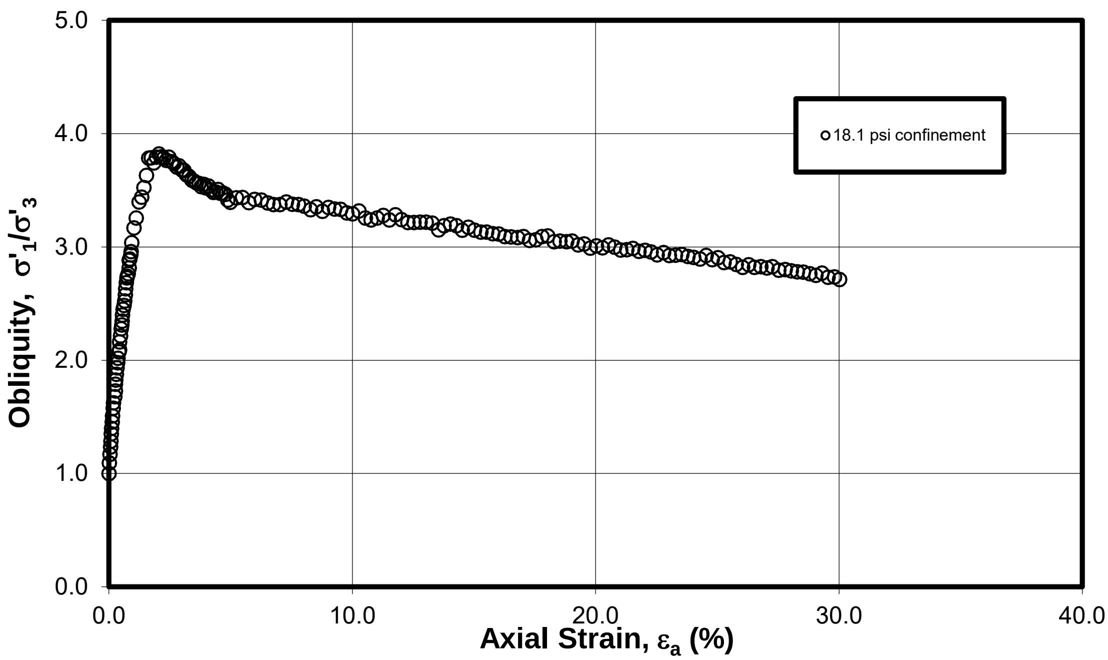
UNDRAINED TRIAXIAL COMPRESSION TEST

Isotropically Consolidated

Sample: 9b - Depth: 29.00 ft

Boring COF-B008



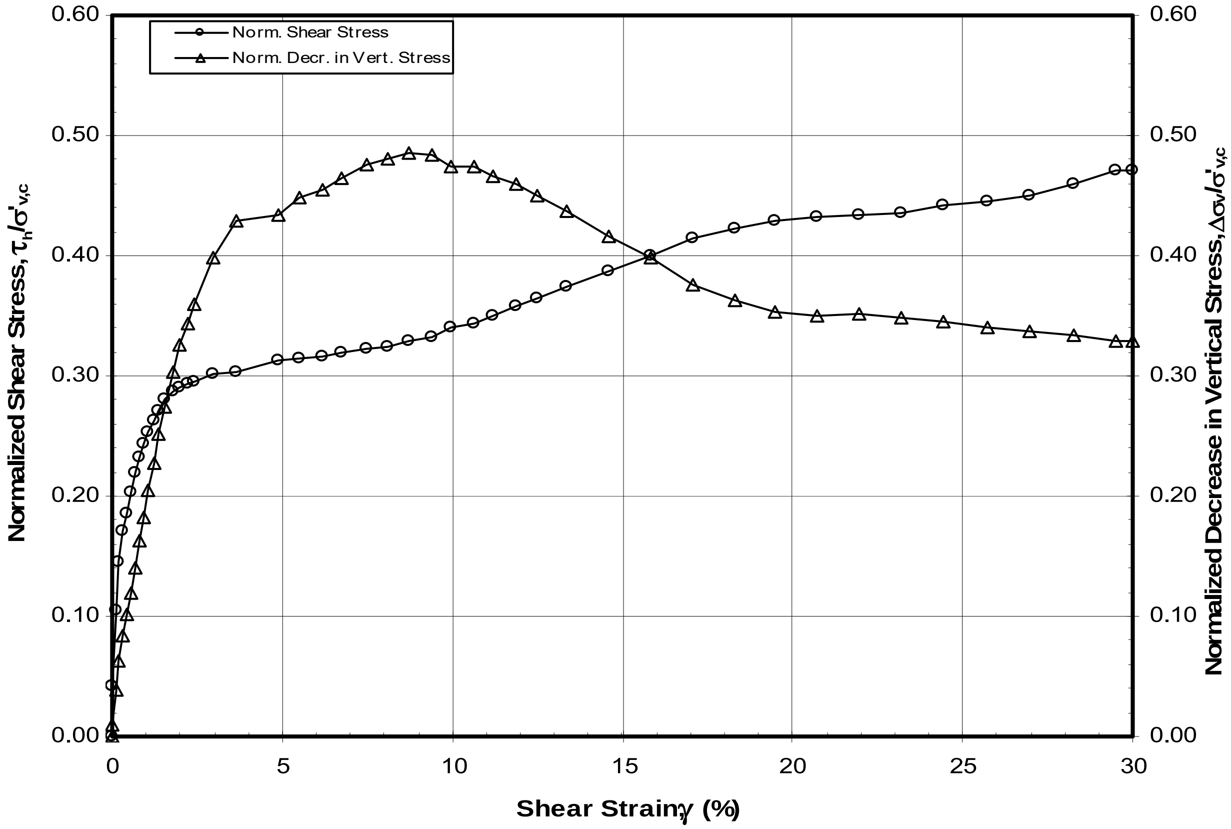


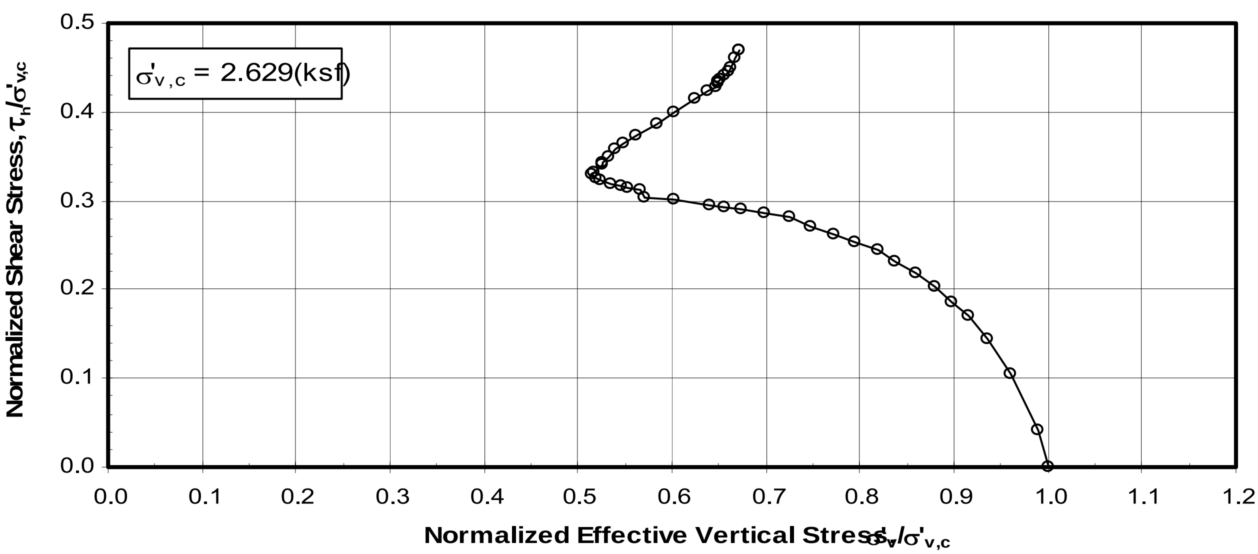
UNDRAINED TRIAXIAL COMPRESSION TEST

Isotropically Consolidated

Sample: 9b - Depth: 29.00 ft

Boring COF-B008





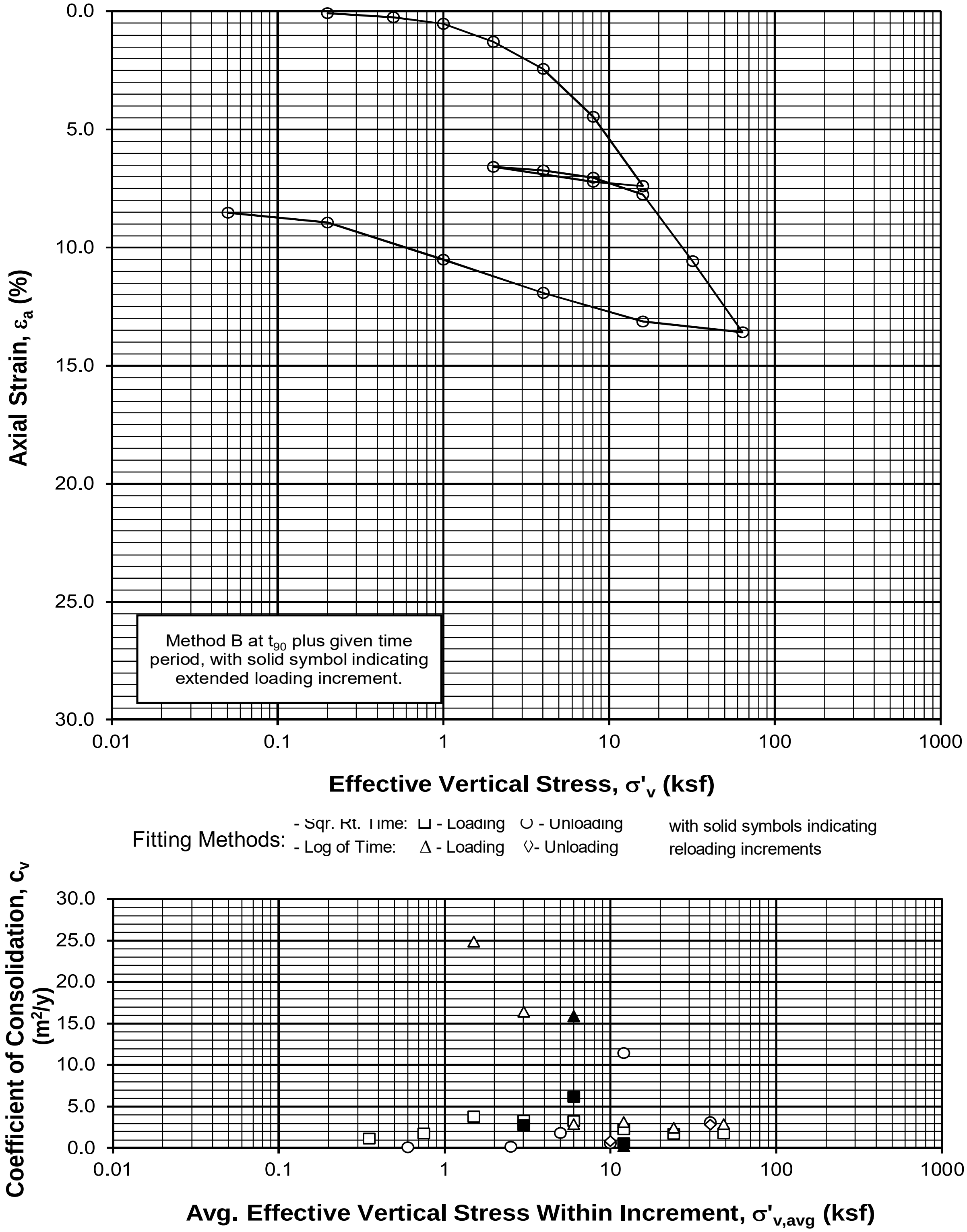
STATIC DSS TEST

K_o Consolidation - OCR = 1

Sample: 9b - Depth: 29.50 ft

Boring COF-B008

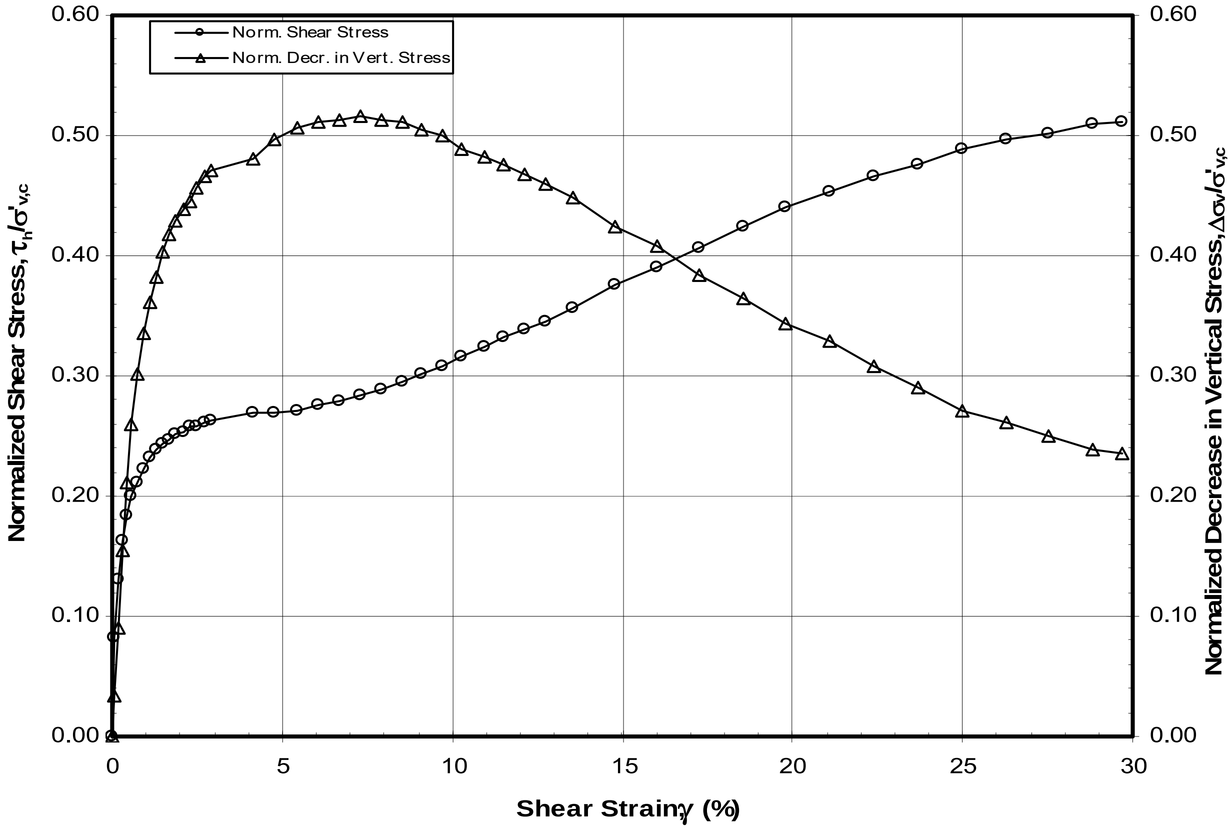
Denegy CCR Assessment of Plants - Coffeen Power Station

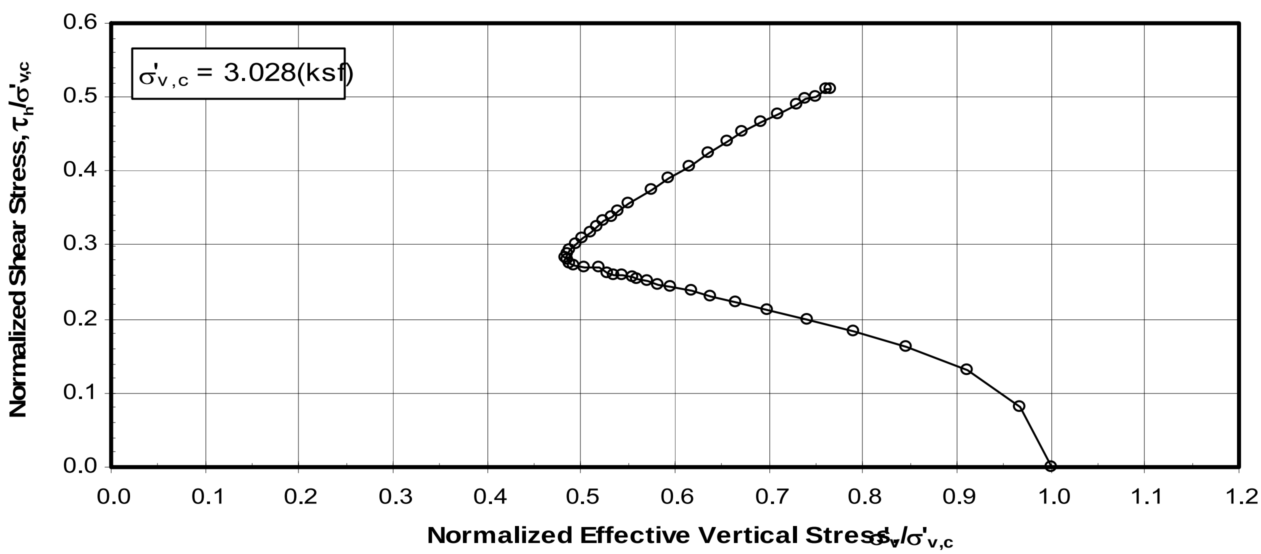


1-D CONSOLIDATION TEST: INC

Sample No. 9b Depth 29.5 ft

Boring COF-B008





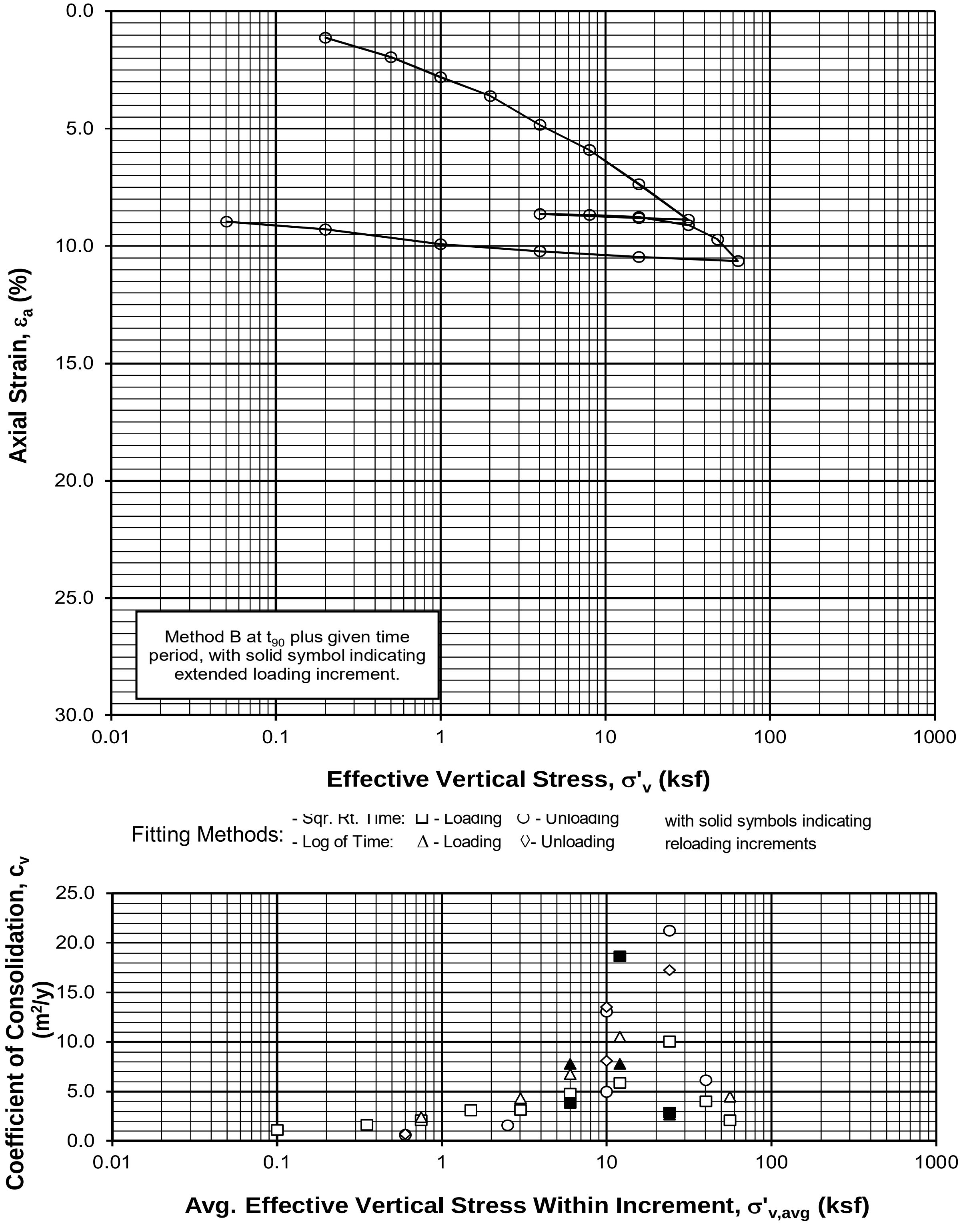
STATIC DSS TEST

K_o Consolidation - OCR = 1

Sample: 11h - Depth: 32.00 ft

Boring COF-B011

Denegy CCR Assessment of Plants - Coffeen Power Station



1-D CONSOLIDATION TEST: INC

Sample No. 11i Depth 30.46 ft

Boring COF-B011

Denegy CCR Assessment of Plants - Coffeen Power Station

Attachment F. Analysis Section Development Calculations

Calculation Notes

AECOM

Subject: Coffeen Ash Pond No. 1 Section Development   Project Name: Dynegy CCR

By: Brian Gomez   Date: 02/09/2016   Project No: 60480701

Checked By: Meaghan Kenna   Date: 02/09/2016   Task No.: 01

OBJECTIVE:

This calculation package presents the slope stability sections analyzed at Coffeen Ash Pond No. 1. Geometry revisions were made to the previously analyzed sections using recent boring and Cone Penetration Test (CPT) logs. The approach used to identify the foundation material contacts and phreatic surfaces based on the recent field investigation data are discussed below.

BACKGROUND:

The material characterizations for the stability analyses were completed using CPT and boring logs from a subsurface investigation program completed in August 2015. The investigation included 6 soil borings and 22 CPT soundings. Boring and CPT sounding locations are shown relative to the slope stability analysis sections on the plan view drawing of exploration locations and sections in Appendix A. Field testing included Standard Penetration Tests (SPT), CPT dissipation testing, and shear wave velocity measurements using seismic CPT. Open well and vibrating wire piezometers were installed in select borings and CPTs, respectively. Based on the results of the investigation, five stratigraphic layers were identified at the site:

- **Impounded Ash**: Well-graded or medium- to coarse-grained SAND (cinders), with trace of silt or clay, very loose to medium dense, moist to wet, and black.
- **Embankment Fill**: Generally classified as silty CLAY, sandy CLAY, or CLAY with sand (CL), with a trace of fine gravel, soft to very stiff, low to medium plasticity, moist to wet, and brown to gray. Trace amounts of organic material and ash were sometimes encountered.
- **Foundation Clay**: Native clay of wind-blown origin (loess), with some coarse-grained layers. The fine-grained soils (clays) encountered in the borings were generally classified as low to medium plasticity silty CLAY, sandy CLAY, or CLAY with sand (CL) often with a trace of gravel; or high plasticity clay (CH), often with a trace of sand. The CL and CH soils were soft to very stiff, very moist to saturated, and brown to gray. The coarse-grained soils encountered in the borings were classified as clayey SAND (SC), silty SAND (SM), or fine- to coarse-grained SAND (SP), with a trace of gravel, loose to dense, wet to very wet, and brown to gray.
- **Soft Foundation Clay**: A thin layer of native silty or sandy clay (CL) was encountered in several borings and in CPT soundings between the foundation clay and underlying glacial till deposits. The clay was very soft to medium stiff, low to medium plasticity, very wet, and orange brown to gray.
- **Till:** Generally classified as CLAY, or silty to sandy CLAY (CL), with a trace of fine gravel, hard, low plasticity, moist to very wet, and brown to gray. In one boring, the till was classified as silty, fine- to coarse-grained sand (SP) underlain by clayey, fine to coarse grained sand (SC), with a trace of gravel, very dense, very wet, and brown.

APPROACH AND ASSUMPTIONS:

Section Development

The ash and embankment surface geometry for each section was developed using the 2013 USGS ortho-imagery. A total of five study sections were developed to represent critical areas of the embankment including the following:

- **Station 13+00**: Represents the critical section on the west reach of the impoundment.
- **Station 30+00**: Represents the critical section on the south reach of the impoundment.
- **Station 36+50**: Represents the critical section on the east reach of the impoundment.
- **Station 39+00**: Represents the critical section on the northeast corner where a sheet pile wall is located at the toe of the embankment.
- **Station 46+50**: Represents the critical section on the north reach of the impoundment.

Each section along with a plan view is provided in Appendix A.

STA 13+00

The internal geometry at section STA 13+00 was developed primarily from CPTs COF-C014, C015, C016, and C017. CPTs C016 and C017 were projected perpendicularly from the northwest corner to the section. CPTs C014 and C015 and boring B003 were projected perpendicularly from the south along the west reach. The geometry at section STA 13+00 is shown in Figure 1.

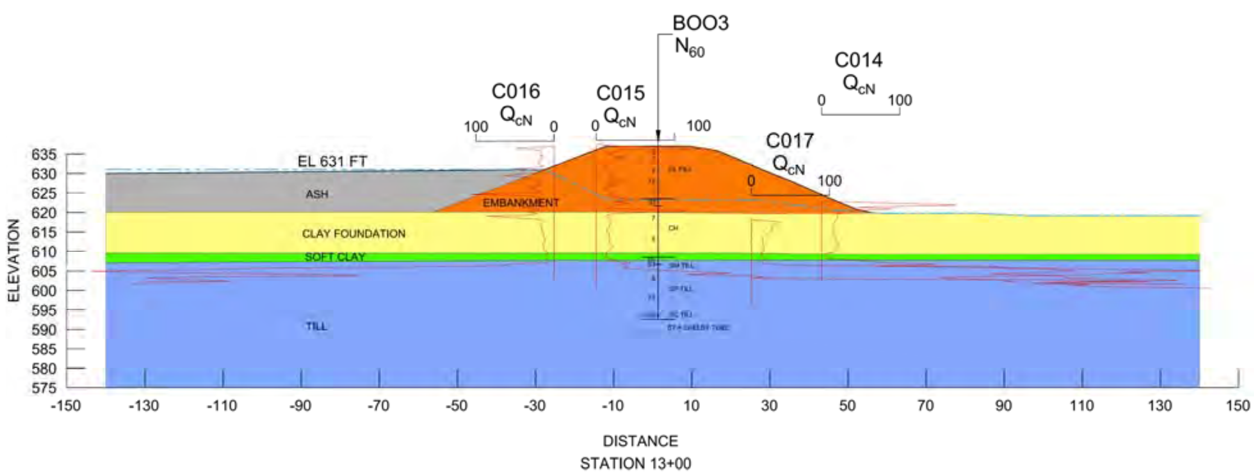


Figure 1: Section STA 13+00

STA 30+00

The internal geometry at section STA 30+00 was developed using CPTs COF-C005, C007, C008, and C009. CPTs C007, C008, and C009 and boring B002 were projected perpendicularly from the west along the south reach. CPT C005 was projected perpendicularly to the section from the southwest corner of the impoundment. The geometry at section STA 30+00 is shown in Figure 2.

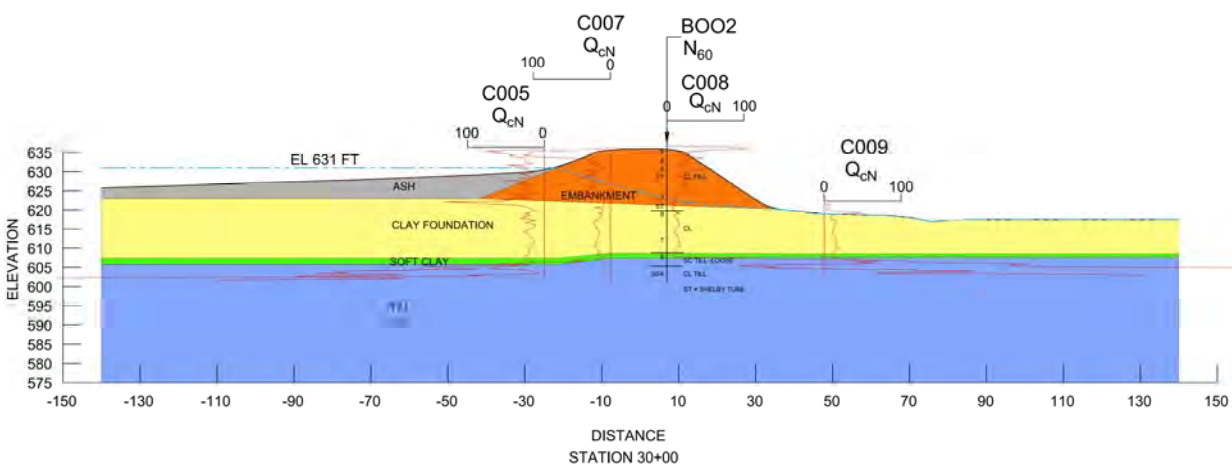


Figure 2: Section STA 30+00

STA 36+50

The internal geometry at section STA 36+50 was developed using CPTs COF-C001, C002, C020 and C024. CPTs C001 and C002 were projected perpendicularly from the south along the west reach to the section. The geometry at section STA 36+50 is shown in Figure 3.

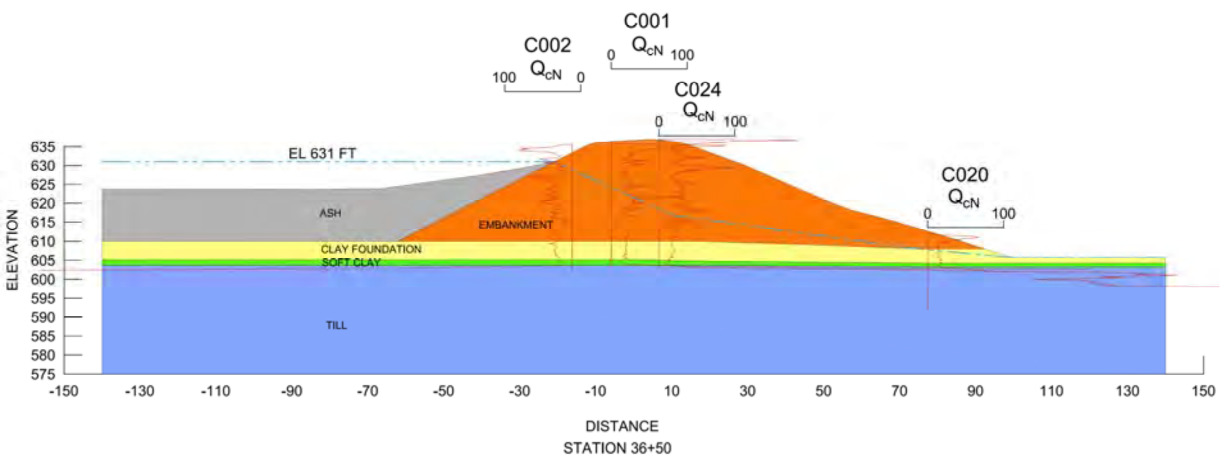


Figure 3: Section STA 36+50

STA 39+00

The internal geometry at section STA 39+00 was developed using CPTs COF-C020, C022, and C023. CPTs C020 and C023 and boring B005 were performed at the section and were projected perpendicularly. CPT C020 is located at the toe along the east reach and was projected perpendicularly. The geometry at section STA 39+00 is shown in Figure 4.

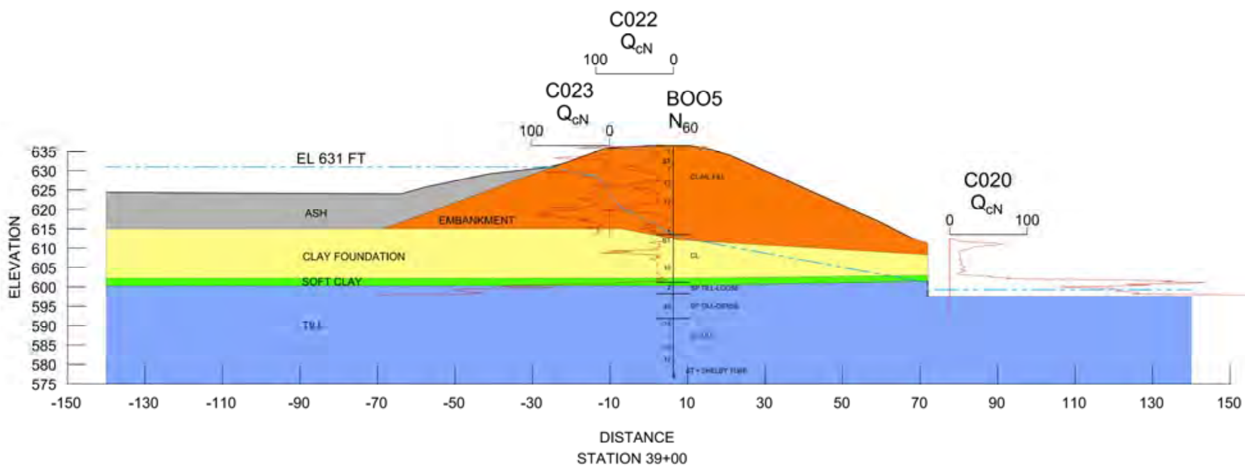


Figure 4: Section STA 39+00

STA 46+50

The internal geometry at section STA 46+50 was developed using CPTs COF-C018 and C019 and boring B004, which were performed east of the section along the north reach. The geometry at section STA 46+50 is shown in Figure 5.

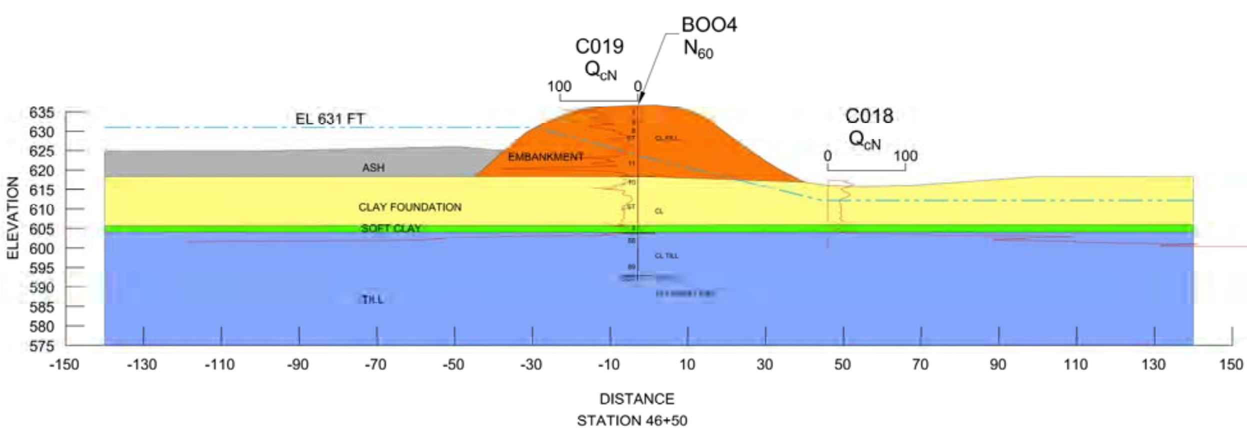


Figure 5: Section STA 46+50

Phreatic Surface

The normal operating pool elevation is 631 feet. A phreatic surface for each section was developed primarily using piezometer water level measurements, and secondarily using static pore pressure profiles interpreted from CPT pore pressure dissipation tests judged to be representative of steady state conditions. The highest piezometer water level readings from five measurement events (8/29/15, 10/5/15, 10/30/15, 11/23/15, and 12/23/15) were conservatively used. Where stability sections are located between piezometers and/or CPTs, water levels were interpolated using a weighted average method and projected as a phreatic surface onto the sections.

APPENDICES:

- Appendix A – Field Exploration Plan and Sections
- Appendix B – CPT Data and Boring Logs

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Section Development

Project Name: Dynegy CCR

By: Brian Gomez Date: 02/09/2016

Project No: 60480701

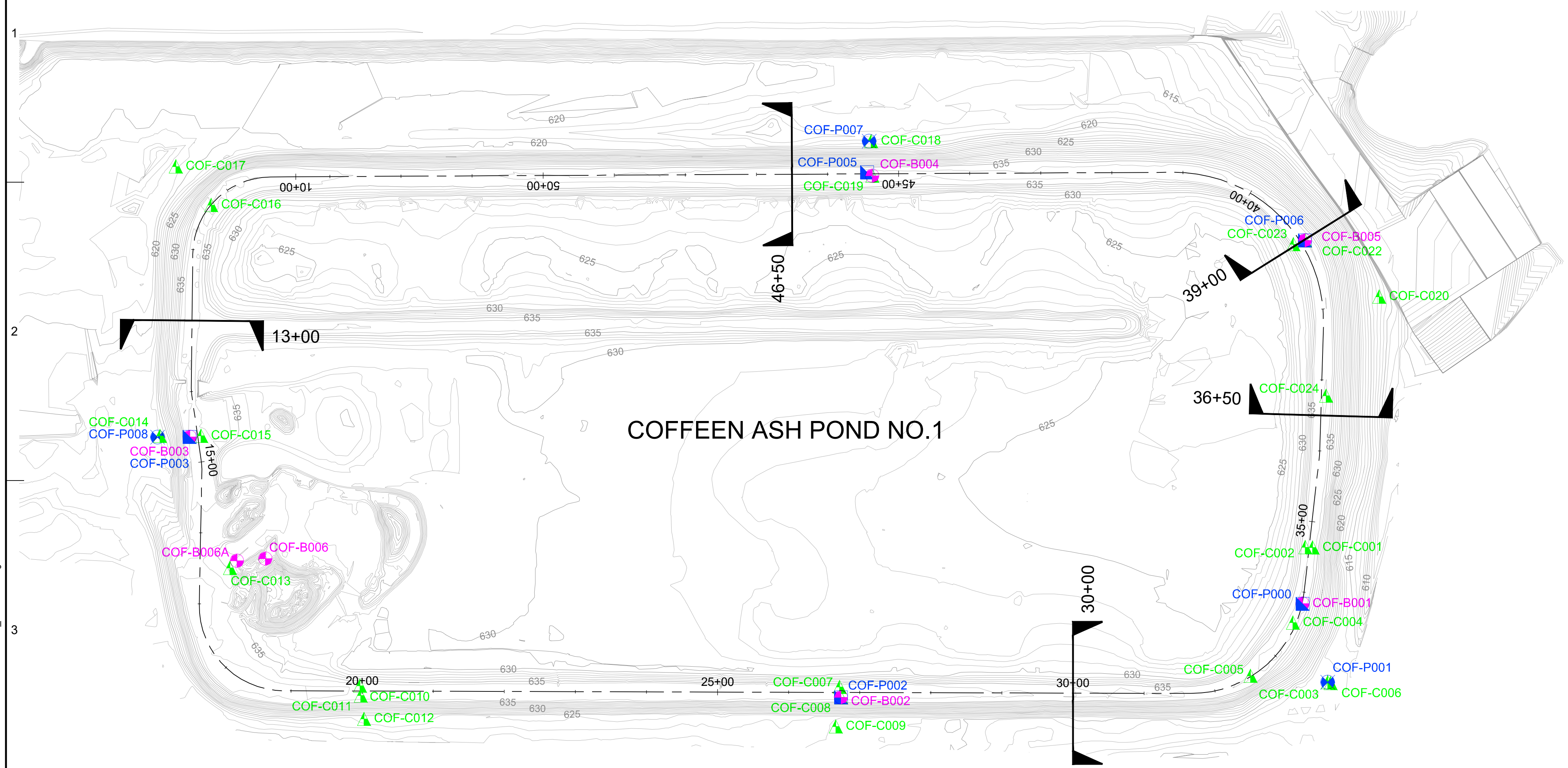
Checked By: Meaghan Kenna Date: 02/09/2016

Task No.: 01

APPENDIX A

Field Exploration Plan and Sections

SMITH, CURT, 2/9/2016 11:41 AM



NOTES:

1. CONTOURS ARE 1 FOOT ELEVATION INTERVALS.
2. SURVEY BENCHMARKS WILL BE PROVIDED BY THE OWNER.
3. GROUND CONTOURS SOURCES: FINAL RESULTS OF LIDAR SURVEY BY SURDEX CORPORATION DATED AUGUST 17 2015, DRAWINGS FOR COAL COMBUSTION BY-PRODUCT MANAGEMENT FACILITY PROJECT DATED JANUARY 2011, AND INTERPRETED FROM COFFEEN POWER STATION DRAWINGS DATED APRIL 1978.
4. BATHYMETRIC CONTOURS SOURCE: SURVEY BY WEAVER CONSULTANTS GROUP DATED SEPTEMBER 2015.
5. STATION 10+00 IS THE BEGINNING OF STATIONING.

LEGEND

COF-B000	AECOM BORING LOCATION
COF-C000	AECOM CONE PENETROMETER TESTING LOCATION
COF-P000	AECOM PIEZOMETER LOCATION
COF-P000	AECOM VIBRATING WIRE PIEZOMETER (VWP) LOCATION
	LOCATION OF GEOPHYSICAL INVESTIGATION
	STUDY SECTION

N

0 100 200 300

SCALE IN FEET

AECOM
1001 Highlands Plaza Drive, Suite 300
St. Louis, Mo. 63110
314 429-0100 (phone)
314-429-0462 (fax)

DYNEGY
Dynegy Inc.
1500 East Port Plaza Drive
Collinsville, IL 62234

CCR RULE ASSESSMENT OF PLANTS

COFFEEN POWER PLANT COFFEEN, ILLINOIS

GEOTECHNICAL REPORT ASH POND NO. 1

ISSUED FOR BIDDING DATE BY

ISSUED FOR CONSTRUCTION DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	
DRAWN BY:	GJH
DESIGNED BY:	EJV
CHECKED BY:	MCR
DATE CREATED:	12/23/2015
PLOT DATE:	2/9/2016
SCALE:	AS SHOWN
ACAD VER:	2014

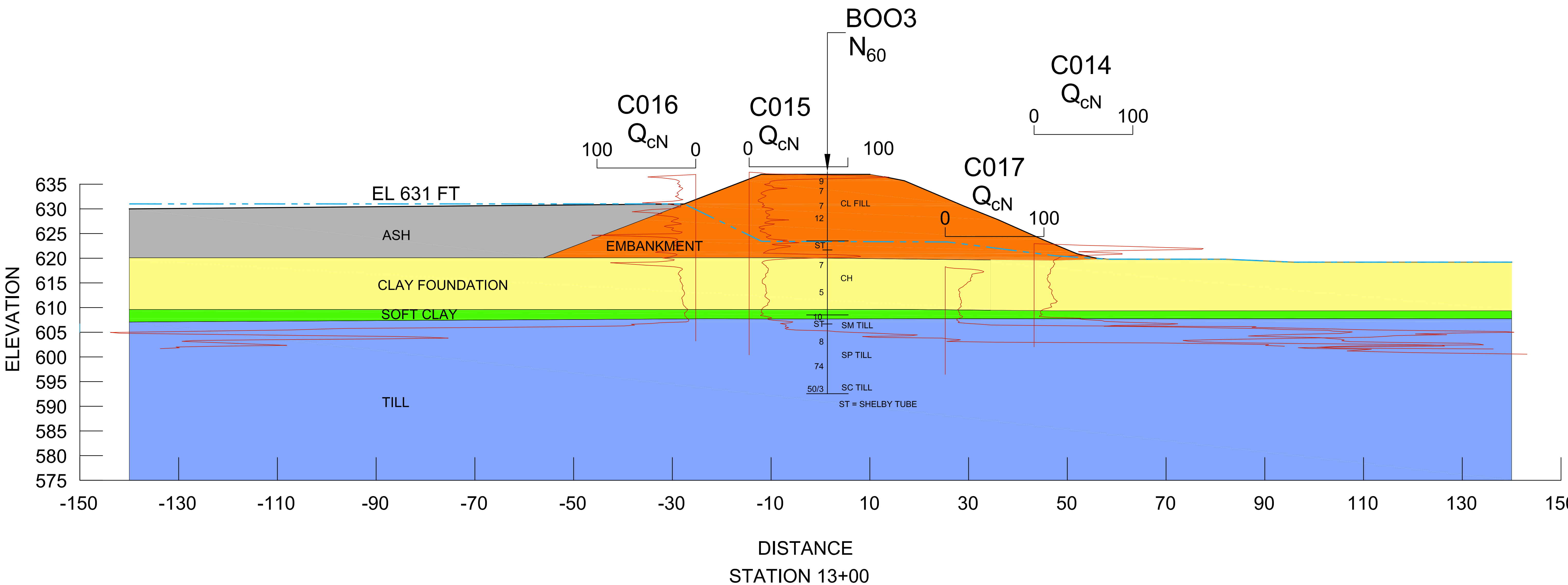
SHEET TITLE

BORING, CPT, PIEZOMETER AND CROSS SECTION LOCATIONS

SHEET 1 OF 1

DRAWING PATH:P:\Projects\Geotech\60428794_DynegyCCR\04Tasks\01 Coffeen Tasks\7.0_CAD_GIS\7.09_Exhibits\Exploration Location Plans\COF-POND-1-EXPLORATION_02072016.dwg

AECOM



PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 13+00	FIGURE 5-1
	AECOM		

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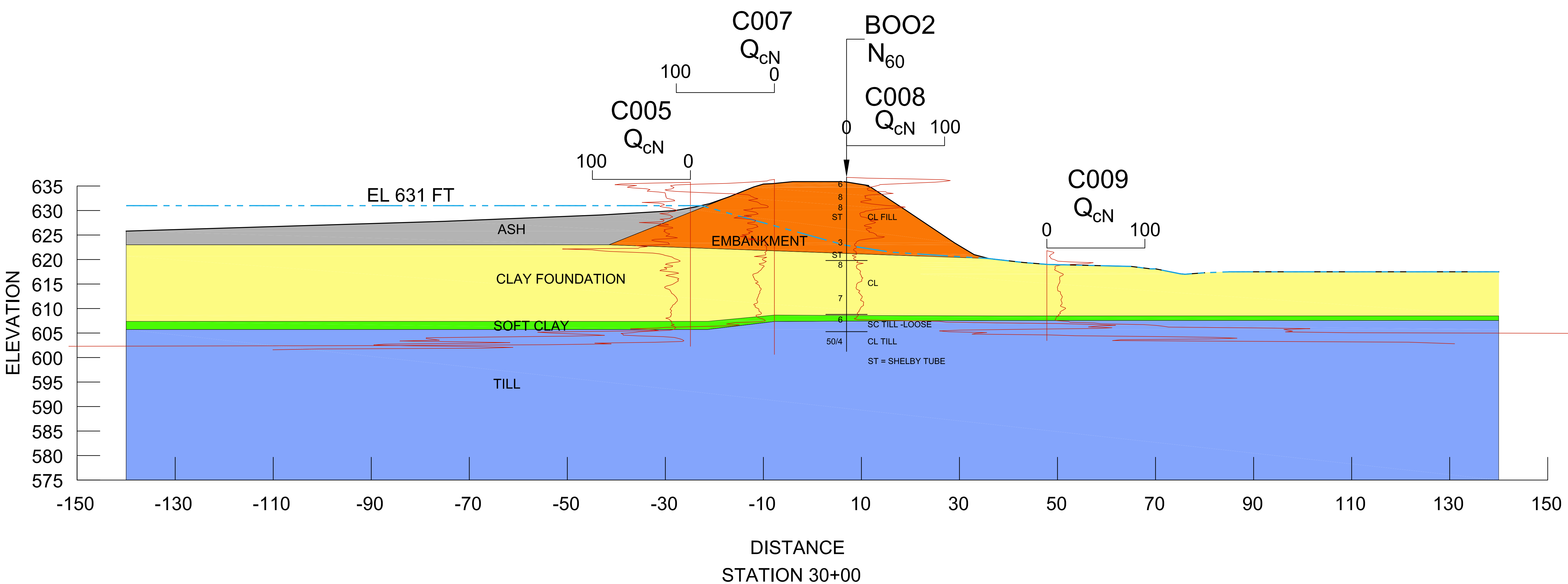

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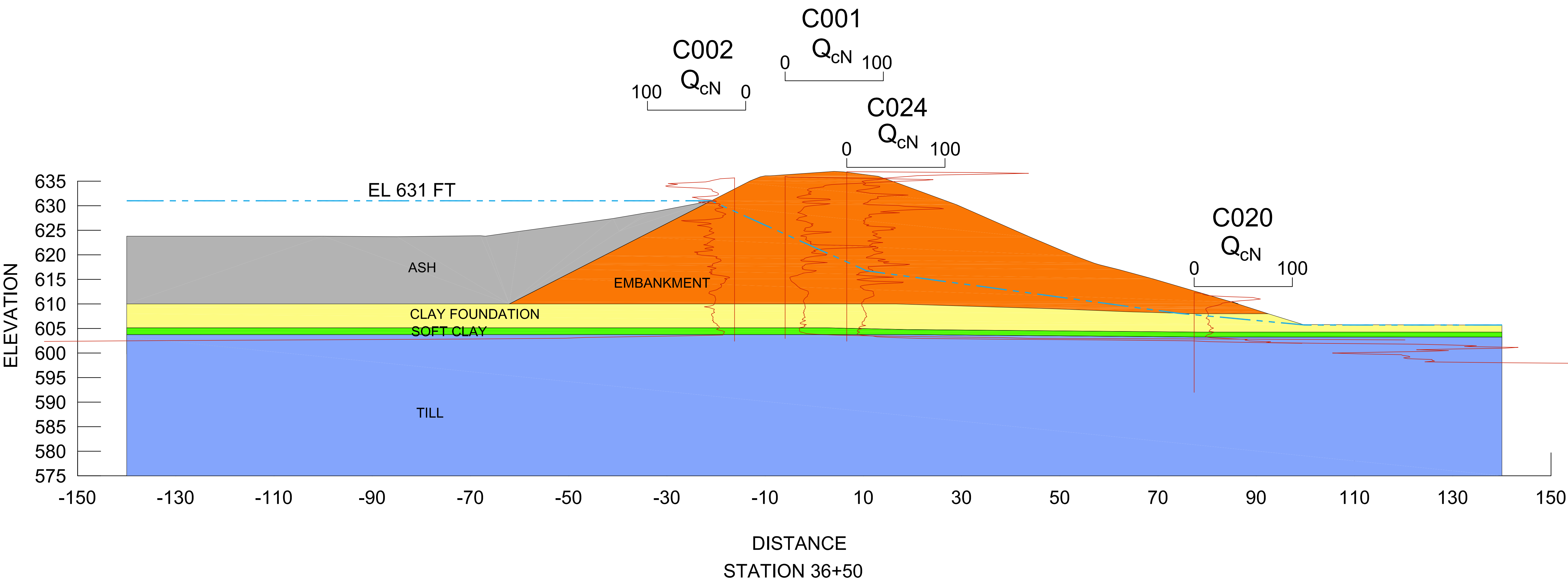
PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 30+00	FIGURE 5-2
	AECOM		



PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 36+50	FIGURE 5-3
	AECOM		

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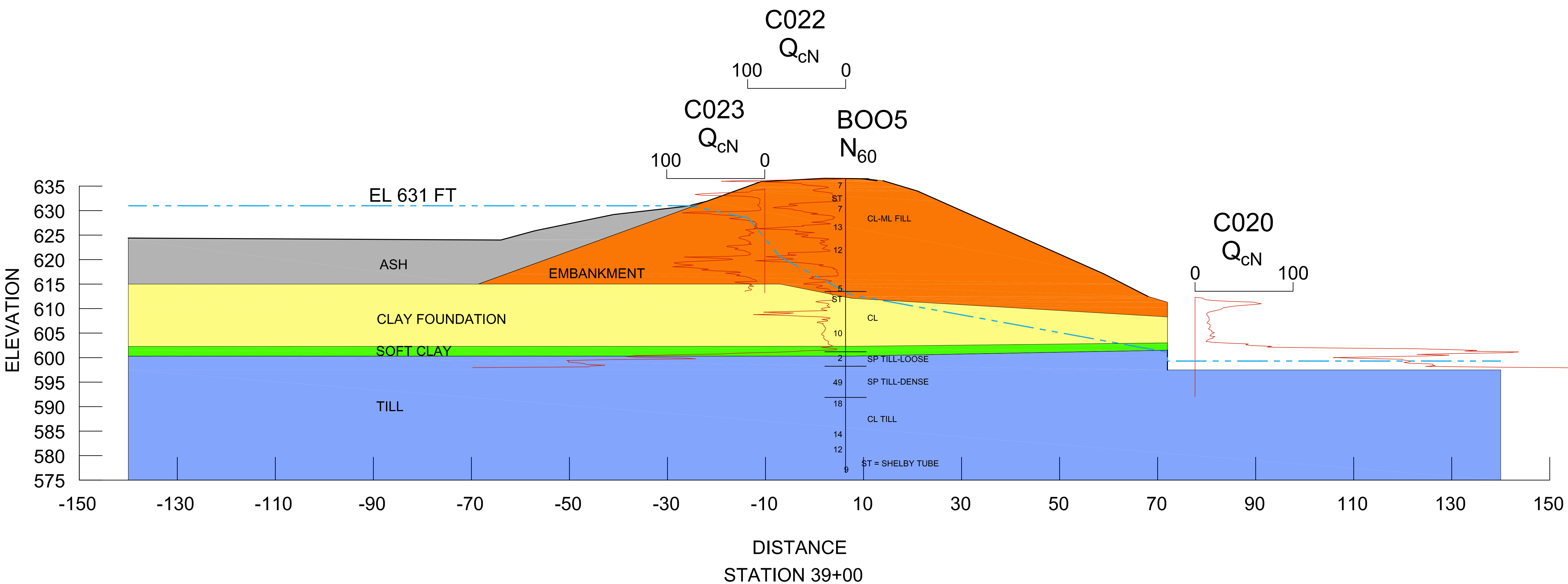
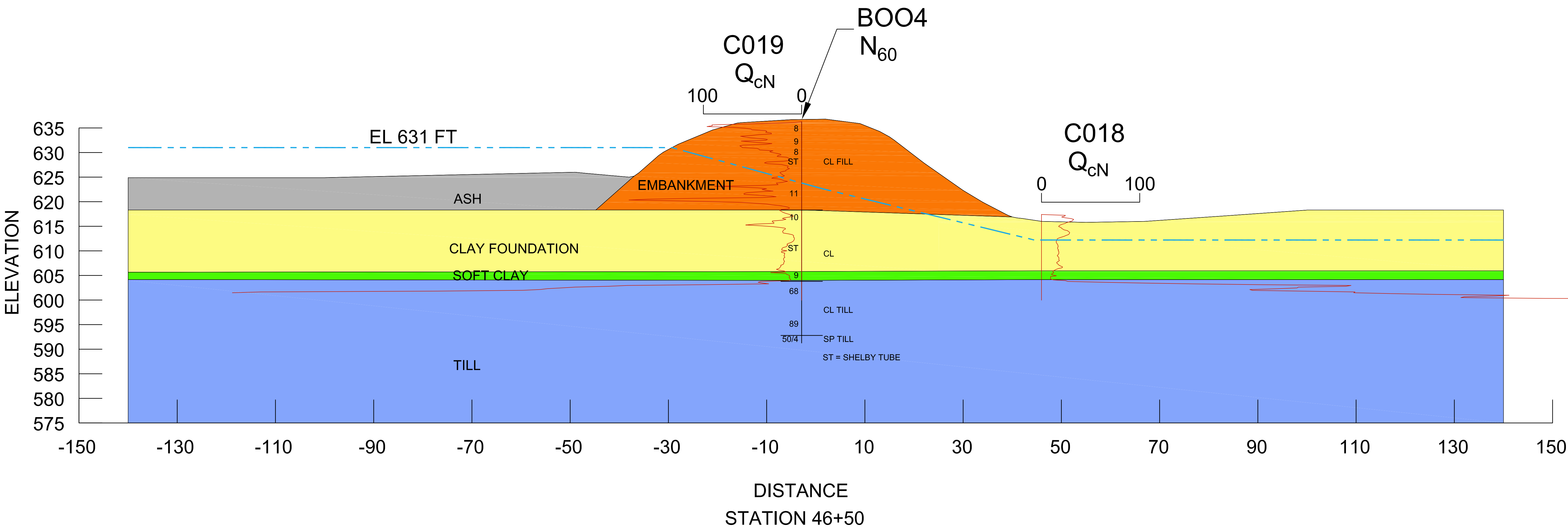


PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 39+00	FIGURE 5-4
	AECOM		



PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 46+50	FIGURE 5-5
	AECOM		

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Calculation Notes

Subject: Coffeen Ash Pond No. 1 Section Development

Project Name: Dynegy CCR

By: Brian Gomez

Date: 02/09/2016

Project No: 60480701

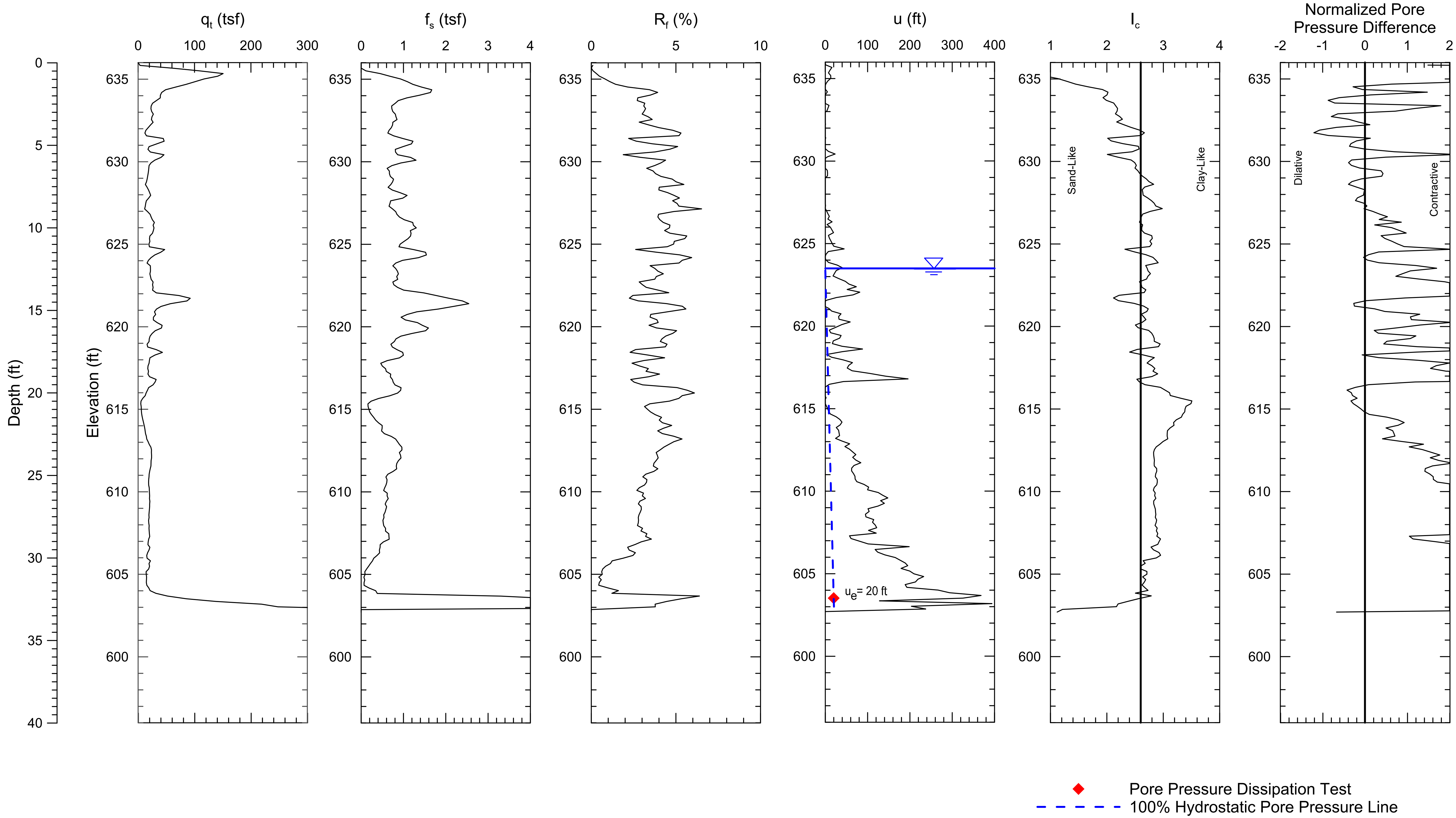
Checked By: Meaghan Kenna

Date: 02/09/2016

Task No.: 01

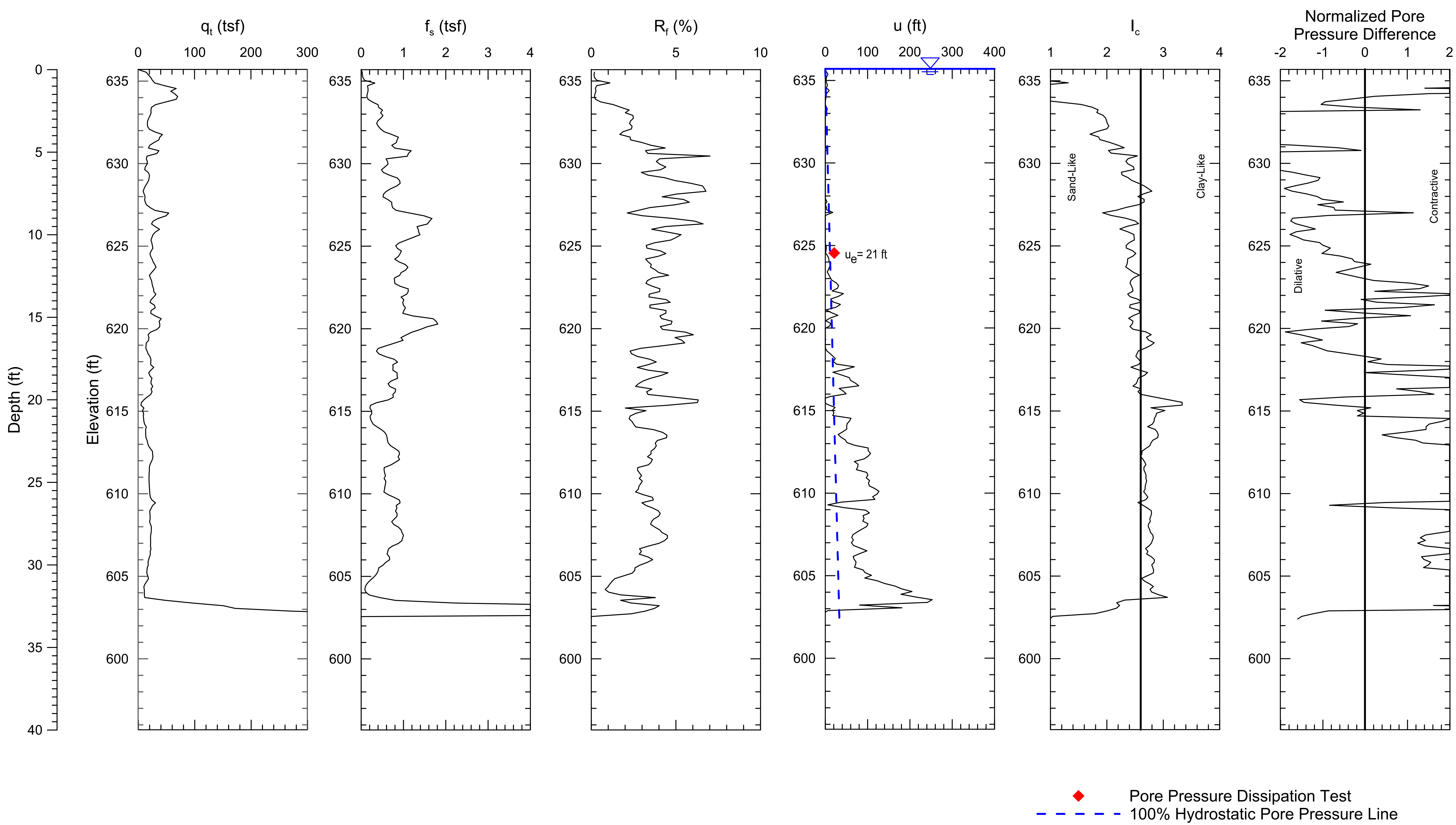
APPENDIX B

CPT Data and Boring Logs



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-001 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

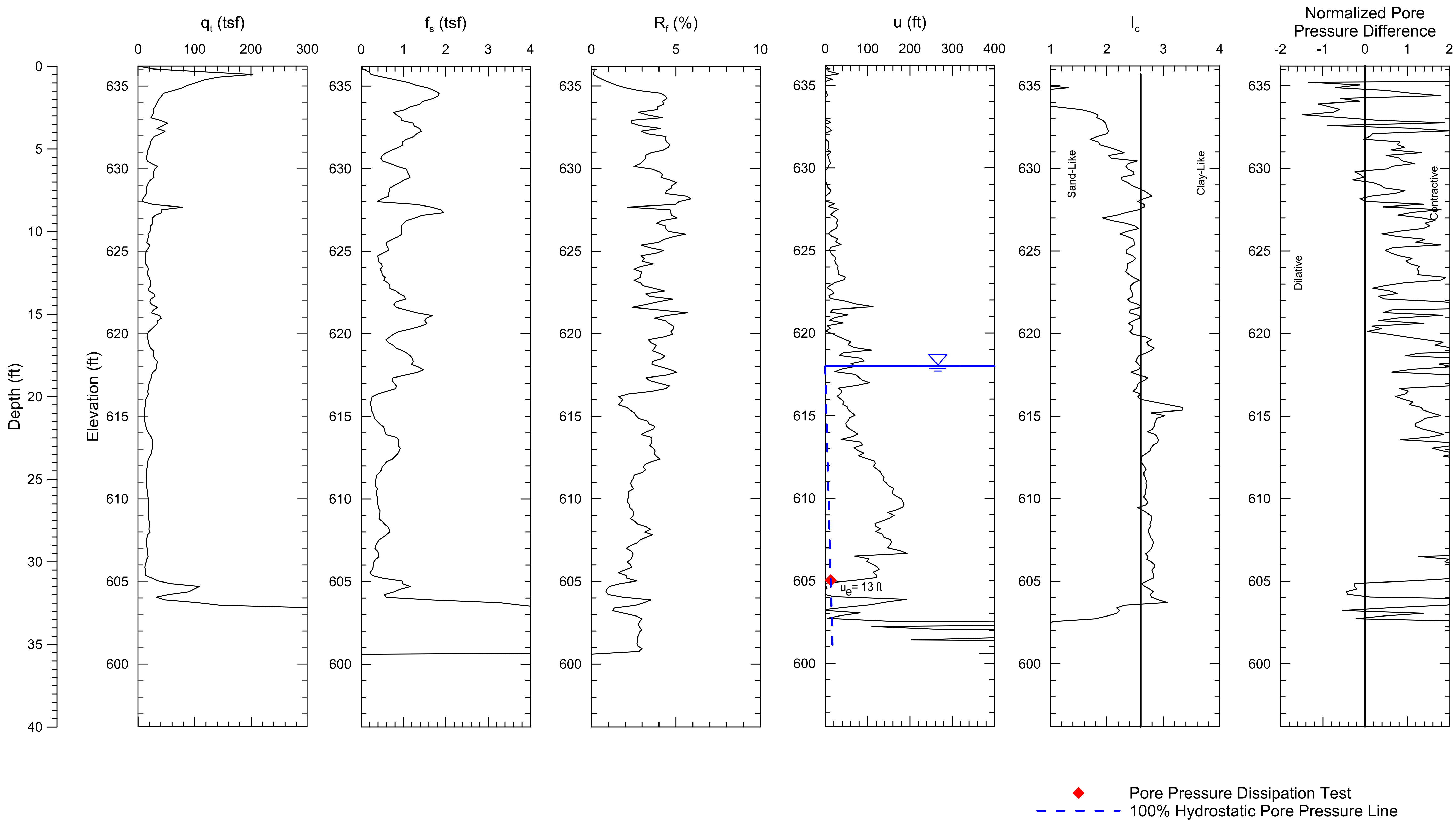


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-002 Coffeen Ash Pond No. 1	FIGURE
AECOM			

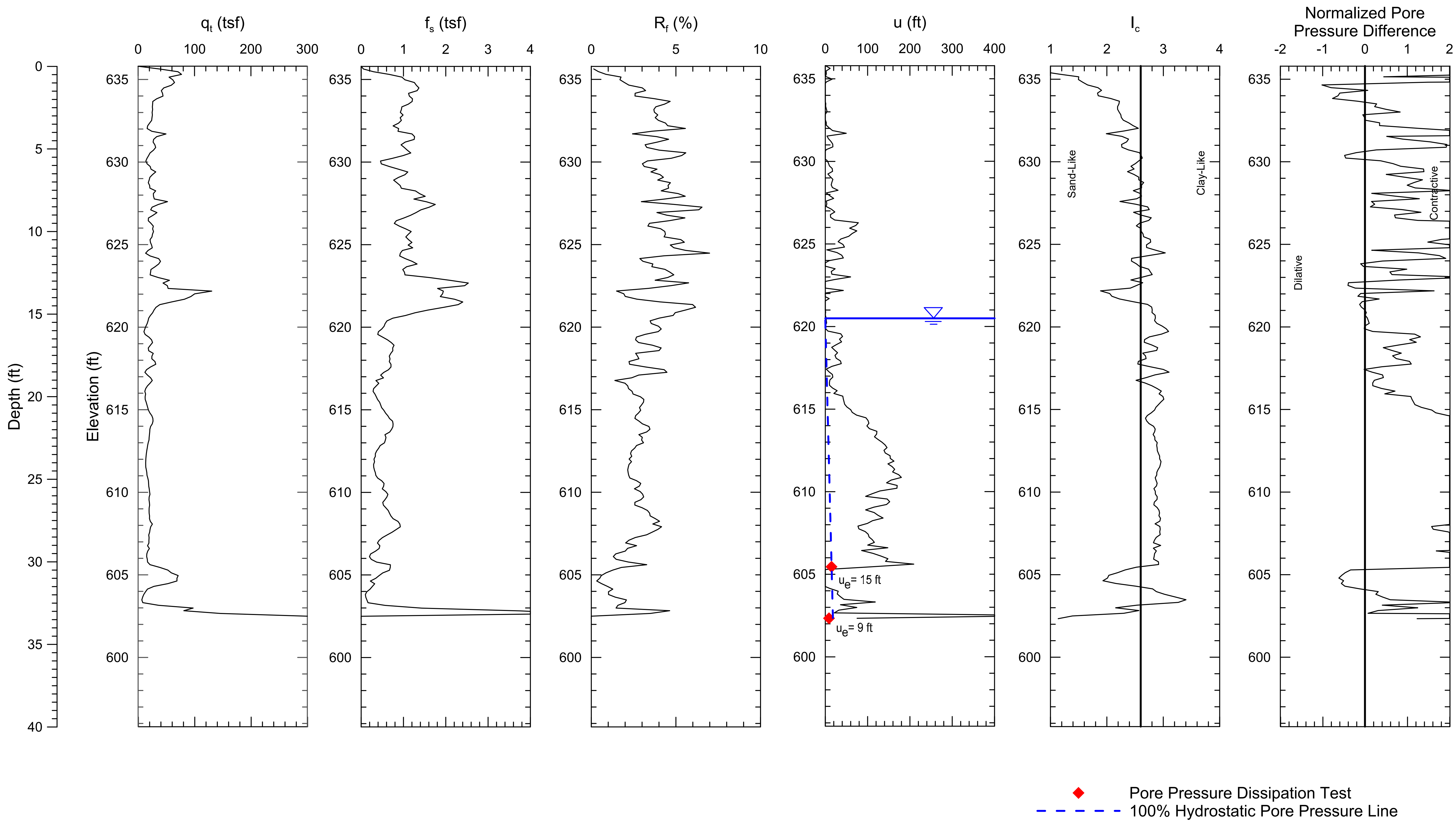


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

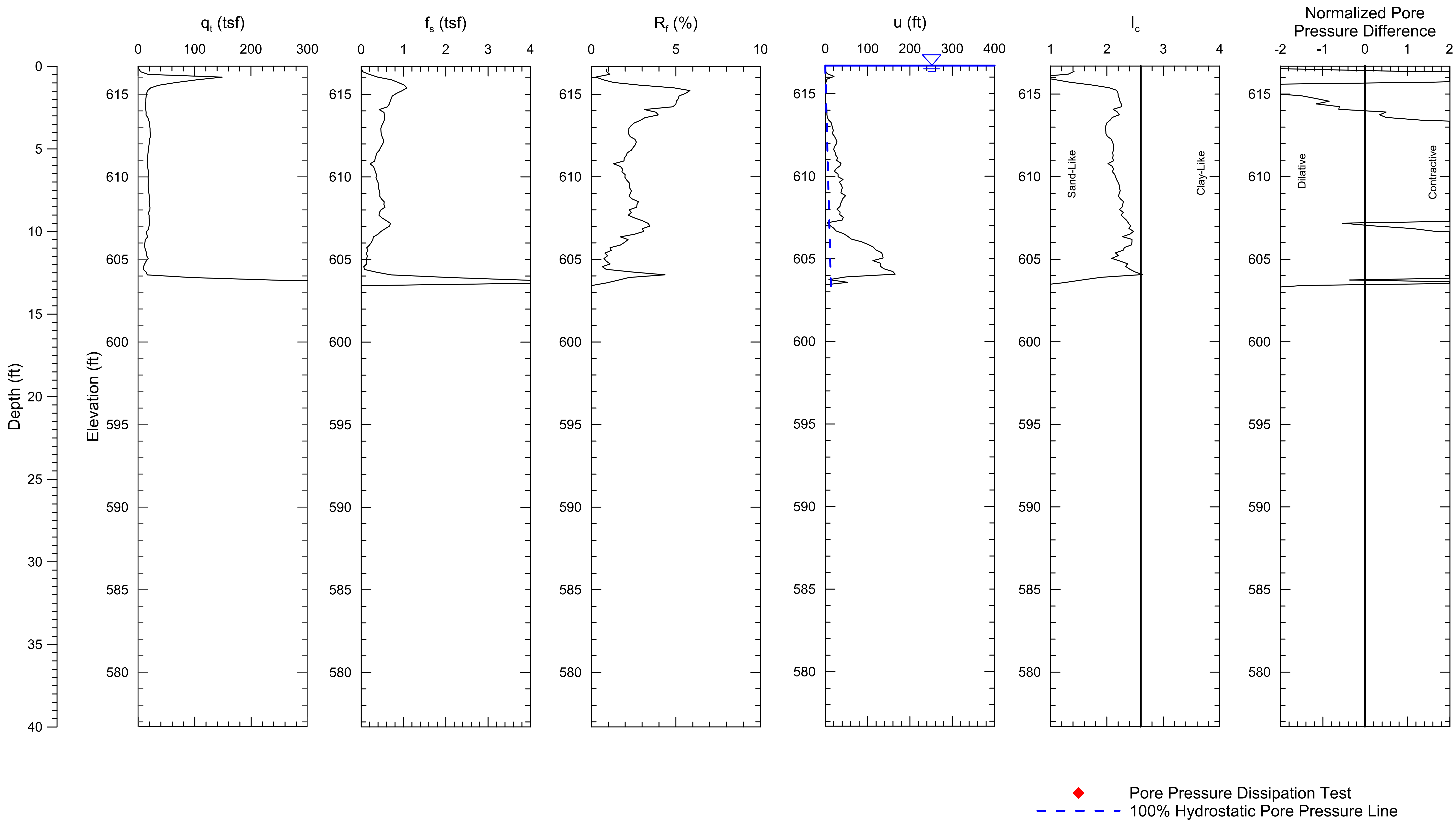
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-004 Coffeen Ash Pond No. 1	FIGURE
AECOM			



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-005 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

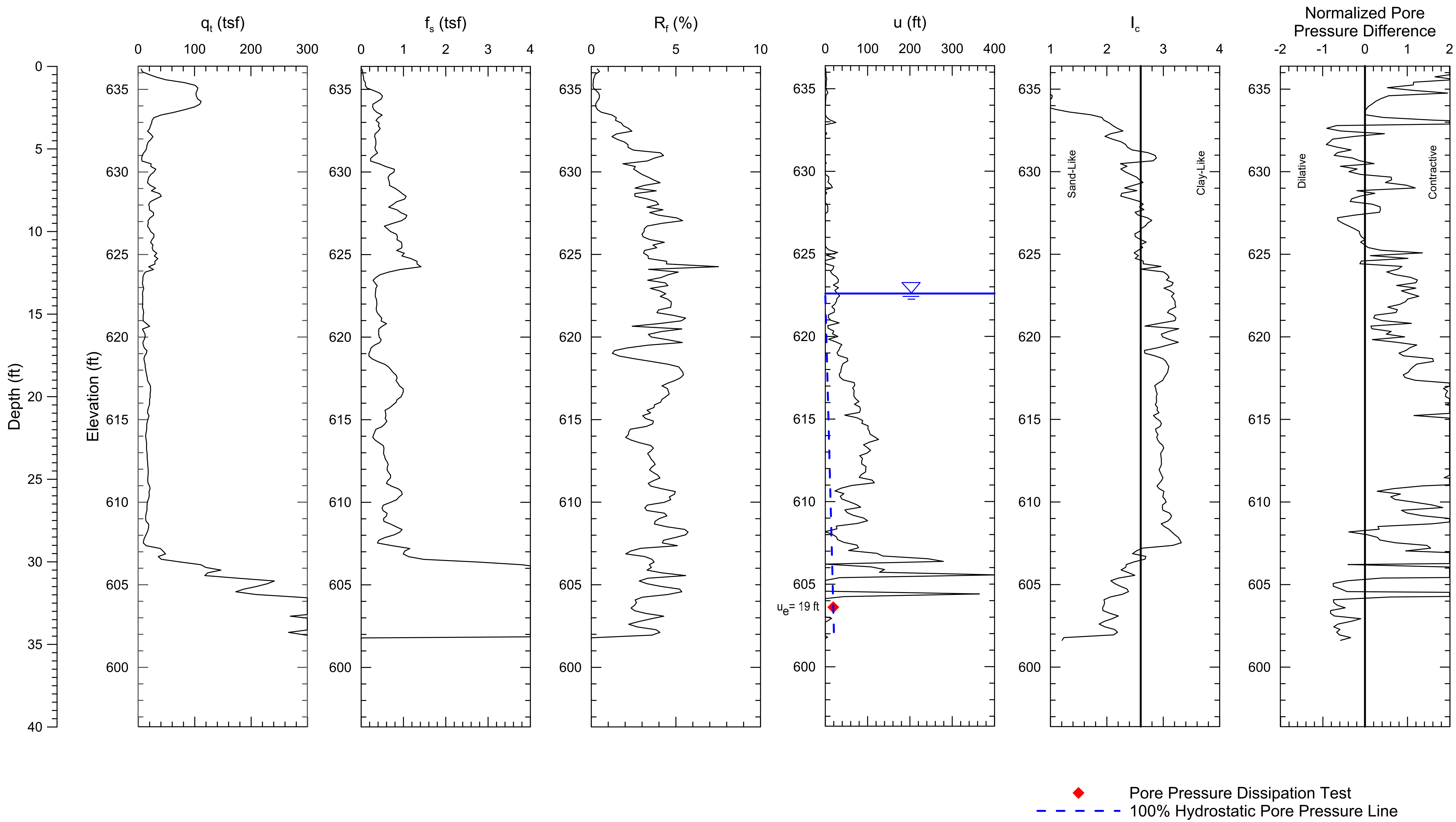


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

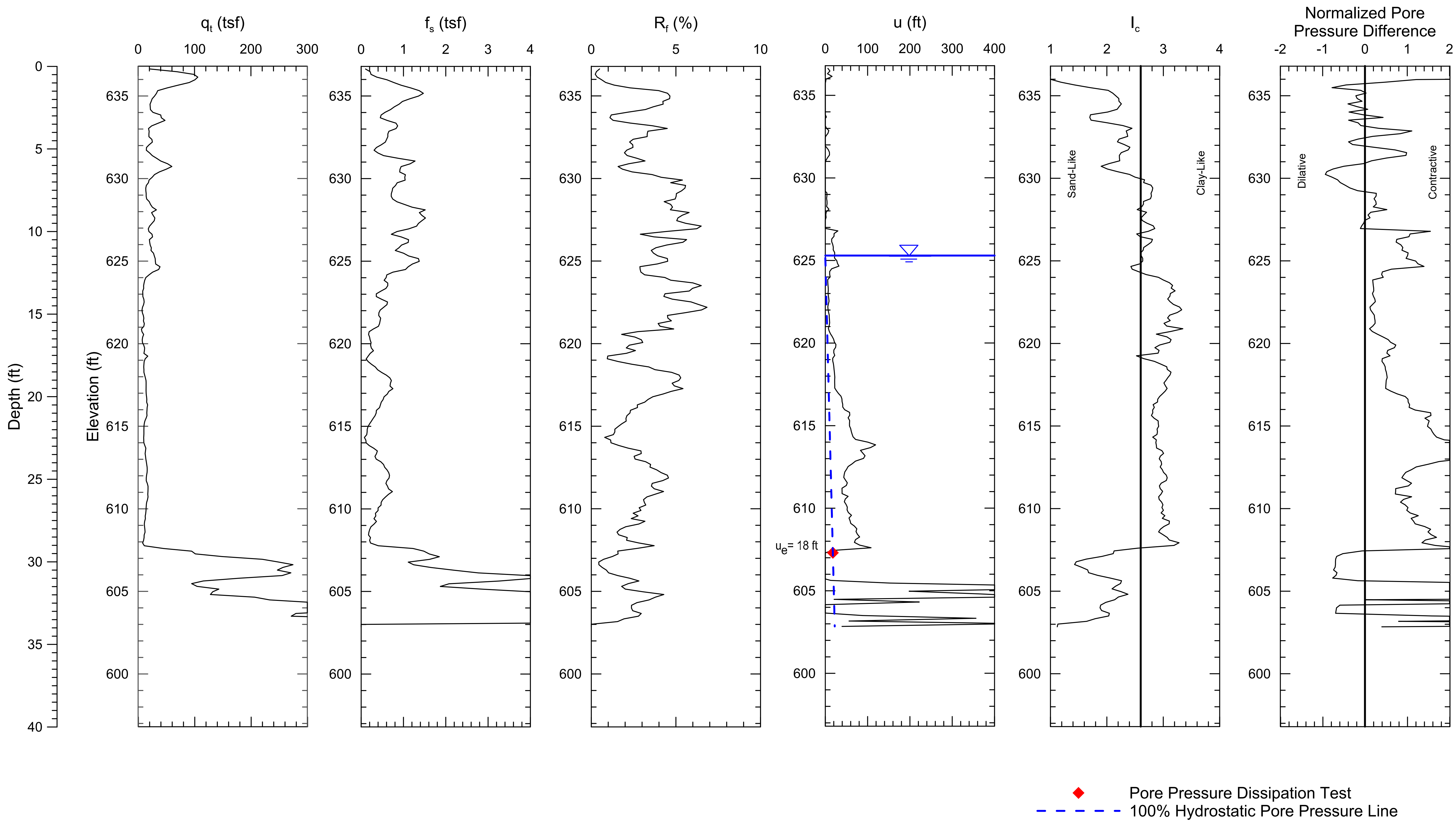
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-006 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



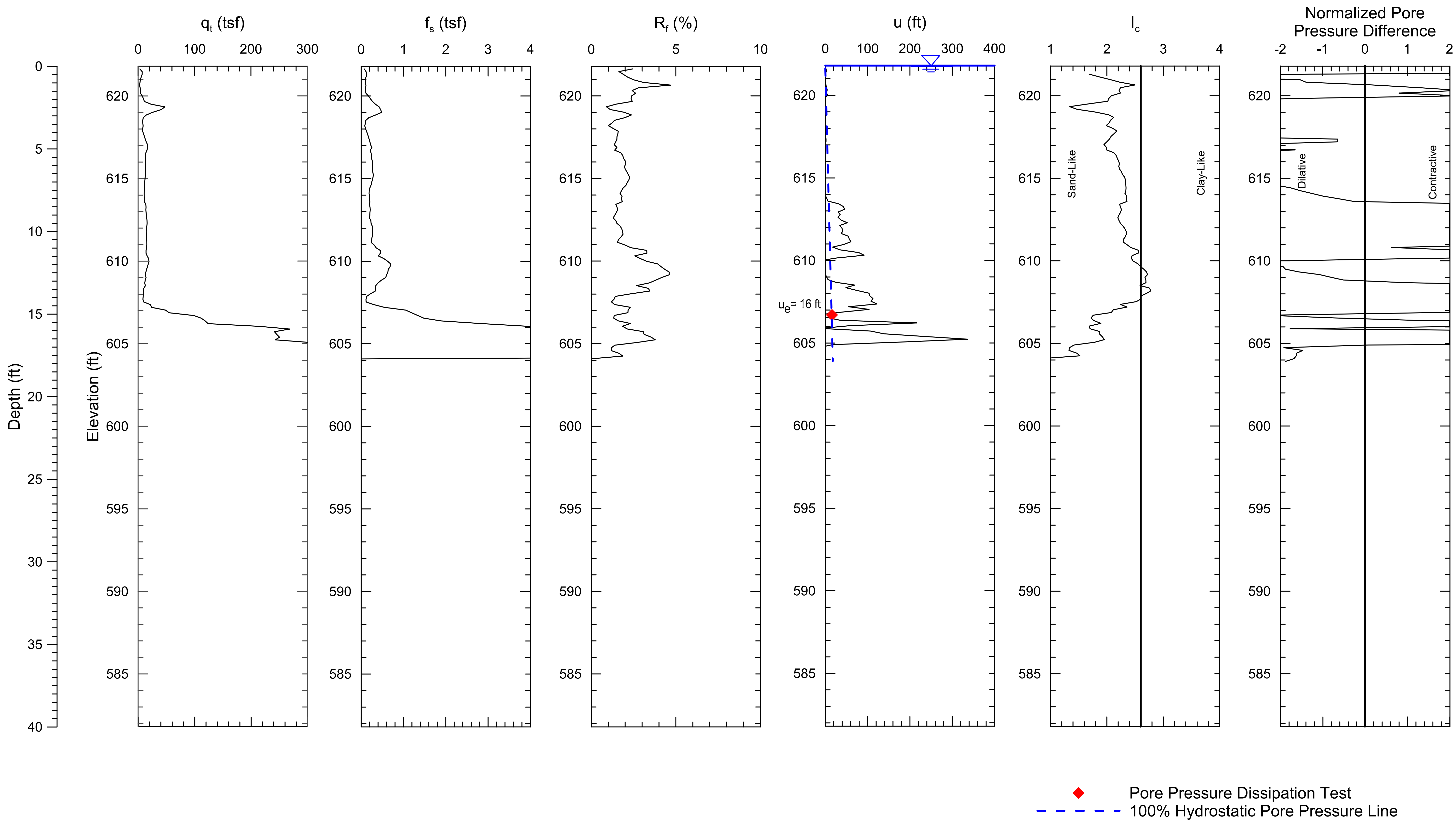
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-007 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



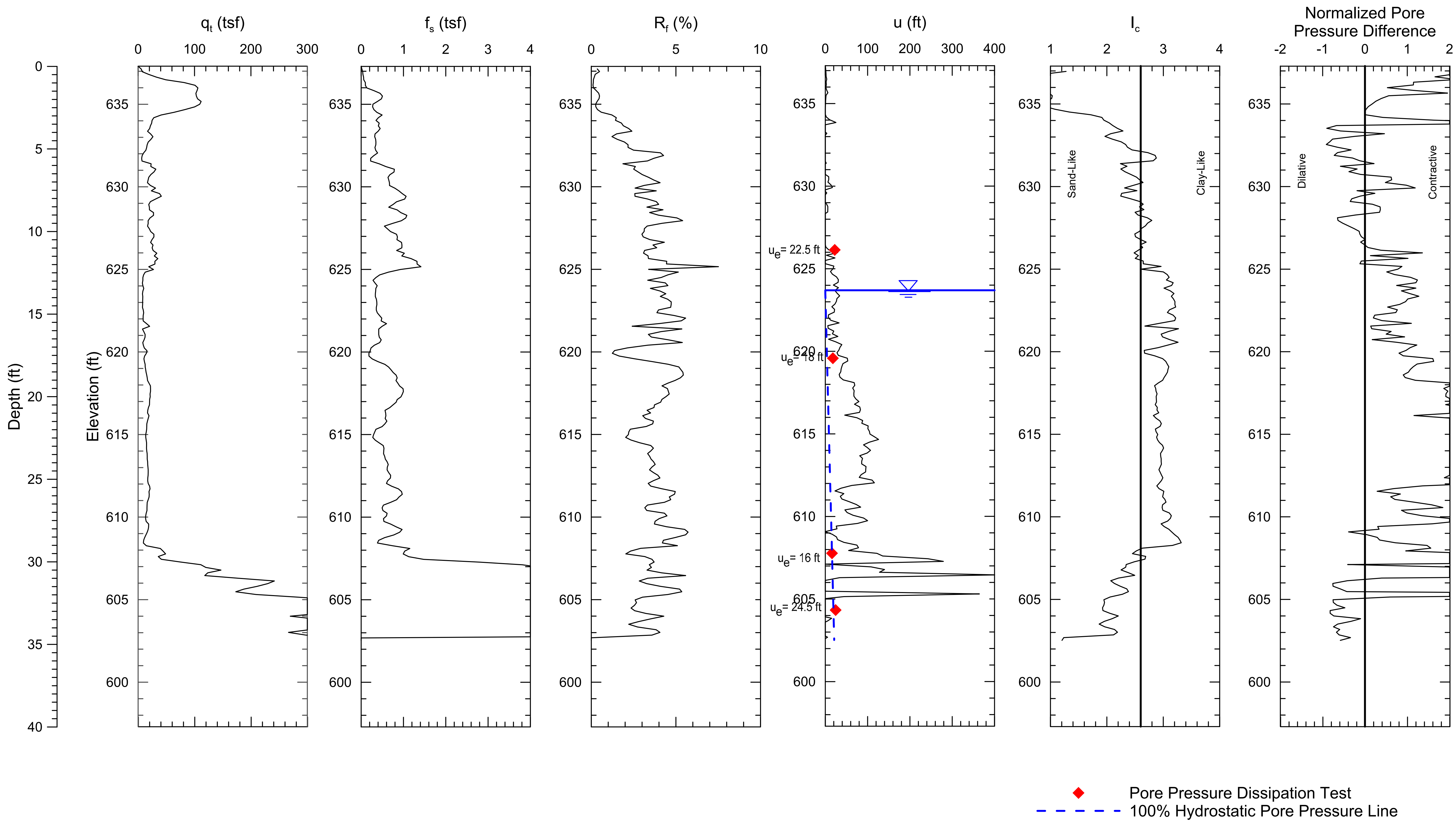
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-008 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



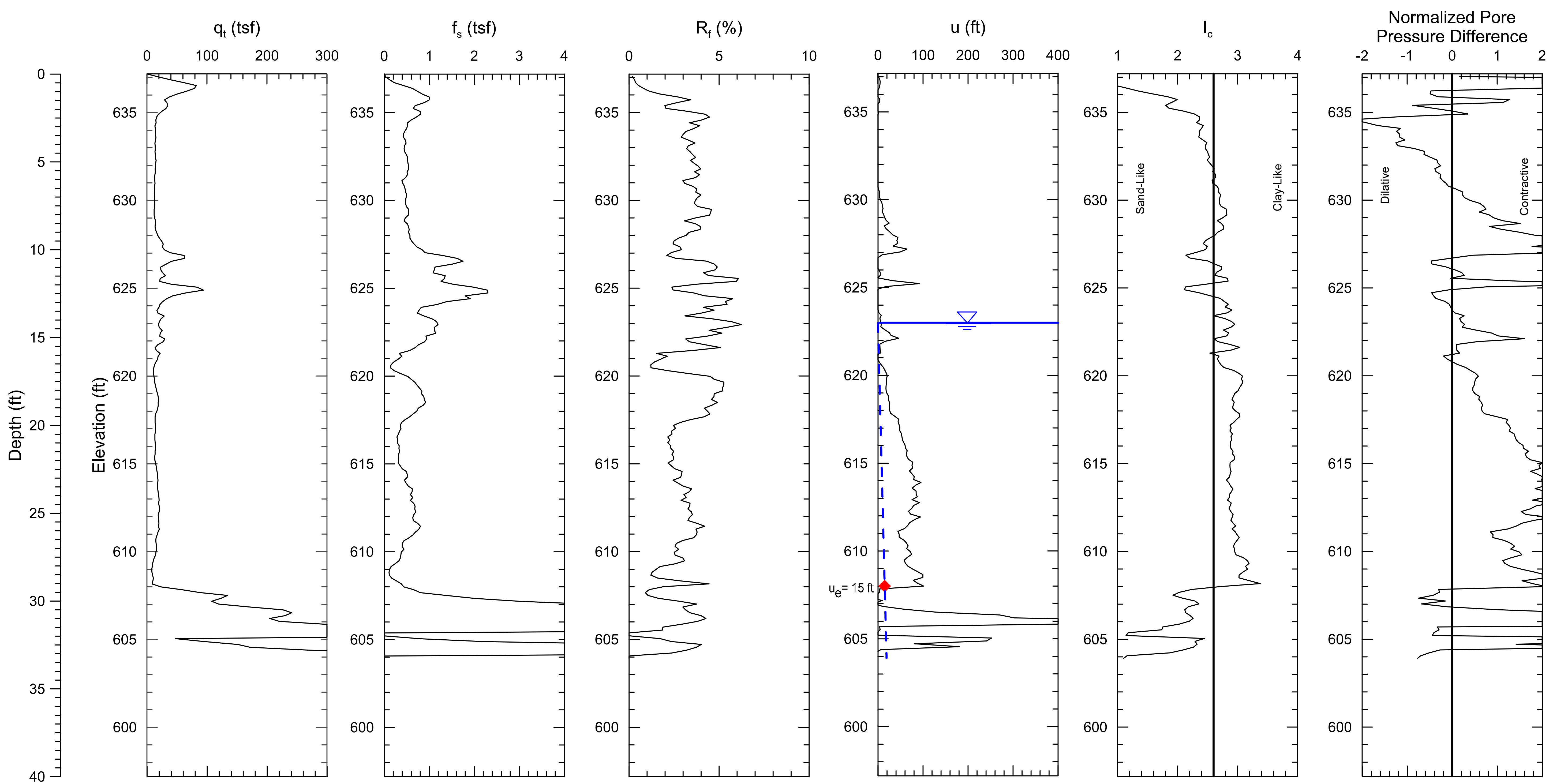
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-009 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-010 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



◆ Pore Pressure Dissipation Test

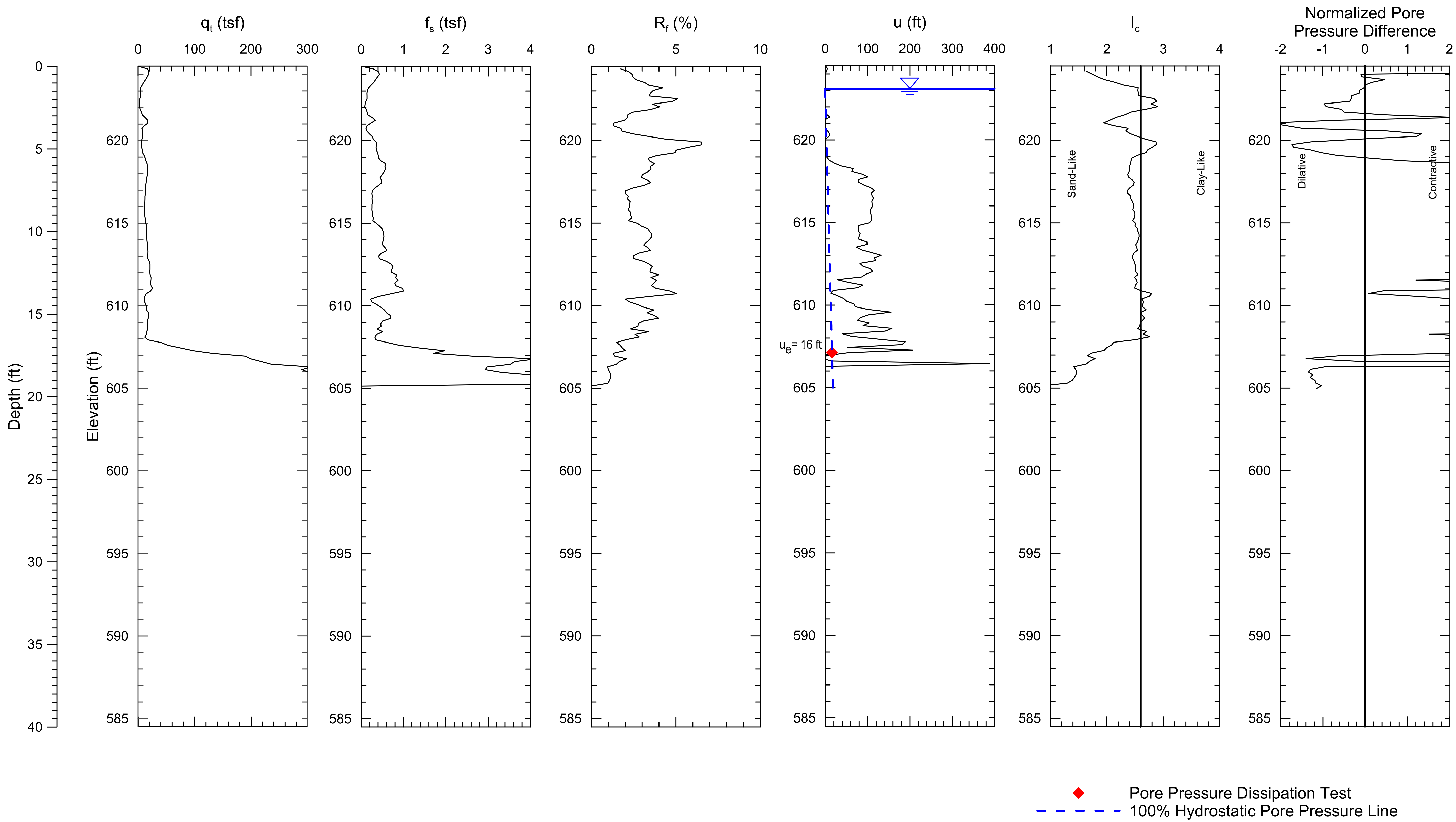
- - - 100% Hydrostatic Pore Pressure Line

Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-011 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

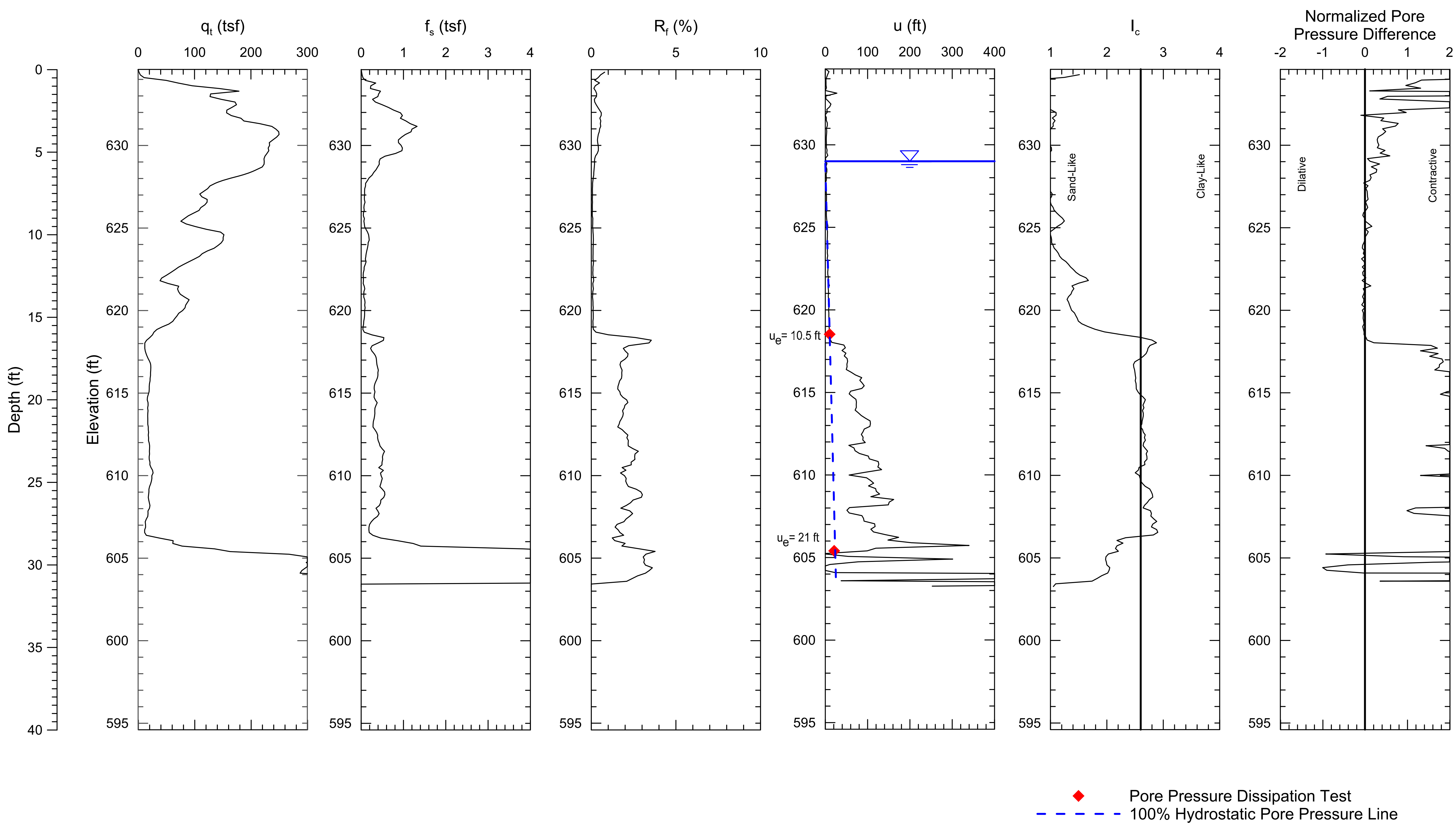


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

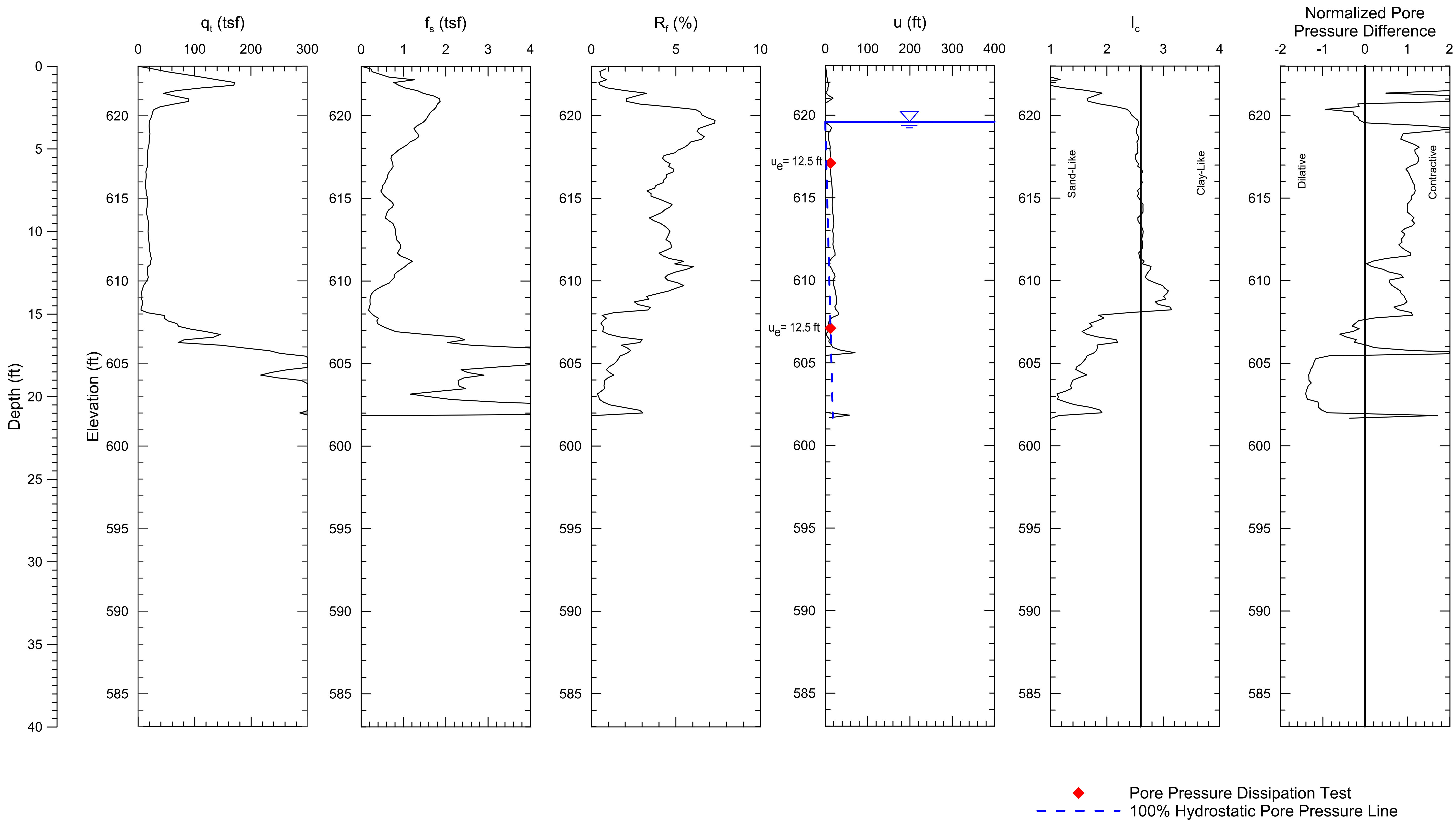
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-012 Coffeen Ash Pond No. 1	FIGURE
AECOM			



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-013 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

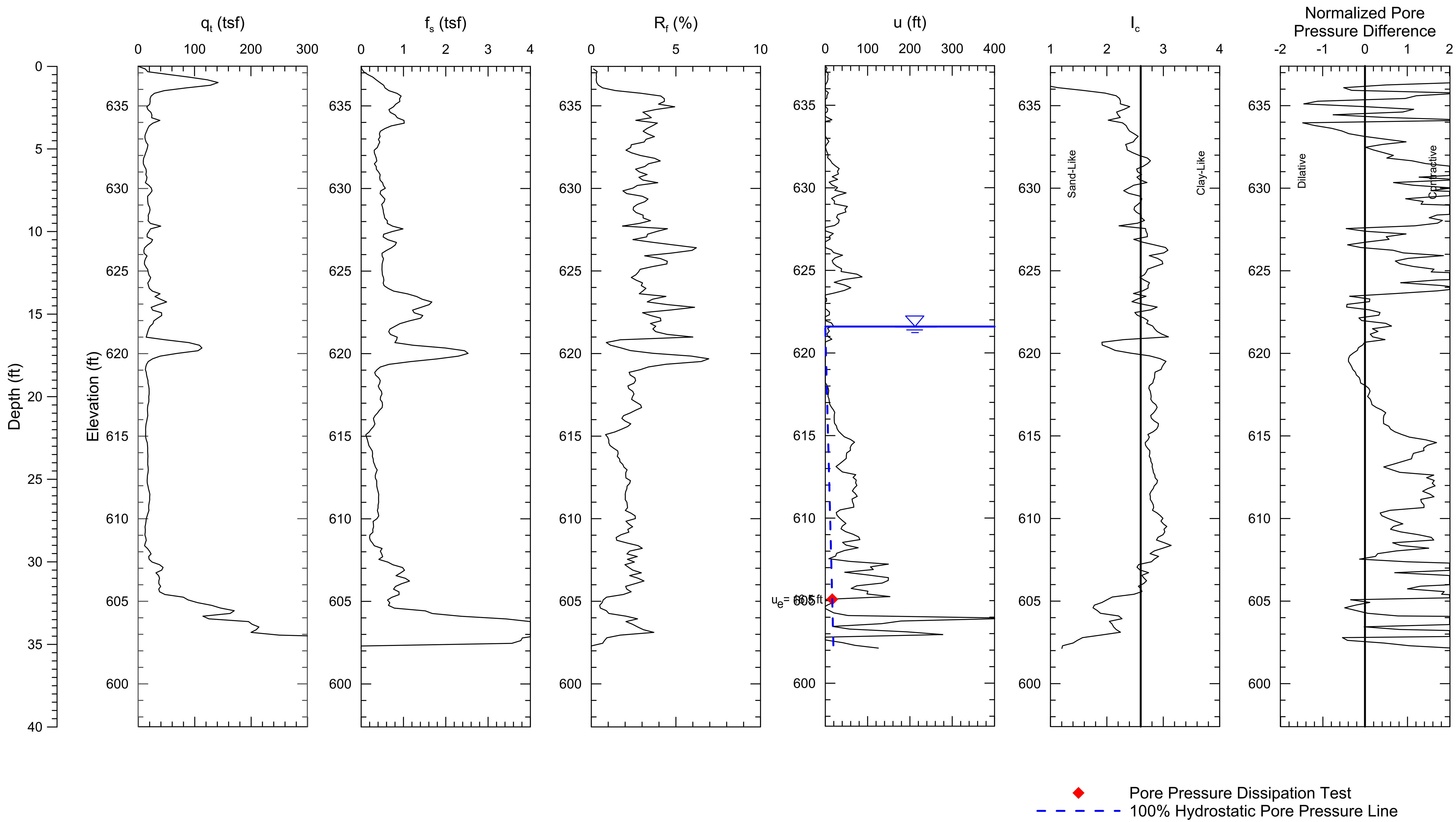


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

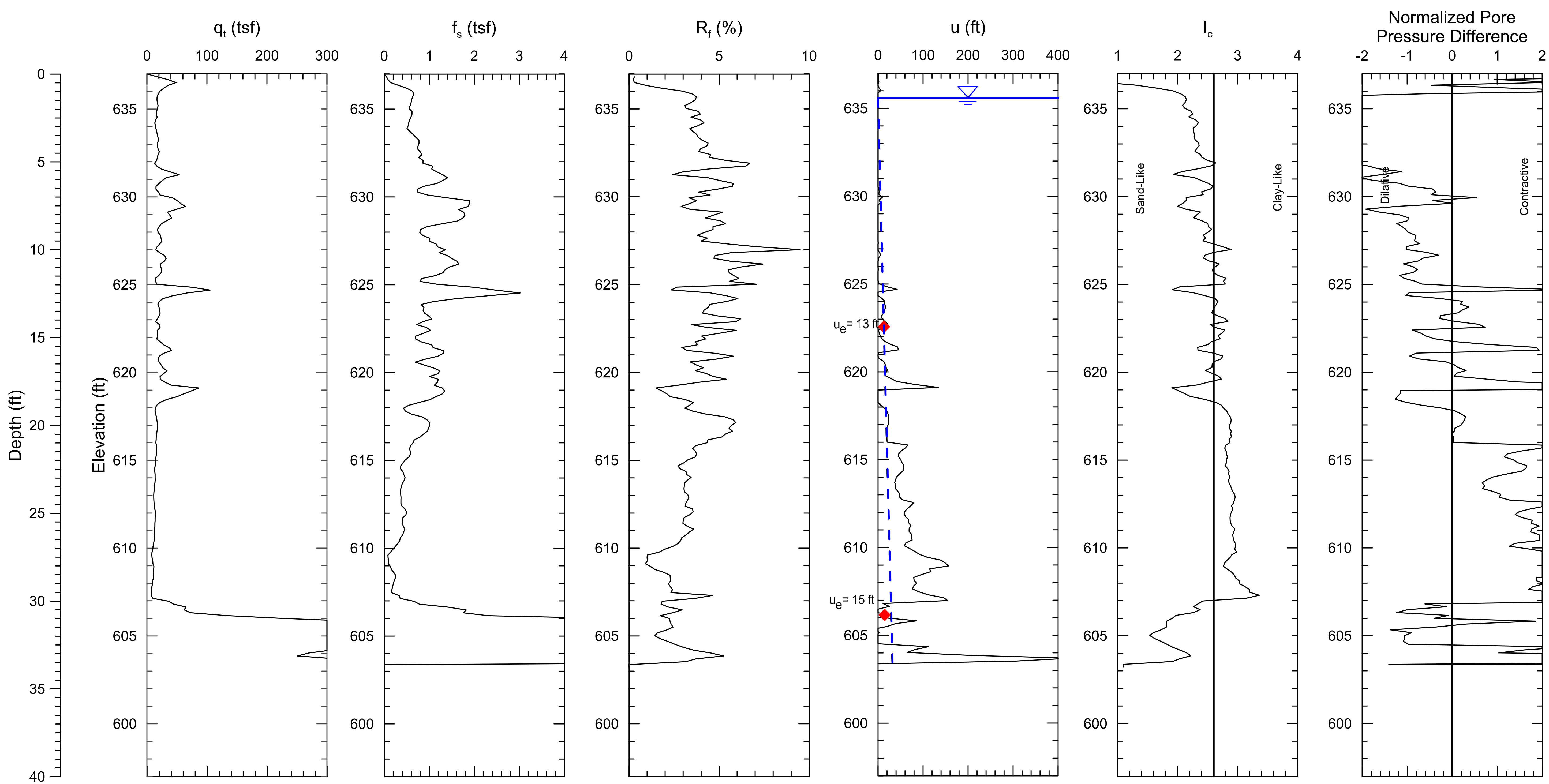
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-014 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-015 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



◆ Pore Pressure Dissipation Test

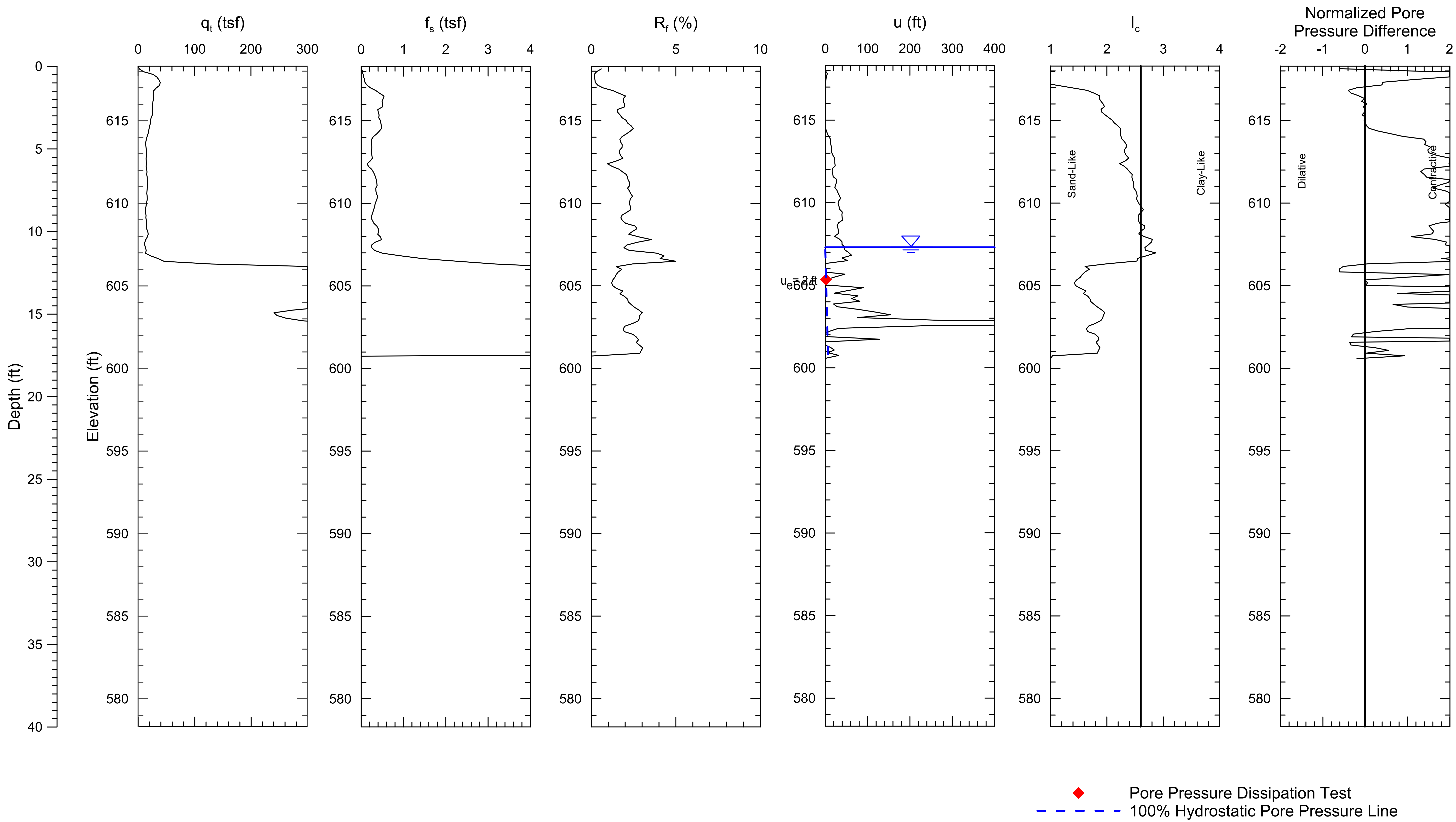
- - - 100% Hydrostatic Pore Pressure Line

Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-016 Coffeen Ash Pond No. 1	FIGURE
AECOM			

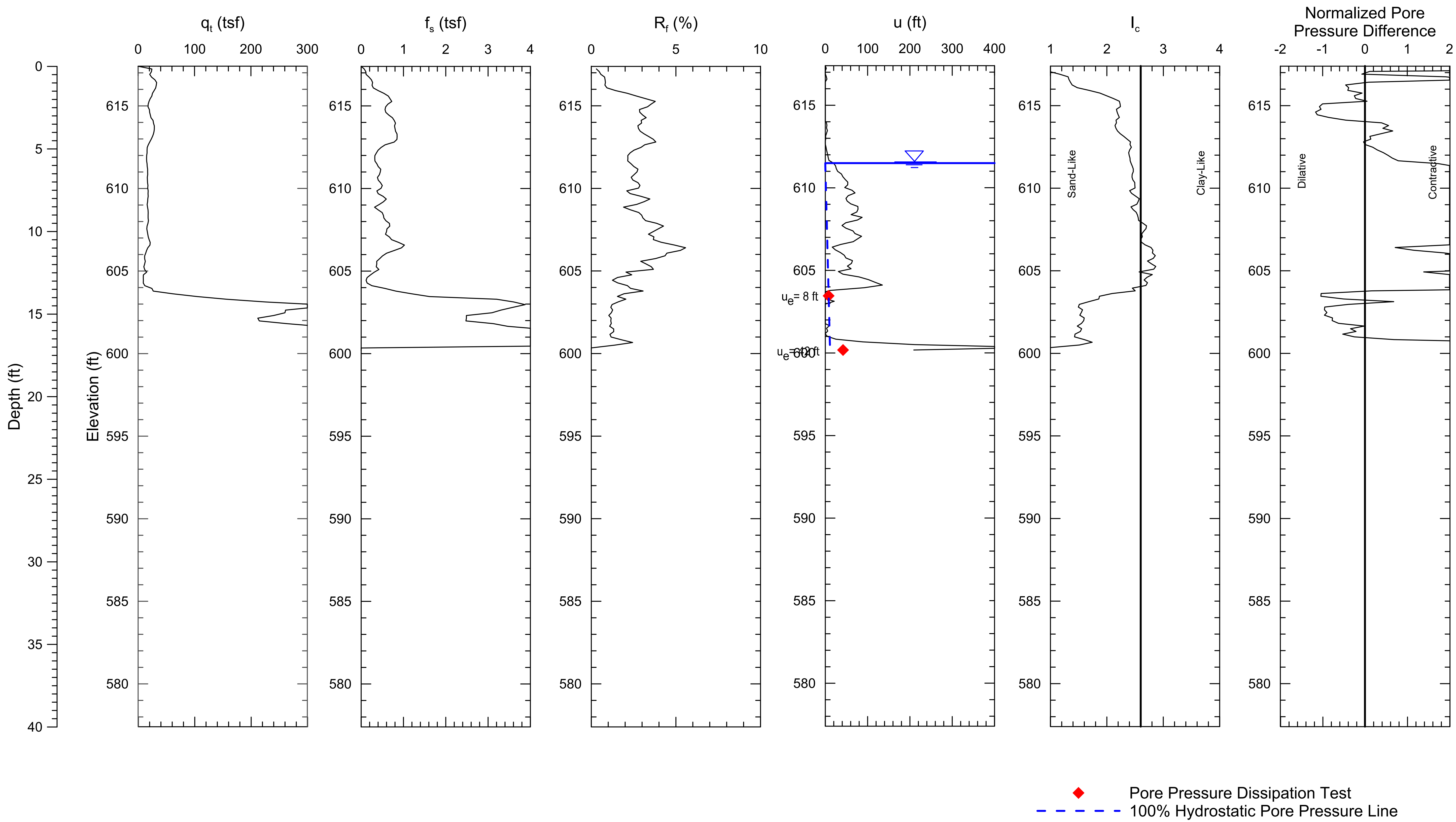


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

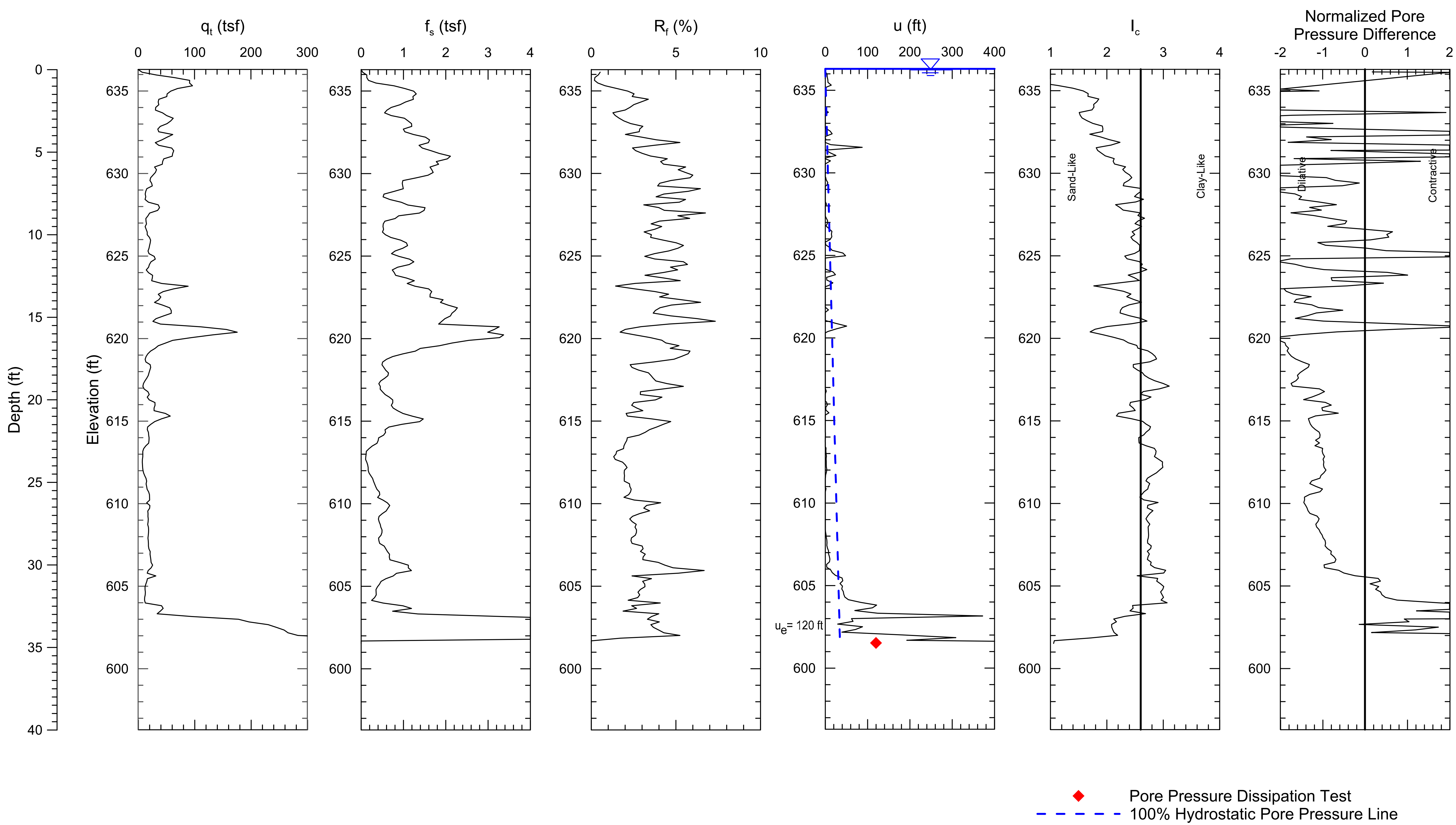
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-017 Coffeen Ash Pond No. 1	FIGURE
AECOM			



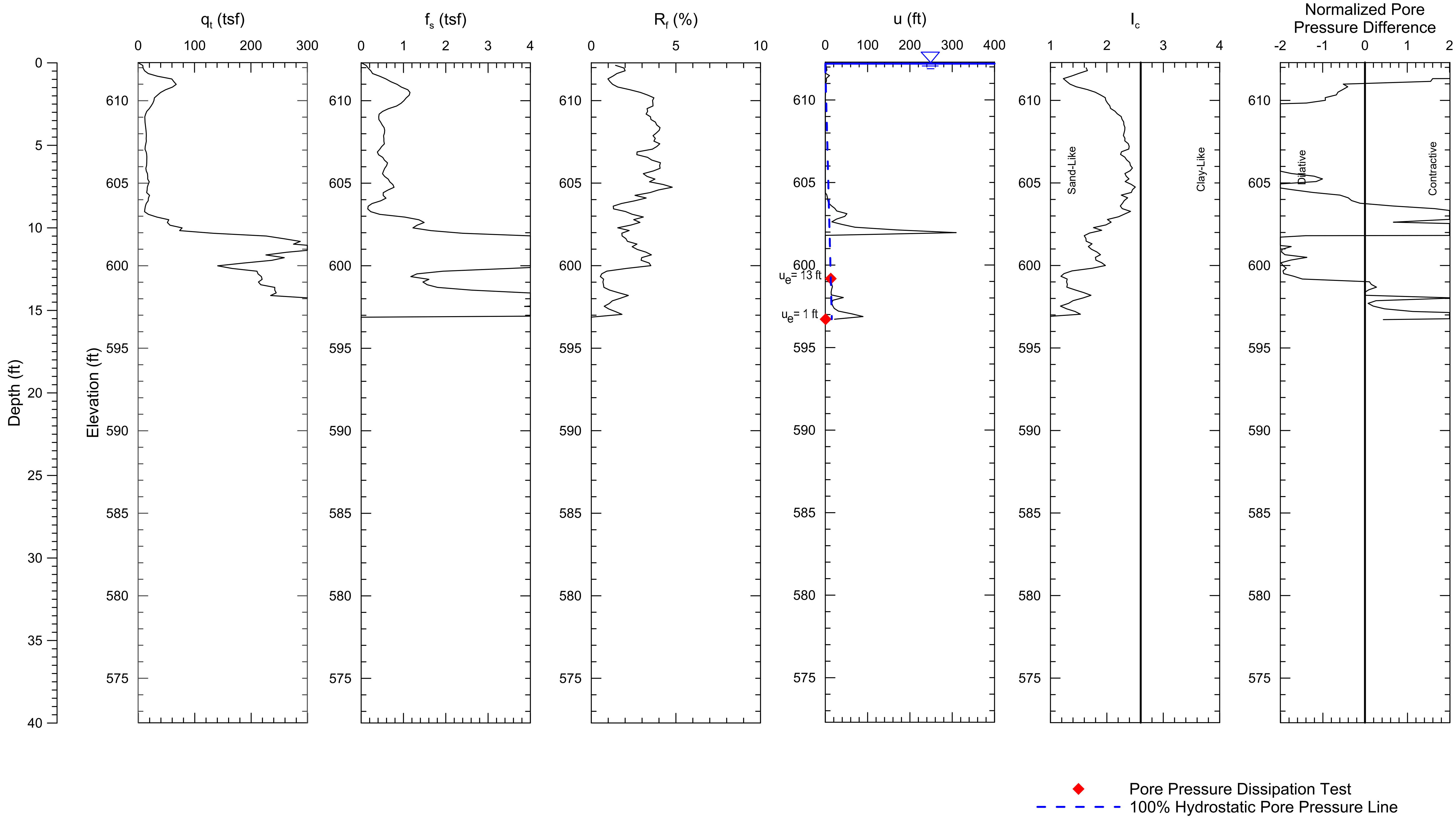
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-018 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



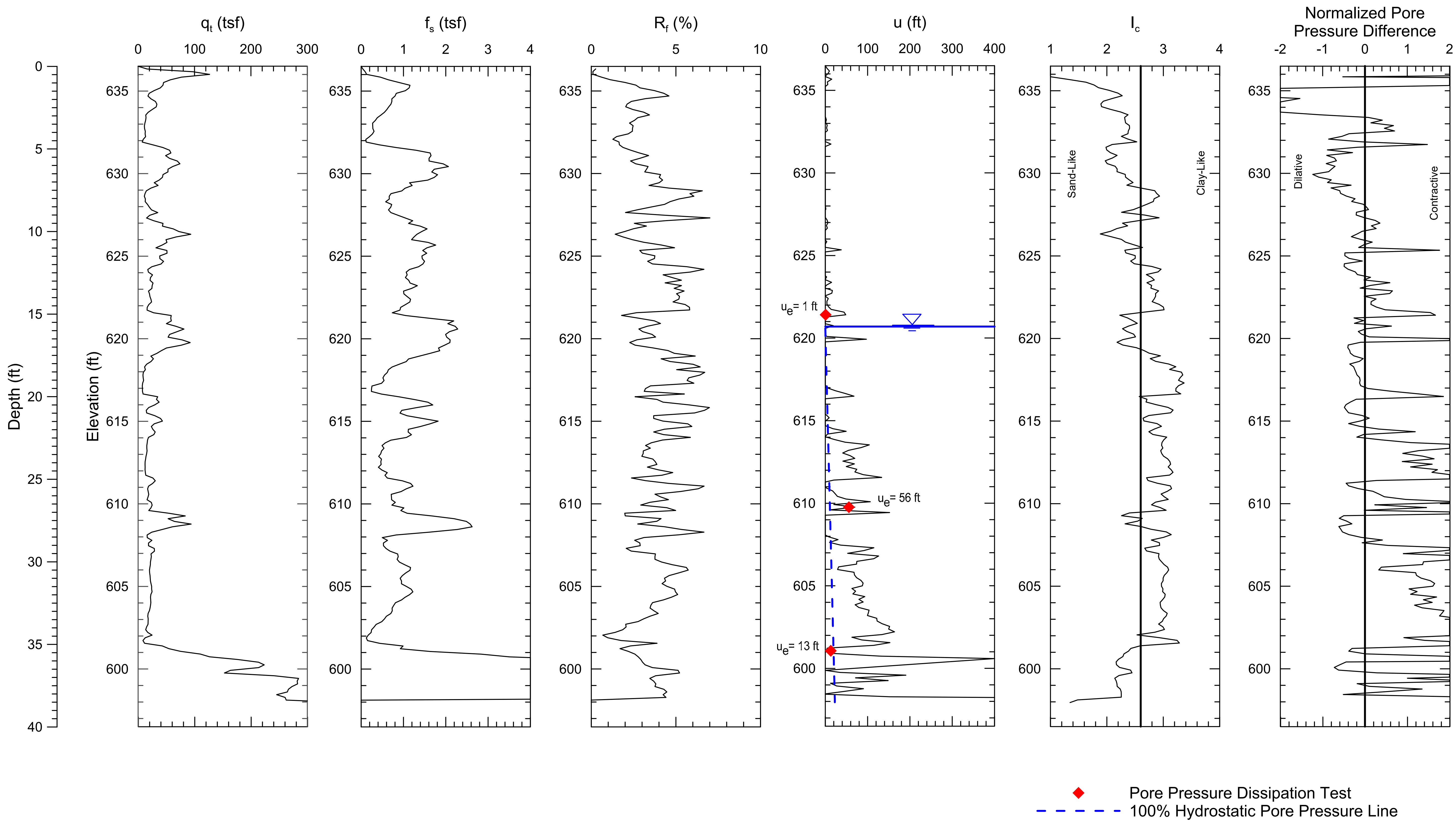
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-019 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-020 Coffeen Ash Pond No. 1	FIGURE
AECOM			

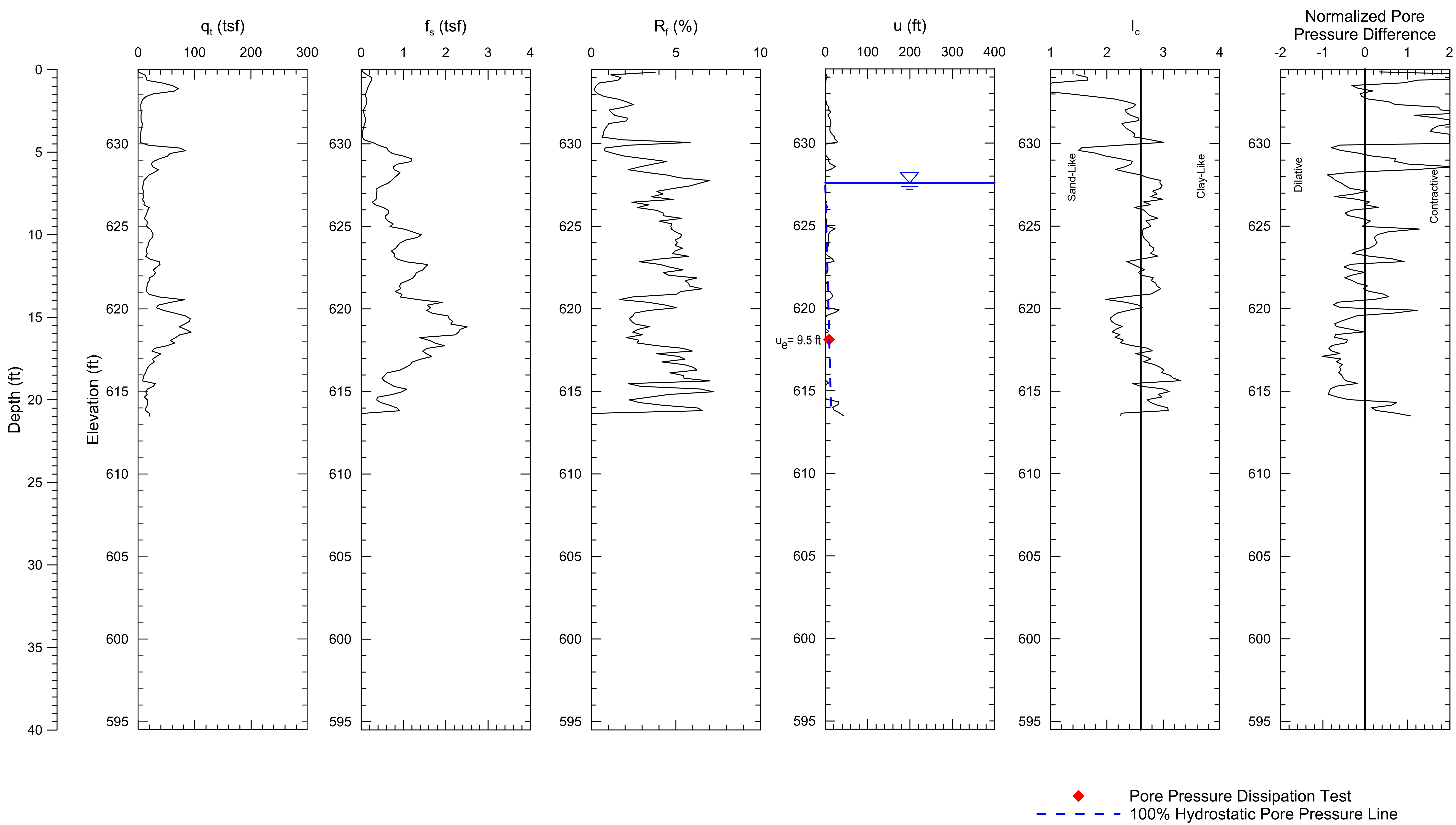


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-022 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

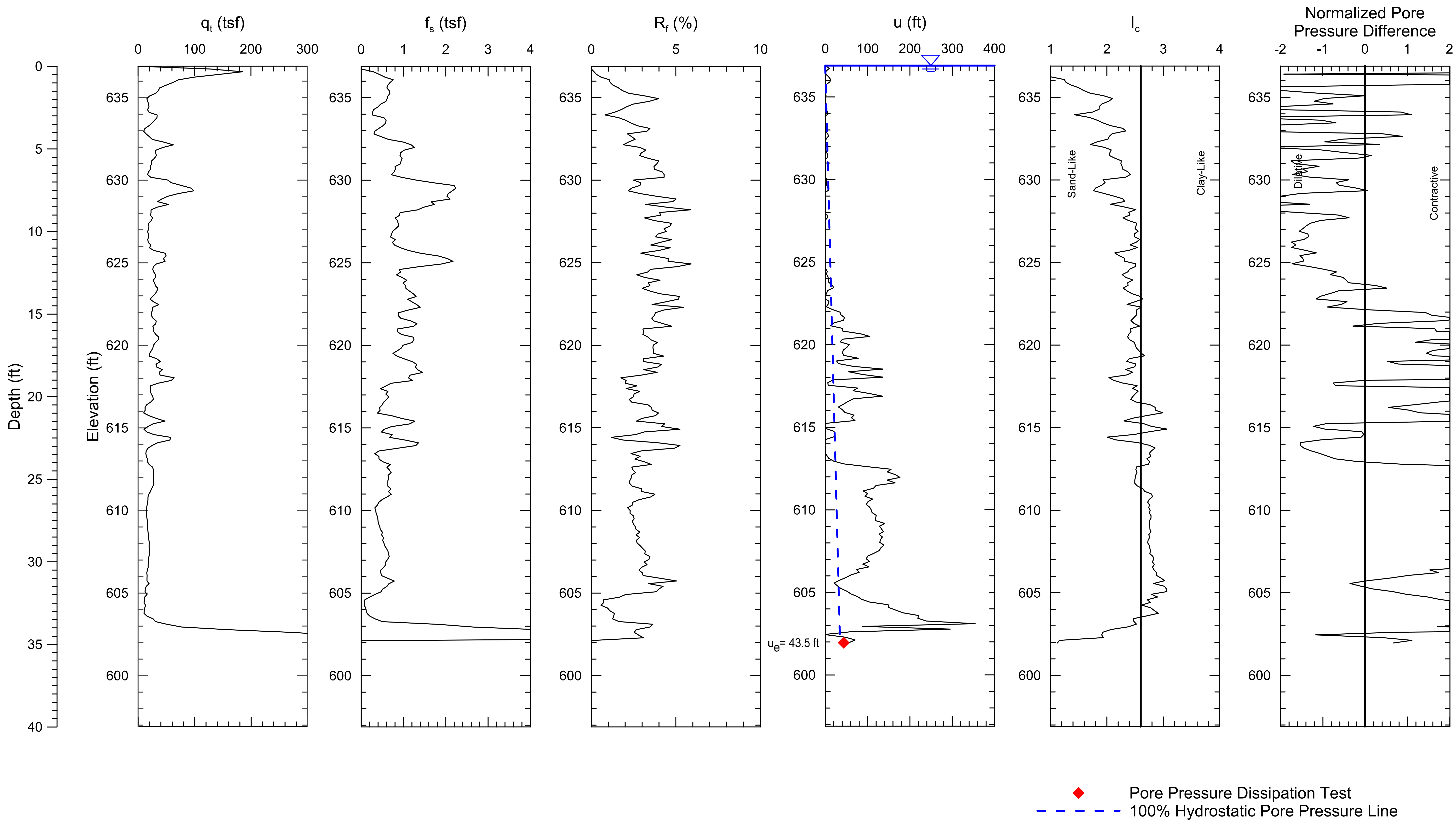


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-023 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-024 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B001

Date(s) Drilled	08/07/2015 8:40 AM to 08/07/2015 4:10 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	35.0 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.016 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P000 5 ft South of COF-B001)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871590.925 E 2516693.603 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Elevation (feet)	MATERIAL DESCRIPTION	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	0					636.0		0.0								
635		SS	S1	3 4 6	67		Stiff, moist, brown and gray, silty and sandy CLAY, trace fine gravel, topsoil upper 2 inches, (CL) (EMBANKMENT FILL).		12.9				3.5			
	5	SS	S2	2 4 6	61		Stiff, moist, brown and gray, low plasticity, silty and sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).		20.3		31	17	2.5			
630		SS	S3	2 5 7	72		Stiff, very moist, brown and gray, low plasticity, silty and sandy CLAY, trace gravel (CL) (EMBANKMENT FILL).		15.4				1.75			
	10	SS	S4	2 4 5	83		Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, with gray silt seams, (CL) (EMBANKMENT FILL).		16.1				1.5			
625																
620	15	ST	S5		92		Very stiff, very moist, dark grayish brown with yellowish brown and dark gray, low plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).		14.7	129.4	35	20	2.5			
						617.0	Very stiff to 19'	19.0								
	20	SS	S6	1 2 2	83		Soft, wet, brown and gray, low plasticity, silty CLAY, trace fine sand and decayed organic matter, organic odor, (CL) (NATIVE).		23.2							
615						615.0		21.0								
		ST	S7		92		Gray with yellowish brown, high plasticity, CLAY, with sand, (CH).		23.4	125.7	66	44				
						613.0		23.0								
	25	SS	S8	1 4 5	100		Stiff, very moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL).		19.6		41	26	1.5			
610																
	30	SS	S9	1 3 3	100	606.5		29.5	16.8				< 0.25			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B001

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30						Medium stiff, very wet, orange brown, medium plasticity, sandy CLAY, trace silt, (CL).								Pushed 14" then refused. Hard at tip of tube.
605		Shelby tube	S10		58		604.8 — 31.2					4.5			
							Hard, sandy CLAY, trace fine gravel, trace silt, low plasticity, (CL) (TILL).								
		Split spoon	S11	8 17 24	78		Hard, brown and gray, low plasticity, CLAY, trace fine gravel, trace silt, (CL) (TILL).	11.7		30	17	4.5			
	35						601.0 — 35.0								
							End of Boring at 35 ft								Installed Piezometer COF-P000 with 5 ft offset to the South.
600															
595	40														
590	45														
585	50														
580	55														
575	60														
	65														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B002

Date(s) Drilled	08/06/2015 9:30 AM to 08/06/2015 3:00 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	35.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.774 ft NAVD88
Borehole Backfill	Piezometer COF-P002	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871459.02 E 2516044.226 (ft NAD83)	Groundwater Level(s)	28 ft on 8/6/2015 1:00:00 PM		

Elevation (feet)	Depth (feet)	Samples: Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.8	0.0														
635		SS	S1	1 2 4	78		Medium stiff, very moist, brown and gray, low plasticity, CLAY, trace organics, (CL) (EMBANKMENT FILL).	25.4				2.0			
	5	SS	S2	2 3 5	89		Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	25.9		35	18	1.0			
630		SS	S3	1 3 5	83		Medium stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	25.9				1.25			
	10	ST	S4		100		Very stiff, very moist, gray with yellowish brown, medium plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).	17.8	134.5	40	25	3.5			
625															
	15	SS	S5	1 1 2	78		Soft, moist to wet, brown and gray, low plasticity, CLAY, with fine sand, trace fine gravel, (CL) (EMBANKMENT FILL).	23.3				0.75			
		ST	S6		100		Soft, very moist, gray with brown, low plasticity, silty CLAY, (CL) (EMBANKMENT FILL).	26.7	120.2	25	7	0.75			
620 / 619.8	17.0														
	20	SS	S7	2 3 5	94		Medium stiff, very moist, brown and gray, medium plasticity, CLAY, trace fine sand, with brown silt seams, (CL) (NATIVE).	25.4		47	29	1.5			
615															
	25	SS	S8	2 3 4	100			18.9				0.75			
610															
608.8	28.0						Loose, very wet, brown, fine to coarse clayey SAND, trace gravel, (SC) (NATIVE).								
	30	SS	S9	1 2 4				13.6							

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B002

Elevation (feet)	Depth (feet)	Samples: Type	Samples: Number	Samples: Sampling Resist. OR Core RQD (%)	Samples: Recovery (%)	Graphic Symbol	Material Description	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	Remarks
	30														*Till ~ 31.5' harder drilling*
605.3	31.5						Very dense, moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, with iron staining, (CL) (TILL).								
			S10	34/50 4"				9.5		20	7				
601.3	35.5						End of Boring at 35.5 ft								*Very hard drilling with new teeth. Installed Piezometer COF-P002 in boring.*

Elevation scale (feet): 605, 600, 595, 590, 585, 580, 575

Depth scale (feet): 30, 35, 40, 45, 50, 55, 60, 65

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B003

Date(s) Drilled	08/05/2015 11:30 AM to 08/05/2015 5:30 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	45.0 ft
Drill Rig Type	CME 550X (Rubber Tire ATV)	Drilling Contractor	Geotechnology	Surface Elevation	637.523 ft NAVD88
Borehole Backfill	Piezometer COF-P003	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871825.695 E 2515128.189 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Sample Type	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
				Elevation 637.5 ft, Depth 0.0 ft								
SS	S1	3 5 4	50	Stiff, dry, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, trace coarse ash, (CL) (EMBANKMENT FILL).	14.2				4.5			
SS	S2	2 3 4	67	Medium stiff, moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, trace coarse ash, (CL) (EMBANKMENT FILL).	18.1		42	26	1.25			
SS	S3	2 2 5	67	Medium stiff, moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	15.0				2.5			
SS	S4	2 4 8		Stiff, very moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	17.4				1.5			
				Elevation 623.5 ft, Depth 14.0 ft								
ST	S5		92	Stiff, very moist, dark gray to yellowish brown, high plasticity, CLAY, trace fine sand, (CH).	21.8	127.5	54	36	1.75			
SS	S6	2 3 4	83	Medium stiff, very moist, brown and gray, high plasticity, CLAY, trace fine sand, (CH).	26.0				1.75			
SS	S7	WOH 2 3	100	Medium stiff, very moist, brown and gray, medium-high plasticity, CLAY, with sand, with iron stained seams, (CL-CH).	20.8		50	34	1.75			
				Elevation 608.5 ft, Depth 29.0 ft								
SS	S8	2 1 9	100	Stiff, very moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, (CL).	12.5		21	6	3.5			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B003

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30		S9		100			11.8	141.7			4.5			
606.5	31.0						Dense, wet, dark yellowish brown with grayish brown, silty SAND, trace gravel, (SM).								S9 refusal at 30.8'
604.0	33.5		S10	2 2 6			Loose, very wet, brown, fine to coarse SAND, (SP).								Top of S10 full of water
599.0	38.5		S11	19 34 40	61		Very dense, very wet, brown, silty fine to coarse SAND, trace gravel, (SP) (TILL).	9.5							
594.0	43.5		S12	30 60 50/3"	100		Very dense, very wet, brown and gray, fine to coarse clayey SAND, trace fine gravel, (SC) (TILL).	9.9							Installed Piezometer COF-P003 in boring.
592.5	45.0						End of Boring at 45 ft								

Elevation scale: 605, 600, 595, 590, 585, 580, 575

Depth scale: 30, 35, 40, 45, 50, 55, 60, 65

AECOM

Report: GEO_SOIL; File \\USDEN5FP0001\GEOCIVIL$\PROJECTS\60428794_DYNEGY_CCR_RULEASMT\SUB_00\10.0_CALCULATIONS_ANALYSIS_DATA\SITE INVESTIGATION\COFFEEN\BORINGS\GINT TEMPLATE\DYNEGY_COFFEEN_2015.GPJ; 2/9/2016 1:22

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B004

Date(s) Drilled	08/04/2015 10:20 AM to 08/05/2015 11:00 AM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	45.0 ft
Drill Rig Type	CME 550X (Rubber Tire ATV)	Drilling Contractor	Geotechnology	Surface Elevation	636.258 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P005 5 ft West of COF-B004)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 872193.263 E 2516088.178 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.3	0.0														
635		SS	S1	2 3 5	67		Medium stiff, moist, brown, low plasticity, CLAY, with fine sand, trace fine gravel, (CL) (EMBANKMENT FILL).	18.0				1.75			
	5	SS	S2	3 4 5	67		Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	10.9				3.5			
630		SS	S3	2 4 4	72		Medium stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	11.0				2.25			
	10	ST	S4		79		Medium stiff, moist, yellowish brown with gray, low plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).	12.8	136.6	39	24	2.25			
625															
	15	SS	S5	3 5 6	94		Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	13.1		26	12	4.0			
620															
618.3	18.0						Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, with gray silt seams, (CL) (NATIVE).								
	20	SS	S6	2 3 7	83			21.8				1.75			
615															
	25	ST	S7		92		Very stiff, very moist, reddish brown, high plasticity, silty CLAY, trace fine sand, with dark gray silt seams, (CL).	20.6	129.5	51	34	2.75			
610															
	30	SS	S8	1 4 5	100		Stiff, very moist, brown and gray silt seams, medium plasticity, CLAY, with fine to medium sand, (CL).	24.2		43	27	1.75			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B004

Elevation (feet)	Depth (feet)	Samples: Type	Samples: Number	Samples: Sampling Resist. OR Core RQD (%)	Samples: Recovery (%)	Graphic Symbol	Material Description (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	Remarks
603.8	32.5						Hard, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (TILL).								
			S9	16 31 37	100			8.4		21	8	4.5+			
			S10	14 45 44	83		Hard, moist, brown and gray, low plasticity, sandy silty CLAY, trace fine to coarse gravel, (CL) (TILL). 38.5' - 39.2' gray silt seams	8.8				4.5+			
592.8	43.5		S11	19 54 50/4"	94		Hard, wet, brown and gray, low plasticity, sandy silty CLAY, trace gravel, (CL) (TILL).	14.8				-			
591.3	45.0						End of Boring at 45 ft								*Installed Piezometer COF-P005 with 5 ft offset to the West.*

Elevation scale (feet): 605, 600, 595, 590, 585, 580, 575

Depth scale (feet): 30, 35, 40, 45, 50, 55, 60, 65

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B005

Date(s) Drilled	08/08/2015 7:45 AM to 08/08/2015 12:00 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	60.0 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.496 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P006 5 ft South of COF-B005)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 872102.375 E 2516696.89 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Samples: Type	Samples: Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.5	0.0														
635		SS	S1	2 3 4	83		Medium stiff, moist, brown and gray, low plasticity, CLAY, (CL) (EMBANKMENT FILL).	21.1				1.5			
	5	ST	S2		54		Stiff, moist, brown, low plasticity, sandy CLAY, (CL) (EMBANKMENT FILL).	8.0	136.6	22	9	3.0			
630		SS	S3	1 3 4	72		Medium stiff, moist, brown, low plasticity, sandy CLAY, (CL) (EMBANKMENT FILL).	13.1				0.75			
	10	SS	S4	2 7 6	89		Stiff, moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	9.9		20	6	3.0			*Shale in tip*
625															
	15	SS	S5	2 6 6	78		Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	10.3				2.0			
620															
	20	SS	S6	WOH 2 3	67		Medium stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	9.4				1.0			
615															
613.5	23.0														
	25	ST	S7		92		Stiff to very stiff, gray with grayish brown, low plasticity, CLAY, with sand, with organics, (CL) (NATIVE).	18.7	131.4	37	20	1.5			
610															
608.0	28.5														
	30	SS	S8	1 4 6	89		Stiff, brown and gray, low plasticity, CLAY, trace fine sand, trace organics, (CL).	21.9				2.0			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B005

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Elevation (feet)	MATERIAL DESCRIPTION	Depth (feet)	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
604.5	32.0		S9	1 1 1	100	604.5	Very stiff, low plasticity, sandy CLAY, with organics, (CL).	32.0	26.7		22	6	2.5			
602.5	34.0					602.5	Very loose, saturated, brown and gray, silty, clayey SAND, (SC-SM).	34.0								*35': Attempt ST refusal at 35.5'*
601.0	35.5		S10	8 22 27	100	601.0	Dense, wet, brown and gray, clayey SAND, trace fine gravel, (SC) (TILL)	35.5	11.6				-			
593.5	43.0		S11	4 7 11	100	593.5	Very stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)	43.0	12.8		32	17	3.25			
			S12	2 6 8	100		Stiff, saturated, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)		15.5		32	17	3.0			
			S13	2 5 7	100		Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)		23.2				1.25			
			S14	2 3 6	100		Stiff, brown and gray, medium plasticity, CLAY, with sand, (CL) (TILL)		23.3		47	30	1.25			
576.5	60.0					576.5	End of Boring at 60 ft	60.0								*Installed Piezometer COF-P006 with 5 ft offset to the South.*

Elevation scale: 605, 600, 595, 590, 585, 580, 575. Depth scale: 30, 35, 40, 45, 50, 55, 60, 65.

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B006

Date(s) Drilled	08/06/2015 4:00 PM to 08/07/2015 7:30 AM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	33.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	631.9* ft NAVD88
Borehole Backfill	Cement-Bentonite Grout	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871654.5 E 2515234.7* (ft NAD83)	Groundwater Level(s)	4 ft on 8/6/2015 5:00:00 PM		

Elevation (feet)	Depth (feet)	Samples: Type	Samples: Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
631.9*	0						0.0 — Medium dense, moist, black, well-graded sand (cinders), trace silt, trace fine gravel, (ASH).								
		SS	S1	5 13 15	78			6.6							
							Very loose, wet, black, well-graded sand (cinders), trace clay, (ASH).								
		SS	S2	2 2 2	100			48.3							
	5														
		ST	S3		17			22.2							
		SS	S4	3 4 6	100		Loose, wet, black, well-graded sand (cinders), trace clay, (ASH).	16.7							
	10														
-8846.6	14.0						Medium stiff, very moist, brown and gray, high plasticity, CLAY, trace fine sand, (CH) (NATIVE).								
		SS	S5	WOH 2 3				24.4		57	37	1.75			
	15														
		SS	S6	1 3 4	67			21.9				1.25			
	20														
-14533.7	23.0						Very soft, very wet, brown, low plasticity, sandy CLAY, (CL).								
		SS	S7	1 1 1	100			19.8		23	9	0.5			
	25														
-16429.4	26.0						Hard, very wet, brown and gray, low plasticity, sandy CLAY, (CL) (TILL).								
		SS	S8	20 50/4"				16.1							
	30														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B006

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30														
			S9	24 34 50/5"	94		Hard, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (TILL).	8.1		25	12				*Hard augering below 32'*
							-21168.7 / 33.5								
							*Final survey coordinates/elevation are not available. End of Boring at 33.5 ft								
	35														
	40														
	45														
	50														
	55														
	60														
	65														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B006A

Date(s) Drilled	08/19/2015 7:15 AM to 08/19/2015 10:15 AM	Logged By	A. Grossman	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	25.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	633.583 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout	Sampling Method(s)	Piston	Hammer Data	-
Boring Location	N 871651.263 E 2515194.552 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Sample Type / Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
633.6	0.0				ASH	Loose, moist, black, medium to coarse grained sand (cinders), (ASH).								
		PS-1		75										
		PS-2		20										
621.1	12.5				CL	Stiff, light grayish brown, low plasticity, silty CLAY, some ash, (CL).								
		PS-3		70							1.25			
		PS-4		83							1.25			
		PS-5		73							1.25			
		PS-6		93		Stiff to very stiff, grayish brown, low plasticity, CLAY, (CL).					2.0			
608.1	25.5					End of Boring at 25.5 ft								*Auger refusal at 25.5' bgs.*

AECOM

Attachment G. Material Characterization Calculations

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Material Characterization | Project Name: Dynegy CCR

By: Julie Heitland | Date: 01/06/2016 | Project No: 60480701

Checked By: Amanda Duvigneaud | Date: 01/11/2016 | Task No.: 01

Objective

A material characterization was performed to estimate material properties for the embankment and foundation clay soils at Coffeen Ash Pond No. 1. Coffeen Ash Pond No. 1 is a Coal Combustion Residuals (CCR) unit at Dynegy's Coffeen Station located in Coffeen, Montgomery County, Illinois. Selected material properties for slope stability analyses are summarized in the following sections.

Subsurface Conditions

A subsurface investigation was conducted at Coffeen Ash Ponds No. 1 and No. 2 in August 2015 by AECOM. Field and laboratory test results from both ash ponds were used to evaluate subsurface stratigraphy and shear strength properties of the materials with more emphasis generally applied to the results from Coffeen Ash Pond No. 1.

The investigation included 6 soil borings and 22 Cone Penetration Test (CPT) soundings at Coffeen Ash Pond No. 1 and 7 soil borings and 22 CPT soundings at Coffeen Ash Pond No. 2. Borings and CPTs were drilled or pushed through the ash deposit and along the crest and toe of the existing embankments. Boring and CPT locations for Coffeen Ash Pond No. 1 are shown in Figure 1. Boring logs and CPT soundings are included at the end of this calculation package for reference.

Field testing included Standard Penetration Tests (SPT), CPT dissipation testing, and shear wave velocity measurements using the seismic CPT. Open well and vibrating well piezometers were installed in select borings and CPTs. CPT soundings were used to develop the subsurface stratigraphic profile. Boring logs were also used for comparison and visual confirmation of the CPT data. Based on results of the investigation, five stratigraphic materials were identified at the site:

- **Impounded Ash**: Well-graded or medium- to coarse-grained SAND (cinders), with trace of silt or clay, very loose to medium dense, moist to wet, and black.
- **Embankment Fill**: Generally classified as silty CLAY, sandy CLAY, or CLAY with sand (CL), with a trace of fine gravel, soft to very stiff, low to medium plasticity, moist to wet, and brown to gray. Trace amounts of organic material and ash were sometimes encountered.
- **Foundation Clay**: Native clay of wind-blown origin (loess), with some coarse-grained layers. The fine-grained soils (clays) encountered in the borings were generally classified as low to medium plasticity silty CLAY, sandy CLAY, or CLAY with sand (CL) often with a trace of gravel; or high plasticity clay (CH), often with a trace of sand. The CL and CH soils were soft to very stiff, very moist to saturated, and brown to gray. The coarse-grained soils encountered in the borings were classified as clayey SAND (SC), silty SAND (SM), or fine- to coarse-grained SAND (SP), with a trace of gravel, loose to dense, wet to very wet, and brown to gray.

- **Soft Foundation Clay**: A thin layer of native silty or sandy clay (CL) was encountered in several borings and in CPT soundings between the foundation clay and underlying glacial till deposits. The clay was very soft to medium stiff, low to medium plasticity, very wet, and orange brown to gray.
- **Till:** Generally classified as CLAY, or silty to sandy CLAY (CL), with a trace of fine gravel, hard, low plasticity, moist to very wet, and brown to gray. In one boring, the till was classified as silty, fine- to coarse-grained sand (SP) underlain by clayey, fine to coarse grained sand (SC), with a trace of gravel, very dense, very wet, and brown.

Representative samples of the embankment and foundation clay materials were collected at regular intervals from the borings for laboratory testing. Laboratory tests were assigned to characterize the site materials including index (moisture content, unit weight, Atterberg limits, specific gravity, and gradation analysis), permeability, and consolidation testing. Strength testing included isotropically consolidated-undrained triaxial tests with pore pressure measurements (CIU') and direct simple shear tests (DSS) on the embankment and foundation clay materials. Laboratory test results are included at the end of this calculation package for reference.

Material Properties

Approach, Analysis, and Assumptions

Material properties for slope stability analyses were developed using both laboratory testing data (index and strength testing) and strength correlations from CPT data. Since the materials at Coffeen Ash Ponds No. 1 and No. 2 are relatively similar, laboratory test results pertaining to strength testing from both sites were used to evaluate shear strength properties. However, more emphasis was generally applied to the results from Coffeen Ash Pond No. 1 to characterize materials at this site.

The following is a summary of the specific material properties developed for the impounded ash, embankment, foundation clay materials, and till:

- Unit Weight
- Drained Shear Strength
- Undrained Shear Strength
- Post-Earthquake Shear Strength

A detailed material characterization was performed for the embankment and foundation clay materials. Material properties for the impounded ash and till were conservatively estimated based on empirical correlations and experience with similar materials.

Unit Weight

Unit weight for the embankment and foundation clay materials were evaluated using measured results from samples collected within the materials at Coffeen Ash Pond No. 1. Measured total unit weights ranged from 120 to 137 pounds per cubic foot (pcf) within the embankment and 120 to 142 pcf within the foundation clay materials. A total unit weight of 135 pcf was selected for the embankment, and a total unit weight of 125 pcf was selected for the foundation clay materials (both the foundation clay and soft foundation clay). Measured unit weights versus depth, as well as other index properties for Coffeen Ash Pond No. 1 are presented in Figure A.1 included in Appendix A.

Drained Shear Strength

Peak drained shear strengths for the embankment and foundation clay materials were evaluated for the normal operating (steady-state) loading condition using results from CIU' and DSS tests on samples collected at Coffeen Ash Ponds No. 1 and No. 2. CIU' strength tests were performed on five undisturbed tube samples collected within the embankment and four undisturbed tube samples collected within the foundation clay. DSS strength tests were performed on three undisturbed tube samples collected within the foundation clay and one undisturbed tube sample collected within the soft foundation clay. CIU' stress paths, DSS test paths, and stress vs strain plots for the various lab tests are shown in figures included in Appendices B through D. CIU' test results were evaluated using peak obliquity (maximum principle stress ratio) failure criteria, and DSS test results were evaluated using 10% strain failure criteria. For each material tested, the shear stress on the failure plane (τ_{ff}) and corresponding effective normal stress on the failure plane (σ'_{ff}) at failure were plotted and a strength envelope was fit to the data.

The peak drained shear strength for the embankment was characterized with a nonlinear strength envelope to assign the shear strength as a function of the effective normal stress on the failure plane. The nonlinear strength envelope is curved below an effective normal stress of 1,440 pounds per square foot (psf) and linear above 1,440 psf, as shown in Figure B.1 in Appendix B. A curved envelope was fit to the data at lower stresses since the compacted embankment material is more overconsolidated within the lower stress range. The linear portion of the envelope is defined by an effective stress friction angle (ϕ') of 31 degrees and zero effective cohesion (c').

The peak drained shear strength for the foundation clay was characterized based on the orientation of the failure plane below the embankment and in the free field (or near the toe of the embankment). The shear strength below the embankment is more representative of a failure plane resulting from CIU' tests, while the shear strength in the free field is more representative of a failure plane resulting from DSS tests. Therefore, a nonlinear strength envelope using CIU' test results was used to characterize the foundation clay below the embankment, and a linear strength envelope using DSS test results was used to characterize the foundation clay in the free field. Similar to the embankment, the nonlinear strength envelope is curved below an effective normal stress of 2,160 psf and linear above 2,160 psf, as shown in Figure C.1 in Appendix C. A curved envelope was fit to the data at lower stresses since the foundation clay below the embankment is generally overconsolidated within the lower stress range and becomes more normally consolidated at higher stresses. The linear portion of the envelope is defined by an effective stress friction angle (ϕ') of 32 degrees and zero effective cohesion (c'). The linear strength envelope using DSS test results is defined by an effective stress friction angle (ϕ') of 30 degrees and zero effective cohesion (c'), as shown in Figure C.1 in Appendix C.

One DSS test was performed on a sample of the soft foundation clay from Coffeen Ash Pond No. 2. However, the sample collected may have been taken in the transition zone from the foundation clay above to the softer clay below. The peak drained shear strength for the soft foundation clay was therefore characterized with a linear strength envelope using the DSS test result and limiting the strength to that evaluated for the foundation clay in the free field. The strength envelope for the soft foundation clay is defined by an effective stress friction angle (ϕ') of 30 degrees and zero effective cohesion (c'), as shown in Figure D.1 in Appendix D.

Undrained Shear Strength

Peak undrained shear strengths for the embankment and foundation clay materials were evaluated for the probable maximum flood (PMF) loading condition using the same CIU' and DSS test results that were used to evaluate the drained shear strength discussed above. For each material tested, the shear stress on the failure plane (τ_{ff}) and corresponding effective confining stress (σ'_{fc}) at failure were plotted and a strength envelope was fit to the data.

The peak undrained shear strength for both the embankment and foundation clay materials were characterized using a linear strength envelope with a specified minimum undrained shear strength. The linear strength envelope represents the undrained strength ratio (S_u/p'). A minimum undrained shear strength (min S_u) was assigned to better represent the strength at lower stresses. The strength envelope for the embankment is defined by an undrained strength ratio (S_u/p') of 0.60 and minimum undrained shear strength (min S_u) of 450 psf, as shown in Figure B.2 in Appendix B.

Similar to the drained shear strength, the peak undrained shear strength for the foundation clay was characterized using two strength envelopes based on the orientation of the failure plane below the embankment and in the free field (or near the toe of the embankment). Therefore, CIU' test results were used to characterize the foundation clay below the embankment, and DSS test results were used to characterize the foundation clay in the free field. In addition to the lab results, correlated values for peak undrained strength from CPT results were applied to the undrained strength characterization for the foundation clay. The undrained strength evaluated from CPT results was plotted versus depth for both the foundation clay below the embankment and the foundation clay in the free field and compared to the lab results, as shown in Figures E.1 and E.2 in Appendix E. An N_{kt} value of 15 was used to correlate peak undrained shear strength values from the CPT test results, based on calibration of the correlated undrained strength values to the results of laboratory shear strength testing. The strength envelopes for the foundation clay below the embankment and in the free field are defined by undrained strength ratios (S_u/p') of 0.45 and 0.28 and minimum undrained shear strengths (min S_u) of 700 psf and 450 psf, respectively, as shown in Figure C.2 in Appendix C.

Since one DSS test was performed on a sample of the soft foundation clay and the sample collected may not be entirely within the layer, correlated values for peak undrained strength from CPT results were used in conjunction with the DSS test result to characterize the undrained shear strength for the soft foundation clay. To identify the soft foundation clay layer, the undrained strength evaluated from CPT results was plotted versus depth next to the corresponding CPT tip resistance signature, as shown in Figures E.4 through E.17 in Appendix E. The soft clay foundation layer was identified by the relatively low tip resistance just above the till (indicated by a large jump in tip resistance). Based on the lab and CPT results, the strength envelope for the soft foundation clay is defined by an undrained strength ratio (S_u/p') of 0.28 and minimum undrained shear strength (min S_u) of 275 psf, as shown in Figure D.2 in Appendix D. The undrained strength ratio was limited at the value selected for the foundation clay in the free field and matches well with the DSS test result.

Post-Earthquake Shear Strength

Earthquake loading is a rapid loading that may cause excess pore water pressures in saturated, fine-grained materials and strength loss immediately following loading. Therefore, peak undrained shear strengths were assigned to all materials for the pseudo-static loading condition. Shear strengths under the post-earthquake loading condition were evaluated by identifying the relative behavior of the materials and performing a liquefaction triggering analysis on the materials. Results of the lab testing and liquefaction triggering analysis generally indicate no strain softening in the embankment, foundation clay, and till materials, excluding the soft foundation clay. Therefore, the embankment and foundation clay were assigned peak undrained shear strengths for the post-earthquake loading condition. Peak undrained shear strengths were applied to the embankment both above and below the phreatic surface since the embankment has a saturation of 80 percent above the phreatic surface and may behave similarly to saturated material below the phreatic surface during earthquake loading.

In the soft foundation clay, liquefaction triggering factors of safety were generally less than 1.20 and the correlated values of peak and residual undrained strength from the CPT results indicate a potential for strain softening of this material. The soft foundation clay was therefore assigned a residual undrained shear strength for the post-earthquake loading condition based on correlated values for residual undrained strength from CPT results, as shown in Figures E.4 through E.17 in Appendix E. The residual strength envelope for the soft foundation clay is defined by an undrained strength ratio (S_u/p’) of 0.16 and minimum undrained shear strength (min S_u) of 200 psf, as shown in Figure D.3 in Appendix D. A quasi steady state strength using the static DSS test result was evaluated for comparison, as shown in Figure D.3. However, the CPT characterization was considered more representative of the post-earthquake shear strength for the soft foundation clay.

Impounded Ash and Till

Material properties for the impounded ash and till were conservatively estimated since preliminary slope stability analyses indicated these materials do not have a significant impact on the stability of the impoundment. A unit weight of 112 pcf was assumed for the impounded ash based on experience with similar manmade materials and deposition methods. The drained shear strength of the impounded ash was characterized using CPT soundings pushed within the impoundment. The ash CPT signature indicates tip resistances greater than 150 tons per square foot (tsf), sleeve frictions of 1 to 4 tsf, and soil behavior type indices between 1 and 1.5, indicating sand-like behavior. The effective stress friction angle for the impounded ash was estimated using the Kulhawy and Mayne (1990) CPT friction angle correlation. The correlation indicates a range of friction angles between 35 and 47 degrees. A conservative effective stress friction angle (ϕ’) of 32 degrees was assumed based on preliminary slope stability analyses indicating that as the failure surface moves towards the upstream crest of the embankment, the factor of safety increases. This conservative assumption was made in part due to the indication that the ash material does not affect the stability of the embankment. The coarse nature and pore pressure behavior from the CPT soundings indicate the material will be well-drained, and thus an undrained strength ratio (S_u/p’) of 0.40 (equivalent to 22 degrees) was assumed for the undrained shear strength.

For the post-earthquake shear strength, liquefaction triggering analyses were completed on cone penetration sounding COF-C013, which was pushed within the ash material. This cone shows about 17 feet of ash material underlain by native soils. Based on the simplified liquefaction analyses, the saturated sand-like material indicates factors of safety against liquefaction less than 1.2, and thus the potential for liquefaction. The residual strength for the potentially liquefiable ash was estimated using the residual shear strength correlation to cone penetration provided in “Soil Liquefaction During Earthquakes” by I.M. Idriss and R.W. Boulanger (2008). The residual strength was estimated as the sleeve friction (f_s) value from the CPT sounding. Based on the correlation, the residual strength ranges from 0.10 to 0.15 within the zone of saturated, liquefiable material indicated in the triggering analyses, as shown in the residual liquefied strength figure for COF-C013 in Figure E.3 in Appendix E. A residual undrained strength ratio of 0.10 was applied to the ash.

The unit weight and drained shear strength for the till were estimated using the Duncan and Buchignani (1976) SPT blow count correlations with dry unit weight and effective stress friction angle. SPT blow counts within the till were generally greater than 50 blows per foot. The correlations indicate unit weights greater than 140 pcf (assuming 10 percent moisture content) and friction angles greater than 38 degrees. A unit weight of 135 pcf and effective stress friction angle (ϕ') of 40 degrees were assumed for the till. An undrained strength ratio of 0.64 (equivalent to 32 degrees) was estimated for the undrained shear strength based on results of CPT correlations with undrained strength ratio. To prohibit failure surfaces from propagating into the stronger till layer below the foundation clay, a minimum undrained shear strength equal to the value selected for the foundation clay (min S_u = 700 psf) was also assigned to the till.

As mentioned previously, results of the liquefaction triggering analysis generally indicate no strain softening in the till. Therefore, the till was assigned peak undrained shear strengths for the post-earthquake loading condition.

Results

The table on the following page summarizes the material properties used for slope stability analyses at Coffeen Ash Pond No. 1.

Coffeen Ash Pond No. 1 Slope Stability Material Properties					
Material	**Unit Weight (pcf)**	**Peak Drained Shear Strength**		**Peak Undrained Shear Strength**	**Post-Earthquake Shear Strength**
		Cohesion, c′ (psf)	**Friction Angle, ϕ′ (degrees)**	**S_u/p'**	**S_u/p'**
Ash	112	0	32	0.40	0.10
Embankment	135	0	31 *with curved envelope for σ'_{ff} < 1440 psf (SEE NOTE 1)*	S_u/p' = 0.60, Minimum S_u = 450 psf	Peak Undrained
Foundation Clay	125	0	Below Embankment: ϕ' = 32 *with curved envelope for σ'_{ff} < 2160 psf (SEE NOTE 2)* Free Field: ϕ' = 30	Below Embankment: S_u/p' = 0.45, Minimum S_u = 700 psf Free Field: S_u/p' = 0.28, Minimum S_u = 450 psf	Peak Undrained
Soft Clay Foundation	125	0	30	S_u/p' = 0.28, Minimum S_u = 275 psf	S_u/p' = 0.16, Minimum S_u = 200 psf
Till	135	0	40	0.64, Minimum Su = 700 psf	Peak Undrained

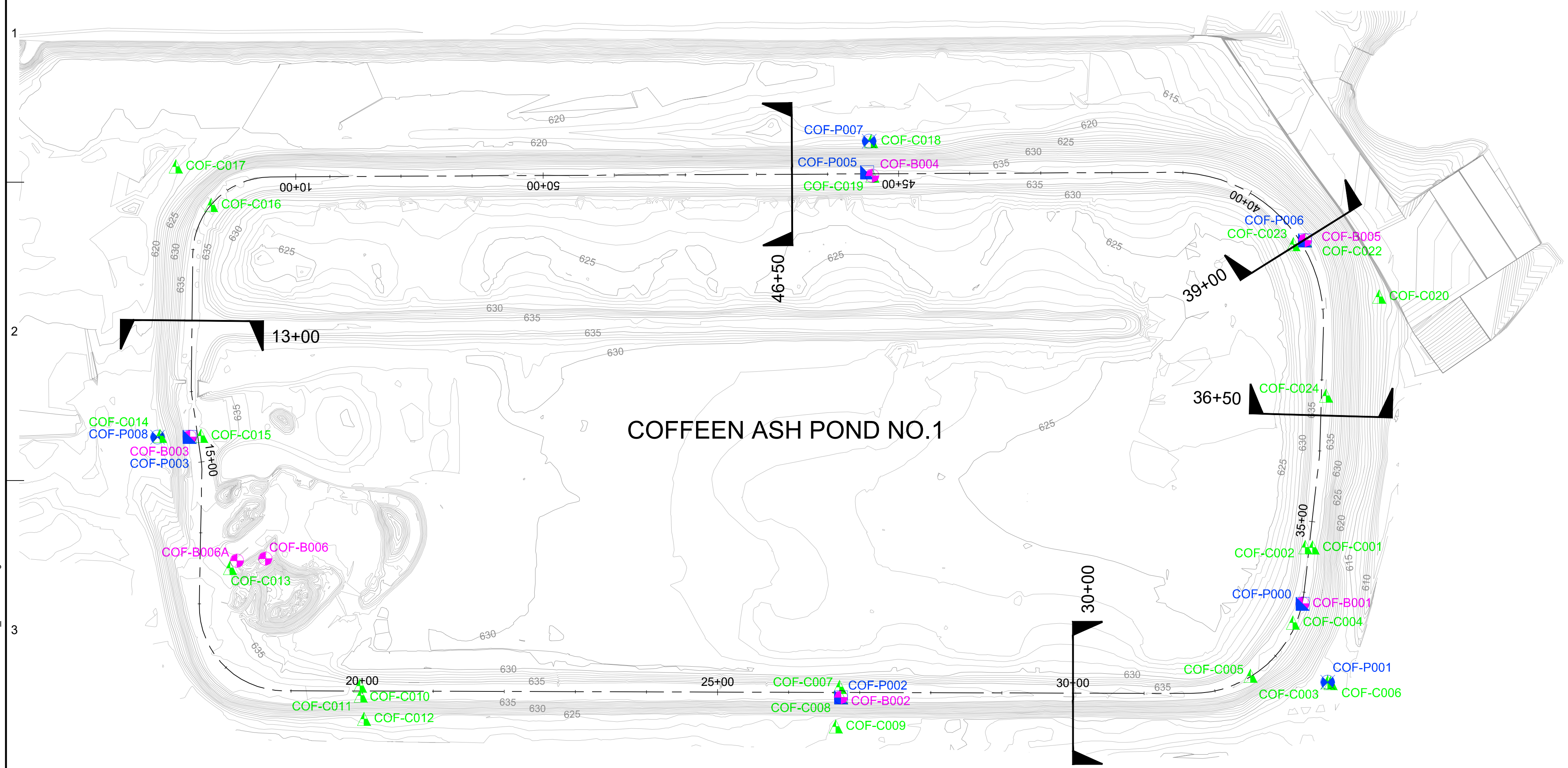
Notes: 1 - Embankment Nonlinear Drained Shear Strength Envelope

σ'_{ff} (psf)	τ_{ff} (psf)
0	0
432	389
864	634
1440	865
5040	3028

2 - Foundation Clay **Below Embankment** Nonlinear Drained Shear Strength Envelope

σ'_{ff} (psf)	τ_{ff} (psf)
0	0
432	389
864	677
1440	1008
2160	1350
5040	3149

SMITH, CURT, 2/9/2016 11:41 AM

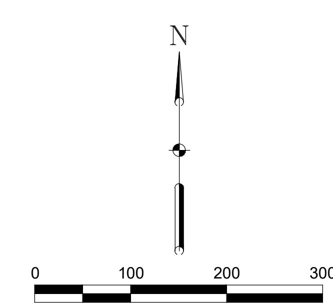


NOTES:

1. CONTOURS ARE 1 FOOT ELEVATION INTERVALS.
2. SURVEY BENCHMARKS WILL BE PROVIDED BY THE OWNER.
3. GROUND CONTOURS SOURCES: FINAL RESULTS OF LIDAR SURVEY BY SURDEX CORPORATION DATED AUGUST 17 2015, DRAWINGS FOR COAL COMBUSTION BY-PRODUCT MANAGEMENT FACILITY PROJECT DATED JANUARY 2011, AND INTERPRETED FROM COFFEEN POWER STATION DRAWINGS DATED APRIL 1978.
4. BATHYMETRIC CONTOURS SOURCE: SURVEY BY WEAVER CONSULTANTS GROUP DATED SEPTEMBER 2015.
5. STATION 10+00 IS THE BEGINNING OF STATIONING.

LEGEND

COF-B000	AECOM BORING LOCATION
COF-C000	AECOM CONE PENETROMETER TESTING LOCATION
COF-P000	AECOM PIEZOMETER LOCATION
COF-P000	AECOM VIBRATING WIRE PIEZOMETER (VWP) LOCATION
	LOCATION OF GEOPHYSICAL INVESTIGATION
	STUDY SECTION



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CCR RULE ASSESSMENT OF PLANTS

COFFEEN POWER PLANT
COFFEEN, ILLINOIS

GEOTECHNICAL REPORT
ASH POND NO. 1

ISSUED FOR BIDDING DATE BY

ISSUED FOR CONSTRUCTION DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	
DRAWN BY:	GJH
DESIGNED BY:	EJV
CHECKED BY:	MCR
DATE CREATED:	12/23/2015
PLOT DATE:	2/9/2016
SCALE:	AS SHOWN
ACAD VER:	2014

SHEET TITLE

BORING, CPT, PIEZOMETER AND CROSS SECTION LOCATIONS

SHEET 1 OF 1

DRAWING PATH:P:\Projects\Geotech\60428794_DynegyCCR\04Tasks\01 Coffeen Tasks\7.0_CAD_GIS\7.09_Exhibits\Exploration Location Plans\COF-POND-1-EXPLORATION_02072016.dwg

Calculation Notes

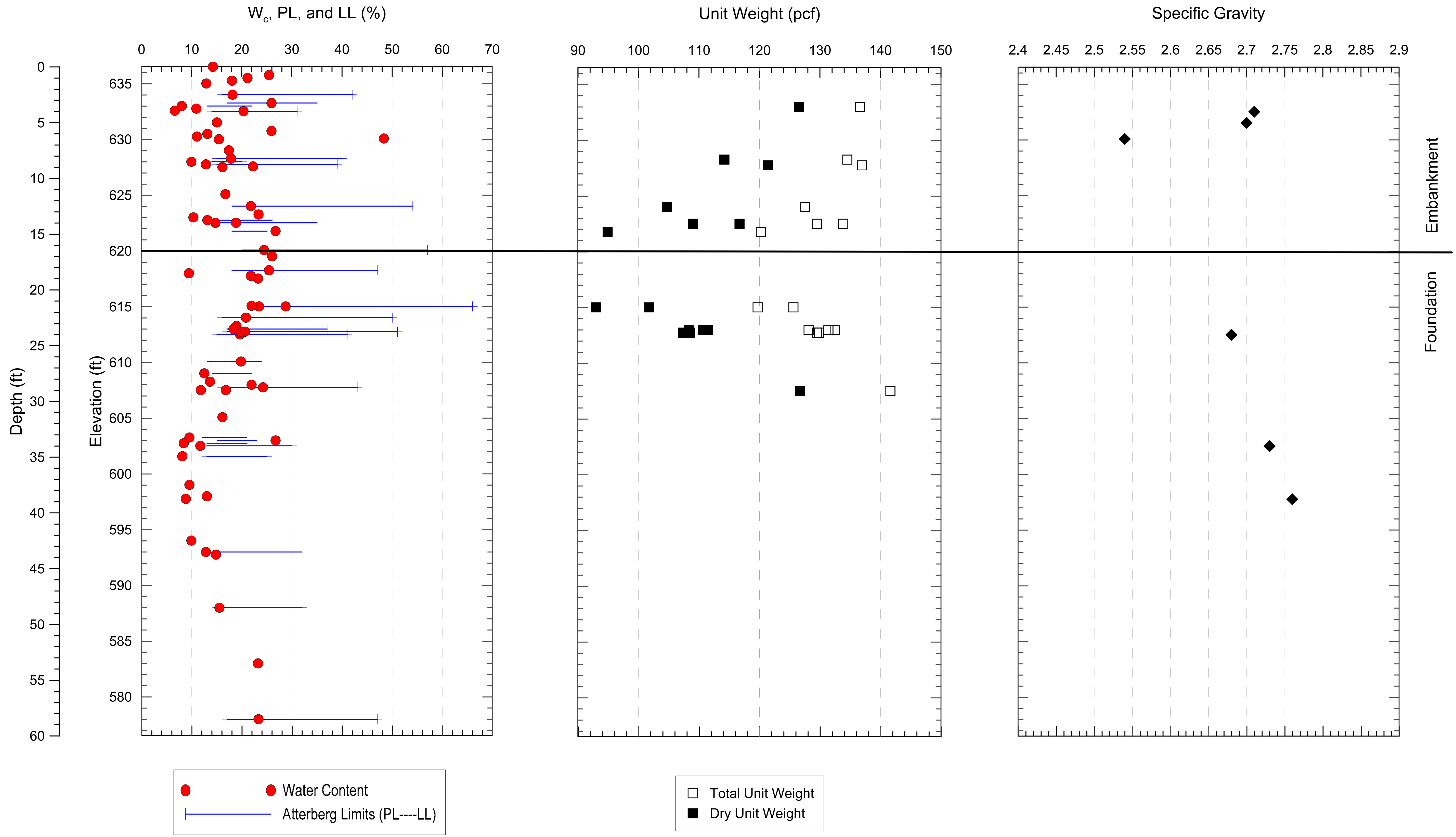
Subject: Coffeen Ash Pond No. 1 Material Characterization | Project Name: Dynegy CCR

By: Julie Heitland | Date: 01/06/2016 | Project No: 60480701

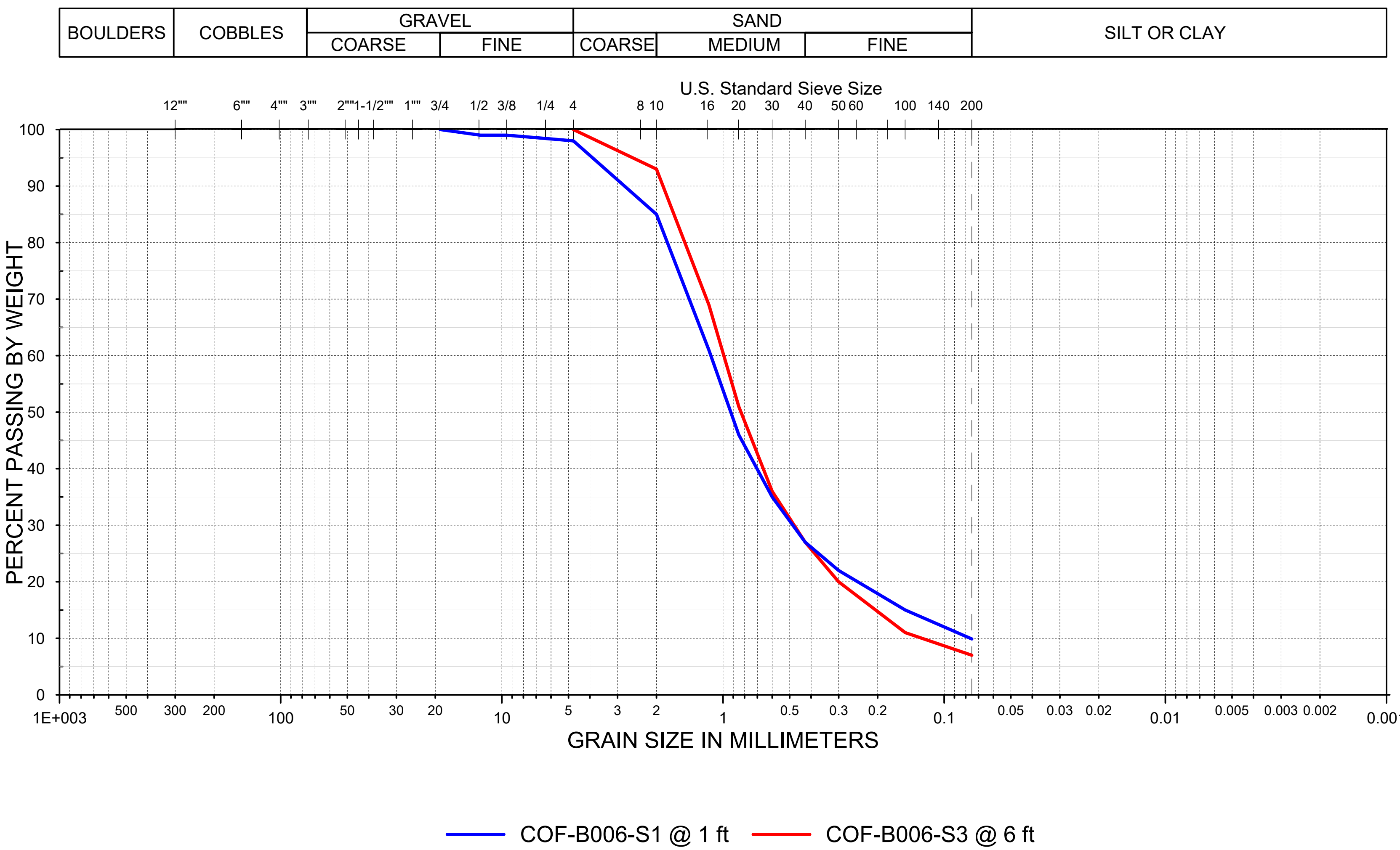
Checked By: Amanda Duvigneaud | Date: 01/11/2016 | Task No.: 01

APPENDIX A

Index Properties

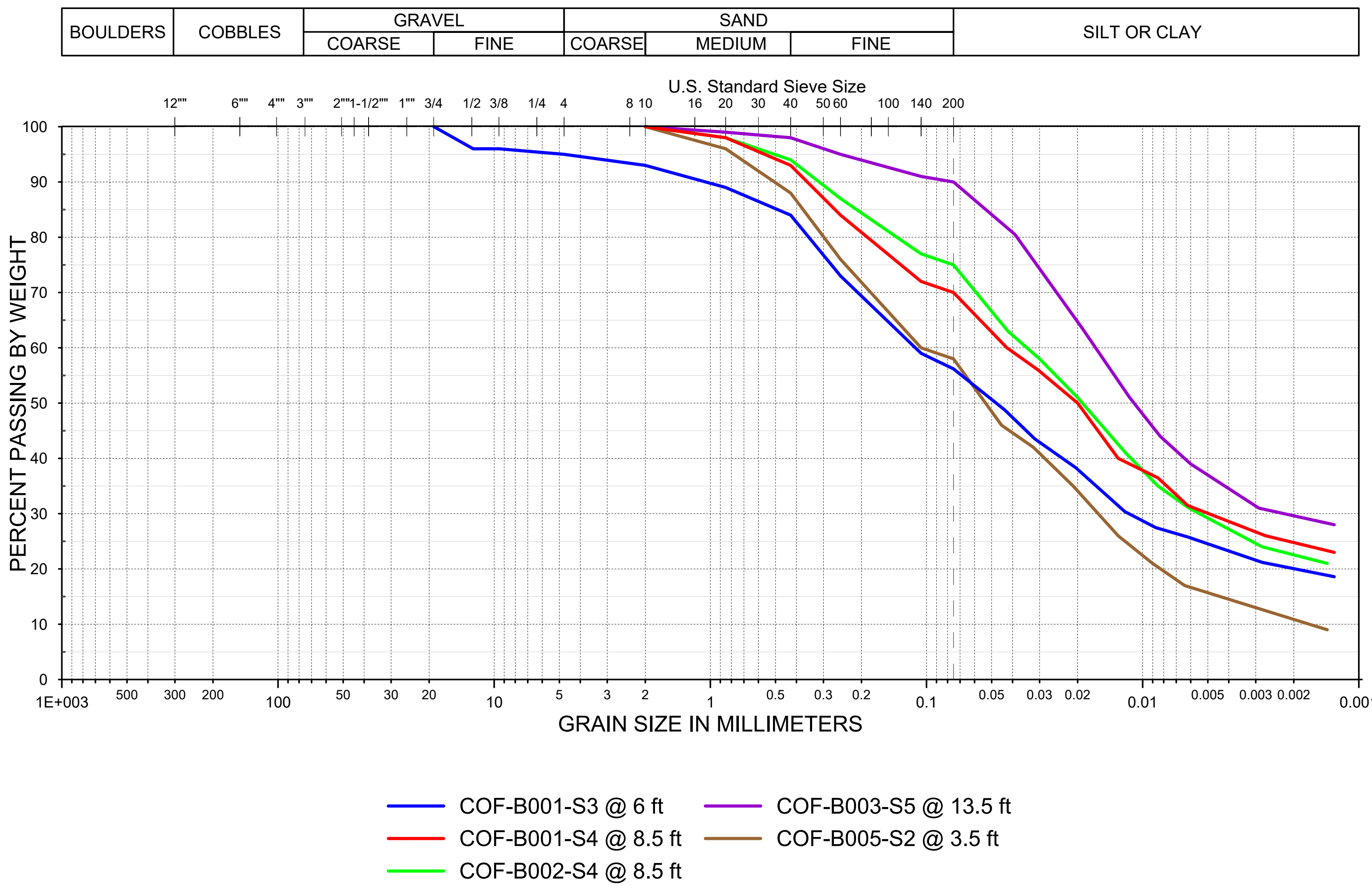


Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 Water Content, Atterberg Limits, Unit Weight, and Specific Gravity	FIGURE A.1
	AECOM		



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Impounded Ash** Gradations	FIGURE A.2
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Index Testing\Coffeen 1_Gradations_Impounded Ash.grf



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Embankment** Gradations	FIGURE A.3
	AECOM		

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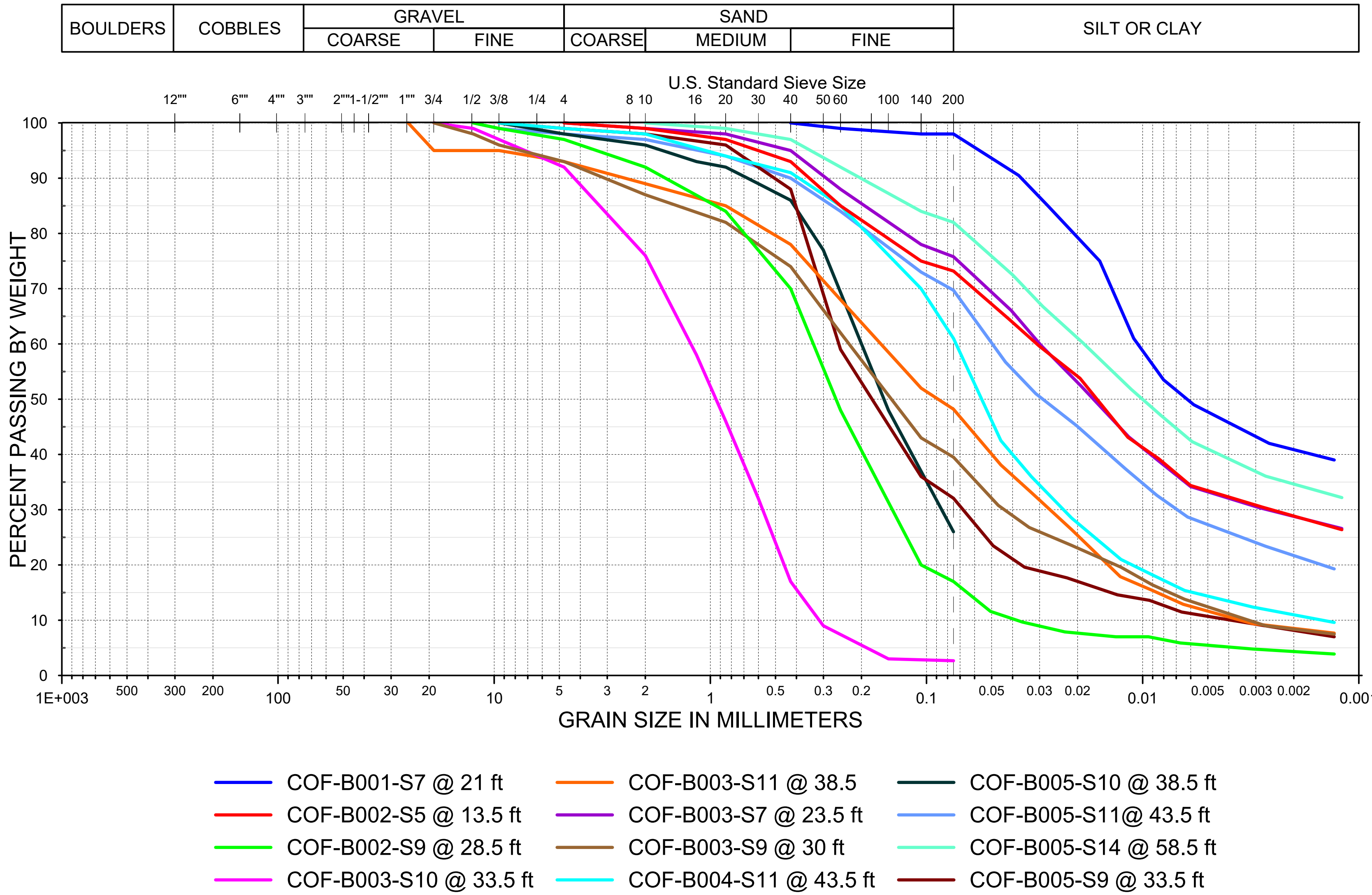

Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Foundation Clay** Gradations	FIGURE A.4
AECOM			

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Calculation Notes

Subject: Coffeen Ash Pond No. 1 Material Characterization

Project Name: Dynegy CCR

By: Julie Heitland Date: 01/06/2016

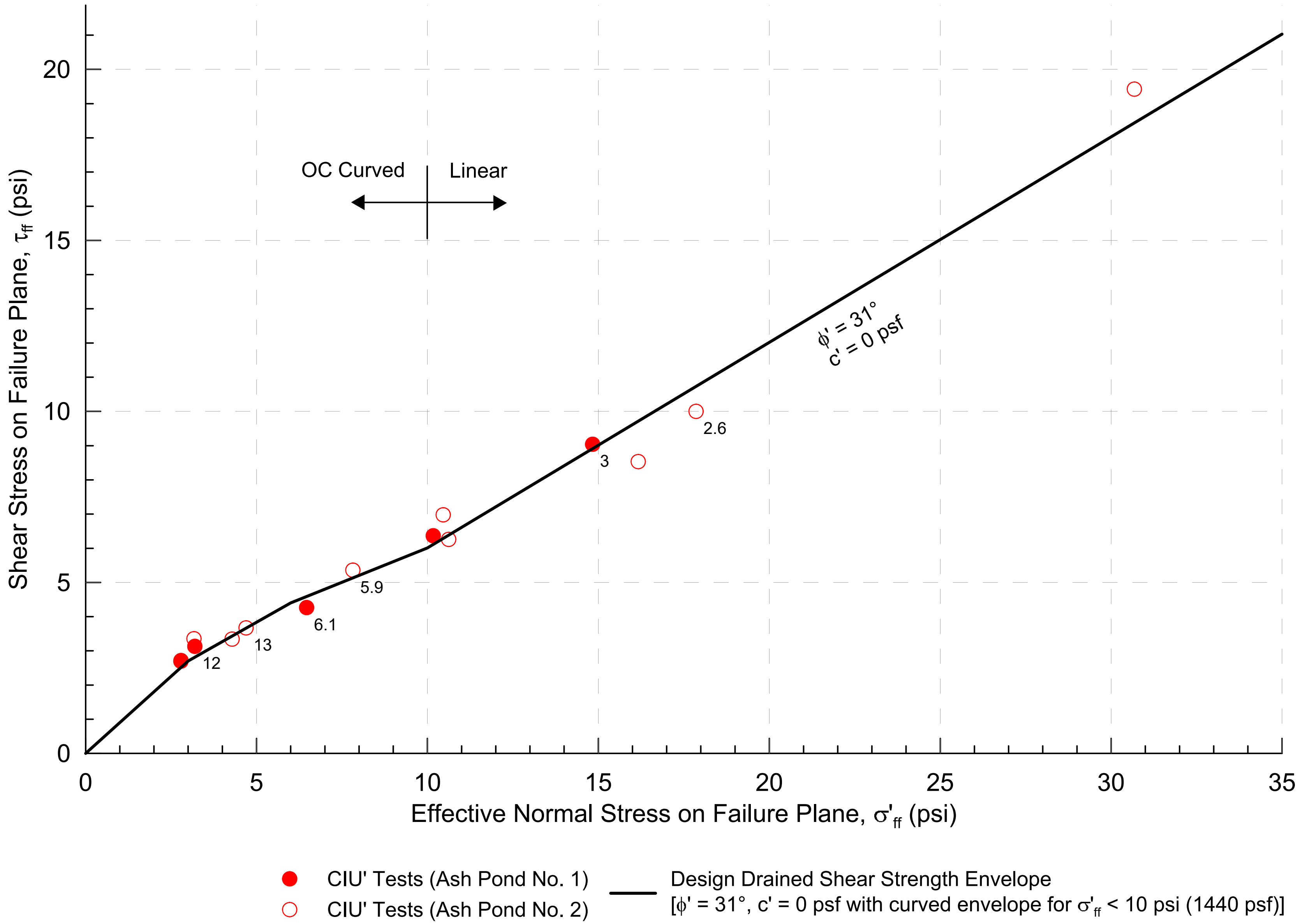
Project No: 60480701

Checked By: Amanda Duvigneaud Date: 01/11/2016

Task No.: 01

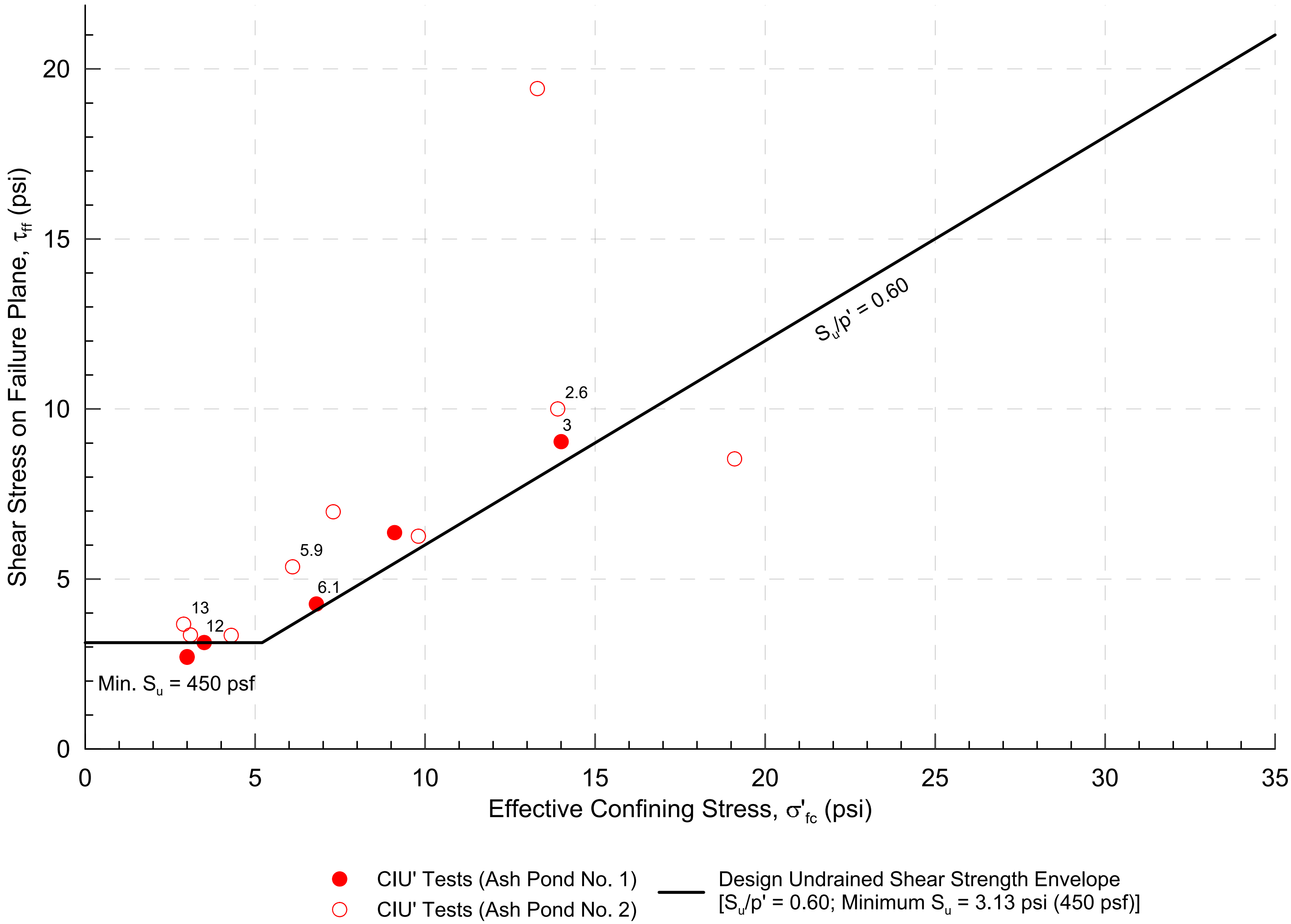
APPENDIX B

Embankment Shear Strength Characterization



Note:
1. Number next to point is OCR of sample tested.

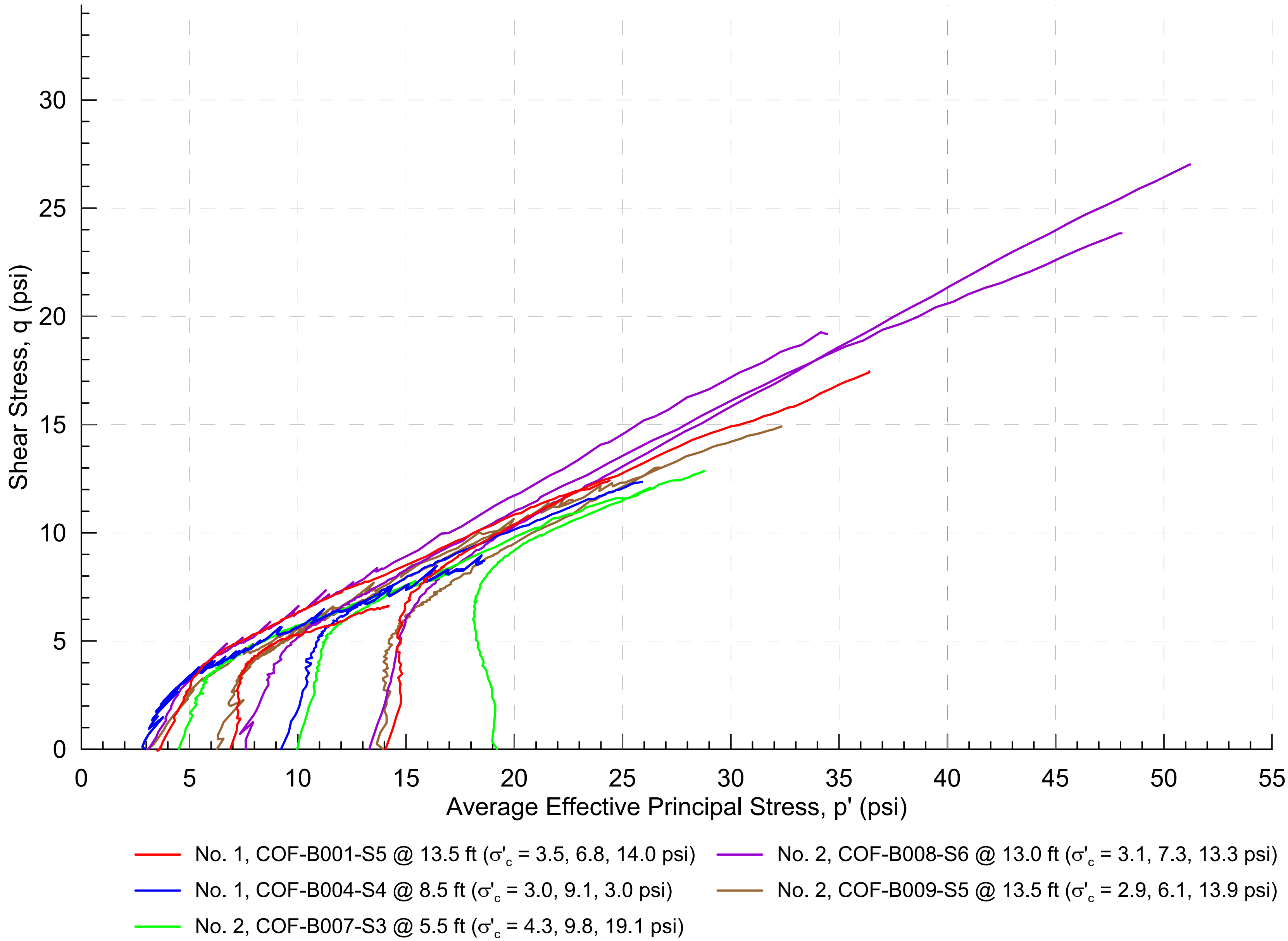
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Embankment** Drained Shear Strength Characterization	Figure B.1
	AECOM		



Note:
1. Number next to point is OCR of sample tested.

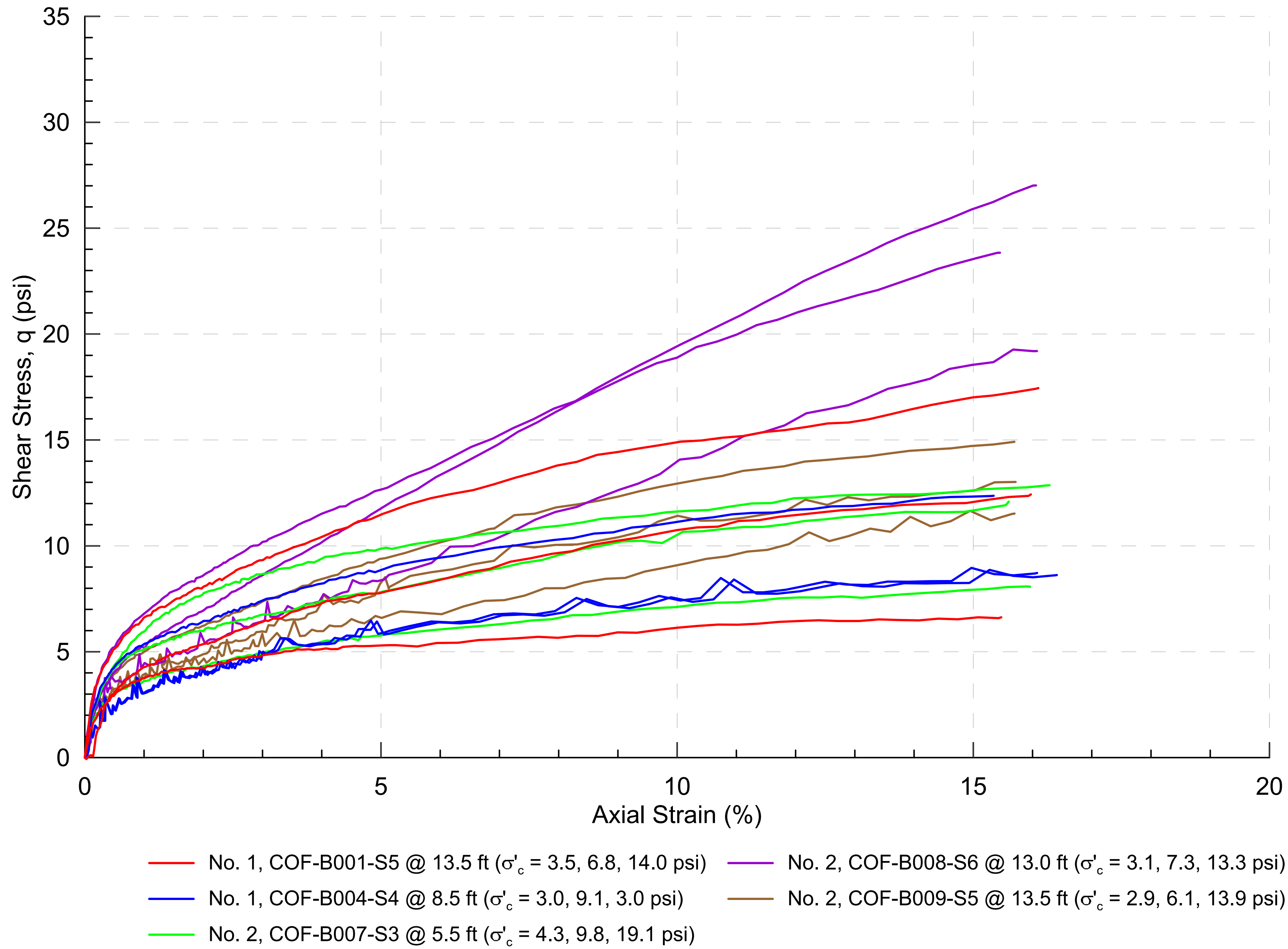
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Embankment** Undrained Shear Strength Characterization	Figure B.2
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Embankment Plots\2015 Coffeen Embankment Undrained Strength Characterization.grf



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 and No. 2 **Embankment** CIU' Stress Paths	Figure B.3
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Embankment Plots\2015 Coffeen Embankment CIU' Stress Paths.grf



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 and No. 2 **Embankment** CIU' Stress vs Strain	Figure B.4
	AECOM		

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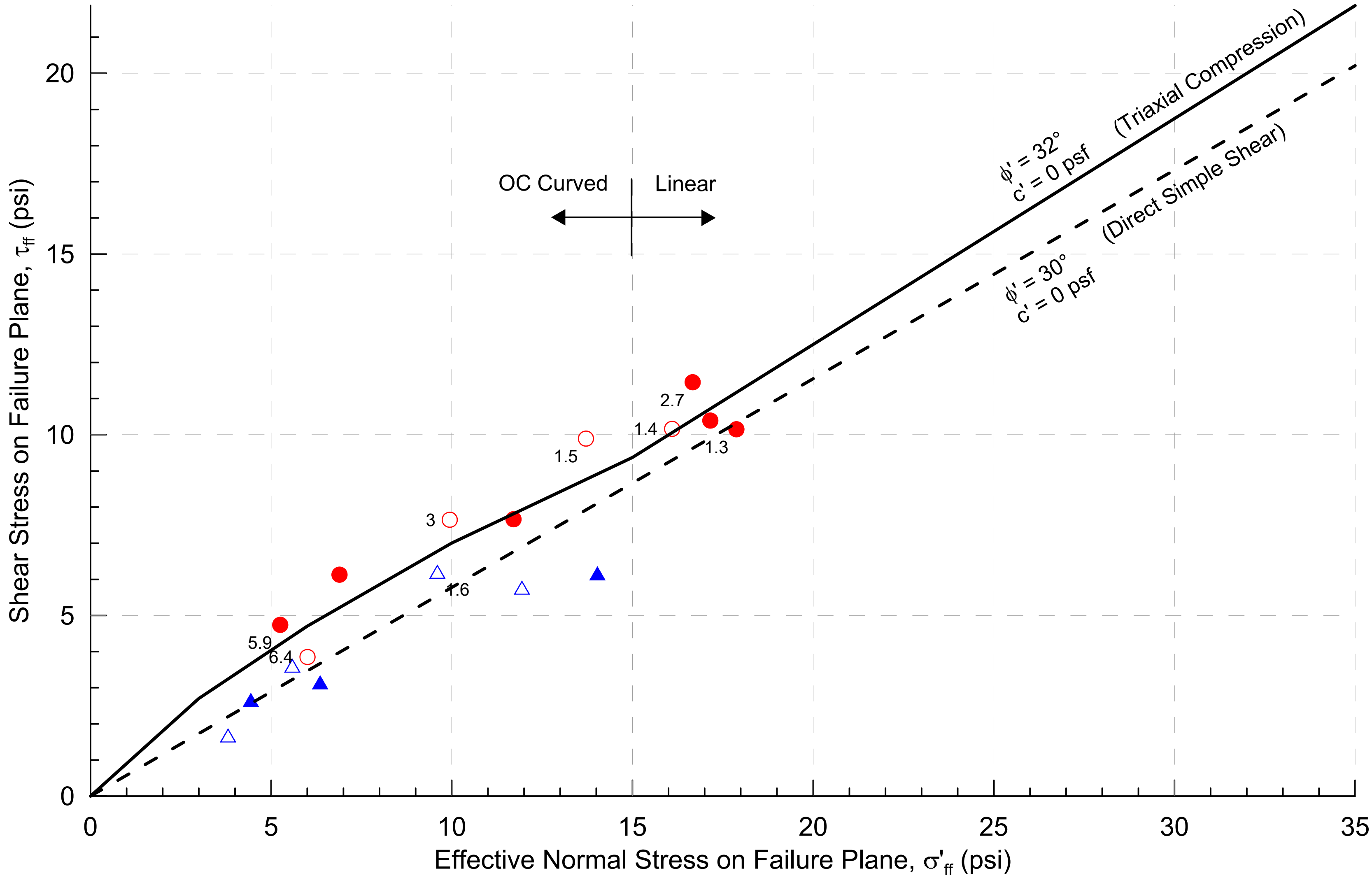
APPENDIX C

Foundation Clay Shear Strength Characterization



CIU' Tests (Ash Pond No. 1)

CIU' Tests (Ash Pond No. 2)

DSS Tests (Ash Pond No. 1)

DSS Tests (Ash Pond No. 2)

Design Drained Shear Strength Envelope - Below Embankment [ϕ' = 32°, c' = 0 psf with curved envelope for σ'_{ff} < 15 psi (2160 psf)]

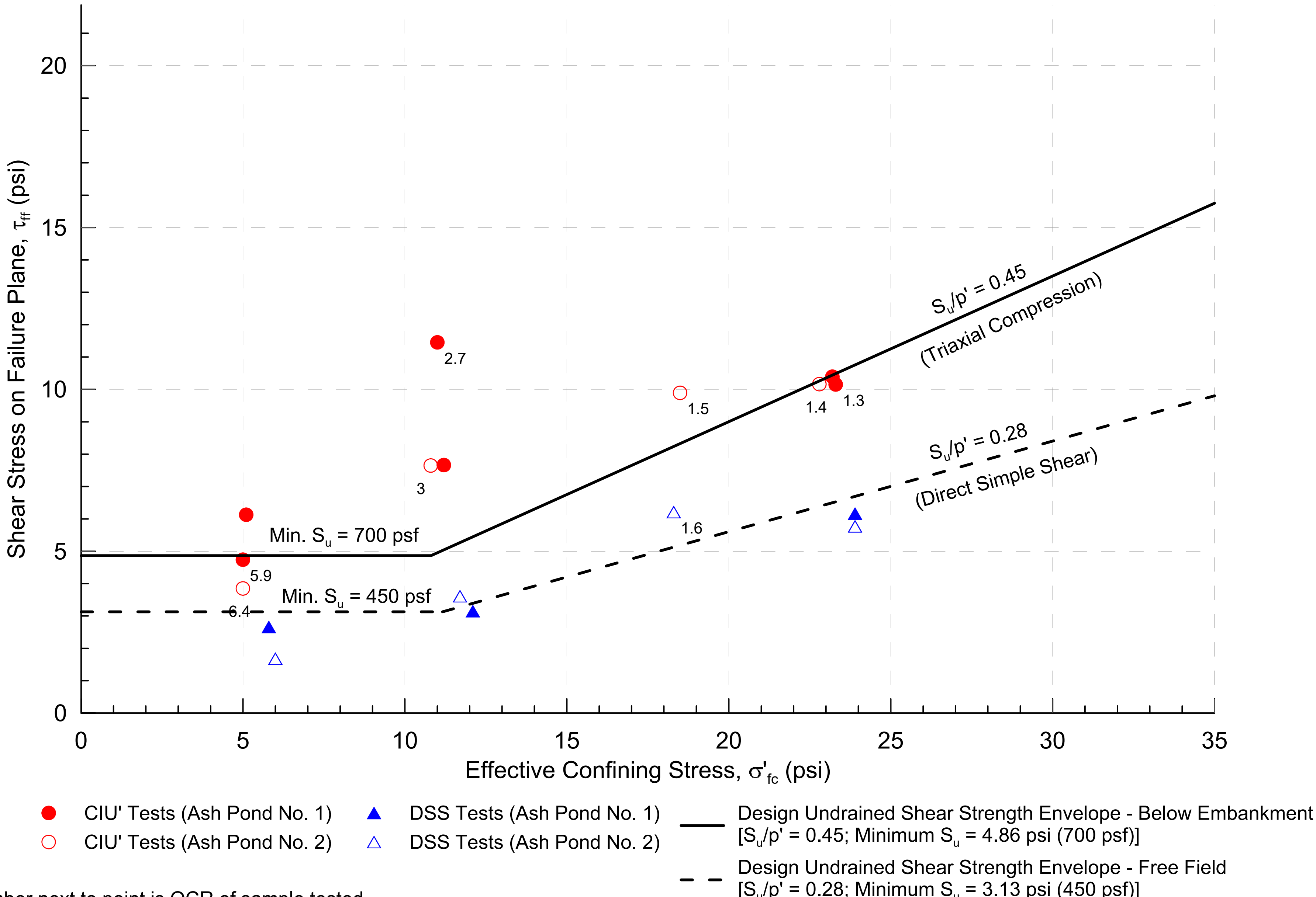
Design Drained Shear Strength Envelope - Free Field [ϕ' = 30°, c' = 0 psf]

Notes:

1. Number next to point is OCR of sample tested.
2. Strength based on orientation of failure plane below the embankment and in the free field. Strength below embankment based on triaxial compression (CIU' tests), and strength in free field based on direct simple shear (DSS tests).

Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Foundation Clay** Drained Shear Strength Characterization	Figure C.1
	AECOM		

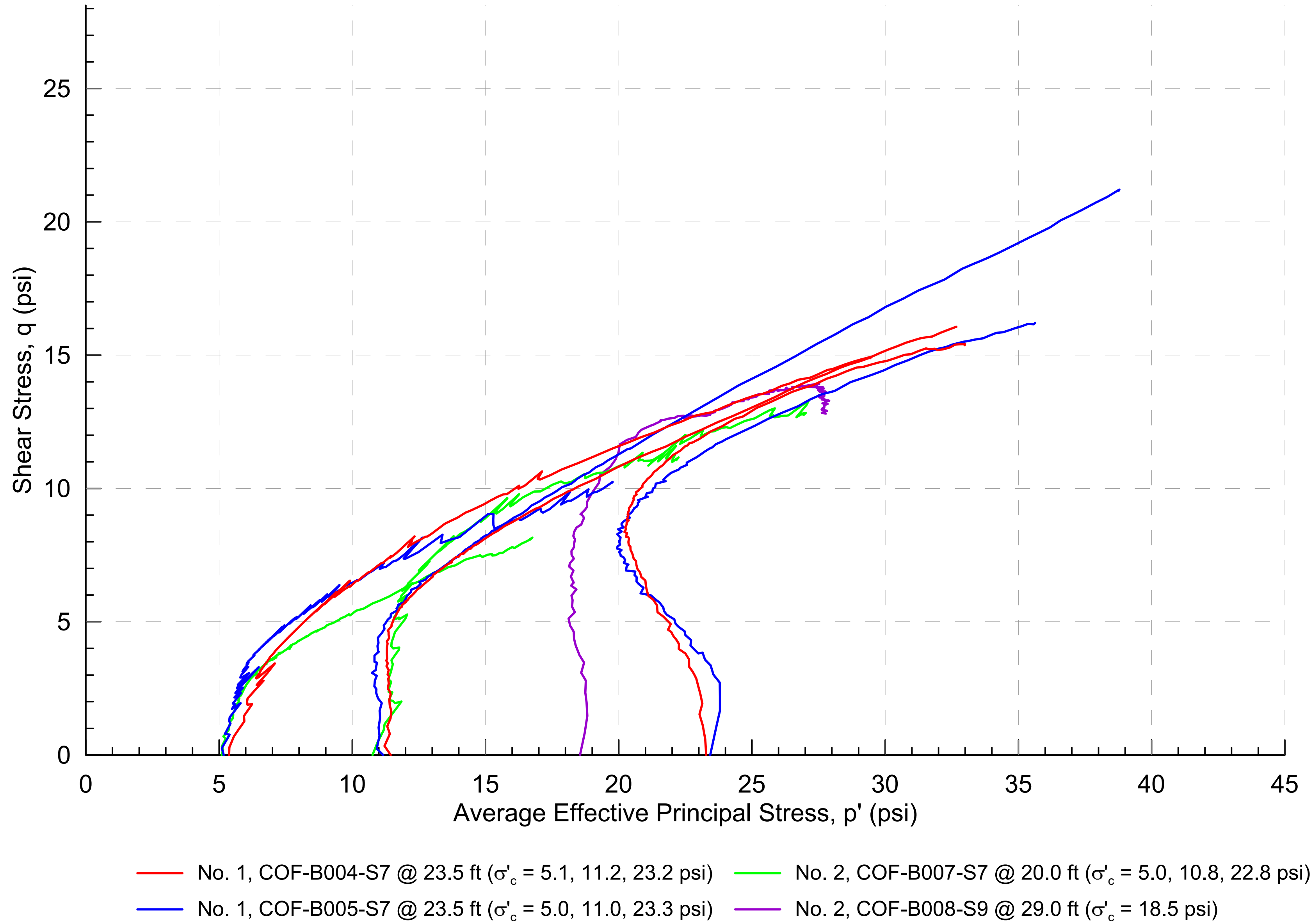
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Foundation Clay Plots\2015 Coffeen Foundation Clay Drained Strength Char



Notes:
1. Number next to point is OCR of sample tested.
2. Strength based on orientation of failure plane below the embankment and in the free field. Strength below embankment based on triaxial compression (CIU' tests), and strength in free field based on direct simple shear (DSS tests).

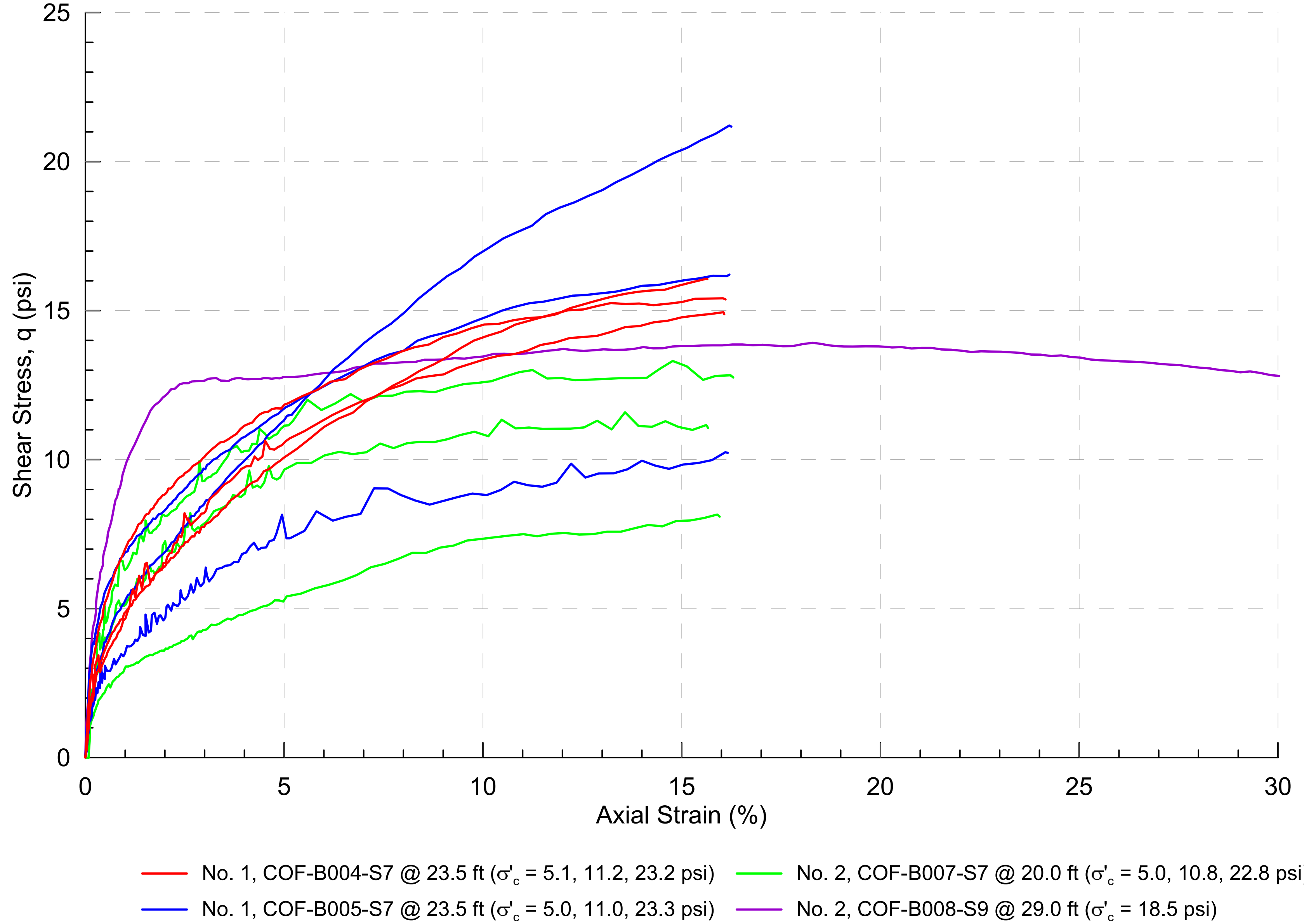
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Foundation Clay** Undrained Shear Strength Characterization	Figure C.2
AECOM			

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Foundation Clay Plots\2015 Coffeen Foundation Clay Undrained Strength Characterization.grf



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 and No. 2 **Foundation Clay** CIU' Stress Paths	Figure C.3
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Foundation Clay Plots\2015 Coffeen Foundation Clay CIU' Stress Paths.grf



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 and No. 2 **Foundation Clay** CIU' Stress vs Strain	Figure C.4
AECOM			

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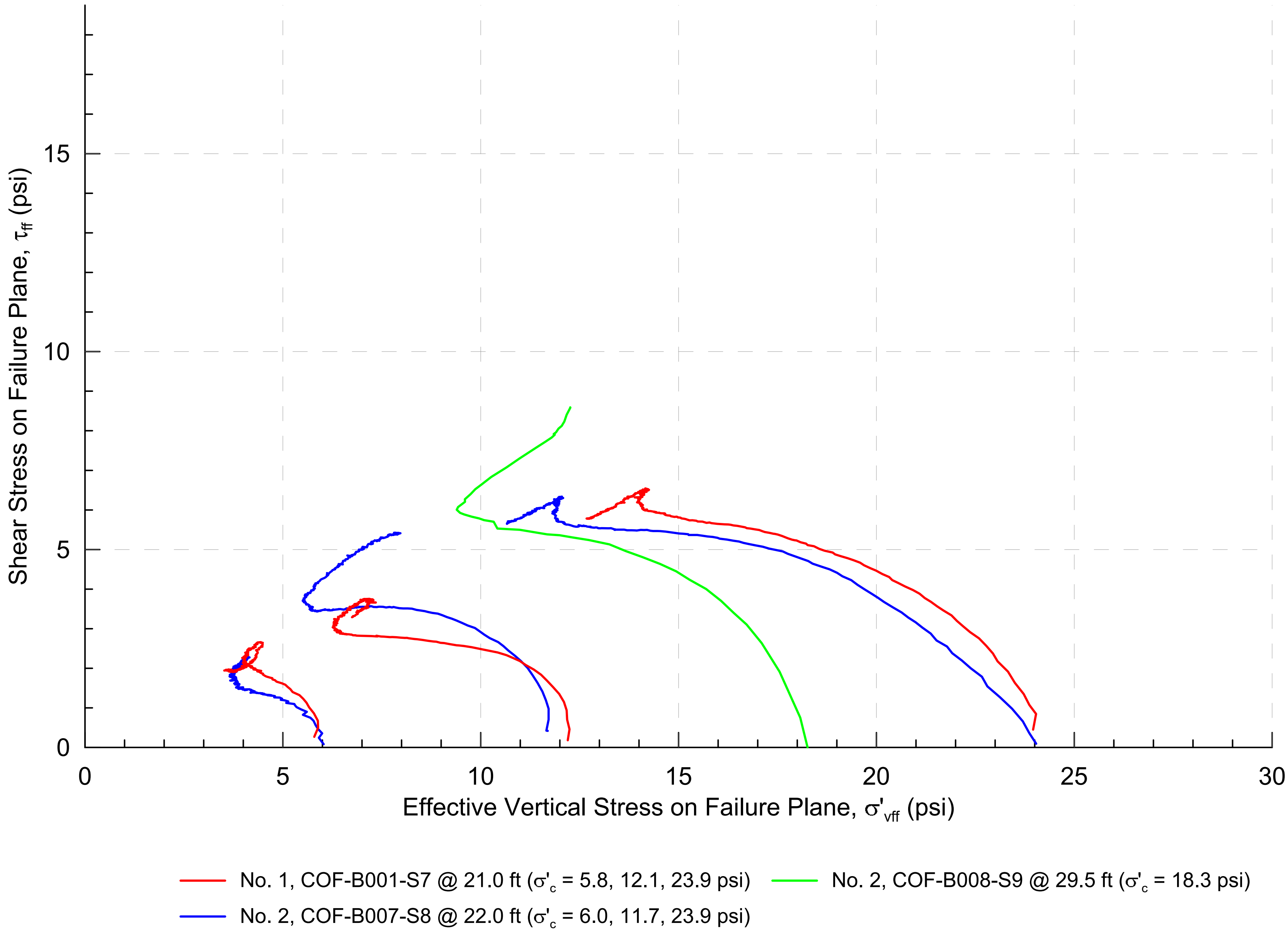
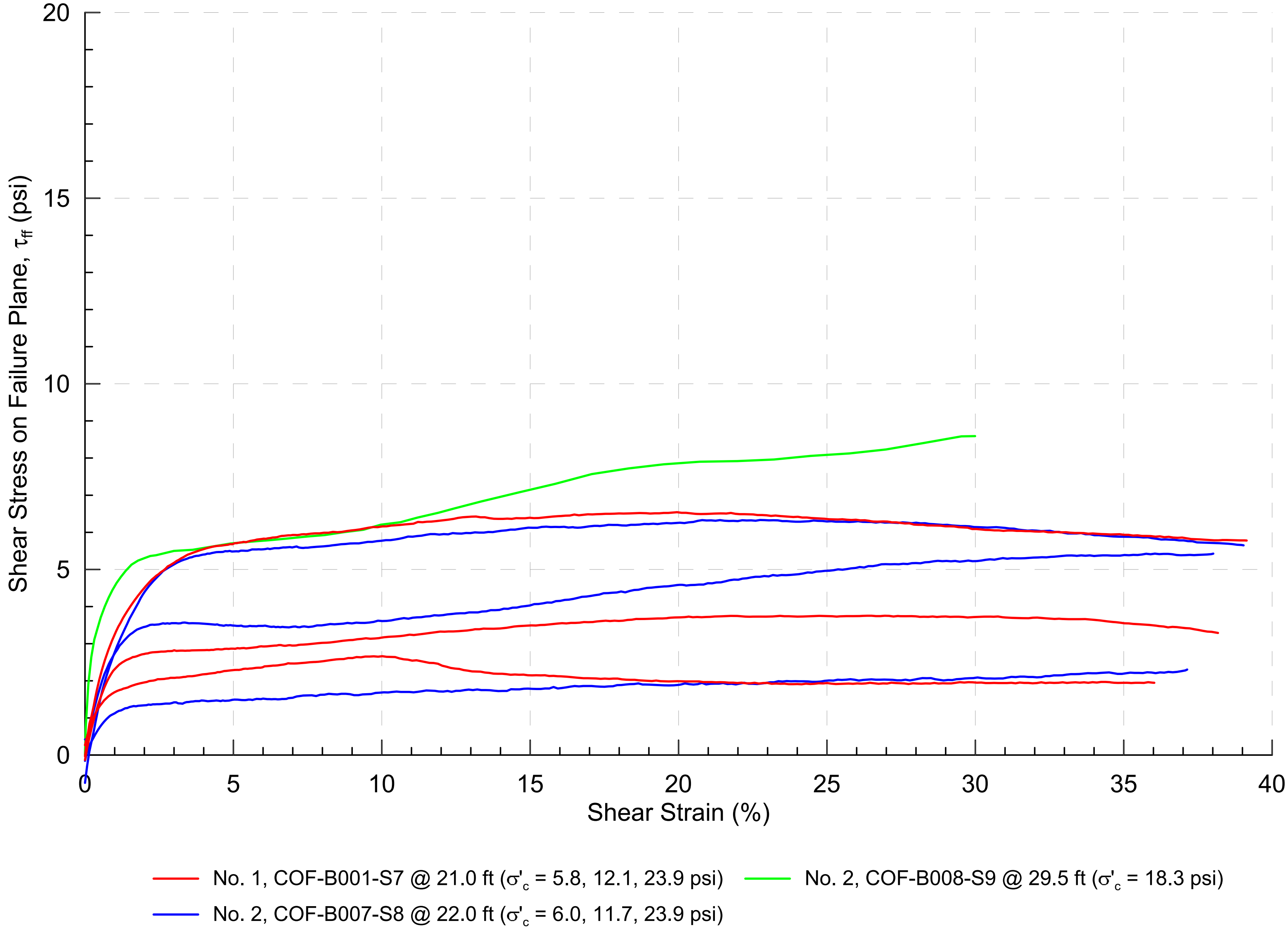


Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 and No. 2 **Foundation Clay** DSS Test Paths	Figure C.5
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Foundation Clay Plots\2015 Coffeen Foundation Clay DSS Test Paths.grf



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 and No. 2 **Foundation Clay** DSS Stress vs Strain	Figure C.6
AECOM			

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Calculation Notes AECOM

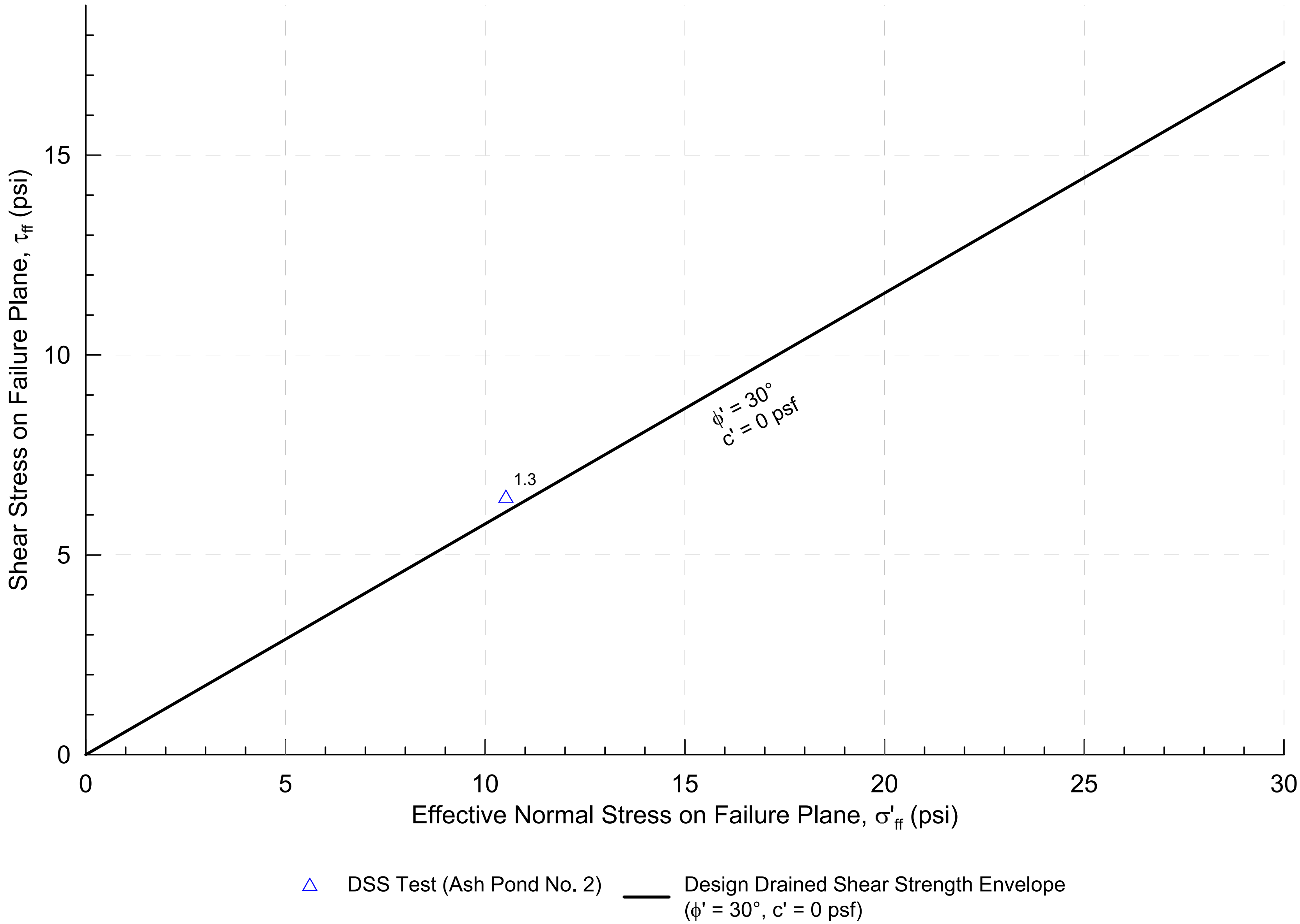
Subject: Coffeen Ash Pond No. 1 Material Characterization Project Name: Dynegy CCR

By: Julie Heitland Date: 01/06/2016 Project No: 60480701

Checked By: Amanda Duvigneaud Date: 01/11/2016 Task No.: 01

APPENDIX D

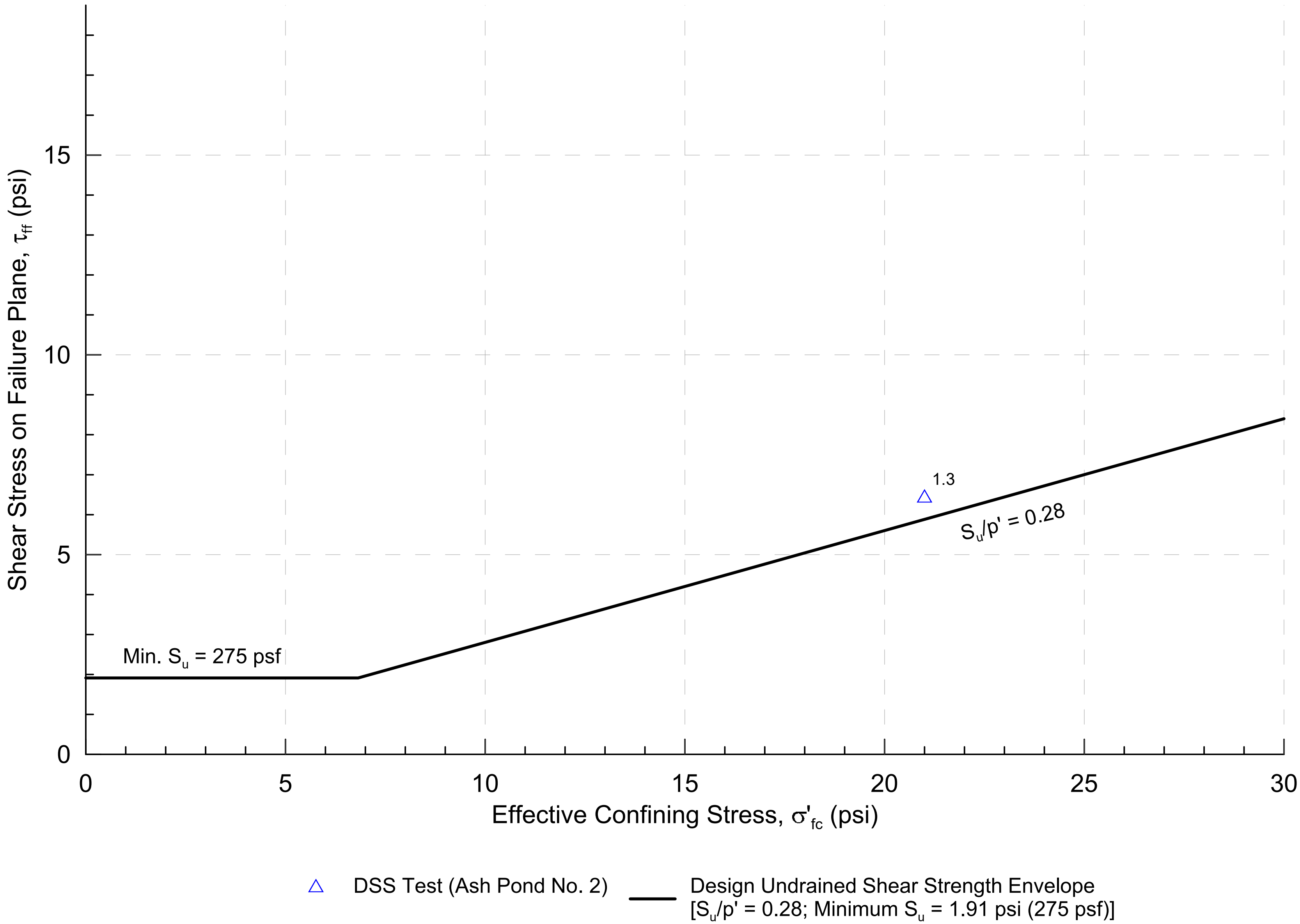
Soft Foundation Clay Shear Strength Characterization



Note:
1. Number next to point is OCR of sample tested.

Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Soft Foundation Clay** Drained Shear Strength Characterization	Figure D.1
	AECOM		

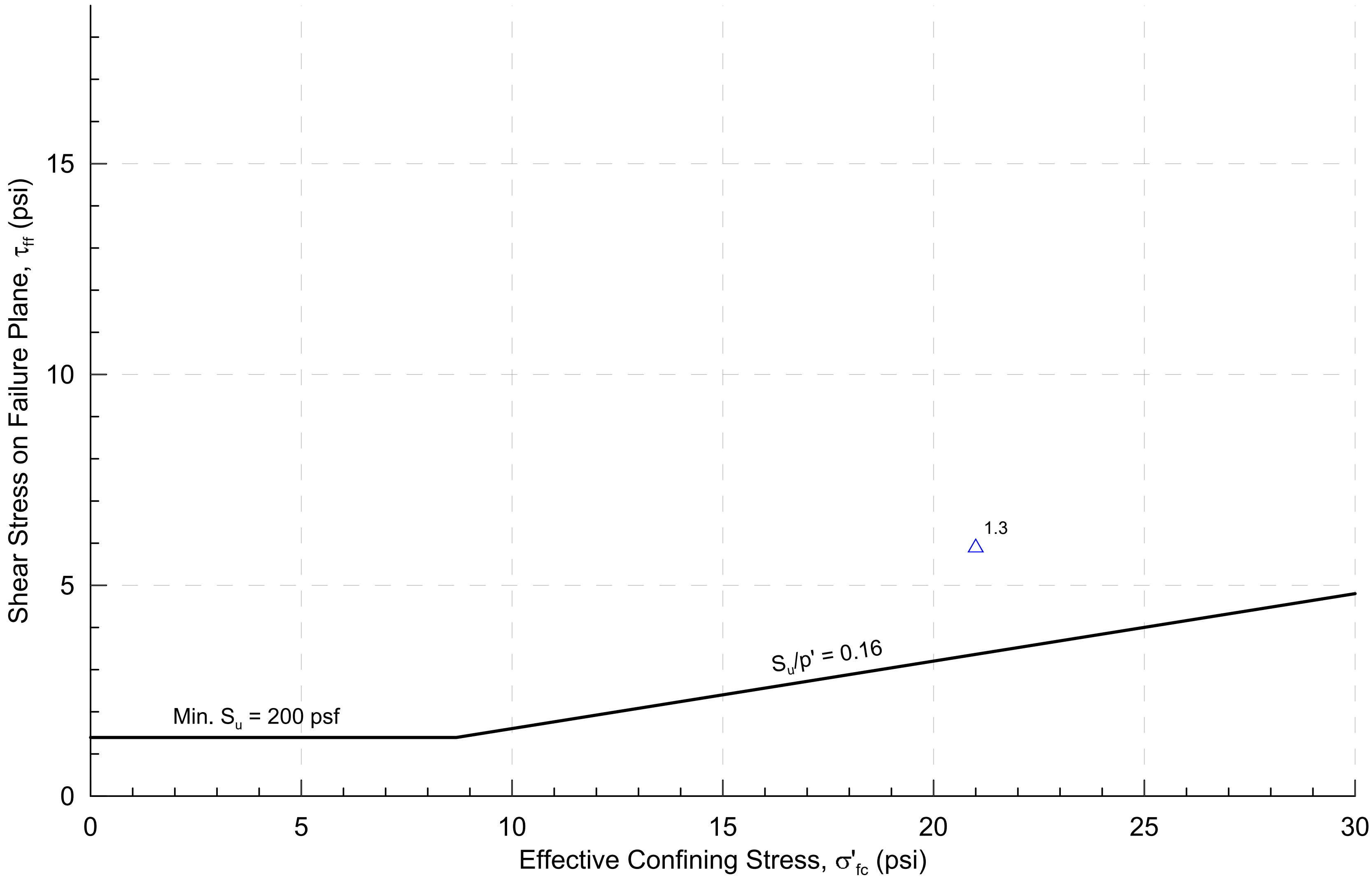
N:\Projects\60428794 Dynegy CCR RuleAsmt\Sub 00\10.0 Calculations Analysis Data\Geotechnical\Material Characterization Final\Coffeen\Lab Characterization\Soft Clay Foundation Plots\2015 Coffeen Soft Clay Foundation Drained Strer



Note:
1. Number next to point is OCR of sample tested.

Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Soft Foundation Clay** Undrained Shear Strength Characterization	Figure D.2
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Soft Clay Foundation Plots\2015 Coffeen Soft Clay Foundation Undrained Strength Characterization.grf



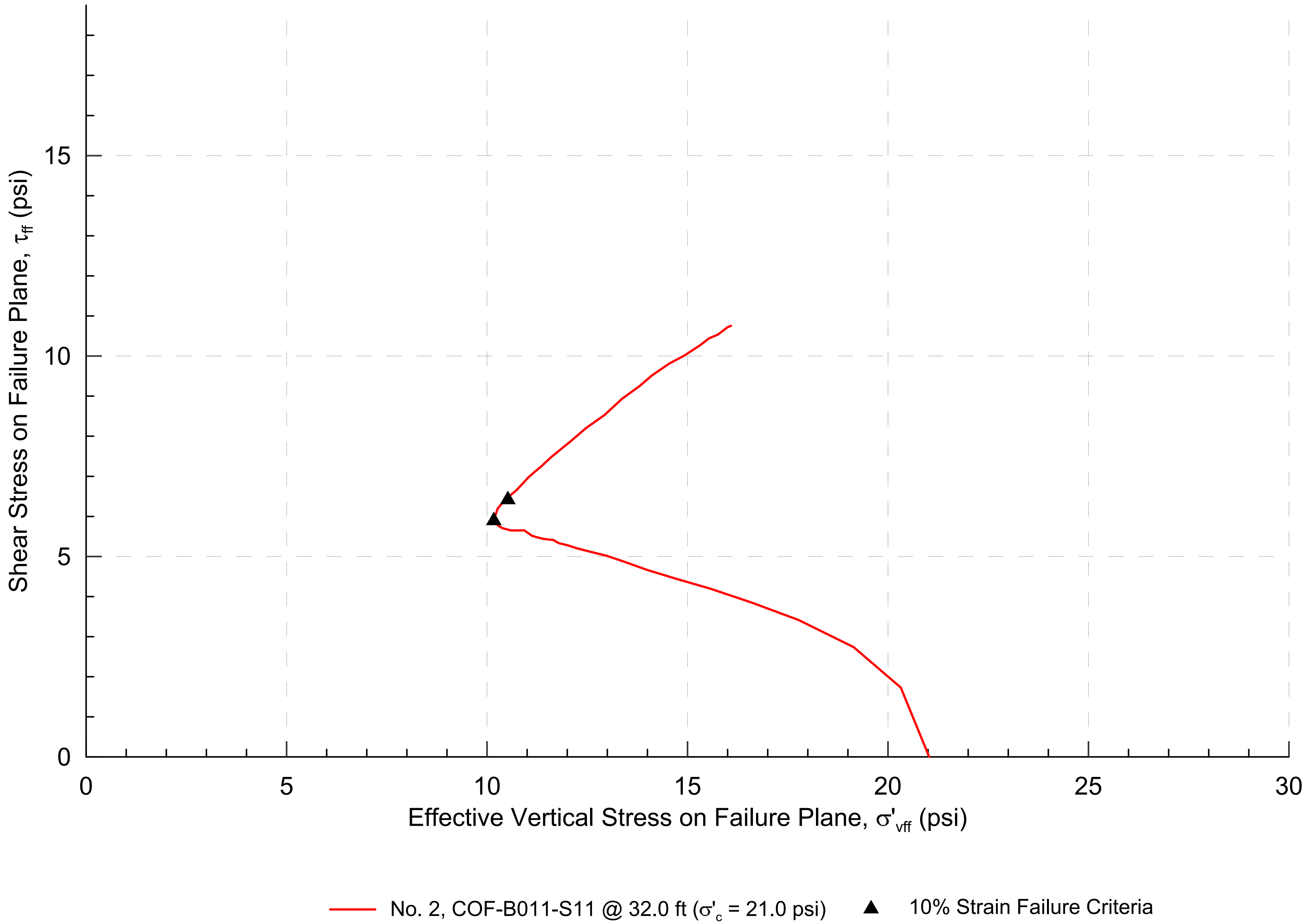
△ Quasi Steady State Static DSS Test (Ash Pond No. 2)

— Design Post-Earthquake Shear Strength Envelope [S_u/p' = 0.16; Minimum S_u = 1.39 psi (200 psf) - CPT Characterization]

<u>Note</u>:
1. Number next to point is OCR of sample tested.

Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 **Soft Foundation Clay** Post-Earthquake Shear Strength Characterization	Figure D.3
	AECOM		

N:\Projects\604287~2\Sub_00\1091C4~1.0_C\GEOTEC~1\MATERI~2\Coffeen\LABCHA~1\SOFTCL~1\2015 Coffeen Soft Clay Foundation Post Earthquake Strength Characterization.grf



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 and No. 2 **Soft Foundation Clay** DSS Test Path	Figure D.4
	AECOM		

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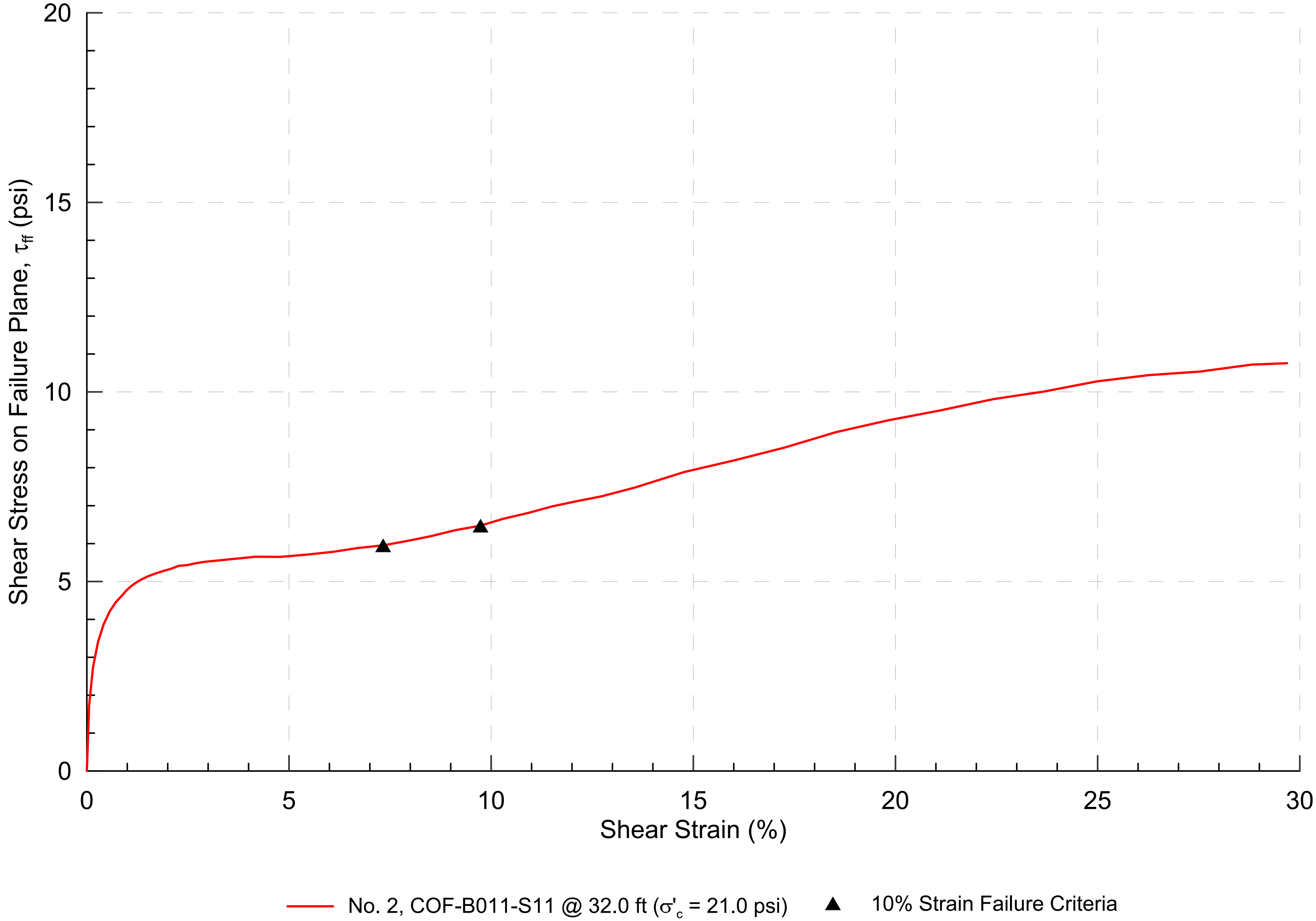


Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 and No. 2 **Soft Foundation Clay** DSS Stress vs Strain	Figure D.5
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\Lab Characterization\Soft Clay Foundation Plots\2015 Coffeen Soft Clay Foundation DSS Stress v

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Material Characterization

Project Name: Dynegy CCR

By: Julie Heitland Date: 01/06/2016

Project No: 60480701

Checked By: Amanda Duvigneaud Date: 01/11/2016

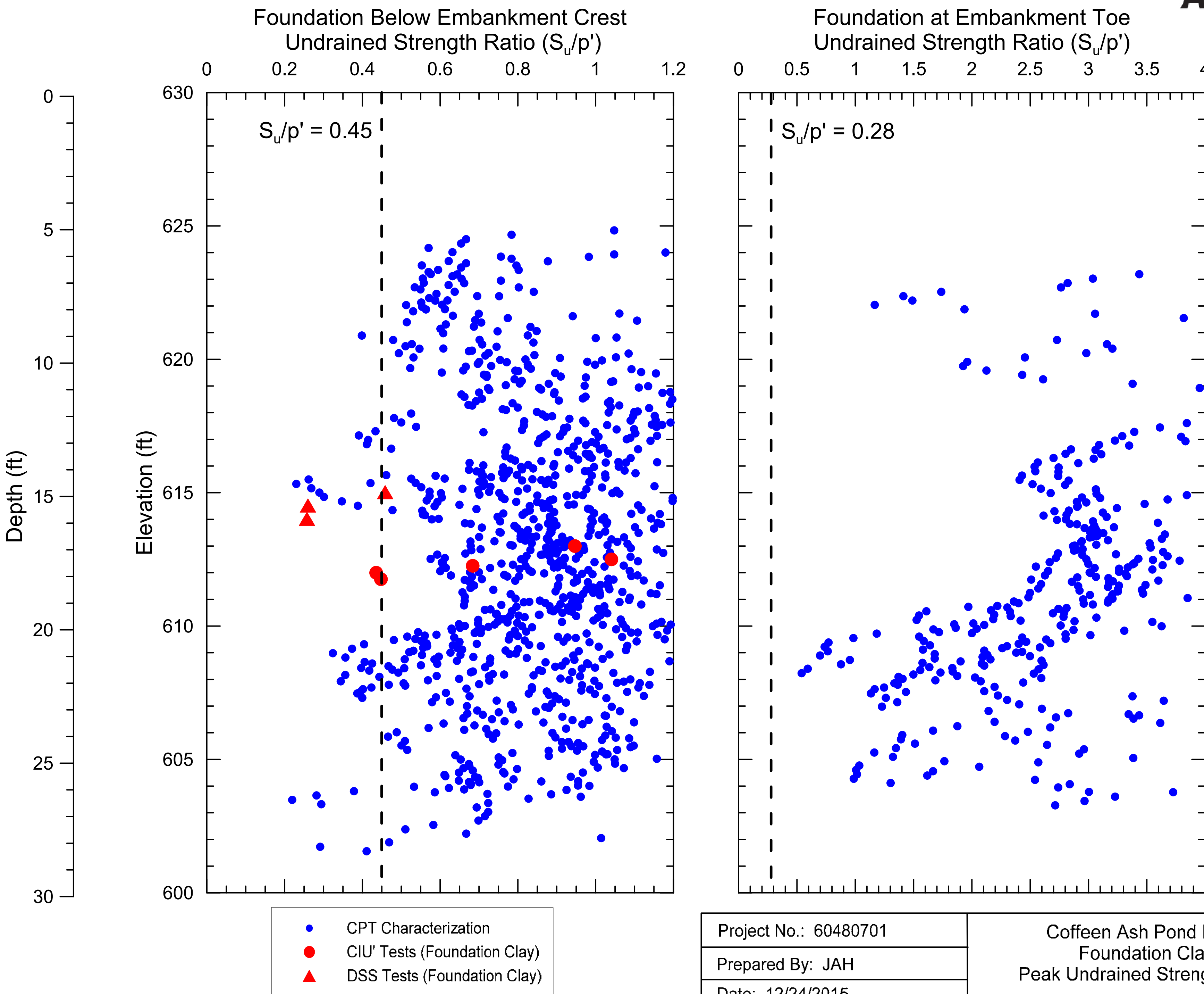
Task No.: 01

APPENDIX E

CPT Plots

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\Material Characterization_Final\Coffeen\CPT Characterization\Coffeen 1_Su_p' vs Depth_Foundation at Crest and Toe_rat

AECOM



Project No.: 60480701	Coffeen Ash Pond No. 1 Foundation Clay Peak Undrained Strength Ratio
Prepared By: JAH	
Date: 12/24/2015	

FIGURE E.1

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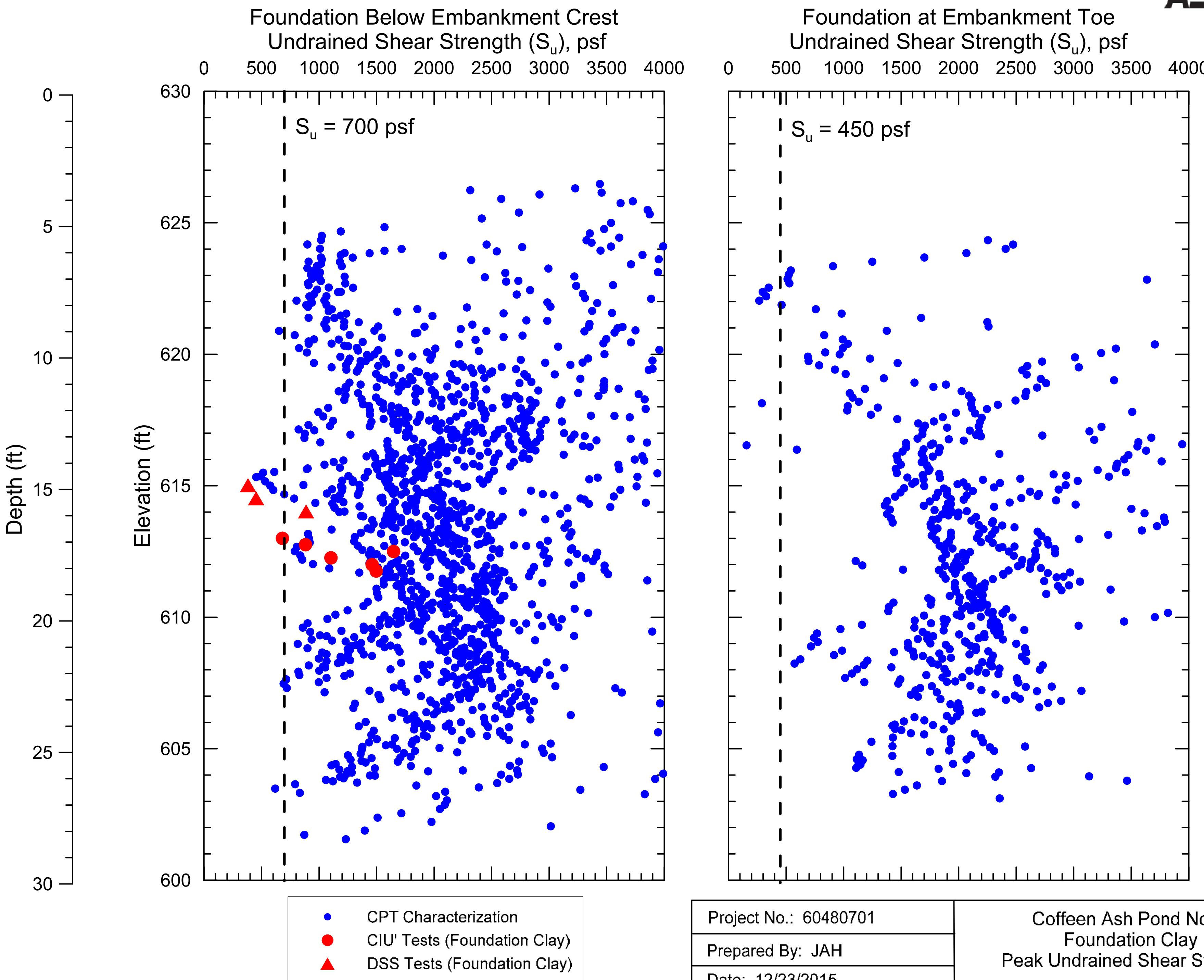
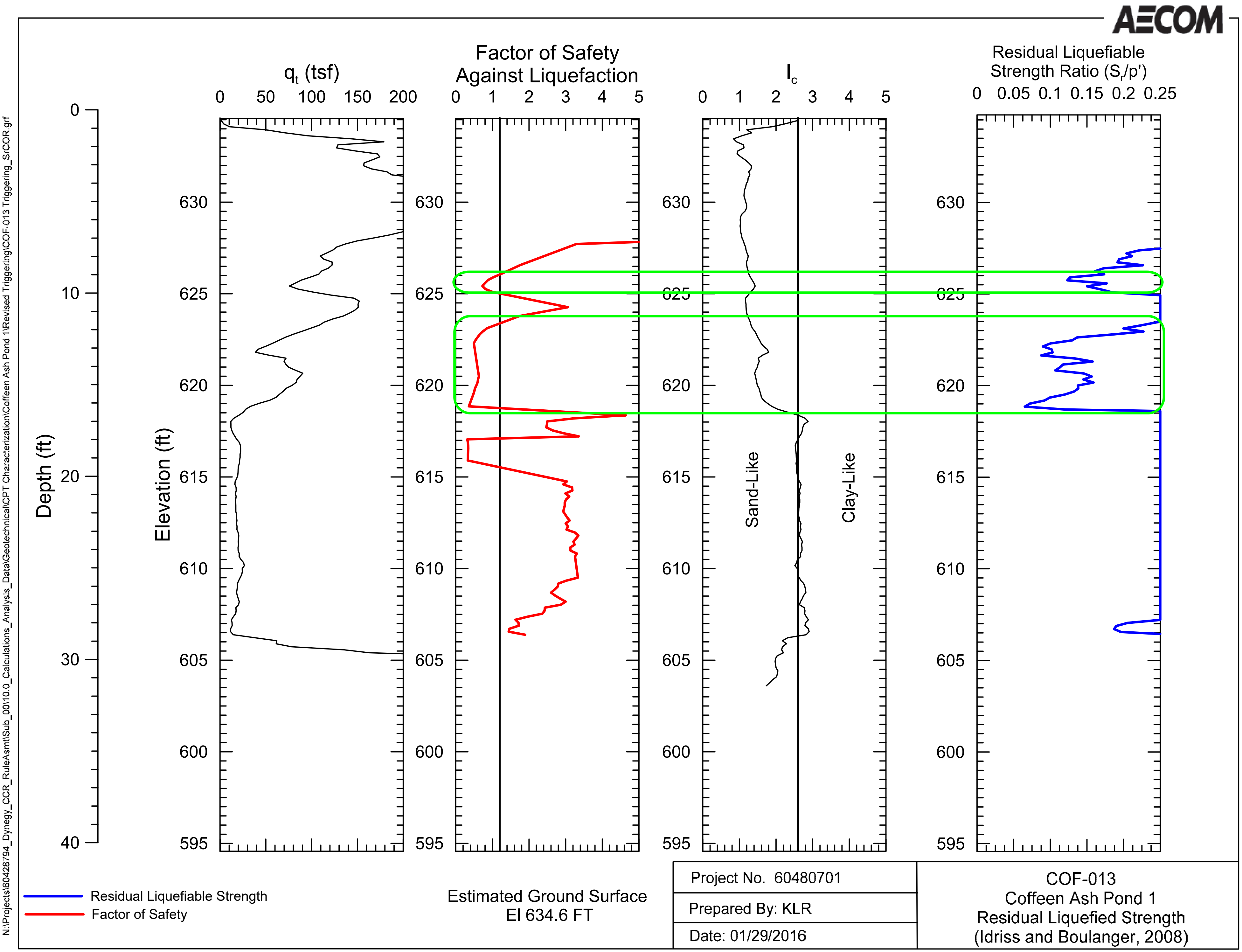
AECOM



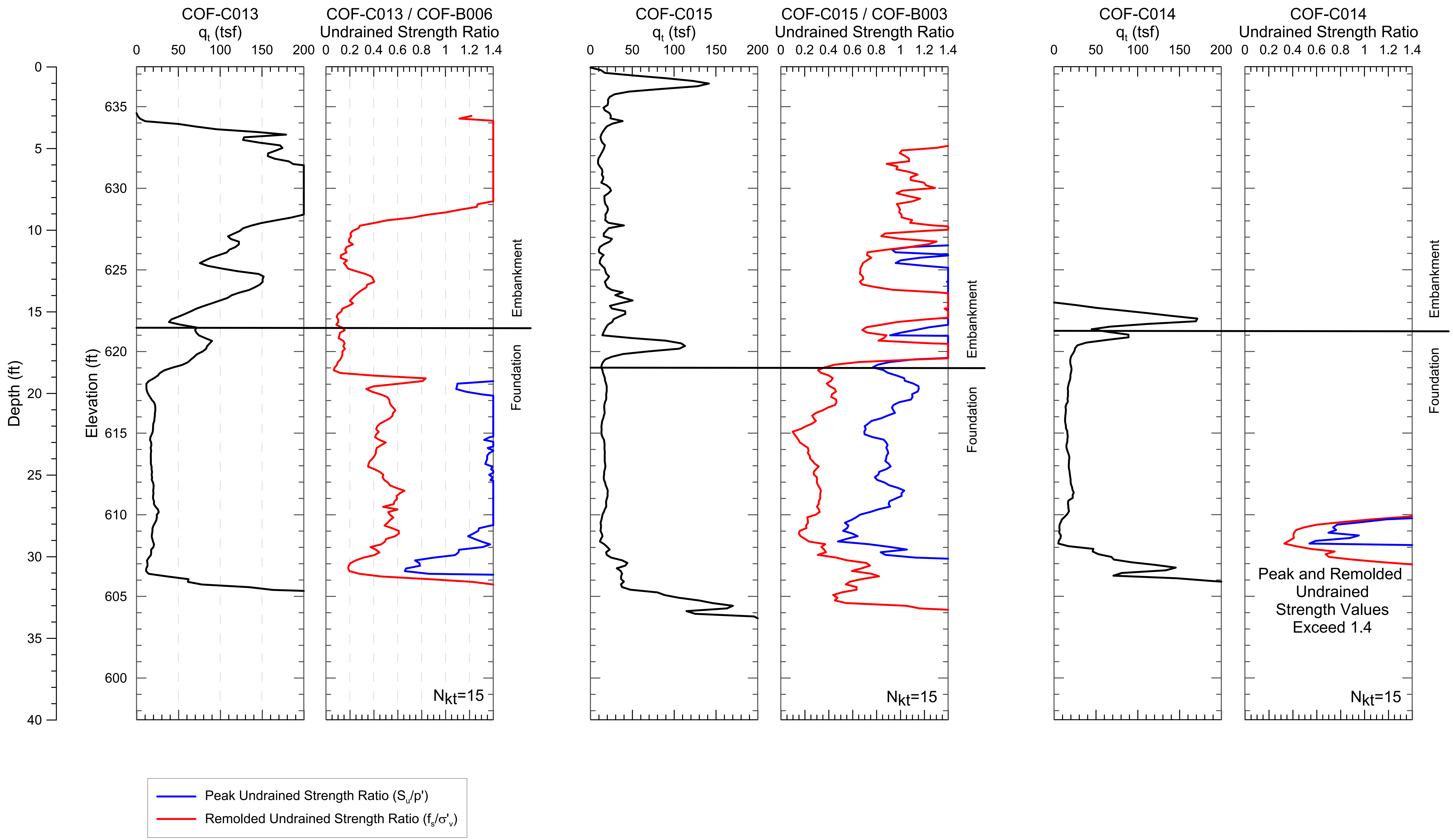
Project No.: 60480701	Coffeen Ash Pond No. 1 Foundation Clay Peak Undrained Shear Strength
Prepared By: JAH	
Date: 12/23/2015	

FIGURE E.2

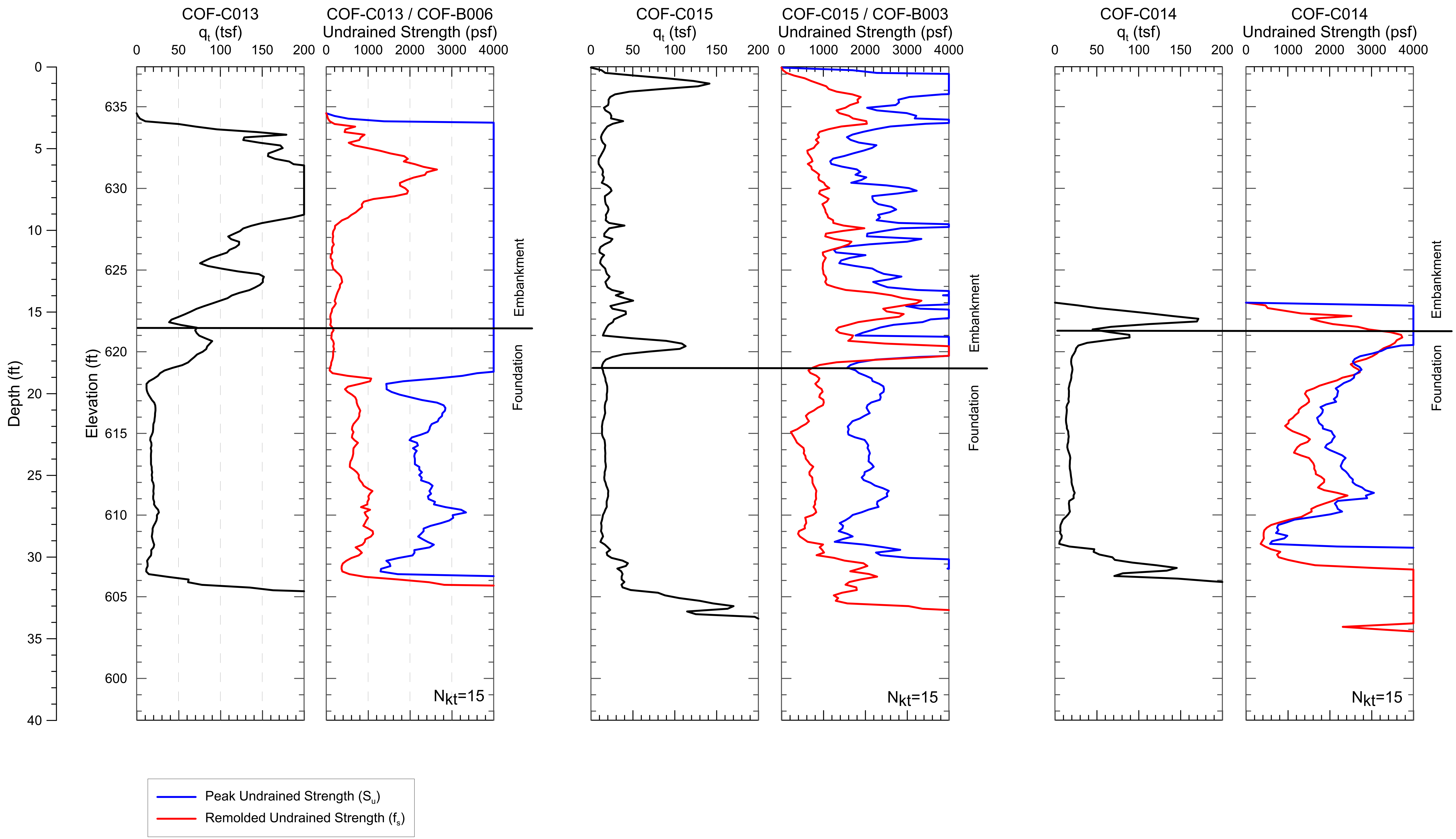


Project No. 60480701	COF-013 Coffeen Ash Pond 1 Residual Liquefied Strength (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 01/29/2016	

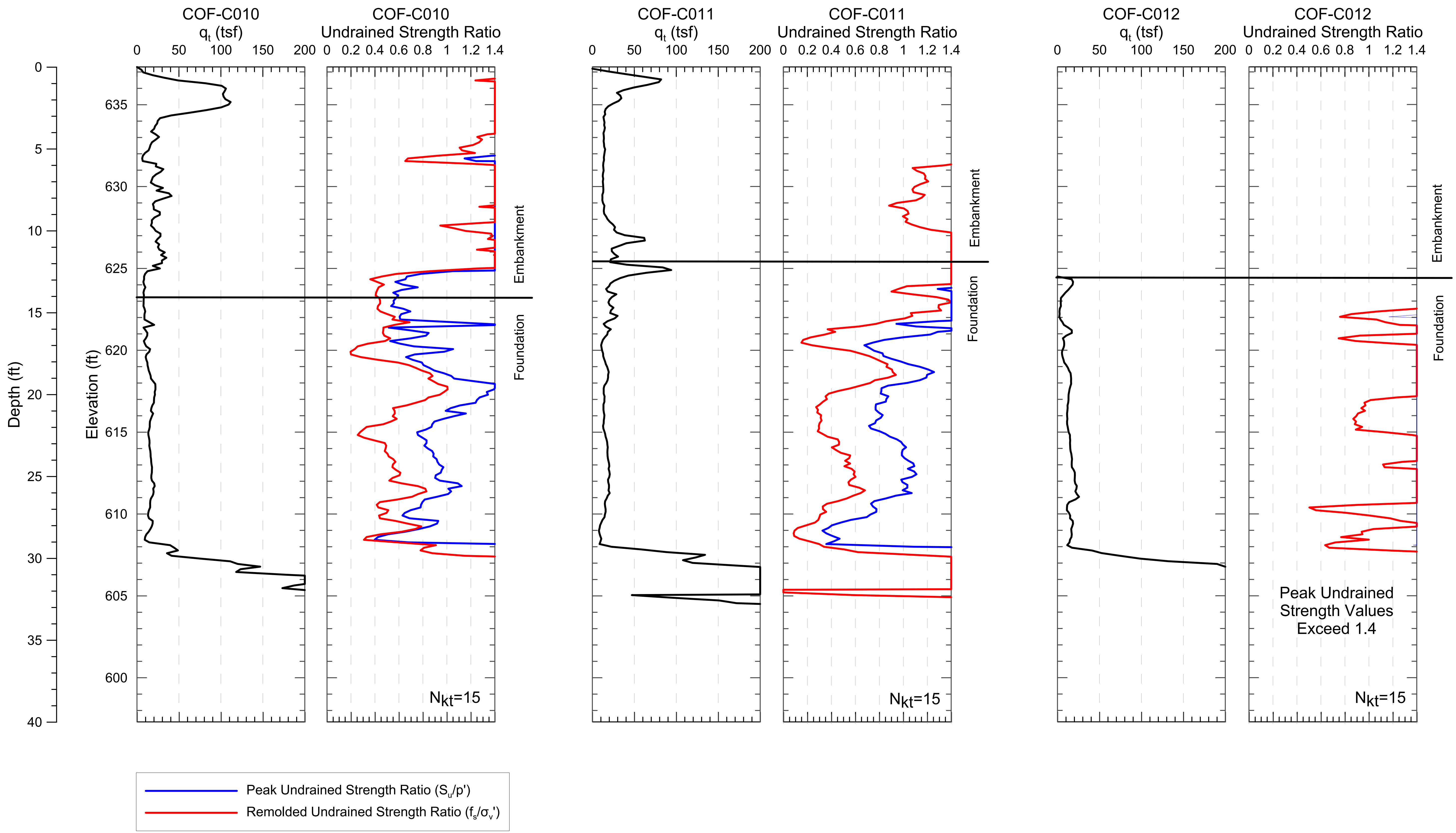
FIGURE E.3



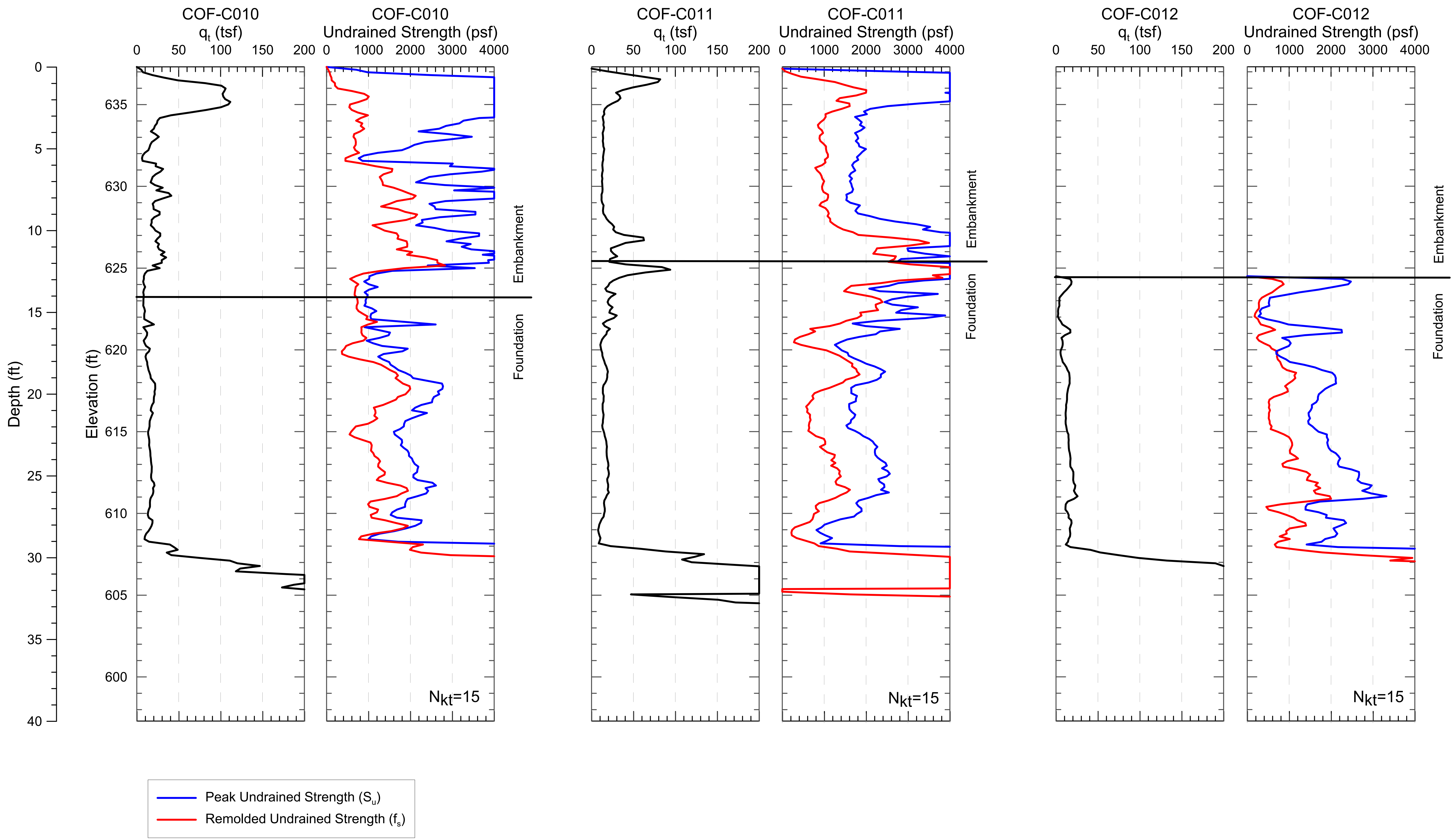
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 14+50 CPT and Undrained Strength Ratio	FIGURE E.4
	AECOM		



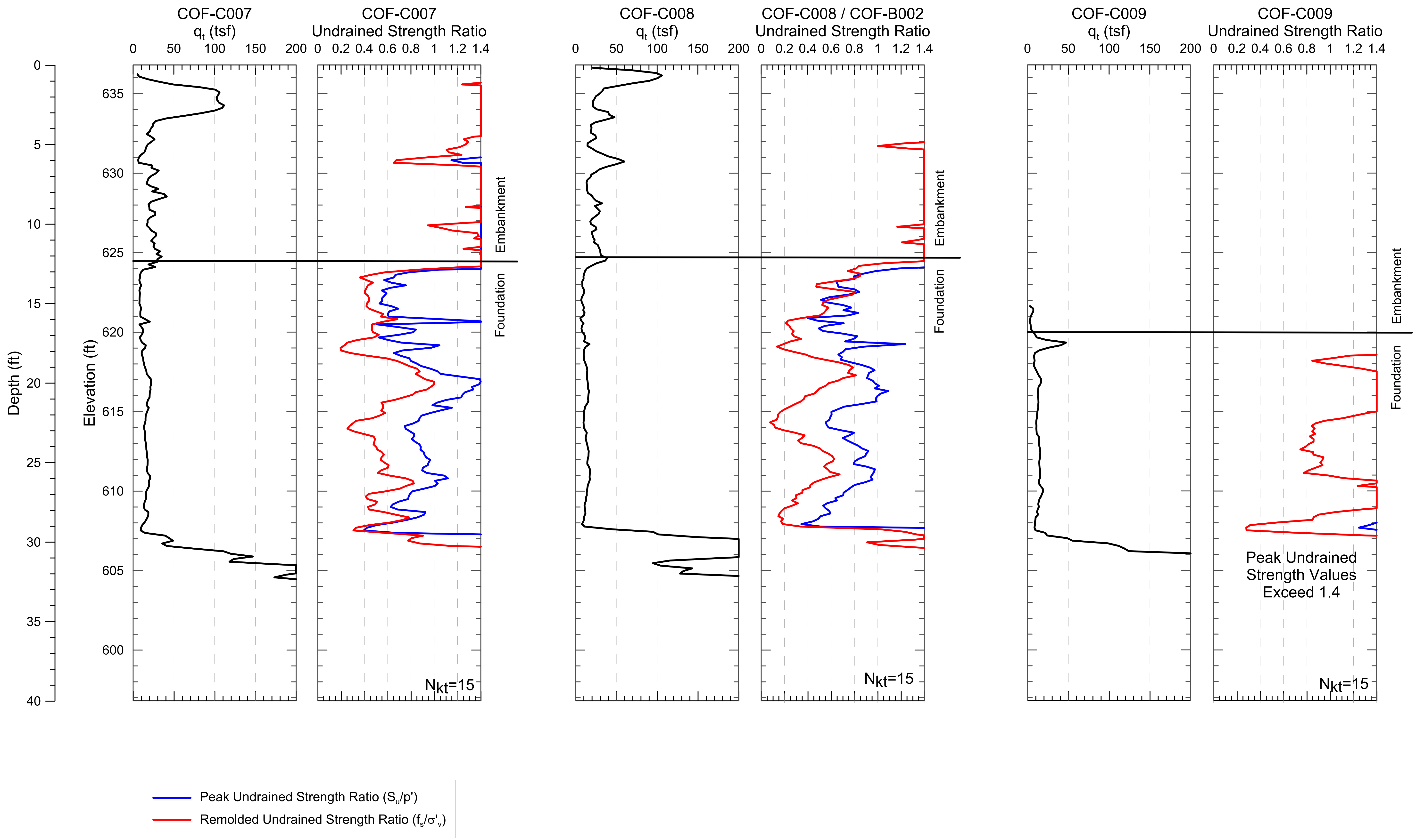
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 14+50 CPT and Undrained Strength	FIGURE E.5
	AECOM		



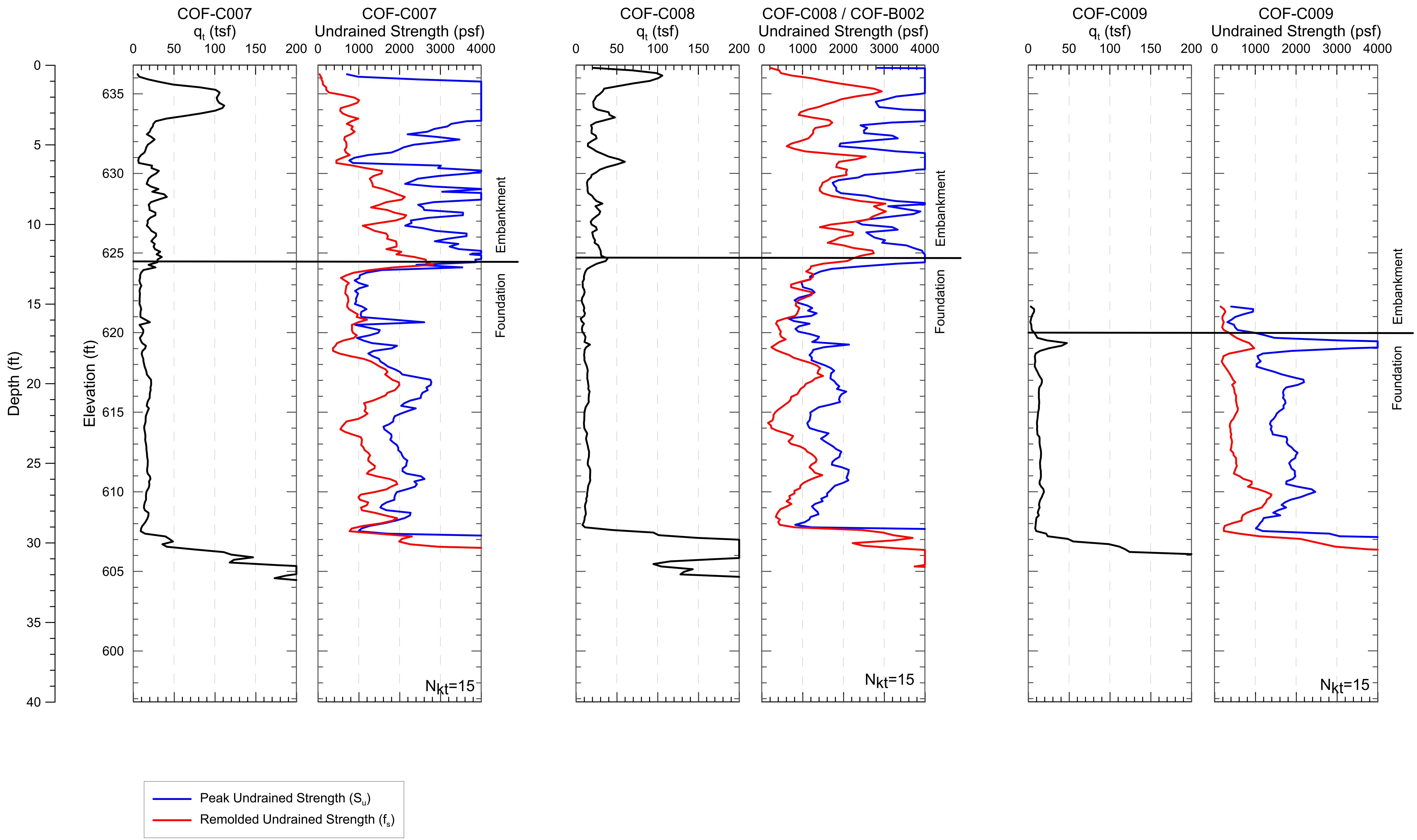
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 20+00 CPT and Undrained Strength Ratio	FIGURE E.6
	AECOM		



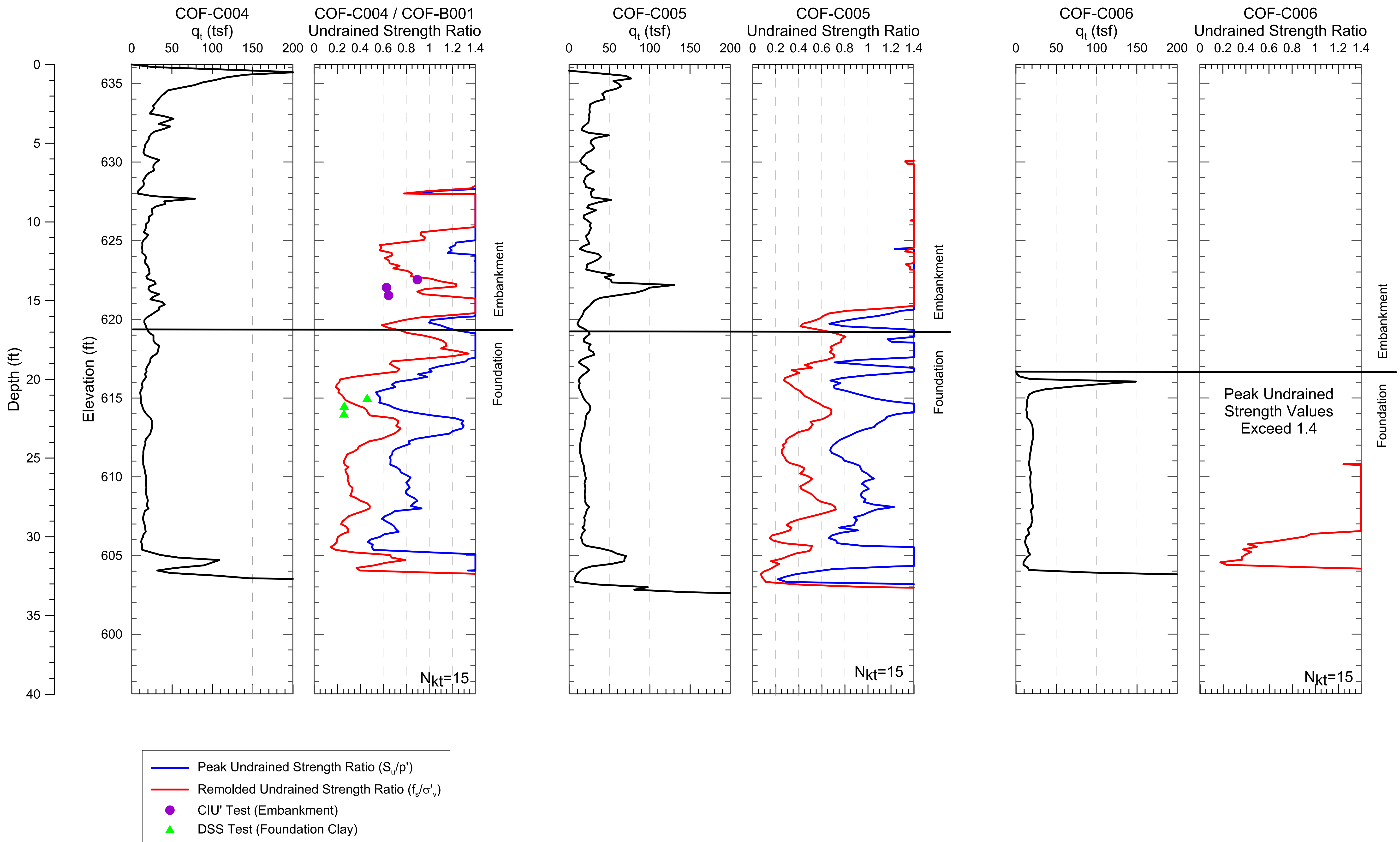
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 20+00 CPT and Undrained Strength	FIGURE E.7
	AECOM		



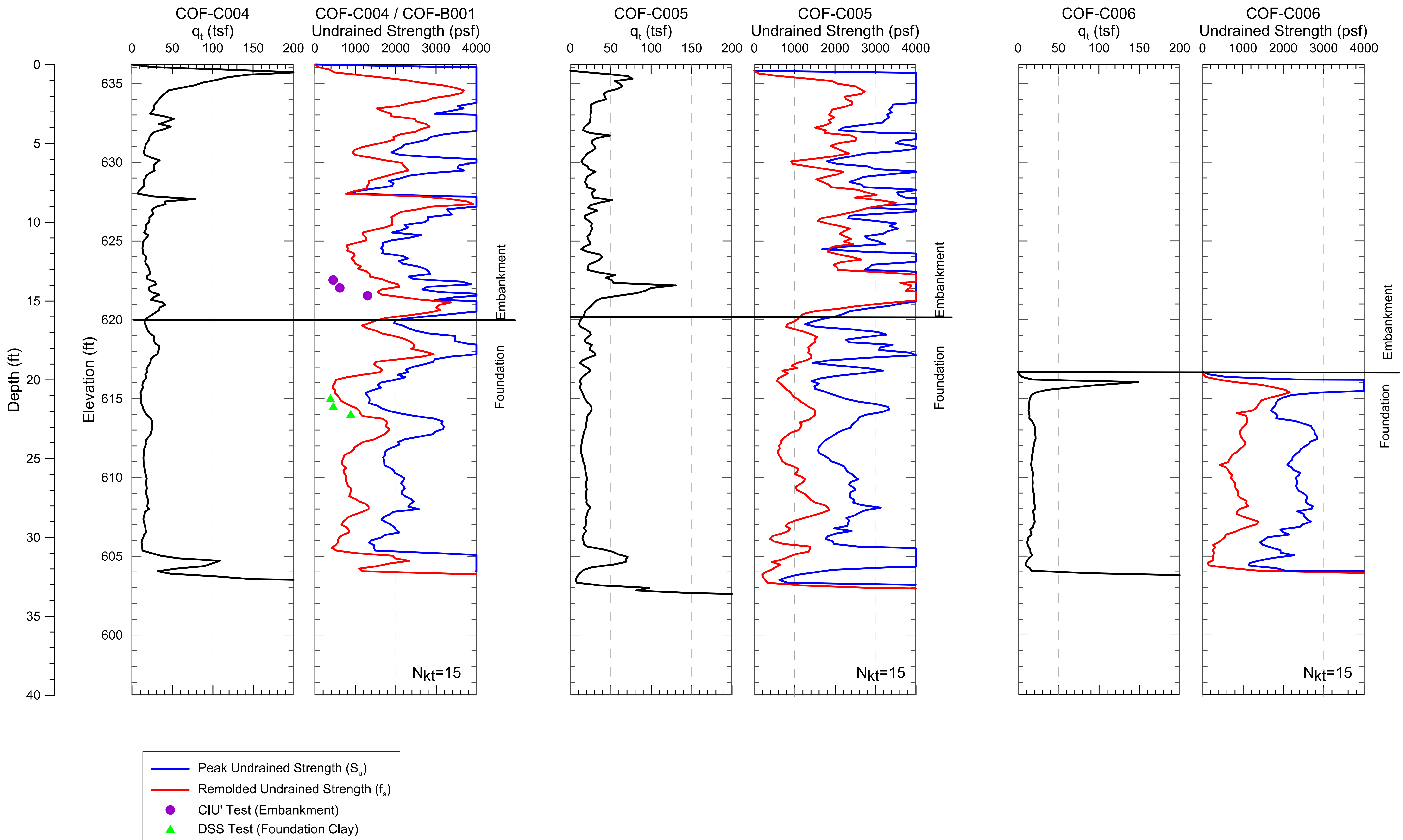
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 26+50 CPT and Undrained Strength Ratio	FIGURE E.8
	AECOM		



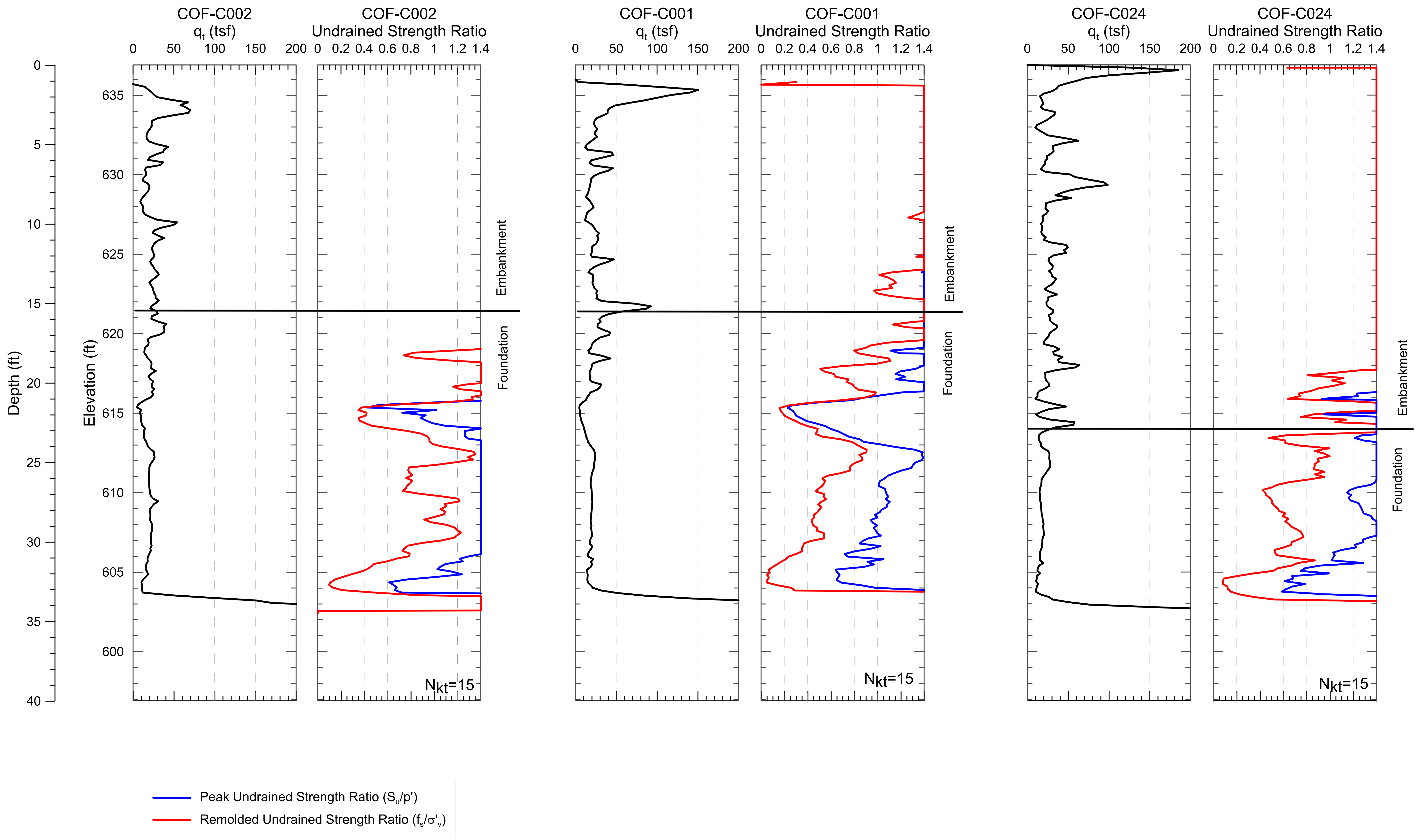
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 26+50 CPT and Undrained Strength	FIGURE E.9
	AECOM		



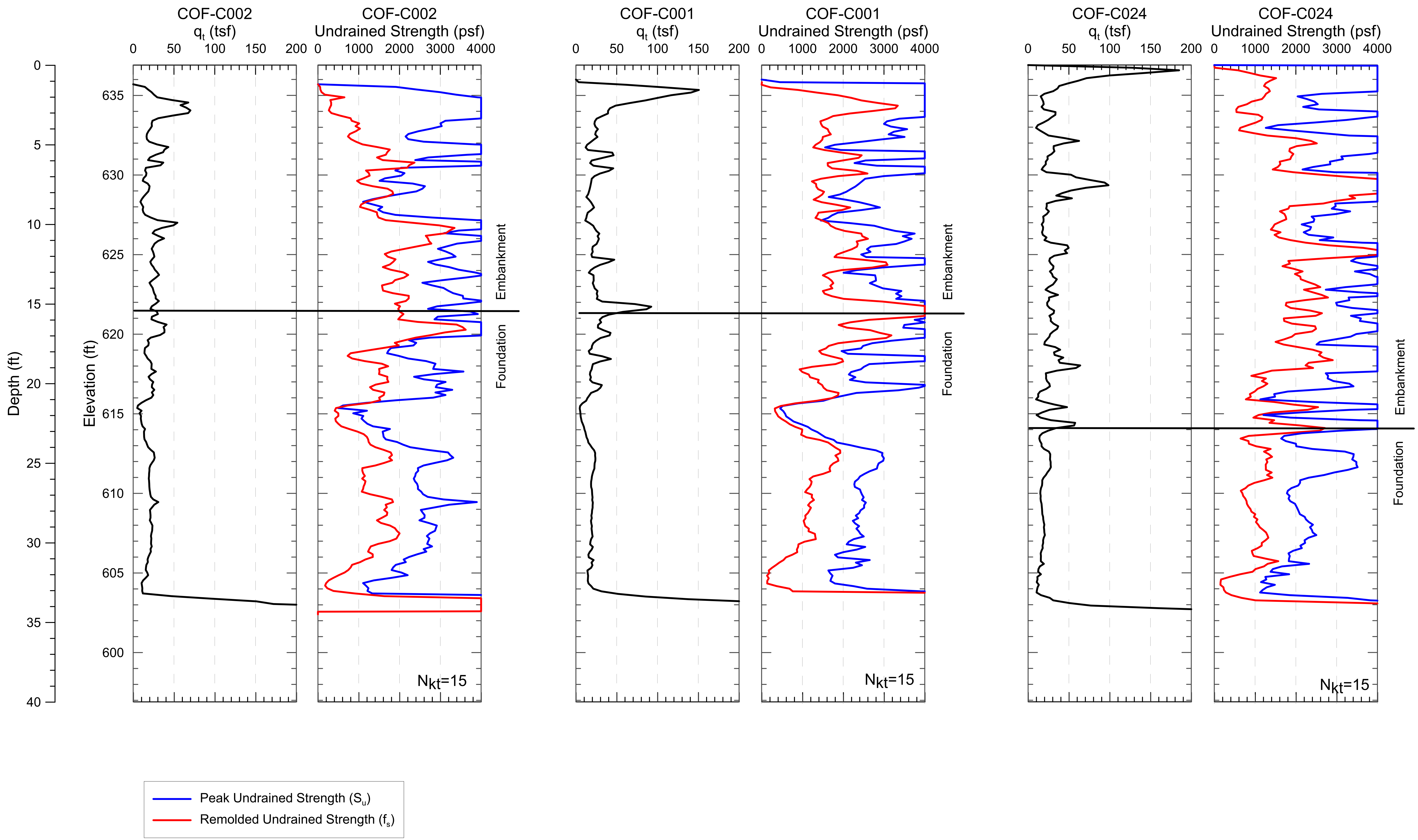
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 33+00 CPT and Undrained Strength Ratio	FIGURE E.10
	AECOM		



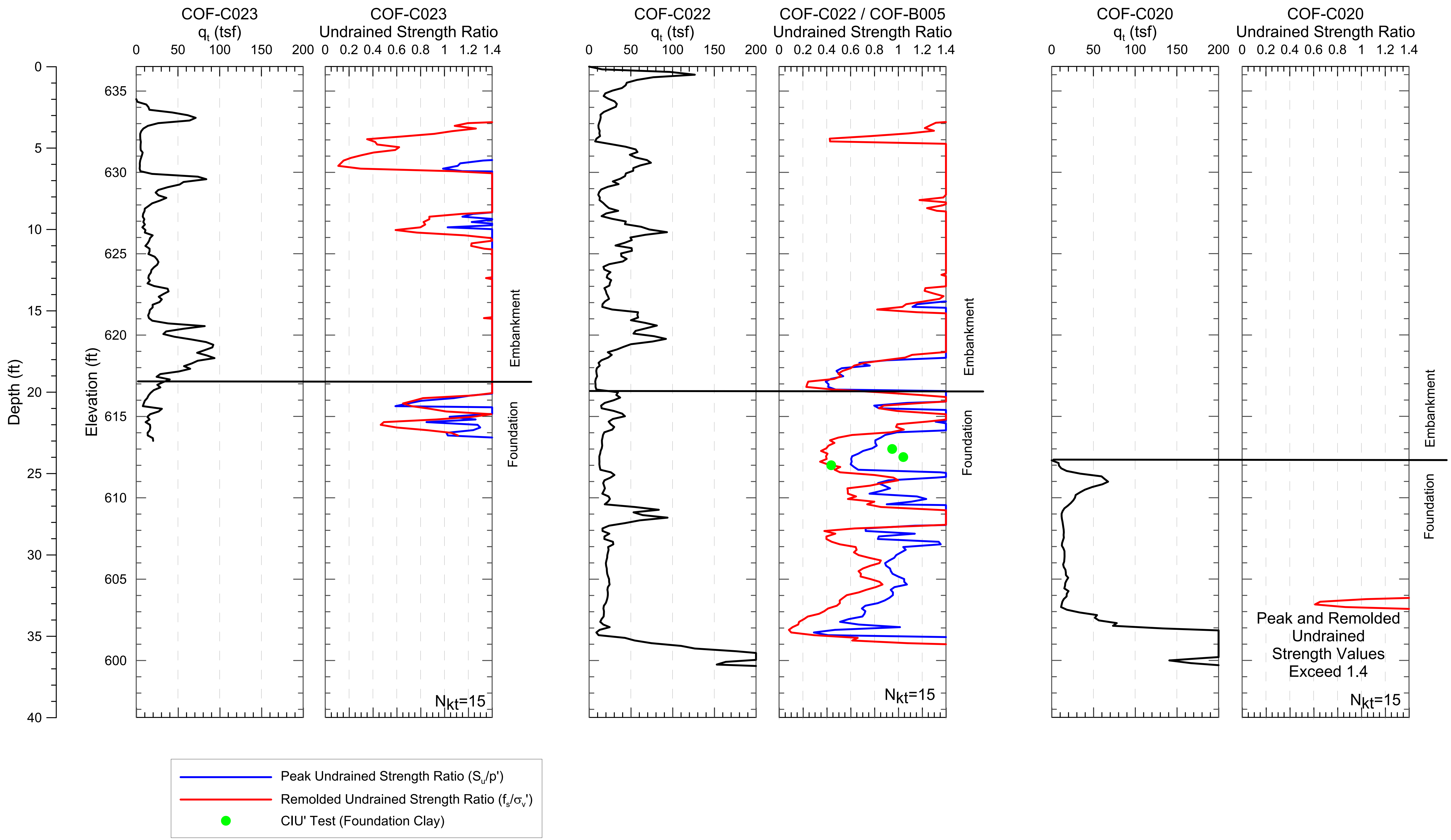
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 33+00 CPT and Undrained Strength	FIGURE E.11
	AECOM		



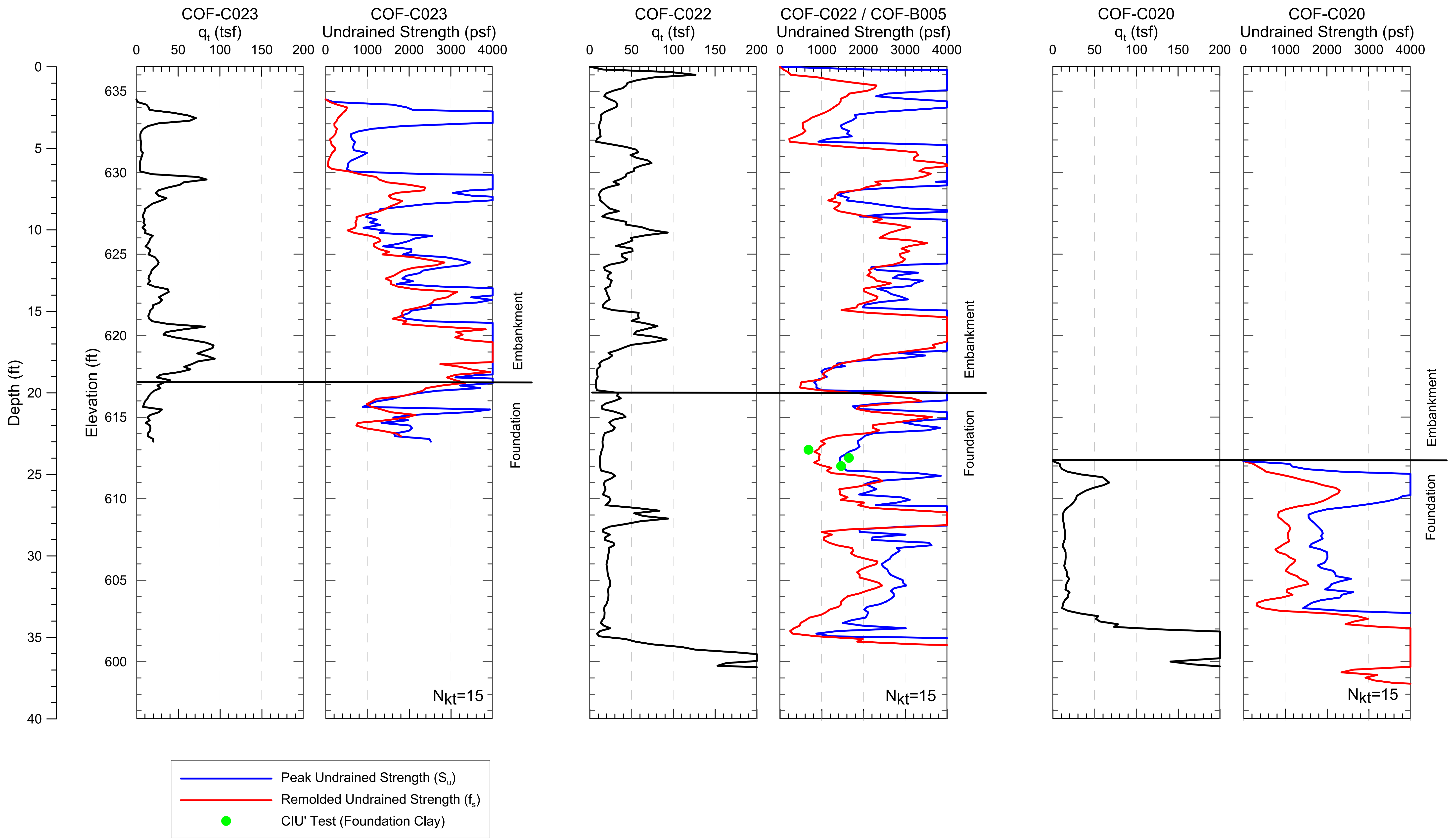
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 34+50 CPT and Undrained Strength Ratio	FIGURE E.12
	AECOM		



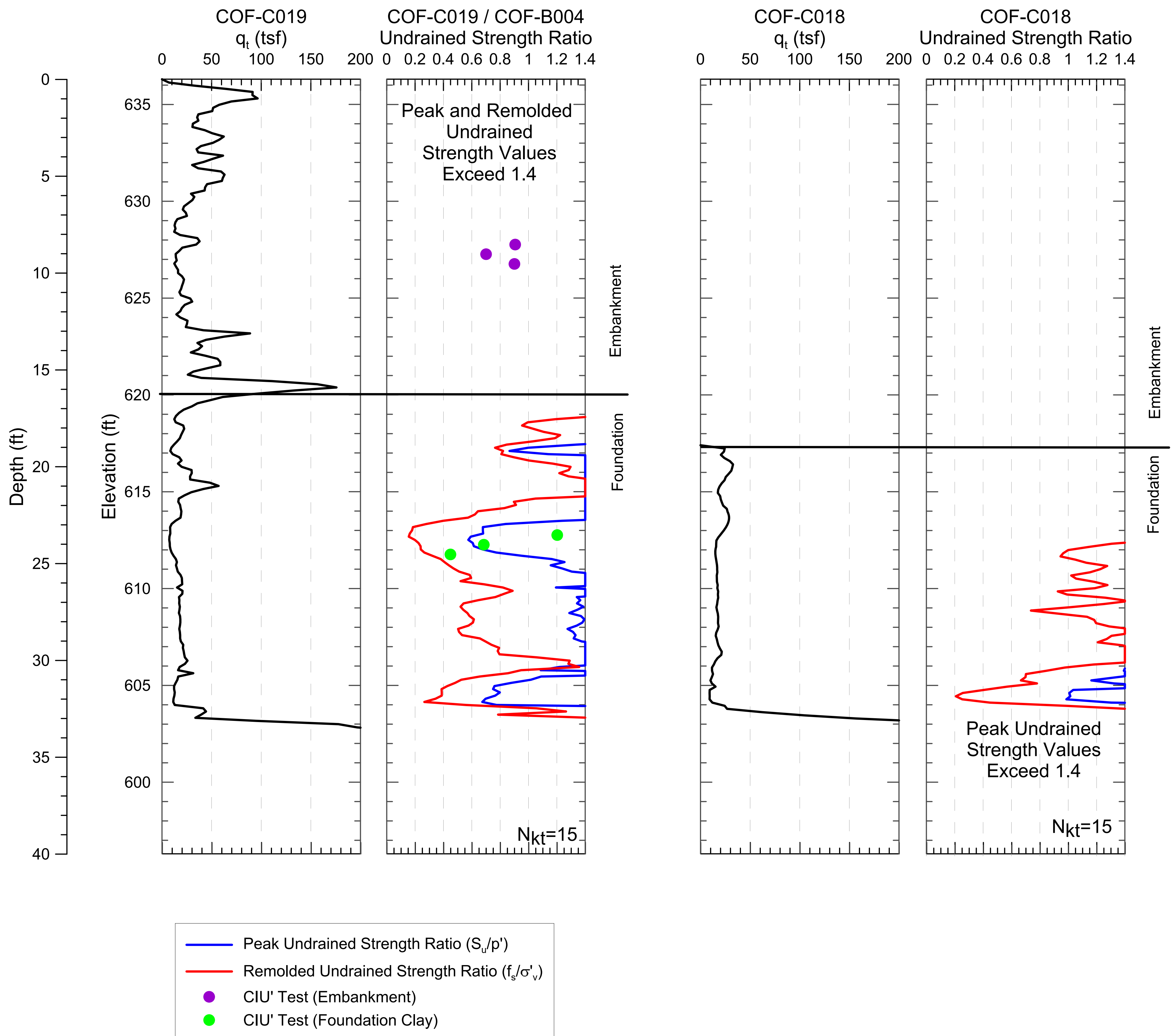
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 34+50 CPT and Undrained Strength	FIGURE E.13
	AECOM		



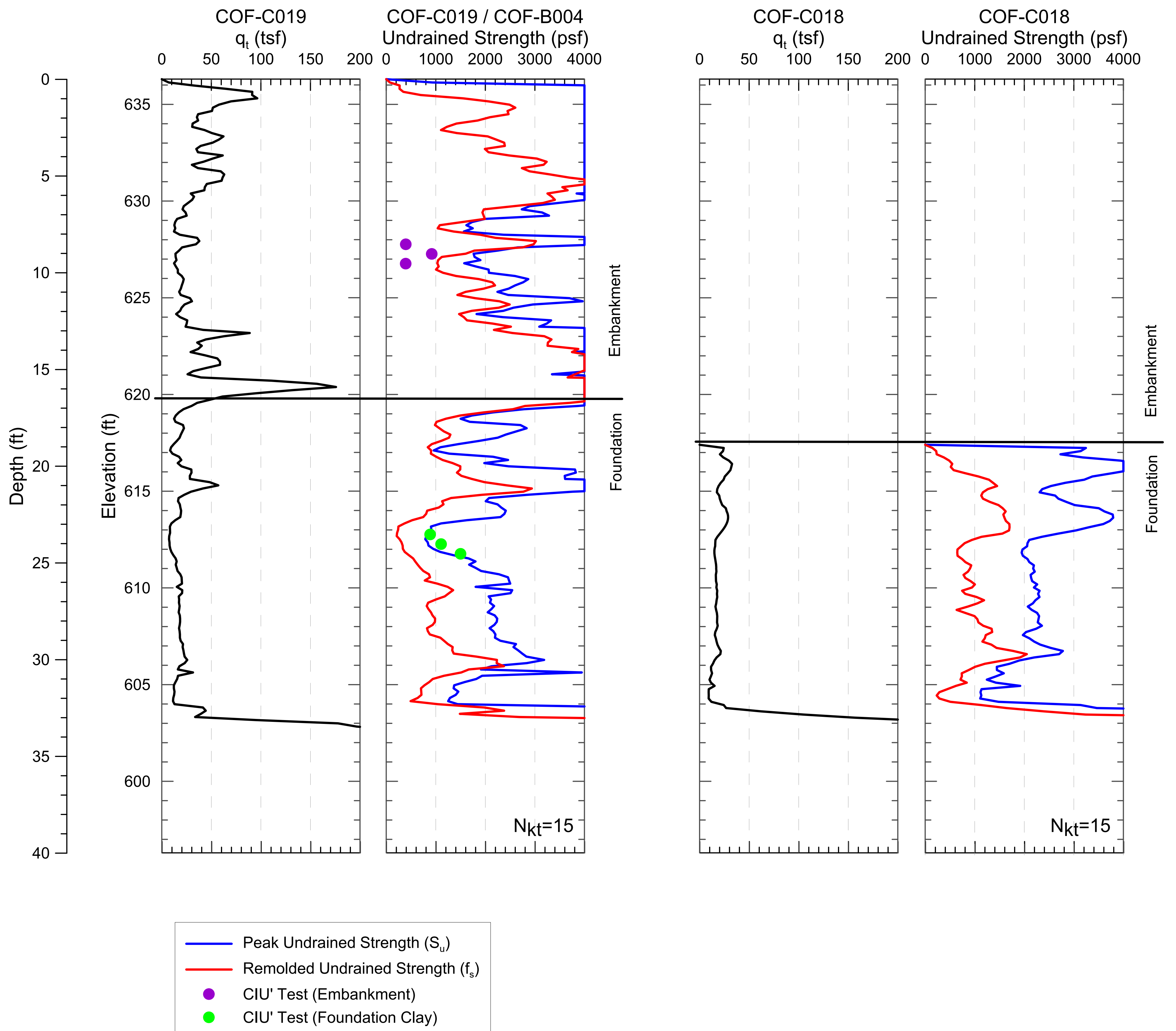
Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 39+00 CPT and Undrained Strength Ratio	FIGURE E.14
	AECOM		



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 39+00 CPT and Undrained Strength	FIGURE E.15
	AECOM		



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 45+50 CPT and Undrained Strength Ratio	FIGURE E.16
	AECOM		



Project No. 60480701	Dynegy - Coffeen Site	Coffeen Ash Pond No. 1 STA 45+50 CPT and Undrained Strength	FIGURE E.17
	AECOM		

Calculation Notes

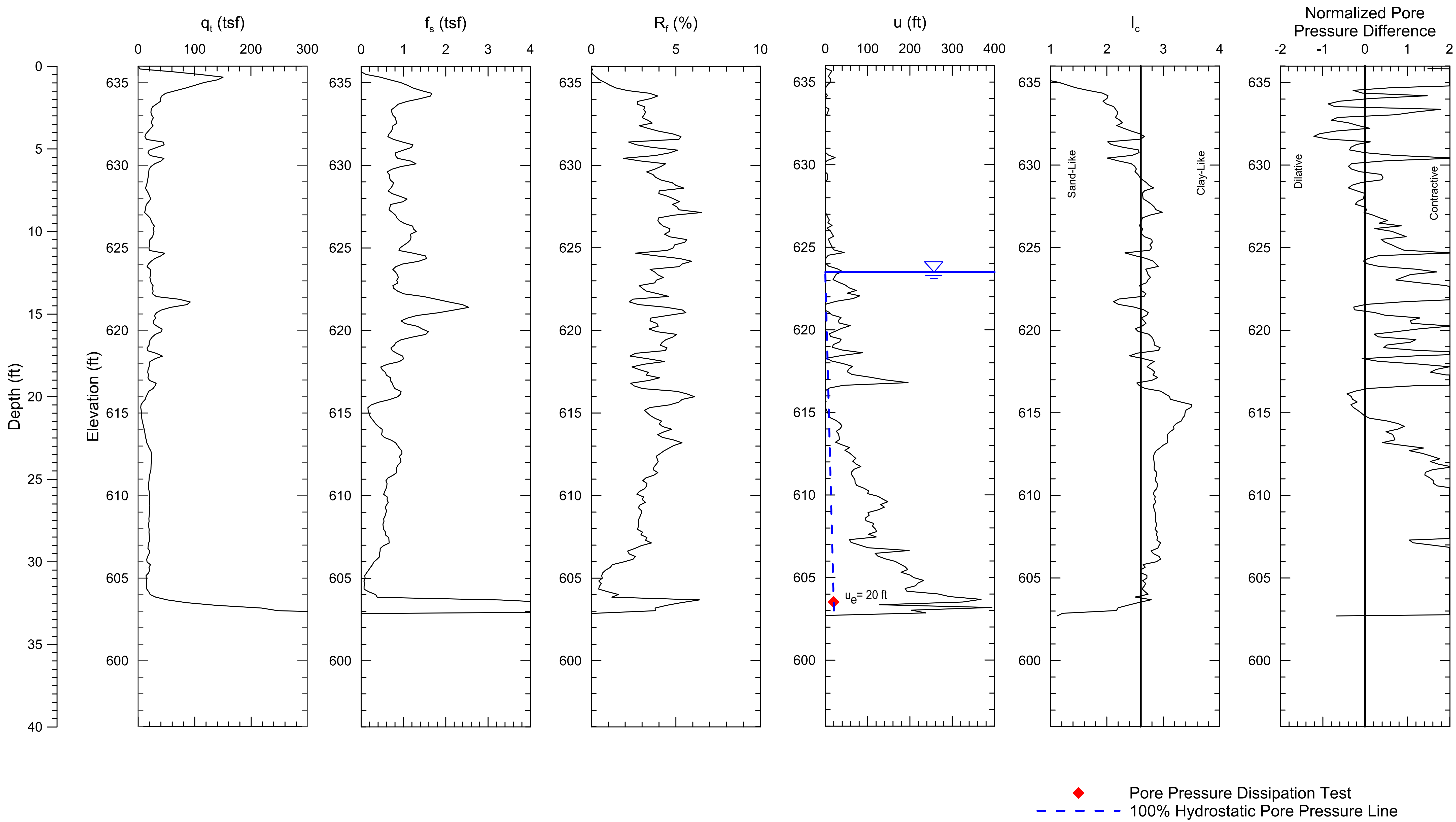
Subject: Coffeen Ash Pond No. 1 Material Characterization | Project Name: Dynegy CCR

By: Julie Heitland | Date: 01/06/2016 | Project No: 60480701

Checked By: Amanda Duvigneaud | Date: 01/11/2016 | Task No.: 01

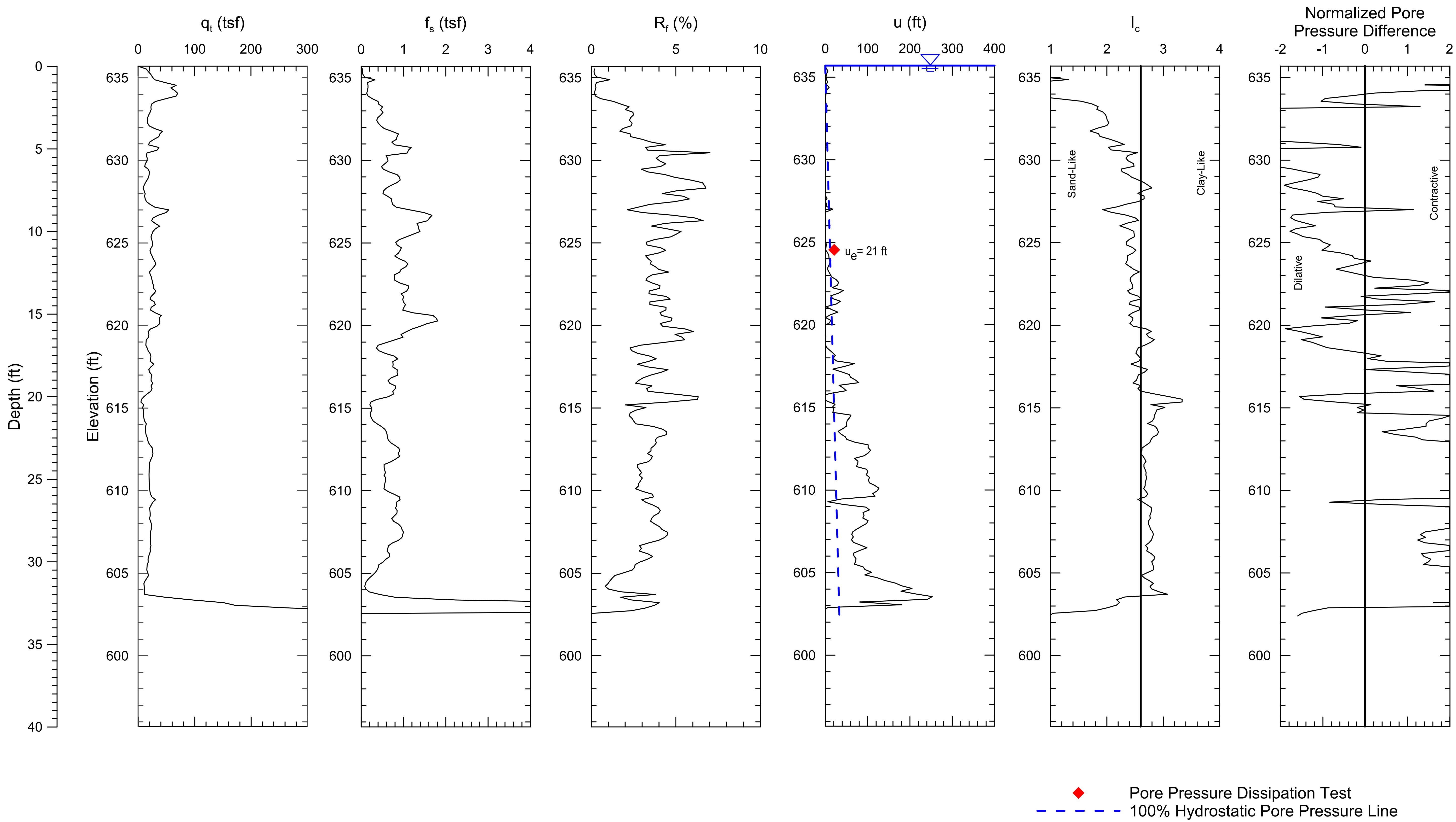
APPENDIX F

CPT Soundings



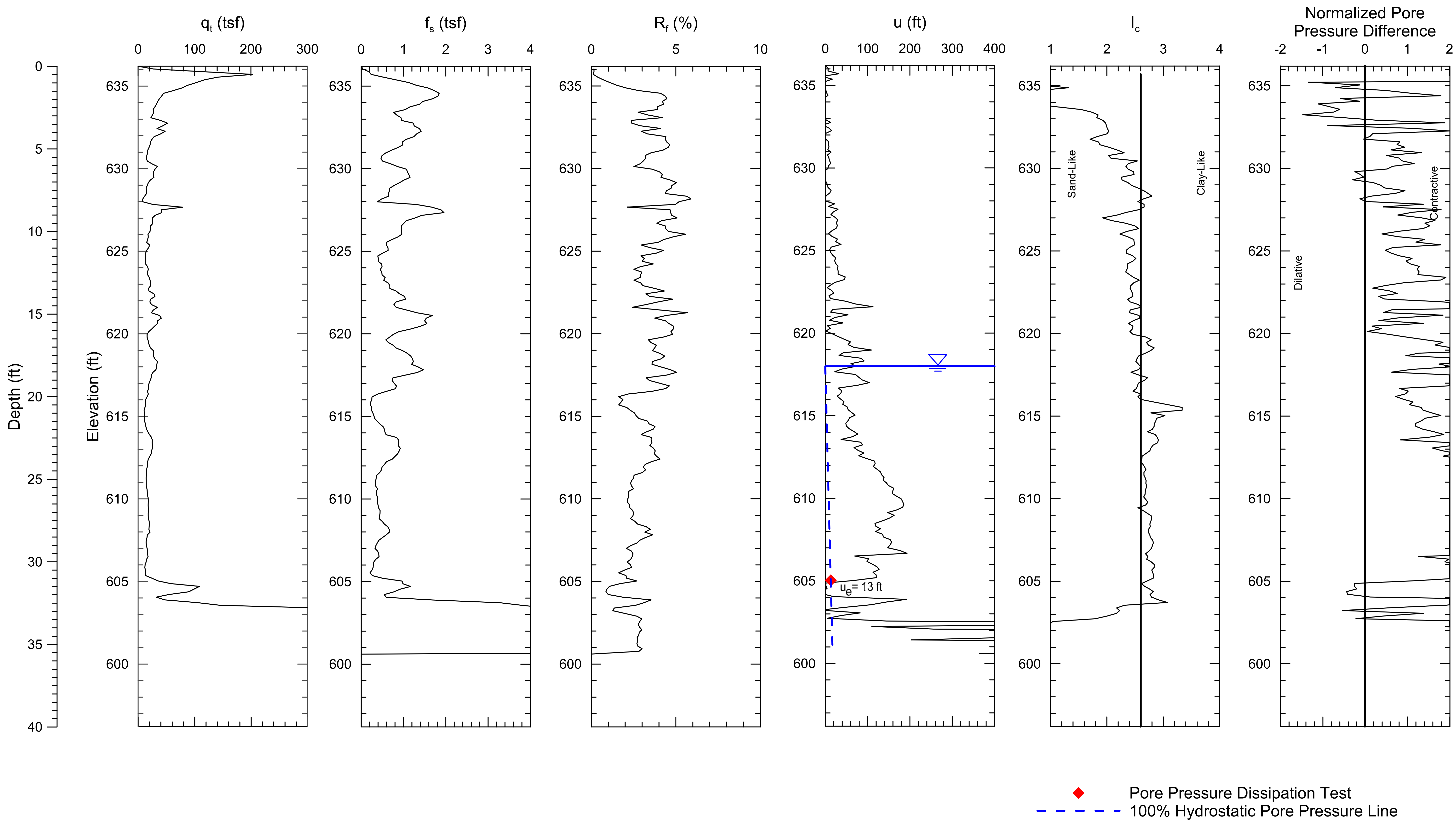
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-001 Coffeen Ash Pond No. 1	FIGURE
AECOM			



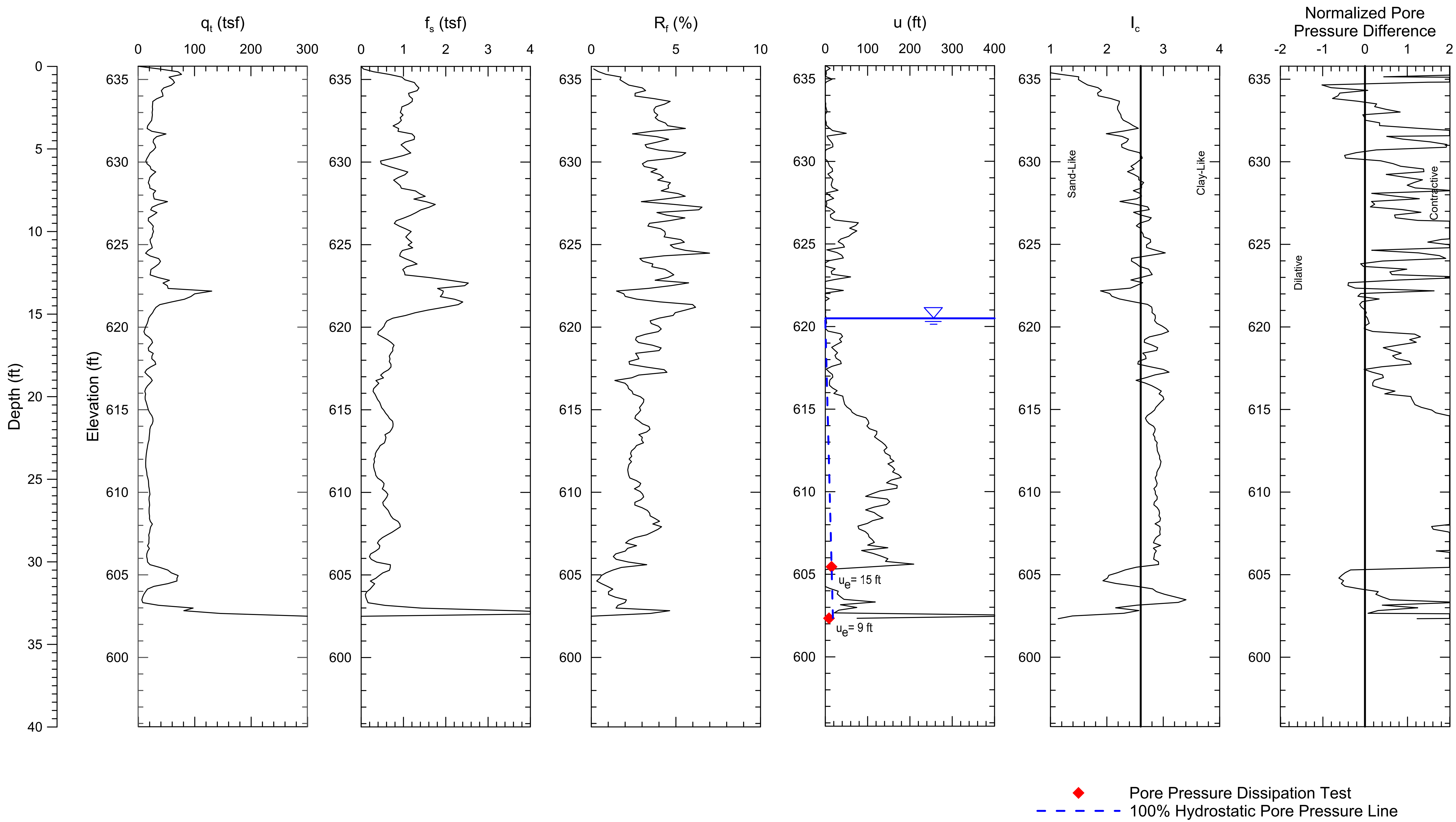
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-002 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-004 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

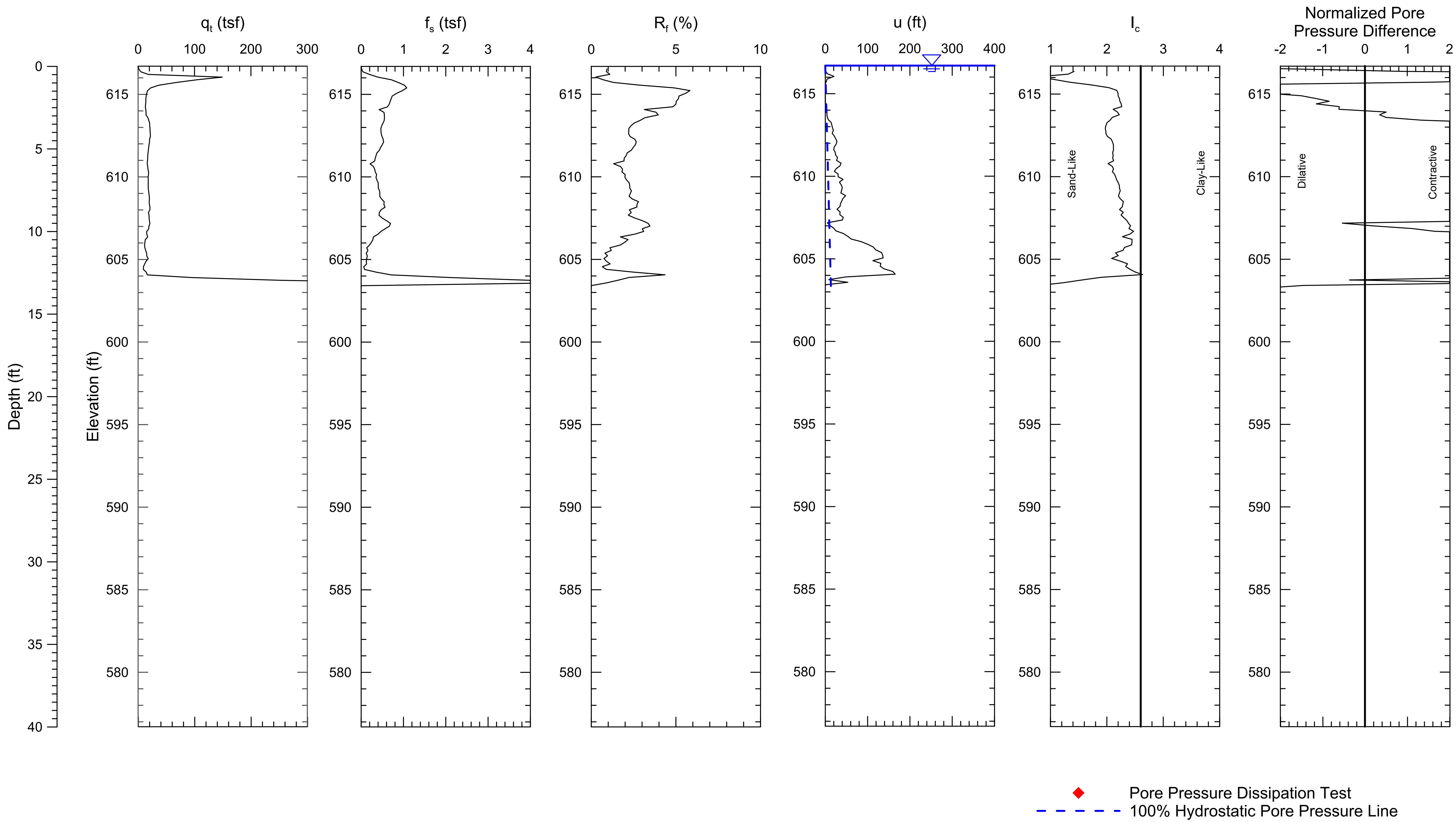


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

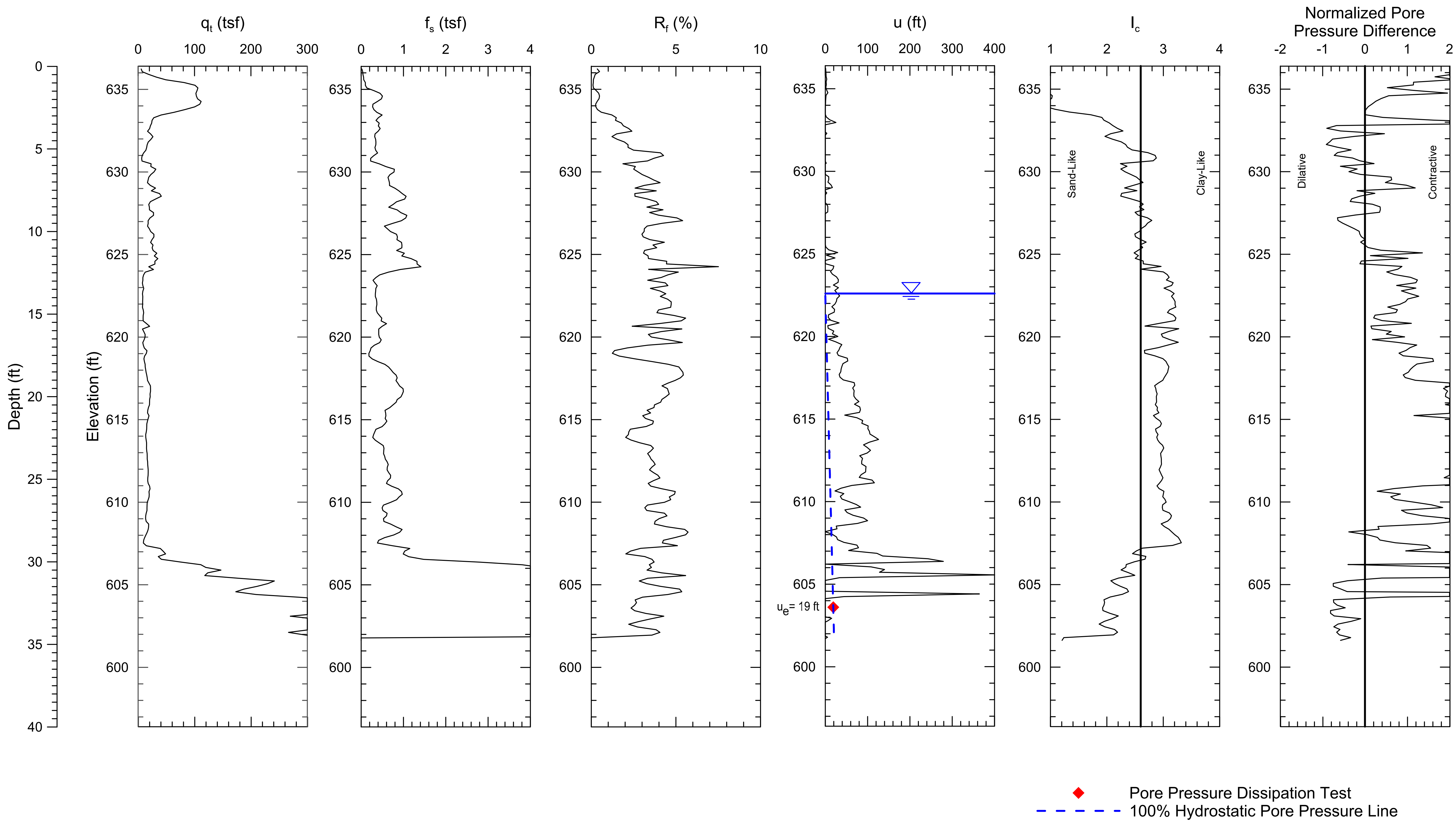
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-005 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



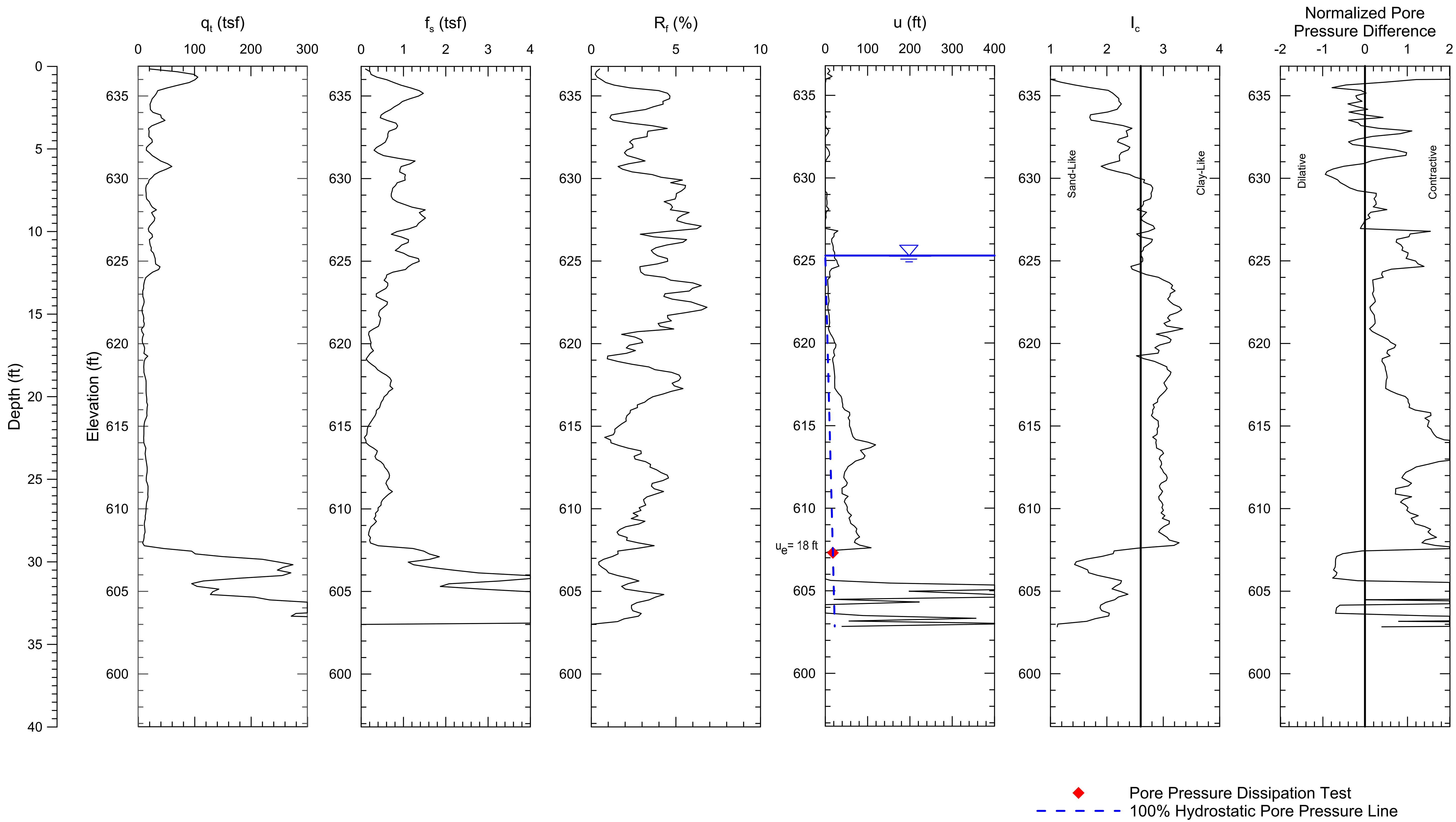
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-006 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-007 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

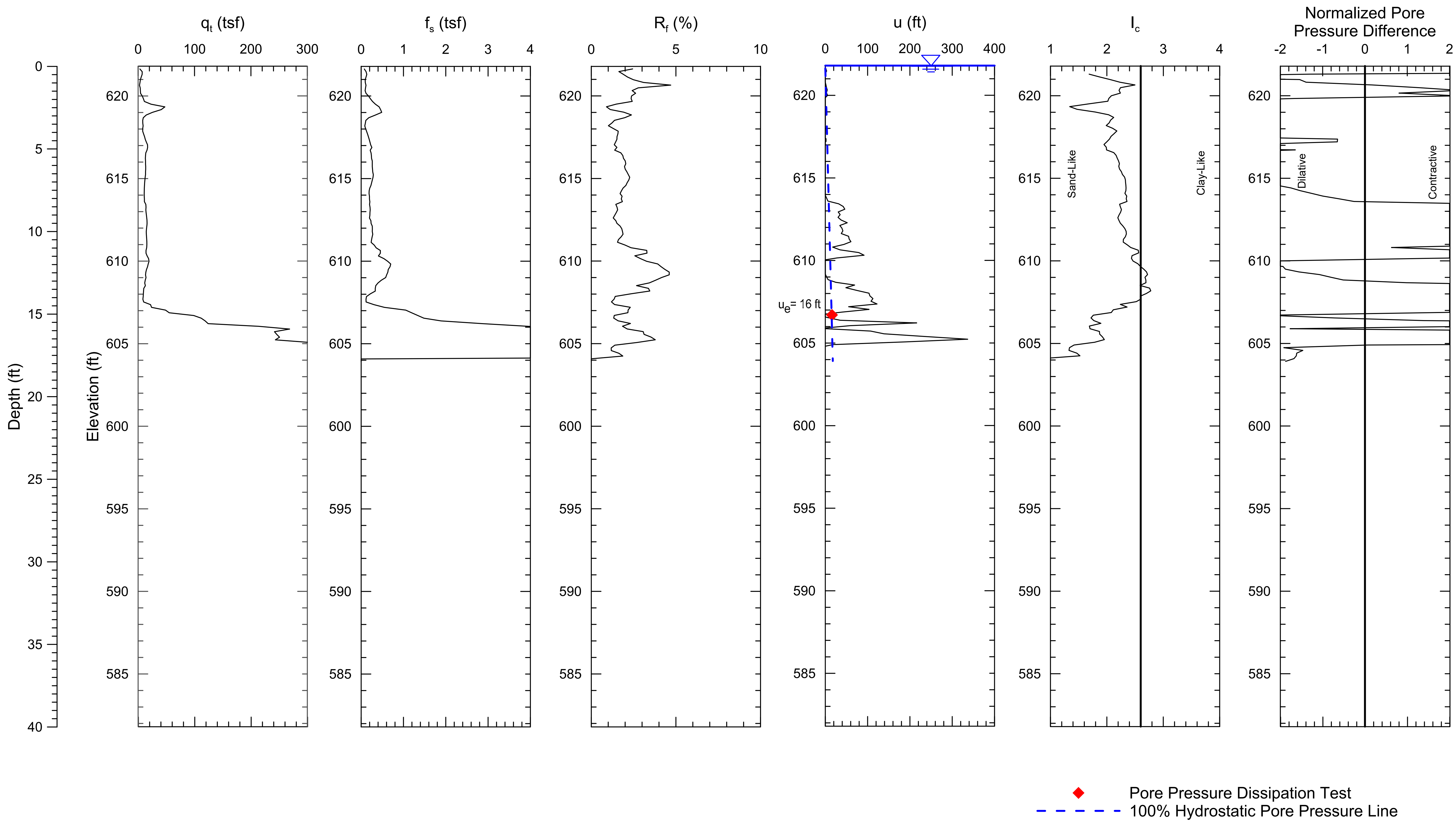


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

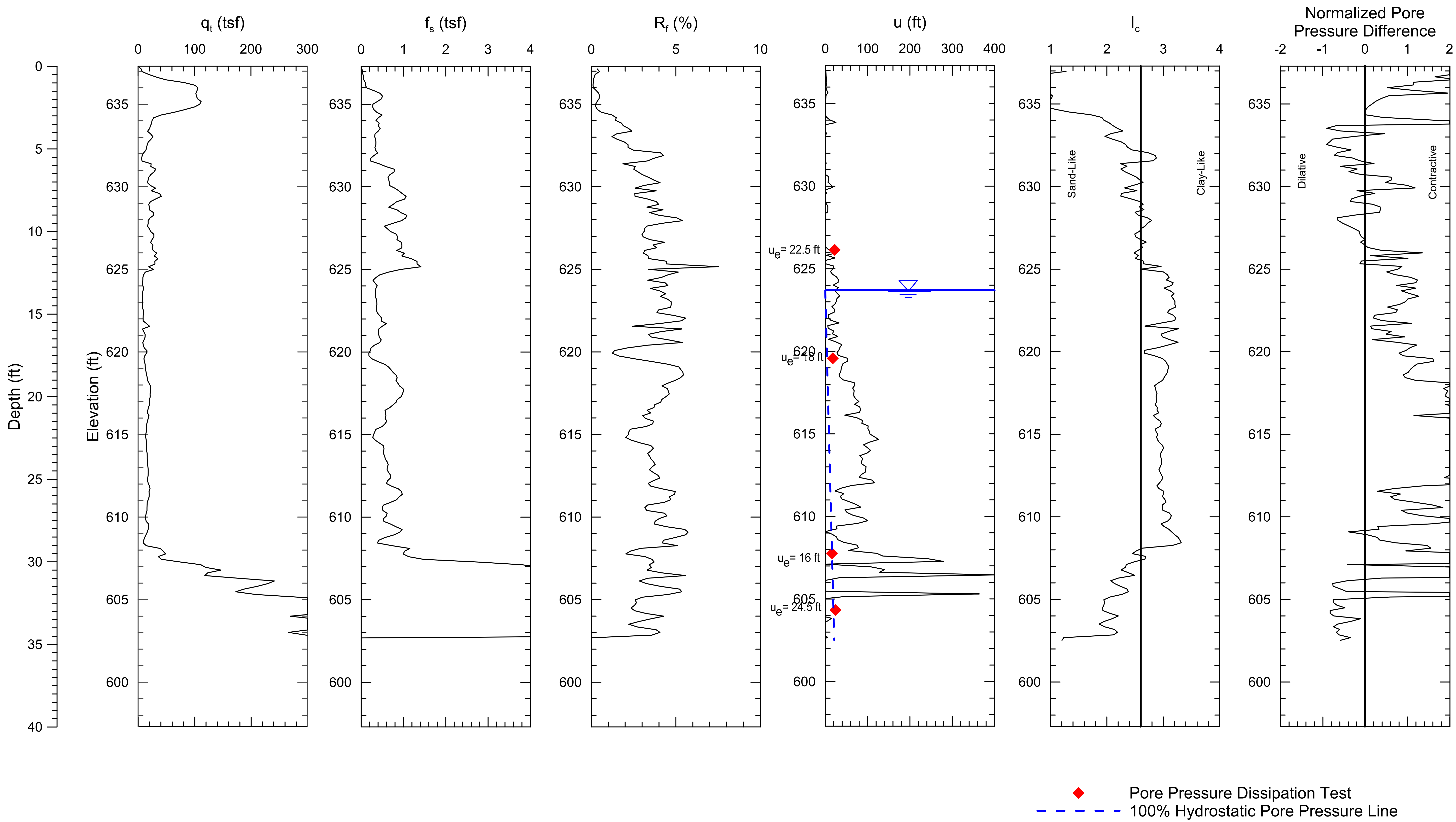
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-008 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



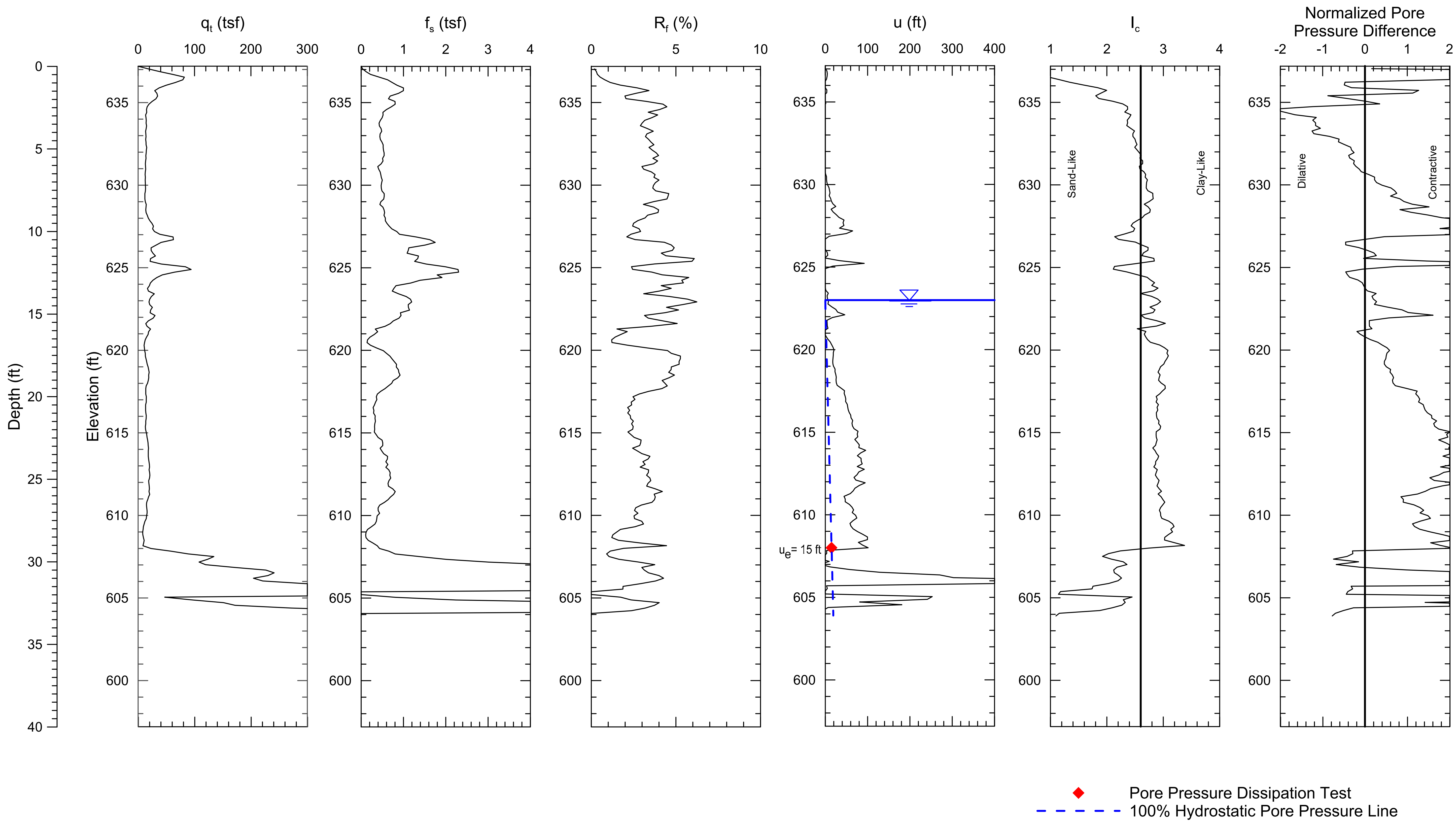
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-009 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



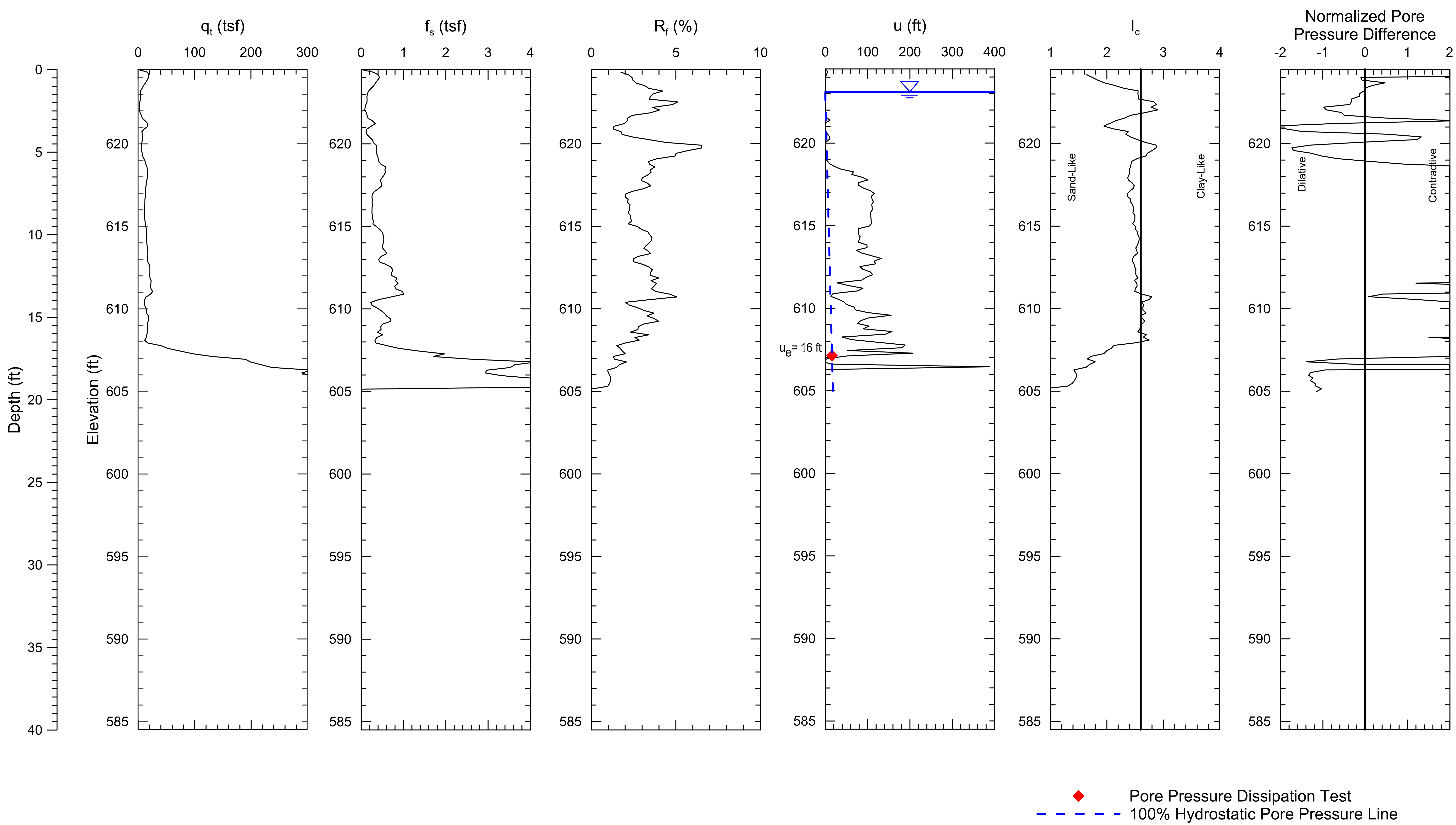
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-010 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-011 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

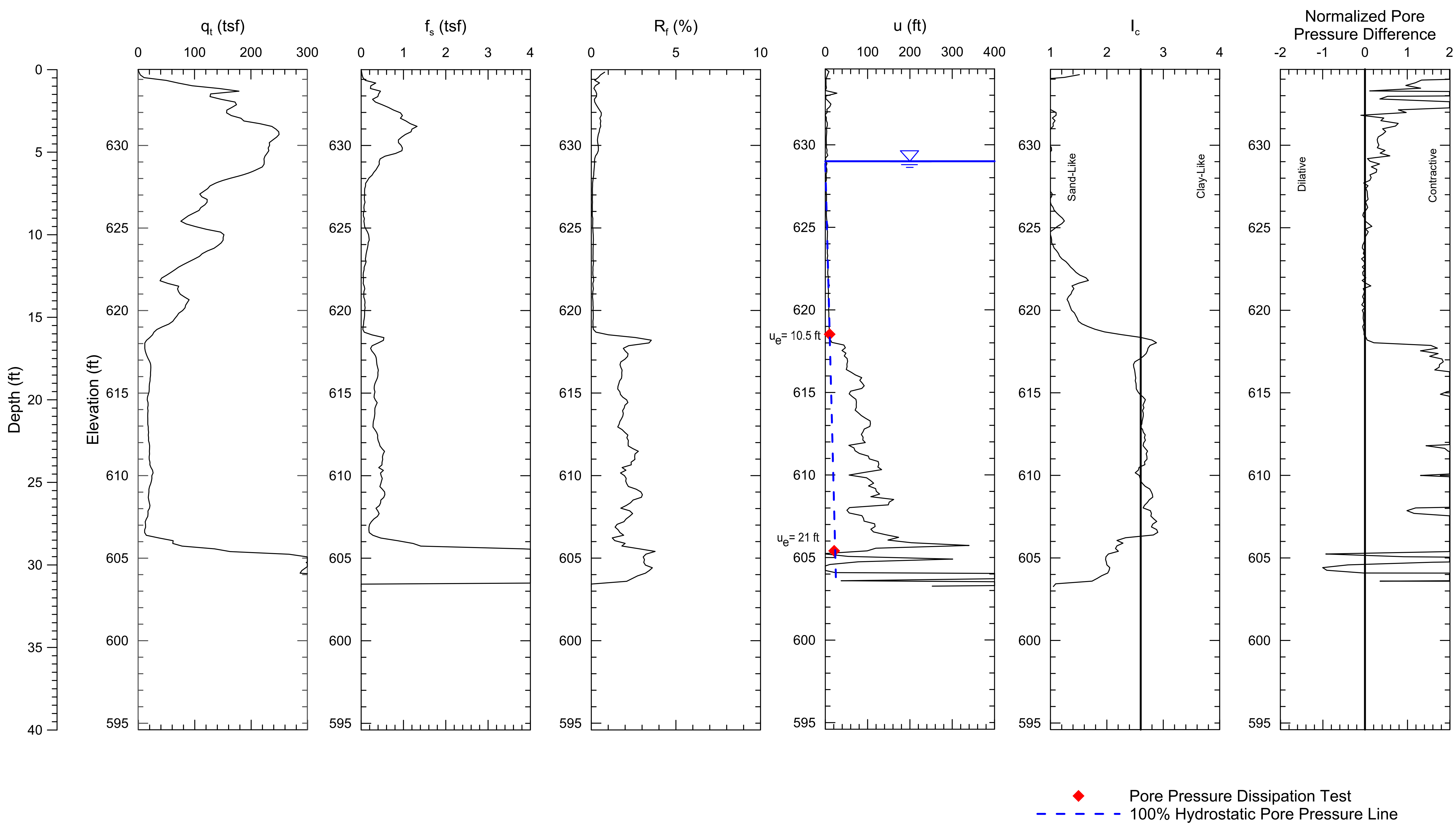


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

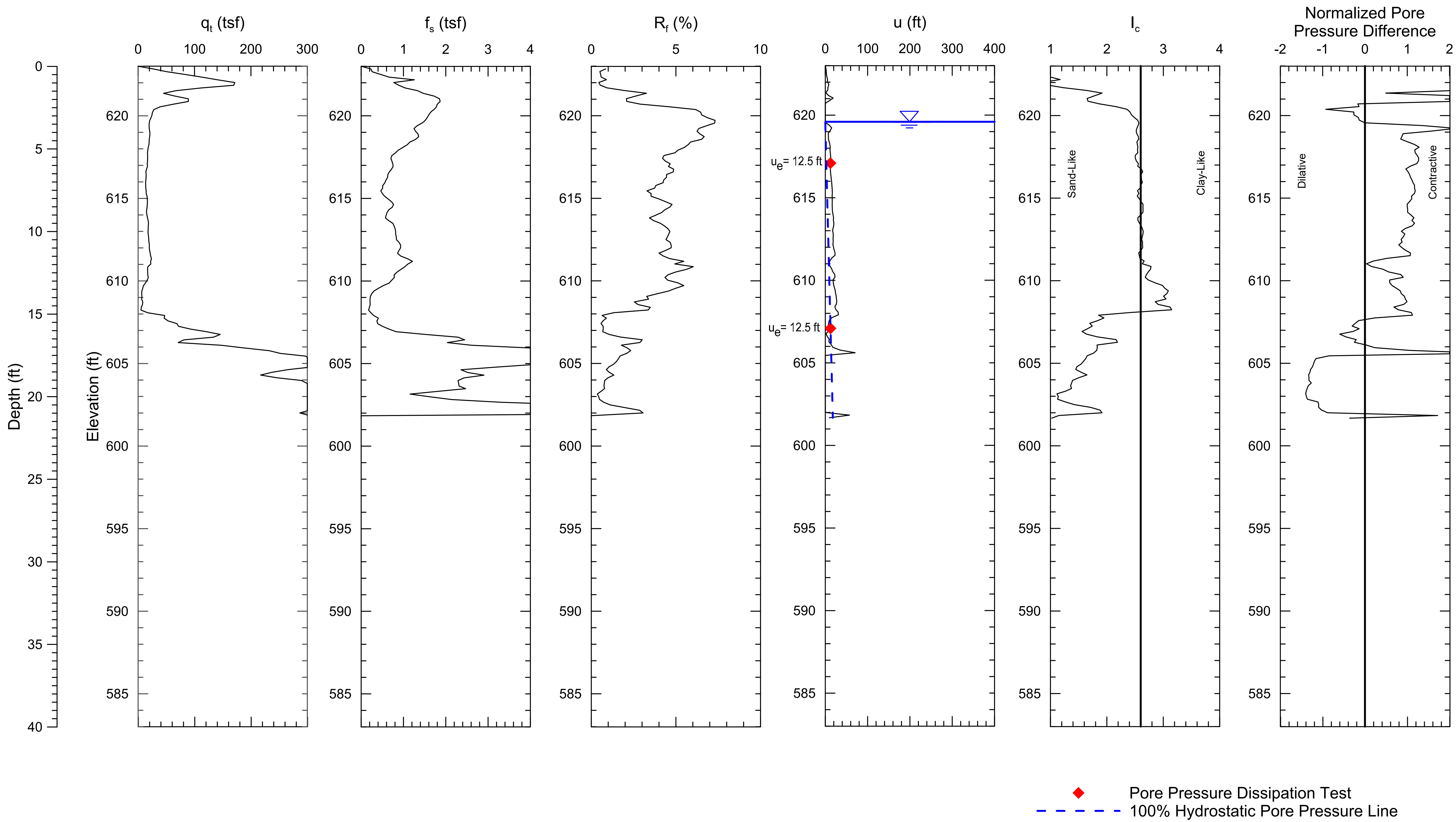
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-012 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-013 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

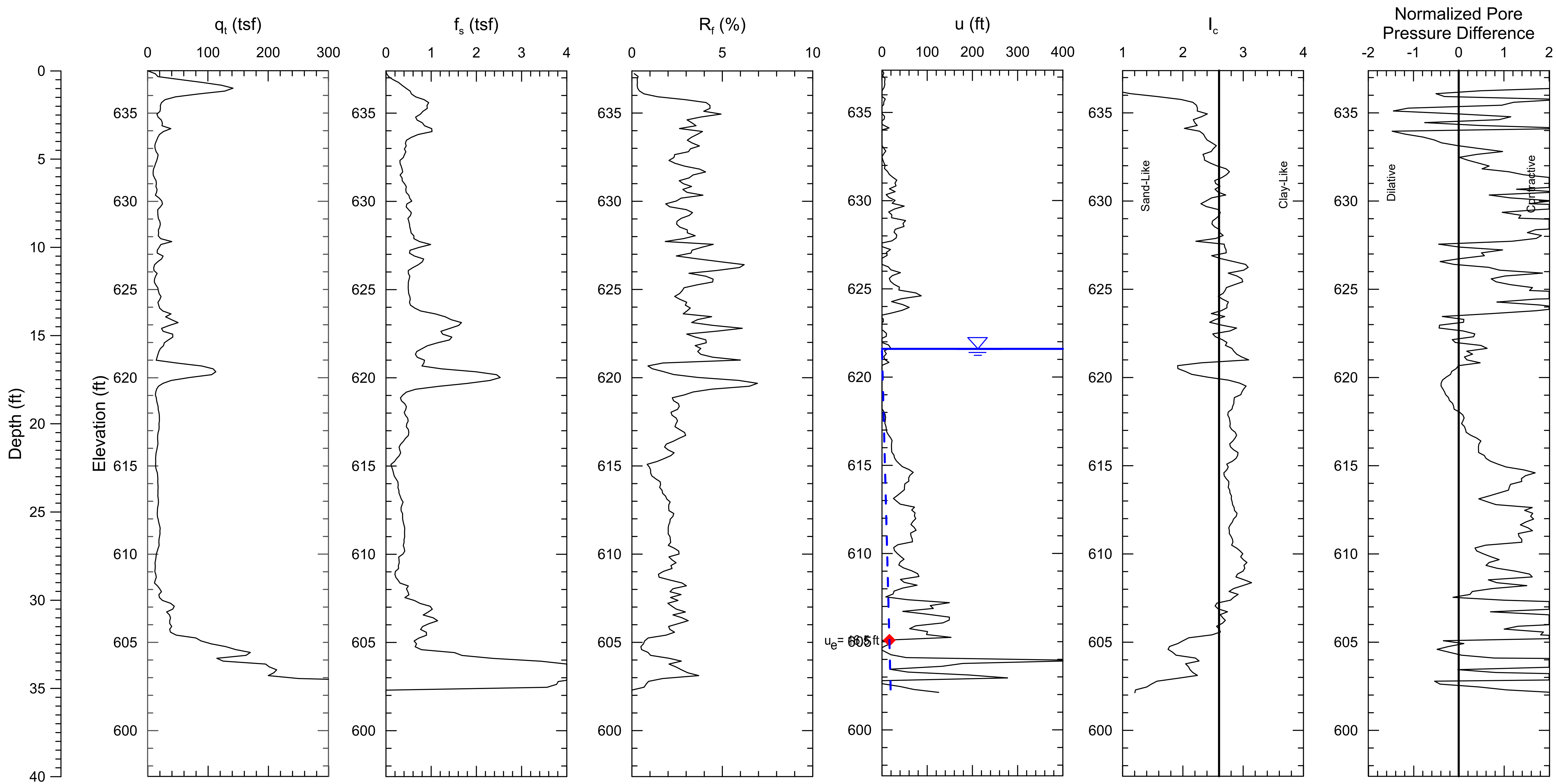


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

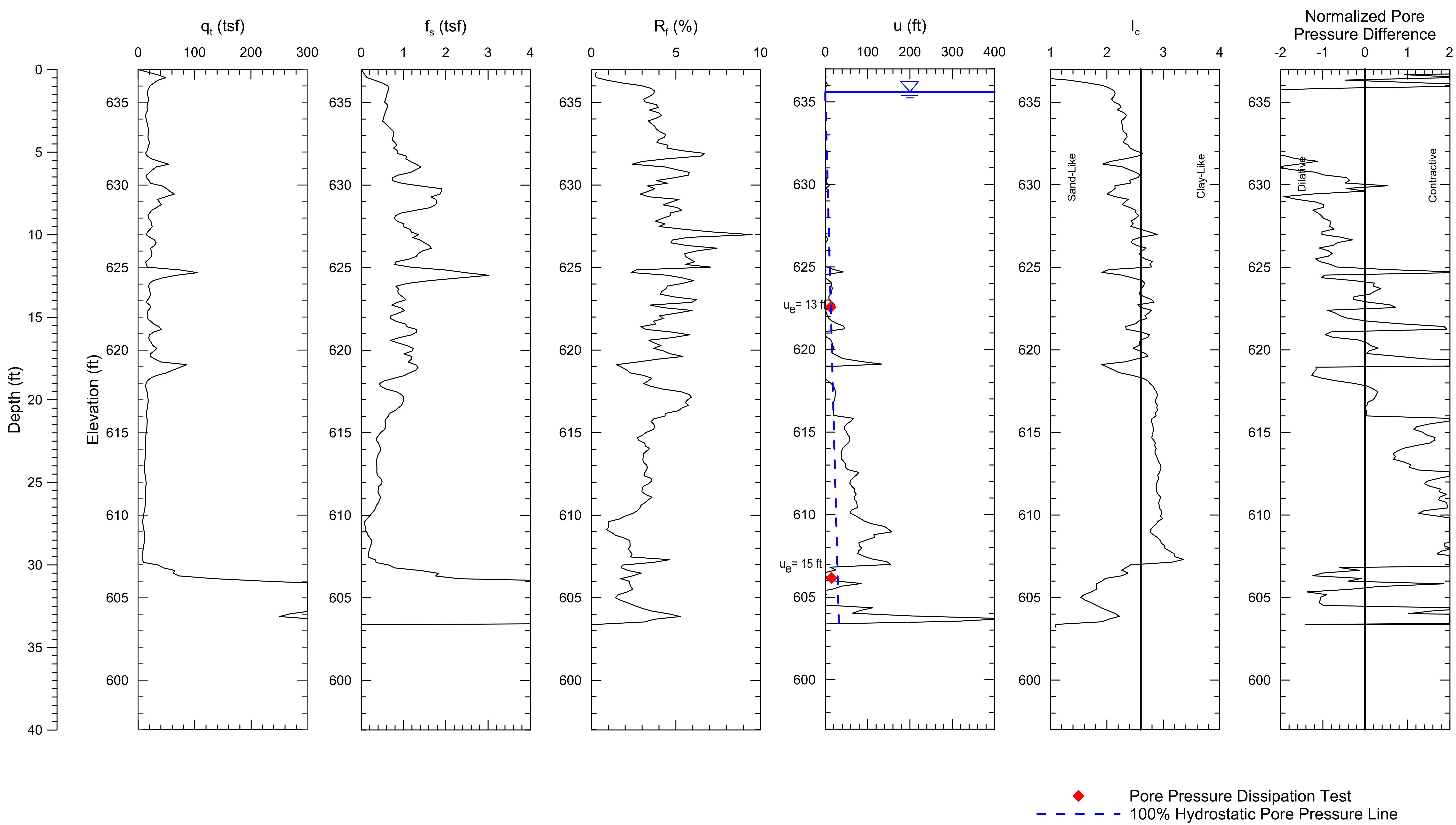
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-014 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Pore Pressure Dissipation Test
100% Hydrostatic Pore Pressure Line

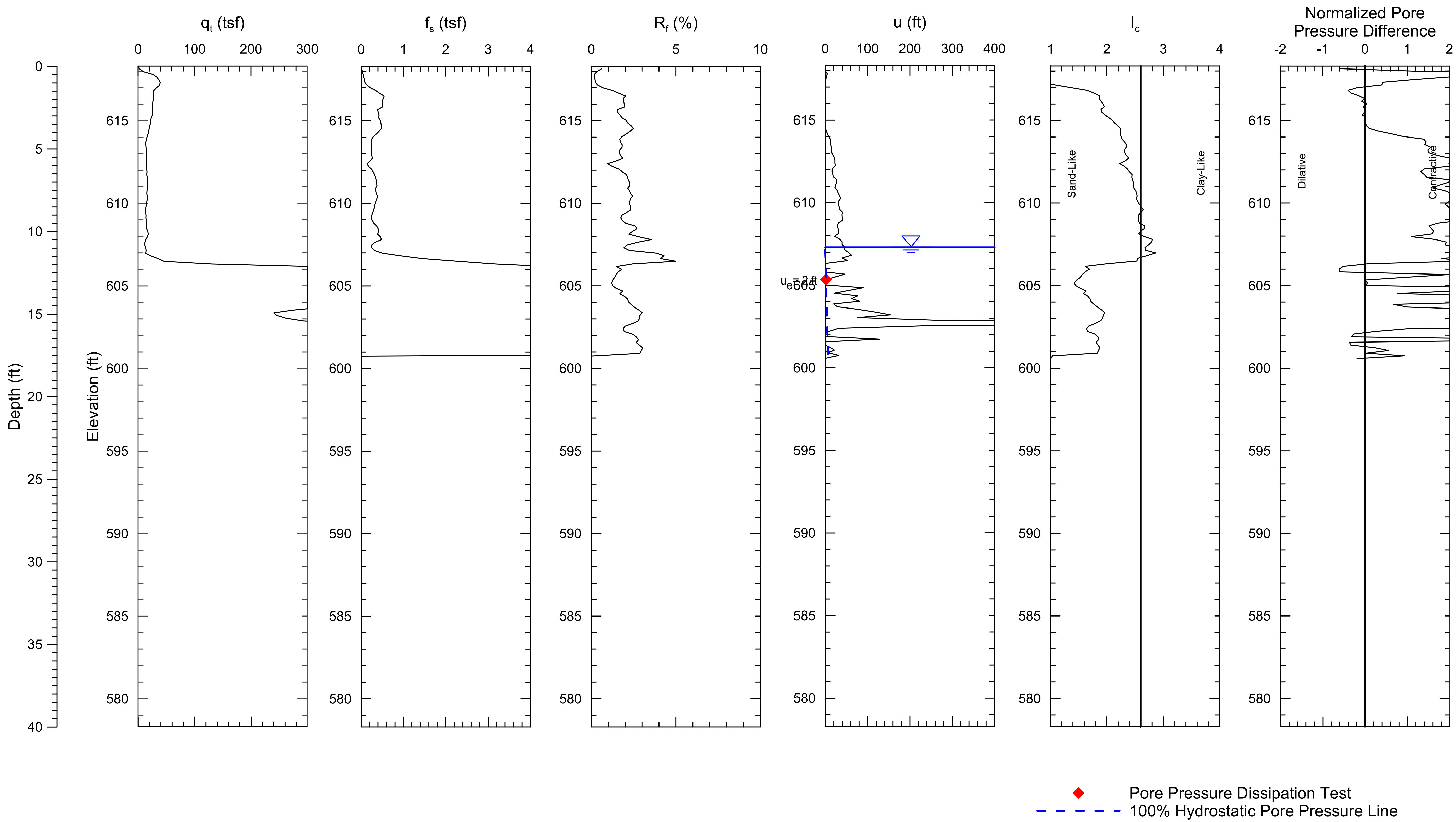
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-015 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



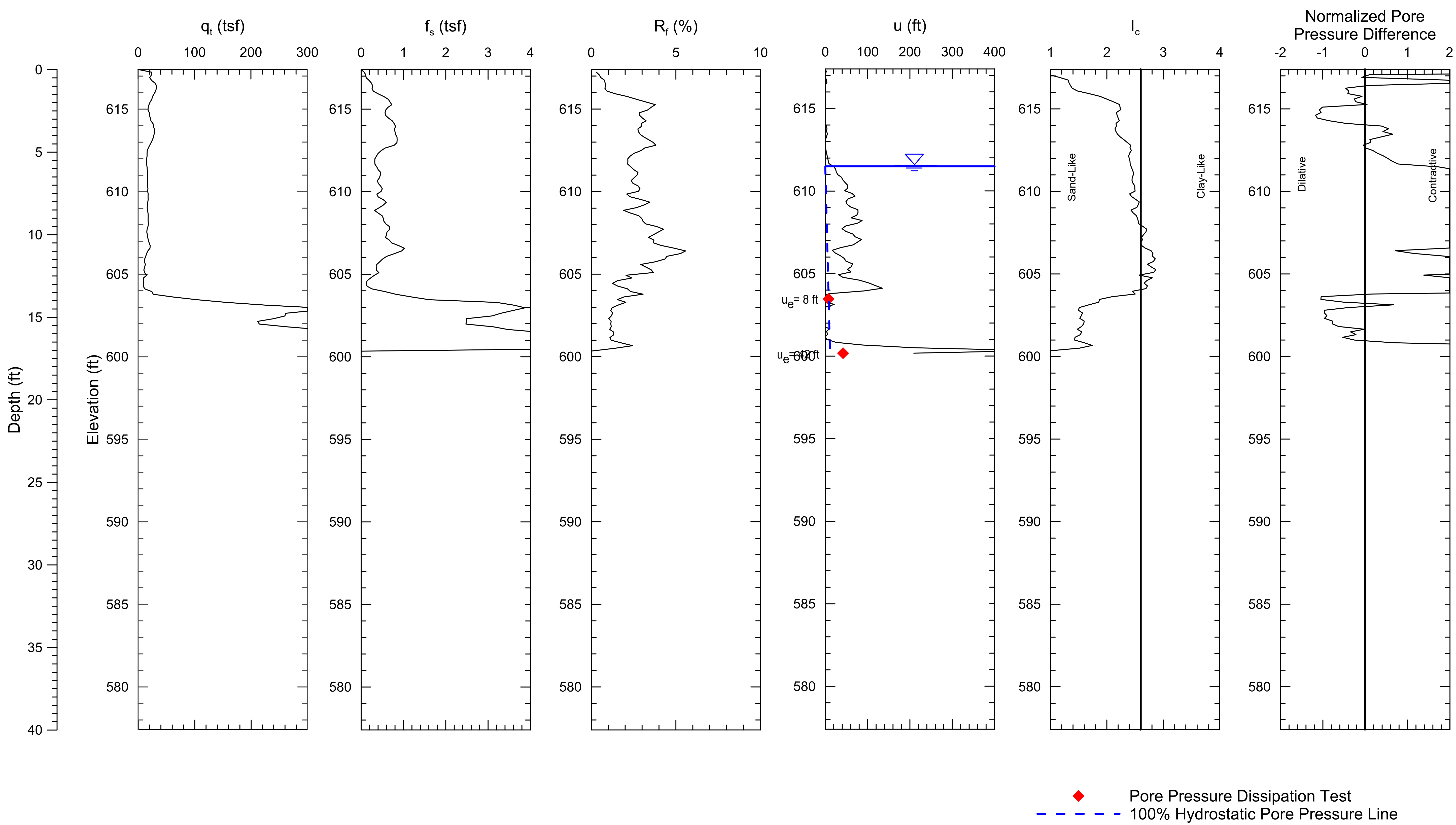
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-016 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-017 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

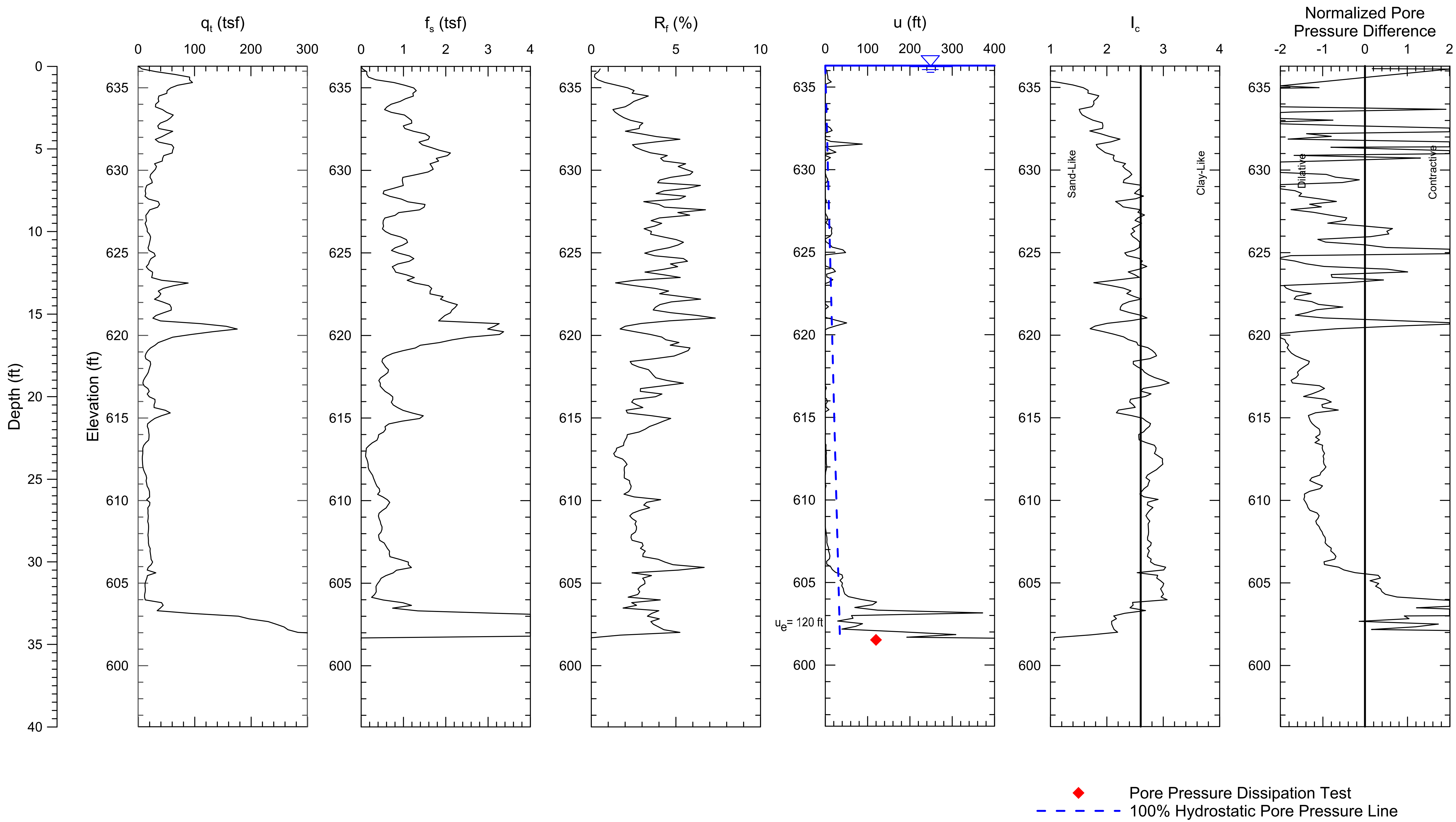


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

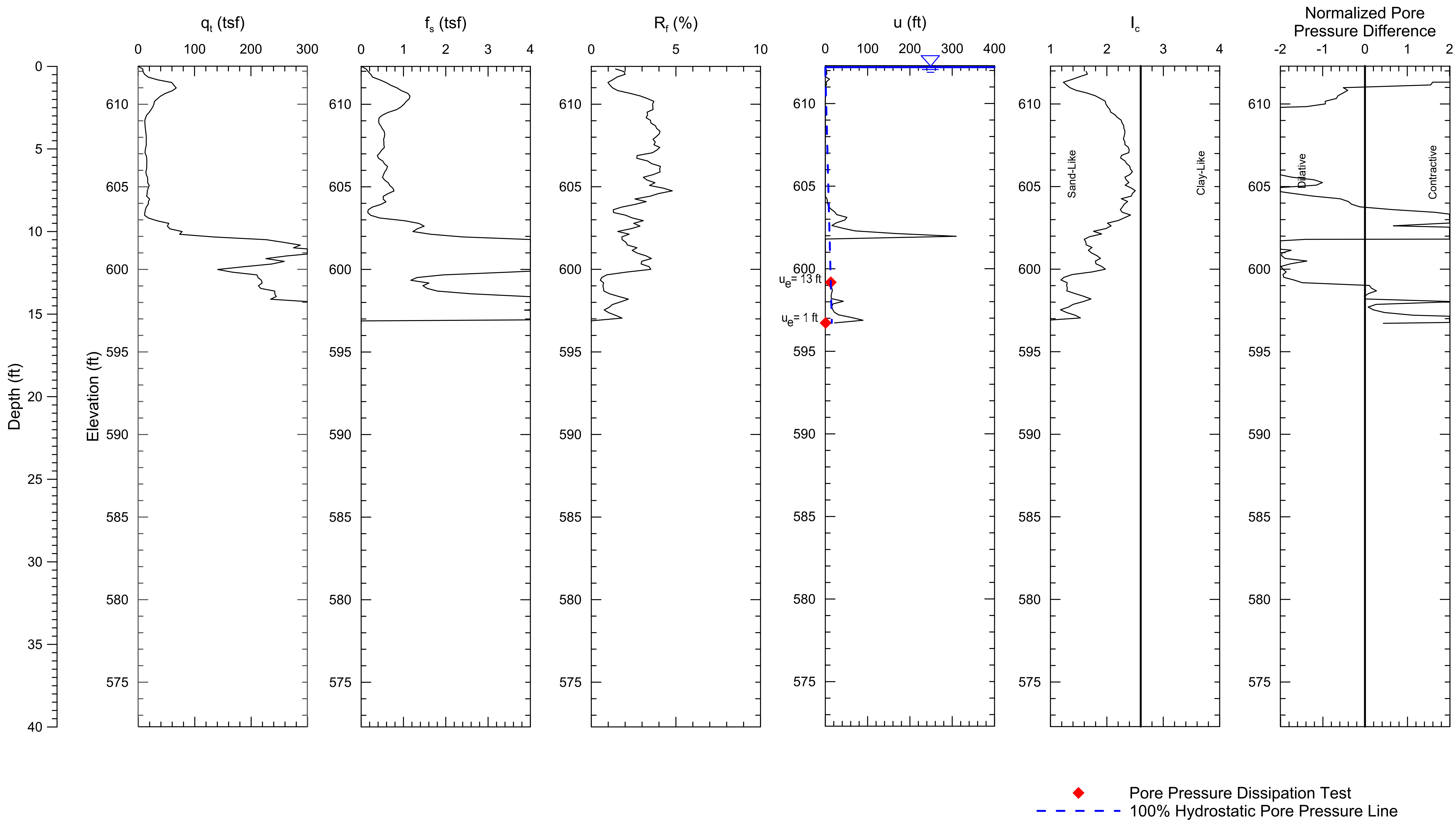
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-018 Coffeen Ash Pond No. 1	FIGURE
AECOM			



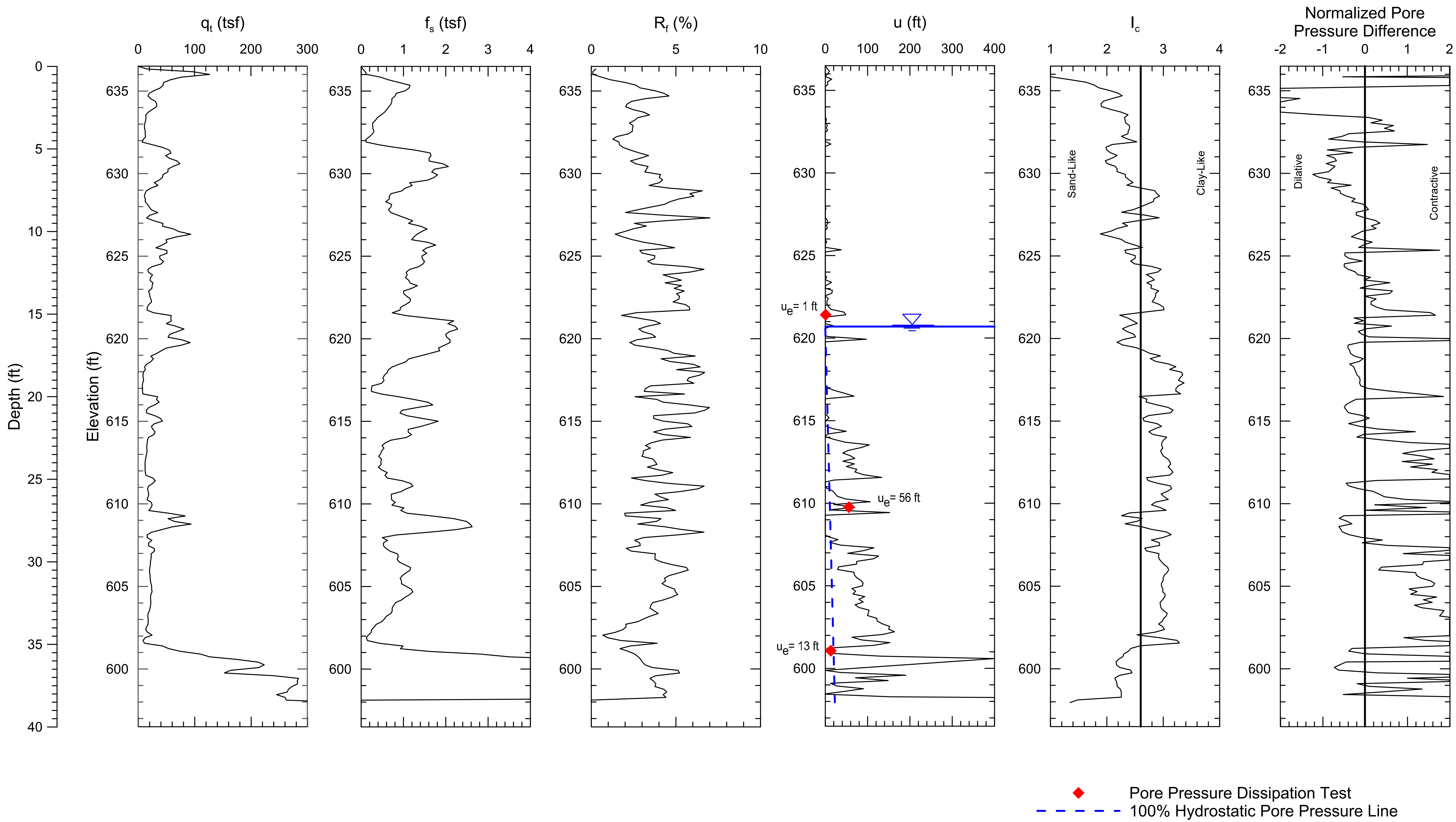
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-019 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



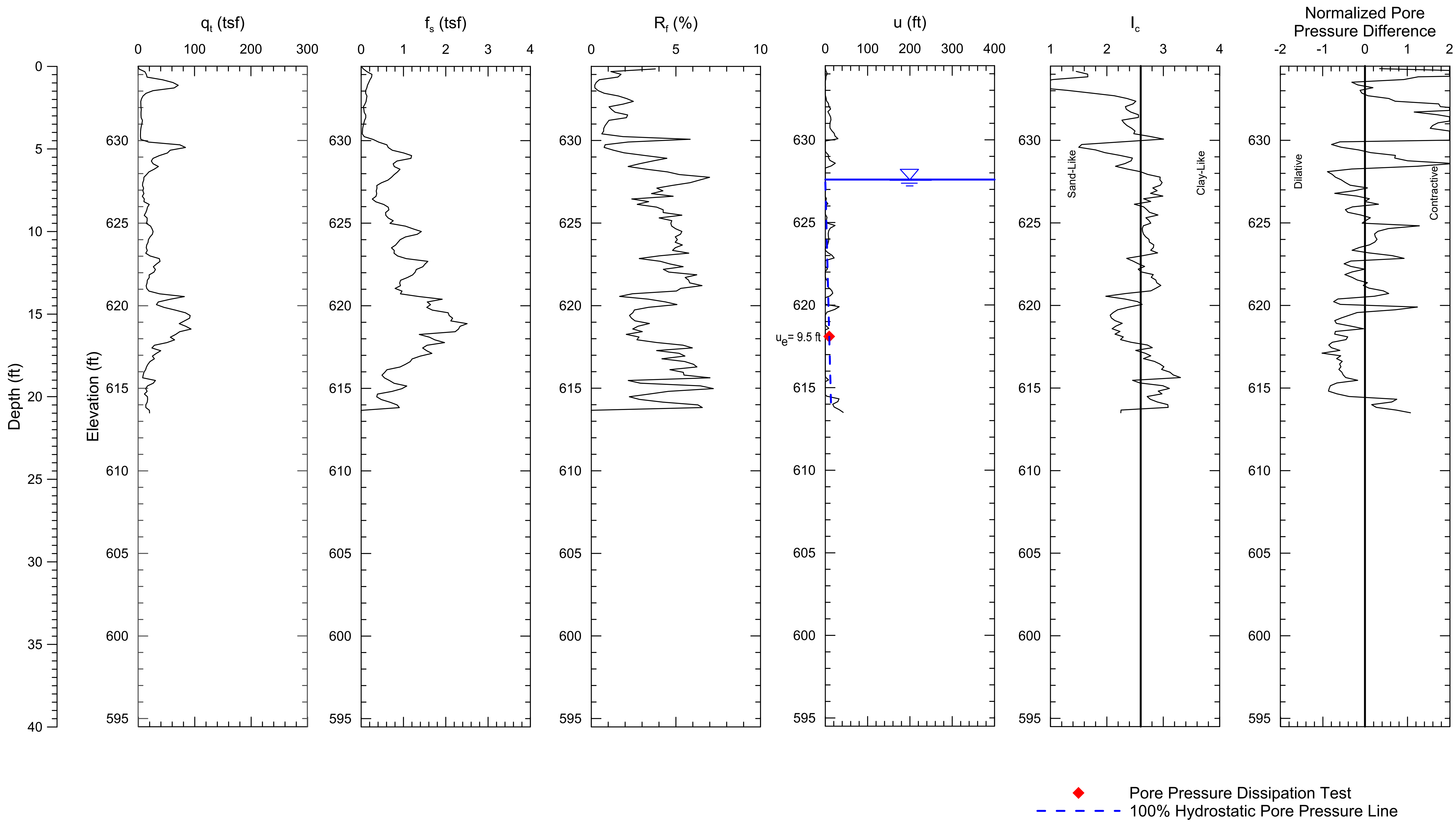
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-020 Coffeen Ash Pond No. 1	FIGURE
AECOM			



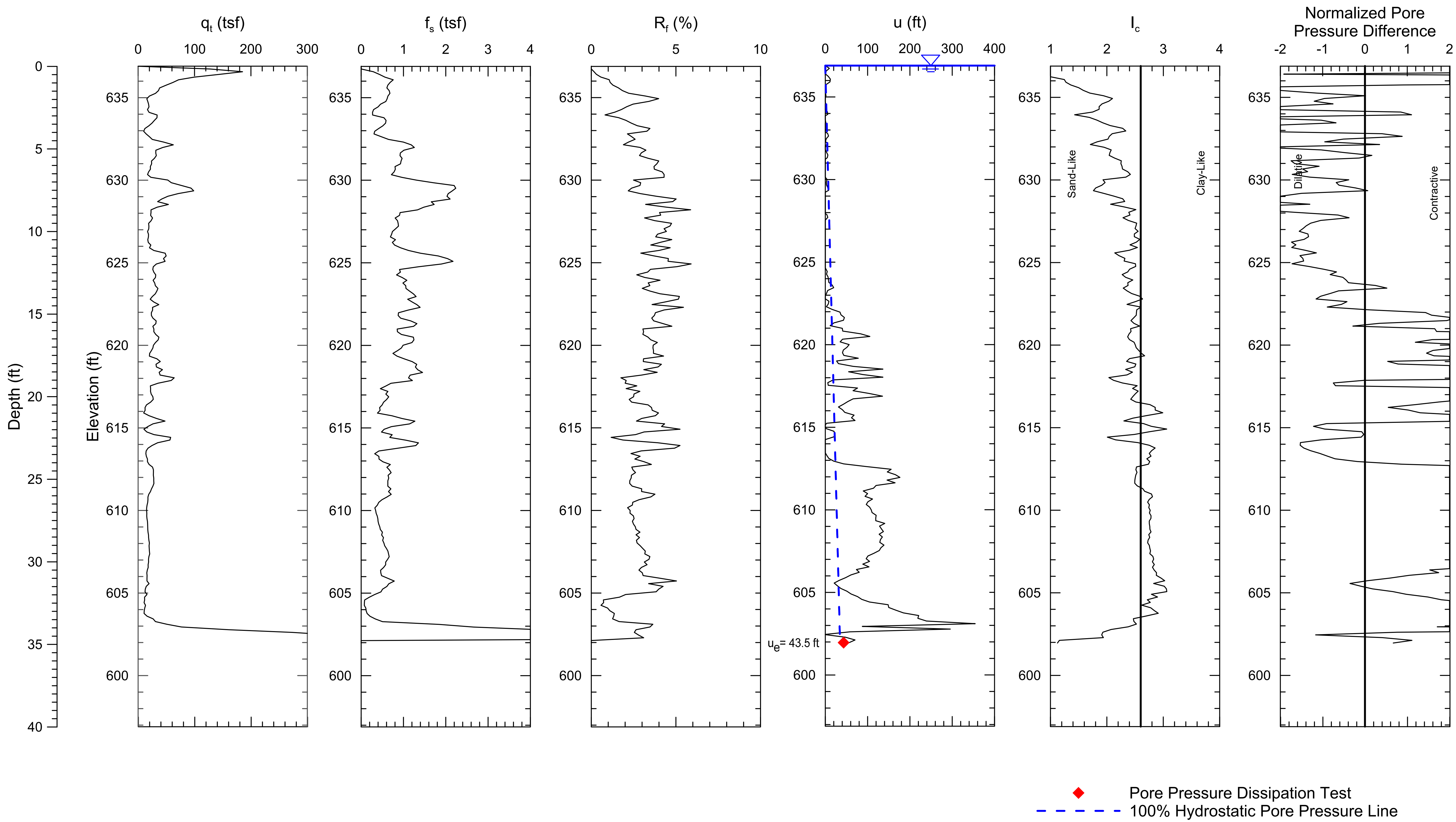
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-022 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-023 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-024 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Material Characterization | Project Name: Dynegy CCR

By: Julie Heitland | Date: 01/06/2016 | Project No: 60480701

Checked By: Amanda Duvigneaud | Date: 01/11/2016 | Task No.: 01

APPENDIX G

Boring Logs

Project:	DYNEGY CCR RULE ASSESSMENT OF PLANTS
Project Location:	COFFEEN POWER STATION MONTGOMERY COUNTY, ILLINOIS
Project Number:	60480701

Key to Soil Boring Logs

	Graphic Symbol	Description	USCS Classification
SAND AND GRAVEL		SAND poorly graded	SP
		Silty SAND	SM
		Clayey SAND	SC
LOW PLASTIC SILTS AND CLAYS		Inorganic low plastic CLAY	CL
HIGH PLASTIC CLAYS		Inorganic high plastic CLAY	CH
SURFACE MATERIAL		Ash	

NOTE: Dual classifications on the logs (eg. SP–SC) are represented by two graphical patterns.

TERMS DESCRIBING DENSITY OR CONSISTENCY

Coarse grained soils (major portion retained on No. 200 sieve) include gravels and sands. Density is based on the Standard Penetration Test (SPT).

Density	SPT blows per foot
Very loose	0 – 5
Loose	5 – 10
Medium dense	10 – 30
Dense	30 – 50
Very dense	Greater than 50

Fine grained soils (major portion passing No. 200 sieve) include clays and silts. Consistency is rated according to shearing strength, as indicated by uncorrected SPT blows per foot.

Descriptive Term	SPT blows per foot	Estimated undrained shear strength (ksf)	Hand Test
Very soft	0–2	< 0.25	Extrudes between fingers
Soft	2–4	0.25–0.5	Molded by slight pressure
Medium stiff	4–8	0.5–1.0	Molded by strong pressure
Stiff	8–15	1.0–2.0	Indented by thumb
Very stiff	15–30	2.0–4.0	Indented by thumbnail
Hard	> 30	> 4.0	Difficult to indent

LEGEND AND NOMENCLATURE

Standard penetration split spoon test sample

Undisturbed shelby tube sample

PP qu Pocket penetrometer unconfined compressive strength
NMC Natural Moisture Content, %
LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
NP Non–plastic
∇ Depth Groundwater enters at time of drilling.
▼ Groundwater Level at some specified time after drilling
Su Undrained Shear Strength
TXUU Triaxial Unconsolidated Undrained
DTW Depth to water
N/A Not Applicable

SAMPLING RESISTANCE

P Sample pushed by hydraulic rig action.

3 6 9 Numbers indicate blows per 6 in. of sampler penetration. Standard penetration test sampler, (2–in O.D.) and oversize penetration sample (3–in O.D.) are driven by a 140 lb hammer falling freely 30–in

50/2 Number of blows (50) used to drive a penetration sampler a certain number of inches (2)
WOH Weight of hammer
WOR Weight of rods

ABBREVIATIONS USED UNDER "REMARKS"

HSA	Hollow Stem Auger	No.	Number
ATD	At Time of Drilling	CIU	Isotropically Consolidated Undrained
AD	After Drilling	ST	Shelby Tube
ID	Inside Diameter	SS	Split Spoon
OD	Outside Diameter		
RQD	Rock Quality Designation		
-#200	(% Pass #200 Sieve)		
Sa (%)	Sieve Analysis (% Passing #200)		

AECOM

Filename: N:\PROJECTS\60428794_DYNEGY_CCR_RULEASMT\SUB_0017.0_CAD_GIS\17.05_WORKING_FILES\FIELD EXPLORATION\COFFEEN\COFFEEN SOIL LOG KEY.DWG

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B001

Date(s) Drilled	08/07/2015 8:40 AM to 08/07/2015 4:10 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	35.0 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.016 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P000 5 ft South of COF-B001)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871590.925 E 2516693.603 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.0	0						636.0 / 0.0								
635		SS	S1	3 4 6	67		Stiff, moist, brown and gray, silty and sandy CLAY, trace fine gravel, topsoil upper 2 inches, (CL) (EMBANKMENT FILL).	12.9				3.5			
	5	SS	S2	2 4 6	61		Stiff, moist, brown and gray, low plasticity, silty and sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	20.3		31	17	2.5			
630		SS	S3	2 5 7	72		Stiff, very moist, brown and gray, low plasticity, silty and sandy CLAY, trace gravel (CL) (EMBANKMENT FILL).	15.4				1.75			
	10	SS	S4	2 4 5	83		Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, with gray silt seams, (CL) (EMBANKMENT FILL).	16.1				1.5			
625															
	15	ST	S5		92		Very stiff, very moist, dark grayish brown with yellowish brown and dark gray, low plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).	14.7	129.4	35	20	2.5			
620															
617.0	19.0	SS	S6	1 2 2	83		Very stiff to 19'								
	20						Soft, wet, brown and gray, low plasticity, silty CLAY, trace fine sand and decayed organic matter, organic odor, (CL) (NATIVE).	23.2							
615.0	21.0	ST	S7		92		Gray with yellowish brown, high plasticity, CLAY, with sand, (CH).	23.4	125.7	66	44				
613.0	23.0	SS	S8	1 4 5	100		Stiff, very moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL).	19.6		41	26	1.5			
610	25														
606.5	29.5	SS	S9	1 3 3	100			16.8				< 0.25			
	30														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B001

Elevation (feet)	Depth (feet)	SAMPLES: Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
605	30		S10		58		Medium stiff, very wet, orange brown, medium plasticity, sandy CLAY, trace silt, (CL). 604.8 / 31.2					4.5			*Pushed 14" then refused. Hard at tip of tube.*
							Hard, sandy CLAY, trace fine gravel, trace silt, low plasticity, (CL) (TILL).								
			S11	8 17 24	78		Hard, brown and gray, low plasticity, CLAY, trace fine gravel, trace silt, (CL) (TILL). 601.0 / 35.0	11.7		30	17	4.5			
600	35						End of Boring at 35 ft								*Installed Piezometer COF-P000 with 5 ft offset to the South.*
595	40														
590	45														
585	50														
580	55														
575	60														
	65														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B002

Date(s) Drilled	08/06/2015 9:30 AM to 08/06/2015 3:00 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	35.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.774 ft NAVD88
Borehole Backfill	Piezometer COF-P002	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871459.02 E 2516044.226 (ft NAD83)	Groundwater Level(s)	28 ft on 8/6/2015 1:00:00 PM		

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.8	0.0														
635			S1	1 2 4	78		Medium stiff, very moist, brown and gray, low plasticity, CLAY, trace organics, (CL) (EMBANKMENT FILL).	25.4				2.0			
	5		S2	2 3 5	89		Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	25.9		35	18	1.0			
630			S3	1 3 5	83		Medium stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	25.9				1.25			
	10		S4		100		Very stiff, very moist, gray with yellowish brown, medium plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).	17.8	134.5	40	25	3.5			
625															
	15		S5	1 1 2	78		Soft, moist to wet, brown and gray, low plasticity, CLAY, with fine sand, trace fine gravel, (CL) (EMBANKMENT FILL).	23.3				0.75			
			S6		100		Soft, very moist, gray with brown, low plasticity, silty CLAY, (CL) (EMBANKMENT FILL).	26.7	120.2	25	7	0.75			
620 / 619.8	17.0														
	20		S7	2 3 5	94		Medium stiff, very moist, brown and gray, medium plasticity, CLAY, trace fine sand, with brown silt seams, (CL) (NATIVE).	25.4		47	29	1.5			
615															
	25		S8	2 3 4	100			18.9				0.75			
610															
608.8	28.0						Loose, very wet, brown, fine to coarse clayey SAND, trace gravel, (SC) (NATIVE).								
	30		S9	1 2 4				13.6							

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B002

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Material Description	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	Remarks
	30													*Till ~ 31.5' harder drilling*
605.3	31.5					Very dense, moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, with iron staining, (CL) (TILL).								
			S10	34/50 4"			9.5		20	7				
601.3	35.5					End of Boring at 35.5 ft								*Very hard drilling with new teeth. Installed Piezometer COF-P002 in boring.*

Elevation scale: 605, 600, 595, 590, 585, 580, 575

Depth scale: 30, 35, 40, 45, 50, 55, 60, 65

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B003

Date(s) Drilled	08/05/2015 11:30 AM to 08/05/2015 5:30 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	45.0 ft
Drill Rig Type	CME 550X (Rubber Tire ATV)	Drilling Contractor	Geotechnology	Surface Elevation	637.523 ft NAVD88
Borehole Backfill	Piezometer COF-P003	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871825.695 E 2515128.189 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	SAMPLES Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
637.5	0.0												
		S1	3 5 4	50	Stiff, dry, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, trace coarse ash, (CL) (EMBANKMENT FILL).	14.2				4.5			
		S2	2 3 4	67	Medium stiff, moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, trace coarse ash, (CL) (EMBANKMENT FILL).	18.1		42	26	1.25			
		S3	2 2 5	67	Medium stiff, moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	15.0				2.5			
		S4	2 4 8		Stiff, very moist, brown and gray, medium plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	17.4				1.5			
623.5	14.0	S5		92	Stiff, very moist, dark gray to yellowish brown, high plasticity, CLAY, trace fine sand, (CH).	21.8	127.5	54	36	1.75			
		S6	2 3 4	83	Medium stiff, very moist, brown and gray, high plasticity, CLAY, trace fine sand, (CH).	26.0				1.75			
		S7	WOH 2 3	100	Medium stiff, very moist, brown and gray, medium-high plasticity, CLAY, with sand, with iron stained seams, (CL-CH).	20.8		50	34	1.75			
608.5	29.0	S8	2 1 9	100	Stiff, very moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, (CL).	12.5		21	6	3.5			

AECOM

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B003

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30		S9		100			11.8	141.7			4.5			
606.5	31.0						Dense, wet, dark yellowish brown with grayish brown, silty SAND, trace gravel, (SM).								S9 refusal at 30.8'
604.0	33.5		S10	2 2 6			Loose, very wet, brown, fine to coarse SAND, (SP).								Top of S10 full of water
599.0	38.5		S11	19 34 40	61		Very dense, very wet, brown, silty fine to coarse SAND, trace gravel, (SP) (TILL).	9.5							
594.0	43.5		S12	30 60 50/3"	100		Very dense, very wet, brown and gray, fine to coarse clayey SAND, trace fine gravel, (SC) (TILL).	9.9							Installed Piezometer COF-P003 in boring.
592.5	45.0						End of Boring at 45 ft								

Elevation scale: 605, 600, 595, 590, 585, 580, 575
Depth scale: 30, 35, 40, 45, 50, 55, 60, 65

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B004

Date(s) Drilled	08/04/2015 10:20 AM to 08/05/2015 11:00 AM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	45.0 ft
Drill Rig Type	CME 550X (Rubber Tire ATV)	Drilling Contractor	Geotechnology	Surface Elevation	636.258 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P005 5 ft West of COF-B004)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 872193.263 E 2516088.178 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.3	0.0													
		SS	S1	2 3 5	67	Medium stiff, moist, brown, low plasticity, CLAY, with fine sand, trace fine gravel, (CL) (EMBANKMENT FILL).	18.0				1.75			
		SS	S2	3 4 5	67	Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	10.9				3.5			
		SS	S3	2 4 4	72	Medium stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	11.0				2.25			
		ST	S4		79	Medium stiff, moist, yellowish brown with gray, low plasticity, CLAY, with sand, (CL) (EMBANKMENT FILL).	12.8	136.6	39	24	2.25			
		SS	S5	3 5 6	94	Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	13.1		26	12	4.0			
618.3	18.0	SS	S6	2 3 7	83	Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, with gray silt seams, (CL) (NATIVE).	21.8				1.75			
		ST	S7		92	Very stiff, very moist, reddish brown, high plasticity, silty CLAY, trace fine sand, with dark gray silt seams, (CL).	20.6	129.5	51	34	2.75			
		SS	S8	1 4 5	100	Stiff, very moist, brown and gray silt seams, medium plasticity, CLAY, with fine to medium sand, (CL).	24.2		43	27	1.75			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B004

Elevation (feet)	Depth (feet)	SAMPLES Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
603.8	32.5						Hard, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (TILL).								
	34		S9	16 31 37	100			8.4		21	8	4.5+			
	39		S10	14 45 44	83		Hard, moist, brown and gray, low plasticity, sandy silty CLAY, trace fine to coarse gravel, (CL) (TILL). 38.5' - 39.2' gray silt seams	8.8				4.5+			
592.8	43.5		S11	19 54 50/4"	94		Hard, wet, brown and gray, low plasticity, sandy silty CLAY, trace gravel, (CL) (TILL).	14.8				-			
591.3	45.0						End of Boring at 45 ft								*Installed Piezometer COF-P005 with 5 ft offset to the West.*

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B005

Date(s) Drilled	08/08/2015 7:45 AM to 08/08/2015 12:00 PM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	60.0 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	636.496 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout (Installed COF-P006 5 ft South of COF-B005)	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 872102.375 E 2516696.89 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION (Elevation (feet) / Depth (feet))	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
636.5	0.0													
	1.0–2.5	SS	S1	2 3 4	83	Medium stiff, moist, brown and gray, low plasticity, CLAY, (CL) (EMBANKMENT FILL).	21.1				1.5			
	3.5–5.5	ST	S2		54	Stiff, moist, brown, low plasticity, sandy CLAY, (CL) (EMBANKMENT FILL).	8.0	136.6	22	9	3.0			
	6.0–7.5	SS	S3	1 3 4	72	Medium stiff, moist, brown, low plasticity, sandy CLAY, (CL) (EMBANKMENT FILL).	13.1				0.75			
	8.5–10.0	SS	S4	2 7 6	89	Stiff, moist, brown, low plasticity, sandy silty CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	9.9		20	6	3.0			*Shale in tip*
	13.5–15.0	SS	S5	2 6 6	78	Stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	10.3				2.0			
	18.5–20.0	SS	S6	WOH 2 3	67	Medium stiff, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (EMBANKMENT FILL).	9.4				1.0			
613.5	23.0													
	23.5–25.5	ST	S7		92	Stiff to very stiff, gray with grayish brown, low plasticity, CLAY, with sand, with organics, (CL) (NATIVE).	18.7	131.4	37	20	1.5			
608.0	28.5													
	28.5–30.0	SS	S8	1 4 6	89	Stiff, brown and gray, low plasticity, CLAY, trace fine sand, trace organics, (CL).	21.9				2.0			

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B005

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
604.5	32.0					Very stiff, low plasticity, sandy CLAY, with organics, (CL).								
602.5	34.0		S9	1 1 1	100	Very loose, saturated, brown and gray, silty, clayey SAND, (SC-SM).	26.7		22	6	2.5			
601.0	35.5													35': Attempt ST refusal at 35.5'
			S10	8 22 27	100	Dense, wet, brown and gray, clayey SAND, trace fine gravel, (SC) (TILL)	11.6				-			
593.5	43.0		S11	4 7 11	100	Very stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)	12.8		32	17	3.25			
			S12	2 6 8	100	Stiff, saturated, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)	15.5		32	17	3.0			
			S13	2 5 7	100	Stiff, very moist, brown and gray, low plasticity, sandy CLAY, trace gravel, iron stained vertical seams, (CL) (TILL)	23.2				1.25			
			S14	2 3 6	100	Stiff, brown and gray, medium plasticity, CLAY, with sand, (CL) (TILL)	23.3		47	30	1.25			
576.5	60.0					End of Boring at 60 ft								*Installed Piezometer COF-P006 with 5 ft offset to the South.*

Elevation scale: 605, 600, 595, 590, 585, 580, 575. Depth scale: 30, 35, 40, 45, 50, 55, 60, 65.

AECOM

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B006

Date(s) Drilled	08/06/2015 4:00 PM to 08/07/2015 7:30 AM	Logged By	E. Drumright	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	33.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	631.9* ft NAVD88
Borehole Backfill	Cement-Bentonite Grout	Sampling Method(s)	SS / ST	Hammer Data	Automatic
Boring Location	N 871654.5 E 2515234.7* (ft NAD83)	Groundwater Level(s)	4 ft on 8/6/2015 5:00:00 PM		

Elevation (feet)	Depth (feet)	Samples: Type	Samples: Number	Samples: Sampling Resist. OR Core RQD (%)	Samples: Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
631.9*	0.0						Medium dense, moist, black, well-graded sand (cinders), trace silt, trace fine gravel, (ASH).								
		SS	S1	5 13 15	78			6.6							
							Very loose, wet, black, well-graded sand (cinders), trace clay, (ASH).								
		SS	S2	2 2 2	100			48.3							
	5														
		ST	S3		17			22.2							
		SS	S4	3 4 6	100		Loose, wet, black, well-graded sand (cinders), trace clay, (ASH).	16.7							
	10														
-8846.6	14.0														
		SS	S5	WOH 2 3			Medium stiff, very moist, brown and gray, high plasticity, CLAY, trace fine sand, (CH) (NATIVE).	24.4		57	37	1.75			
	15														
		SS	S6	1 3 4	67			21.9				1.25			
	20														
-14533.7	23.0						Very soft, very wet, brown, low plasticity, sandy CLAY, (CL).								
		SS	S7	1 1 1	100			19.8		23	9	0.5			
	25														
-16429.4	26.0						Hard, very wet, brown and gray, low plasticity, sandy CLAY, (CL) (TILL).								
		SS	S8	20 50/4"				16.1							
	30														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B006

Elevation (feet)	Depth (feet)	Type	Number	Sampling Resist. OR Core RQD (%)	Recovery (%)	Graphic Symbol	MATERIAL DESCRIPTION	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	REMARKS
	30														
-21168.7	33.5		S9	24 34 50/5"	94		Hard, moist, brown and gray, low plasticity, sandy CLAY, trace fine gravel, (CL) (TILL).	8.1		25	12				*Hard augering below 32'*
							*Final survey coordinates/elevation are not available. End of Boring at 33.5 ft								
	35														
	40														
	45														
	50														
	55														
	60														
	65														

Project: Dynegy

Project Location: Coffeen Power Station, IL

Project Number: 60440742

Log of Boring COF-B006A

Date(s) Drilled	08/19/2015 7:15 AM to 08/19/2015 10:15 AM	Logged By	A. Grossman	Checked By	D. Swanson
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	7.5 inch O.D. HSA	Borehole Depth	25.5 ft
Drill Rig Type	CME 550X	Drilling Contractor	Geotechnology	Surface Elevation	633.583 ft NAVD88
Borehole Backfill	Cement-Bentonite Grout	Sampling Method(s)	Piston	Hammer Data	-
Boring Location	N 871651.263 E 2515194.552 (ft NAD83)	Groundwater Level(s)	Not Encountered		

Elevation (feet)	Depth (feet)	Samples: Type Number	Samples: Sampling Resist. OR Core RQD (%)	Samples: Recovery (%)	Graphic Symbol	Material Description	Natural Moisture Content (%)	Total Unit Weight (pcf)	Liquid Limit	Plasticity Index	Pocket Pen. Su (ksf)	Torvane Su (ksf)	TXUU (ksf)	Remarks
633.6	0.0					Loose, moist, black, medium to coarse grained sand (cinders), (ASH).								
		PS-1		75										
		PS-2		20										
621.1	12.5					Stiff, light grayish brown, low plasticity, silty CLAY, some ash, (CL).								
		PS-3		70							1.25			
		PS-4		83							1.25			
		PS-5		73							1.25			
		PS-6		93		Stiff to very stiff, grayish brown, low plasticity, CLAY, (CL).					2.0			
608.1	25.5					End of Boring at 25.5 ft								*Auger refusal at 25.5' bgs.*

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Material Characterization

Project Name: Dynegy CCR

By: Julie Heitland Date: 01/06/2016

Project No: 60480701

Checked By: Amanda Duvigneaud Date: 01/11/2016

Task No.: 01

APPENDIX H

Lab Test Results

2015 CIU' Triaxial Test Data

Project: Coffeen Ash Pond No. 1 and No. 2 (Dynegy)
Project No.: 60480701

Notes:

1. Deviator stress (shear stress at failure) calculated using the formula: $q = S_u = (\sigma'_1-\sigma'_3)/2$
2. Effective stress friction angle calculated using the fomula: $\phi' = \sin^{-1}[(\sigma'_1-\sigma'_3)/(\sigma'_1+\sigma'_3)]$
3. Shear stress on the failure plane calculated using the formula: $\tau_{ff} = q*\cos(\phi')$
4. Effective normal stress on the failure plane calculated using the formula: $\sigma'_{ff} = p' - q\sin\phi'$
5. Overconsolidation ratio calculated using the formula: $OCR = \sigma'_{max}/\sigma'_c$

CIU' Triaxial Shear Strength Characterization - Failure Criteria: Peak Obliquity (Max PSR)

Sample	Material Description	Raw Test Number	Location: Ground Elevation (ft)	Location: Sample Depth (ft)	Location: Sample Elevation (ft)	Input Data from Lab Sheets: Effective Consolidation Stress σ'_c (psi)	Input Data from Lab Sheets: Principle Stress Ratio (PSR) σ'_1/σ'_3	Input Data from Lab Sheets: Average Effective Principle Stress $p' = (\sigma'_1+\sigma'_3)/2$ (psi)	Input Data from Lab Sheets: Strain (%)	Calculated Data: σ'_1 (psi)	Calculated Data: σ'_3 (psi)	Calculated Data: q [1] (psi)	Calculated Data: ϕ' [2] (degrees)	Calculated Data: τ_{ff} [3] (psi)	Calculated Data: τ_{ff}/σ'_c	Calculated Data: σ'_{ff} [4] (psi)	Conversion to PSF: Effective Consolidation Stress σ'_c (psf)	Conversion to PSF: σ'_{1f} (psf)	Conversion to PSF: σ'_3 (psf)	Conversion to PSF: τ_{ff} [3] (psf)	Conversion to PSF: τ_{ff}/σ'_c	Stress History: Consolidation Test No.	Stress History: Max Past Pressure σ'_{max} (psi)	Stress History: Tested OCR [5]	Atterberg Limits: Liquid Limit LL	Atterberg Limits: Plastic Limit PL	Atterberg Limits: Plasticity Index PI
Embankment																						Embankment			Embankment		
COF-B001-S5	Embankment Clay	COF-B001-S5-13.5	634.8	13.5	621.3	3.5	5.66	6.26	1.09	10.64	1.88	4.38	44.4	3.13	0.89	3.20	504.00	1532.18	270.70	450.62	0.89	COF-B001-S5	41.67	11.9	35	15	20
COF-B001-S5	Embankment Clay	COF-B001-S5-13.5	634.8	14.0	620.8	6.8	3.45	9.28	3.58	14.39	4.17	5.11	33.4	4.27	0.63	6.47	979.20	2072.05	600.59	614.18	0.63	COF-B001-S5	41.67	6.1			
COF-B001-S5	Embankment Clay	COF-B001-S5-13.5	634.8	14.5	620.3	14.0	3.17	20.34	4.13	30.92	9.76	10.58	31.4	9.04	0.65	14.83	2016.00	4453.14	1404.78	1301.55	0.65	COF-B001-S5	41.67	3.0			
COF-B004-S4	Embankment Clay	COF-B004-S4-8.5	635.0	8.5	626.5	3.0	5.60	5.43	0.87	9.21	1.65	3.78	44.2	2.71	0.90	2.79	432.00	1326.89	236.95	390.80	0.90			0.0	39	15	24
COF-B004-S4	Embankment Clay	COF-B004-S4-8.5	635.0	9.0	626.0	9.1	3.26	14.15	3.07	21.66	6.64	7.51	32.0	6.36	0.70	10.17	1310.40	3118.58	956.62	916.32	0.70			0.0			
COF-B004-S4	Embankment Clay	COF-B004-S4-8.5	635.0	9.5	625.5	3.0	5.56	5.40	0.89	9.15	1.65	3.75	44.0	2.70	0.90	2.79	432.00	1318.13	237.07	388.58	0.90			0.0			
COF-B007-S3	Embankment Clay	COF-B007-S3-5.5	638.0	5.5	632.5	4.3	4.19	6.89	1.89	11.12	2.66	4.23	37.9	3.34	0.78	4.29	619.20	1601.98	382.34	481.03	0.78			0.0	43	17	26
COF-B007-S3	Embankment Clay	COF-B007-S3-5.5	638.0	6.0	632.0	9.8	3.06	14.31	3.81	21.57	7.05	7.26	30.5	6.26	0.64	10.63	1411.20	3106.19	1015.09	900.97	0.64			0.0			
COF-B007-S3	Embankment Clay	COF-B007-S3-5.5	638.0	6.5	631.5	19.1	2.75	20.67	4.48	30.32	11.02	9.65	27.8	8.53	0.45	16.17	2750.40	4365.50	1587.46	1228.50	0.45			0.0			
COF-B008-S6	Embankment Clay	COF-B008-S6-13.0	635.7	13.0	622.7	3.1	6.32	6.72	0.92	11.60	1.84	4.88	46.6	3.35	1.08	3.17	446.40	1670.97	264.39	483.07	1.08			0.0	35	15	20
COF-B008-S6	Embankment Clay	COF-B008-S6-13.0	635.7	13.5	622.2	7.3	3.49	15.11	2.83	23.49	6.73	8.38	33.7	6.97	0.96	10.46	1051.20	3382.49	969.19	1004.10	0.96			0.0			
COF-B008-S6	Embankment Clay	COF-B008-S6-13.0	635.7	14.0	621.7	13.3	3.30	42.98	12.50	65.97	19.99	22.99	32.3	19.42	1.46	30.68	1915.20	9499.58	2878.66	2797.09	1.46			0.0			
COF-B009-S5	Embankment Clay	COF-B009-S5-13.5	635.2	13.5	621.7	2.9	4.20	7.56	1.11	12.21	2.91	4.65	38.0	3.67	1.26	4.70	417.60	1758.57	418.71	528.06	1.26	COF-B009-S5	36.25	12.5	50	15	35
COF-B009-S5	Embankment Clay	COF-B009-S5-13.5	635.2	14.0	621.2	6.1	3.60	11.49	3.54	17.98	5.00	6.49	34.4	5.36	0.88	7.82	878.40	2589.75	719.37	771.47	0.88	COF-B009-S5	36.25	5.9			
COF-B009-S5	Embankment Clay	COF-B009-S5-13.5	635.2	14.5	620.7	13.9	2.91	23.46	7.25	34.92	12.00	11.46	29.2	10.00	0.72	17.86	2001.60	5028.48	1728.00	1439.95	0.72	COF-B009-S5	36.25	2.6			
Foundation Clay																						Foundation Clay			Foundation Clay		
COF-B004-S7	Foundation Clay	COF-B004-S7-23.5	635.0	23.5	611.5	5.1	4.96	12.34	2.50	20.54	4.14	8.20	41.6	6.13	1.20	6.89	734.40	2957.62	596.30	882.37	1.20			0.0	51	17	34
COF-B004-S7	Foundation Clay	COF-B004-S7-23.5	635.0	24.0	611.0	11.2	3.42	16.72	4.12	25.87	7.57	9.15	33.2	7.66	0.68	11.71	1612.80	3725.91	1089.45	1103.09	0.68			0.0			
COF-B004-S7	Foundation Clay	COF-B004-S7-23.5	635.0	24.5	610.5	23.2	3.15	23.45	5.47	35.60	11.30	12.15	31.2	10.39	0.45	17.16	3340.80	5126.23	1627.37	1496.35	0.45			0.0			
COF-B005-S7	Foundation Clay	COF-B005-S7-23.5	635.1	23.5	611.6	5.0	5.05	9.52	3.03	15.89	3.15	6.37	42.0	4.73	0.95	5.25	720.00	2288.58	453.18	681.74	0.95	COF-B005-S7	29.44	5.9	37	17	20
COF-B005-S7	Foundation Clay	COF-B005-S7-23.5	635.1	24.0	611.1	11.0	3.61	24.53	6.99	38.42	10.64	13.89	34.5	11.45	1.04	16.67	1584.00	5532.18	1532.46	1648.47	1.04	COF-B005-S7	29.44	2.7			
COF-B005-S7	Foundation Clay	COF-B005-S7-23.5	635.1	24.5	610.6	23.3	2.95	23.64	4.95	35.31	11.97	11.67	29.6	10.15	0.44	17.88	3355.20	5084.69	1723.63	1461.47	0.44	COF-B005-S7	29.44	1.3			
COF-B007-S7	Foundation Clay	COF-B007-S7-20.0	638.0	20.0	618.0	5.0	3.34	8.47	3.46	13.04	3.90	4.57	32.6	3.85	0.77	6.01	720.00	1877.30	562.06	553.84	0.77	COF-B007-S7	32.08	6.4	52	17	35
COF-B007-S7	Foundation Clay	COF-B007-S7-20.0	638.0	20.5	617.5	10.8	4.12	15.82	4.12	25.46	6.18	9.64	37.5	7.64	0.71	9.95	1555.20	3666.29	889.88	1100.68	0.71	COF-B007-S7	32.08	3.0			
COF-B007-S7	Foundation Clay	COF-B007-S7-20.0	638.0	21.0	617.0	22.8	3.29	22.51	5.59	34.53	10.49	12.02	32.3	10.16	0.45	16.10	3283.20	4971.72	1511.16	1463.14	0.45	COF-B007-S7	32.08	1.4			
Lower Foundation Clay																						Lower Foundation Clay			Lower Foundation Clay		
COF-B008-S9	NC Foundation Clay	COF-B008_9b_NF_CIU	635.7	29.0	606.7	18.5	3.82	20.85	2.06	33.05	8.65	12.20	35.8	9.89	0.53	13.71	2664.00	4758.99	1245.81	1424.57	0.53	COF-B008_9b_NF_consol	28.47	1.5			

Note: Foundation Clay + Lower Foundation Clay combined into a single layer termed "Foundation Clay"

Project: Coffeen Ash Pond No. 1 and No. 2 (Dynegy)
Project No.: 60480701

Notes:
1. Effective stress friction angle calculated using the fomula: $\phi' = \tan^{-1}(\tau_{ff}/\sigma'_v)$
2. Equivalent friction angle calculated using the fomula: $\psi = \tan^{-1}(\tau_{ff}/\sigma'_c)$

Direct Simple Shear Strength Characterization - Failure Criteria: See Individual Test

Sample	Material Description	Raw Test Number	Location			Input Data from Lab Sheets				Calculated Data				Conversion to PSF				Stress History			Atterberg Limits		
			Ground Elevation (ft)	Sample Depth (ft)	Sample Elevation (ft)	Effective Consolidation Stress σ'_c (psi)	Vertical Effective Stress σ'_v (psi)	Shear Stress on the Failure Plane at Failure τ_{ff} (psi)	Strain(%)	ϕ' (1) (degrees)	τ_{ff}/σ'_c	ψ (2) (degrees)	Failure Criteria	Effective Consolidation Stress σ'_c (psi)	Vertical Effective Stress σ'_v (psi)	τ_{ff} (psf)	τ_{ff}/σ'_c	Consolidation Test No.	Max Past Pressure σ'_{max} (psi)	Tested OCR [5]	Liquid Limit LL	Plastic Limit PL	Plasticity Index PI
								Foundation Clay											Foundation Clay			Foundation Clay	
COF-B001-S7	Foundation Clay	DSS COF-B001-S7-23.0	634.8	21.0	613.8	5.8	4.44	2.66	10.02	30.9	0.46	24.6	Max Shear Stress/10% Strain	835.20	639.36	383.04	0.46			0	66	22	44
COF-B001-S7	Foundation Clay	DSS COF-B001-S7-23.0	634.8	21.5	613.3	12.1	6.36	3.15	9.91	26.3	0.26	14.6	10% Strain	1742.40	915.84	453.60	0.26			0			
COF-B001-S7	Foundation Clay	DSS COF-B001-S7-23.0	634.8	22.0	612.8	23.9	14.03	6.16	10.01	23.7	0.26	14.5	10% Strain	3441.60	2020.32	887.04	0.26			0			
COF-B007-S8	Foundation Clay	DSS COF-B007-S8-22.0	638.0	22.0	616.0	6.0	3.81	1.68	9.93	23.8	0.28	15.6	10% Strain	864.00	548.64	241.92	0.28			0	43	16	27
COF-B007-S8	Foundation Clay	DSS COF-B007-S8-22.0	638.0	22.5	615.5	11.7	5.59	3.61	10.02	32.9	0.31	17.1	10% Strain	1684.80	804.96	519.84	0.31			0			
COF-B007-S8	Foundation Clay	DSS COF-B007-S8-22.0	638.0	23.0	615.0	23.9	11.94	5.77	9.98	25.8	0.24	13.6	10% Strain	3441.60	1719.36	830.88	0.24			0			
								Lower Foundation Clay											Lower Foundation Clay			Lower Foundation Clay	
COF-B008-S9	NC Foundation Clay	COF-B008_9b_NF	635.7	29.5	606.2	18.3	9.60	6.21	9.96	32.9	0.34	18.7	10% Strain	2635.20	1382.40	894.24	0.34	COF-B008_9b_NF_consol	28.47	1.6			
								Soft Foundation Clay											Soft Foundation Clay			Soft Foundation Clay	
COF-B011-S11	Soft Foundation Clay	COF-B011_11h_NF	635.1	32.0	603.1	21.0	10.52	6.47	9.74	31.6	0.31	17.1	10% Strain	3024.00	1514.88	931.68	0.31	COF-B011_11i_NF_consol	27.78	1.3			

								Quasi Steady State - Soft Foundation Clay											Soft Foundation Clay			Soft Foundation Clay	
COF-B011-S11	Soft Foundation Clay	COF-B011_11h_NF	635.1	32.0	603.1	21.0	10.17	5.95	7.33	30.3	0.28	15.8	QSS	3024.00	1464.48	856.80	0.28	COF-B011_11i_NF_consol	27.78	1.3			

Note: Foundation Clay + Lower Foundation Clay combined into a single layer termed "Foundation Clay"

DYNEGY - COFFEEN, ILLINOIS
15151122
9/9/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test Grade NOTE*	USCS Symbol
COF-B001	S1	1.0	2.5	12.9														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S2	3.5	5.0	20.3		31	14	17			2.71							
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S3	6.0	7.5	15.4					NOTE*									
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Gravel					
	S4	8.5	10.0	16.1						24*						ND1	1	
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S5	13.5	15.5	14.7	116.7	35	15	20					NOTE*	NOTE*				
	Color		dark grayish brown with yellowish brown & dark gray							Visual Classification			Lean Clay with Sand					
	S6	18.5	20.0	23.2														
	Color		brown & gray							Visual Classification			Silty Lean Clay trace Fine Sand & Organics					
	S7	21.0	23.0	23.4	101.8	66	22	44		22*		1.3E-08*			NOTE*	ND1	3	
	Color		gray with yellowish brown							Visual Classification			Fat Clay with Sand					
	S8	23.5	25.0	19.6		41	15	26			2.68							
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S9	28.5	30.0	16.8														
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S10	30.0	32.0															
	Color									Visual Classification								
	S11	33.5	35.0	11.7		30	13	17			2.73							
	Color		brown & gray							Visual Classification			Lean Clay trace Fine Gravel					

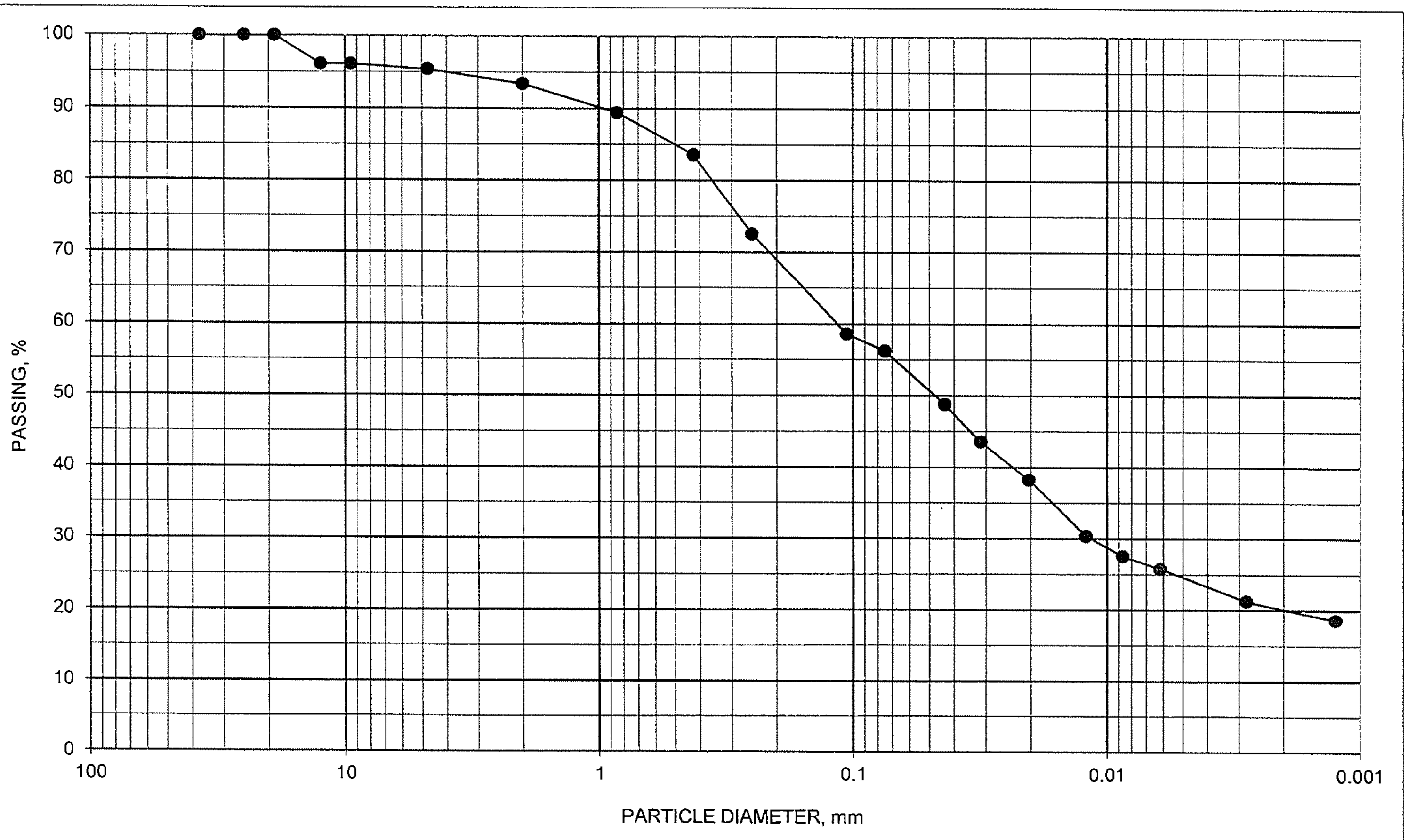
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.
NOT ASSIGNED, RUN WITH CU & DSS

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	96
3/8"	9.50	96
#4	4.75	95
#10	2.00	93
#20	0.850	89
#40	0.425	84
#60	0.250	73
#140	0.106	59
#200	0.075	56.2
	0.0436	48.8
	0.0315	43.5
	0.0204	38.3
	0.0121	30.4
	0.0087	27.5
	0.0062	25.8
	0.0028	21.2
	0.0013	18.6
	D60	0.1155
	D30	0.0116

SPECIFIC GRAVITY 2.68 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

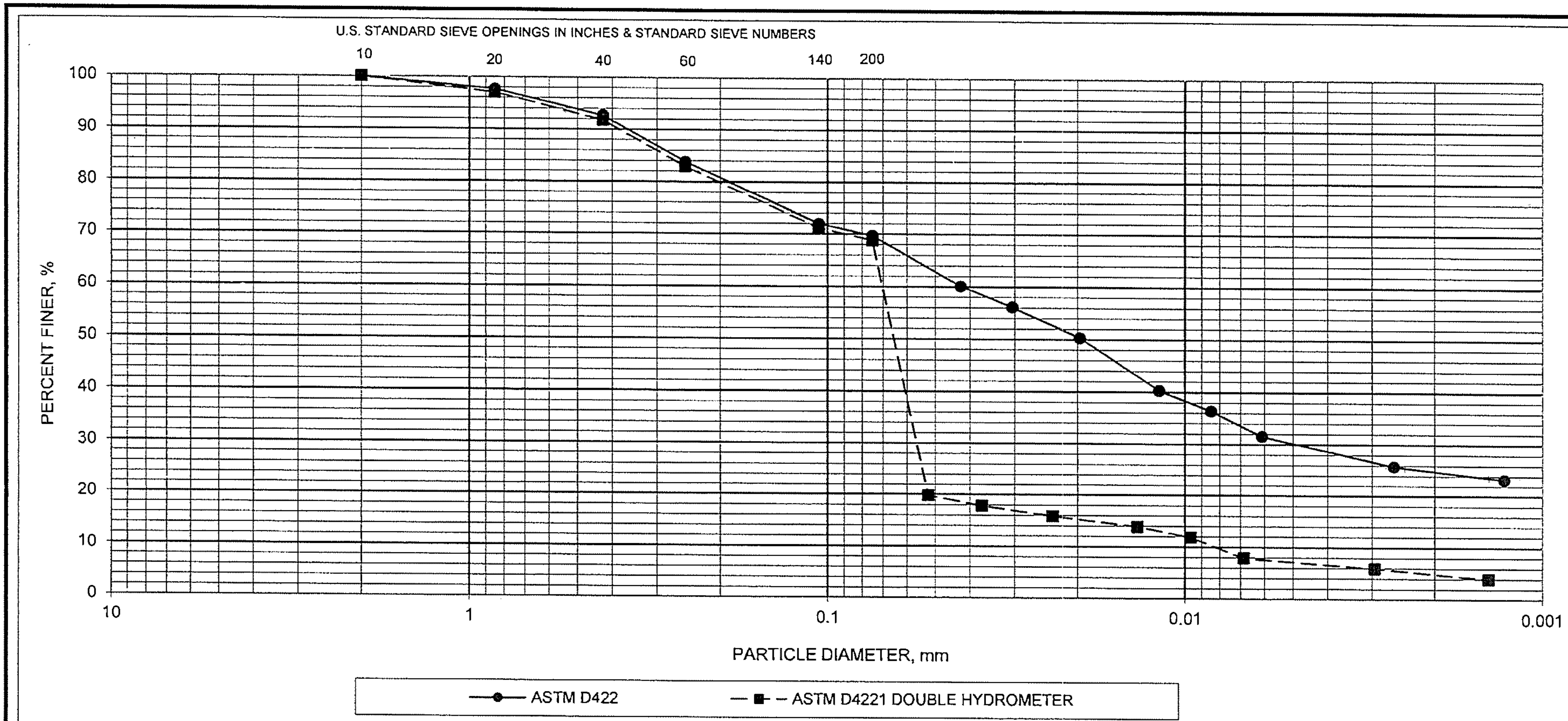
BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B001	S3	6 TO 7.5	SANDY LEAN CLAY TRACE GRAVEL BROWN & GRAY		15.4			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B001-S3-6.0.xlsx]ATTERBERG M%

Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	30.2	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	7.2	DISPERSION, %	24

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B001	S4	8.5 - 10.0	SANDY LEAN CLAY TRACE GRAVEL, BROWN & GRAY					

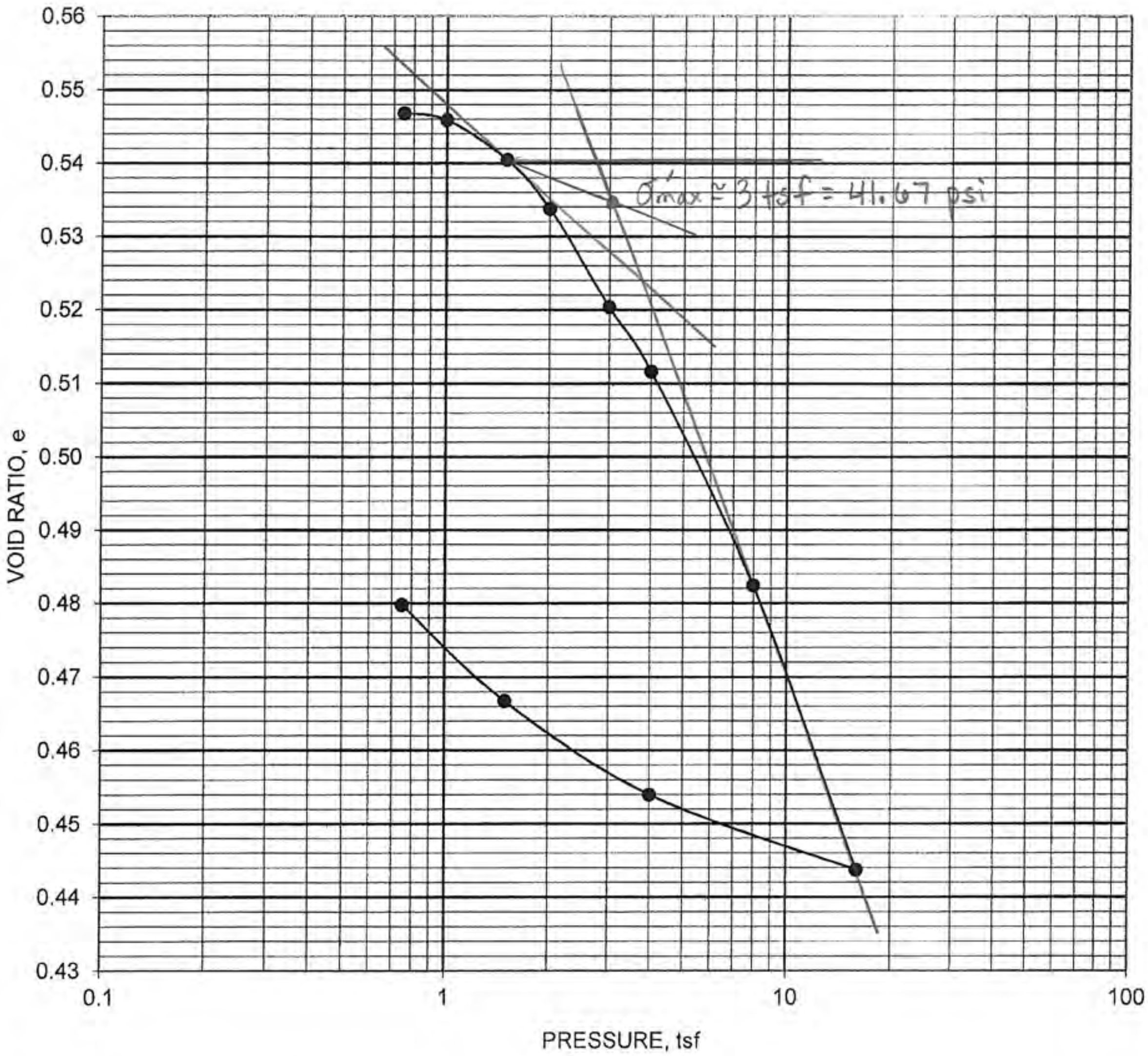
PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/2/2015

Terracon

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B001-S4-8.5.xls]Double Hydrometer Data

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.54	HEIGHT, mm	25.26	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		0.94		MOISTURE, %	18.8	18.1
PRECONSOL. PRESSURE, tsf		3.00		DRY DENSITY, pcf	109.0	113.7
OVER CONSOLIDATION RATIO		3.2		SATURATION, %	93	102
COMPRESSION INDEX		0.13		VOID RATIO	0.547	0.479
REBOUND INDEX		0.036		SAMPLE TYPE	UNDISTURBED	

LIQUID LIMIT	35	PLASTIC LIMIT	15	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	LEAN CLAY WITH SAND, DARK GRAYISH BROWN WITH YELLOWISH BROWN & DARK GRAY						
BORING NO.	COF-B001	SAMPLE NO.	S5	DEPTH, feet	13.5 - 15.5		

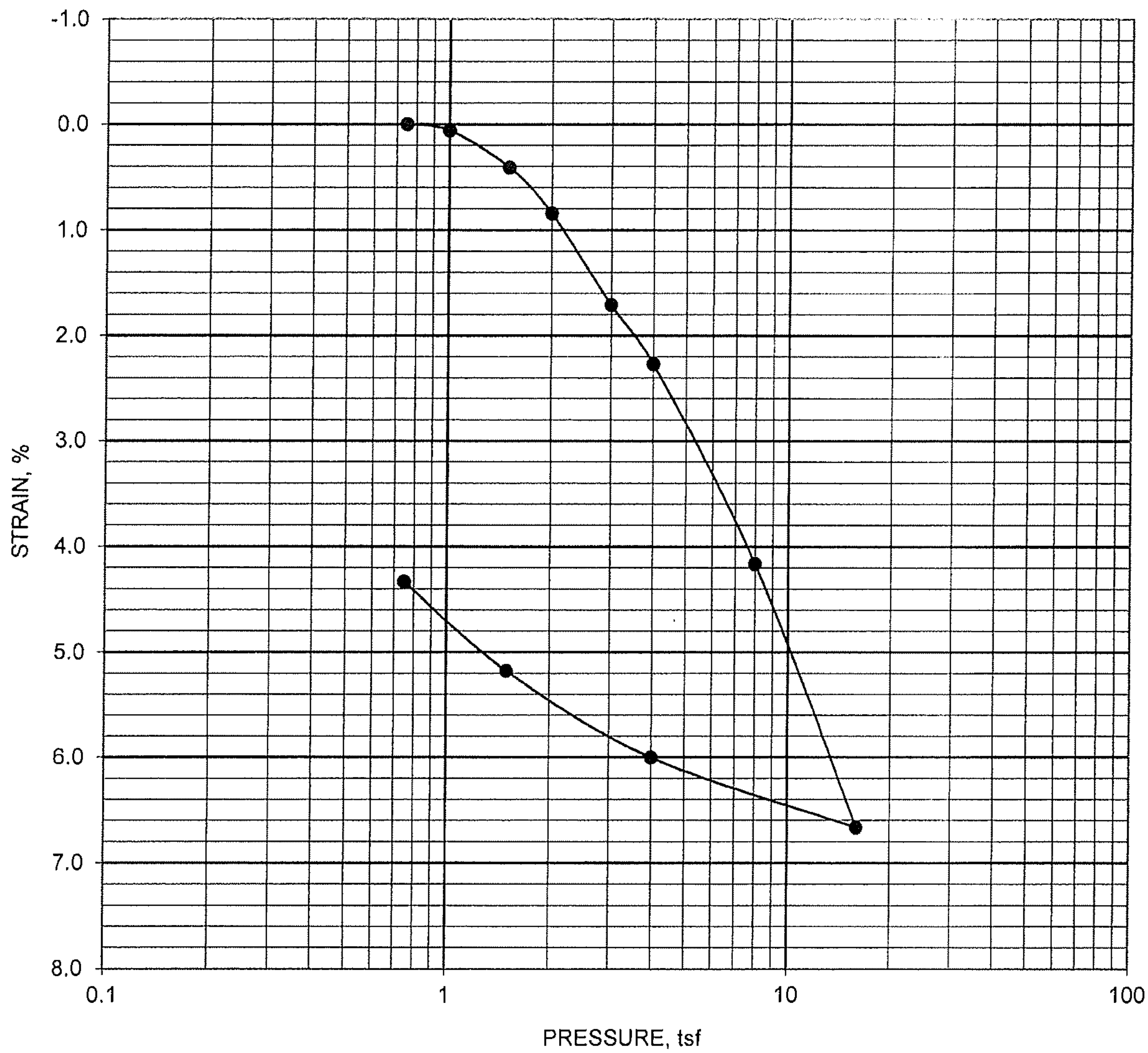
DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B001\[15151122 Consolidation COF-B001-S5

Terracon

Embankment

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.54	HEIGHT, mm	25.26	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf			0.94	MOISTURE, %	18.8	18.1
PRECONSOL. PRESSURE, tsf			3.00	DRY DENSITY, pcf	109.0	113.7
OVER CONSOLIDATION RATIO			3.2	SATURATION, %	93	102
COMPRESSION INDEX			0.13	VOID RATIO	0.547	0.479
REBOUND INDEX			0.036	SAMPLE TYPE	3" SHELBY TUBE	

LIQUID LIMIT	35	PLASTIC LIMIT	15	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.7 ESTIMATED

SAMPLE DESCRIPTION	LEAN CLAY WITH SAND, DARK GRAYISH BROWN WITH YELLOWISH BROWN & DARK GRAY

BORING NO.	COF-B001	SAMPLE NO.	S5	DEPTH, feet	13.5 - 15.5

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B001\[15151122 Consolidation COF-B001-S5

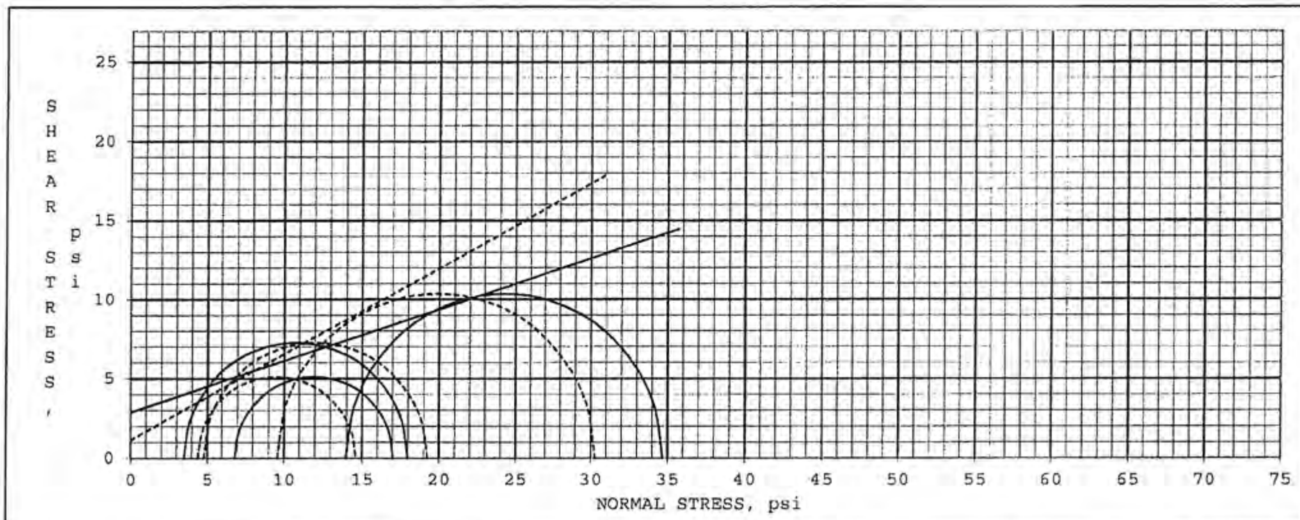
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

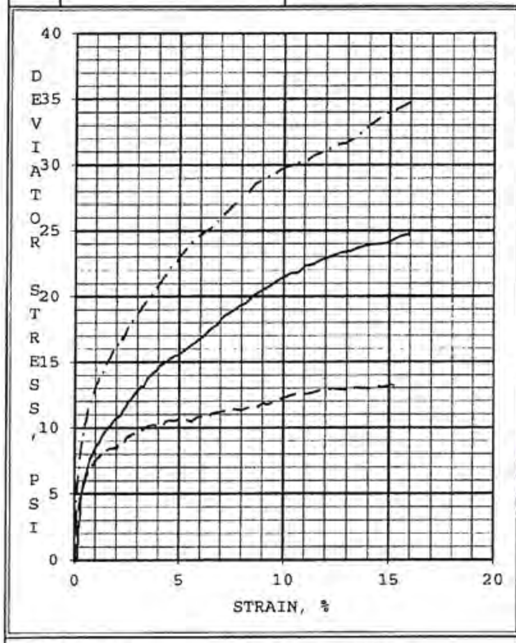
ADDITIONAL CONSOLIDATION DATA

COF-B001
S5
13.5 - 15.5

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.75					
1	1.87E-04	1.88E-04	3.81E-06	2.47E-06	4.61E-10
1.5	7.33E-04	7.38E-04	1.11E-05	7.20E-06	5.28E-09
2	4.30E-04	4.33E-04	1.37E-05	8.87E-06	3.82E-09
3	3.18E-04	3.20E-04	1.37E-05	8.91E-06	2.84E-09
4	1.86E-04	1.87E-04	8.90E-06	5.85E-06	1.09E-09
8	2.22E-04	2.23E-04	7.47E-06	4.94E-06	1.10E-09
16	1.55E-04	1.56E-04	4.95E-06	3.34E-06	5.18E-10
AVERAGE	3.19E-04	3.21E-04	9.08E-06	5.94E-06	2.16E-09



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	28.4	COHESION, psi	1.1
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	18.0	COHESION, psi	2.9



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	14.1	12.8	17.3
INITIAL	DRY DENSITY, pcf	118.3	116.1	115.6
INITIAL	SATURATION, %	89	77	102
INITIAL	VOID RATIO	0.42	0.45	0.46
BEFORE SHEAR	WATER CONTENT, %	15.6	16.1	15.9
BEFORE SHEAR	DRY DENSITY, pcf	118.5	117.4	117.9
BEFORE SHEAR	SATURATION (B PARAMETER)	0.96	0.96	0.95
BEFORE SHEAR	VOID RATIO	0.42	0.43	0.43
BEFORE SHEAR	FINAL BACK PRESSURE, psi	99.6	100.4	100.2
MINOR PRINCIPAL STRESS, psi		3.5	6.8	14.0
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		14.5	10.2	20.7
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		14.5	10.2	20.7
ULTIMATE DEVIATOR STRESS (15% STR), psi		24.1	13.1	34.0
TIME TO 50% PRIMARY CONSOLIDATION, min		23.00	1.60	7.20
STRAIN RATE, % / hour		0.76	2.23	2.34
INITIAL DIAMETER, inch		1.369	1.376	1.368
INITIAL HEIGHT, inch		2.795	2.865	2.757
AREA AFTER CONSOLIDATION, inch2		1.470	1.479	1.450

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, DARK GRAY WITH YELLOWISH BROWN & DARK GRAY

LL 35	PL 15	PI 20	Gs 2.7 EST.

PROJECT NO. 15151122	PROJECT: DYNEGY COFFEEN, ILLINOIS
	BORING #: COF-B001
LABORATORY: TERRACON - LENEXA	SAMPLE #: S5
DATE: 9/8/2015	DEPTH, feet: 13.5 - 15.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

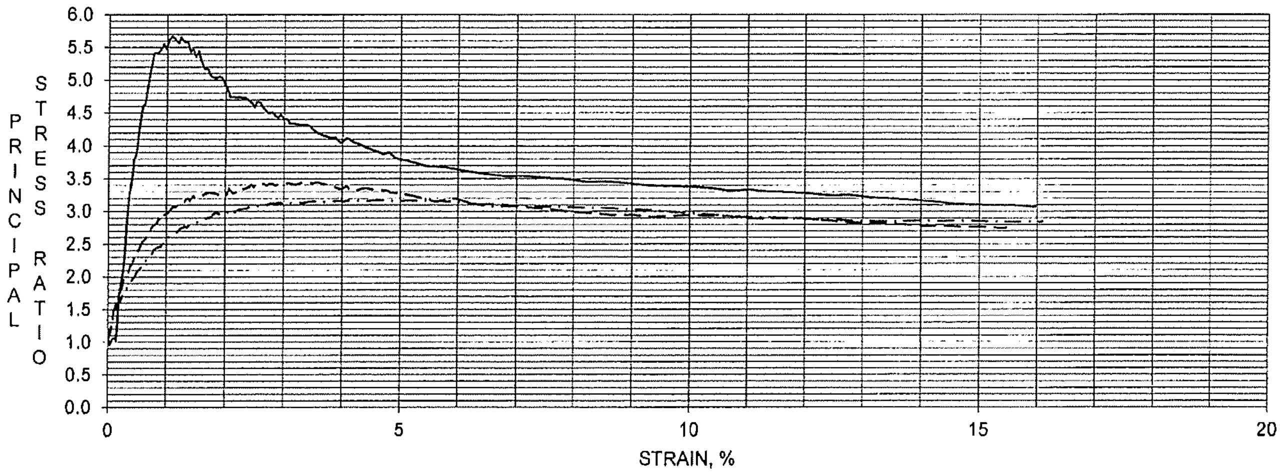
Terracon

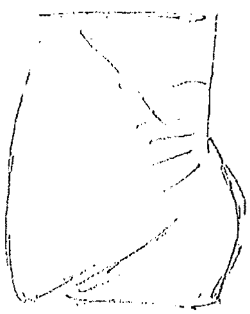
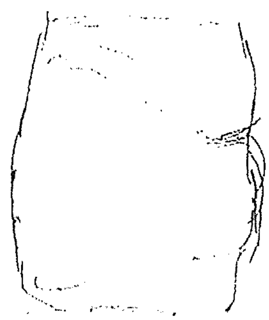
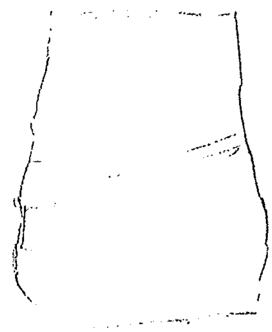
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Triaxial CU COF-B001-S5-13.5.xlsx]REPORT

Embankment

DYNEGY

15151122 COF-B001 S5 13.5 - 15.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

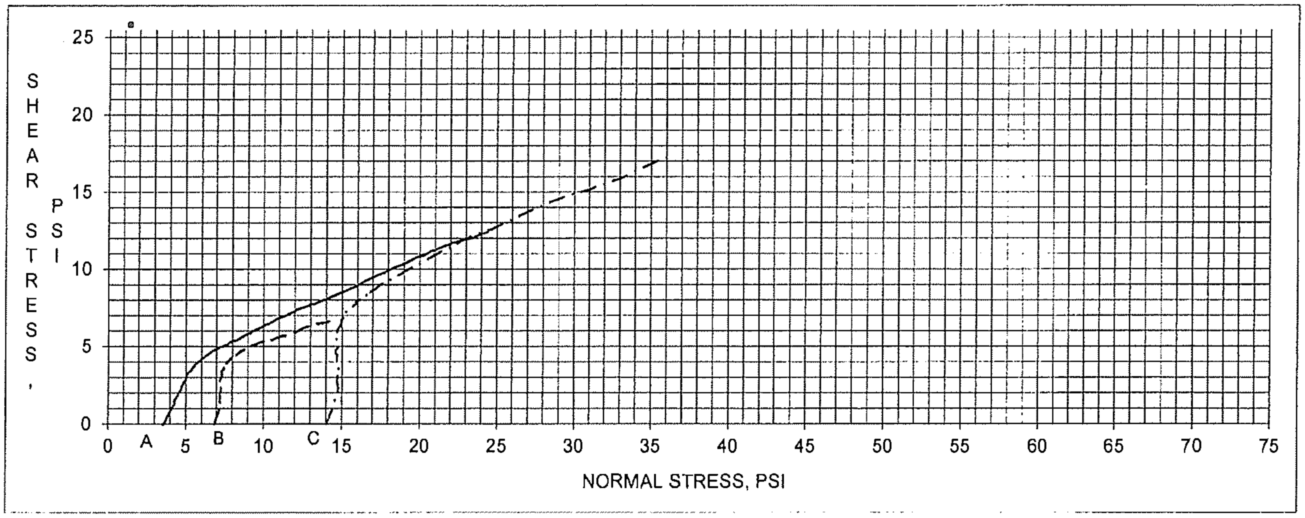
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

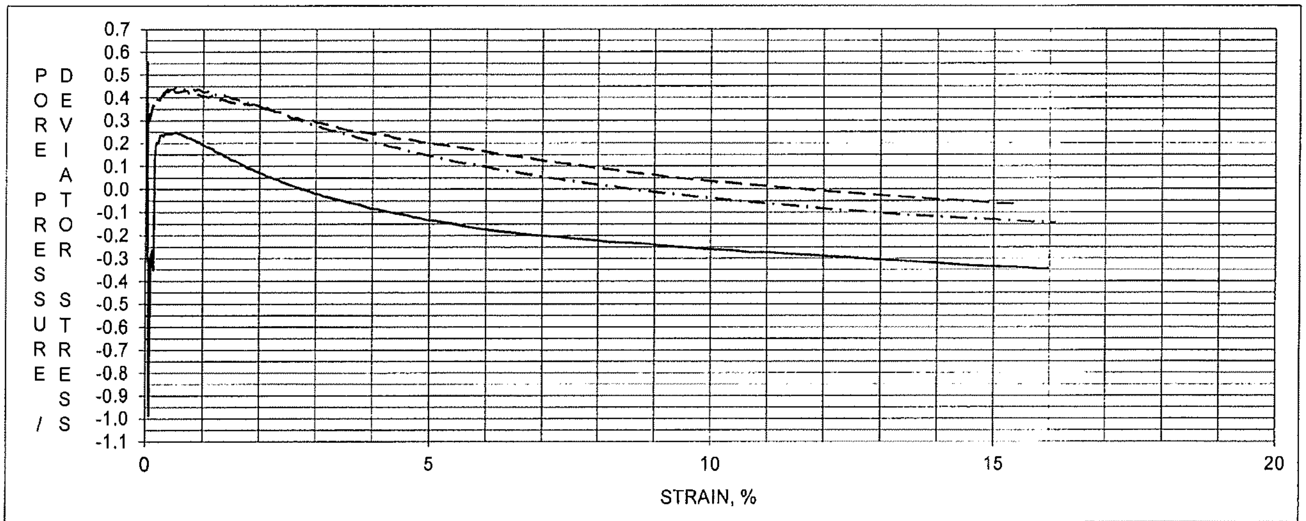
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

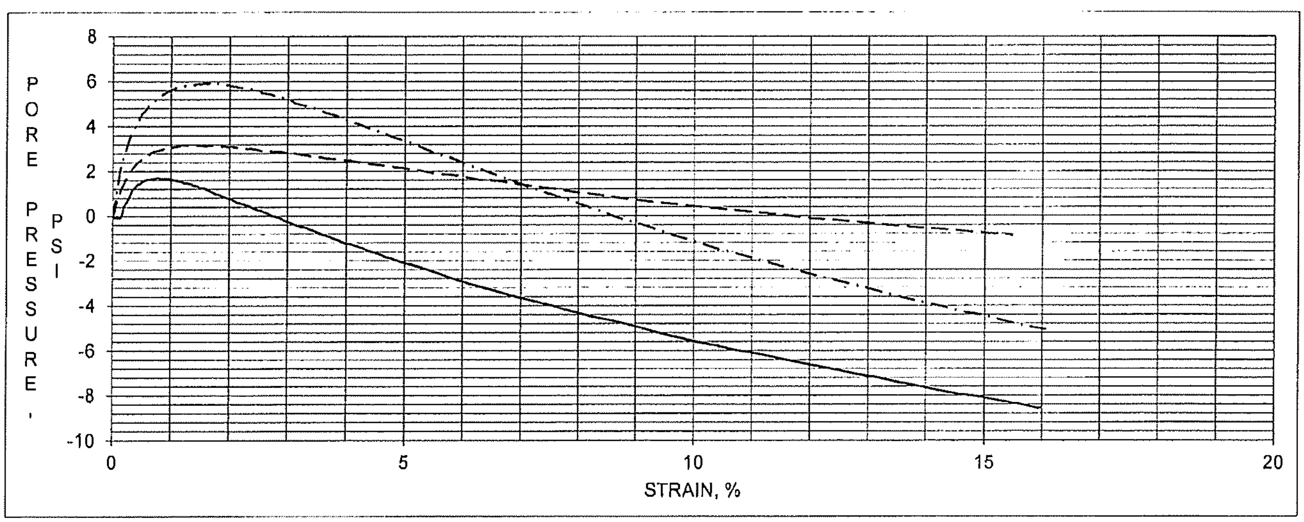
Terracon

DYNEGY

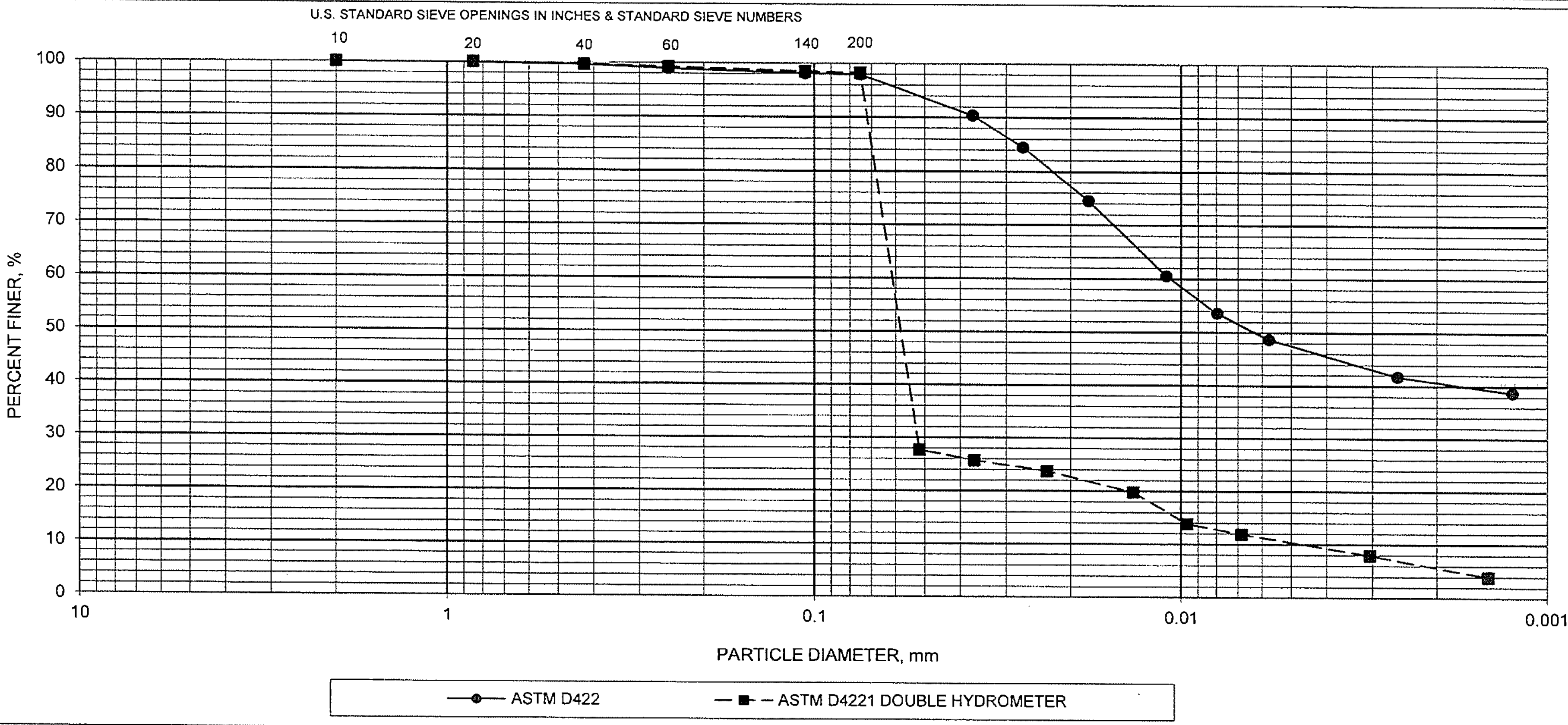
15151122 COF-B001 S5 13.5 - 15.5







Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	47.4	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	10.3	DISPERSION, %	22

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B001	S7	21.0 - 23.0						

PROJECT DYNEGY

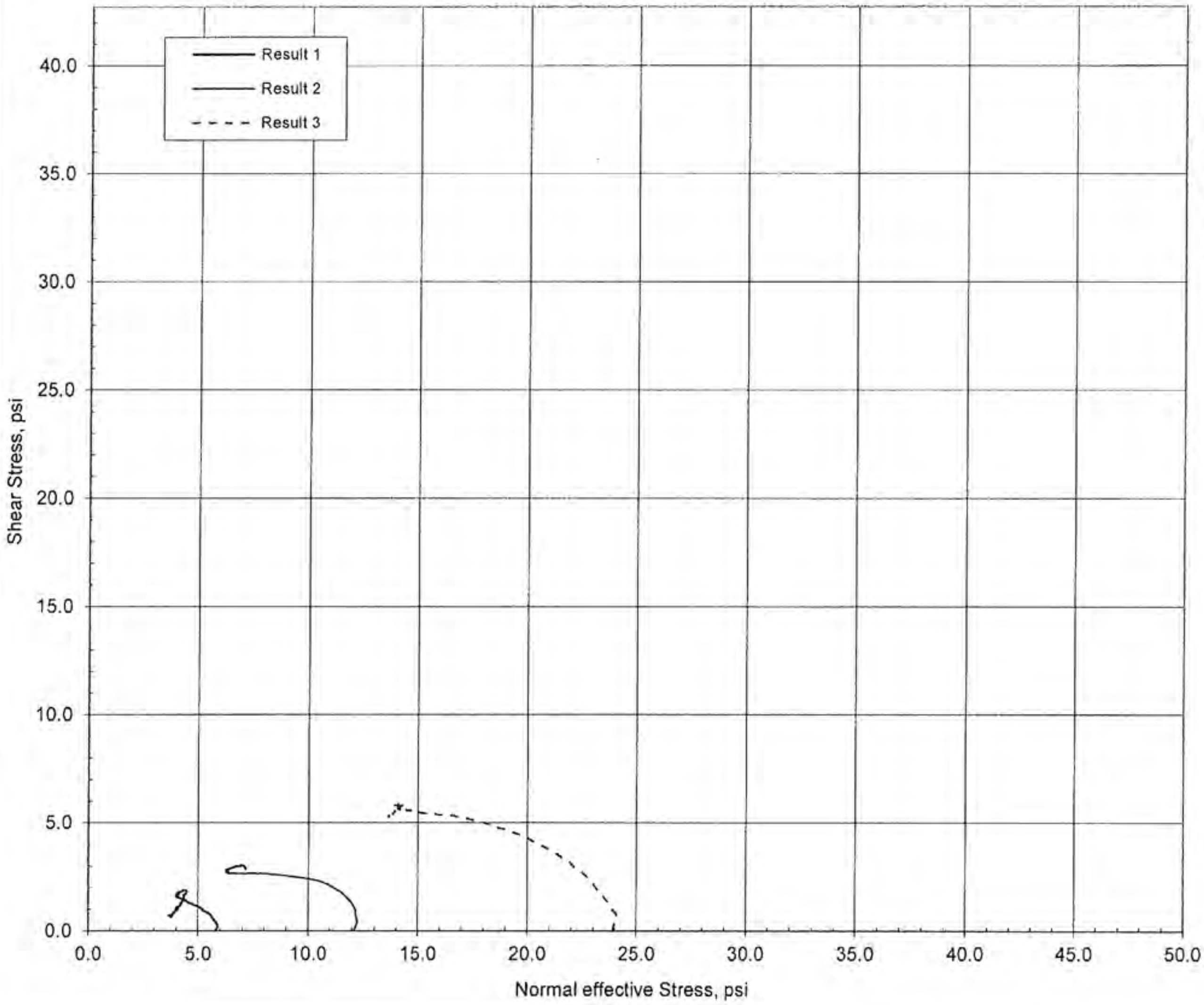
COFFEEN, ILLINOIS

JOB NO. 15151122 DATE 9/2/2015

Terracon

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B001-S7-21.0.xls]Hydrometer Data

CONSOLIDATED UNDRAINED DIRECT SIMPLE SHEAR TESTING OF COHESIVE SOILS
ASTM D6528



	RESULT 1	RESULT 2	RESULT 3		RESULT 1	RESULT 2	RESULT 3
INITIAL DATA				NORMAL EFF. STRESS, psi	5.8	12.1	23.9
AREA, inch2	5.371	5.371	5.379	PRESHEAR MOISTURE, %	30.8	30.6	29.5
HEIGHT, inch	0.704	0.701	0.701	PRESHEAR VOID RATIO	0.80	0.75	0.72
MOISTURE, %	28.2	28.5	29.3	FINAL MOISTURE, %	30.9	30.7	29.6
DRY DENSITY, pcf	92.3	93.5	93.1	FINAL VOID RATIO	0.81	0.77	0.76
SATURATION, %	92	96	98	SHEAR STRAIN RATE, %/min	0.086	0.087	0.090
VOID RATIO	0.83	0.80	0.81	t95 @ MAX STESS, min	0.82	1.58	3.23
LIQUID LIMIT	66		PLASTIC LIMIT	22	PLASTICITY INDEX		44
SAMPLE TYPE	UNDISTURBED			SPECIFIC GRAVITY	2.7 ESTIMATED		
SAMPLE DESCRIPTION	FAT CLAY WITH SAND, GRAY WITH YELLOWISH BROWN						

PROJECT NAME: DYNEGY

BORING NO. COF-B001

LOCATION: COFFEEN, ILLINOIS

SAMPLE NO. S7

JOB NO.: 15151122

DEPTH, feet 21.0 - 23.0

DATE: 9/9/2015

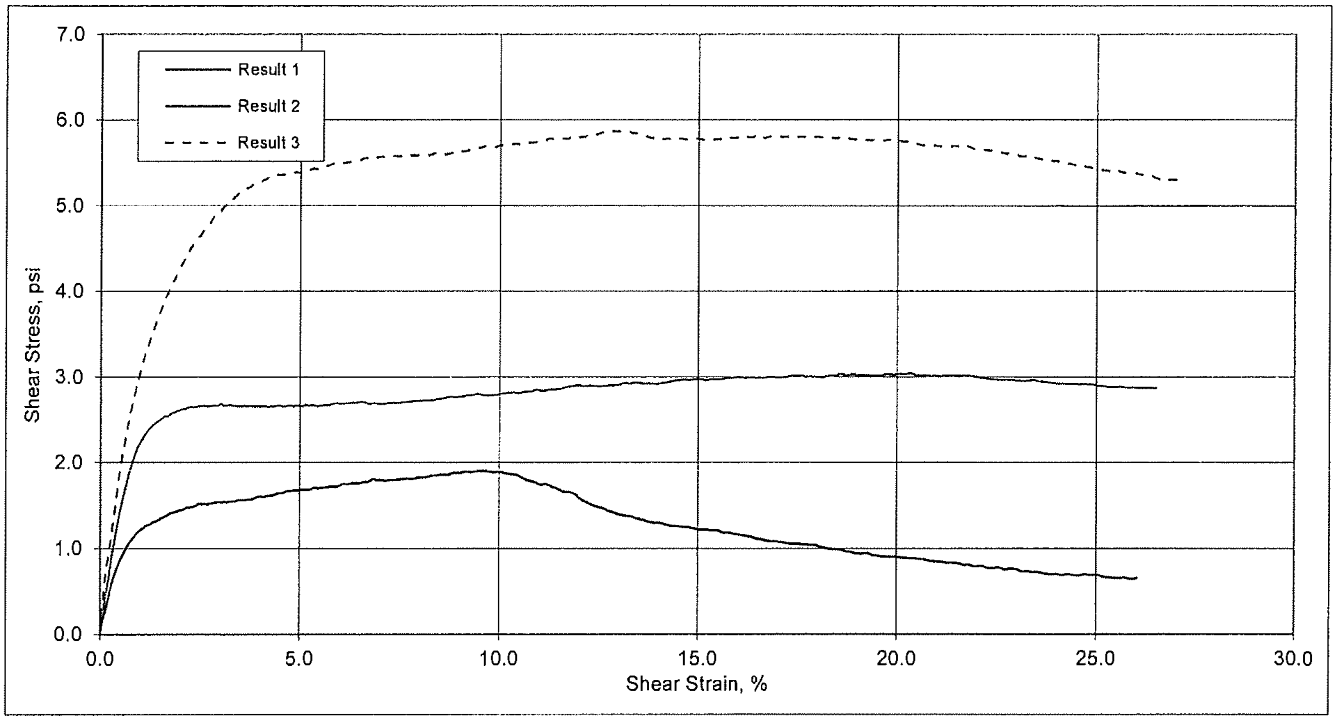
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 DirectSimpleShear COF-BC

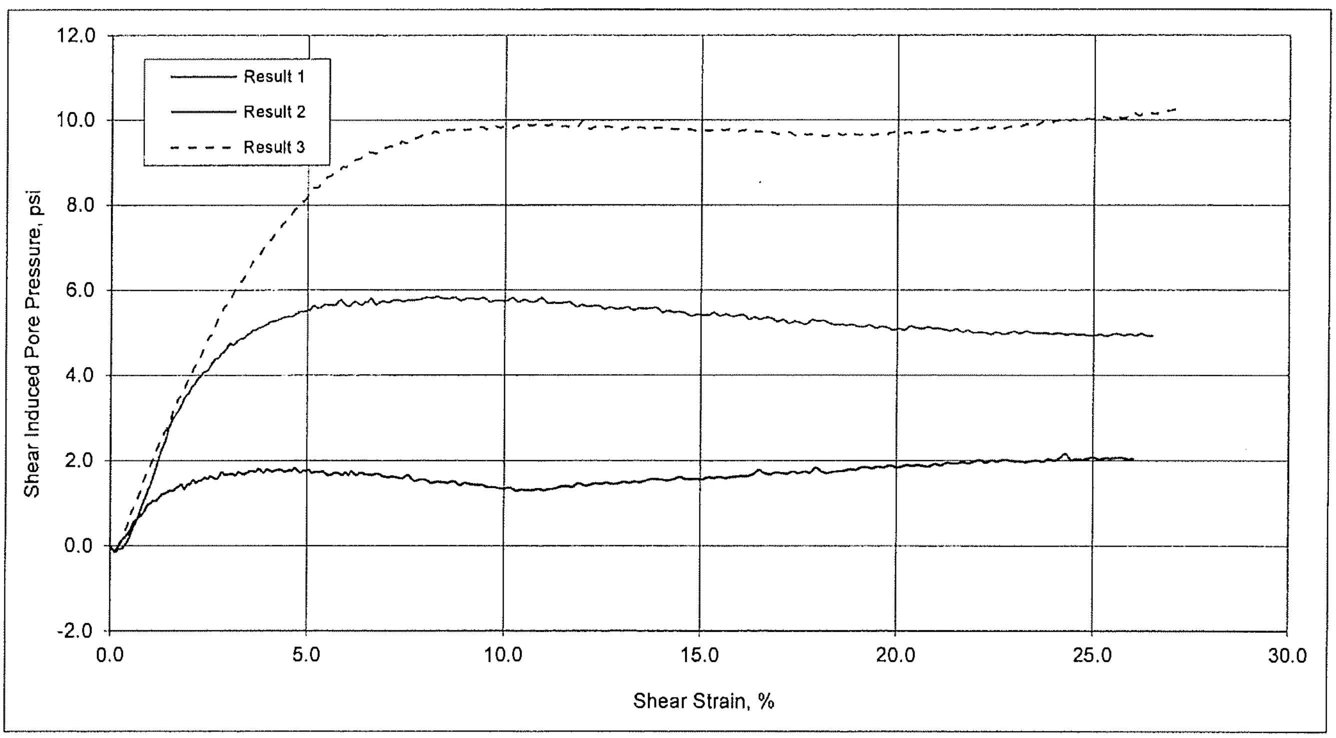
Terracon

Foundation Crust

DYNEGY
COFFEEN, ILLINOIS
15151122
9/9/2015

BORING NO.	COF-B001
SAMPLE NO.	S7
DEPTH, feet	21.0 - 23.0





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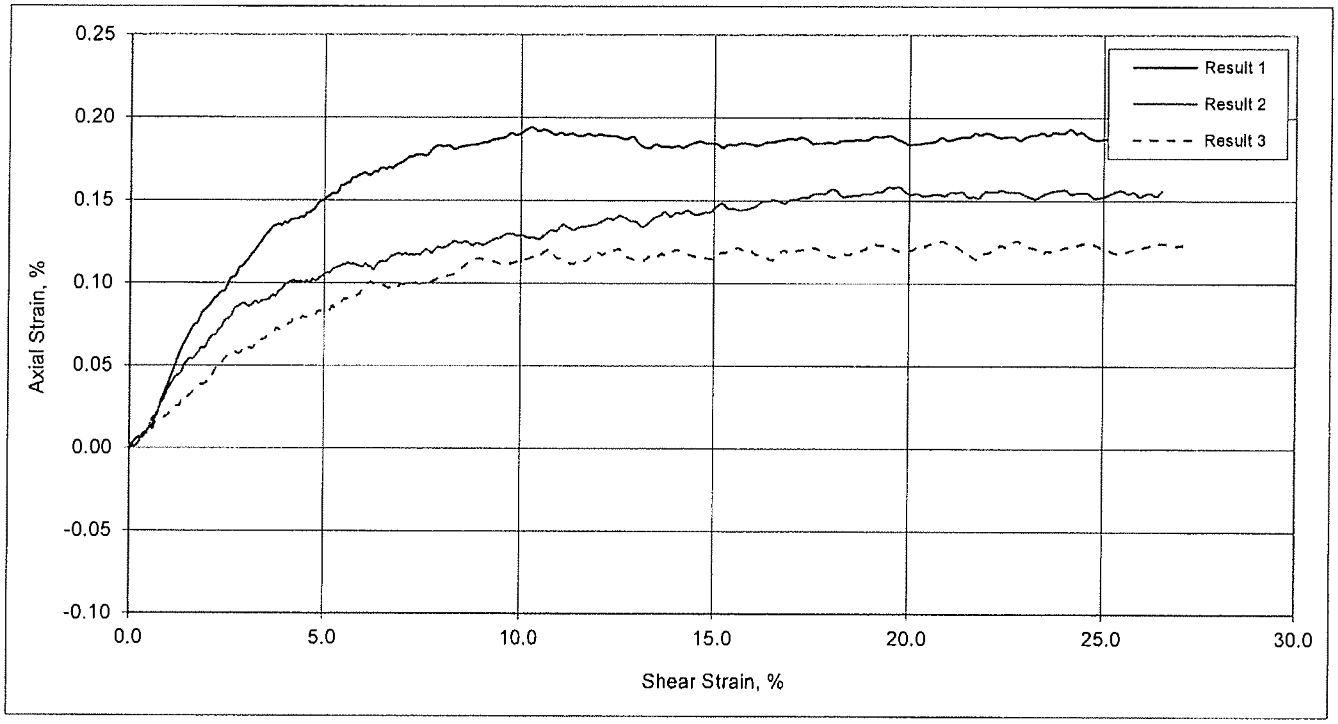
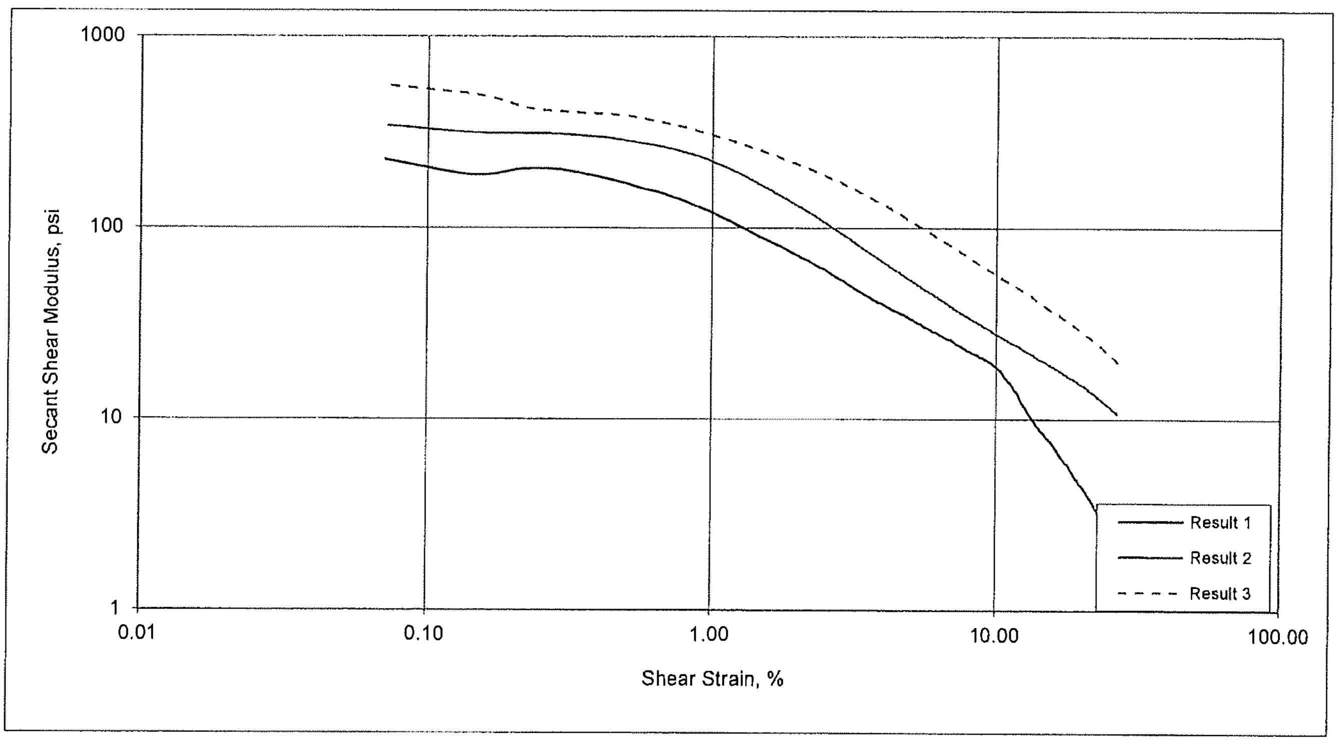
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/9/2015

BORING NO.	COF-B001
SAMPLE NO.	S7
DEPTH, feet	21.0 - 23.0





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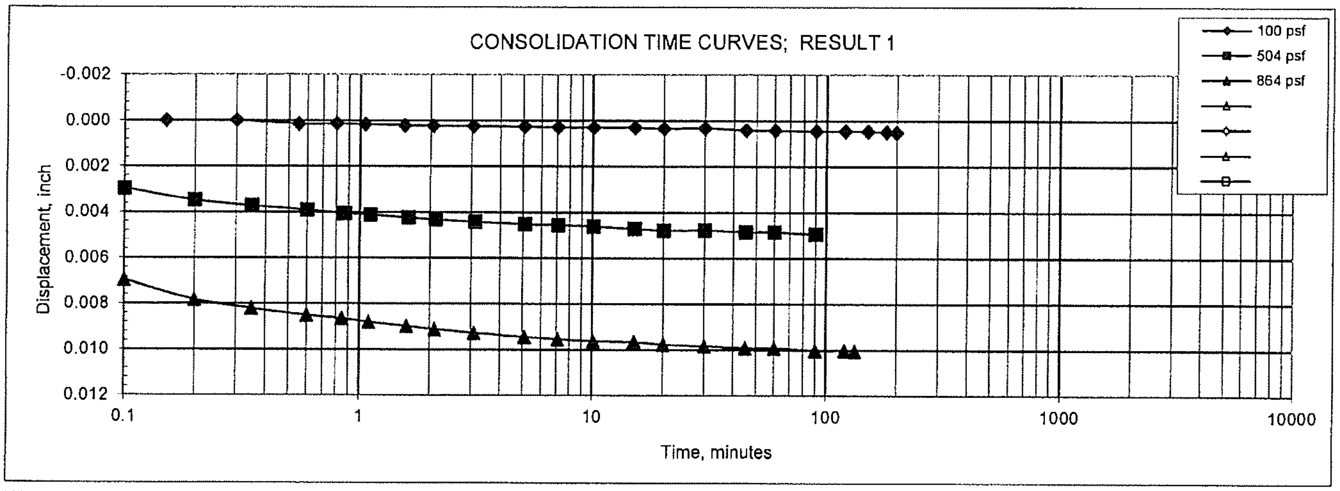
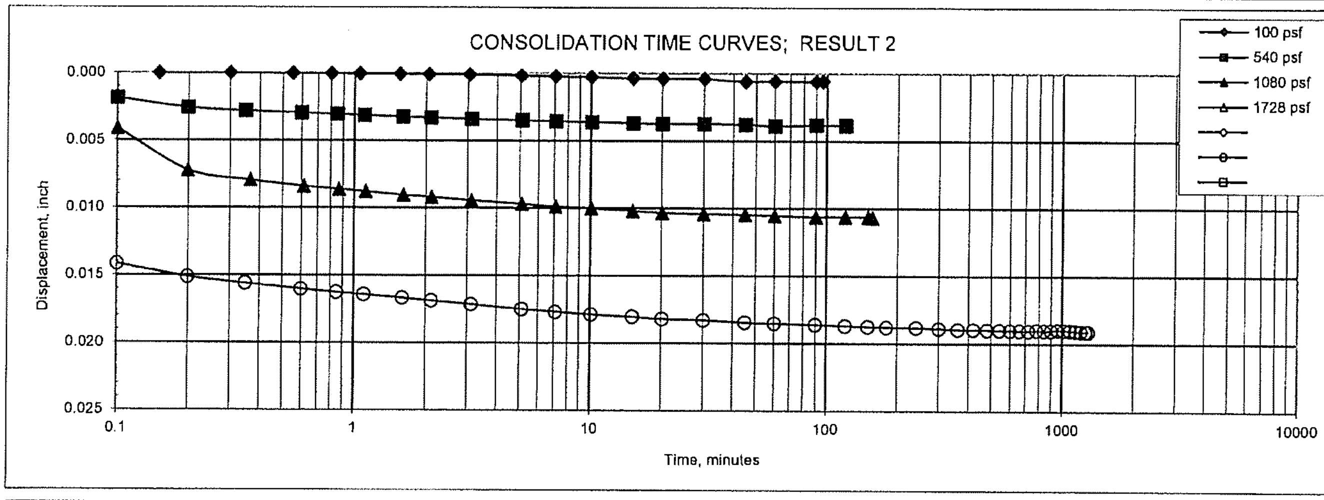
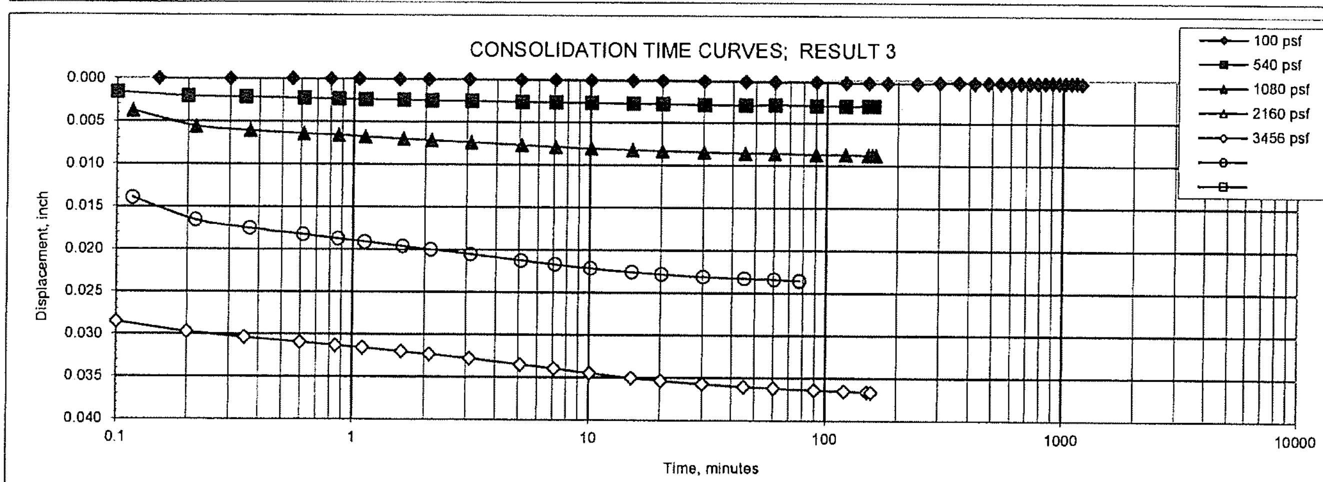
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/9/2015

BORING NO.	COF-B001
SAMPLE NO.	S7
DEPTH, feet	21.0 - 23.0







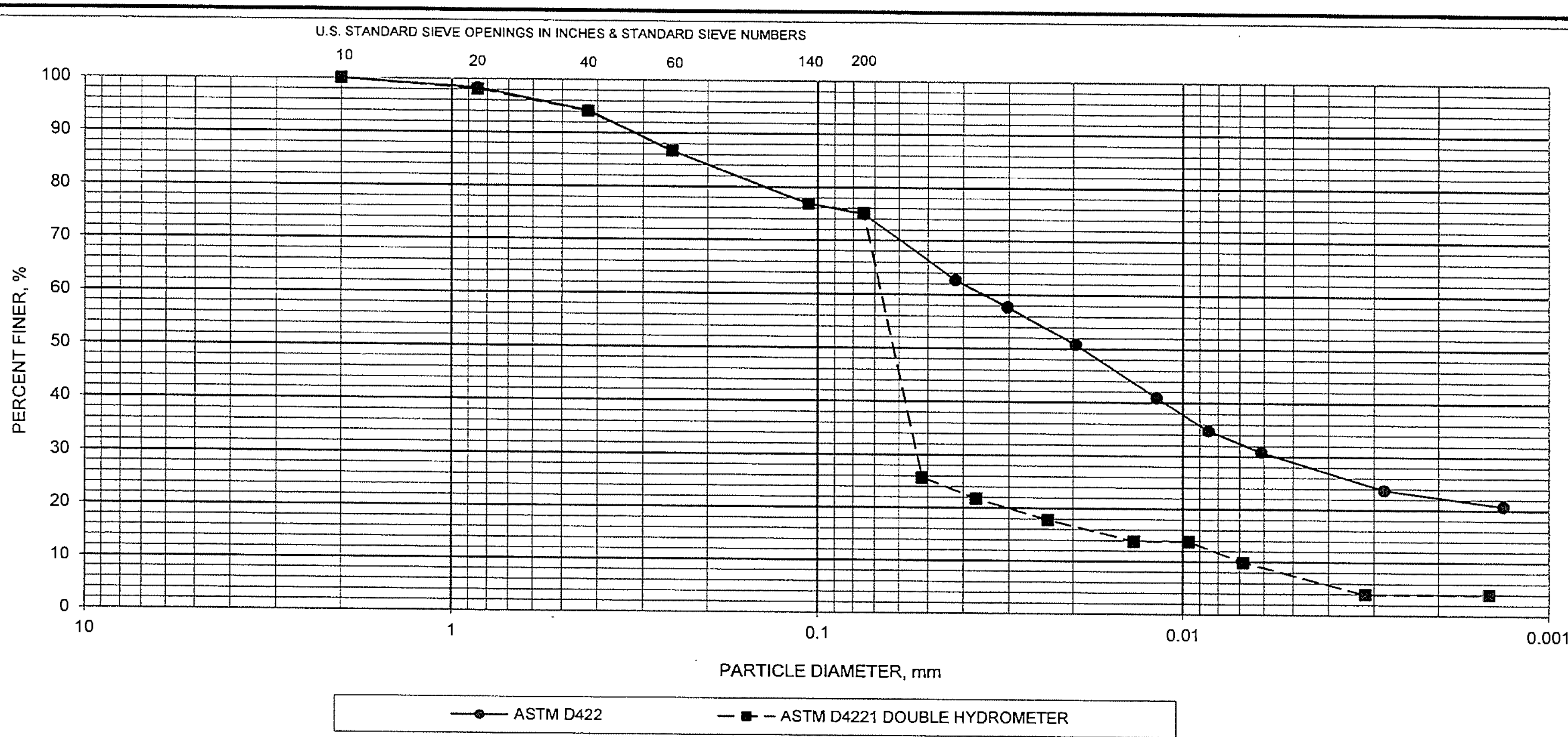
DYNEGY - COFFEEN, ILLINOIS
15151122
9/9/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	Atterberg Limits PL	Atterberg Limits PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B002	S1	1.0	2.5	25.4														
	Color		brown & gray							Visual Classification			Fill: Lean Clay trace Organics					
	S2	3.5	5.0	25.9		35	17	18										
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S3	6.0	7.5	25.9														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S4	8.5	10.5	17.8	114.2	40	15	25		26*		4.1E-09*				ND1*	1*	
	Color		gray with yellowish brown							Visual Classification			Lean Clay with Sand					
	S5	13.5	15.0	23.3					NOTE*									
	Color		brown & gray							Visual Classification			Fill: Lean Clay with Sand trace Gravel					
	S6	15.0	17.0	26.7	94.9	25	18	7					NOTE*					
	Color		gray with brown							Visual Classification			Silty Clay					
	S7	18.5	20.0	25.4		47	18	29										
	Color		brown & gray							Visual Classification			Lean Clay trace Fine Sand					
	S8	23.5	25.0	18.9														
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S9	28.5	30.0	13.6					NOTE*									
	Color		brown							Visual Classification			Clayey Sand trace Gravel					
	S10	33.5	35.0	9.5		20	13	7										
	Color		brown							Visual Classification			Sandy, Silty Clay trace Fine Gravel					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	29.0	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	7.5	DISPERSION, %	26

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B002	S-4	8.5 - 10.5	LEAN CLAY WITH SAND, GRAY WITH YELLOWISH BROWN					

PROJECT DYNEGY

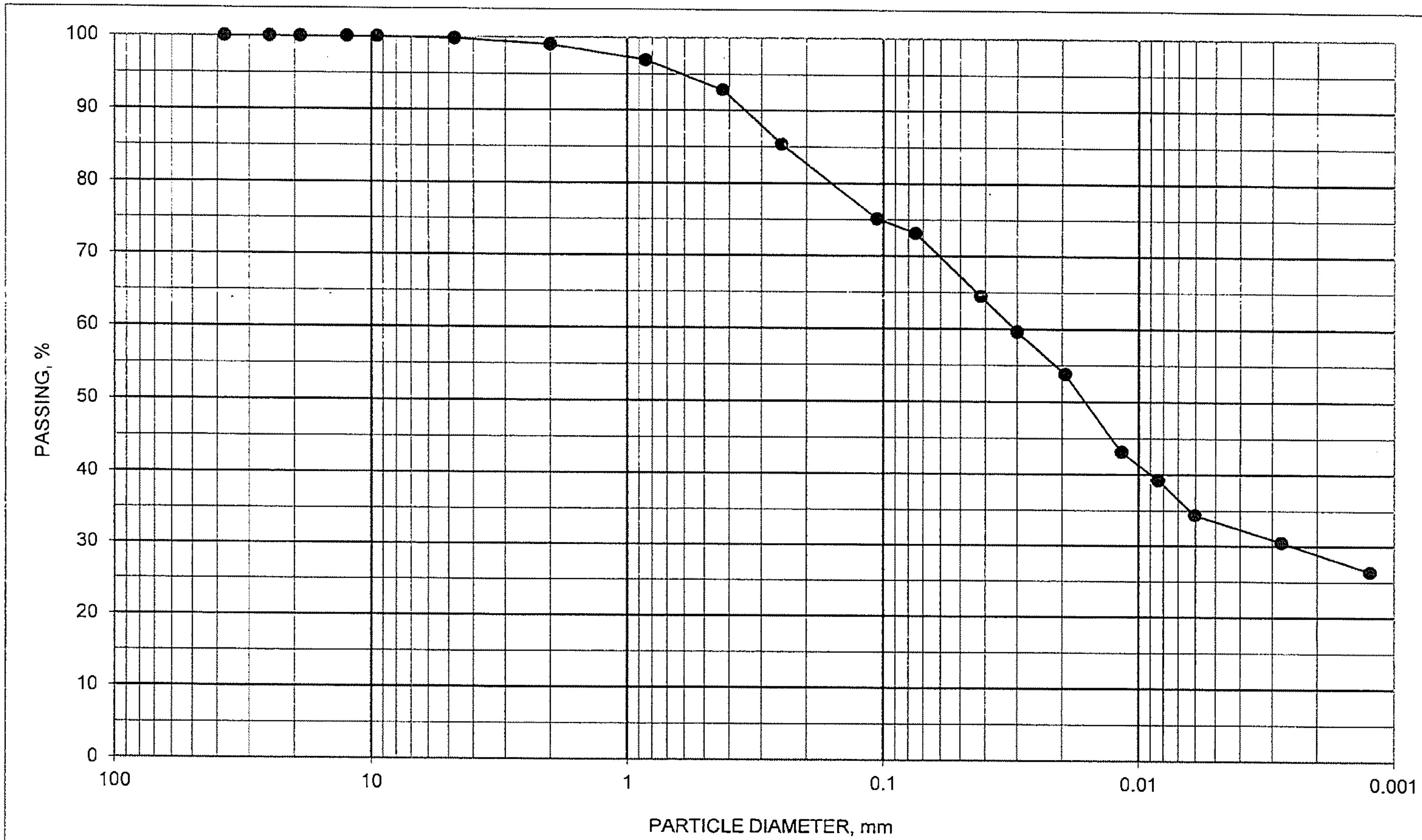
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/2/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 HydrometerDoublePlot COF-B002-S4-8.5.xls]Double Hydrometer Data

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	99
#20	0.850	97
#40	0.425	93
#60	0.250	85
#140	0.106	75
#200	0.075	73.2
	0.0416	64.5
	0.0301	59.6
	0.0195	53.8
	0.0117	43.1
	0.0084	39.2
	0.0060	34.4
	0.0028	30.5
	0.0012	26.4
	D60	0.0308
	D30	0.0025

SPECIFIC GRAVITY 2.69 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B002	S-5	13.5 TO 15	LEAN CLAY WITH SAND TRACE GRAVEL BROWN & GRAY		23.3			

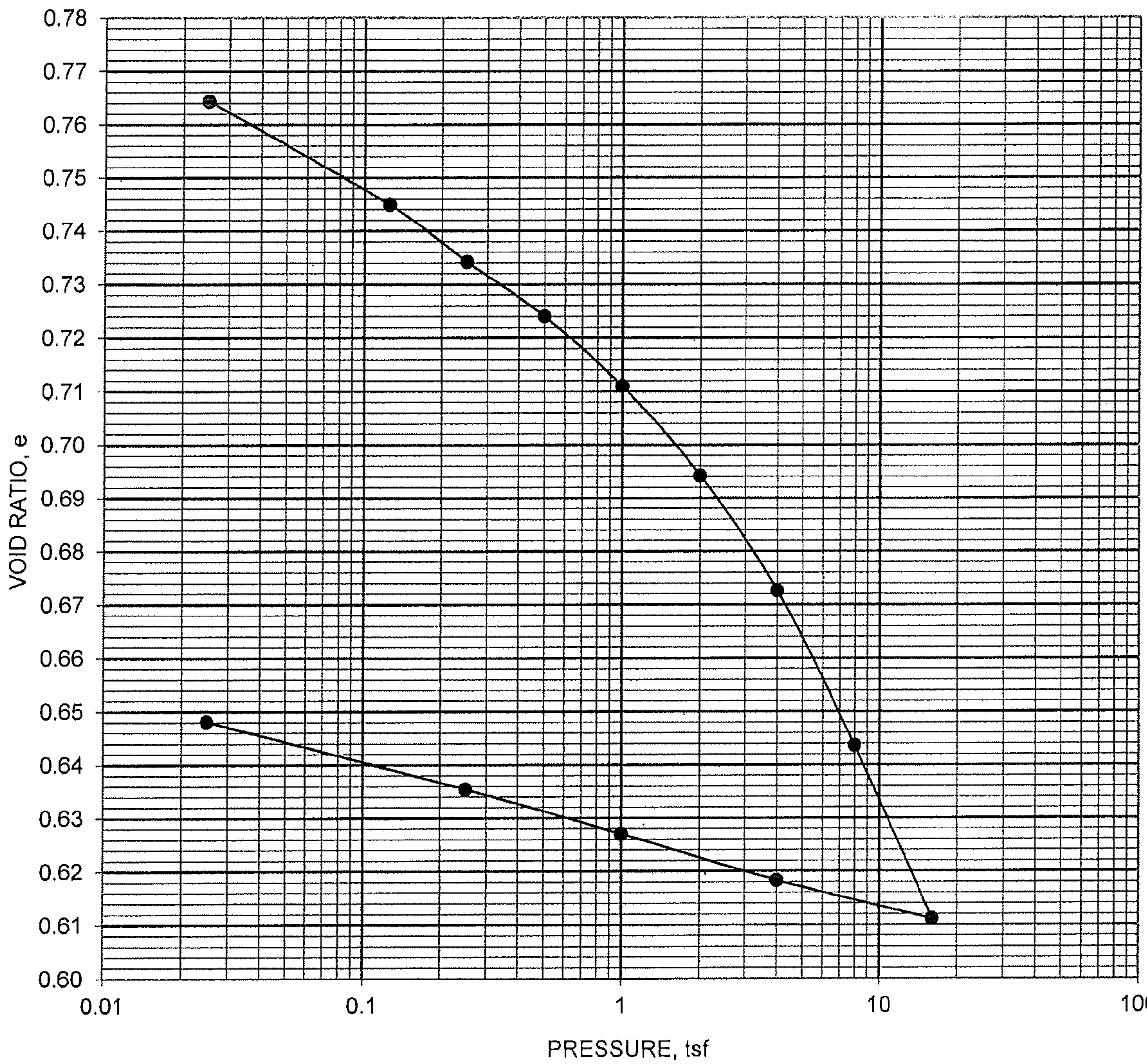
PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B002-S5-13.5.xlsx]ATTERBERG M%

Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.56	HEIGHT, mm	25.26	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		0.96		MOISTURE, %	26.7	23.5
PRECONSOL. PRESSURE, tsf		2.00		DRY DENSITY, pcf	94.9	100.9
OVER CONSOLIDATION RATIO		2.1		SATURATION, %	93	97
COMPRESSION INDEX		0.11		VOID RATIO	0.776	0.648
REBOUND INDEX		0.014		SAMPLE TYPE	UNDISTURBED	

LIQUID LIMIT	25	PLASTIC LIMIT	18	PLASTICITY INDEX	7	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	SILTY CLAY, GRAY WITH BROWN						
BORING NO.	COF-B002	SAMPLE NO.	S6	DEPTH, feet	15.0 - 17.0		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

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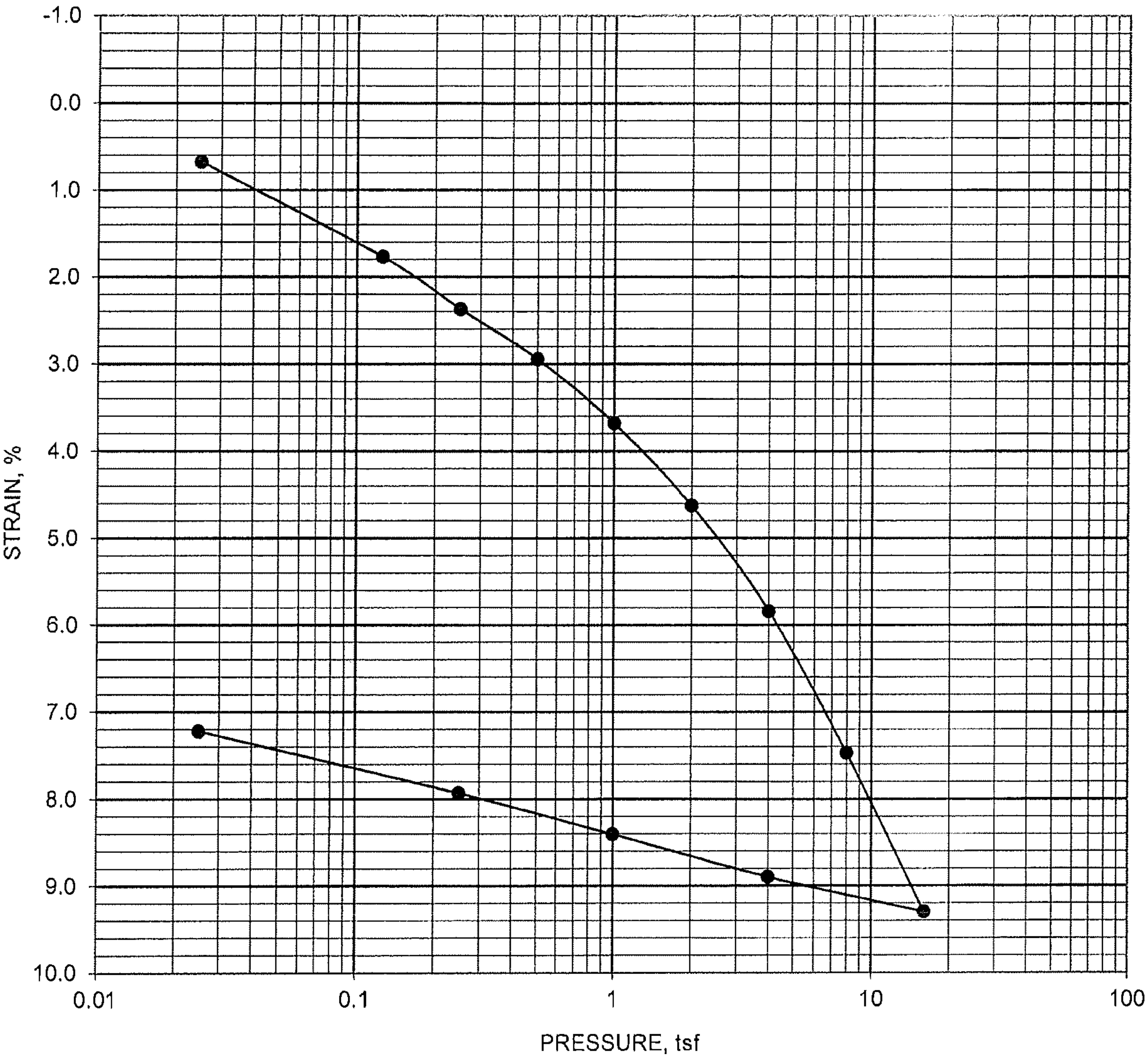
Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.56	HEIGHT, mm	25.26	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf			0.96	MOISTURE, %		26.7	23.5
PRECONSOL. PRESSURE, tsf			2.00	DRY DENSITY, pcf		94.9	100.9
OVER CONSOLIDATION RATIO			2.1	SATURATION, %		93	97
COMPRESSION INDEX			0.11	VOID RATIO		0.776	0.648
REBOUND INDEX			0.014	SAMPLE TYPE		3" SHELBY TUBE	
LIQUID LIMIT	25	PLASTIC LIMIT	18	PLASTICITY INDEX	7	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	SILTY CLAY, GRAY WITH BROWN						
BORING NO.	COF-B002	SAMPLE NO.	S6	DEPTH, feet		15.0 - 17.0	

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

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Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/4/2015

ADDITIONAL CONSOLIDATION DATA

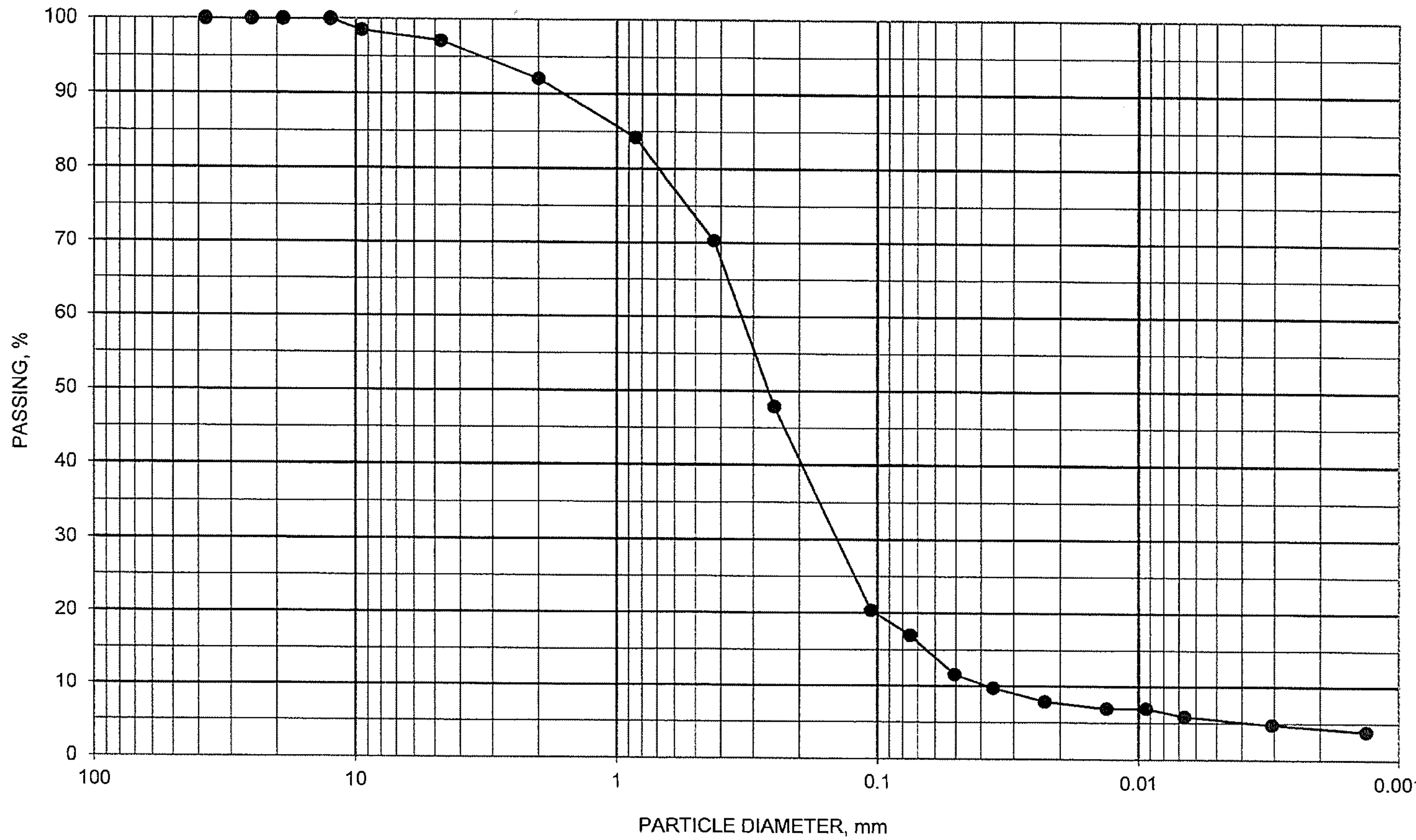
COF-B002
S6
15.0 - 17.0

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.025			4.89E-04	2.75E-04	
0.125	5.68E-04	5.71E-04	1.99E-04	1.13E-04	6.40E-08
0.25	1.07E-03	1.07E-03	8.76E-05	5.02E-05	5.36E-08
0.5	1.24E-03	1.25E-03	4.16E-05	2.40E-05	2.98E-08
1	1.88E-03	1.89E-03	2.66E-05	1.55E-05	2.91E-08
2	3.00E-03	3.02E-03	1.72E-05	1.00E-05	3.01E-08
4	5.10E-03	5.13E-03	1.10E-05	6.52E-06	3.32E-08
8	7.10E-03	7.14E-03	7.39E-06	4.42E-06	3.14E-08
16	3.97E-02	3.99E-02	4.15E-06	2.53E-06	1.00E-07
AVERAGE	7.46E-03	7.50E-03	9.82E-05	5.57E-05	4.64E-08

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	99
#4	4.75	97
#10	2.00	92
#20	0.850	84
#40	0.425	70
#60	0.250	48
#140	0.106	20
#200	0.075	17.0
	0.0506	11.6
	0.0360	9.7
	0.0229	7.9
	0.0133	7.0
	0.0094	7.0
	0.0067	5.9
	0.0031	4.8
	0.0013	3.9

D60	0.3331
D30	0.1432
D10	0.0379
Cu	8.8
Cc	1.6

SPECIFIC GRAVITY 2.65 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B002	S9	28.5 TO 30	CLAYEY SAND TRACE GRAVEL BROWN		13.6			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B002\[15151122 Hydrometer Plot COF-B002-S9-28.5.xlsx]ATTERBERG M%

Terracon

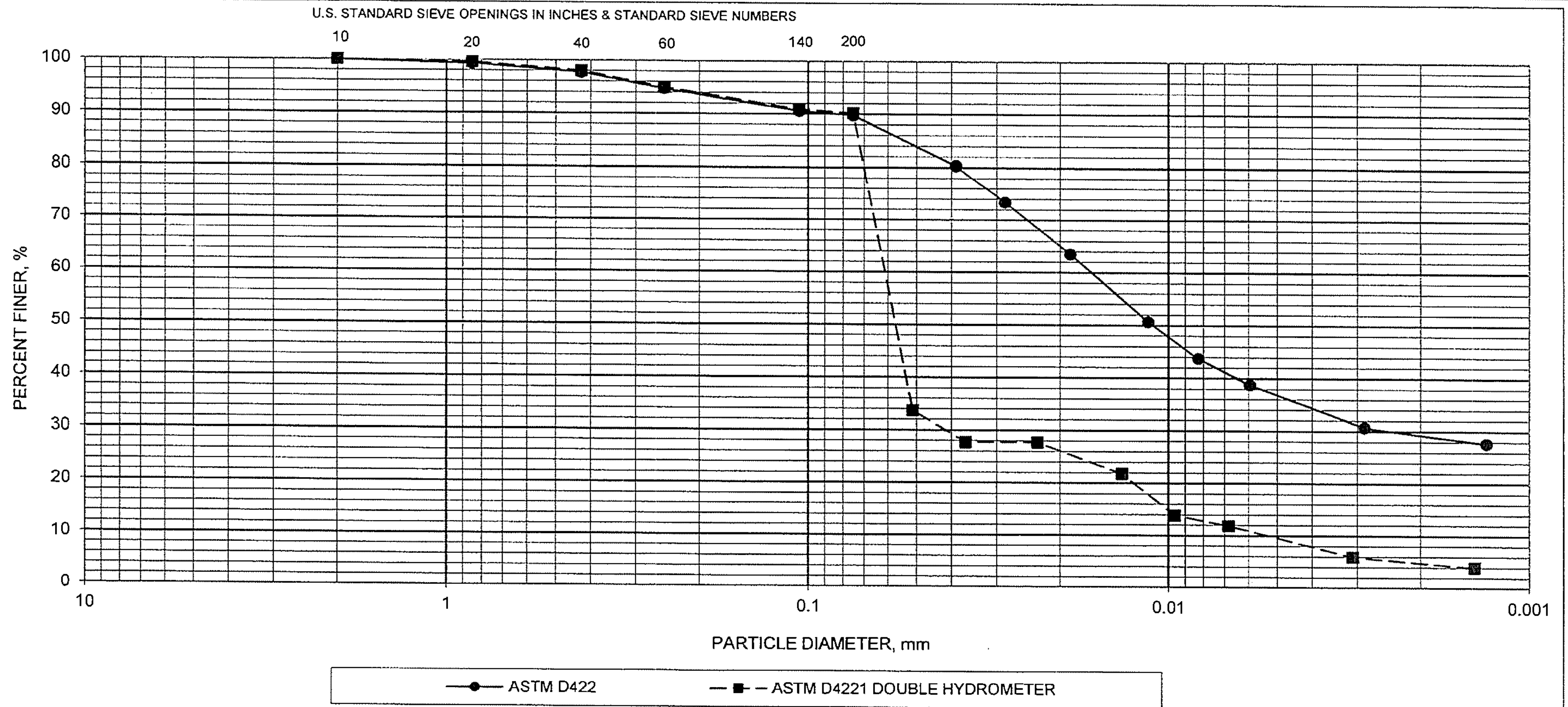
DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B003	S1	1.0	2.5	14.2														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace fine Gravel					
	S2	3.5	5.0	18.1		42	16	26										
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace fine Gravel					
	S3	6.0	7.5	15.0							2.70							
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace fine Gravel					
	S4	8.5	10.0	17.4														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace fine Gravel					
	S5	13.5	15.5	21.8	104.7	54	18	36		26*						ND1*	2*	
	Color		dark gray trace yellowish brown							Visual Classification			Fat Clay					
	S6	18.0	19.5	26.0														
	Color		brown & gray							Visual Classification			Fat Clay trace fine Sand					
	S7	23.5	25.0	20.8		50	16	34	NOTE*									CH
	Color		brown & gray							USCS Classification			Fat Clay with Sand					
	S8	28.5	30.0	12.5		21	15	6										
	Color		brown							Visual Classification			Sandy Silty Clay trace fine Gravel					
	S9	30.0	30.8	11.8	126.7				NOTE*			2.2E-07*						
	Color		dark yellowish brown with grayish brown							Visual Classification			Silty Sand trace Gravel					
	S10	33.5	35.0						** Sieve									SP
	Color		brown							USCA Classification			Poorly Graded Sand					
	S11	38.5	40.0	9.5					NOTE*									
	Color		brown							Visual Classification			Silty Sand trace Gravel					
	S12	43.5	45.0	9.9														
	Color		brown & gray							Visual Classification			Clayey Sand, fine to coarse trace fine Gravel					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	36.8	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	9.5	DISPERSION, %	26

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S5	13.5 - 15.5	FAT CLAY, DARK GRAY TRACE YELLOWISH BROWN					

PROJECT DYNEGY

COFFEEN, ILLINOIS　　JOB NO. 15151122　　DATE 9/2/2015

Terracon

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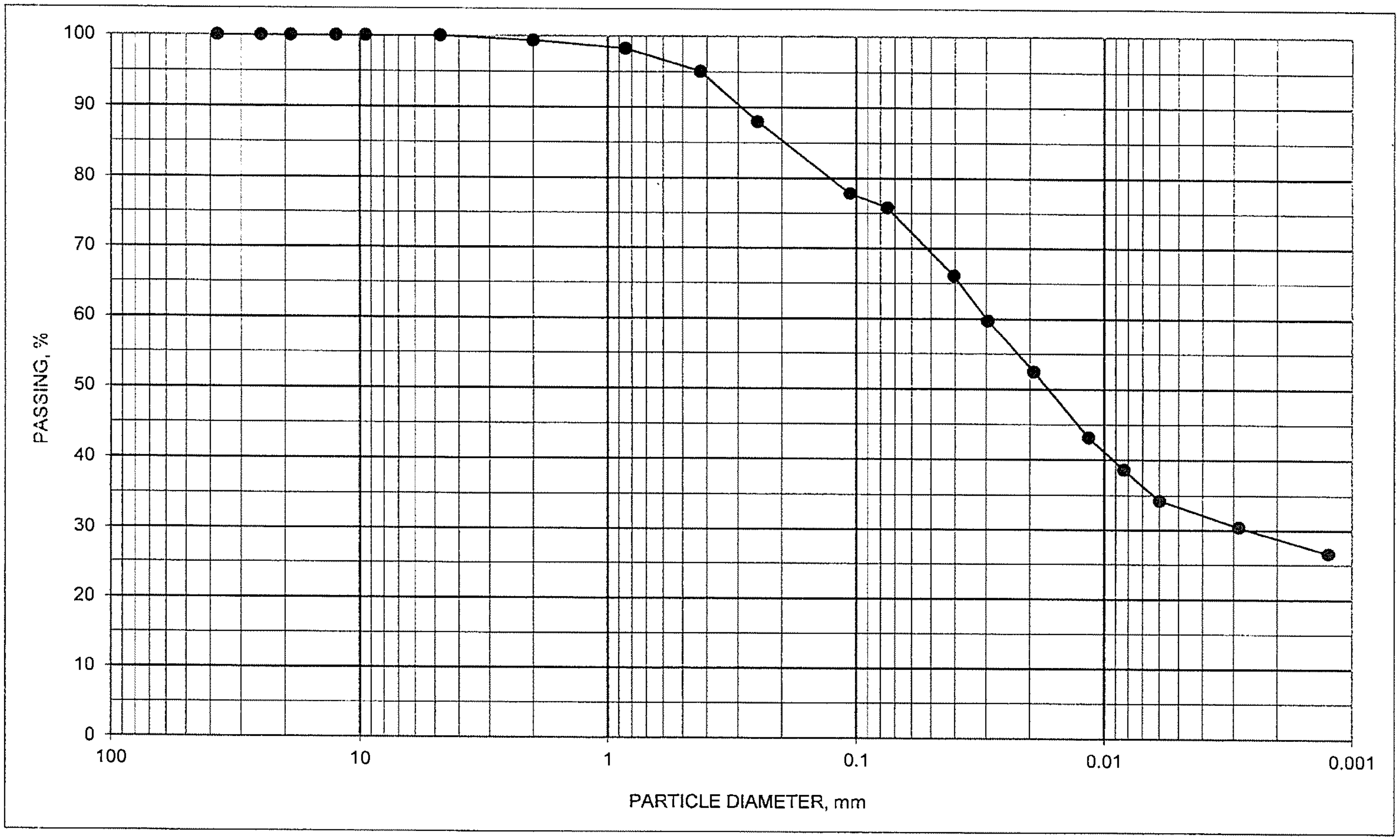
SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	99
#20	0.850	98
#40	0.425	95
#60	0.250	88
#140	0.106	78
#200	0.075	75.8
	0.0406	66.1
	0.0295	59.7
	0.0193	52.4
	0.0116	43.2
	0.0083	38.6
	0.0060	34.2
	0.0029	30.4
	0.0012	26.6
	D60	0.0299
	D30	0.0026

SPECIFIC GRAVITY 2.69 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S7	23.5 TO 25	FAT CLAY WITH SAND BROWN & GRAY	CH	20.8	50	16	34

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

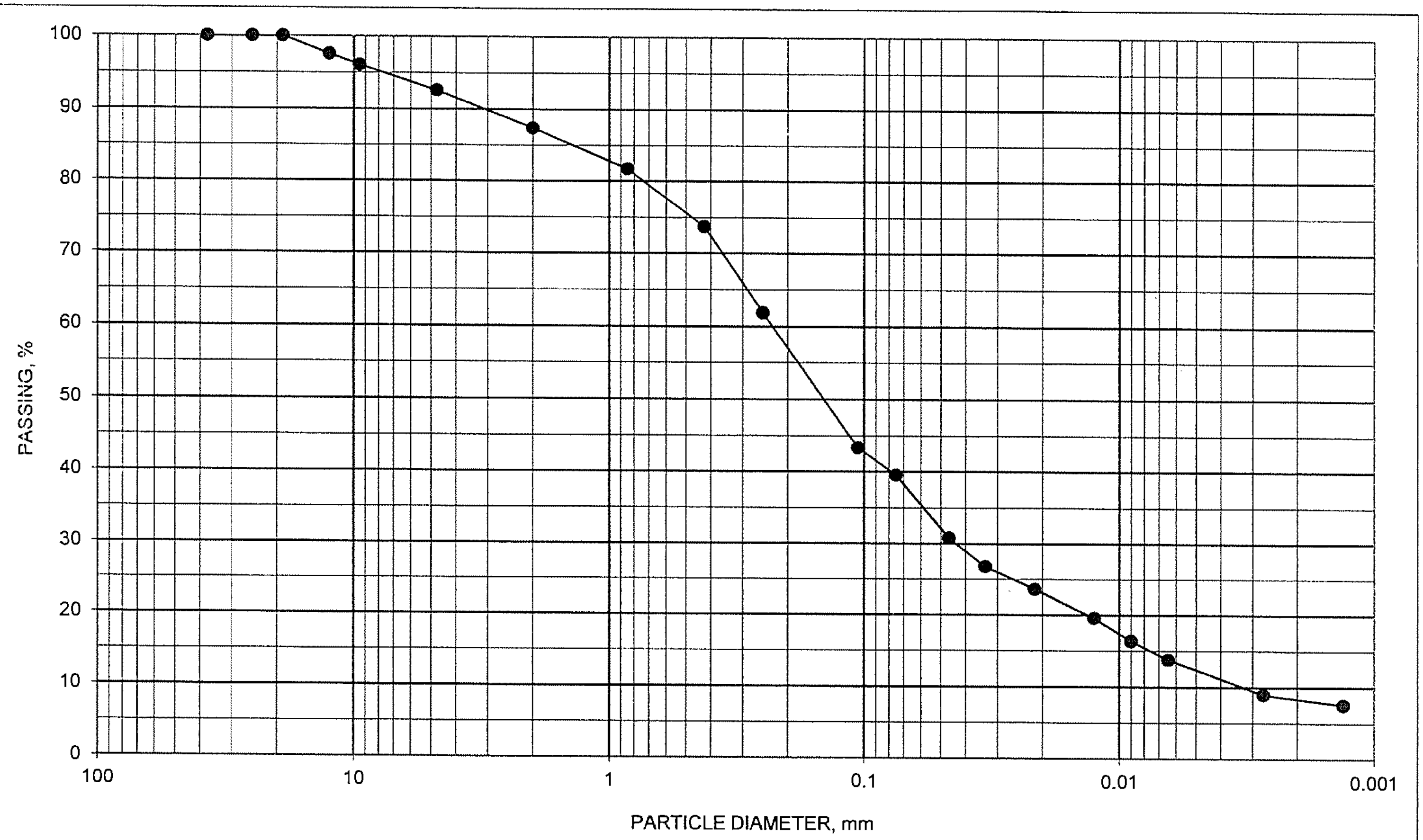
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B003-S7-23.5.xlsx]ATTERBERG M%

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	98
3/8"	9.50	96
#4	4.75	93
#10	2.00	87
#20	0.850	82
#40	0.425	74
#60	0.250	62
#140	0.106	43
#200	0.075	39.5
	0.0466	30.8
	0.0335	26.8
	0.0215	23.6
	0.0126	19.6
	0.0090	16.4
	0.0064	13.8
	0.0027	9.0
	0.0013	7.5

D60	0.2296
D30	0.0437
D10	0.0033
Cu	70.3
Cc	2.5

SPECIFIC GRAVITY 2.67 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S9	30 TO 30.8	SILTY SAND TRACE GRAVEL DARK YELLOWISH BROWN WITH GRAYISH BROWN		11.8			

PROJECT DYNEGY

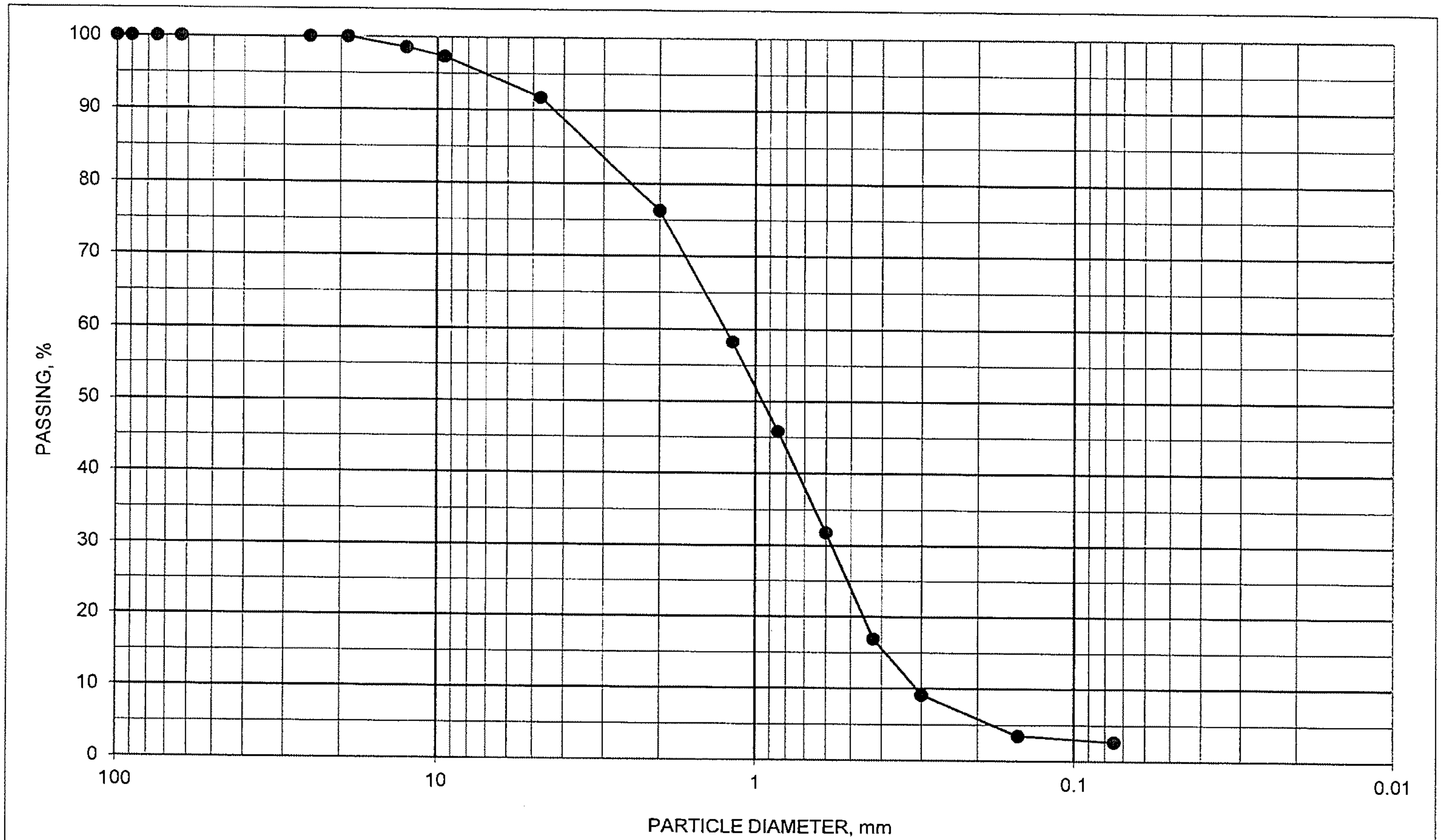
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B003-S9-30.0.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	99
3/8"	9.5	97
#4	4.8	92
#10	2.00	76
#16	1.18	58
#20	0.85	46
#30	0.600	32
#40	0.425	17
#50	0.300	9
#100	0.150	3
#200	0.075	2.7

D60	1.2430
D30	0.5757
D10	0.3120
Cu	4.0
Cc	0.9



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S-10	33.5 TO 35	POORLY GRADED SAND BROWN	SP				

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

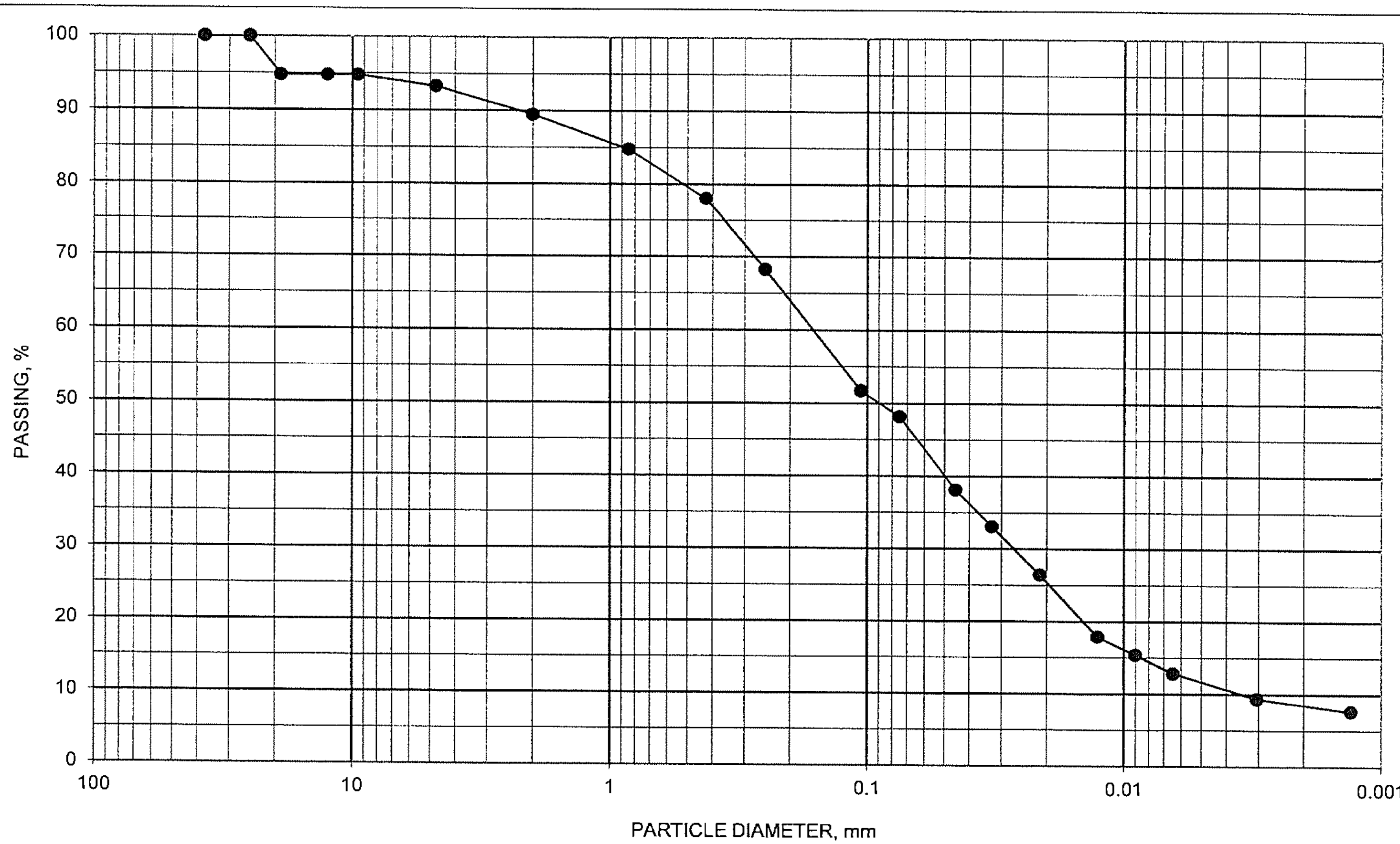
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Summary DYNEGY-COFFEEN 150904.xlsx]Task 0001

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	95
1/2"	12.5	95
3/8"	9.50	95
#4	4.75	93
#10	2.00	89
#20	0.850	85
#40	0.425	78
#60	0.250	68
#140	0.106	52
#200	0.075	48.2
	0.0453	38.1
	0.0327	33.1
	0.0213	26.4
	0.0127	17.9
	0.0090	15.4
	0.0065	12.9
	0.0031	9.4
	0.0013	7.7

D60	0.1630
D30	0.0268
D10	0.0035
Cu	46.6
Cc	1.3

SPECIFIC GRAVITY 2.67 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B003	S11	38.5 TO 40	SILTY SAND TRACE GRAVEL BROWN		9.5			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B003-S11-38.5.xlsx]GRADATION

Terracon

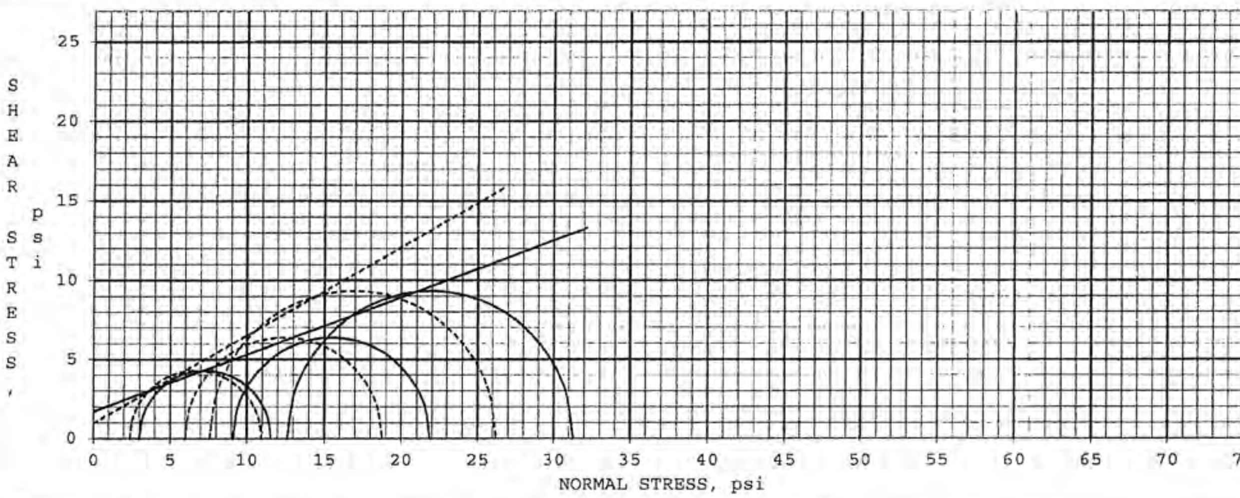
DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B004	S1	1.0	2.5	18.0														
	Color		brown							Visual Classification			Fill: Lean Clay with Fine Sand trace Fine Gravel					
	S2	3.5	5.0	10.9														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S3	6.0	7.5	11.0														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S4	8.5	10.5	12.8	121.4	39	15	24						NOTE*				
	Color		yellowish brown with gray							Visual Classification			Lean Clay with Sand					
	S5	13.5	15.0	13.1		26	14	12										
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S6	18.5	20.0	21.8														
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S7	23.5	25.5	20.6	107.4	51	17	34				5.0E-07*		NOTE*				
	Color		reddish brown with dark gray							Visual Classification								
	S8	28.5	30.0	24.2		43	16	27										
	Color		brown & gray							Visual Classification			Lean Clay with Fine to Med Sand					
	S9	33.5	35.0	8.4		21	13	8										
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S10	38.5	40.0	8.8							2.76							
	Color		brown & gray							Visual Classification			Sandy Silty Lean Clay trace Fine to Coarse Gravel					
	S11	43.5	45.0	14.8					NOTE*									
	Color		brown & gray							Visual Classification			Sandy Silty Clay trace Gravel					

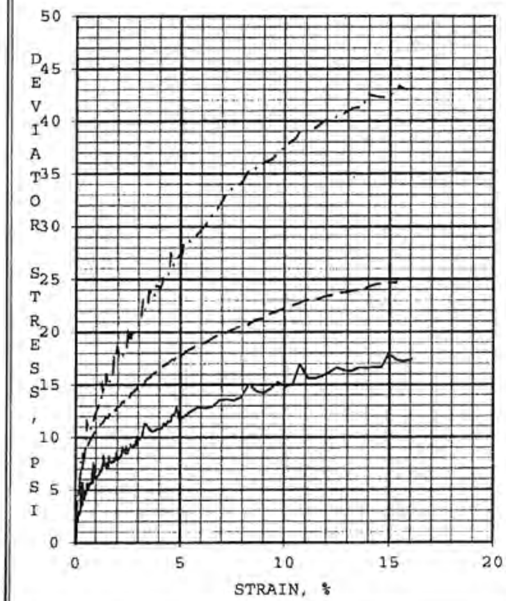
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	29.1	COHESION, psi	1.0
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	19.8	COHESION, psi	1.7



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	12.6	13.0	12.9
INITIAL	DRY DENSITY, pcf	122.9	119.8	121.6
INITIAL	SATURATION, %	91	86	90
INITIAL	VOID RATIO	0.37	0.41	0.39
BEFORE SHEAR	WATER CONTENT, %	13.6	14.7	13.5
BEFORE SHEAR	DRY DENSITY, pcf	123.1	120.6	123.5
BEFORE SHEAR	SATURATION (B PARAMETER)	0.97	0.97	0.97
BEFORE SHEAR	VOID RATIO	0.37	0.40	0.36
BEFORE SHEAR	FINAL BACK PRESSURE, psi	100.6	99.8	101.1
MINOR PRINCIPAL STRESS, psi		3.0	9.1	~~12.6~~ 3.0 (Raw data has 3.0 psi)
EFFECTIVE STRESS PEAK AT % STRAIN		2.0	2.0	2.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		8.6	12.8	18.6
TOTAL STRESS PEAK AT % STRAIN		2.0	2.0	2.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		8.6	12.8	18.6
ULTIMATE DEVIATOR STRESS (15% STR), psi		17.9	24.7	42.7
TIME TO 50% PRIMARY CONSOLIDATION, min		23.00	9.00	4.00
STRAIN RATE, % / hour		0.80	1.95	3.98
INITIAL DIAMETER, inch		1.357	1.362	1.366
INITIAL HEIGHT, inch		2.874	2.885	2.831
AREA AFTER CONSOLIDATION, inch2		1.446	1.454	1.453

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, YELLOWISH BROWN WITH GRAY

LL 39 | PL 15 | PI 24 | Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B004

LABORATORY: TERRACON - LENEXA

SAMPLE #: S4

DATE: 9/10/2015

DEPTH, feet: 8.5 - 10.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

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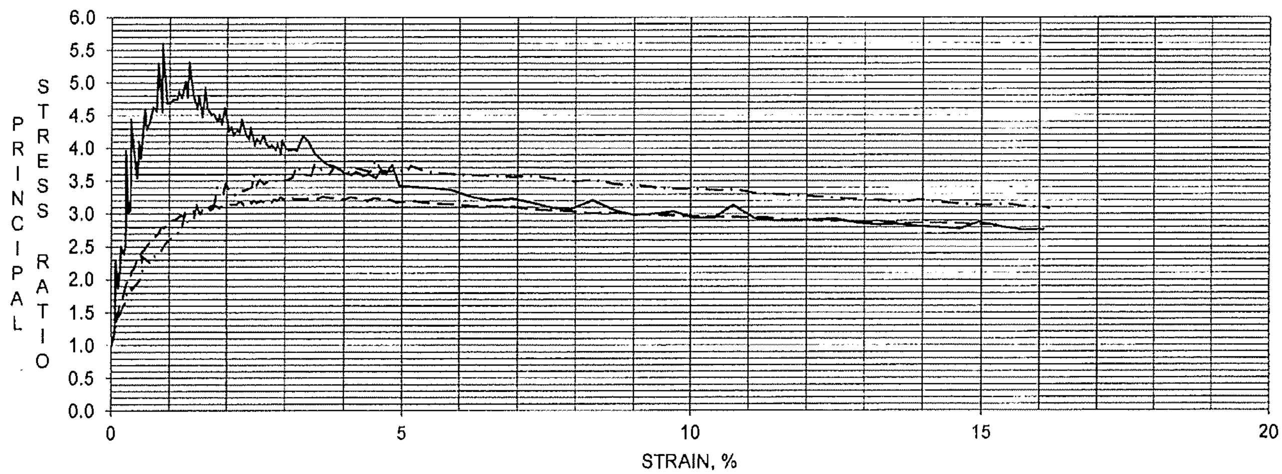
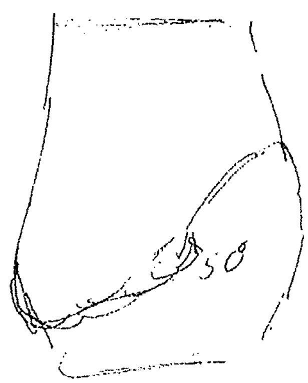
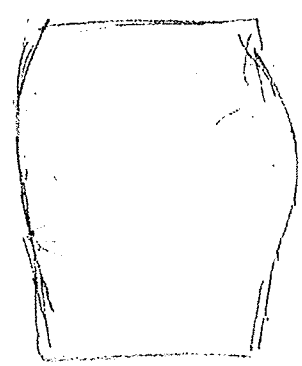
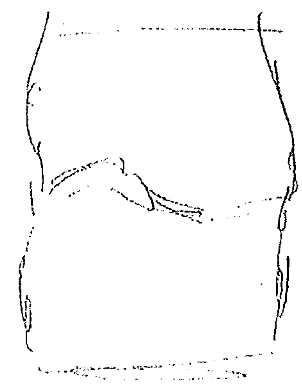
Embankment

DYNEGY

15151122 COF-B004 S4 8.5 - 10.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 2 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 2 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 2 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 2 % STRAIN.

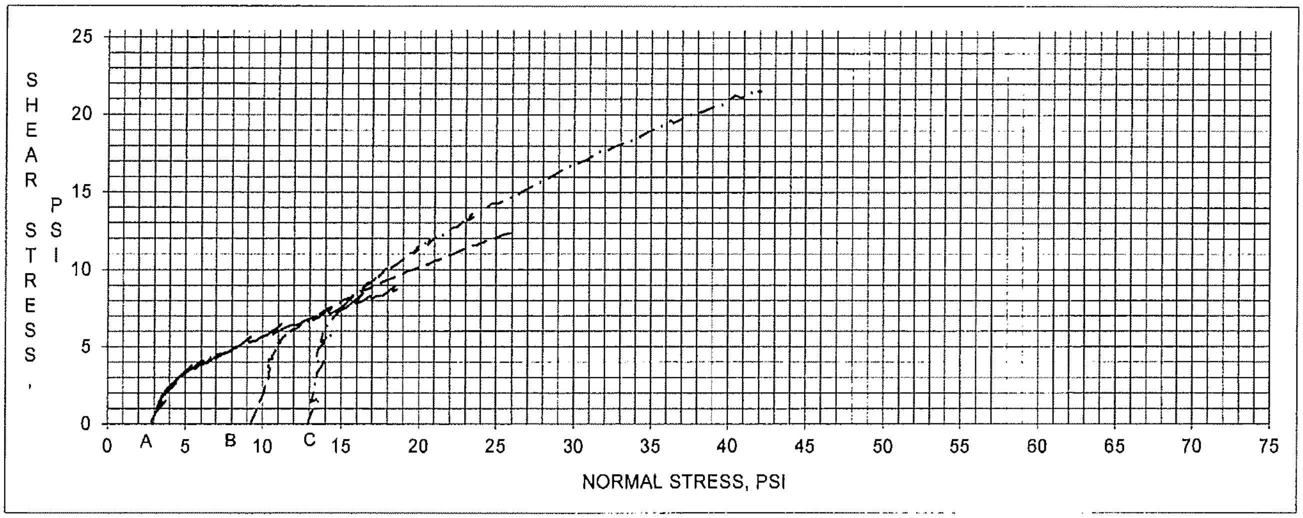
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

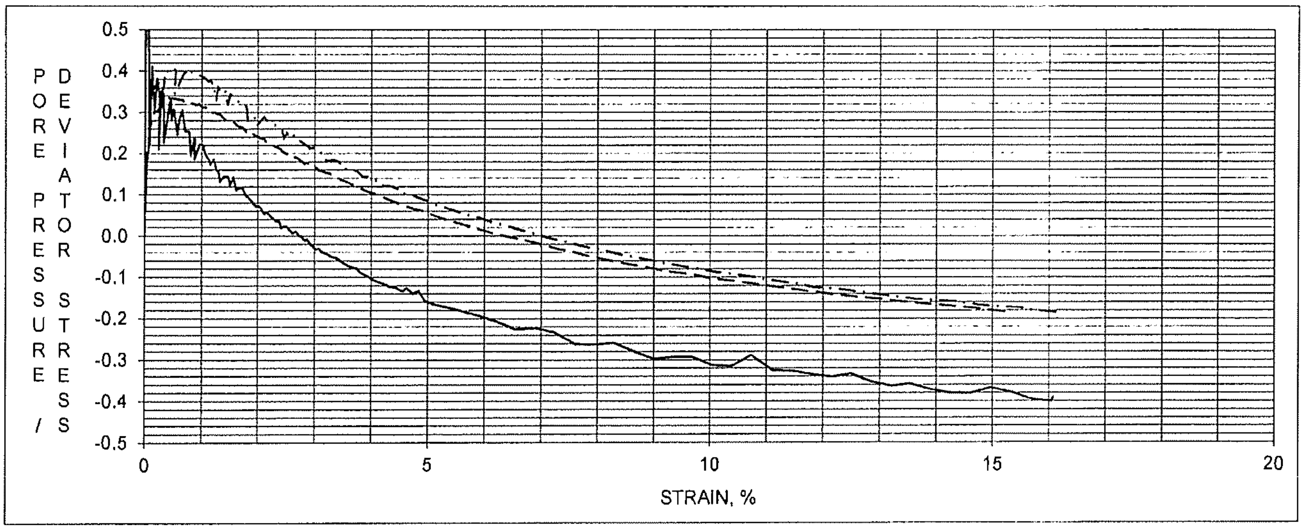
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

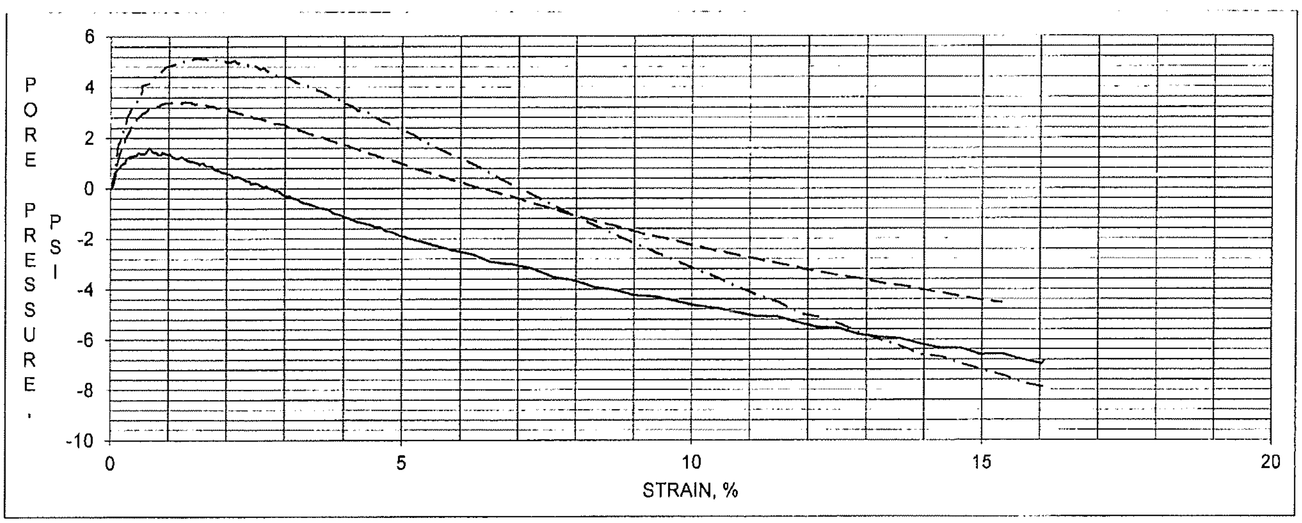
Terracon

DYNEGY

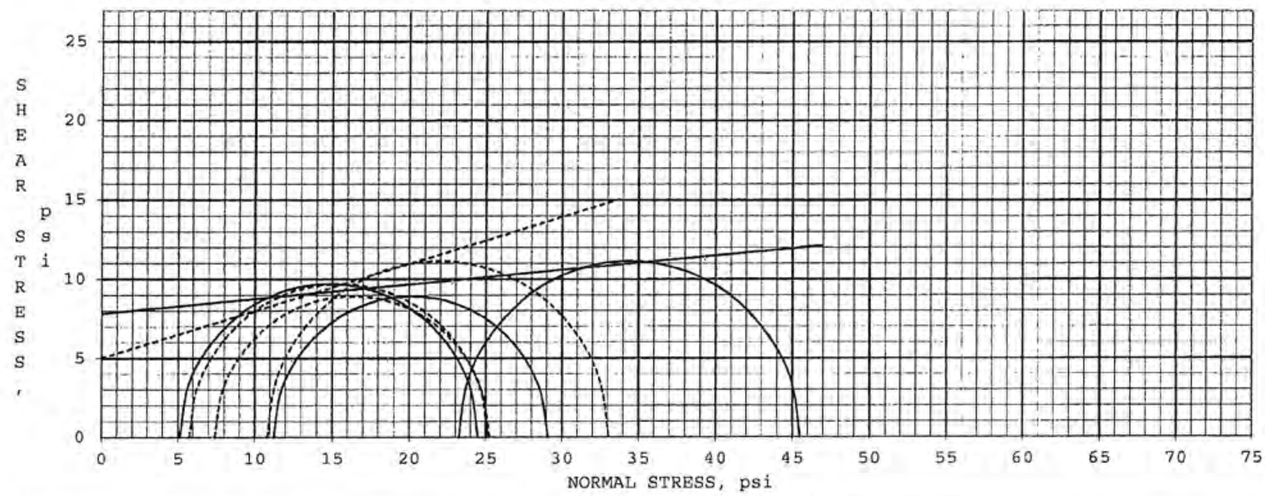
15151122 COF-B004 S4 8.5 - 10.5



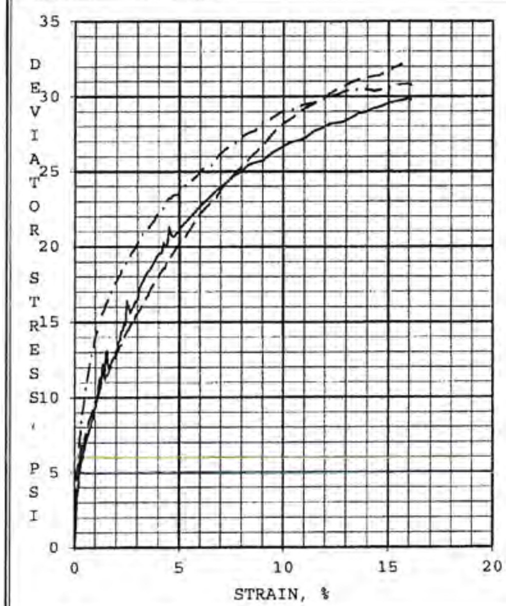




Terracon



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	16.5	COHESION, psi	5.0
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	5.2	COHESION, psi	7.8



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	20.8	17.7	20.6
INITIAL	DRY DENSITY, pcf	106.9	111.0	107.6
INITIAL	SATURATION, %	97	92	98
INITIAL	VOID RATIO	0.58	0.52	0.57
BEFORE SHEAR	WATER CONTENT, %	21.0	18.4	19.1
BEFORE SHEAR	DRY DENSITY, pcf	107.5	112.5	111.1
BEFORE SHEAR	SATURATION (B PARAMETER)	0.98	0.95	0.97
BEFORE SHEAR	VOID RATIO	0.57	0.50	0.52
BEFORE SHEAR	FINAL BACK PRESSURE, psi	100.8	100.7	100.6
MINOR PRINCIPAL STRESS, psi		5.1	11.2	23.2
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		19.4	17.8	22.3
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		19.4	17.8	22.3
ULTIMATE DEVIATOR STRESS (15% STR), psi		29.5	31.7	30.6
TIME TO 50% PRIMARY CONSOLIDATION, min		3.70	5.00	14.30
STRAIN RATE, % / hour		1.26	1.23	1.23
INITIAL DIAMETER, inch		1.368	1.366	1.360
INITIAL HEIGHT, inch		2.842	2.833	2.853
AREA AFTER CONSOLIDATION, inch2		1.464	1.455	1.421

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
SANDY FAT CLAY, REDDISH BROWN WITH DARK GRAY

LL 51 | PL 17 | PI 34 | Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B004

LABORATORY: TERRACON - LENEXA

SAMPLE #: S7

DATE: 9/10/2015

DEPTH, feet: 23.5 - 25.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

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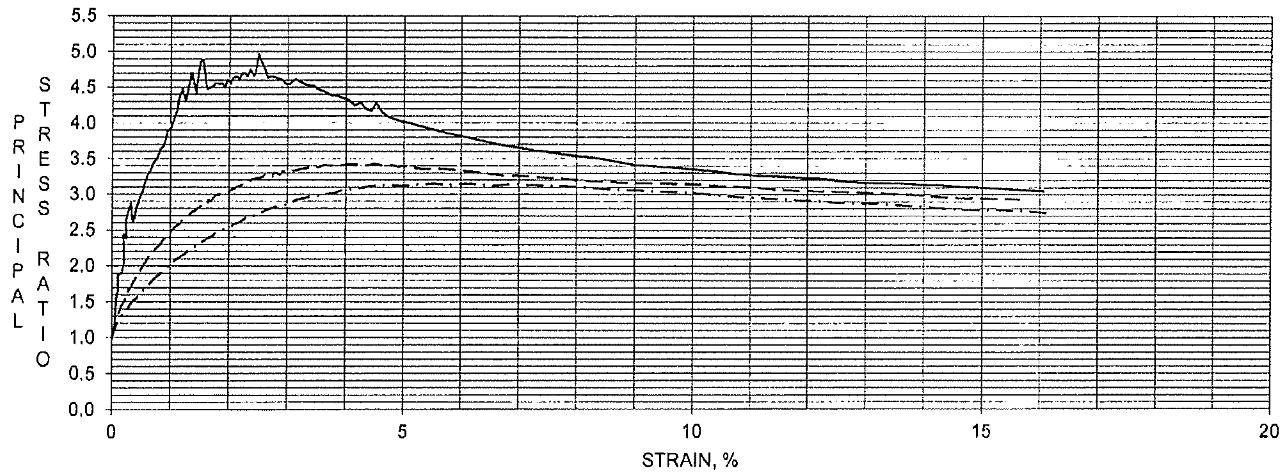
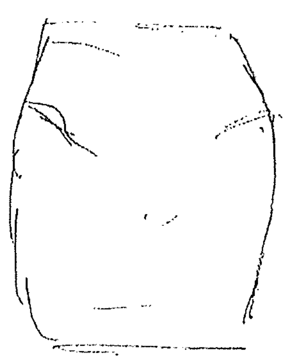
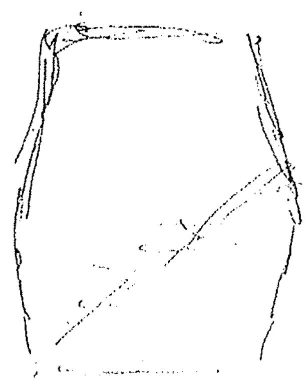
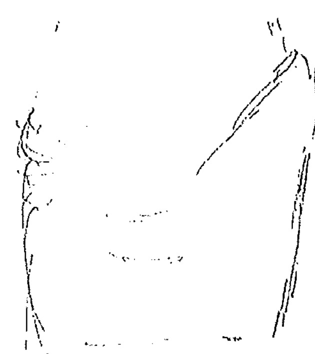
Foundation Crust

DYNEGY

15151122 COF-B004 S7 23.5 - 25.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

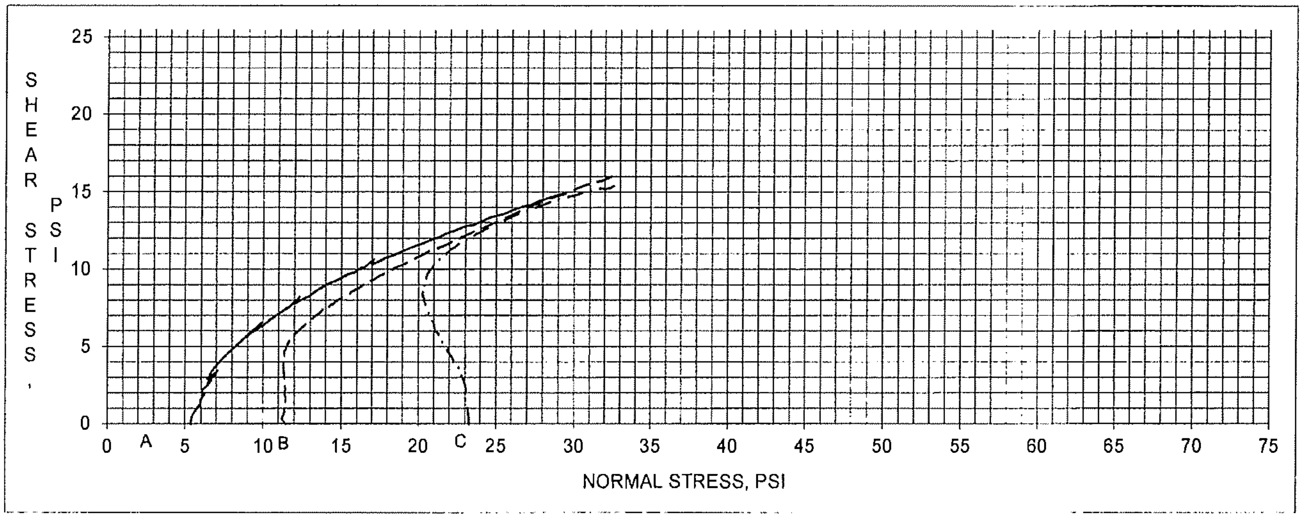
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

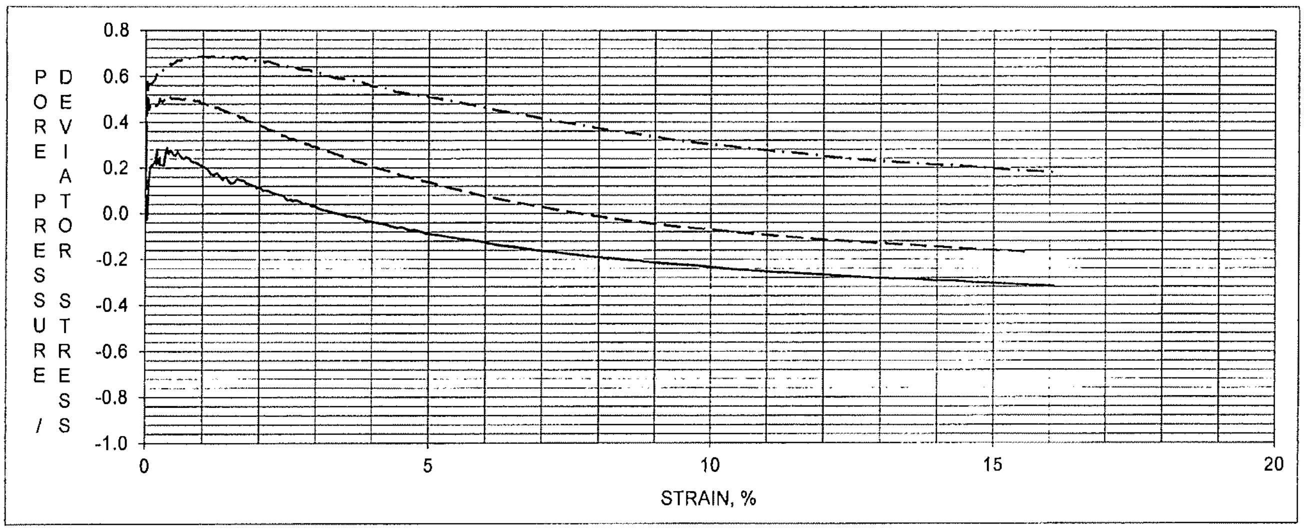
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

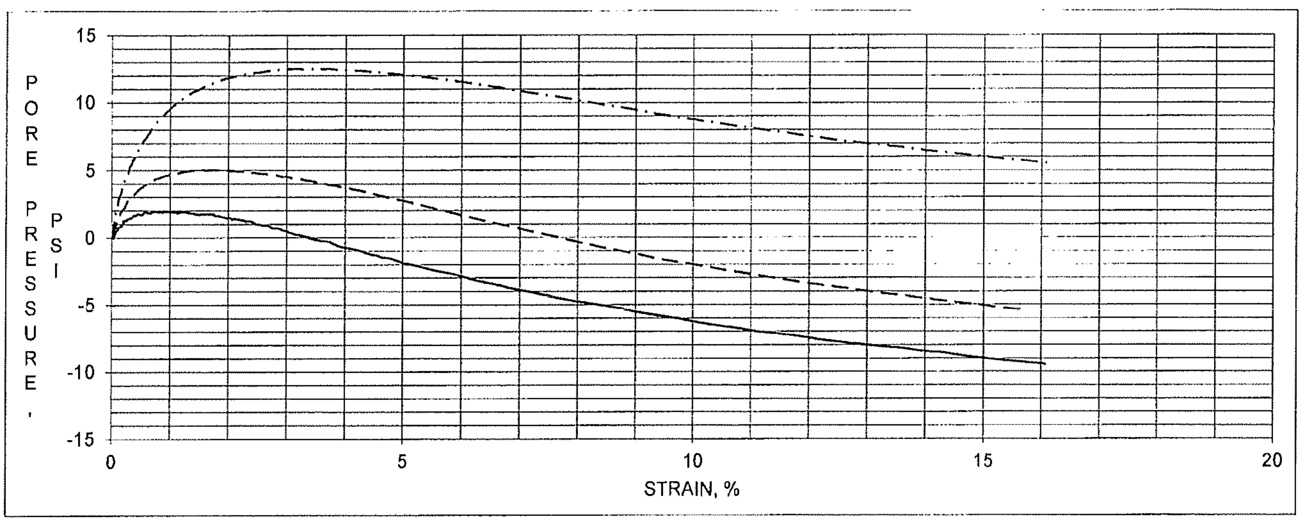
Terracon

DYNEGY

15151122 COF-B004 S7 23.5 - 25.5





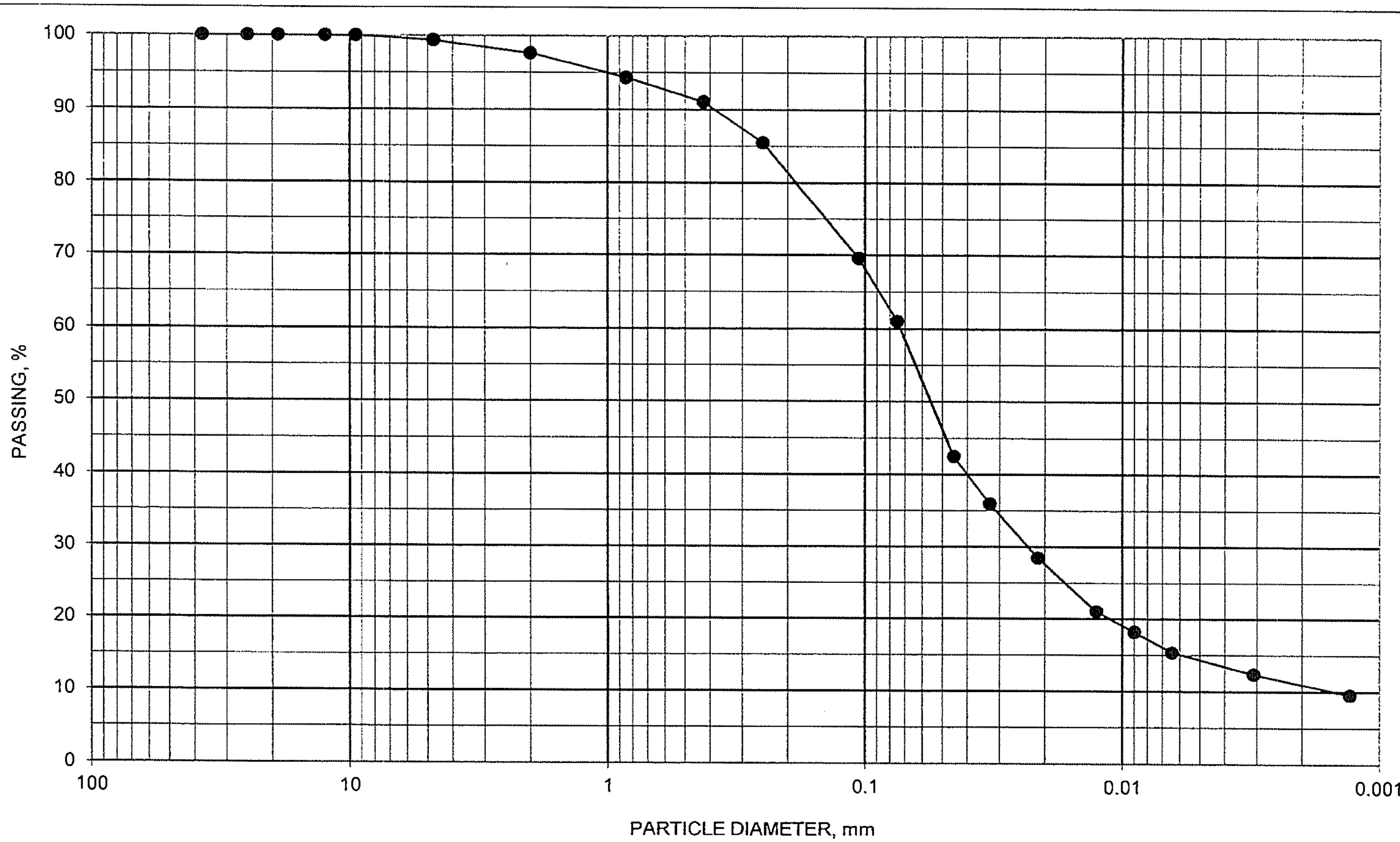


Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	99
#10	2.00	98
#20	0.850	94
#40	0.425	91
#60	0.250	85
#140	0.106	70
#200	0.075	61.0
	0.0453	42.5
	0.0328	36.0
	0.0213	28.5
	0.0126	21.0
	0.0090	18.2
	0.0064	15.4
	0.0031	12.4
	0.0013	9.6

D60	0.0730
D30	0.0232
D10	0.0015
Cu	48.7
Cc	4.9

SPECIFIC GRAVITY 2.68 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B004	S11	43.5 TO 45	SANDY SILTY CLAY TRACE GRAVEL BROWN & GRAY		14.8			

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B004-S11-43.5.xlsx]ATTERBERG M%

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B005	S1	1.0	2.5	21.1														
	Color		brown & gray							Visual Classification			Fill: Lean Clay					
	S2	3.5	5.5	8.0	126.5	22	13	9		58*		7.0E-07*				ND1*	2*	
	Color		brown							Visual Classification			Sandy Lean Clay					
	S3	6.0	7.5	13.1														
	Color		brown							Visual Classification			Fill: Sandy Lean Clay					
	S4	8.5	10.0	9.9		20	14	6										
	Color		brown							Visual Classification			Fill: Sandy, Silty Clay trace Fine Gravel					
	S5	13.5	15.0	10.3														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S6	18.5	20.0	9.4														
	Color		brown & gray							Visual Classification			Fill: Sandy Lean Clay trace Fine Gravel					
	S7	23.5	25.5	18.7	110.7	37	17	20					NOTE*	NOTE*				
	Color		gray with grayish brown							Visual Classification			Lean Clay with Sand					
	S8	28.5	30.0	21.9														
	Color		brown & gray							Visual Classification			Fat Clay trace Fine Sand					
	S9	33.5	35.0	26.7		22	16	6	NOTE*									SC-SM
	Color		brown & gray							USCA Classification			Silty, Clayey Sand					
	S10	38.5	40.0	13.0 CL					** Sieve									
				11.6 SA														
	Color		brown & gray							Visual Classification			Clayey Sand trace Fine Gravel					
	S11	43.5	45.0	12.8		32	15	17	NOTE*									CL
	Color		brown & gray							USCA Classification			Sandy Lean Clay trace Gravel					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

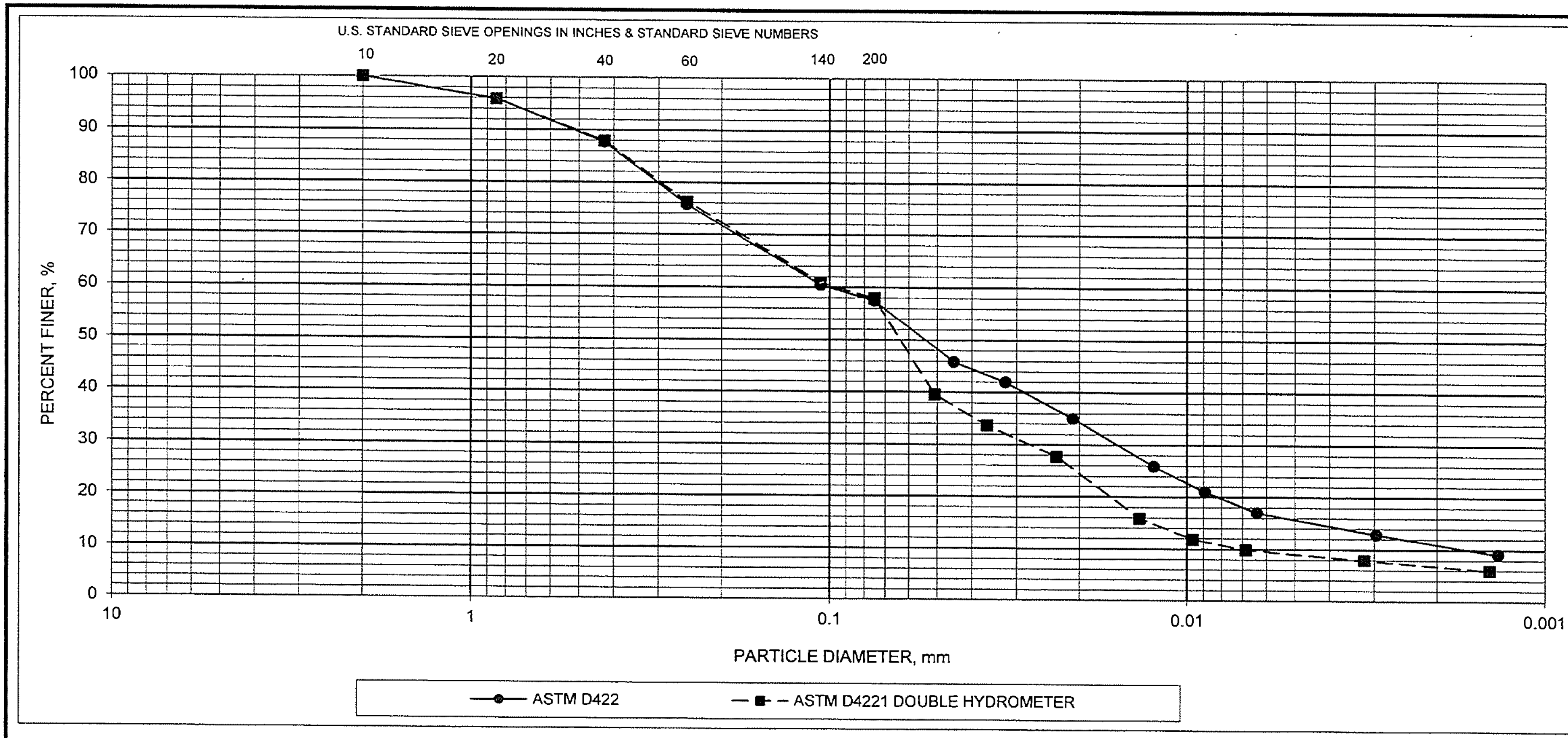
DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B005	S12	48.5	50.0	15.5		32	15	17										
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					
	S13	53.5	55.0	23.2														
	Color		brown & gray							Visual Classification			Lean to Fat Clay trace Fine Sand					
	S14	58.5	60.0	23.3		47	17	30	NOTE*									CL
	Color		brown & gray							USCA Classification			Lean Clay with Sand					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



GRAIN SIZE DISTRIBUTION CURVE

ASTM D422, % 0.005 mm	15.7	ASTM D4221 DOUBLE HYDROMETER, % 0.005 mm	9.1	DISPERSION, %	58

BORING NO.	SAMPLE NO.	DEPTH, feet	ASTM DESCRIPTION	UNIFIED SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S2	3.5 - 5.5	SANDY LEAN CLAY, BROWN					

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/2/2015

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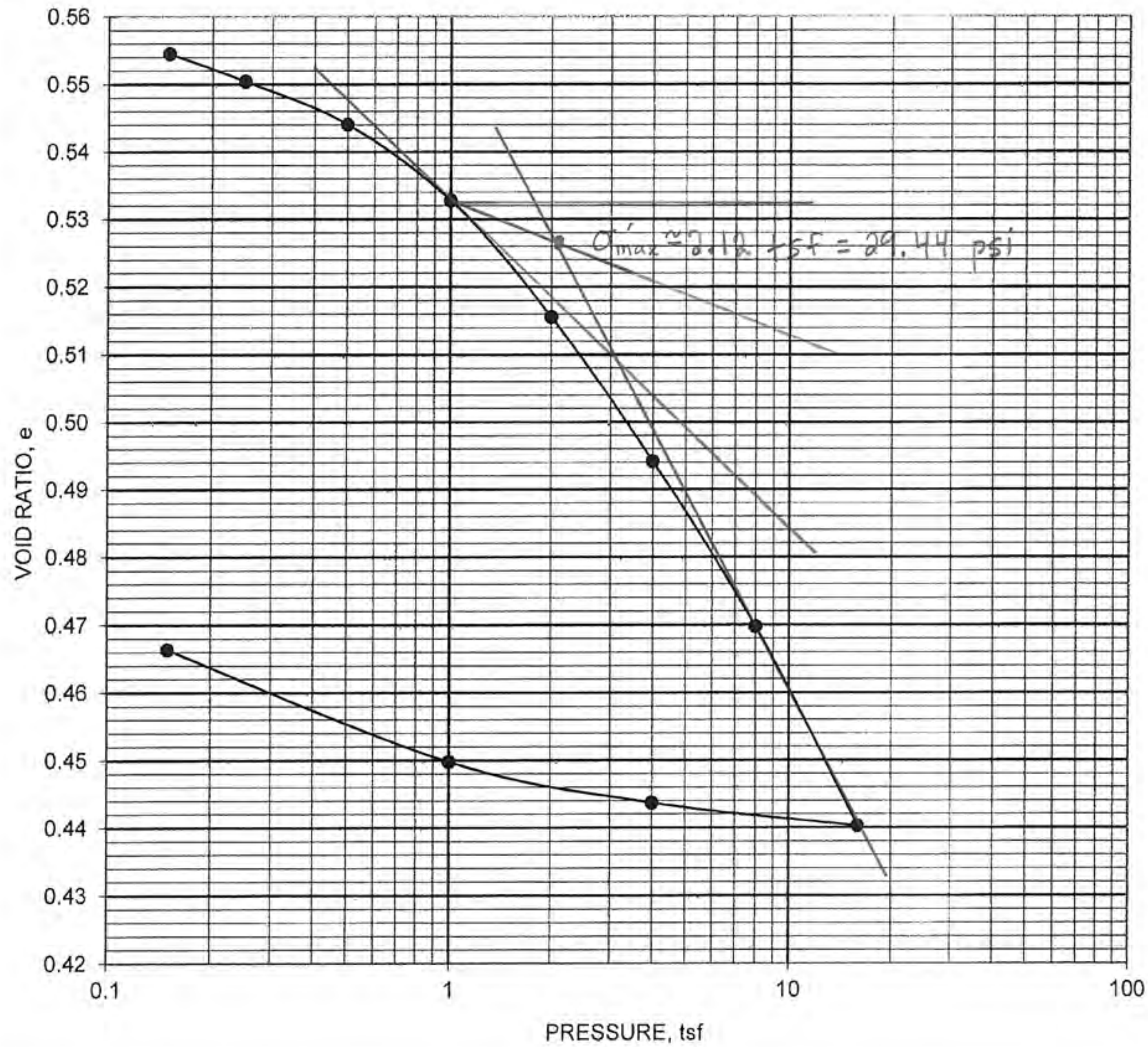
Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.56	HEIGHT, mm	25.30	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		1.03		MOISTURE, %	18.3	15.4
PRECONSOL. PRESSURE, tsf		2.12		DRY DENSITY, pcf	108.3	116.0
OVER CONSOLIDATION RATIO		2.1		SATURATION, %	89	90
COMPRESSION INDEX		0.10		VOID RATIO	0.556	0.466
REBOUND INDEX		0.016		SAMPLE TYPE	UNDISTURBED	

LIQUID LIMIT	37	PLASTIC LIMIT	17	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.7 ESTIMATED

SAMPLE DESCRIPTION: LEAN CLAY WITH SAND, GRAY WITH GRAYISH BROWN

BORING NO.	COF-B005	SAMPLE NO.	S7	DEPTH, feet	23.5 - 25.5

DYNEGY
COFFEEN, ILLINOIS
15151122
9/8/2015

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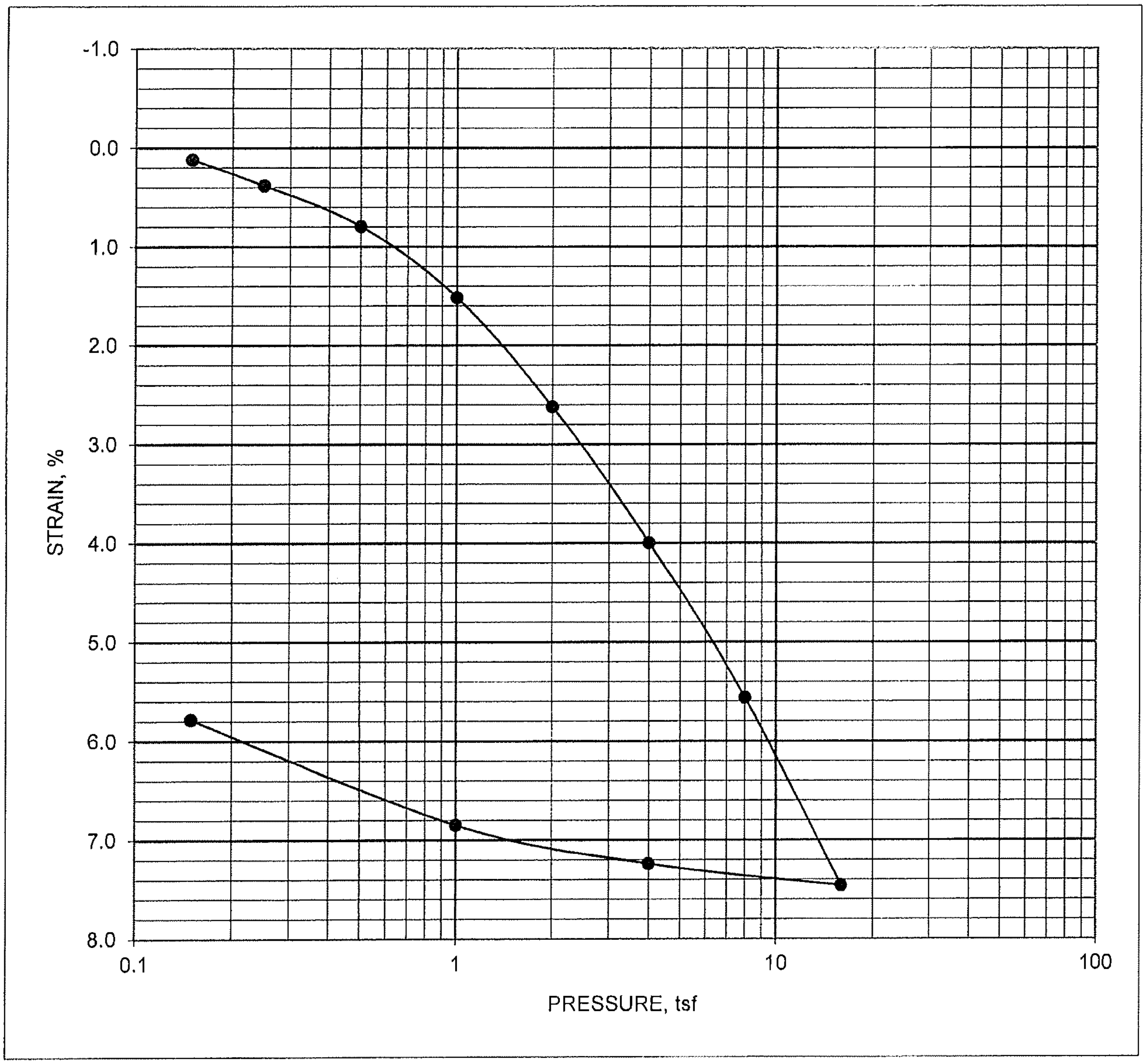
Terracon

Foundation Crust

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.56	HEIGHT, mm	25.30	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf			1.03	MOISTURE, %		18.3	15.4
PRECONSOL. PRESSURE, tsf			2.12	DRY DENSITY, pcf		108.3	116.0
OVER CONSOLIDATION RATIO			2.1	SATURATION, %		89	90
COMPRESSION INDEX			0.10	VOID RATIO		0.556	0.466
REBOUND INDEX			0.016	SAMPLE TYPE		3" SHELBY TUBE	
LIQUID LIMIT	37	PLASTIC LIMIT	17	PLASTICITY INDEX	20	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	LEAN CLAY WITH SAND, GRAY WITH GRAYISH BROWN						
BORING NO.	COF-B005	SAMPLE NO.	S7	DEPTH, feet		23.5 - 25.5	

DYNEGY
COFFEEN, ILLINOIS
15151122
9/8/2015

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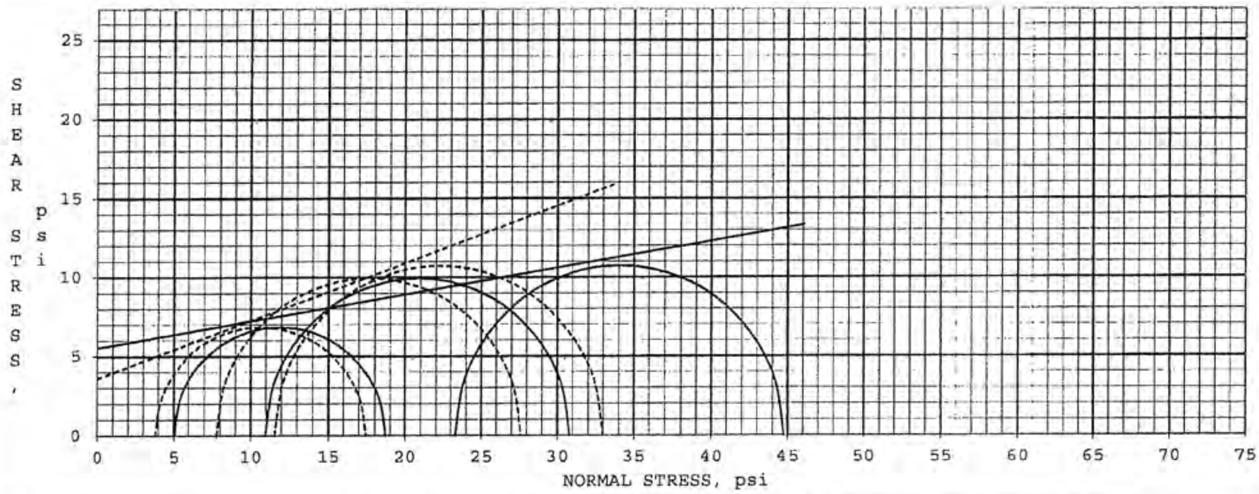
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/8/2015

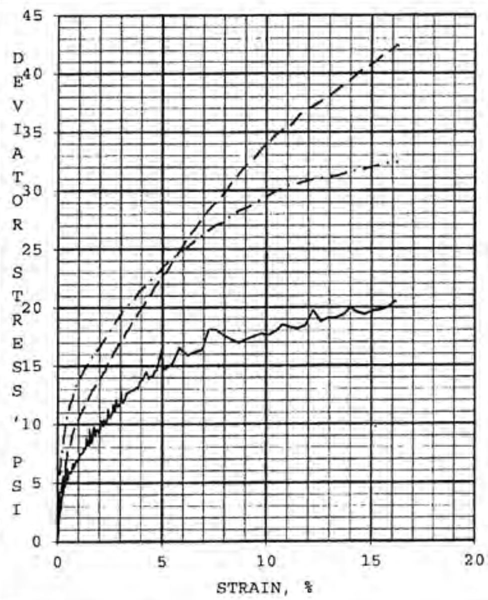
ADDITIONAL CONSOLIDATION DATA

COF-B005
S7
23.5 - 25.5

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.15			1.28E-05	8.21E-06	
0.25	1.58E-03	1.59E-03	4.15E-05	2.67E-05	4.23E-08
0.5	7.63E-04	7.67E-04	2.62E-05	1.69E-05	1.29E-08
1	1.71E-03	1.72E-03	2.30E-05	1.49E-05	2.54E-08
2	3.87E-03	3.89E-03	1.76E-05	1.15E-05	4.43E-08
4	5.26E-03	5.29E-03	1.09E-05	7.22E-06	3.80E-08
8	3.39E-03	3.41E-03	6.23E-06	4.17E-06	1.41E-08
16	2.40E-03	2.41E-03	3.77E-06	2.57E-06	6.16E-09
AVERAGE	2.71E-03	2.73E-03	1.77E-05	1.15E-05	2.62E-08



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	20.0	COHESION, psi	3.6
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	9.6	COHESION, psi	5.5



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	21.1	14.7	20.6
INITIAL	DRY DENSITY, pcf	107.5	119.5	107.6
INITIAL	SATURATION, %	100	97	98
INITIAL	VOID RATIO	0.57	0.41	0.57
BEFORE SHEAR	WATER CONTENT, %	20.4	14.2	23.4
BEFORE SHEAR	DRY DENSITY, pcf	108.6	121.7	103.3
BEFORE SHEAR	SATURATION (B PARAMETER)	0.98	0.99	0.98
BEFORE SHEAR	VOID RATIO	0.55	0.38	0.63
BEFORE SHEAR	FINAL BACK PRESSURE, psi	100.8	101.0	100.6
MINOR PRINCIPAL STRESS, psi		5.0	11.0	23.3
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		13.7	19.8	21.4
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		13.7	19.8	21.4
ULTIMATE DEVIATOR STRESS (15% STR), psi		19.6	40.8	32.0
TIME TO 50% PRIMARY CONSOLIDATION, min		3.70	0.84	3.40
STRAIN RATE, % / hour		4.09	4.09	4.09
INITIAL DIAMETER, inch		1.358	1.363	1.360
INITIAL HEIGHT, inch		2.867	2.739	2.848
AREA AFTER CONSOLIDATION, inch2		1.439	1.446	1.534

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, GRAY WITH GRAYISH BROWN

LL	37	PL	17	PI	20	Gs	2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B005

LABORATORY: TERRACON - LENEXA

SAMPLE #: S7

DATE: 9/8/2015

DEPTH, feet: 23.5 - 25.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

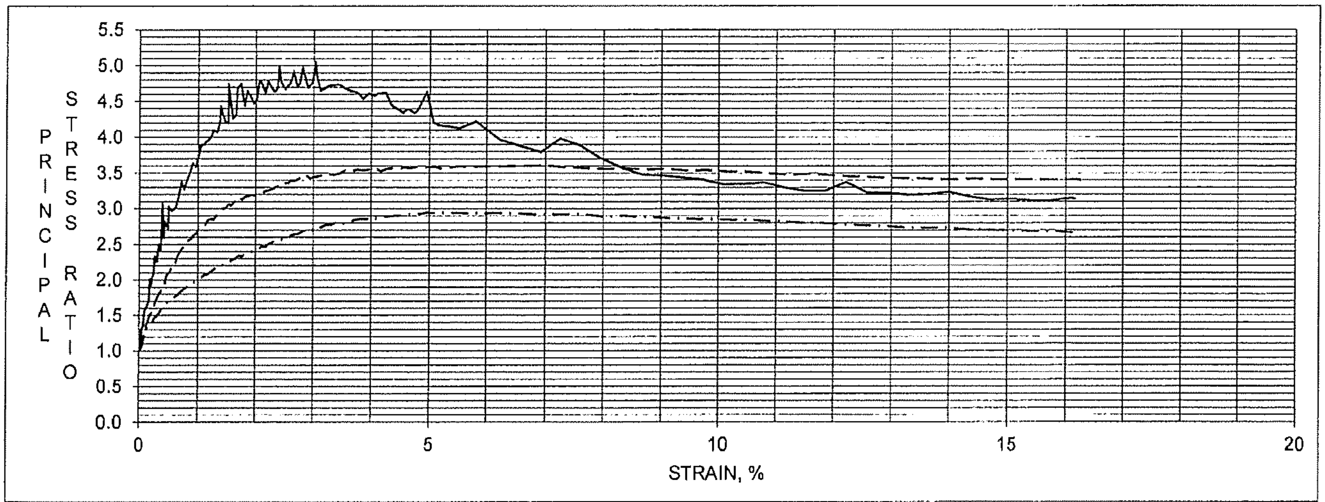
Terracon

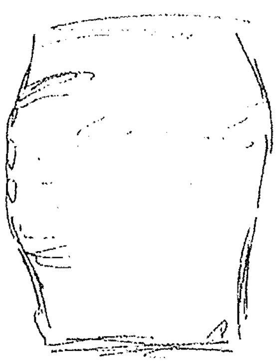
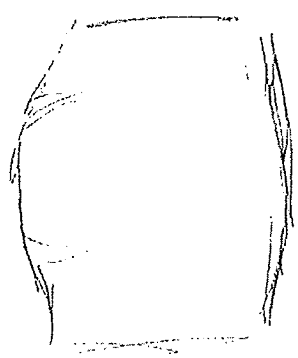
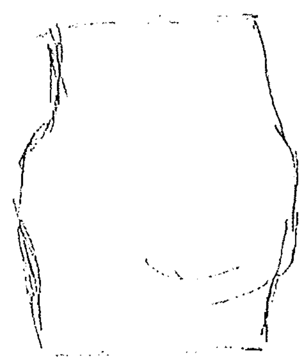
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B005\[15151122 Triaxial CU COF-B005-S7-23.5.xlsx]REPORT

Foundation Crust

DYNEGY

15151122 COF-B005 S7 23.5 - 25.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

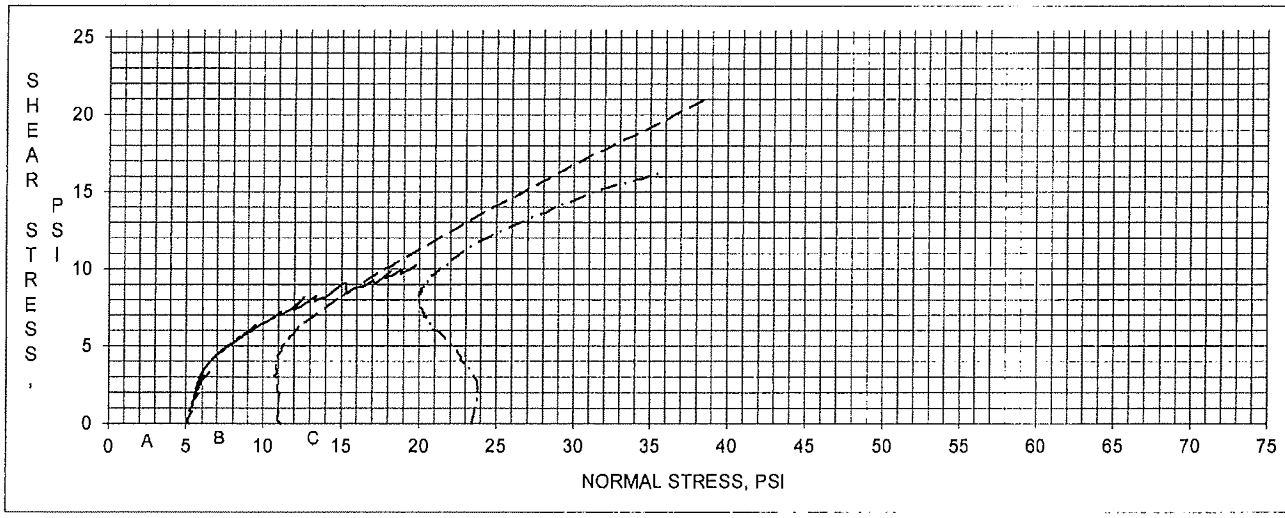
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

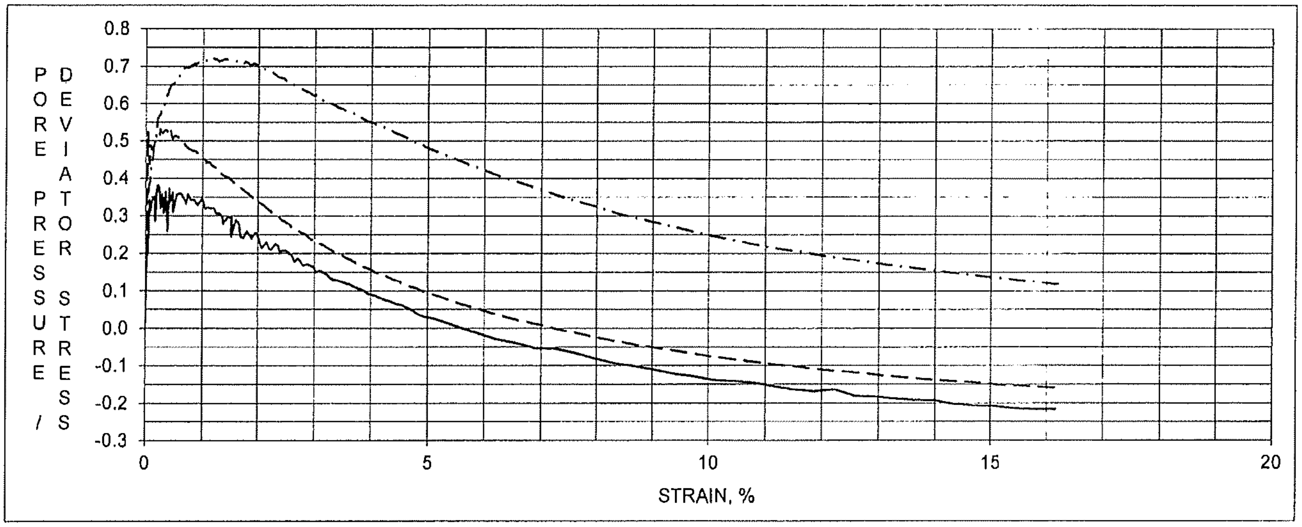
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

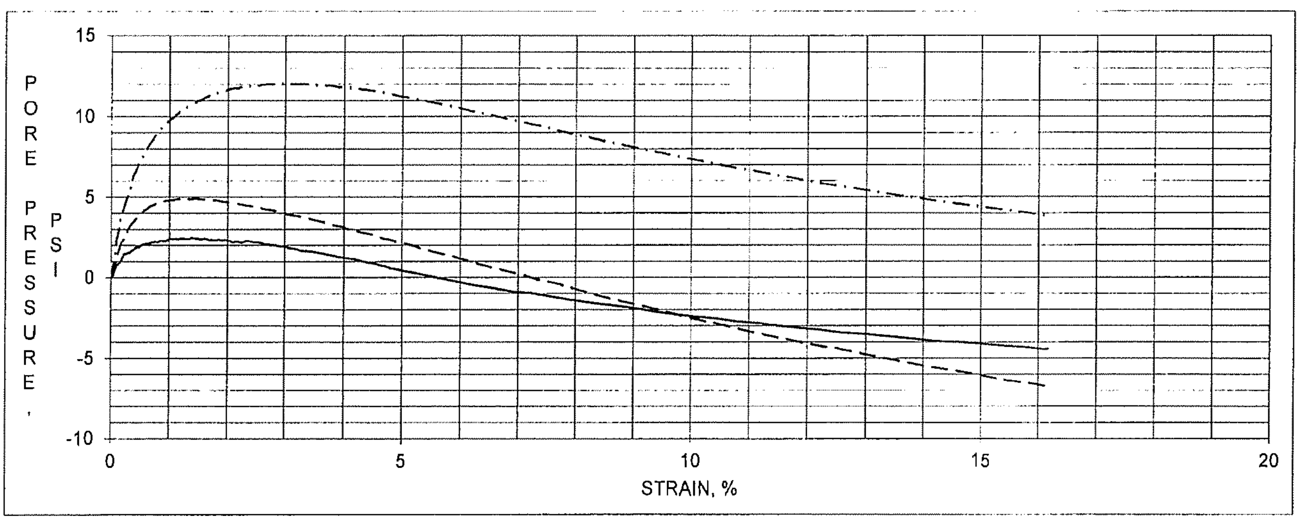
Terracon

DYNEGY

15151122 COF-B005 S7 23.5 - 25.5







Terracon

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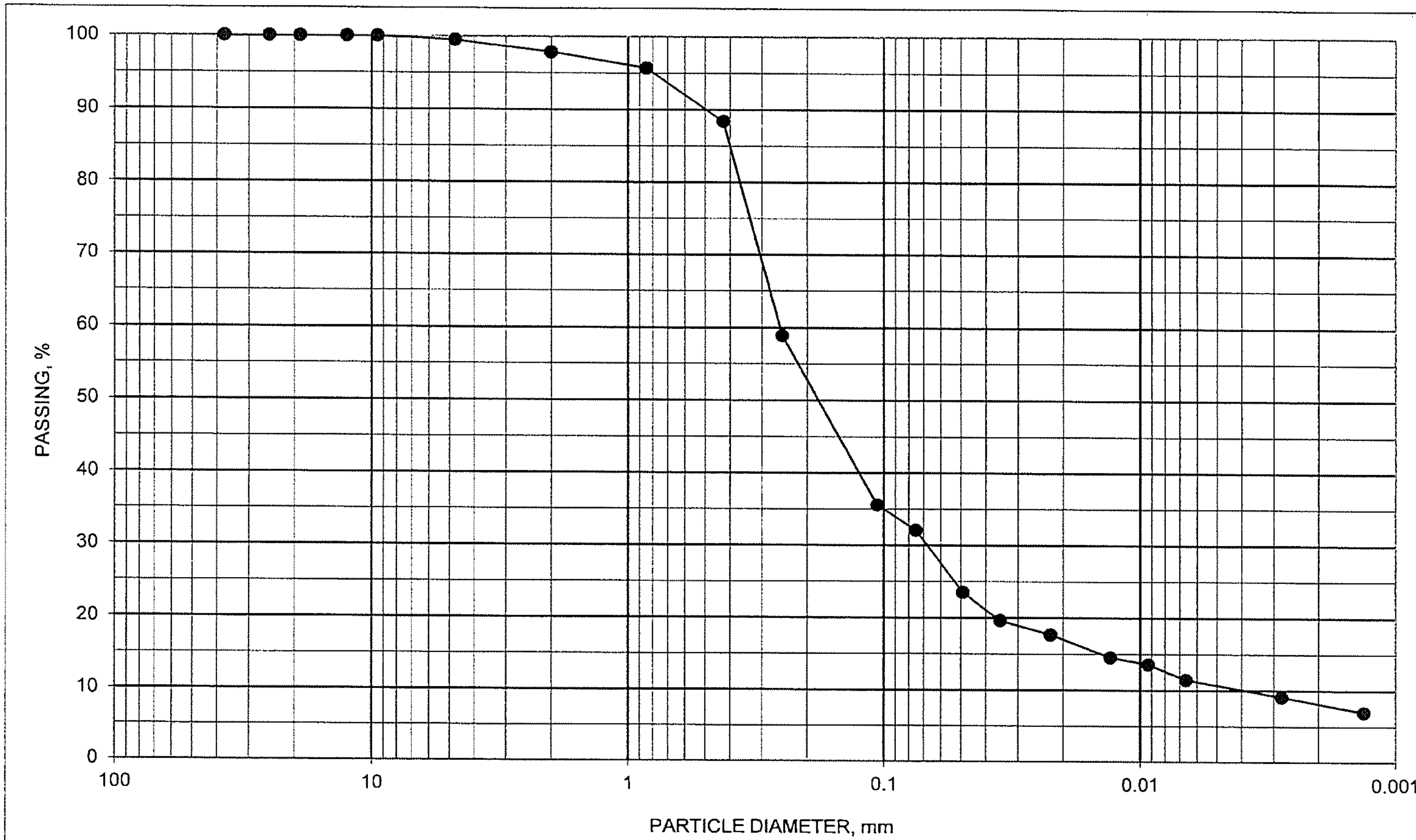
SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	99
#10	2.00	98
#20	0.850	96
#40	0.425	88
#60	0.250	59
#140	0.106	36
#200	0.075	32.1
	0.0492	23.5
	0.0352	19.6
	0.0224	17.7
	0.0131	14.6
	0.0093	13.6
	0.0066	11.5
	0.0028	9.1
	0.0013	7.0

D60	0.2550
D30	0.0677
D10	0.0039
Cu	66.1
Cc	4.7

SPECIFIC GRAVITY 2.65 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S9	33.5 TO 35	SILTY, CLAYEY SAND BROWN & GRAY	SC-SM	26.7	22	16	6

PROJECT DYNEGY

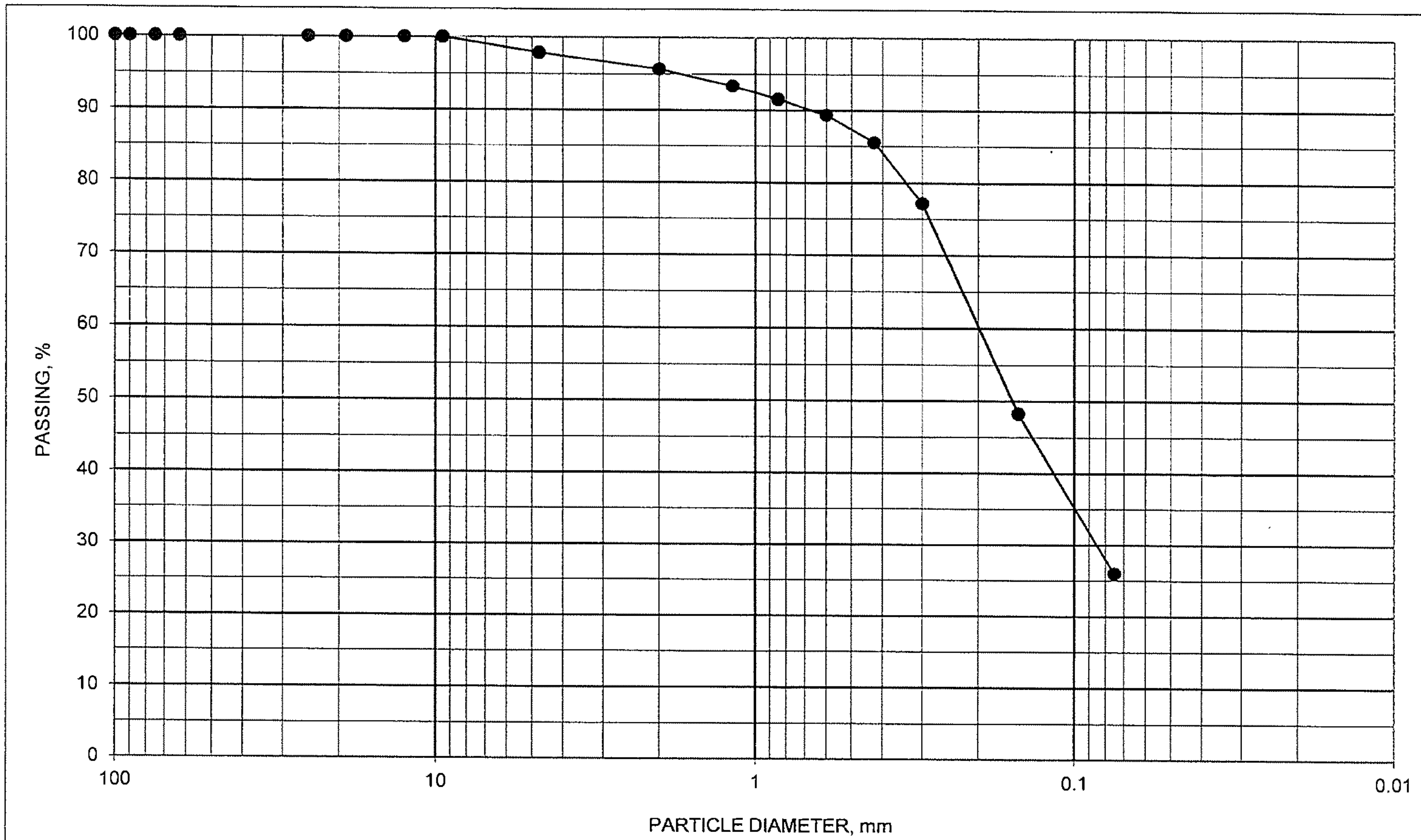
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B005-S9-33.5.xlsx]ATTERBERG M%

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.5	100
#4	4.8	98
#10	2.00	96
#16	1.18	93
#20	0.85	92
#30	0.600	89
#40	0.425	86
#50	0.300	77
#100	0.150	48
#200	0.075	26.0

D60	0.1988
D30	0.0850



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S10	38.5 TO 40	CLAYEY SAND TRACE FINE GRAVEL BROWN & GRAY					

PROJECT DYNEGY

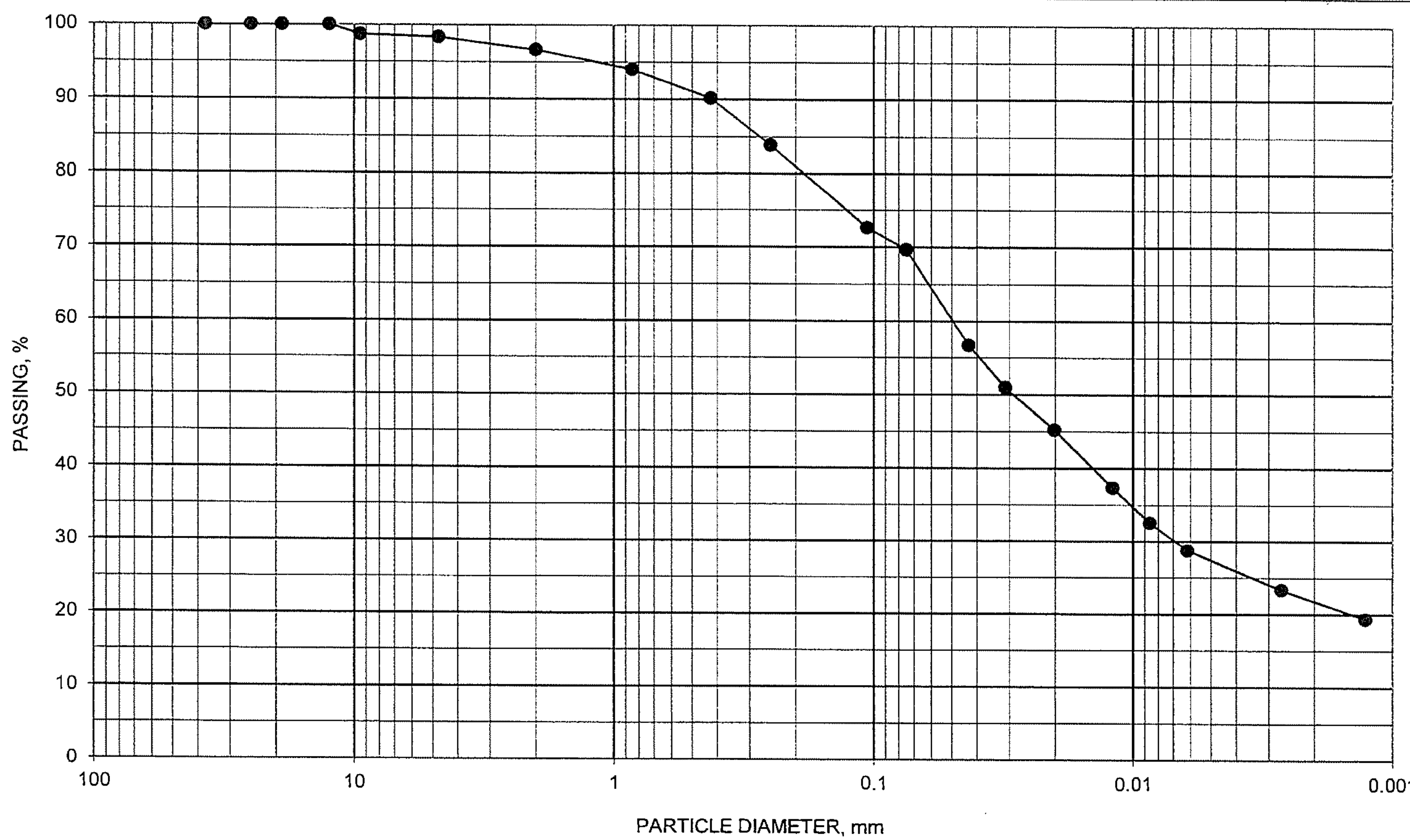
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B005-S10-38.5.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	99
#4	4.75	98
#10	2.00	97
#20	0.850	94
#40	0.425	90
#60	0.250	84
#140	0.106	73
#200	0.075	69.7
	0.0431	56.7
	0.0312	51.0
	0.0202	45.2
	0.0120	37.4
	0.0086	32.6
	0.0062	28.7
	0.0027	23.4
	0.0013	19.3
	D60	0.0496
	D30	0.0069

SPECIFIC GRAVITY 2.69 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S11	43.5 TO 45	SANDY LEAN CLAY BROWN & GRAY	CL	12.8	32	15	17

PROJECT DYNEGY

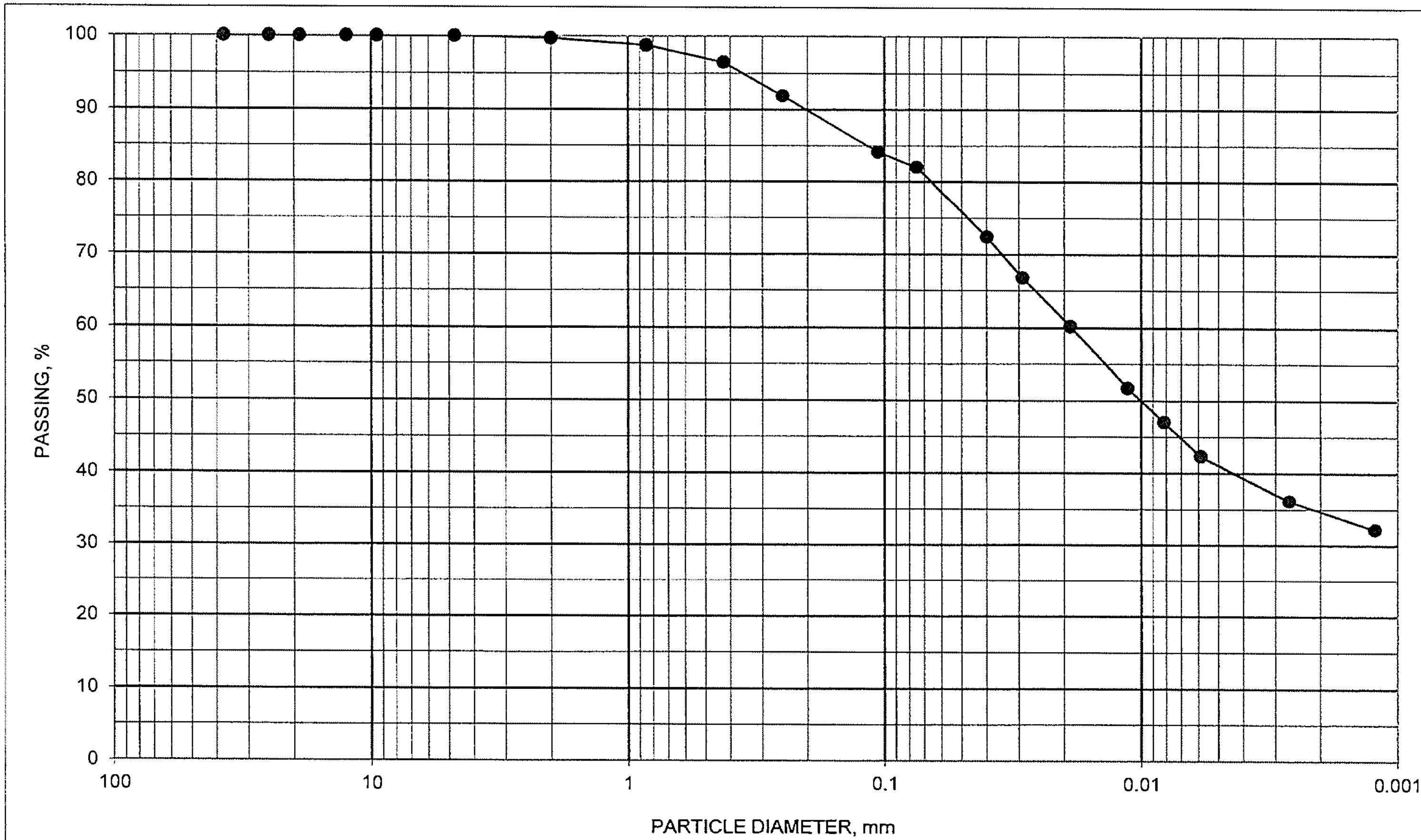
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B005-S11-43.5.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
1.5"	37.5	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	99
#40	0.425	97
#60	0.250	92
#140	0.106	84
#200	0.075	82.0
	0.0400	72.5
	0.0290	66.8
	0.0189	60.2
	0.0113	51.8
	0.0082	47.0
	0.0059	42.3
	0.0027	36.1
	0.0012	32.2
	D60	0.0187

SPECIFIC GRAVITY 2.69 ASSUMED



ASTM D422 PARTICLE-SIZE ANALYSIS OF SOILS

BORING ID	SAMPLE ID	DEPTH, feet	USCS DESCRIPTION	USCS SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B005	S14	58.5 TO 60	LEAN CLAY WITH SAND BROWN & GRAY	CL	23.3	47	17	30

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/1/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 Hydrometer Plot COF-B005-S14-58.5.xlsx]GRADATION

Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/10/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B006	S1	1.0	2.5	6.6					** Sieve									
	Color	black								Visual Classification			Fill: Cinders; Well-Graded Sand with Silt trace Fine Gravel					
	S2	3.5	5.0	48.3							2.54							
	Color	black								Visual Classification			Fill: Cinders with Clay					
	S3	6.0	8.0	22.2					** Sieve									
	Color	black								Visual Classification			Fill: Cinders; Well Graded Sand with Clay					
	S4	8.5	10.0	16.7														
	Color	black								Visual Classification			Fill: Cinders					
	S5	13.5	15.0	24.4		57	20	37										
	Color	brown & gray								Visual Classification			Fat Clay frace Fine Sand					
	S6	18.5	20.0	21.9														
	Color	brown & gray								Visual Classification			Lean to Fat Clay					
	S7	23.5	25.0	19.8		23	14	9										
	Color	brown								Visual Classification			Sandy Lean Clay					
	S8	28.5	30.0	16.1														
	Color	brown & gray								Visual Classification			Sandy Lean CLay					
	S9	32.0	33.5	8.1		25	13	12										
	Color	brown & gray								Visual Classification			Sandy Lean Clay trace Fine Gravel					

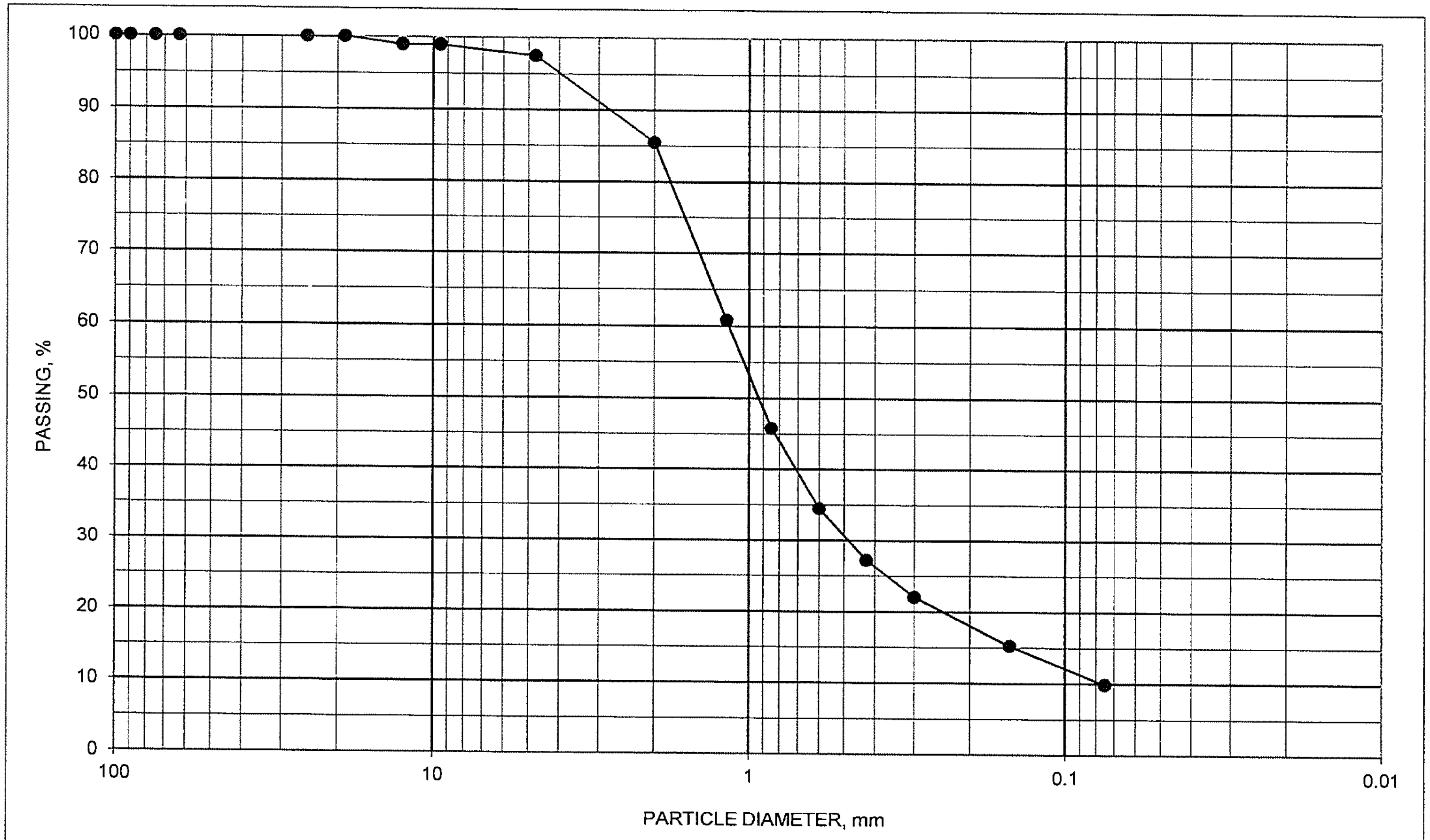
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	99
3/8"	9.5	99
#4	4.8	98
#10	2.00	85
#16	1.18	61
#20	0.85	46
#30	0.600	35
#40	0.425	27
#50	0.300	22
#100	0.150	15
#200	0.075	9.9

D60	1.1603
D30	0.4849
D10	0.0763
Cu	15.2
Cc	2.7



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B006	S-1	1 TO 2.5	CINDERS; WELL-GRADED SAND WITH SILT TRACE FINE GRAVEL BLACK					

PROJECT DYNEGY

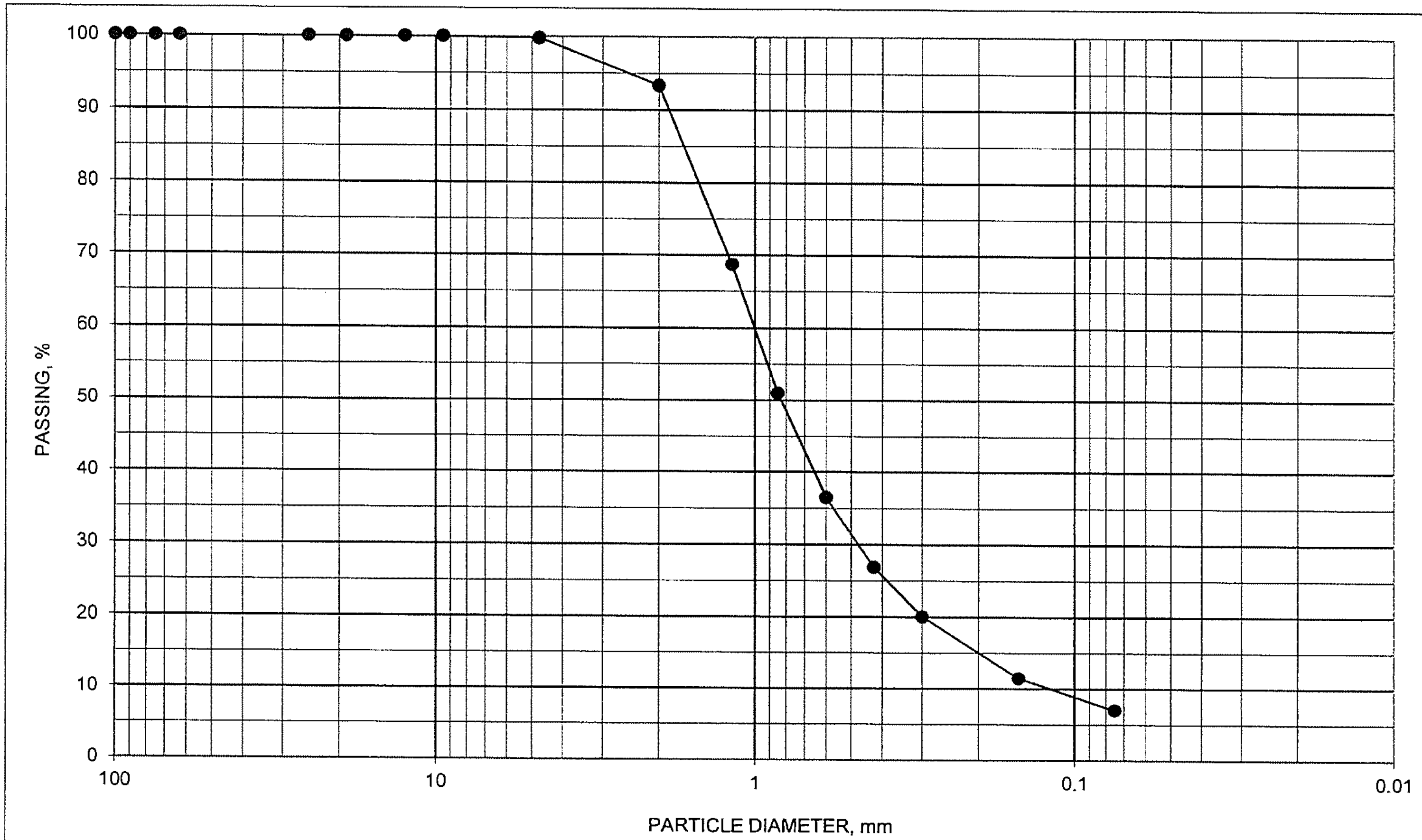
COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B006-S1-1.0.xlsx]GRADATION

Terracon

SIEVE SIZE	DIAMETER, mm	PASS, %
4"	100.0	100
3.5"	90.0	100
3"	75.0	100
2.5"	63.0	100
1"	25.0	100
3/4"	19.0	100
1/2"	12.5	100
3/8"	9.5	100
#4	4.8	100
#10	2.00	93
#16	1.18	69
#20	0.85	51
#30	0.600	36
#40	0.425	27
#50	0.300	20
#100	0.150	11
#200	0.075	7.0

D60	1.0042
D30	0.4757
D10	0.1188
Cu	8.5
Cc	1.9



ASTM D1140 / C117 #200 WASH SIEVE AND C136 SIEVE ANALYSIS

BORING ID	SAMPLE ID	DEPTH, feet	DESCRIPTION	SYMBOL	NAT M%	ATTERBERG LIMITS LL	PL	PI
COF-B006	S3	6 TO 8	CINDERS: WELL-GRADED SAND WITH CLAY BLACK					

PROJECT DYNEGY

COFFEEN, ILLINOIS JOB NO. 15151122 DATE 9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 200 Wash Plot COF-B006-S3-6.0.xlsx]GRADATION

Terracon

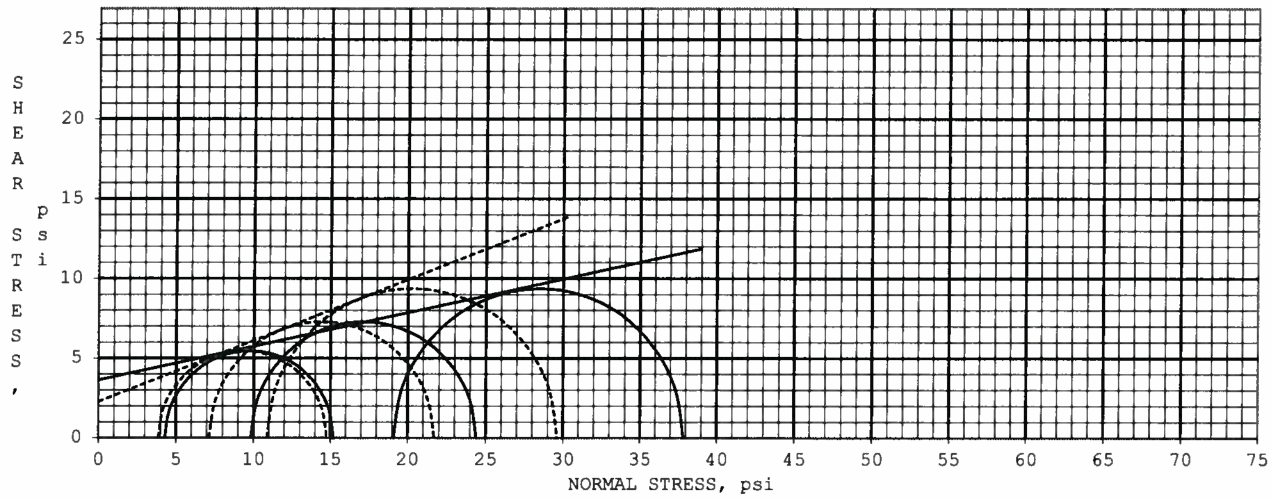
DYNEGY - COFFEEN, ILLINOIS
15151122
9/25/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B007	S1	1.0	2.5	21.4														
	Color			brown						Visual Classification			Fill: Sand, Cinders & Clay					
	S2	3.5	5.5	23.2	102.9	46	19	27										
	Color									Visual Classification								
	S3	5.5	7.5	21.7	107.6	43	17	26						NOTE*				
	Color			gray trace yellowish brown						Visual Classification			Lean Clay with Sand					
	S4	8.5	10.0	25.3					NOTE*									
	Color			brown & gray						Visual Classification			Lean Clay trace Fine Sand					
	S5	13.5	15.0	21.6		47	19	28										
	Color			brown & gray						Visual Classification			Lean Clay trace Fine Sand & Gravel					
	S6	18.5	20.0	24.5														
	Color			brown & gray						Visual Classification			Lean to Fat Clay trace Fine to Coarse Sand					
	S7	20.0	22.0	22.5	103.7	52	17	35					NOTE*	NOTE*				
	Color			yellowish brown with dark gray						Visual Classification			Fat Clay with Sand trace Gravel					
	S8	22.0	24.0	18.3	108.6	43	16	27		20*		7.0E-08*			NOTE*	ND1*	1*	
	Color			yellowish brown						Visual Classification			Sandy Lean Clay					
	S9	28.5	30.0	20.3					NOTE*									
	Color			brown & gray						Visual Classification			Sandy Lean Clay					
	S10	34.0	35.5	11.0		34	15	19										
	Color			gray						Visual Classification			Sandy Lean Clay					
	S11	36.0	37.5	13.6					NOTE*									
	Color			gray						Visual Classification			Lean Clay with Sand					

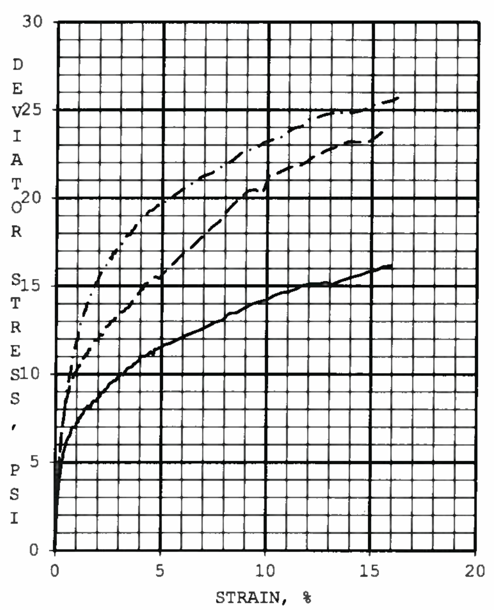
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**20.9**	COHESION, psi	**2.3**
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**11.9**	COHESION, psi	**3.6**



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	23.2	19.6	22.2
	DRY DENSITY, pcf	106.4	109.7	106.7
	SATURATION, %	107	99	104
	VOID RATIO	0.58	0.54	0.58
BEFORE SHEAR	WATER CONTENT, %	21.4	19.2	19.8
	DRY DENSITY, pcf	106.8	111.0	109.7
	SATURATION (B PARAMETER)	0.95	1.00	0.95
	VOID RATIO	0.58	0.52	0.54
	FINAL BACK PRESSURE, psi	100.3	99.6	100.6
MINOR PRINCIPAL STRESS, psi		4.3	9.8	19.1
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		10.9	14.6	18.7
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		10.9	14.6	18.7
ULTIMATE DEVIATOR STRESS (15% STR), psi		15.9	23.3	25.2
TIME TO 50% PRIMARY CONSOLIDATION, min		13.00	60.00	21.00
STRAIN RATE, % / hour		0.84	0.27	0.86
INITIAL DIAMETER, inch		1.358	1.368	1.371
INITIAL HEIGHT, inch		2.883	2.834	2.833
AREA AFTER CONSOLIDATION, inch2		1.446	1.457	1.443

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, GRAY TRACE YELLOWISH BROWN

LL 43	PL 17	PI 26	Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B007

LABORATORY: TERRACON - LENEXA

SAMPLE #: S3

DATE: 9/24/2015

DEPTH, feet: 5.5 - 7.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

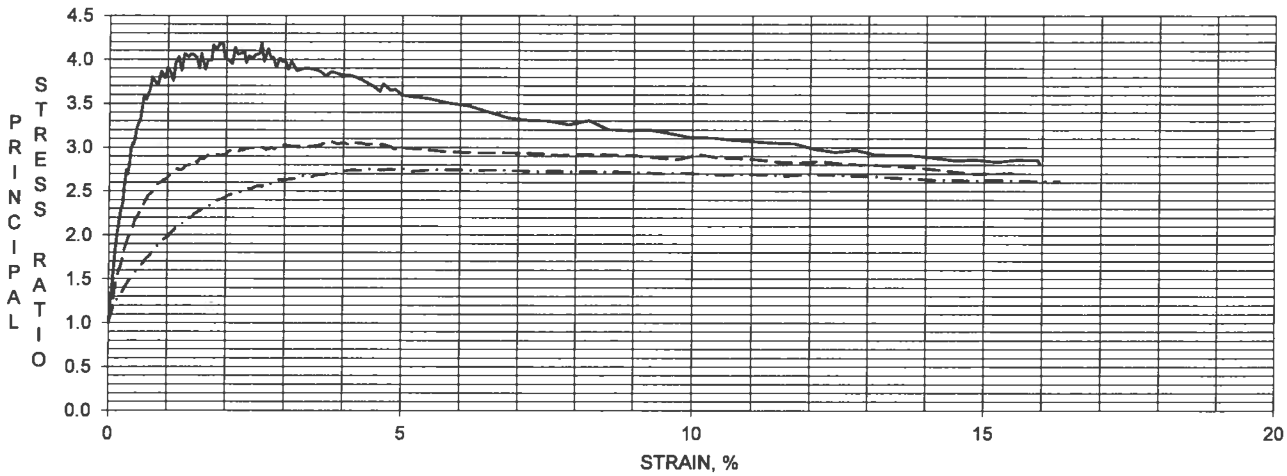
Terracon

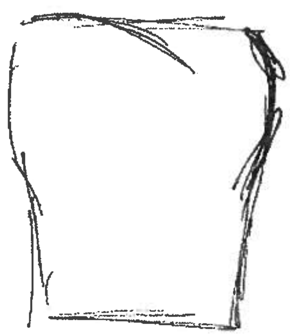
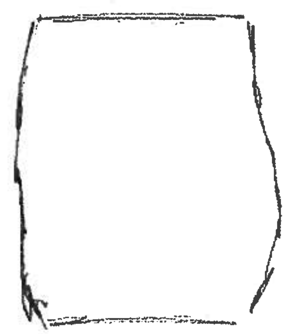
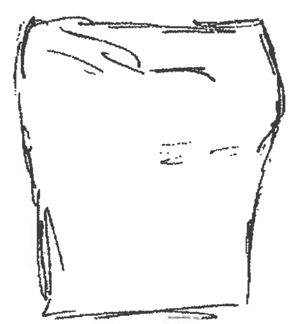
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\COFFEEN\B007\[15151122 Triaxial CU COF-B007-S3-5.5.xlsx]REPORT

Embankment

DYNEGY

15151122 COF-B007 S3 5.5 - 7.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

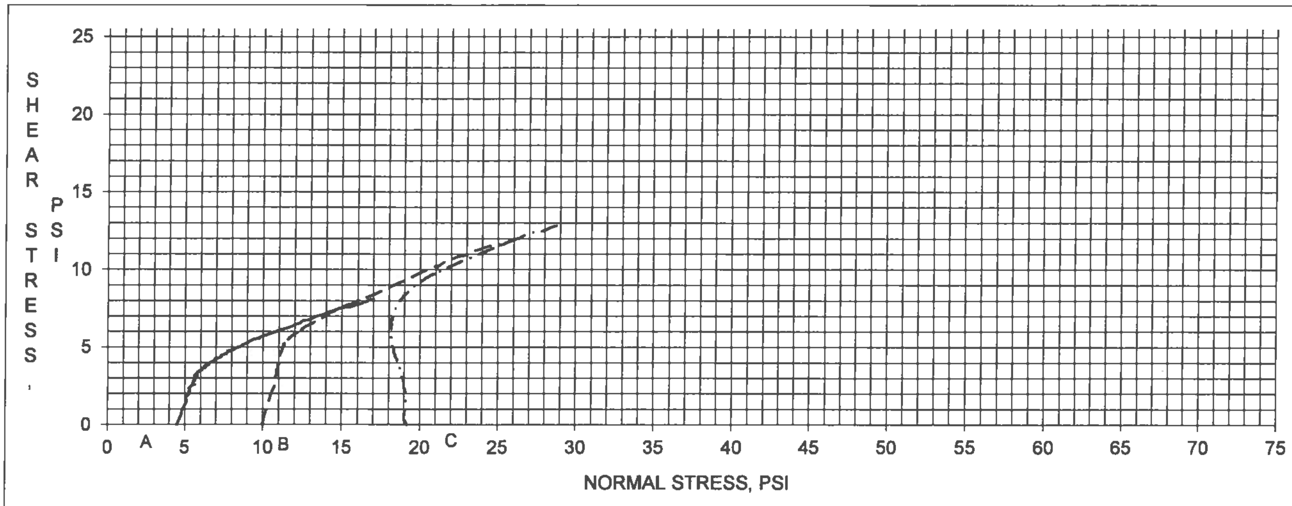
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

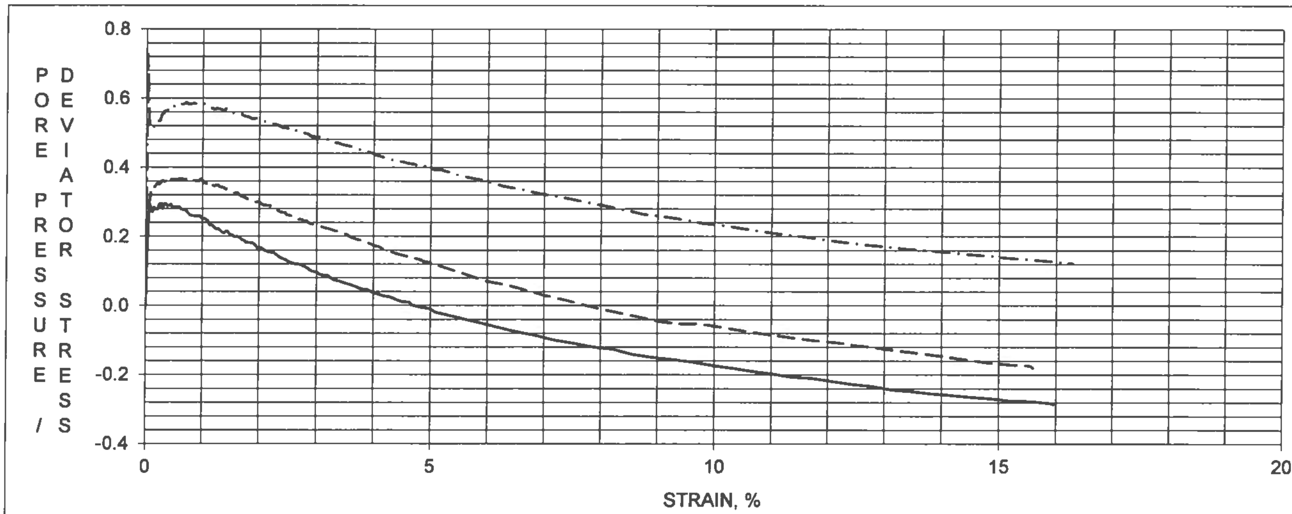
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

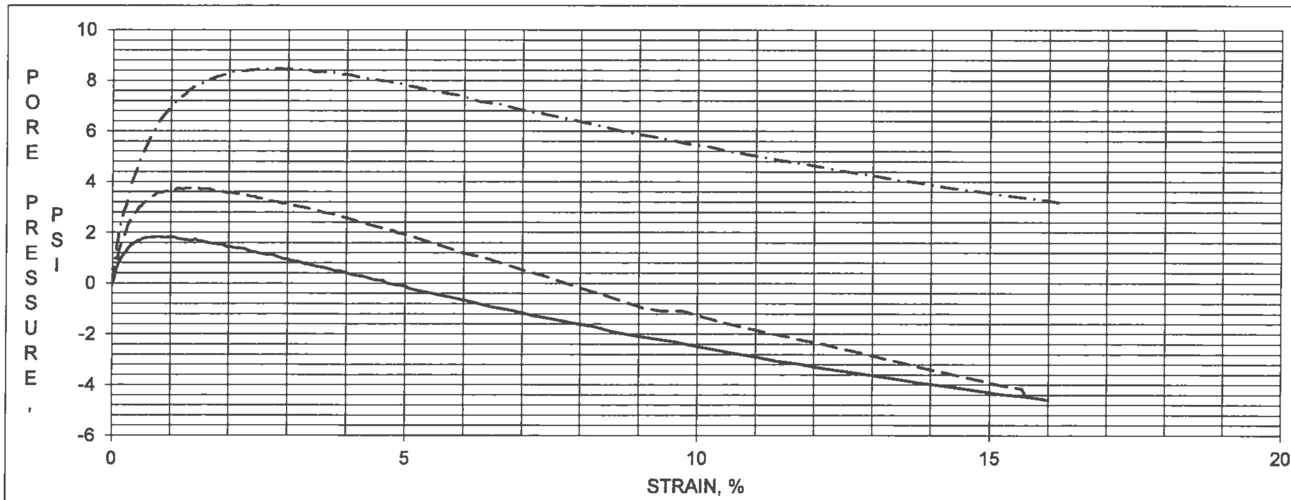
Terracon

DYNEGY

15151122 COF-B007 S3 5.5 - 7.5

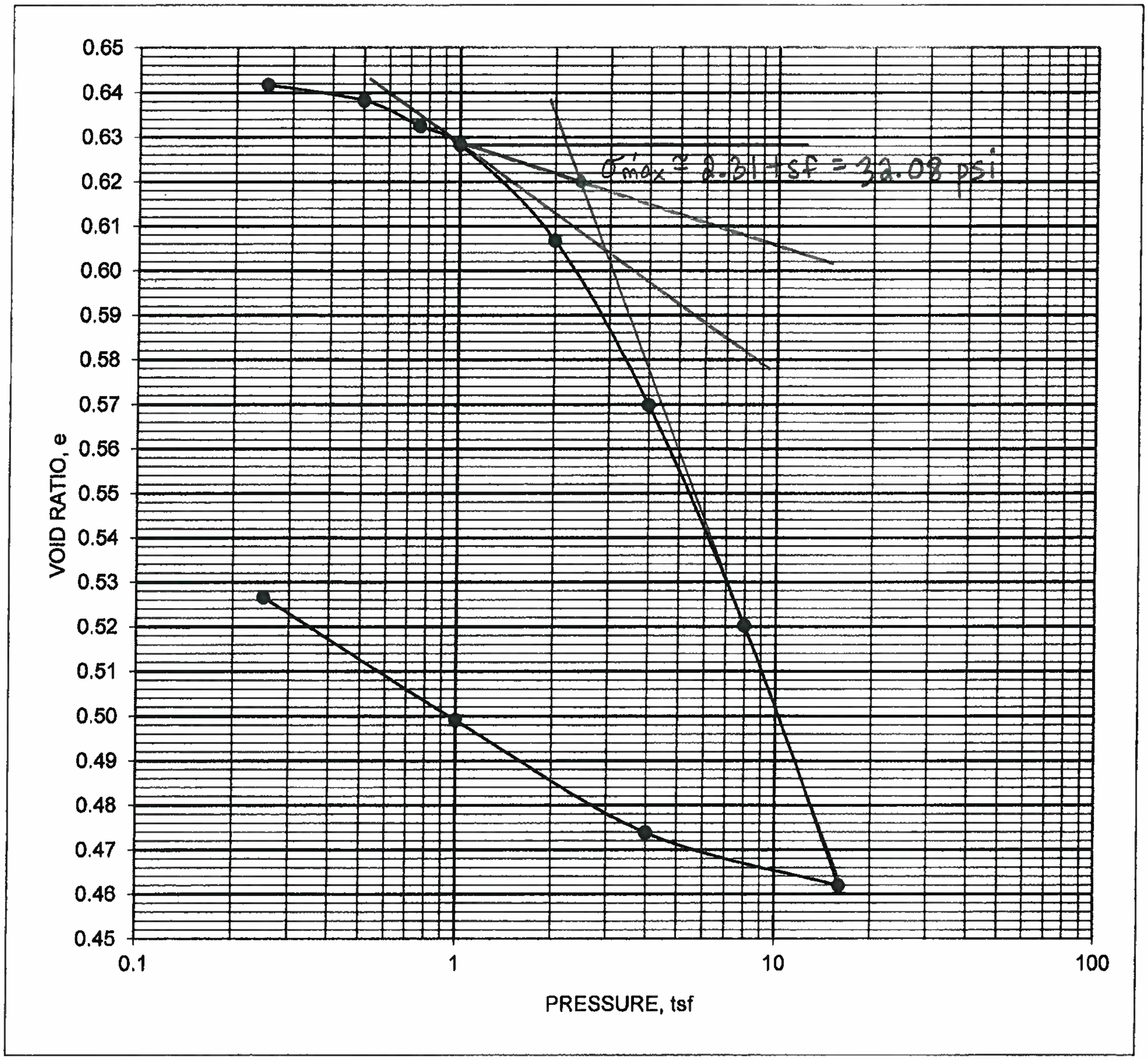






Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.57	HEIGHT, mm	18.98	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		1.32		MOISTURE, %		22.5	19.6
PRECONSOL. PRESSURE, tsf		2.31		DRY DENSITY, pcf		102.6	110.2
OVER CONSOLIDATION RATIO		1.8		SATURATION, %		94	100
COMPRESSION INDEX		0.19		VOID RATIO		0.642	0.526
REBOUND INDEX		0.044		SAMPLE TYPE		UNDISTURBED	
LIQUID LIMIT	52	PLASTIC LIMIT	17	PLASTICITY INDEX	35	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	FAT CLAY WITH SAND TRACE GRAVEL, YELLOWISH BROWN WITH DARK GRAY						
BORING NO.	COF-B007	SAMPLE NO.	S7	DEPTH, feet	20.0 - 22.0		

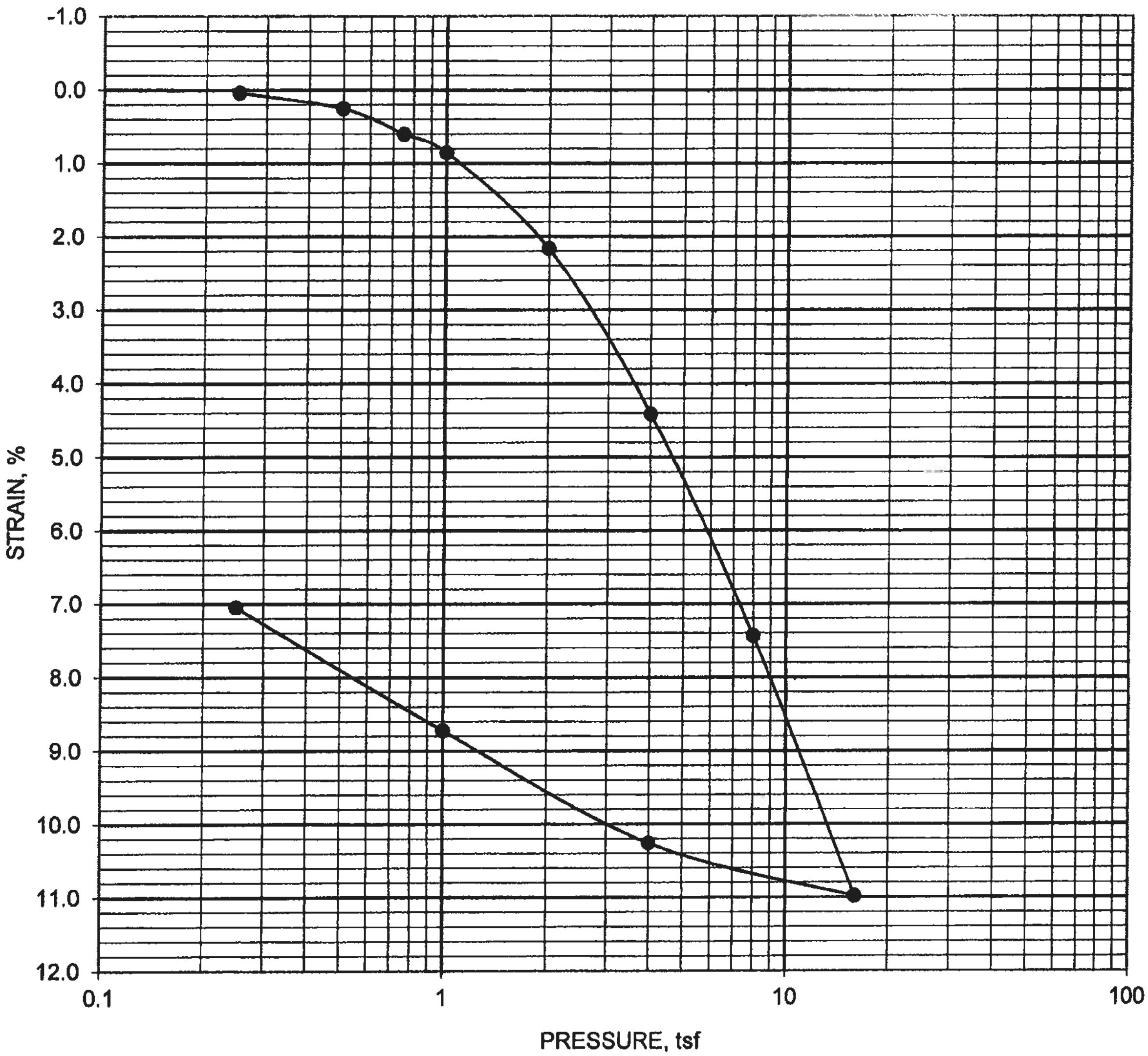
DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B007\[15151122 Consolidation COF-B007-S7

Terracon

Foundation Crust

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.57	HEIGHT, mm	18.98	PROPERTY	BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf			1.32	MOISTURE, %	22.5	19.6
PRECONSOL. PRESSURE, tsf			2.31	DRY DENSITY, pcf	102.6	110.2
OVER CONSOLIDATION RATIO			1.8	SATURATION, %	94	100
COMPRESSION INDEX			0.19	VOID RATIO	0.642	0.526
REBOUND INDEX			0.044	SAMPLE TYPE	3" SHELBY TUBE	

LIQUID LIMIT	52	PLASTIC LIMIT	17	PLASTICITY INDEX	35	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	FAT CLAY WITH SAND TRACE GRAVEL, YELLOWISH BROWN WITH DARK GRAY						
BORING NO.	COF-B007	SAMPLE NO.	S7	DEPTH, feet	20.0 - 22.0		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B007\[15151122 Consolidation COF-B007-S7

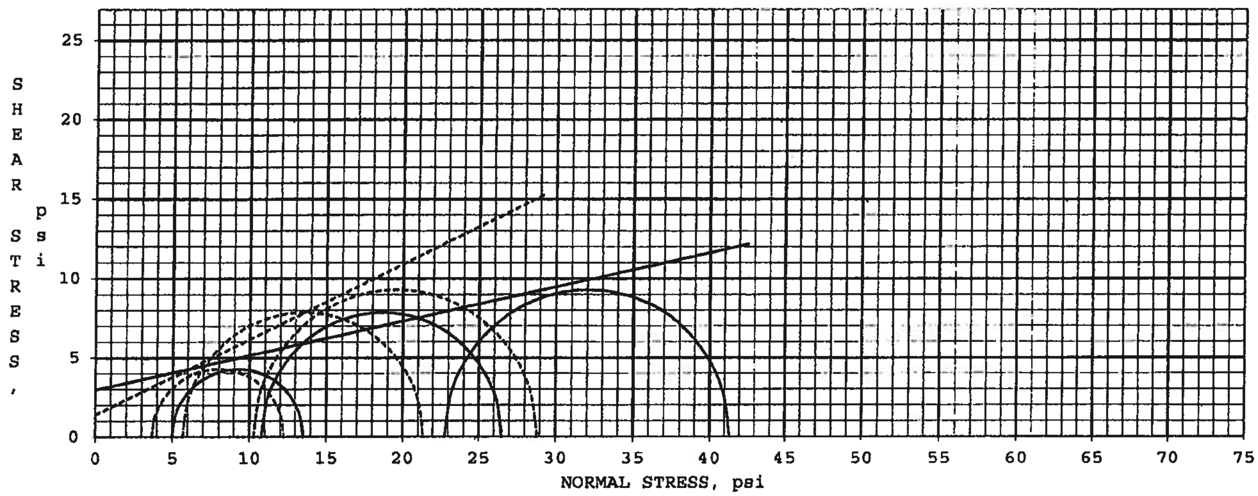
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

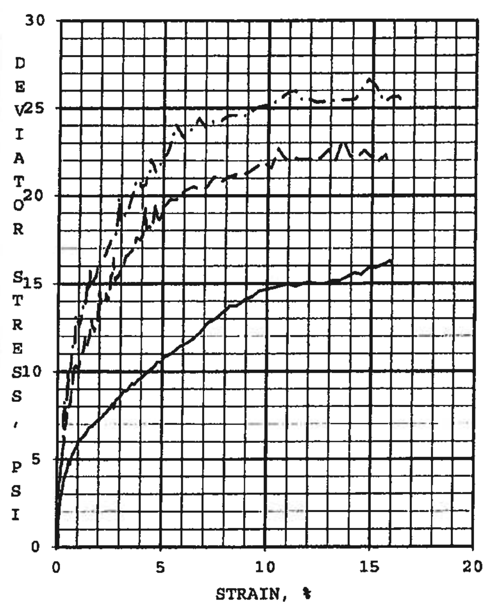
ADDITIONAL CONSOLIDATION DATA

COF-B007
S7
20.0 - 22.0

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.25			2.69E-06	1.64E-06	
0.5	1.09E-03	1.10E-03	1.44E-05	8.75E-06	9.55E-09
0.75	4.88E-04	4.91E-04	2.34E-05	1.43E-05	6.96E-09
1	2.24E-04	2.25E-04	1.71E-05	1.05E-05	2.34E-09
2	1.14E-03	1.15E-03	2.20E-05	1.35E-05	1.55E-08
4	6.72E-04	6.76E-04	1.89E-05	1.17E-05	7.89E-09
8	4.26E-04	4.29E-04	1.27E-05	8.08E-06	3.45E-09
16	2.98E-04	3.00E-04	7.44E-06	4.89E-06	1.46E-09
AVERAGE	6.21E-04	6.24E-04	1.48E-05	9.17E-06	6.73E-09



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	25.4	COHESION, psi	1.4
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	12.2	COHESION, psi	3.0



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	21.1	23.8	22.7
	DRY DENSITY, pcf	105.7	102.5	103.0
	SATURATION, %	96	100	96
	VOID RATIO	0.60	0.64	0.64
BEFORE SHEAR	WATER CONTENT, %	21.5	22.8	21.2
	DRY DENSITY, pcf	106.6	104.2	107.1
	SATURATION (B PARAMETER)	0.98	0.98	0.97
	VOID RATIO	0.58	0.62	0.57
	FINAL BACK PRESSURE, psi	100.7	100.5	100.5
MINOR PRINCIPAL STRESS, psi		5.0	10.8	22.8
EFFECTIVE STRESS PEAK AT % STRAIN		3.0	3.0	3.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		8.6	15.7	18.6
TOTAL STRESS PEAK AT % STRAIN		3.0	3.0	3.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		8.6	15.7	18.6
ULTIMATE DEVIATOR STRESS (15% STR), psi		15.9	22.1	26.4
TIME TO 50% PRIMARY CONSOLIDATION, min		3.10	4.00	5.00
STRAIN RATE, % / hour		3.19	3.14	3.30
INITIAL DIAMETER, inch		1.369	1.363	1.370
INITIAL HEIGHT, inch		2.914	2.832	2.841
AREA AFTER CONSOLIDATION, inch2		1.461	1.444	1.435

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
FAT CLAY WITH SAND TRACE GRAVEL, YELLOWISH BROWN WITH DARK GRAY

LL 52	PL 17	PI 35	Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B007

LABORATORY: TERRACON - LENEXA

SAMPLE #: S7

DATE: 9/8/2015

DEPTH, feet: 20.0 - 22.0

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

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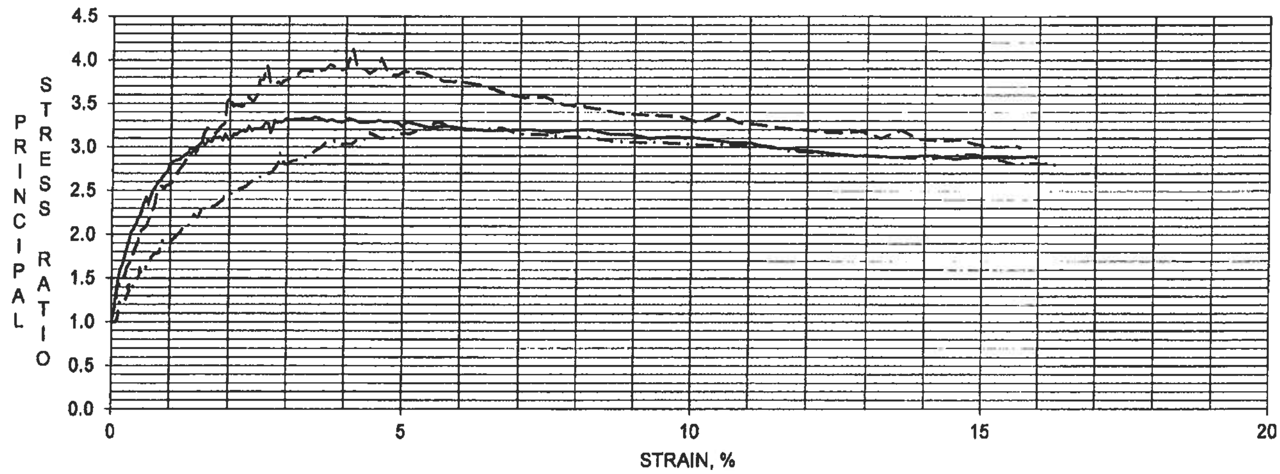
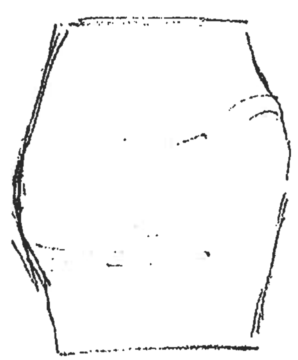
Foundation Crust

DYNEGY

15151122 COF-B007 S7 20.0 - 22.0

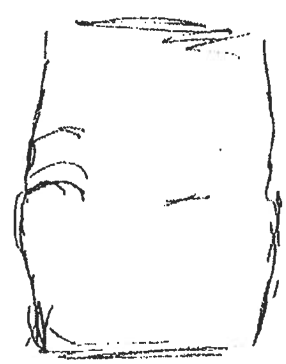


FAILURE SKETCH



SPECIMEN A

FAILURE SKETCH



SPECIMEN B

FAILURE SKETCH

SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 3 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 3 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 3 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 3 % STRAIN.

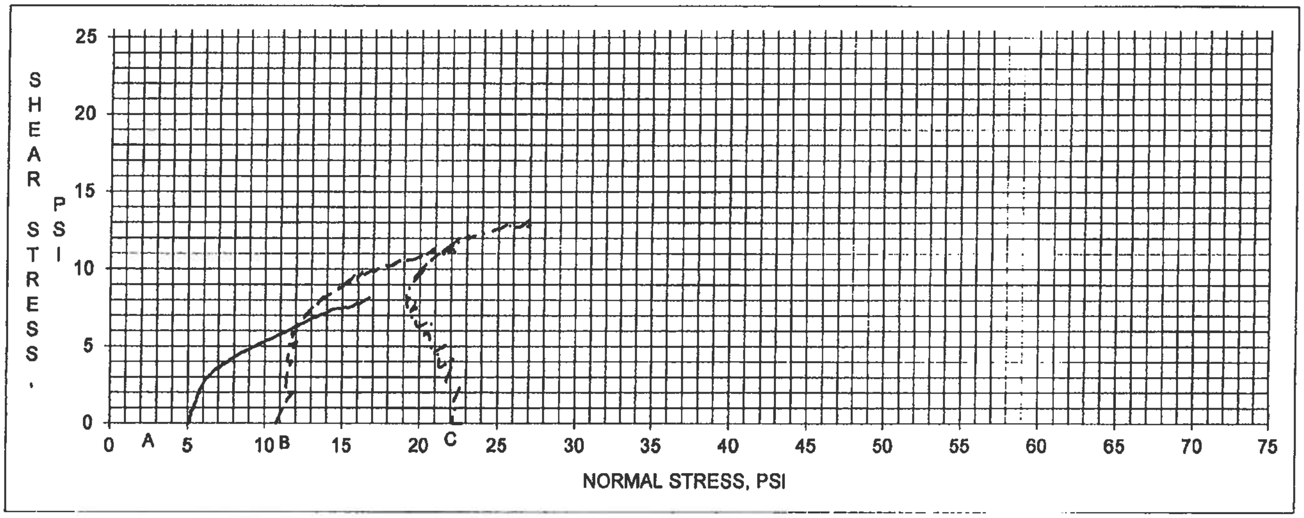
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

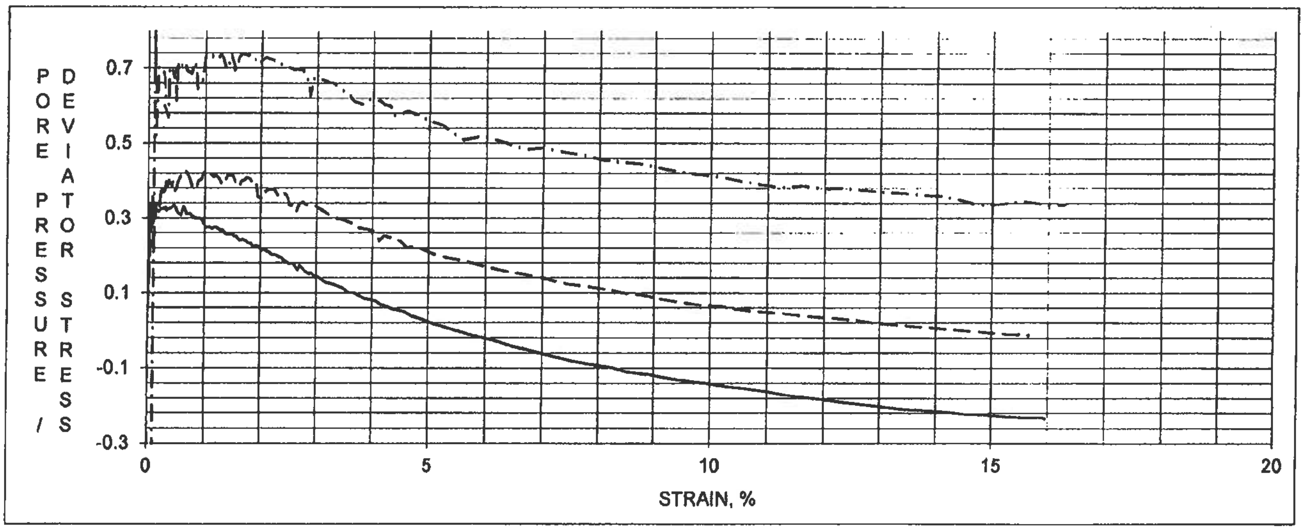
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

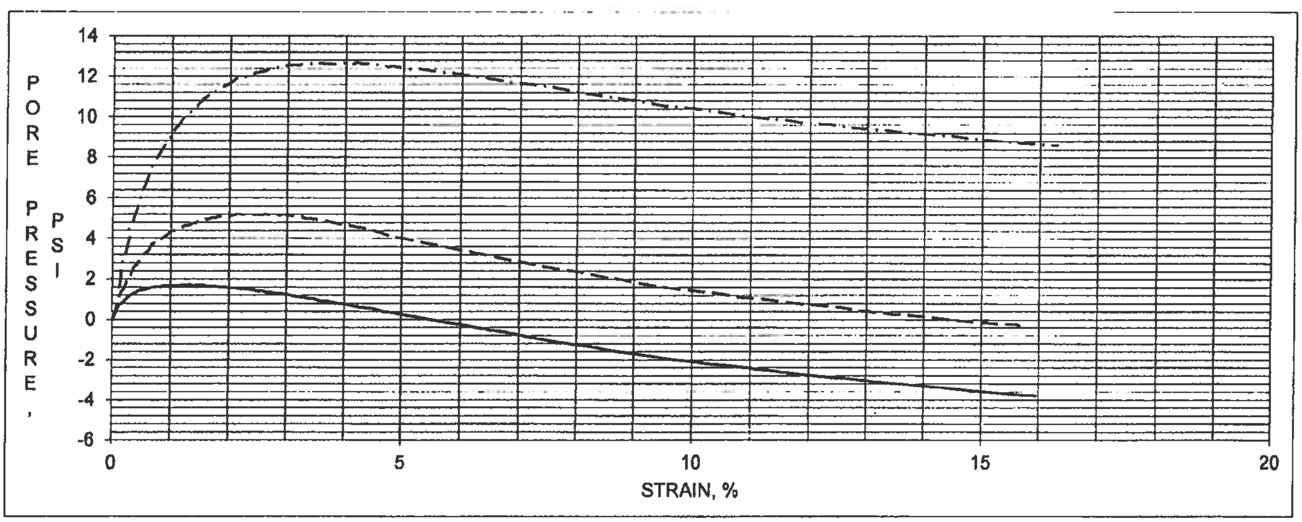
Terracon

DYNEGY

15151122 COF-B007 S7 20.0 - 22.0







Terracon

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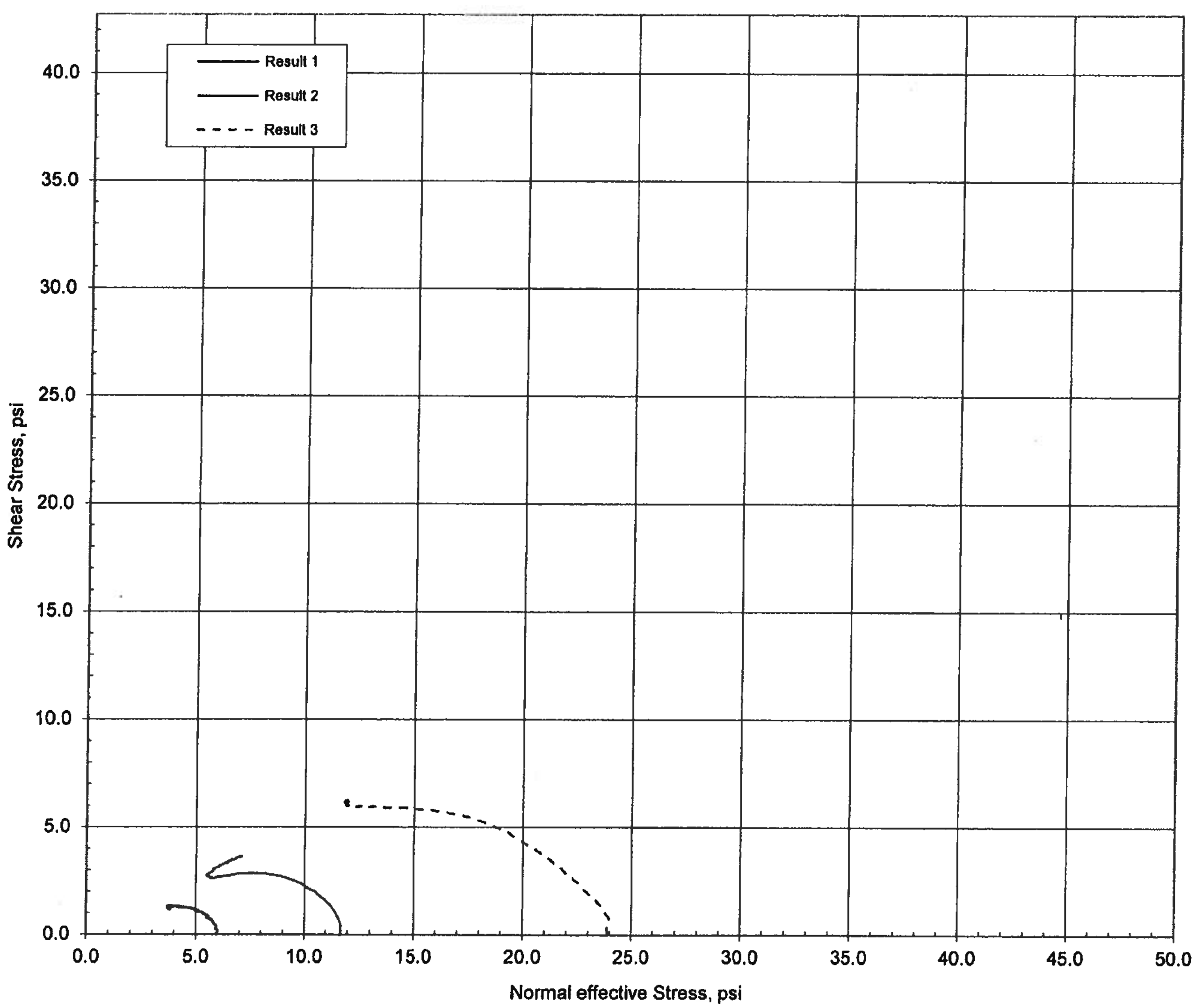
CONSOLIDATED UNDRAINED DIRECT SIMPLE SHEAR TESTING OF COHESIVE SOILS
ASTM D6528



	RESULT 1	RESULT 2	RESULT 3		RESULT 1	RESULT 2	RESULT 3
INITIAL DATA				NORMAL EFF. STRESS, psi	6.0	11.7	23.9
AREA, inch2	5.391	5.383	5.383	PRESHEAR MOISTURE, %	22.6	22.6	22.2
HEIGHT, inch	0.708	0.702	0.703	PRESHEAR VOID RATIO	0.64	0.59	0.58
MOISTURE, %	20.3	20.1	20.5	FINAL MOISTURE, %	22.7	22.6	22.3
DRY DENSITY, pcf	101.4	103.3	101.3	FINAL VOID RATIO	0.66	0.61	0.61
SATURATION, %	83	86	83	SHEAR STRAIN RATE, %/min	0.085	0.087	0.089
VOID RATIO	0.66	0.63	0.66	t95 @ MAX STESS, min	0.59	0.25	0.70
LIQUID LIMIT	43		PLASTIC LIMIT	16	PLASTICITY INDEX		27
SAMPLE TYPE	UNDISTURBED		SPECIFIC GRAVITY		2.7 ESTIMATED		
SAMPLE DESCRIPTION	SANDY LEAN CLAY, YELLOWISH BROWN						

PROJECT NAME: DYNEGY
LOCATION: COFFEEN, ILLINOIS
JOB NO.: 15151122
DATE: 9/10/2015

BORING NO. COF-B007
SAMPLE NO. S8
DEPTH, feet 22.0 - 24.0

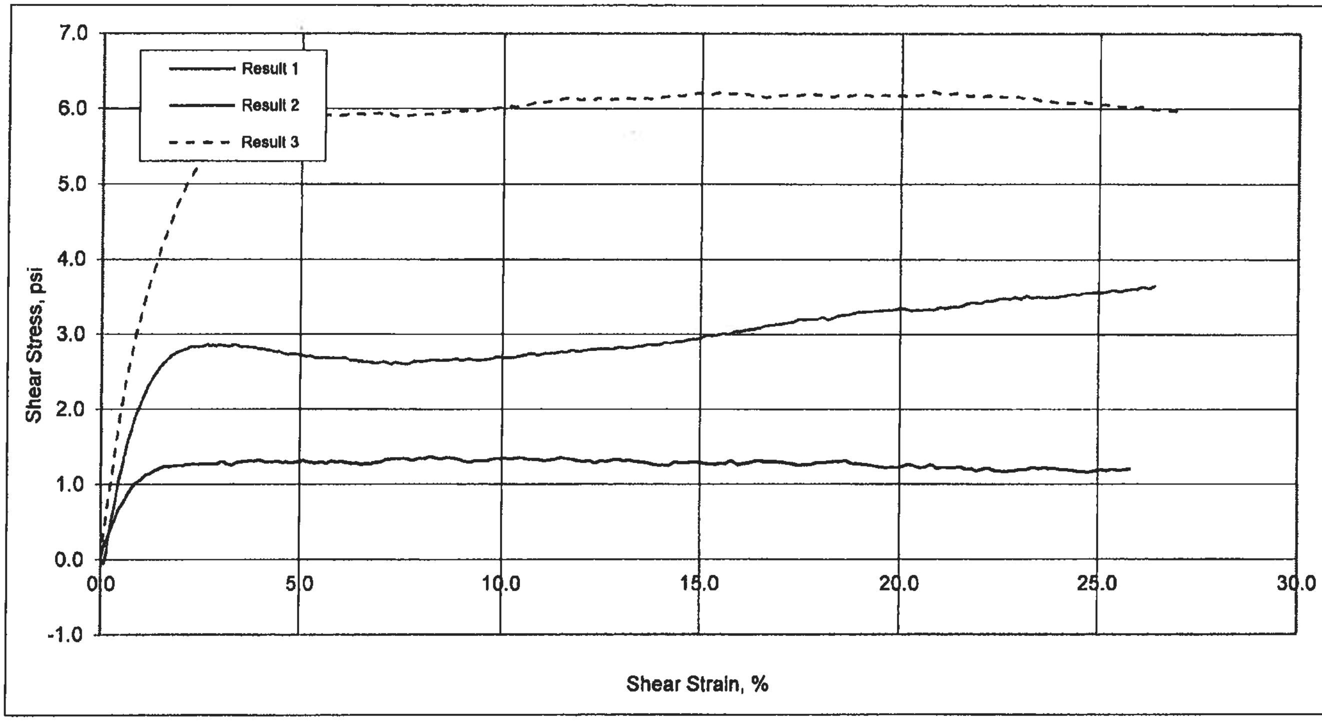
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\[15151122 DirectSimpleShear COF-BC

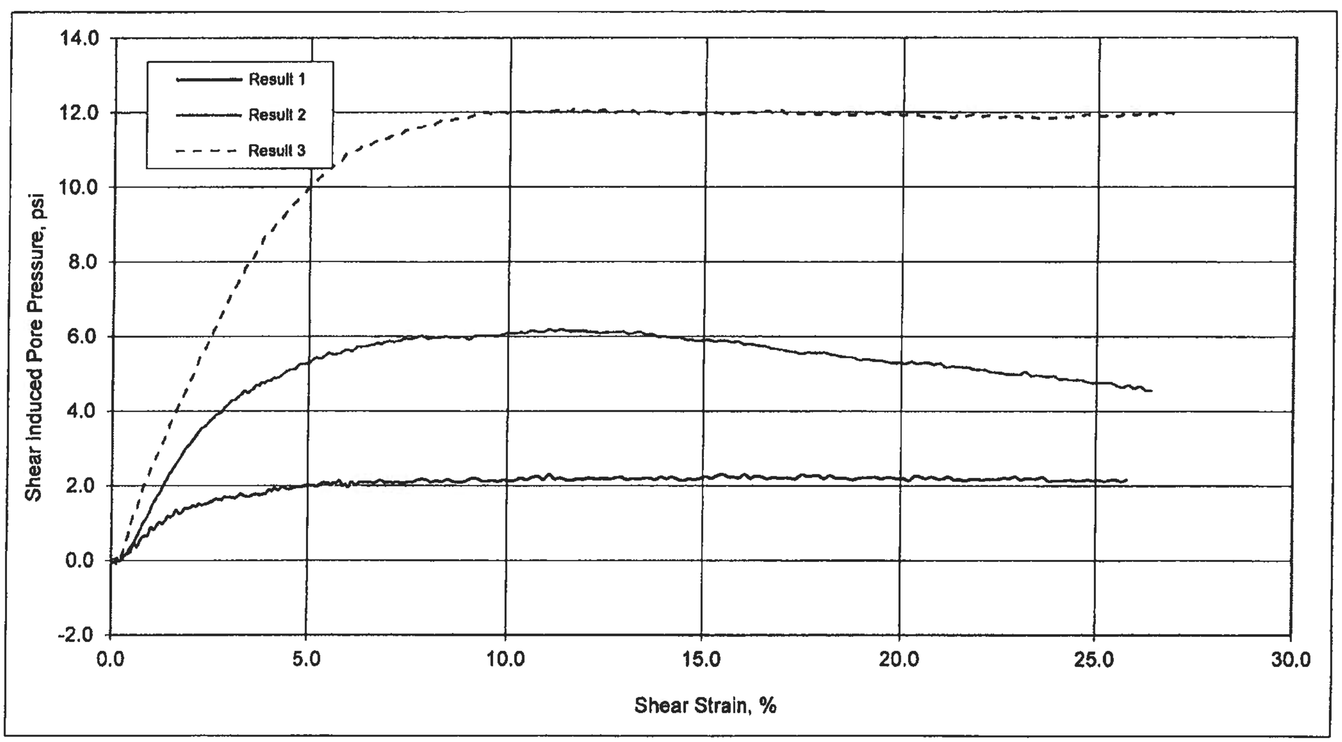
Terracon

Foundation Crust

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

BORING NO.	COF-B007
SAMPLE NO.	S8
DEPTH, feet	22.0 - 24.0





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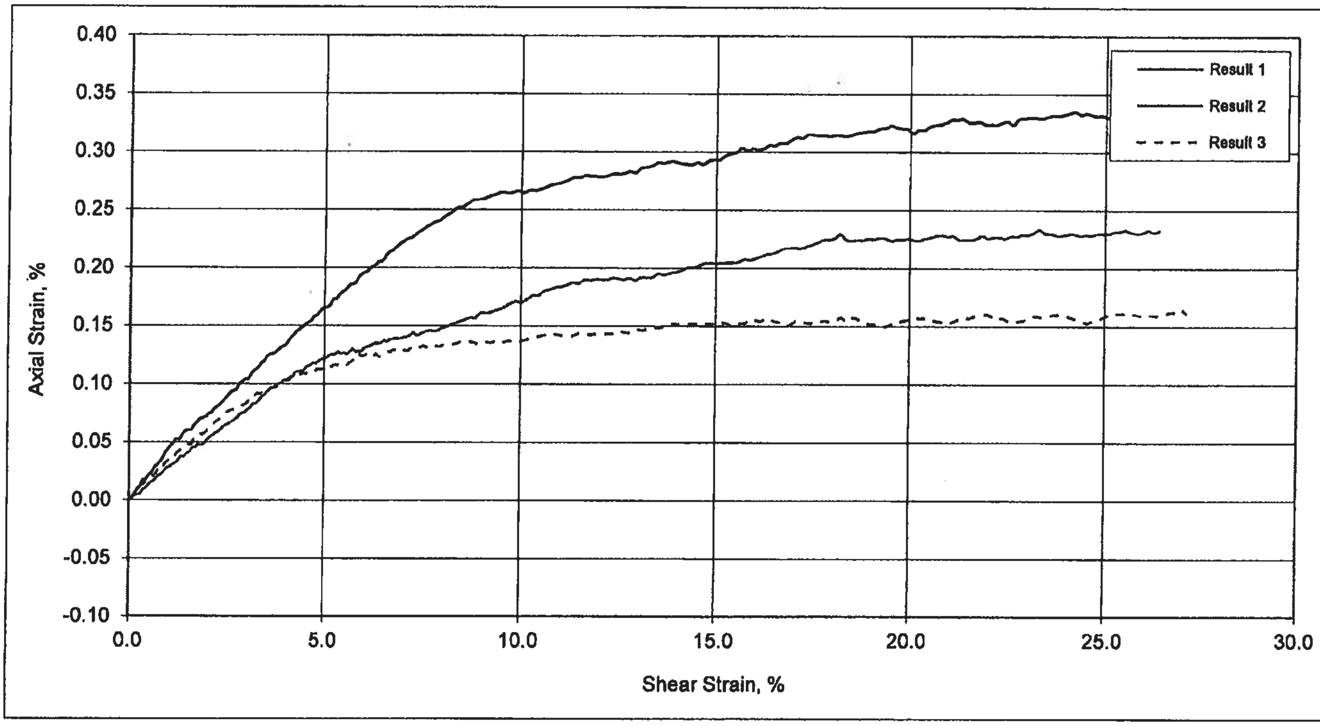
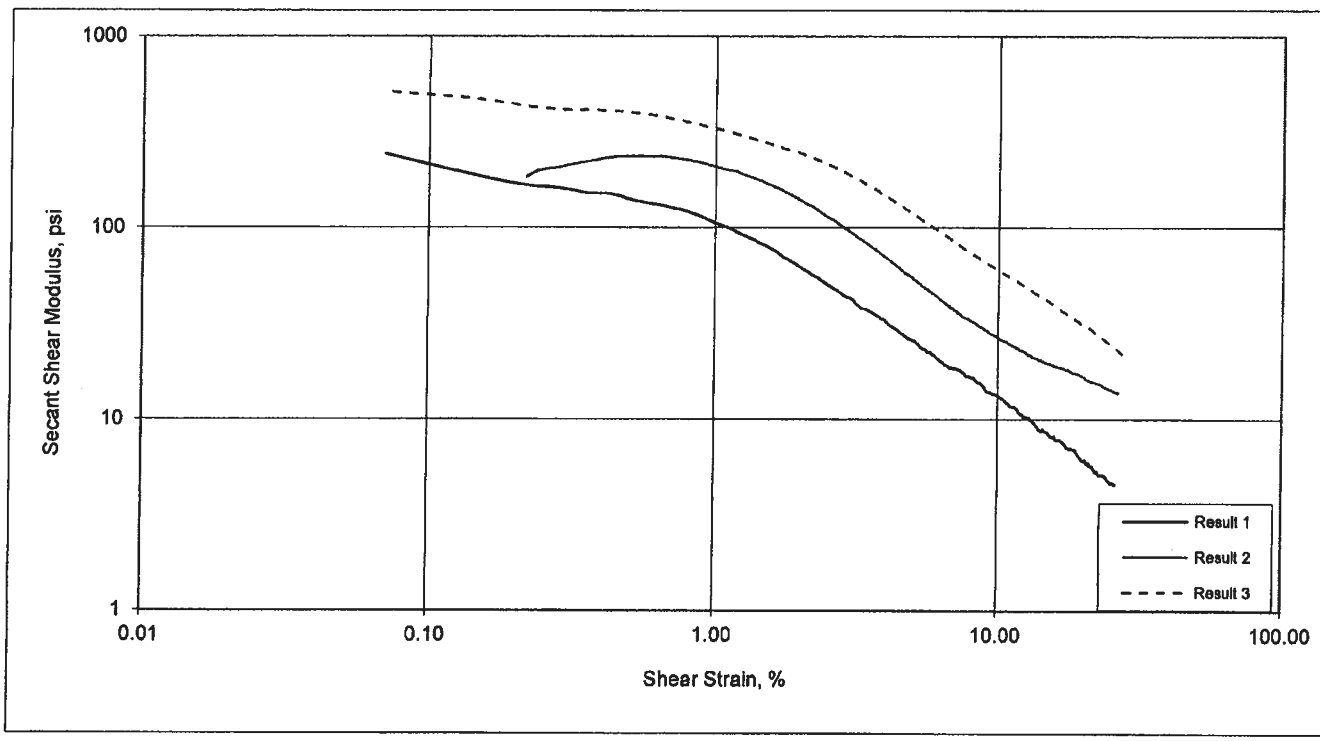
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

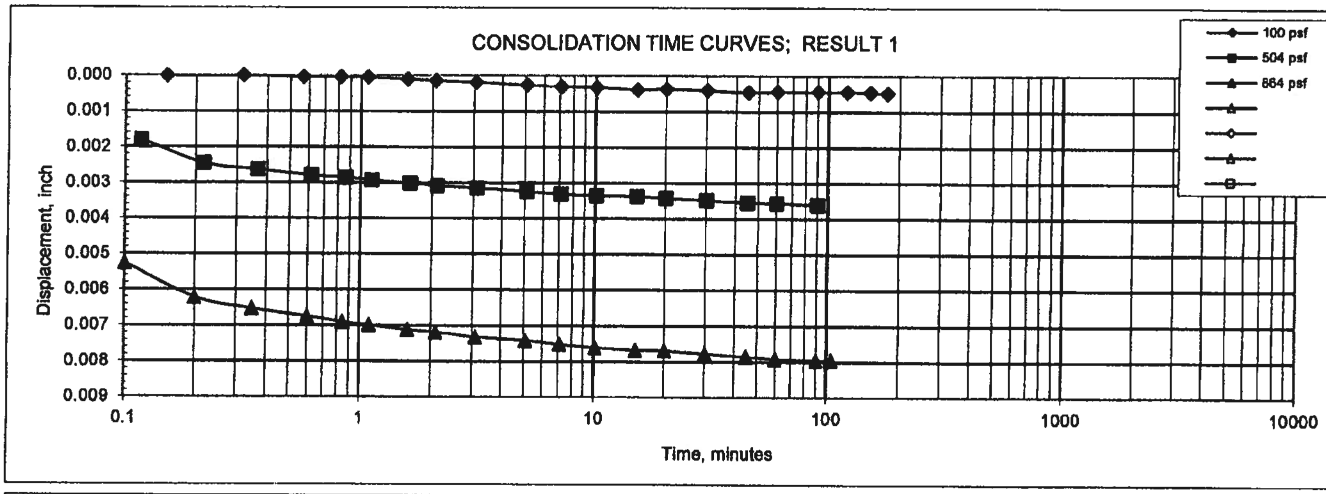
BORING NO.	COF-B007
SAMPLE NO.	S8
DEPTH, feet	22.0 - 24.0

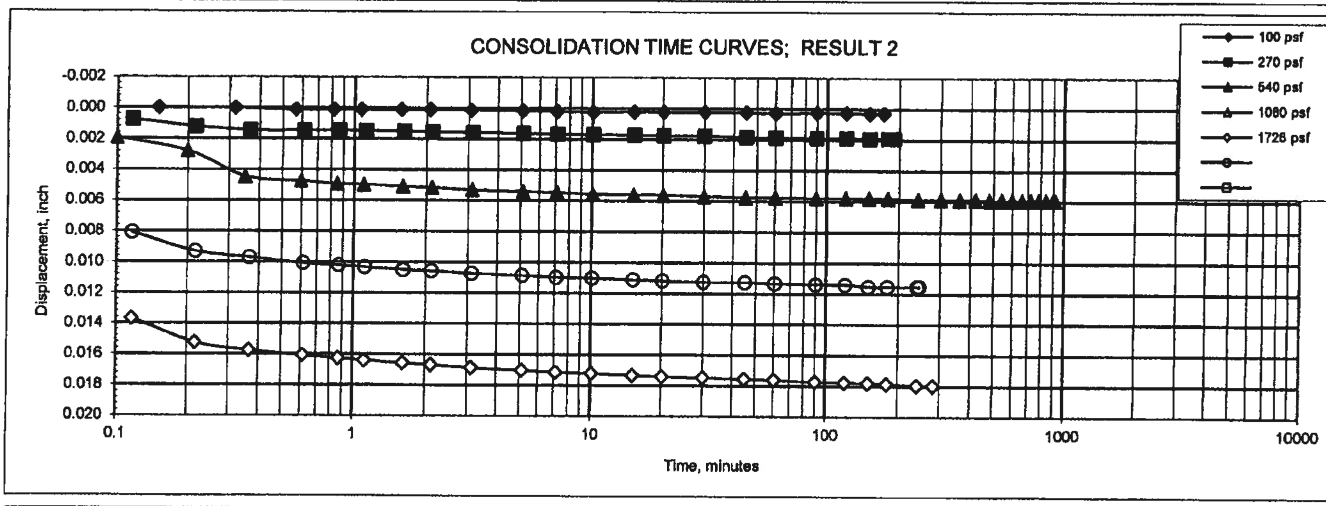


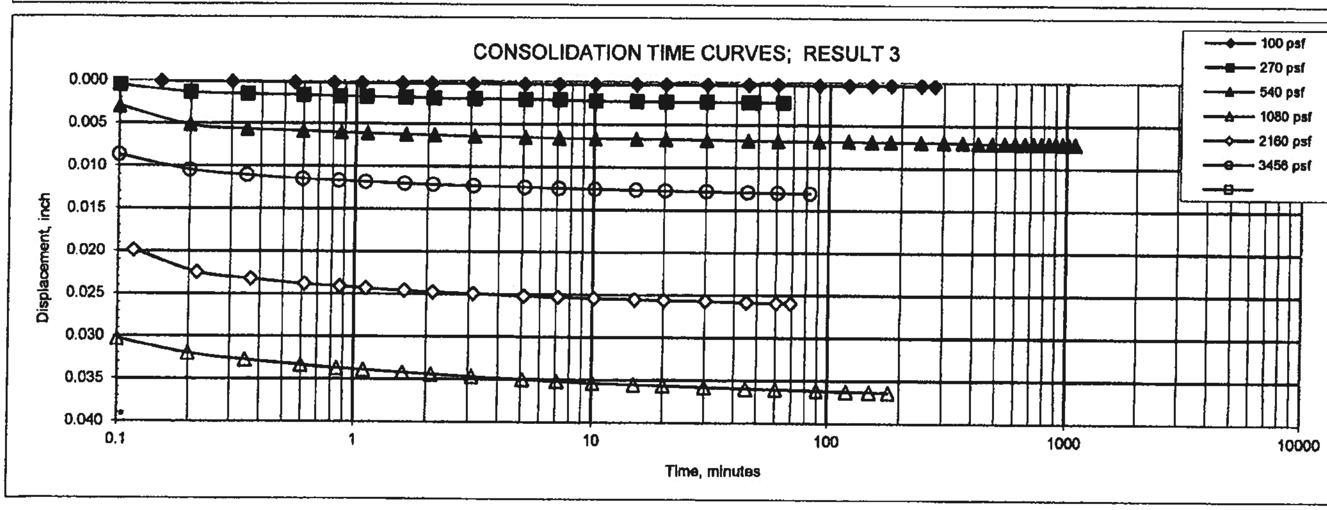


DYNEGY
COFFEEN, ILLINOIS
15151122
9/10/2015

BORING NO.	COF-B007
SAMPLE NO.	S8
DEPTH, feet	22.0 - 24.0







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Terracon

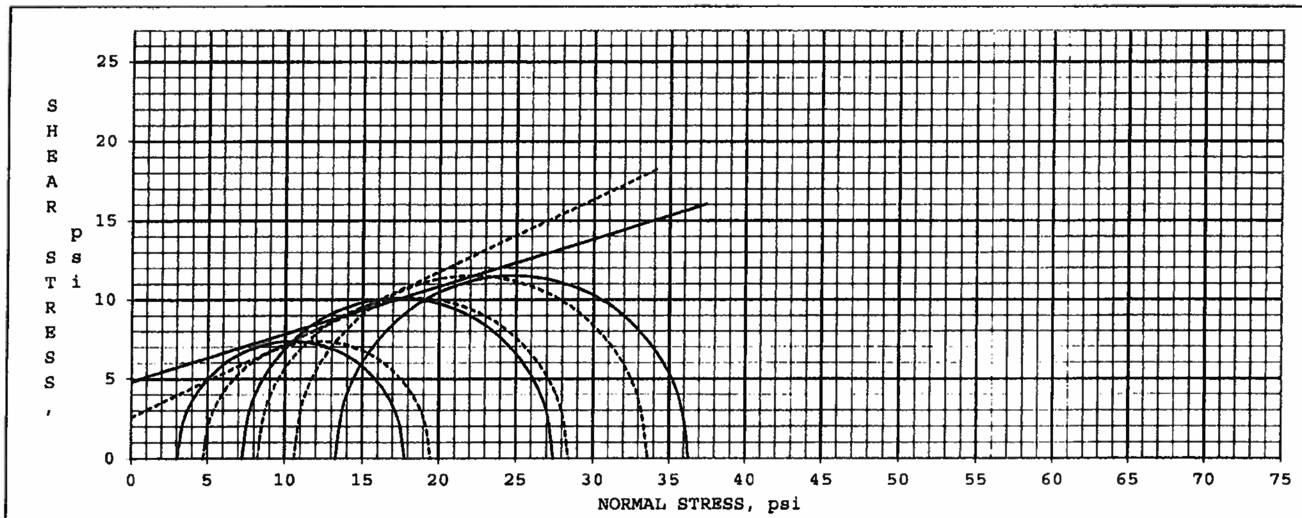
DYNEGY - COFFEEN, ILLINOIS
15151122
9/16/2015

Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B008	S1	1.0	2.5	19.7														
	Color		brown & gray							Visual Classification			Fill: Lean Clay trace Sand					
	S2	3.5	5.0	16.3		46	17	29	NOTE*									CL
	Color		brown							USCS Classification			Lean Clay					
	S3	6.0	7.5	21.7														
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S4	9.5	11.0	21.6		54	18	36										
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S5	11.0	13.0	16.6	112.8	43	16	27				7.9E-09*						
	Color		dark gray with gray trace grayish brown							Visual Classification			Lean Clay with Sand					
	S6	13.0	15.0	13.9	120.5	35	15	20						NOTE*		ND1	4*	
	Color		light yellowish brown with light gray							Visual Classification			Lean Clay with Sand					
	S7	20.0	21.5	20.5						14*								
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S8	25.0	26.5	16.4														
	Color		brown & gray							Visual Classification			Fat Clay with Sand					
	S9	28.0	30.0	Tube to Fugro														
	Color									Visual Classification								
	S10	30.0	30.5	no recovery														
	Color									Visual Classification								
	S11	33.5	35.0	5.8														
	Color		brown & gray							Visual Classification			Sandy Lean Clay trace Fine Gravel					

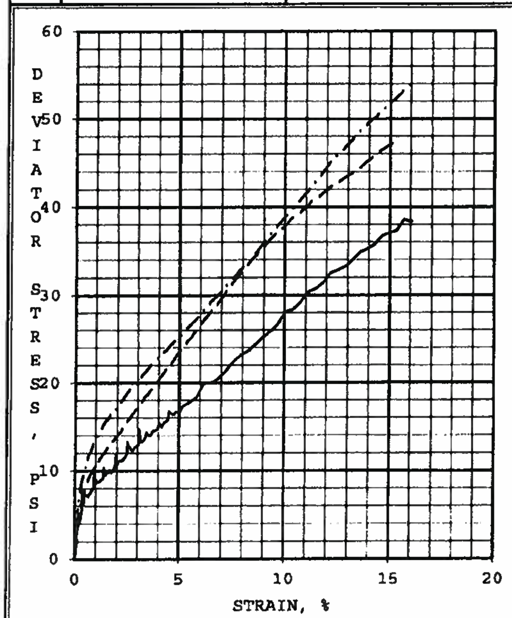
TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	24.6	COHESION, psi	2.6
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	16.7	COHESION, psi	4.8



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	14.9	12.7	14.2
	DRY DENSITY, pcf	119.3	121.2	121.0
	SATURATION, %	98	88	98
	VOID RATIO	0.41	0.39	0.39
BEFORE SHEAR	WATER CONTENT, %	15.2	14.1	13.9
	DRY DENSITY, pcf	119.5	122.0	122.6
	SATURATION (B PARAMETER)	0.98	0.96	0.97
	VOID RATIO	0.41	0.38	0.37
	FINAL BACK PRESSURE, psi	100.0	100.3	100.6
MINOR PRINCIPAL STRESS, psi		3.1	7.3	13.3
EFFECTIVE STRESS PEAK AT % STRAIN		4.0	4.0	4.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		14.7	20.2	23.0
TOTAL STRESS PEAK AT % STRAIN		4.0	4.0	4.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		14.7	20.2	23.0
ULTIMATE DEVIATOR STRESS (15% STR), psi		37.1	47.1	51.8
TIME TO 50% PRIMARY CONSOLIDATION, min		5.30	12.00	9.50
STRAIN RATE, % / hour		1.82	1.41	1.78
INITIAL DIAMETER, inch		1.364	1.366	1.362
INITIAL HEIGHT, inch		2.832	2.857	2.836
AREA AFTER CONSOLIDATION, inch2		1.460	1.457	1.445

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
LEAN CLAY WITH SAND, LIGHT YELLOWISH BROWN WITH LIGHT GRAY

LL	PL	PI	Gs
35	15	20	2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B008

LABORATORY: TERRACON - LENEXA

SAMPLE #: S6

DATE: 9/15/2015

DEPTH, feet: 13.0 - 15.0

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

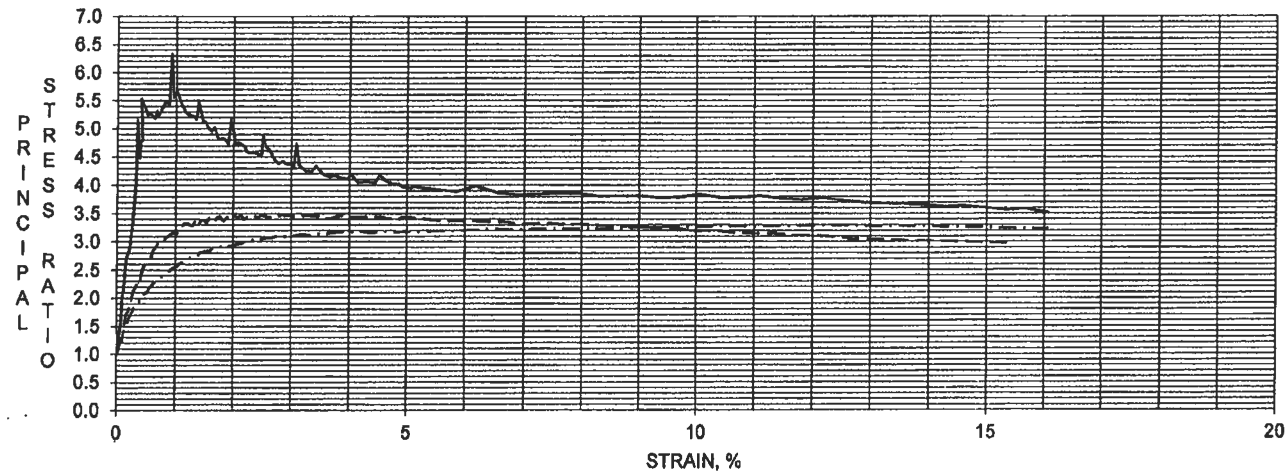
Terracon

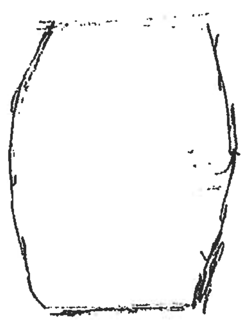
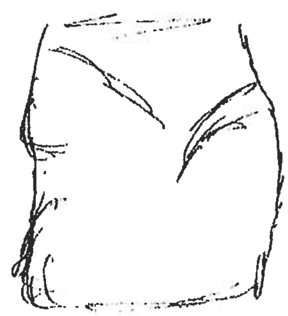
N:\CM\LAB_DATA\00 Projects in Progress\2015 Projects in Progress\15151122 Lab Data\B008\[15151122 Triaxial CU COF-B008-S6-13.0.xlsx]REPORT

Embankment

DYNEGY

15151122 COF-B008 S6 13.0 - 15.0



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 4 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 4 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 4 % STRAIN.

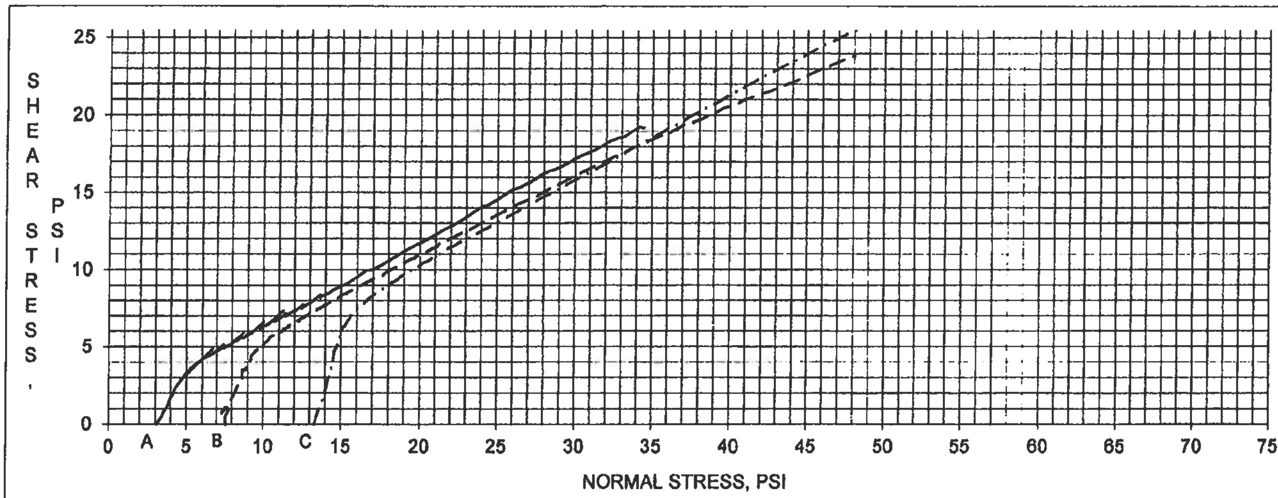
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

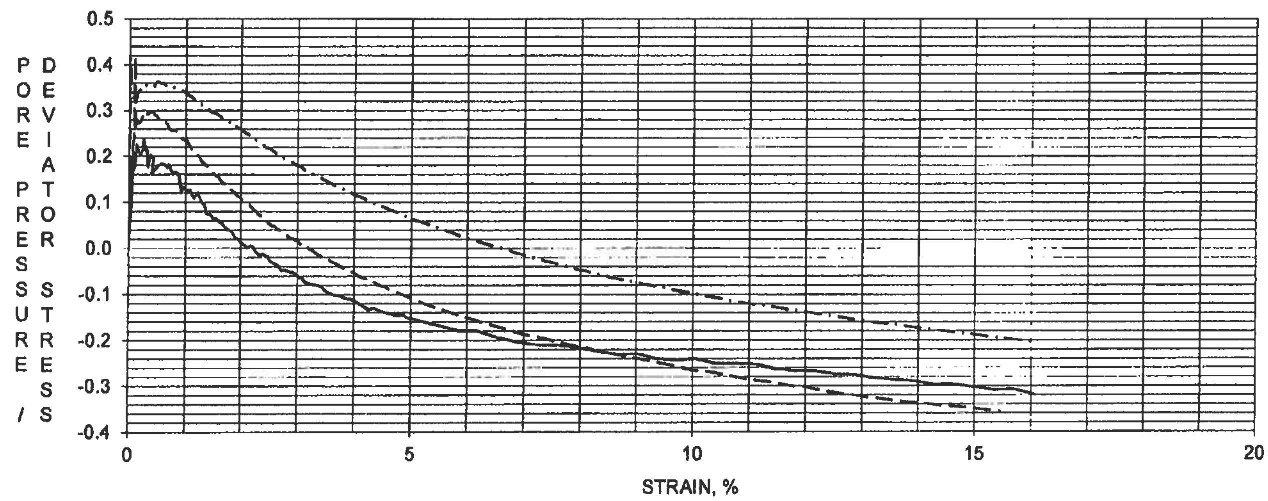
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

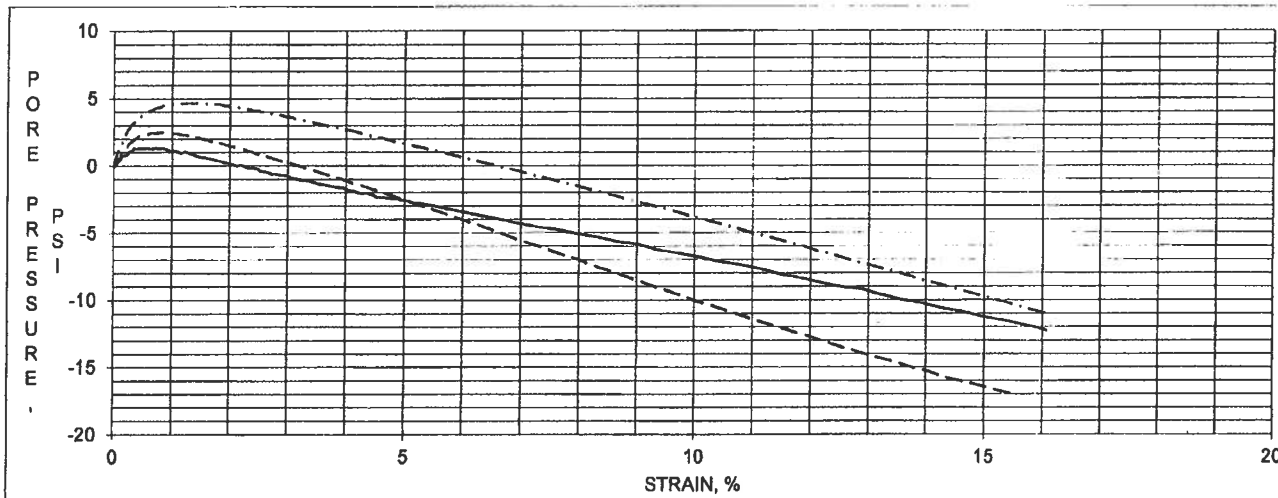
Terracon

DYNEGY

15151122 COF-B008 S6 13.0 - 15.0







Terracon

DYNEGY - COFFEEN, ILLINOIS
15151122
9/18/2015

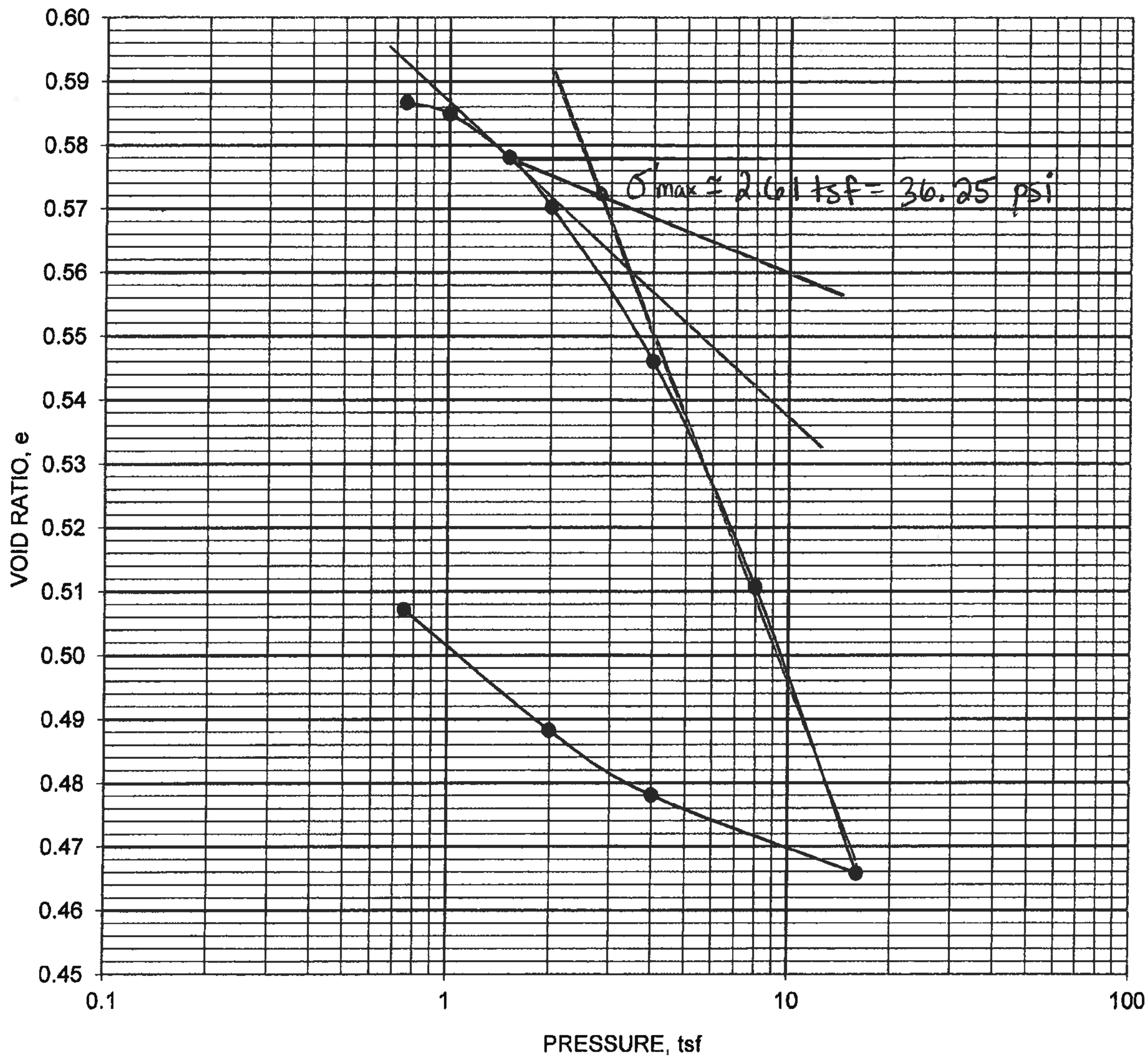
Boring	Sample ID	Depth From, feet	Depth To, feet	Moisture Content, %	Unit Weight	Atterberg Limits LL	PL	PI	Particle Size Analysis NOTE*	Double Hydro % Disp. NOTE*	Specific Gravity	Perm cm/sec NOTE*	Consol NOTE*	CU Triaxial NOTE*	Direct Simple Shear NOTE*	Pinhole Disp. NOTE*	Crumb Test NOTE*	USCS Symbol
COF-B009	S1	1.0	2.5	2.6														
	Color		black							Visual Classification			Fill: Cinders					
	S2	3.5	5.0	26.1														
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S3	6.0	7.5	17.1		58	18	40	NOTE*									CH
	Color		dark grayish brown							USCS Classification			Fat Clay					
	S4	8.5	10.0	22.4														
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S5	13.5	15.5	18.4	111.1	50	15	35					NOTE*	NOTE*				
	Color		olive gray & grayish brown							Visual Classification			Fat Clay with Sand					
	S6	15.5	17.5	23.3	104.2													
	Color		brown & gray							Visual Classification			Lean to Fat Clay					
	S7	18.5	20.0	29.3														
	Color		brown & gray							Visual Classification			Fill: Fat Clay trace Sand					
	S8	23.5	25.0	23.1		48	18	30										
	Color		brown & gray							Visual Classification			Lean Clay trace Sand					
	S9	28.5	30.5	24.9	100.0	62	22	40										
	Color		brown & gray							Visual Classification			Fat Clay					
	S10	33.5	35.0	20.1														
	Color		brown & gray							Visual Classification			Fat Clay trace Sand					
	S11	38.5	40.0	21.6		49	17	32	NOTE*									CL
	Color		brown & gray							USCS Classification			Lean Clay					

TESTED BY: KJL-JDM
APPROVED BY: RMS

NOTE*: SEE ATTACHED DATA SHEETS.

Terracon

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.57	HEIGHT, mm	25.31		
PROPERTY				BEFORE TEST	AFTER TEST

OVERBURDEN PRESSURE, tsf	0.92	MOISTURE, %	19.9	19.3
PRECONSOL. PRESSURE, tsf	2.61	DRY DENSITY, pcf	106.2	109.7
OVER CONSOLIDATION RATIO	2.8	SATURATION, %	92	99
COMPRESSION INDEX	0.14	VOID RATIO	0.587	0.522
REBOUND INDEX	0.040	SAMPLE TYPE	UNDISTURBED	

LIQUID LIMIT	50	PLASTIC LIMIT	15	PLASTICITY INDEX	35	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	FAT CLAY WITH SAND, OLIVE GRAY WITH GRAYISH BROWN						
BORING NO.	COF-B009	SAMPLE NO.	S5	DEPTH, feet	13.5 - 15.5		

DYNEGY
COFFEEN, ILLINOIS
15151122
9/18/2015

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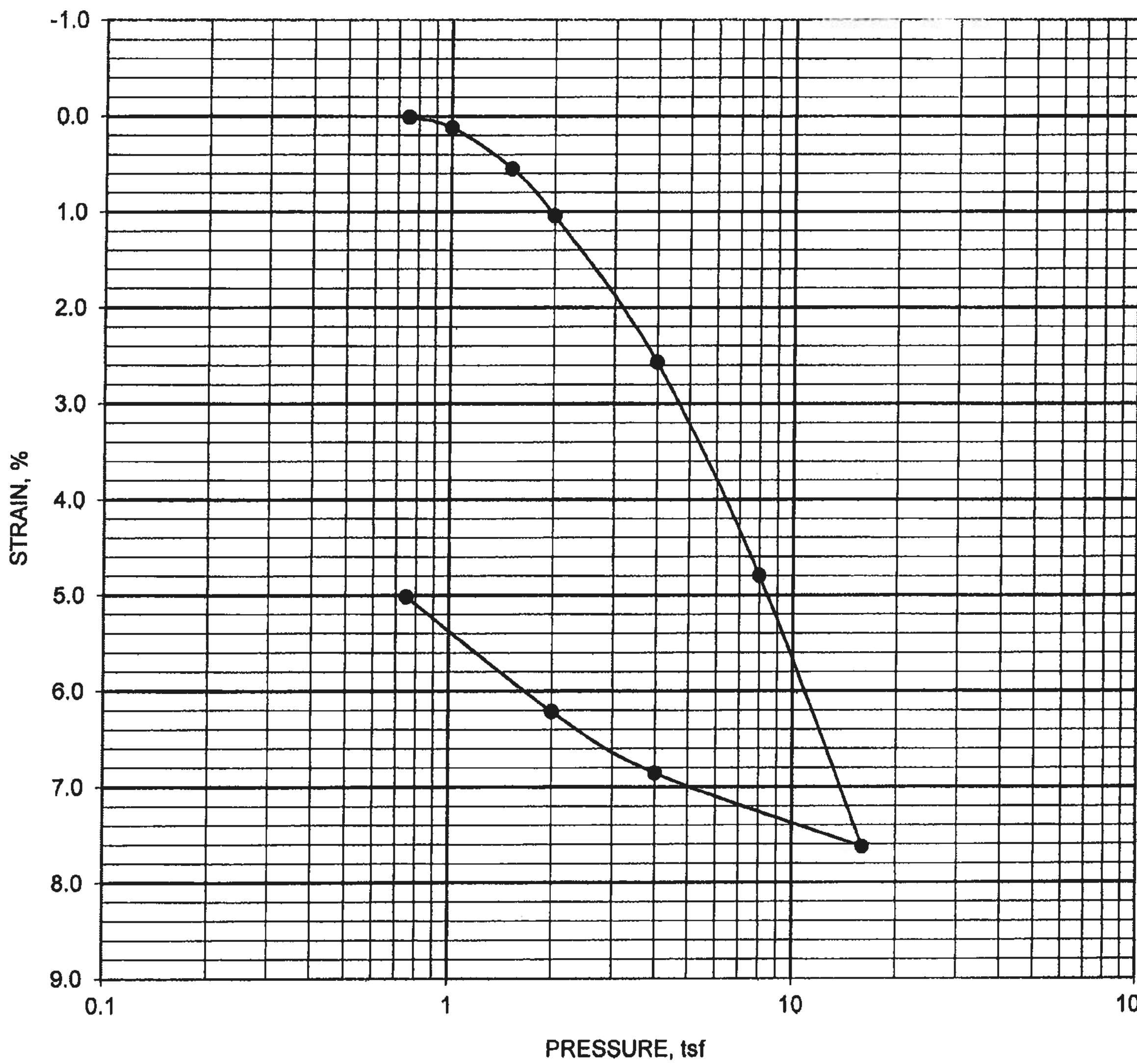
Terracon

Embankment

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435



DIAMETER, mm	63.57	HEIGHT, mm	25.31	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf			0.92	MOISTURE, %		19.9	19.3
PRECONSOL. PRESSURE, tsf			2.61	DRY DENSITY, pcf		106.2	109.7
OVER CONSOLIDATION RATIO			2.8	SATURATION, %		92	99
COMPRESSION INDEX			0.14	VOID RATIO		0.587	0.522
REBOUND INDEX			0.040	SAMPLE TYPE		3" SHELBY TUBE	
LIQUID LIMIT	50	PLASTIC LIMIT	15	PLASTICITY INDEX	35	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION	FAT CLAY WITH SAND, OLIVE GRAY WITH GRAYISH BROWN						
BORING NO.	COF-B009	SAMPLE NO.	S5	DEPTH, feet		13.5 - 15.5	

DYNEGY
COFFEEN, ILLINOIS
15151122
9/18/2015

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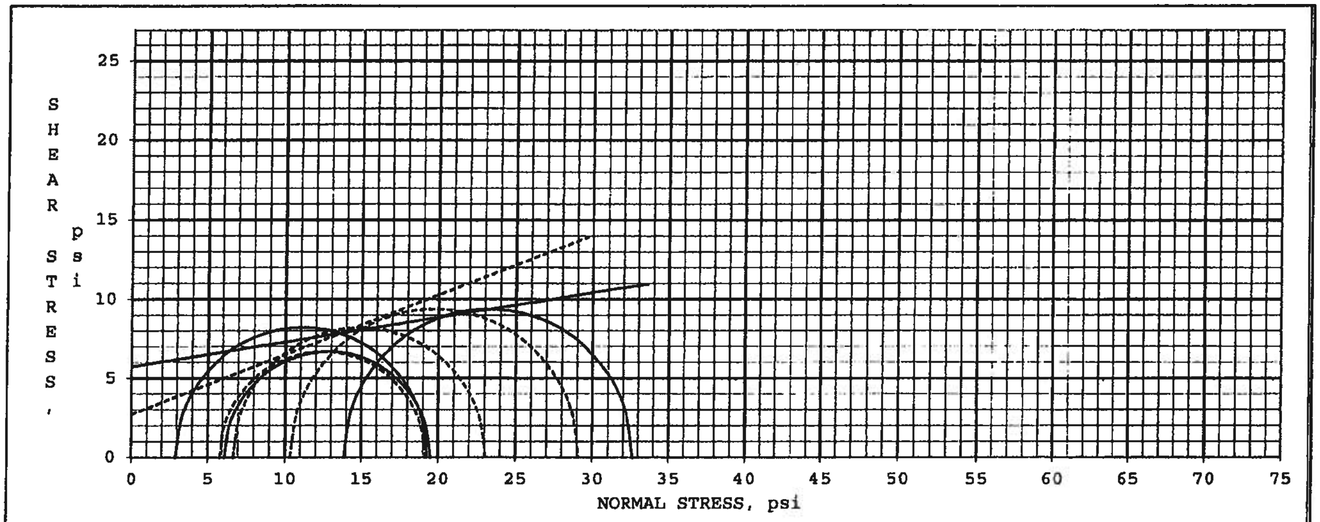
Terracon

DYNEGY
COFFEEN, ILLINOIS
15151122
9/18/2015

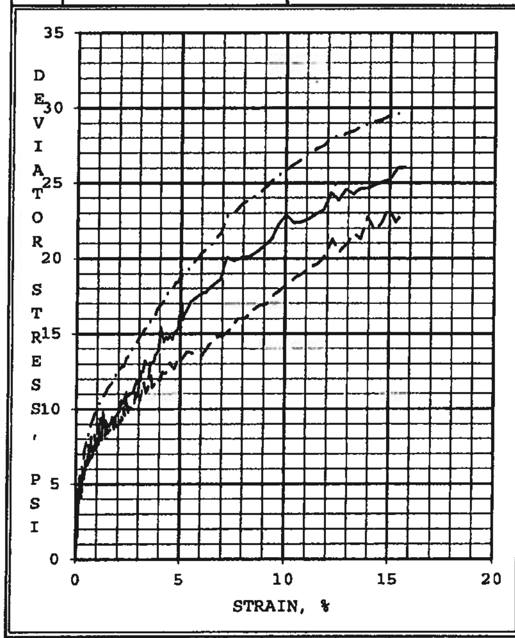
ADDITIONAL CONSOLIDATION DATA

COF-B009
S5
13.5 - 15.5

PRESSURE, tsf	Cv50, cm2/sec	Cv90, cm2/sec	Av, cm2/g	Mv, cm2/g	k, cm/sec
0					
0.75			2.17E-07	1.37E-07	
1	6.10E-04	6.13E-04	7.16E-06	4.51E-06	2.75E-09
1.5	4.35E-04	4.37E-04	1.40E-05	8.83E-06	3.84E-09
2	1.67E-04	1.68E-04	1.59E-05	1.01E-05	1.68E-09
4	1.53E-04	1.54E-04	1.24E-05	7.88E-06	1.21E-09
8	1.01E-04	1.02E-04	9.03E-06	5.84E-06	5.91E-10
16	9.99E-05	1.00E-04	5.74E-06	3.80E-06	3.79E-10
AVERAGE	2.61E-04	2.62E-04	9.21E-06	5.87E-06	1.74E-09



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	20.7	COHESION, psi	2.7
TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	8.9	COHESION, psi	5.7



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	17.9	17.8	17.9
INITIAL	DRY DENSITY, pcf	114.0	111.8	112.5
INITIAL	SATURATION, %	101	95	97
INITIAL	VOID RATIO	0.48	0.51	0.50
BEFORE SHEAR	WATER CONTENT, %	17.7	18.3	17.3
BEFORE SHEAR	DRY DENSITY, pcf	114.1	112.8	114.9
BEFORE SHEAR	SATURATION (B PARAMETER)	0.96	0.96	0.96
BEFORE SHEAR	VOID RATIO	0.48	0.49	0.47
BEFORE SHEAR	FINAL BACK PRESSURE, psi	100.3	101.2	100.0
MINOR PRINCIPAL STRESS, psi		2.9	6.1	13.9
EFFECTIVE STRESS PEAK AT % STRAIN		5.0	5.0	5.0
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		16.4	13.4	18.8
TOTAL STRESS PEAK AT % STRAIN		5.0	5.0	5.0
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		16.4	13.4	18.8
ULTIMATE DEVIATOR STRESS (15% STR), psi		25.5	23.2	29.4
TIME TO 50% PRIMARY CONSOLIDATION, min		5.60	38.00	62.00
STRAIN RATE, % / hour		0.29	0.48	0.29
INITIAL DIAMETER, inch		1.363	1.367	1.367
INITIAL HEIGHT, inch		2.836	2.822	2.837
AREA AFTER CONSOLIDATION, inch2		1.457	1.460	1.443

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
FAT CLAY WITH SAND, OLIVE GRAY & GRAYISH BROWN

LL 50	PL 15	PI 35	Gs 2.7 EST.

PROJECT NO. 15151122

PROJECT: DYNEGY
COFFEEN, ILLINOIS

BORING #: COF-B009

LABORATORY: TERRACON - LENEXA

SAMPLE #: S5

DATE: 9/18/2015

DEPTH, feet: 13.5 - 15.5

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

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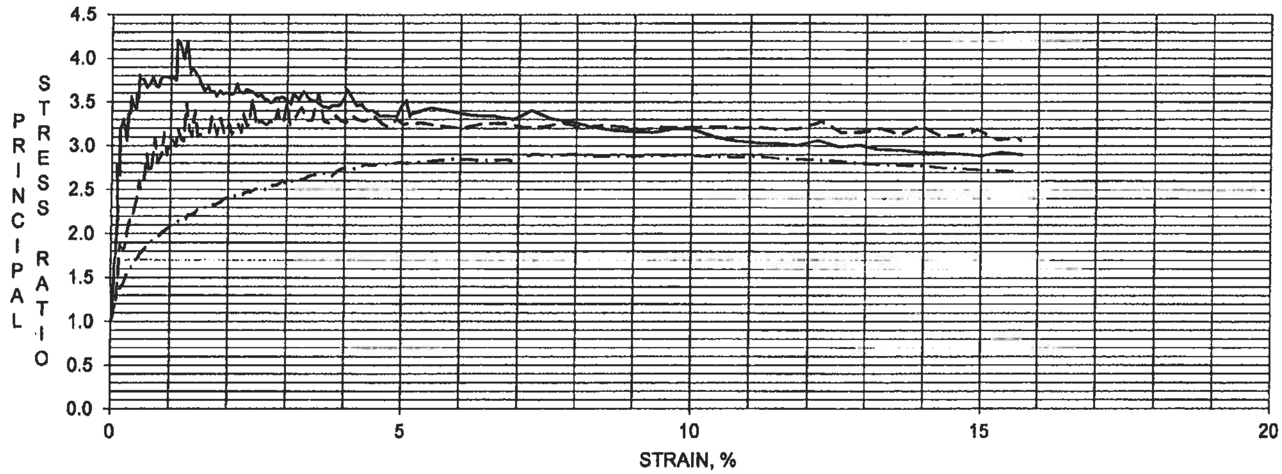
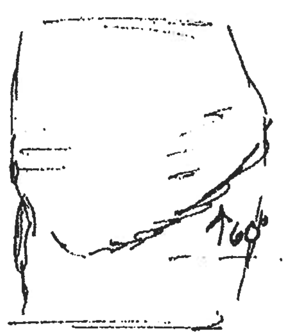
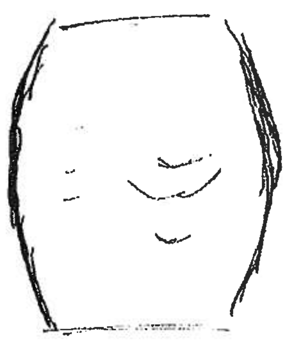
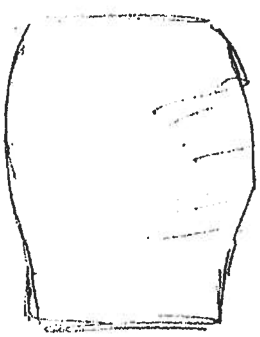
Embankment

DYNEGY

15151122 COF-B009 S5 13.5 - 15.5



FAILURE SKETCH	FAILURE SKETCH	FAILURE SKETCH
		
SPECIMEN A	SPECIMEN B	SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON 5 % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT 5 % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON 5 % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT 5 % STRAIN.

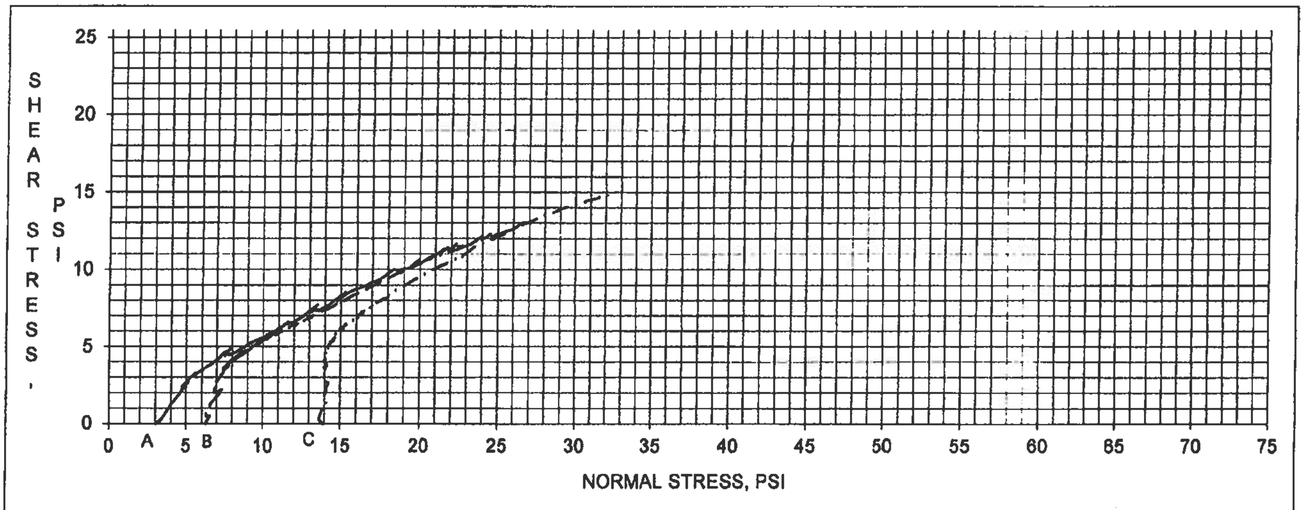
DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

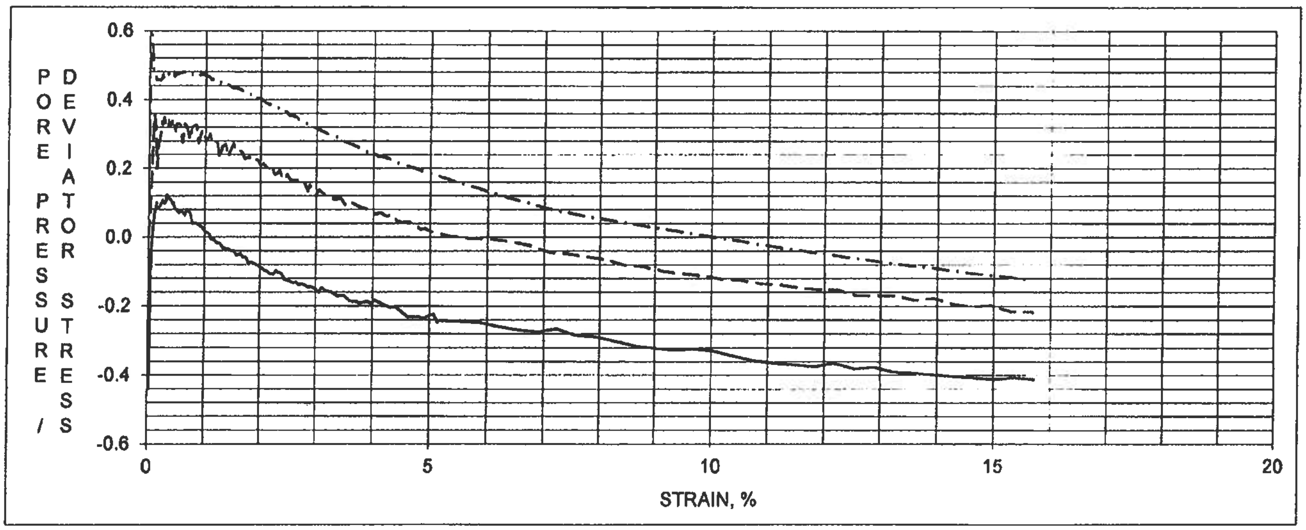
AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

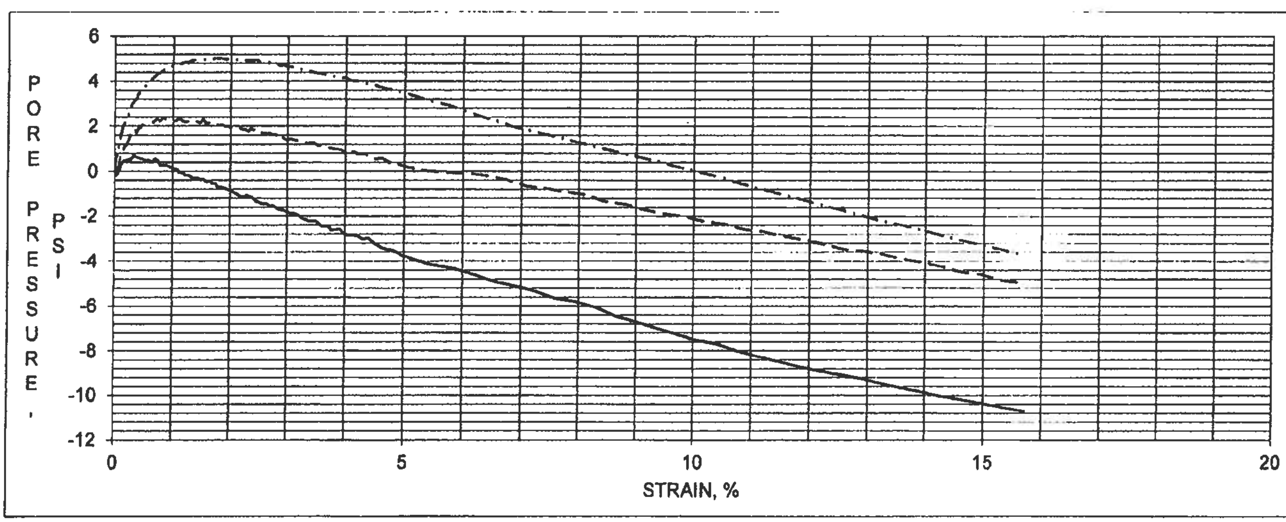
Terracon

DYNEGY

15151122 COF-B009 S5 13.5 - 15.5

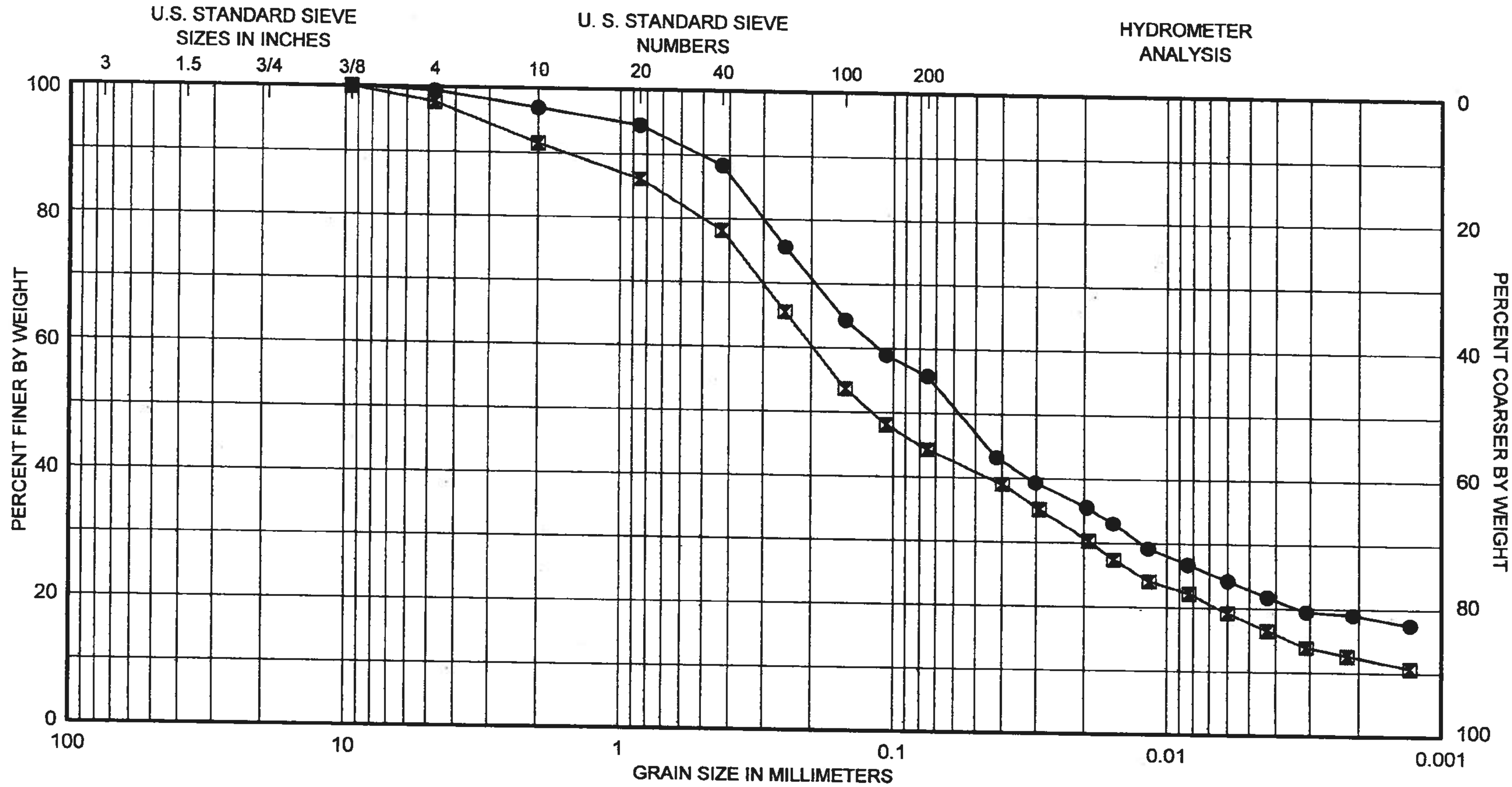






Terracon

Report No. 04.11150025



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

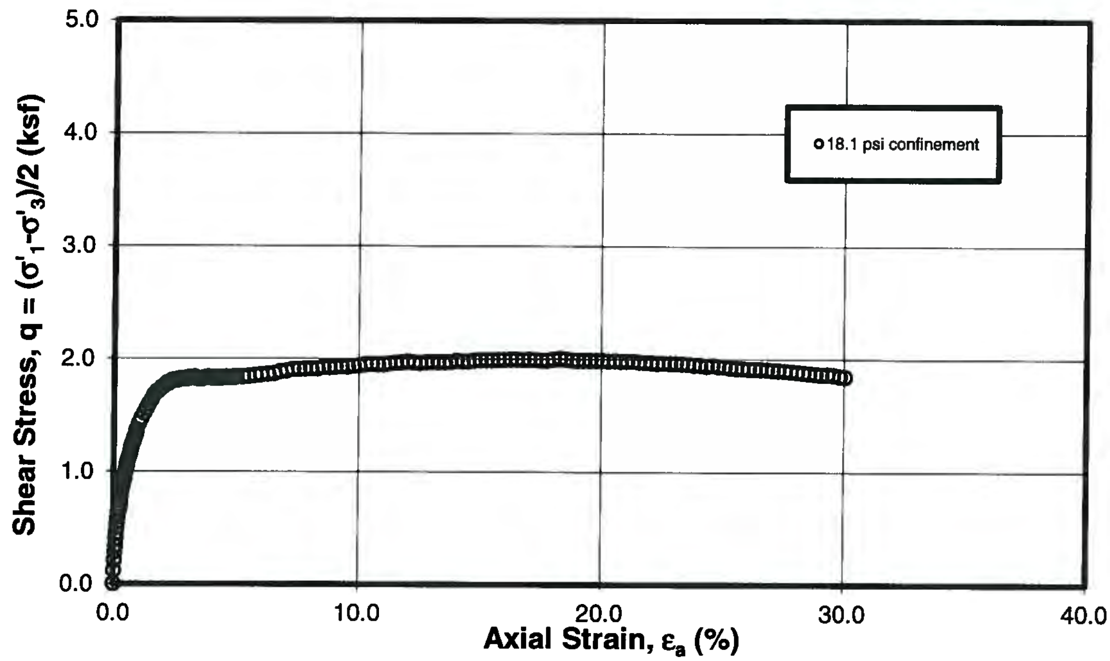
SYMBOL	BORING	DEPTH, FT	C_c	C_u	D_{50}	D_{90}	CLASSIFICATION
●	COF-B008	29.5			0.06	0.51	Sandy Clay, gray, with ferrous stains, gravel, and carbonate nodules
⊠	COF-B011	32			0.12	1.58	Sandy Clay, gray, with sand and gravel
✳							
⊗							

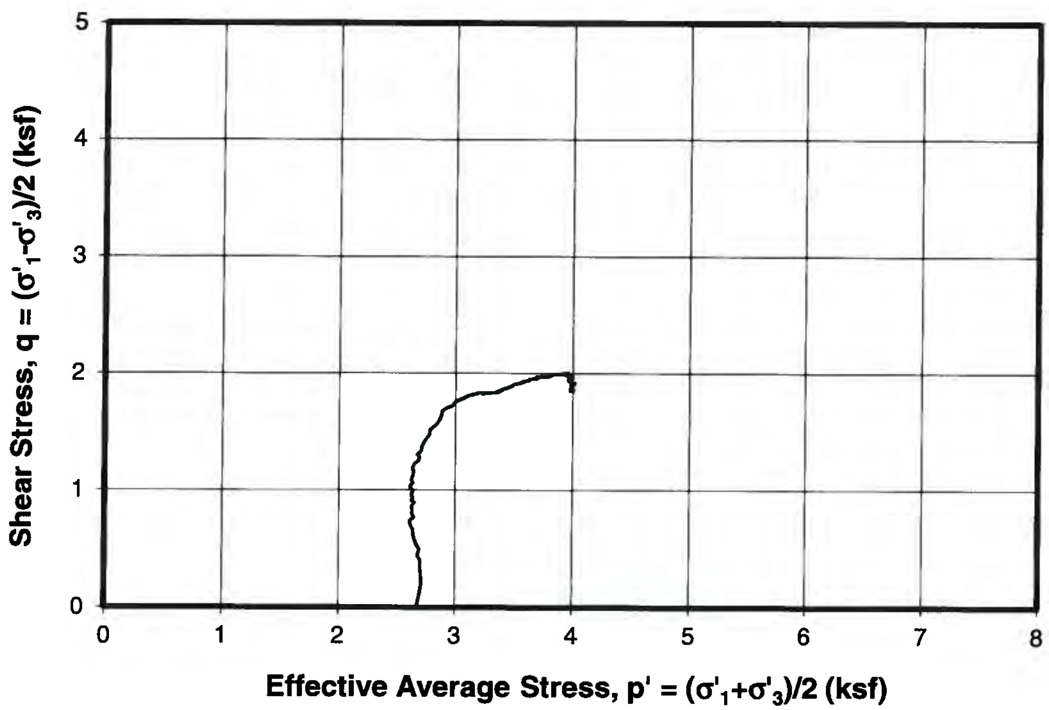
GRAIN SIZE CURVE

Fugro

PLATE

Fugro





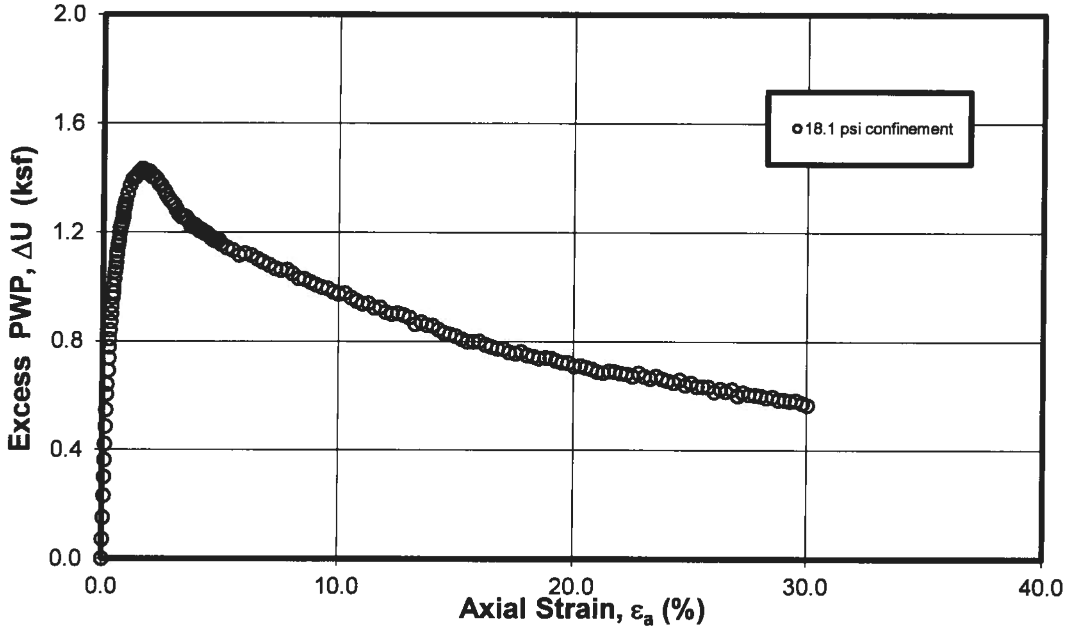
UNDRAINED TRIAXIAL COMPRESSION TEST

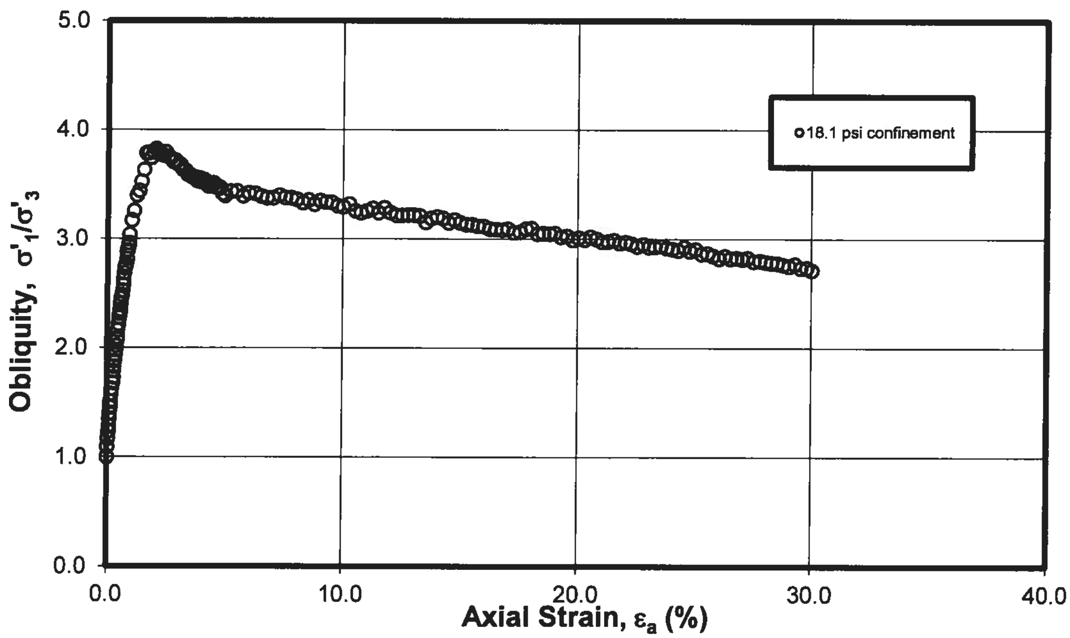
Isotropically Consolidated

Sample: 9b - Depth: 29.00 ft

Boring COF-B008

Lower NC Foundation





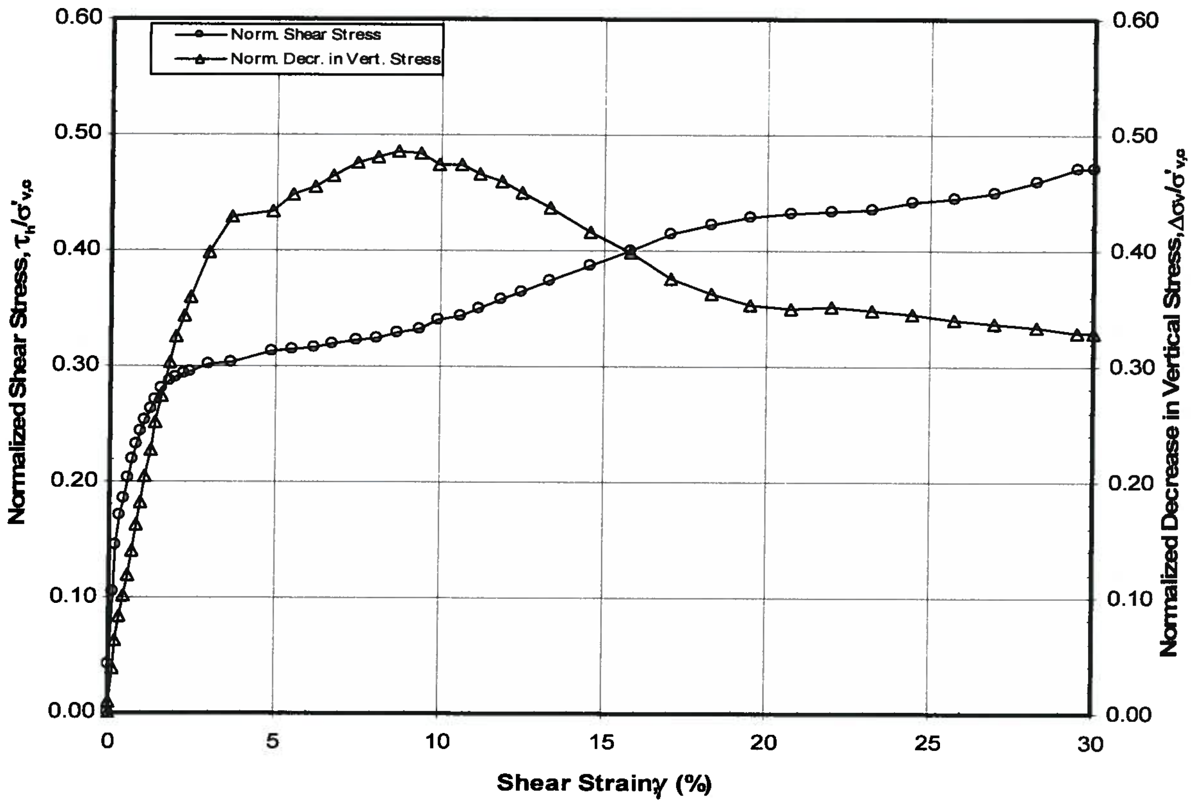
UNDRAINED TRIAXIAL COMPRESSION TEST

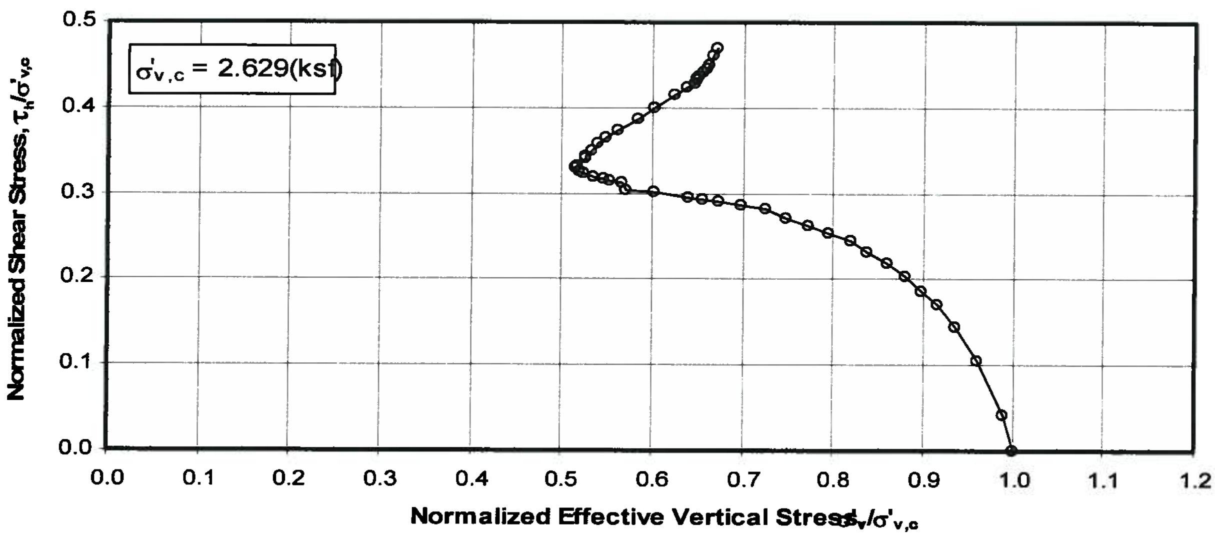
Isotropically Consolidated

Sample: 9b - Depth: 29.00 ft

Boring COF-B008

Fugro





STATIC DSS TEST

K_o Consolidation - OCR = 1

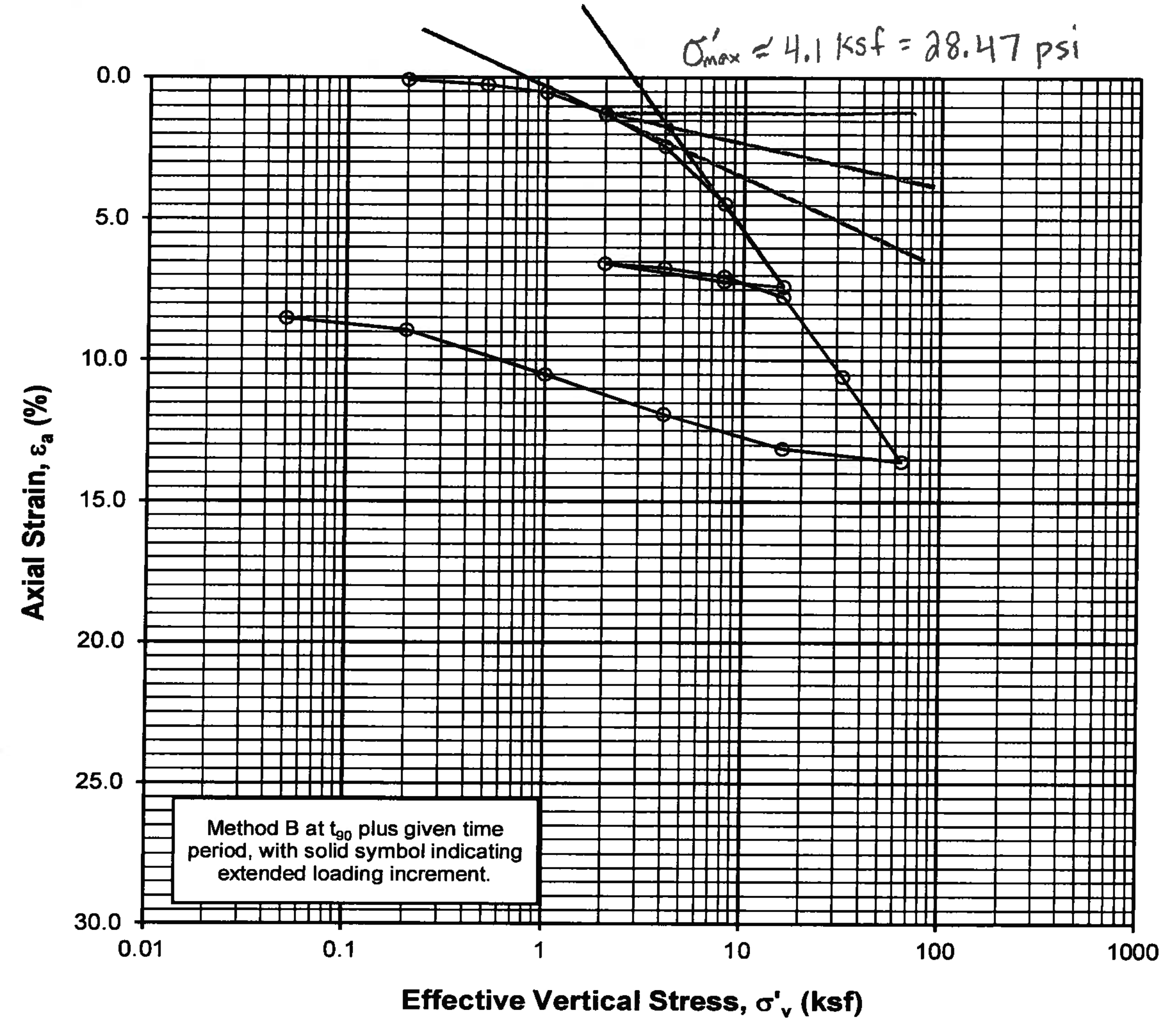
Sample: 9b - Depth: 29.50 ft

Boring COF-B008

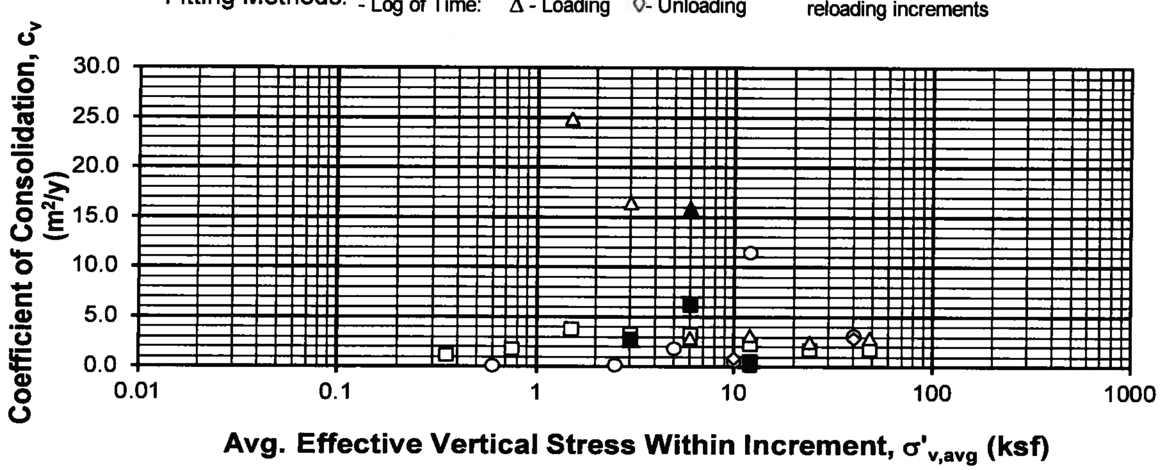
Denegy CCR Assessment of Plants - Coffeen Power Station

Lower NC Foundation

Fugro



Fitting Methods: - Sqr. Rt. Time: □ - Loading ○ - Unloading with solid symbols indicating reloading increments
- Log of Time: Δ - Loading ◊ - Unloading



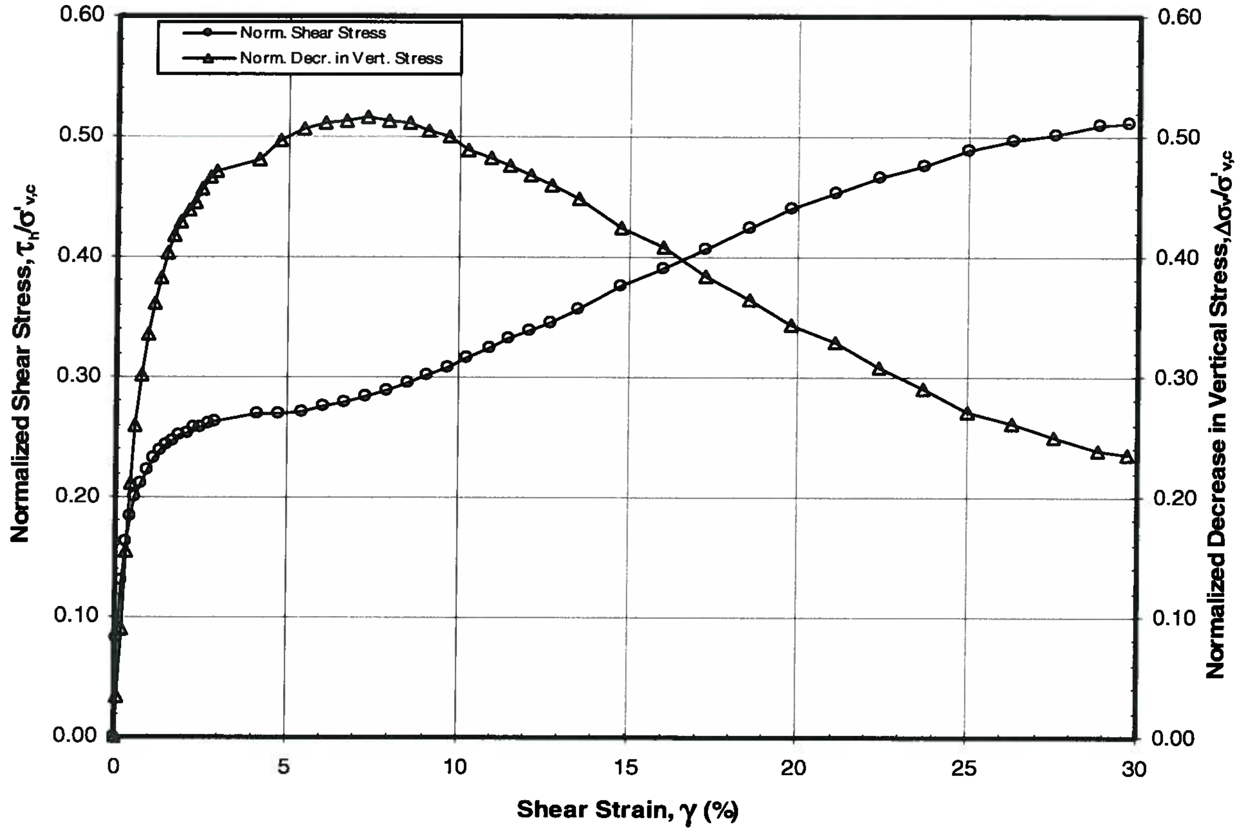
1-D CONSOLIDATION TEST: INC

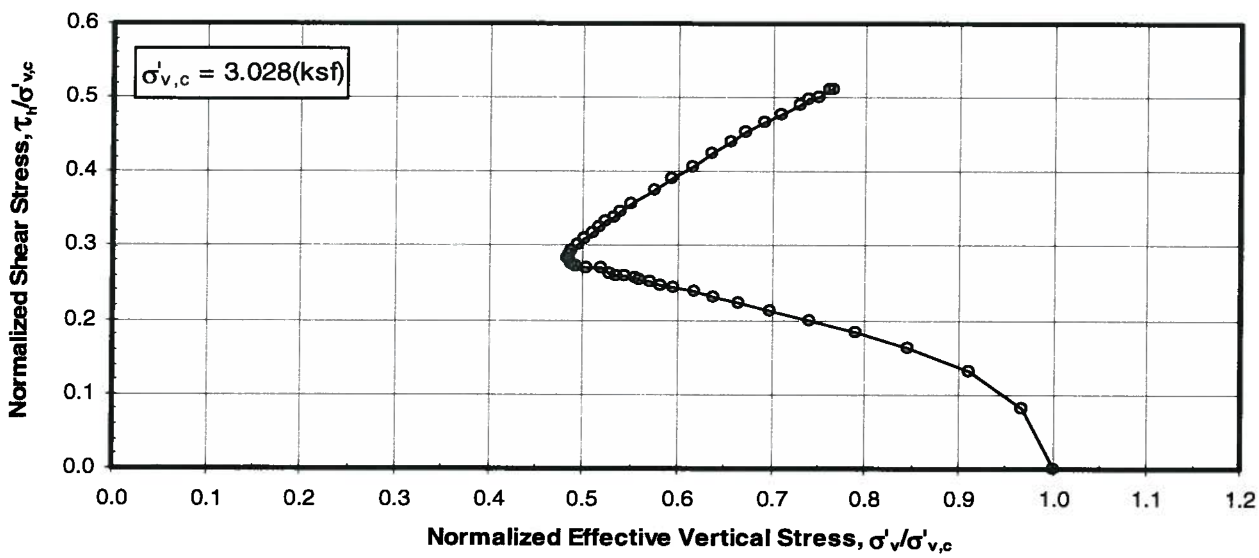
Sample No. 9b Depth 29.5 ft

Boring COF-B008

Lower NC Foundation

Fugro





STATIC DSS TEST

K_o Consolidation - OCR = 1

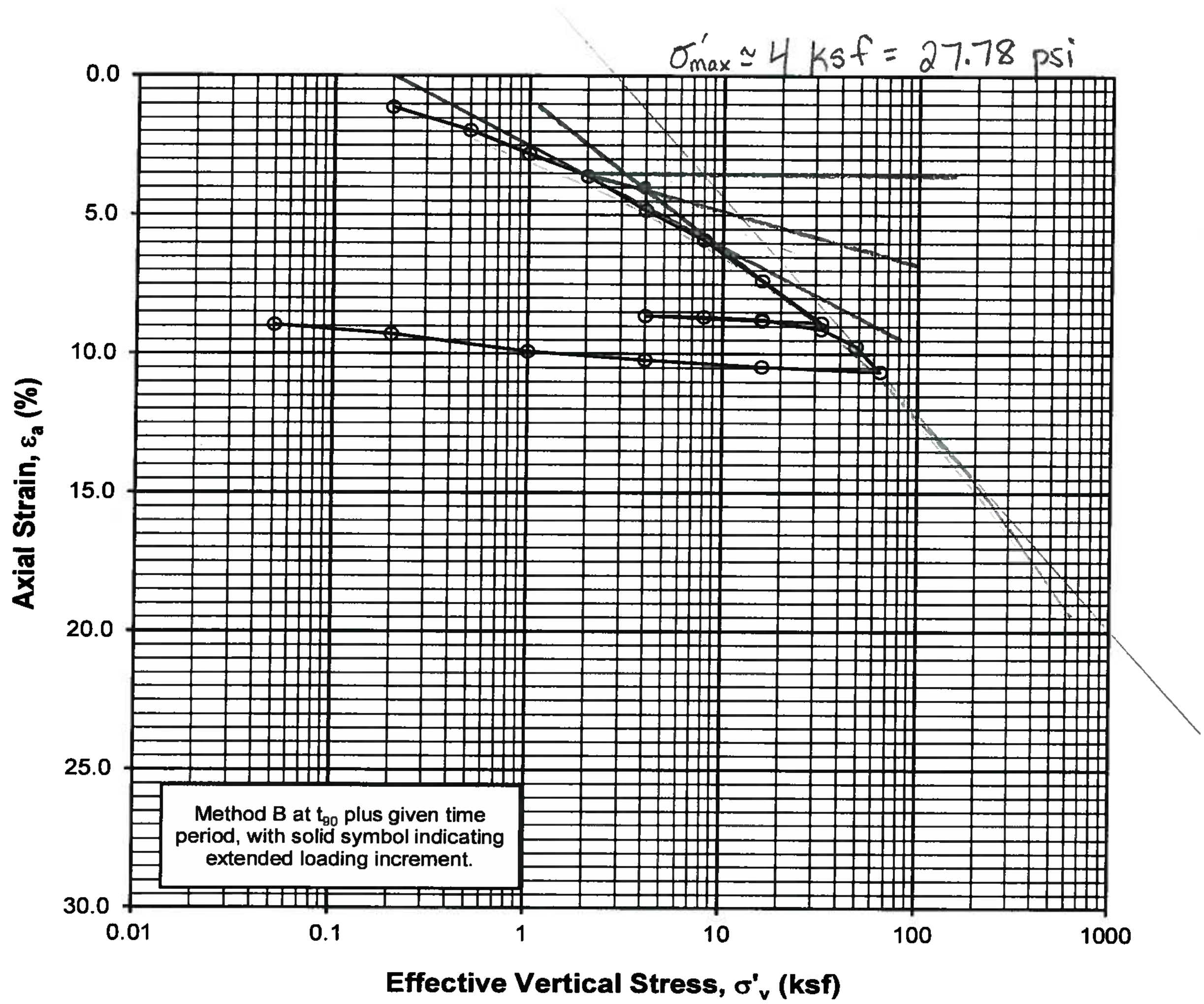
Sample: 11h - Depth: 32.00 ft

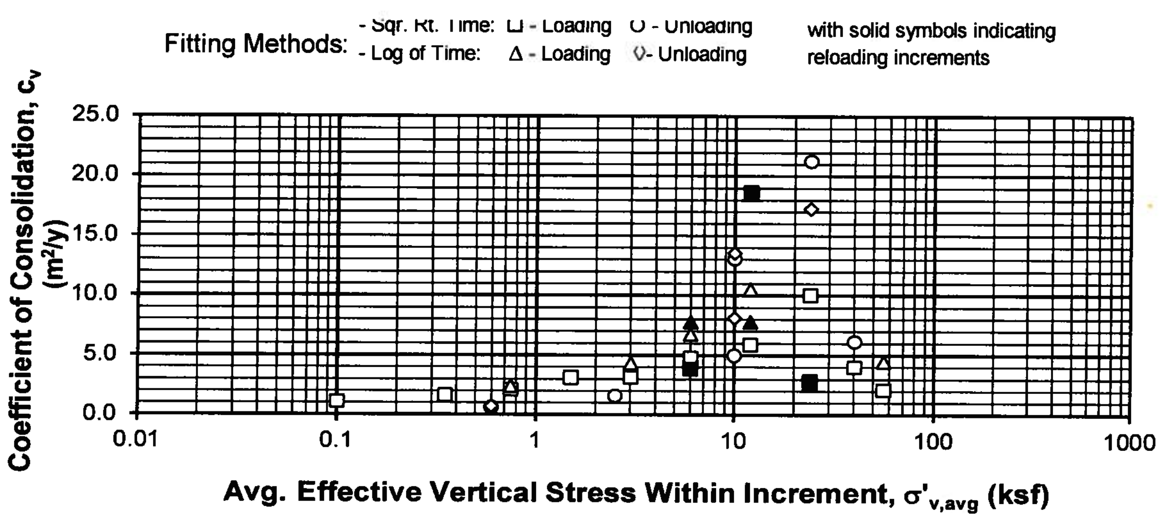
Boring COF-B011

Denegy CCR Assessment of Plants - Coffeen Power Station

Soft Foundation Clay

Fugro





1-D CONSOLIDATION TEST: INC

Sample No. 11i Depth 30.46 ft

Boring COF-B011

Denegy CCR Assessment of Plants - Coffeen Power Station

Soft Foundation Clay

Attachment H. Slope Stability Analysis Calculations

Calculation Notes

AECOM

Subject: Coffeen Ash Pond No. 1 Slope Stability Analysis   Project Name: Dynegy CCR

By: Lucas Carr   Date: 01/19/2016   Project No: 60480701

Checked By: Kevin Ritter   Date: 2-10-2016   Task No.: 01

Objective

A slope stability analysis was performed to calculate factors of safety (FoS) for normal operating conditions, surcharge pool, and earthquake (pseudostatic and post-earthquake) loading conditions at the Coffeen Ash Pond No. 1. The factors of safety have been compared to the USEPA CCR Rule criteria for each loading condition. The methodology used to perform the slope stability analysis is summarized in the following sections.

Development of Sections for Analysis

Slope stability analyses were performed at cross-sections stations 13+00, 30+00, 36+50, 39+00, and 46+50 at Ash Pond No. 1. The rationale behind selecting each section for analysis is described below:

- Station 13+00: Area of tallest and steepest dike along west side of Ash Pond No. 1
- Station 30+00: Area of tallest dike along south side of Ash Pond No. 1
- Station 36+50: Area of tallest dike along east side of Ash Pond No. 1
- Station 39+00: Location of sheet pile at dike toe at northeast corner of Ash Pond No. 1
- Station 46+50: Area of tallest dike along north side of Ash Pond No. 1

Subsurface material boundaries (stratigraphy) at each section were developed by projecting nearby subsurface explorations (CPTs and borings) on to the cross-section. Material interfaces inferred from the subsurface explorations were sketched onto the cross-section and a reasonable interpretation of the subsurface stratigraphy between the subsurface exploration locations was developed. The following materials are present at each cross-section:

- Impounded Ash
- Embankment
- Foundation Clay
- Soft Foundation Clay
- Till

A description of each material can be found in the *Coffeen Ash Pond No. 1 Material Characterization* calculation package.

Analysis Methodology

Loading Conditions

The slope stability analysis evaluated the following loading conditions, as required by the USEPA CCR Rule:

- Long-Term, Maximum Storage Pool Loading Condition (Static Drained), Min FoS = 1.50: This case models the static stability of the embankment under long-term conditions, using drained soil strengths. A maximum operating pool elevation of 631.0 ft was assumed in Ash Pond No. 1, and pore pressures for analysis are taken from a piezometric line based on AECOM's interpretation of groundwater levels from piezometer, CPT, and boring data. Thicknesses of ash retained by the pond are based on 2015 survey data and AECOM's interpretations.
- Maximum Surcharge Pool Loading Condition (Surcharge), Min FoS = 1.40: This case models the static stability of the embankment under short-term flood loading conditions. The flood pool elevation was assumed to be El. 632.0 ft, which corresponds to the 1,000-year flood, per AECOM's hydraulic and hydrologic calculations (AECOM, 2016). Due to the small rise above the max operating pool (1.0 ft), drained soil strengths were assumed as the small increase in pool level is not expected to result in the development of undrained conditions within the dike or foundation soils. Pore pressures in the embankment were assumed to be similar to the static drained conditions, however the pool level in Ash Pond No. 1 was increased to model additional loading from the surcharge pool.
- Seismic Condition (Pseudostatic), Min FoS = 1.00: This case models the stability of the embankment under earthquake loading. Normal pool conditions (El. 631.0 ft) and phreatic conditions are assumed. Seismic loads were taken from a probabilistic seismic hazard analysis (PSHA) and dynamic response analyses performed by AECOM, and were adjusted to account for topographic amplification of the seismic loads by the embankment. A pseudostatic seismic coefficient (k_h) of 0.13 g was selected based on these analyses. Peak undrained soil strengths were used for this analysis, due to the short duration of the loading and the fine-grained, slow-draining nature of the embankment and foundation soils.
- Liquefaction Condition (Post-Earthquake), Min FoS = 1.20: This case models the stability of the embankment immediately following earthquake loading. Normal pool conditions (El. 631.0 ft) and groundwater conditions are assumed. For materials susceptible to cyclic softening and a loss of strength during earthquake loading, as determined from laboratory testing, reduced post-earthquake undrained shear strengths are assumed.

The analysis for Sta. 39+00 includes a sheet pile wall at the toe of the embankment. A structural analysis completed for the sheet pile (in a separate calculation package) found that the pile provides a long-term horizontal stabilizing force of 3,900 lbs/ft to the slope. This was modeled by first analyzing the stability of the slope using block specified and entry-exit slip surfaces, without a sheet pile present. The resulting critical slip surface was then fixed, and the analysis was performed by applying a horizontal point load of 3,900 lbs/ft to the last slide of the critical slip surface, at the location of the sheet pile. The resulting factor of safety was then reported.

Stability Analysis Approach

The slope stability analysis was conducted using SLOPE/W within the GeoStudio 2012 software package (Version 8.15.1.11236). The following approach was used to conduct the analysis:

- Analysis Method: Spencer
- Slip Surface Definition: Entry and exit. Slip surfaces were allowed to enter the ground surface upstream of the middle of the embankment crest and downstream of the embankment toe
    - Note: Block-type slip surfaces were also analyzed for Sta. 39+00, due to the daylight of the soft foundation clay behind the sheet pile
- Minimum Slip Surface Depth: 10 ft
- Optimization: Critical slip surfaces were optimized. This allowed the critical slip surface to pass through the soft foundation clay material in a nearly horizontal manner for many of the analysis cases.
- Tension Cracks: Added if necessary to reduce interslice tensile forces for all loading cases except pseudostatic stability. For pseudostatic stability, the short-duration nature of the loading was assumed to prevent a tension crack from opening. Where included, the tension crack was assumed to be full of water.
- Pore Pressures: From piezometric line

Material Properties

Material properties for analysis were taken from the *Coffeen Ash Pond No. 1 Material Characterization* calculation package. The material properties are summarized in the following tables.

Table 1 – Coffeen Ash Pond No. 1 Slope Stability Material Properties

Material	Unit Weight (pcf)	Peak Drained Shear Strength		Peak Undrained Shear Strength	Post-Earthquake Shear Strength
		Cohesion, c' (psf)	Friction Angle, ϕ' (degrees)	S_u/p'	S_u/p'
Ash	112	0	32	0.40	0.32 (80% of Peak Undrained)
Embankment	135	0	31 *with curved envelope for* *σ'_{ff} < 1440 psf* *(SEE NOTE 1)*	S_u/p' = 0.60, Minimum S_u = 450 psf	Peak Undrained
Foundation Clay	125	0	Below Embankment: ϕ' = 32 *with curved envelope for* *σ'_{ff} < 2160 psf* *(SEE NOTE 2)* Free Field: ϕ' = 30	Below Embankment: S_u/p' = 0.45, Minimum S_u = 700 psf Free Field: S_u/p' = 0.28, Minimum S_u = 450 psf	Peak Undrained
Soft Clay Foundation	125	0	30	S_u/p' = 0.28, Minimum S_u = 275 psf	S_u/p' = 0.16, Minimum S_u = 200 psf
Till	135	0	40	0.64, Minimum Su = 700 psf	Peak Undrained

Table 2 – Embankment Nonlinear Drained Shear Strength Envelope

σ'_{ff} (psf)	τ_{ff} (psf)
0	0
432	389
864	634
1440	865
5040	3028

Table 3 – Foundation Clay Below Embankment Nonlinear Drained Shear Strength Envelope

σ'_{ff} (psf)	τ_{ff} (psf)
0	0
432	389
864	677
1440	1008
2160	1350
5040	3149

As discussed in the calculation package, separate shear strengths were developed for the foundation clay beneath the embankment (based on CIU' triaxial tests) and the foundation clay near and beyond the toe of the embankment (based on direct simple shear [DSS] tests). Within the foundation clay, the boundary between the two different strengths was iterated during the slope stability analysis based on the orientation of the slip surface. DSS strengths were assigned for the near-horizontal portions of the slip surface under and downstream of the embankment while CIU strengths were assigned for inclined portions of the slip surface where it is dipping into the foundation clay.

Results

The table on the following page summarizes the results of the slope stability analyses at Coffeen Ash Pond No. 1. USEPA CCR Rule factor of safety criteria is met for each loading condition.

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Slope Stability Analysis

Project Name: Dynegy CCR

By: Lucas Carr Date: 01/19/2016

Project No: 60480701

Checked By: Kevin Ritter Date: 2-10-2016

Task No.: 01

APPENDIX A

Stability Analysis Output

Stability Analysis Results Table - Dynegy Coffeen Ash Pond No. 1

Cross-Section	Analysis Case	CCR Rule Minimum Factor of Safety	Calculated Factor of Safety - Circle	Caluclated Factor of Safety - Block
Sta. 13+00	Pseudostatic	1.00	1.18	Not Analyzed
	Surcharge Pool	1.40	1.77	
	Post-Earthquake	1.20	1.49	
	Static Drained	1.50	1.77	
Sta. 30+00	Pseudostatic	1.00	1.08	
	Surcharge Pool	1.40	1.52	
	Post-Earthquake	1.20	1.44	
	Static Drained	1.50	1.52	
Sta. 36+50	Pseudostatic	1.00	1.13	
	Surcharge Pool	1.40	1.85	
	Post-Earthquake	1.20	1.34	
	Static Drained	1.50	1.85	
Sta. 39+00	Pseudostatic	1.00	1.13	1.03
	Surcharge Pool	1.40	1.49	1.77
	Post-Earthquake	1.20	1.50	1.31
	Static Drained	1.50	1.50	1.76
Sta. 46+50	Pseudostatic	1.00	1.07	Not Analyzed
	Surcharge Pool	1.40	1.50	
	Post-Earthquake	1.20	1.30	
	Static Drained	1.50	1.50	

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Slope Stability Analysis

Project Name: Dynegy CCR

By: Lucas Carr Date: 01/19/2016

Project No: 60480701

Checked By: Kevin Ritter Date: 2/10/16

Task No.: 01

APPENDIX A

Stability Analysis Output

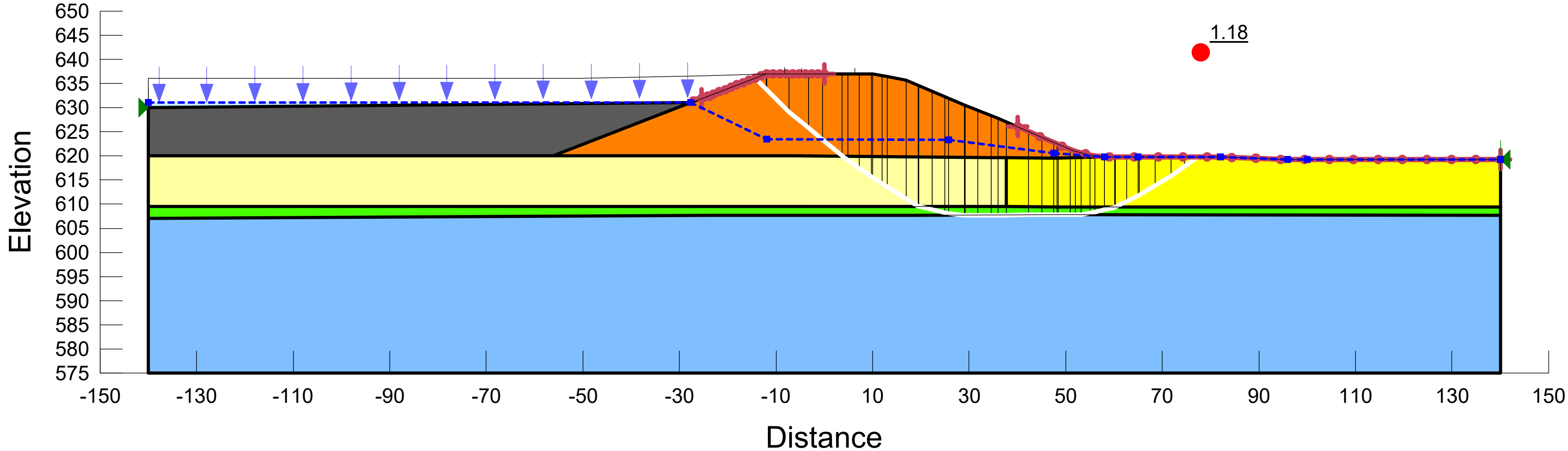
Dynegy Coffeen
Station 13+00
Peak Undrained Soil Strengths
Pseudostatic - Entry and Exit

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.4 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load
kh = 0.14 g



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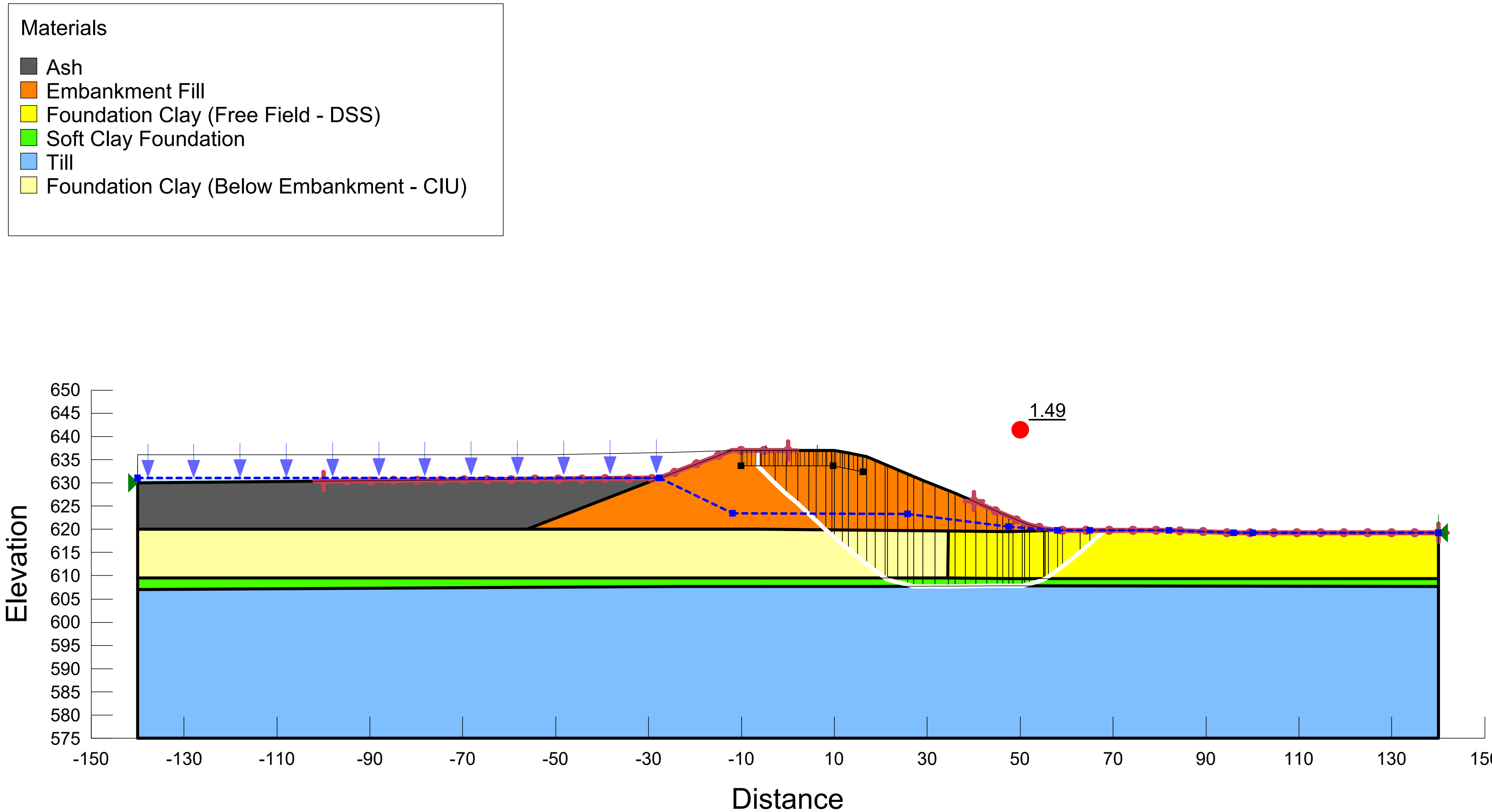
Dynegy Coffeen
Station 13+00
Slope Stability - Post Earthquake

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.1 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1



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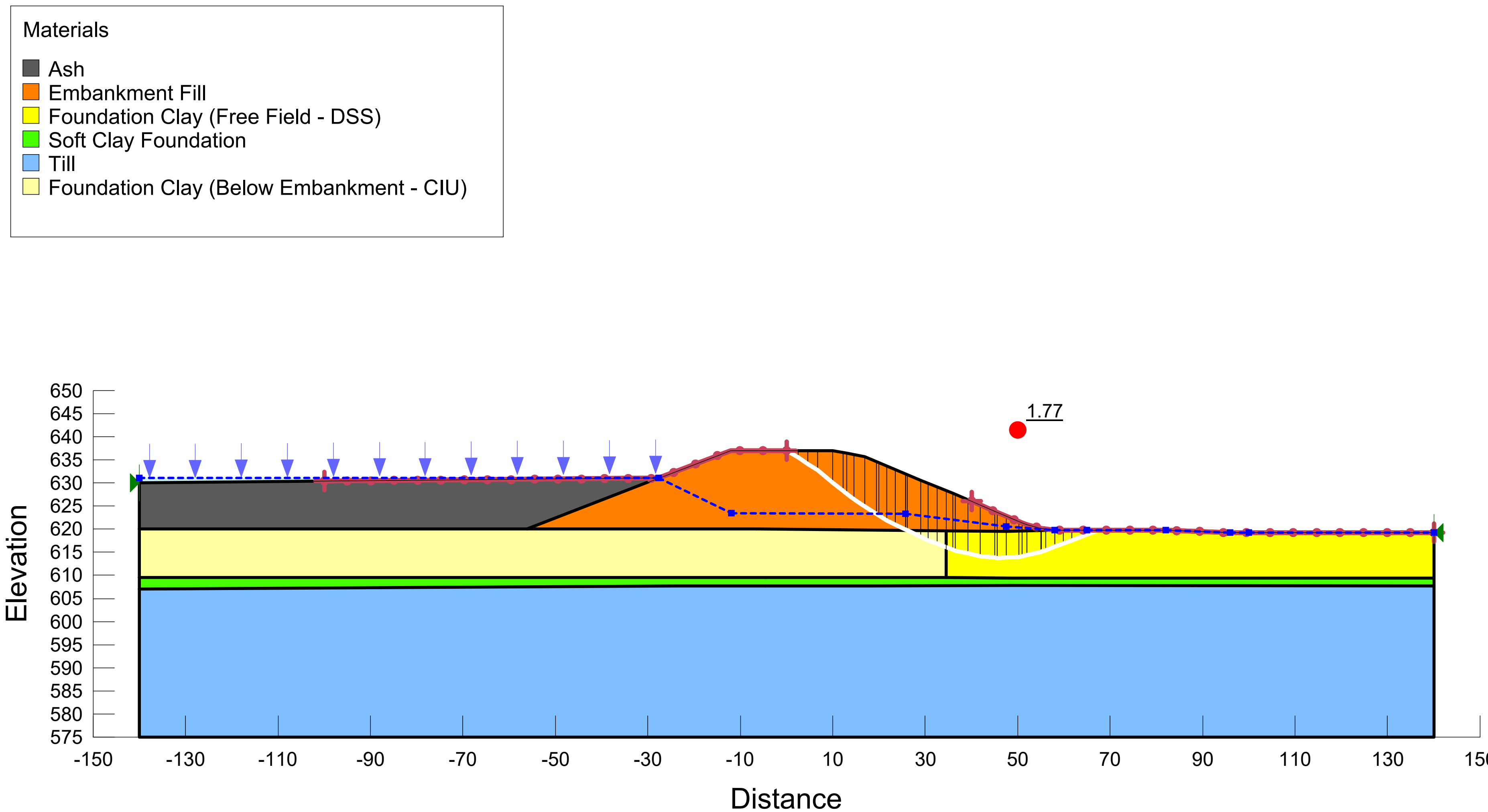
Dynegy Coffeen
Station 13+00
Static Drained - Normal Pool

Design by: ZJF
Date: 2/7/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1



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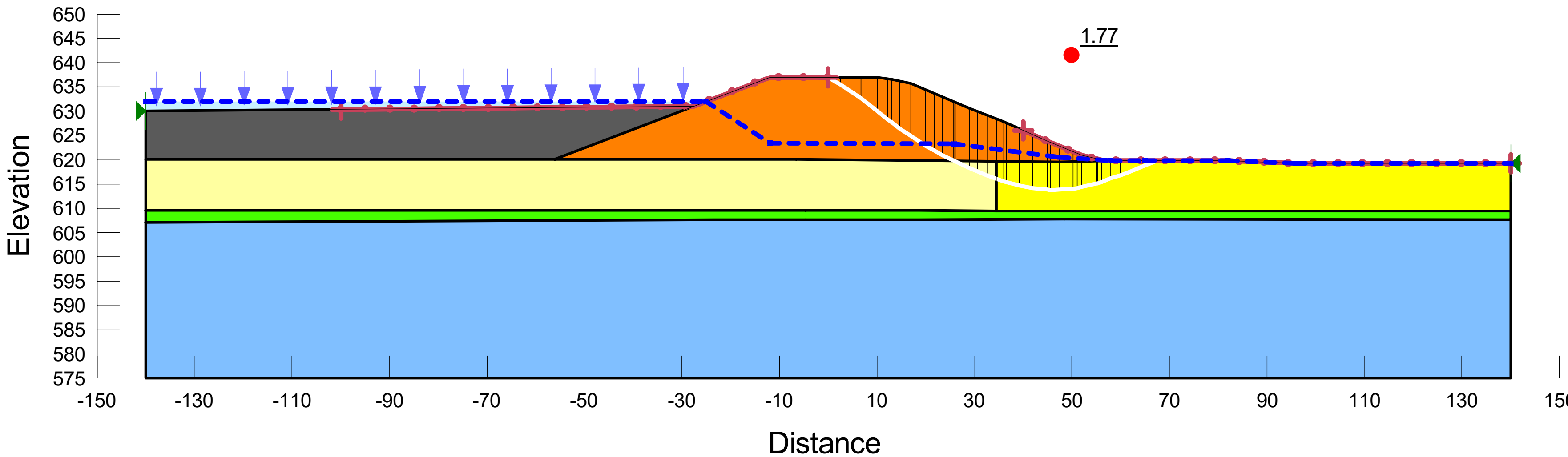
Dynegy Coffeen
Station 13+00
Static Drained - Max Surcharge Pool

Design by: ZJF
Date: 10/12/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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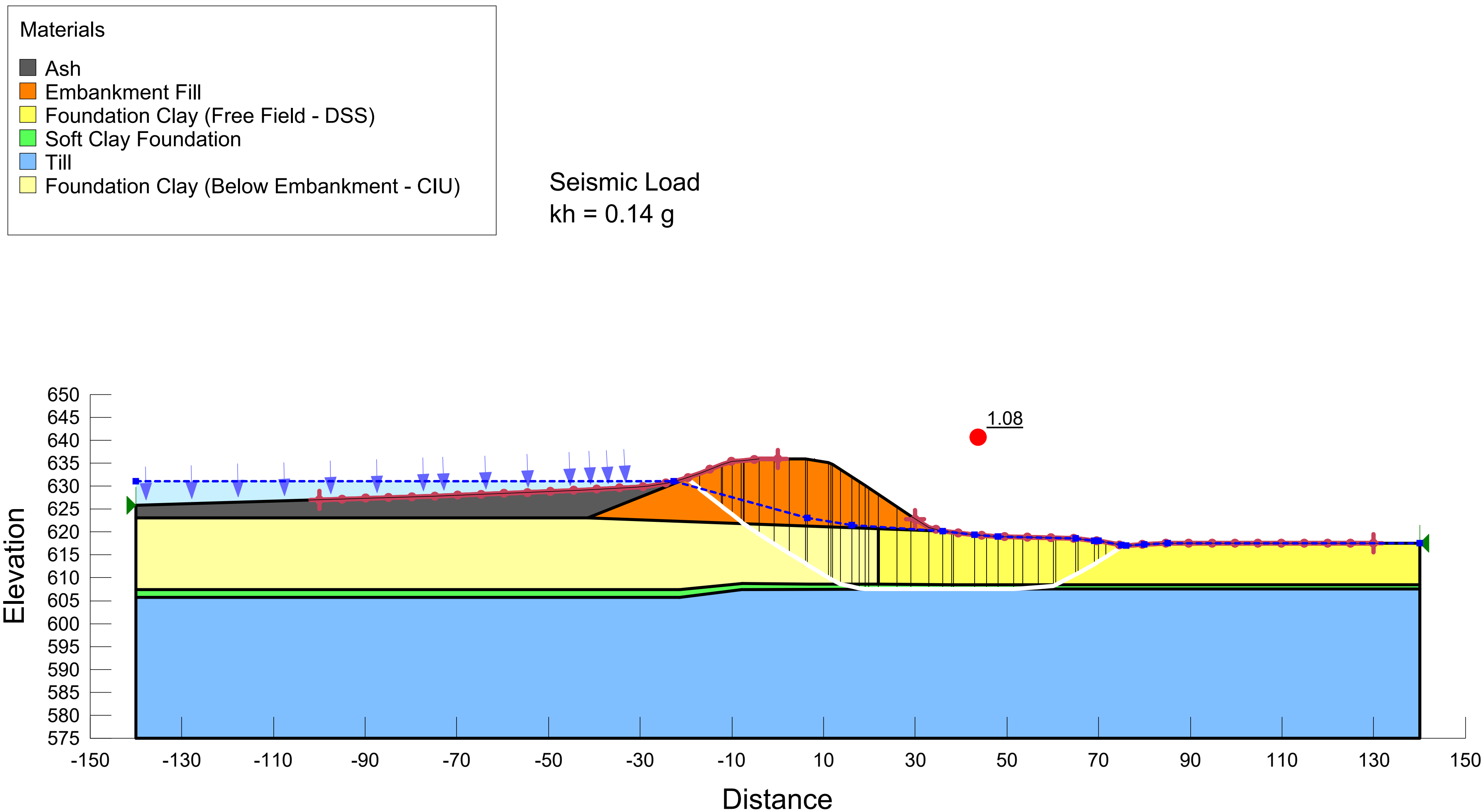
Dynegy Coffeen
Station 30+00
Peak Undrained Soil Strengths
Pseudostatic - Entry & Exit

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.4 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1



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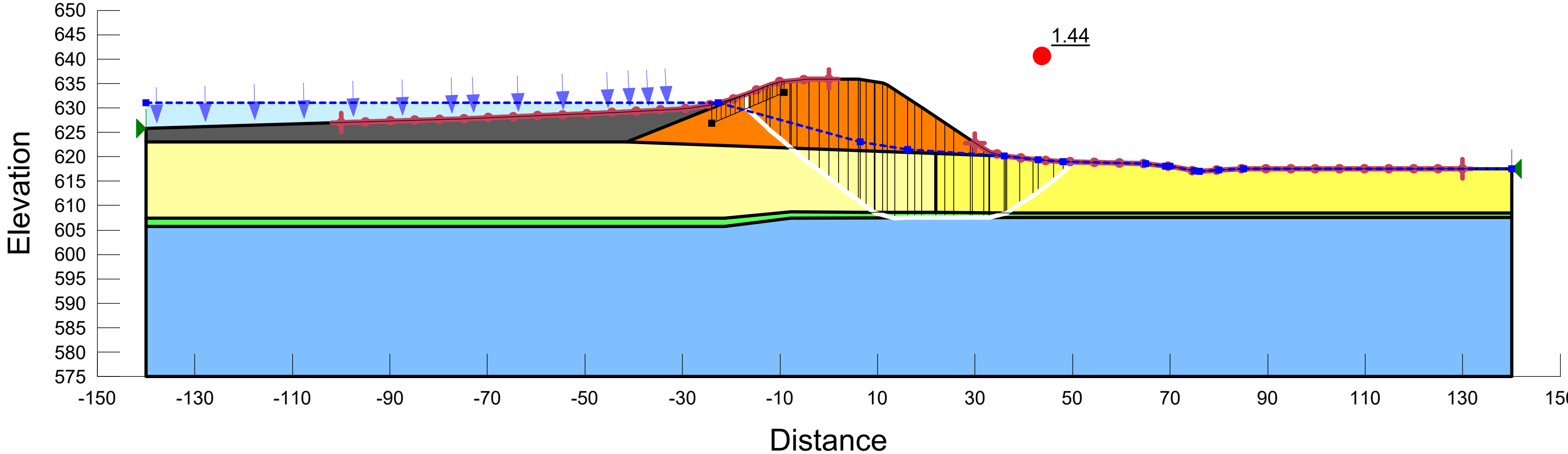
Dynegy Coffeen
Station 30+00
Slope Stability - Post Earthquake

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.1 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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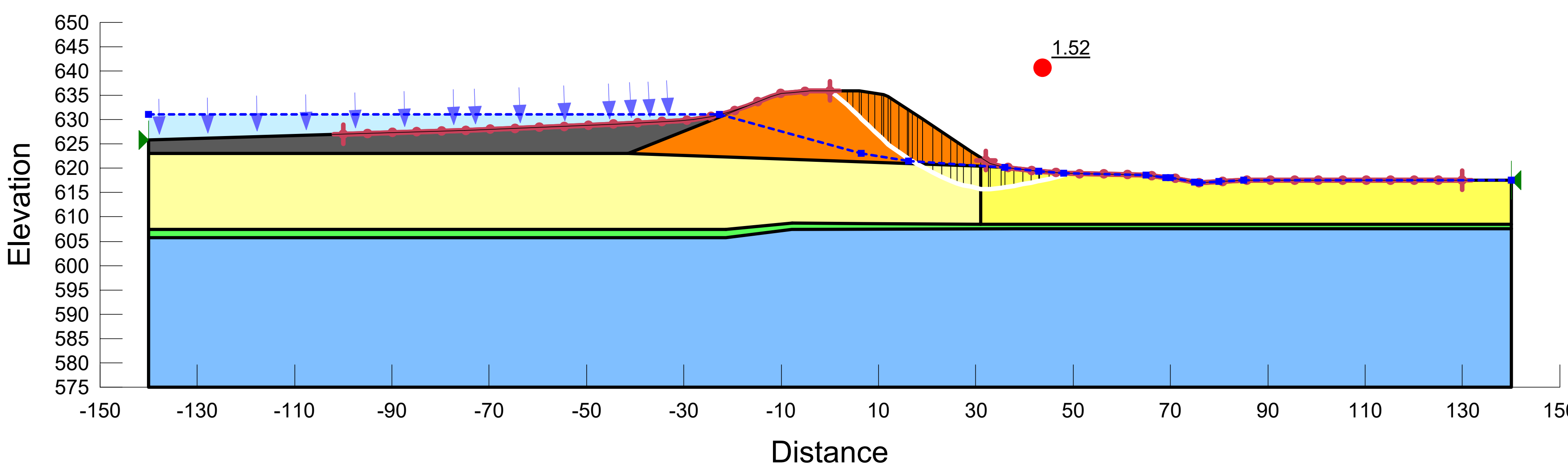
Dynegy Coffeen
Station 30+00
Static Drained - Normal Pool

Design by: ZJF
Date: 2/7/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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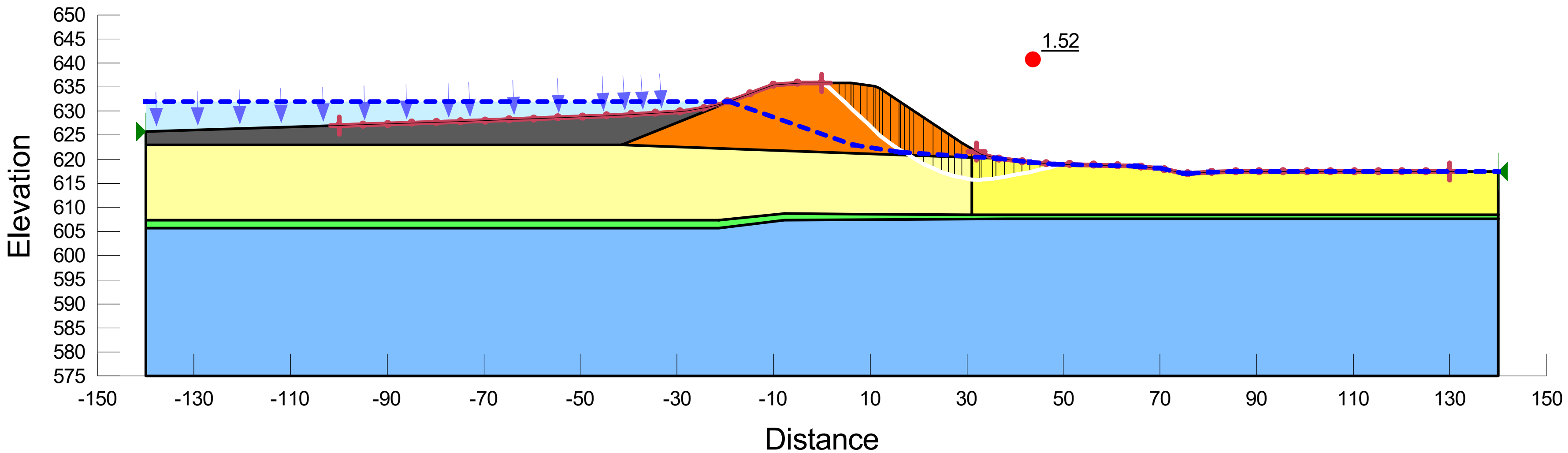
Dynegy Coffeen
Station 30+00
Static Drained - Max Surcharge Pool

Design by: ZJF
Date: 10/12/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials

- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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Dynegy Coffeen
Station 36+50
Peak Undrained Soil Strengths
Pseudostatic - Entry & Exit

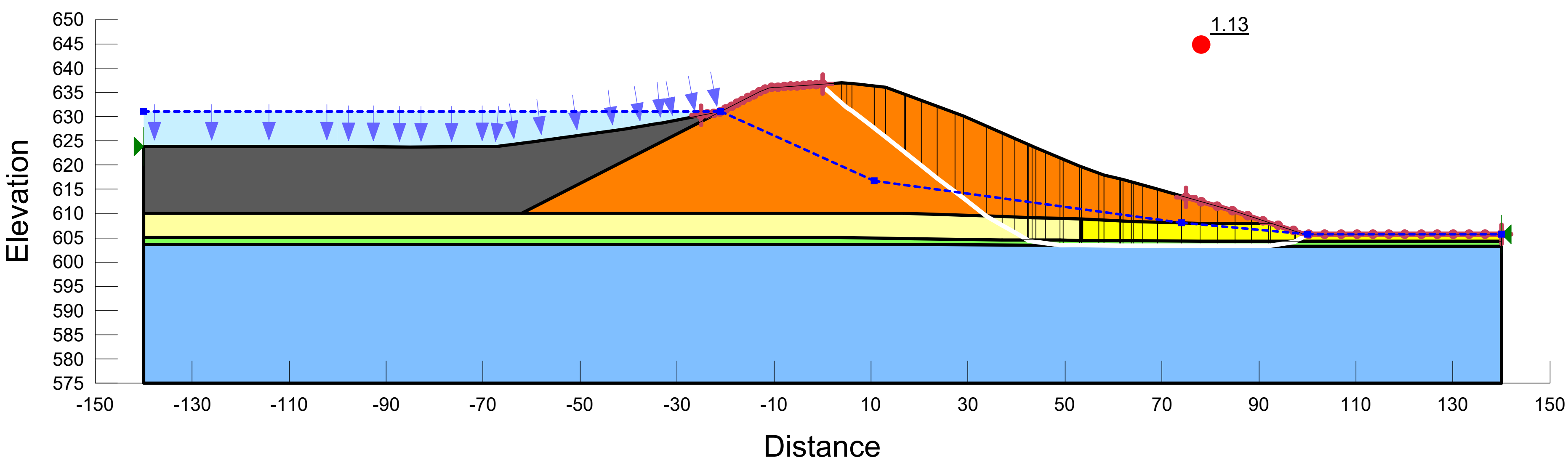
Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.4 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials

- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load
kh = 0.14 g



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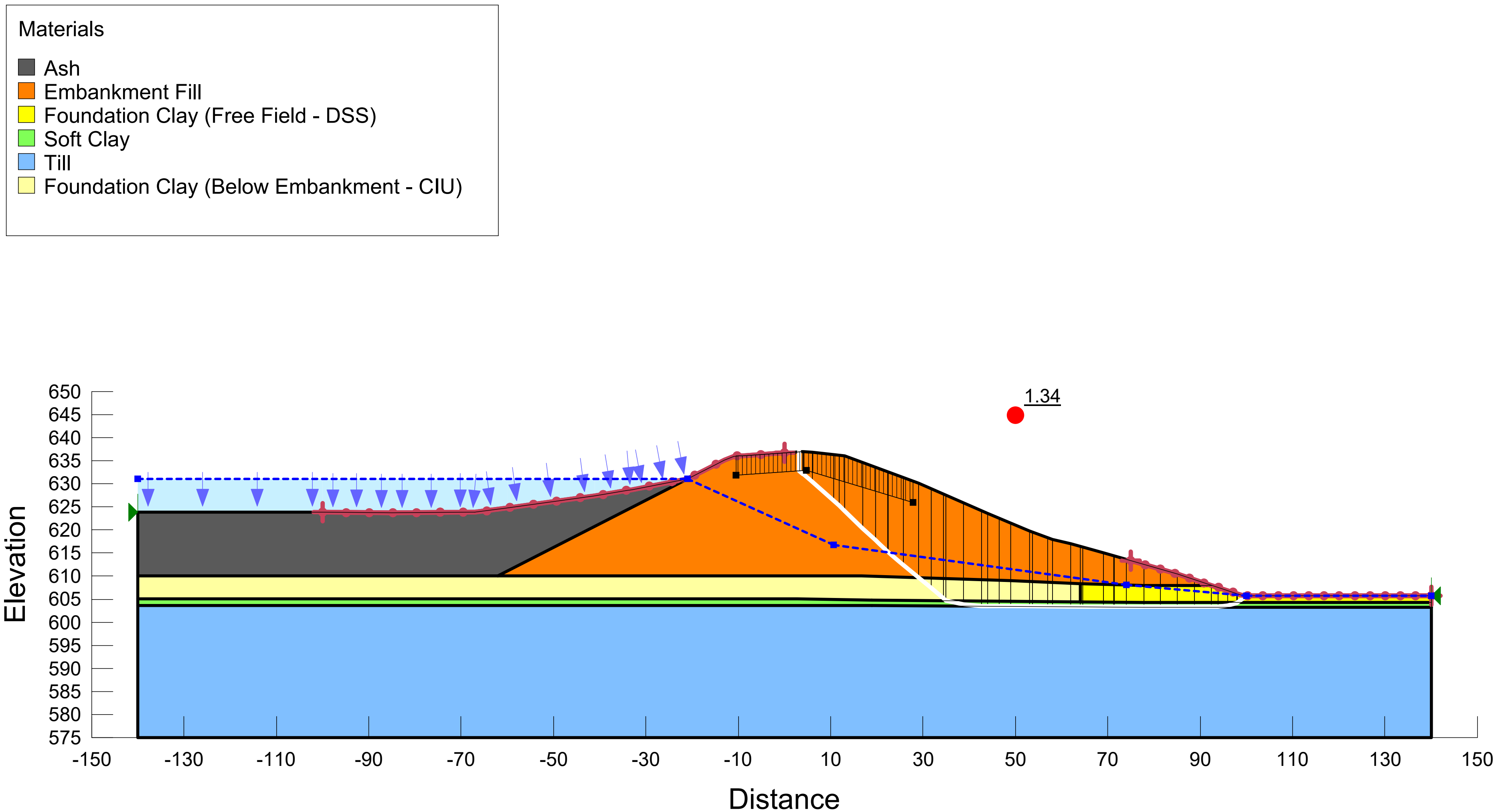
Dynegy Coffeen
Station 36+50
Slope Stability - Post-Earthquake Undrained

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.1 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1



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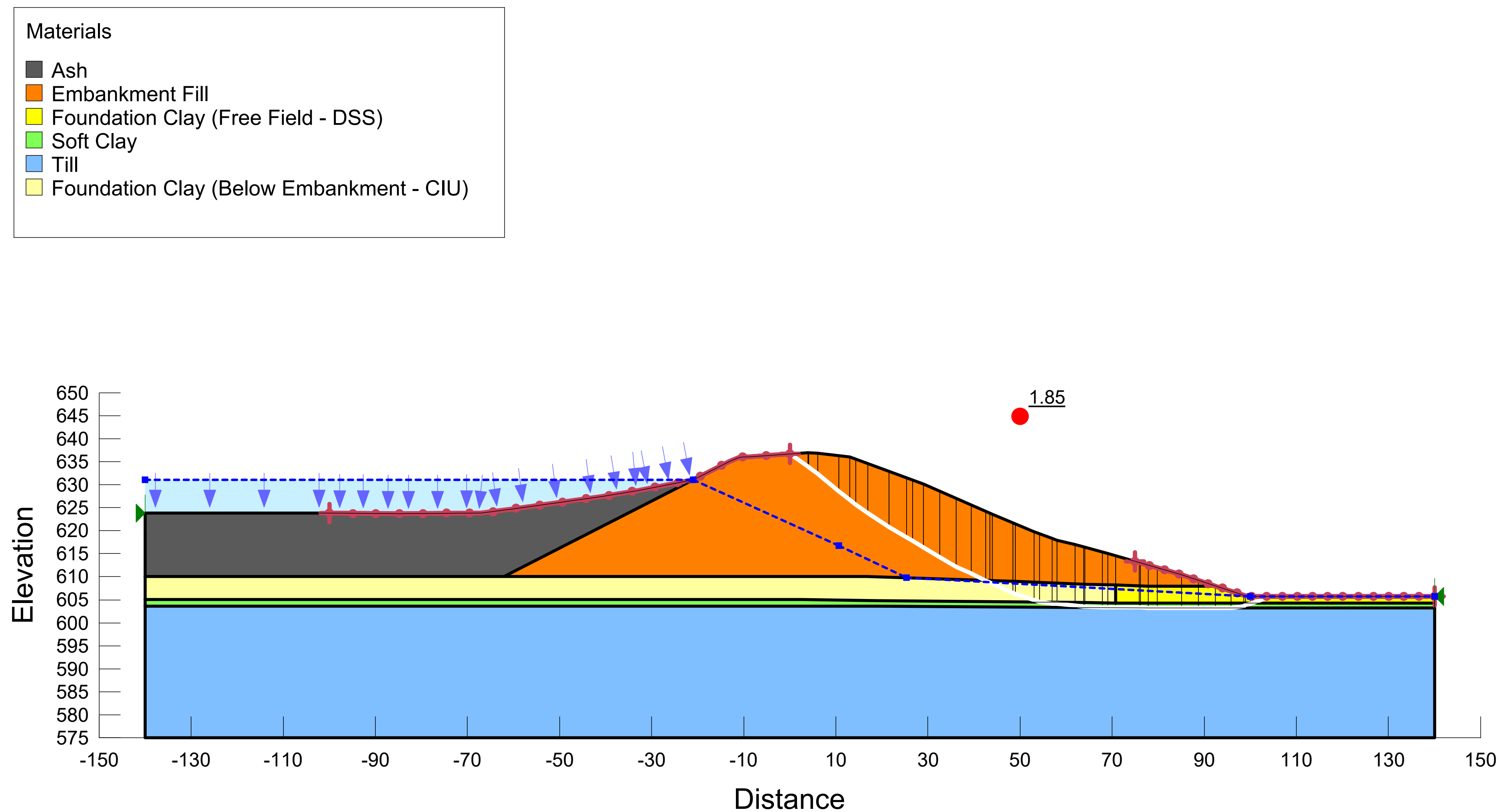
Dynegy Coffeen
Station 36+50
Static Drained - Normal Pool

Design by: ZJF
Date: 10/1/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1



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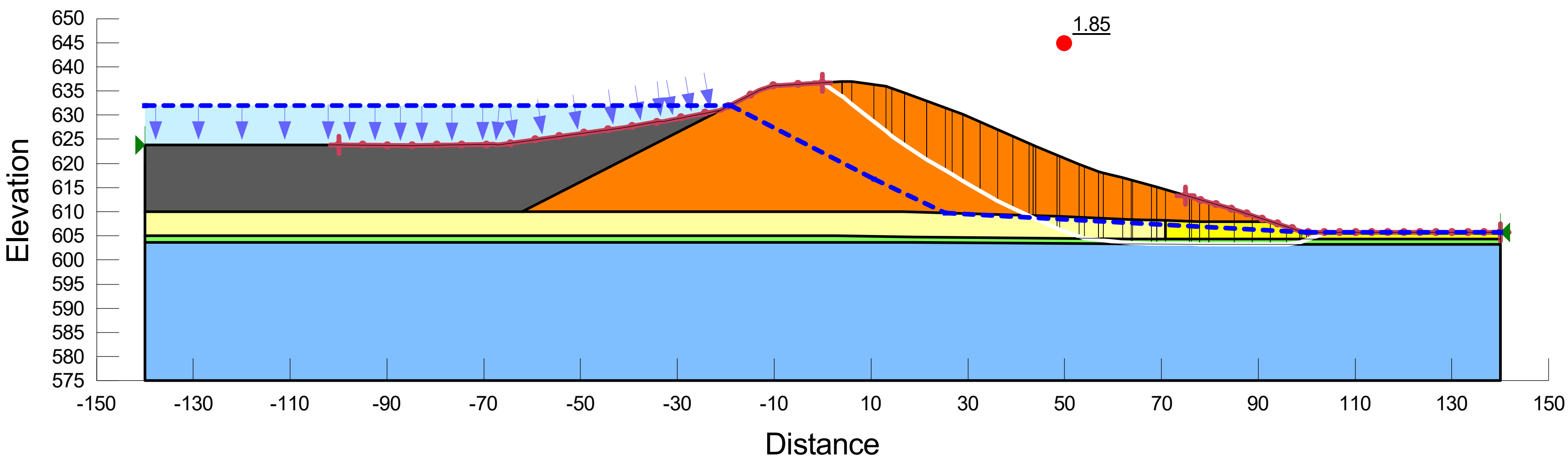
Dynegy Coffeen
Station 36+50
Static Drained - Surcharge Pool

Design by: ZJF
Date: 10/12/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay
- Till
- Foundation Clay (Below Embankment - CIU)



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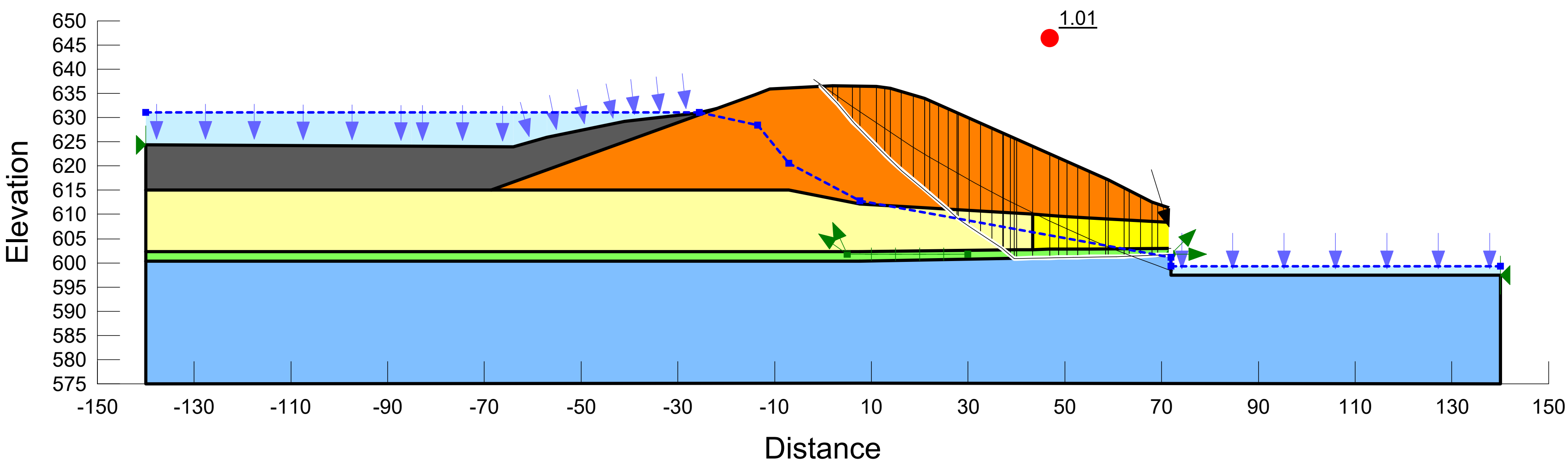
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Peak Undrained Soil Strengths
Pseudostatic - Block

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.4 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load
kh = 0.14 g



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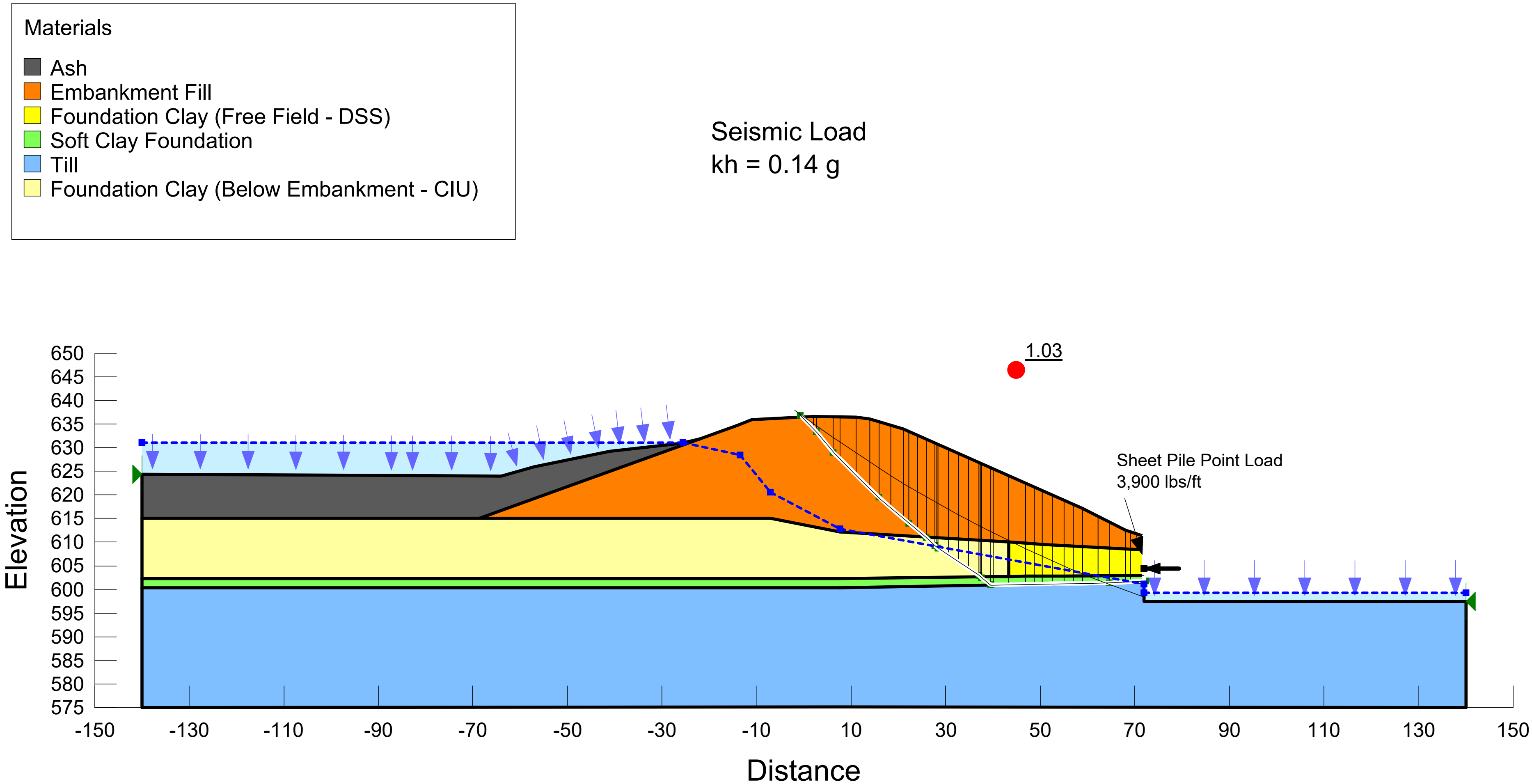
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Peak Undrained Soil Strengths
Pseudostatic - Block - Point Load

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.4 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1



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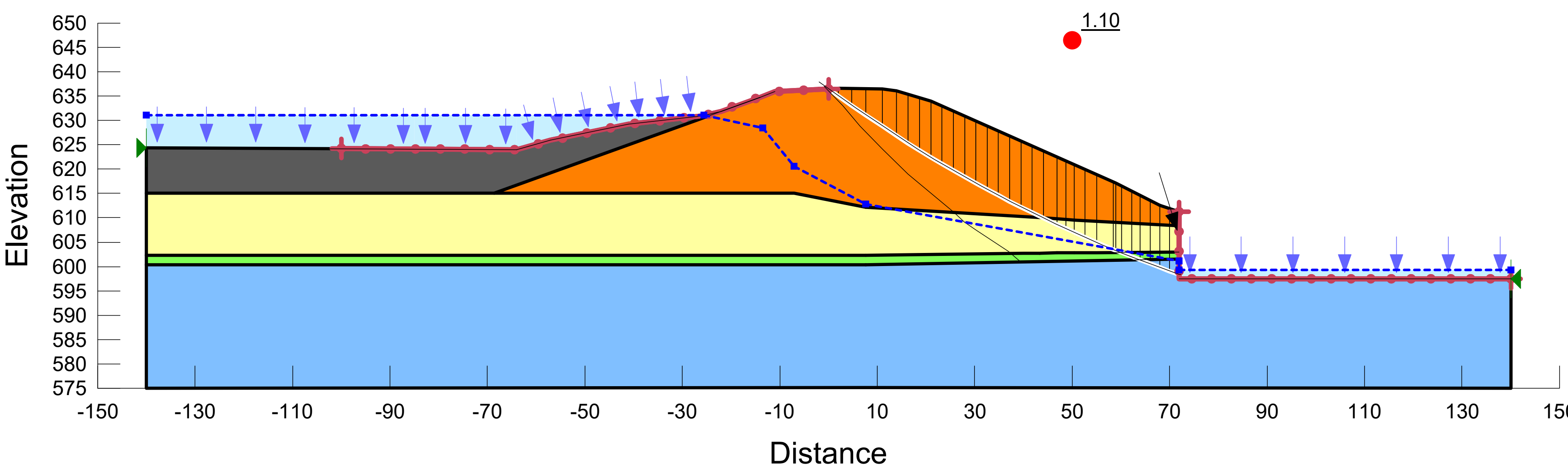
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Peak Undrained Soil Strengths
Pseudostatic - Entry-Exit

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.4 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load
kh = 0.14 g



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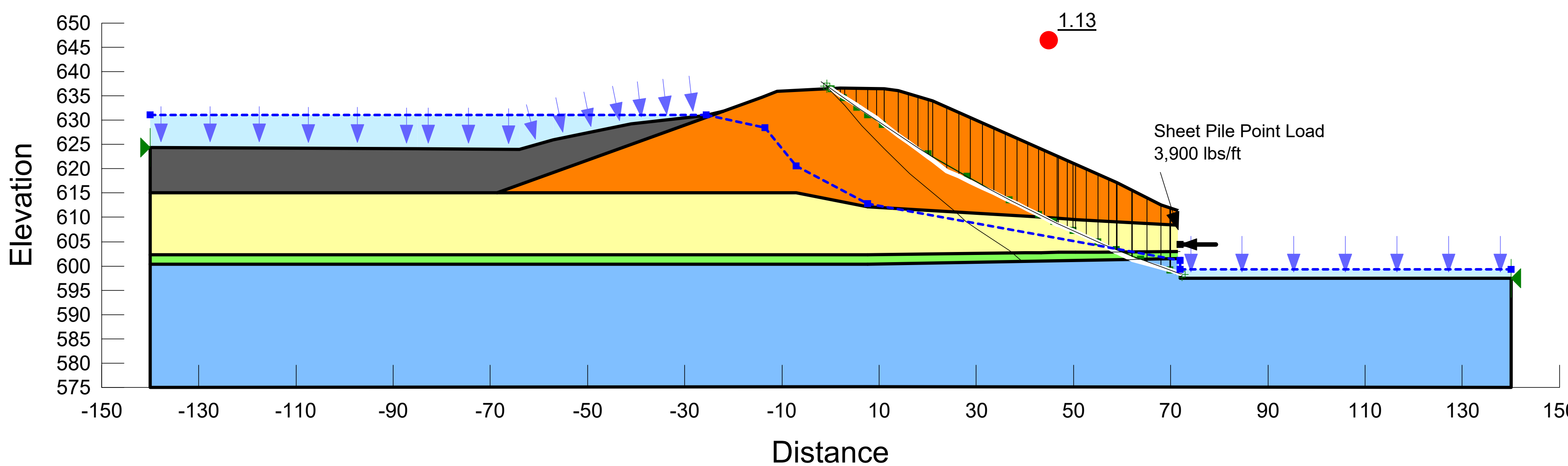
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Peak Undrained Soil Strengths
Pseudostatic - Entry-Exit - Point Load

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.4 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load
kh = 0.14 g



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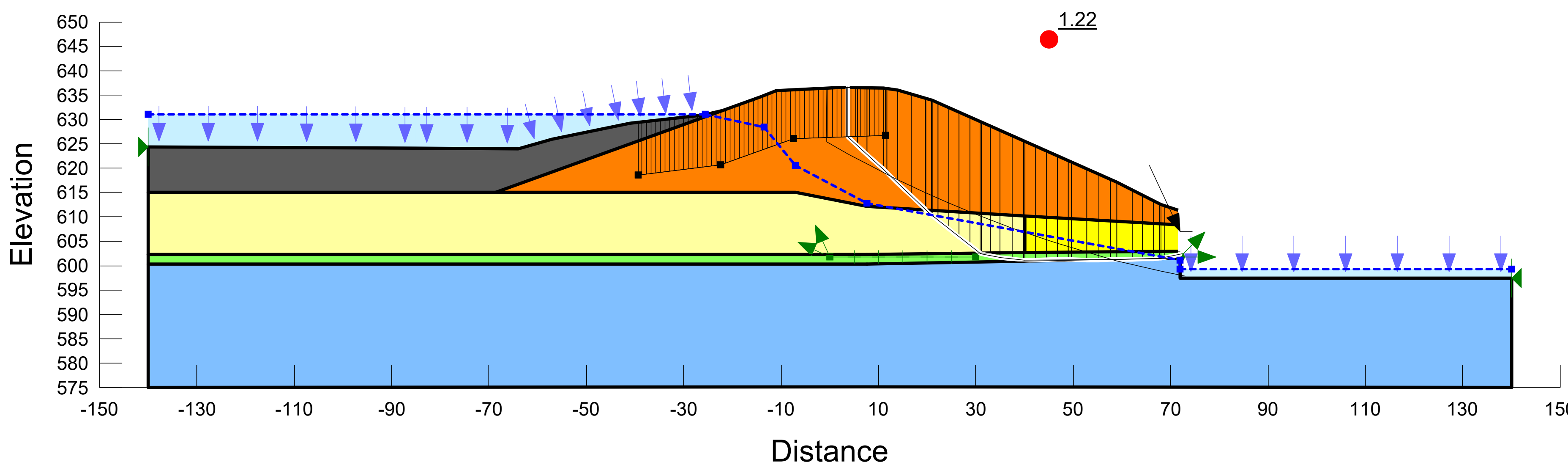
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Post-EQ - Block

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.1 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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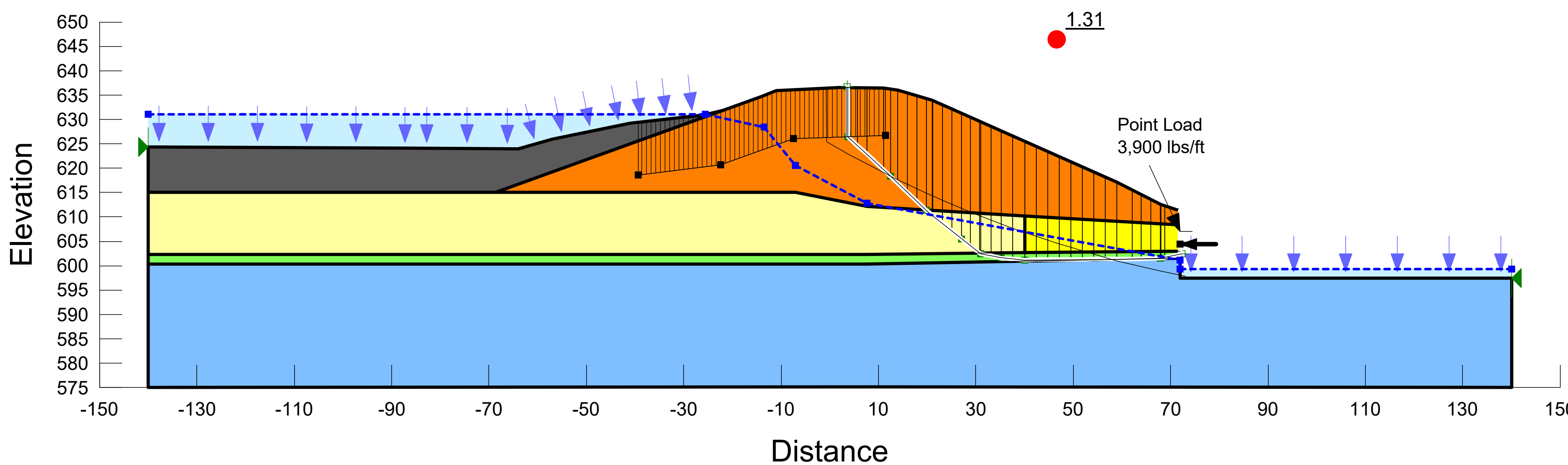
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Post-EQ - Block - Point Load

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.1 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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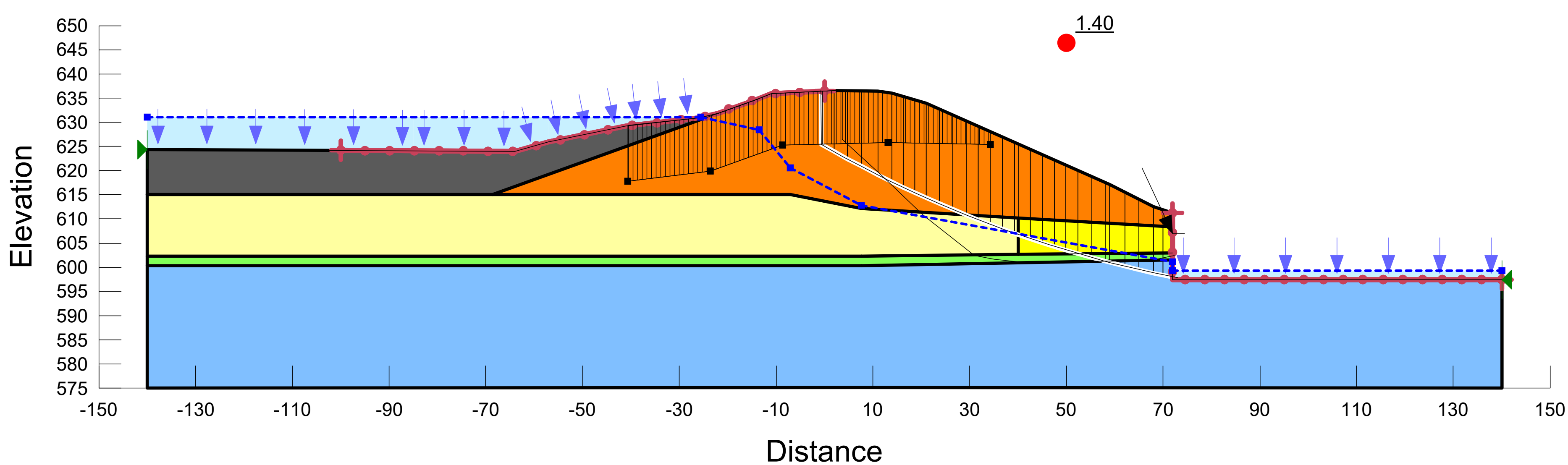
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Post-EQ - Entry-Exit

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.1 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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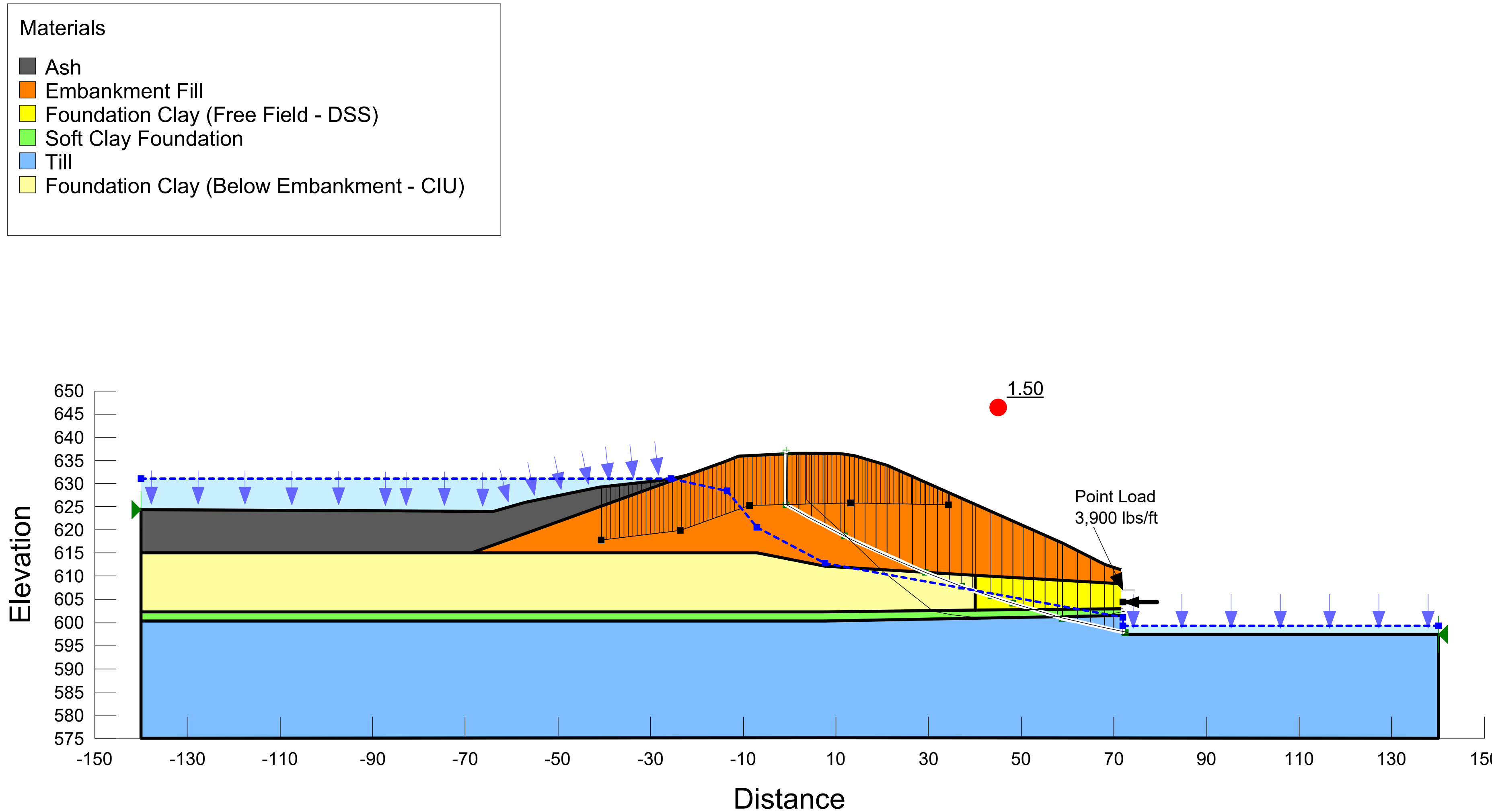
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Post-EQ - Entry-Exit Specified - Point Load

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.1 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1



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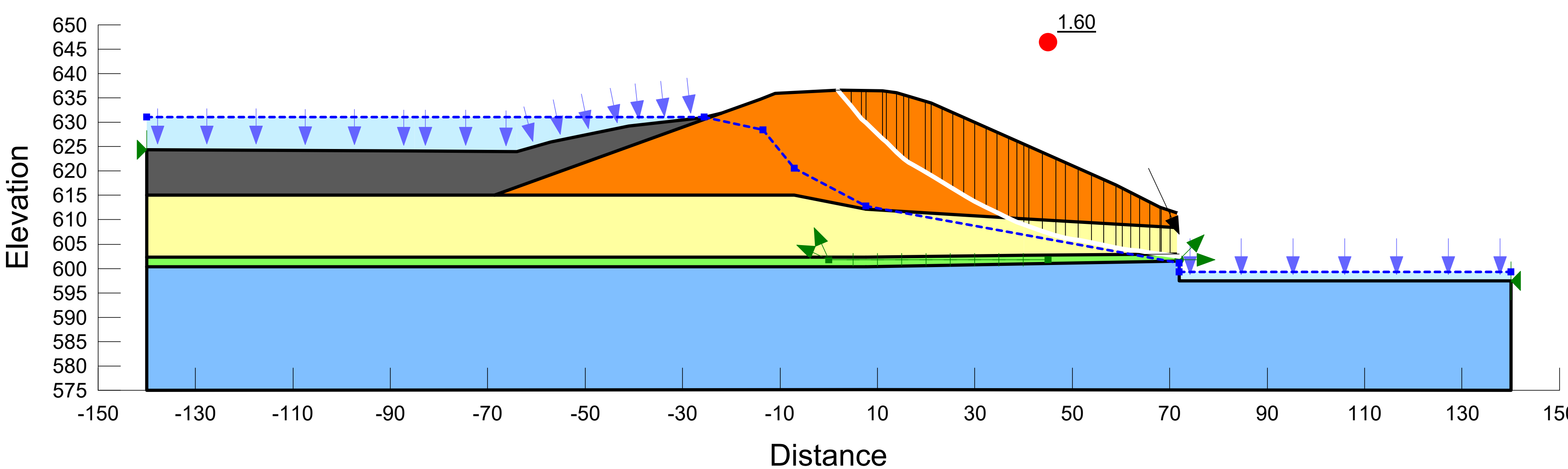
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Static Drained - Normal Pool - Block

Design by: ZJF
Date: 10/1/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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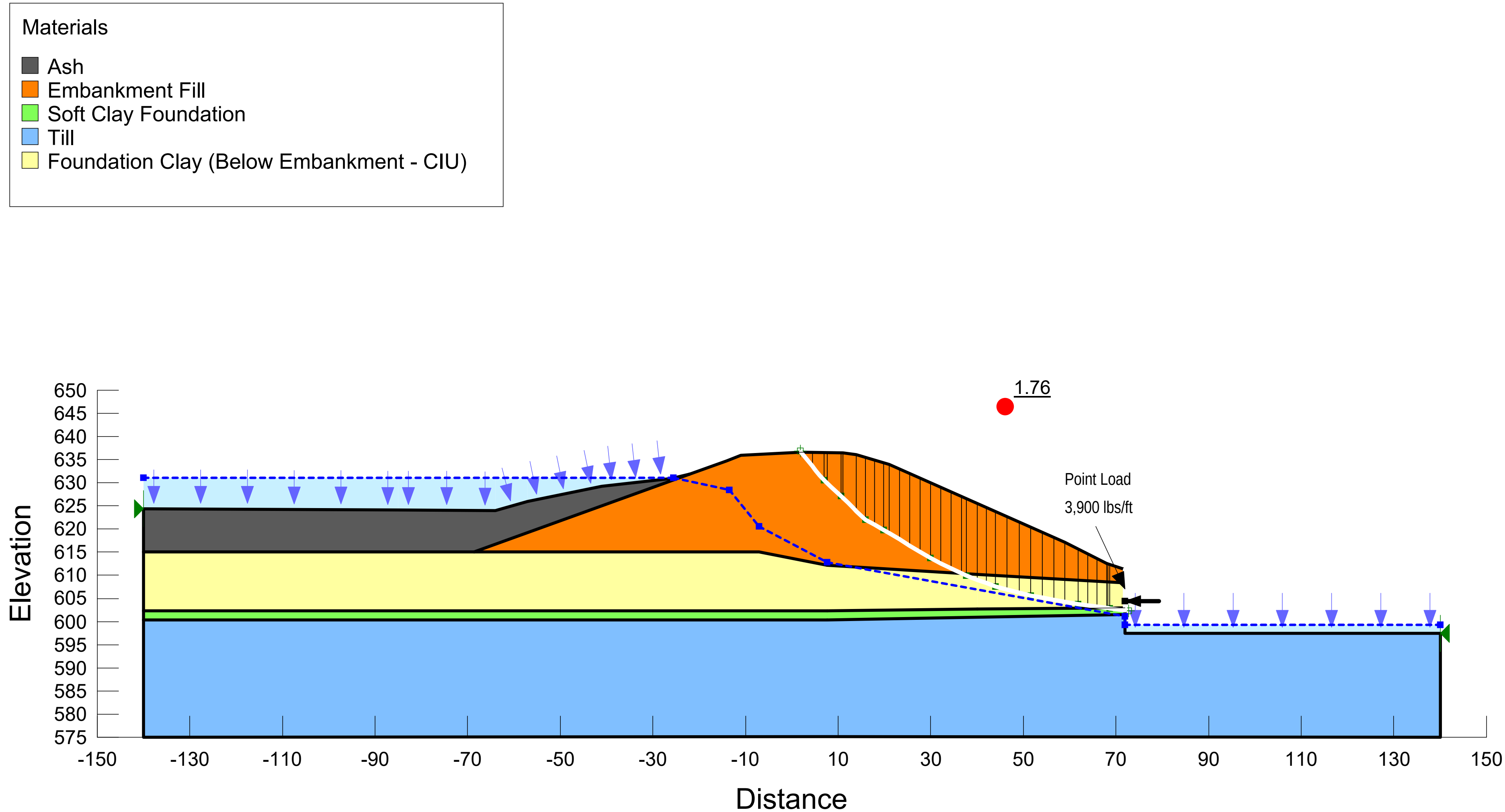
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Static Drained - Normal Pool - Block Specified - Point Load

Design by: ZJF
Date: 10/1/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1



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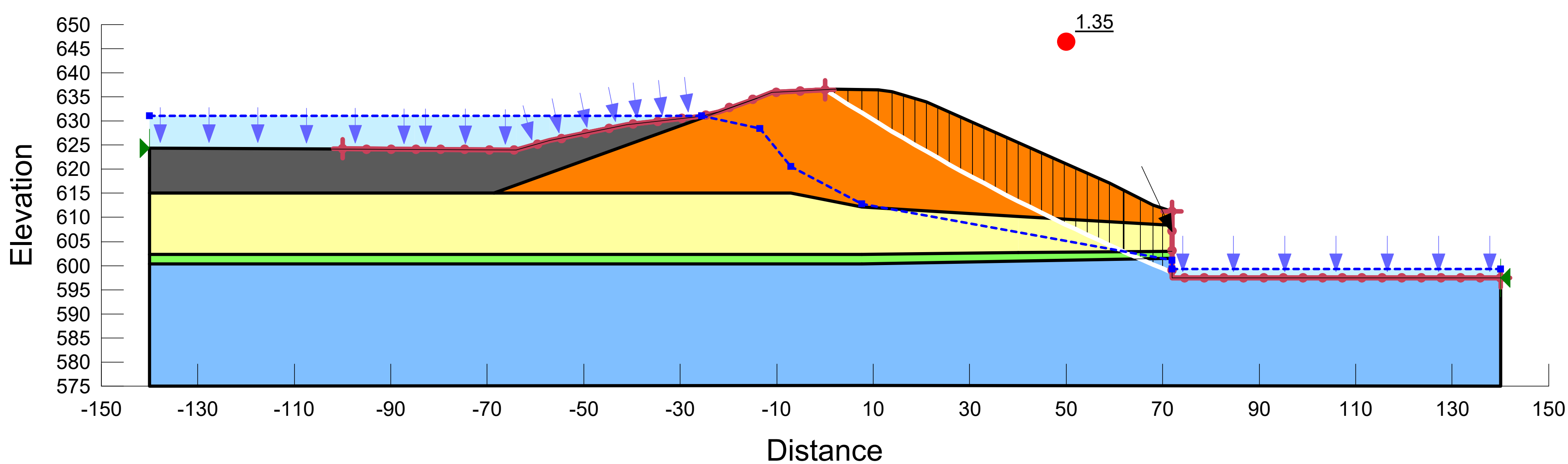
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Static Drained - Normal Pool - Entry-Exit

Design by: ZJF
Date: 10/1/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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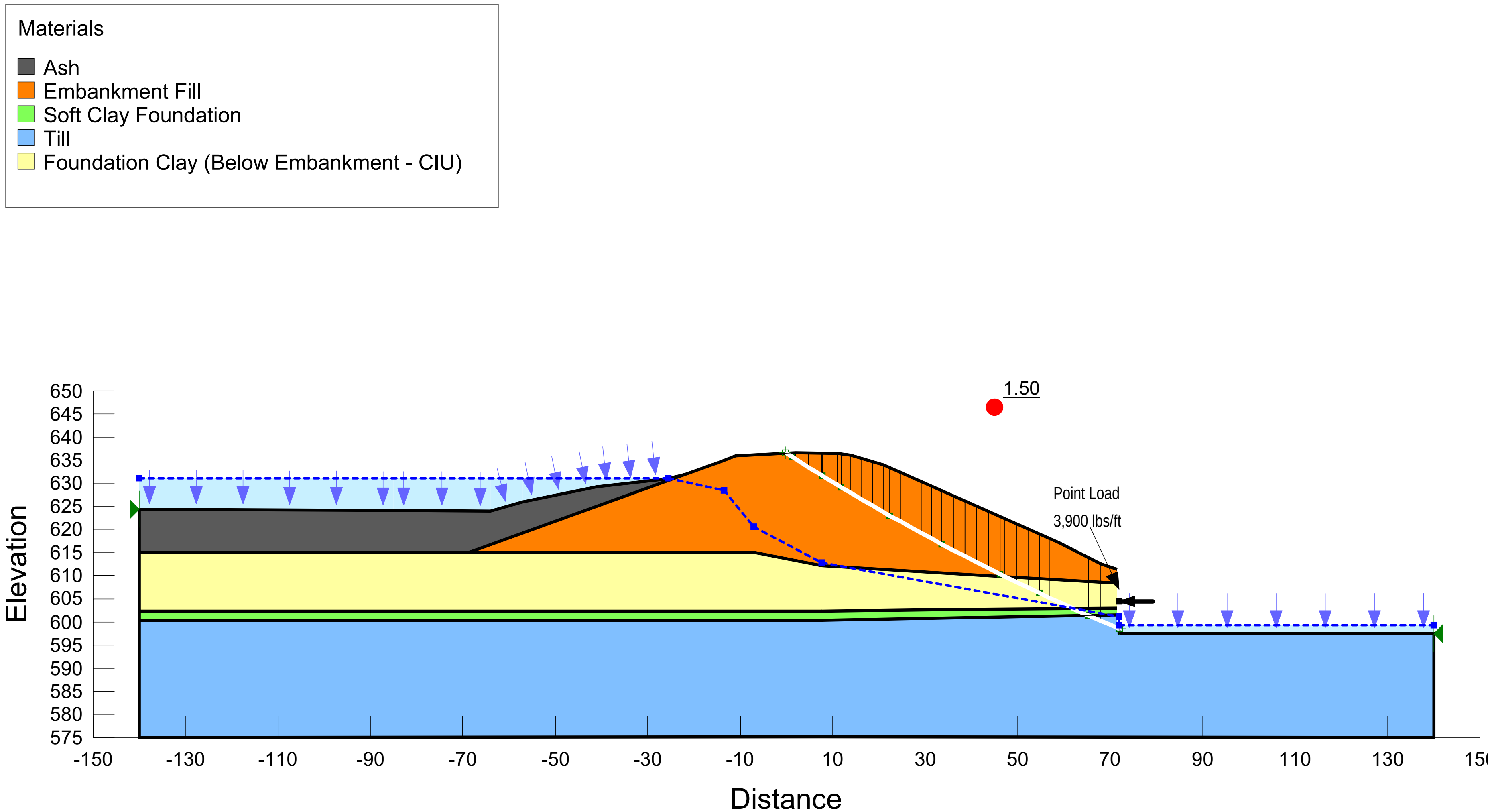
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Static Drained - Normal Pool - Entry-Exit Specified - Point Load

Design by: ZJF
Date: 10/1/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1



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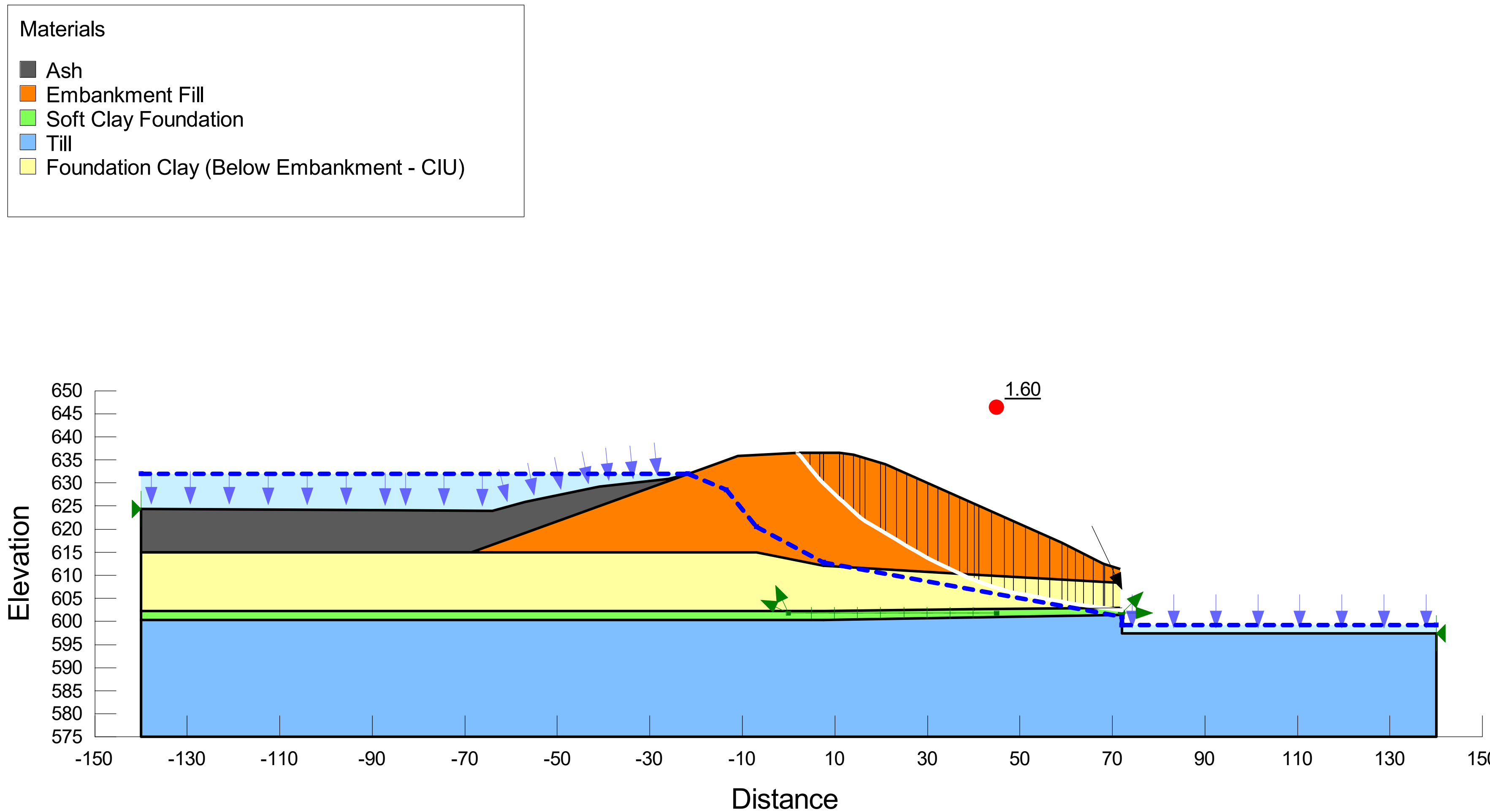
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Static Drained - Surcharge Pool - Block

Design by: ZJF
Date: 10/12/2016

Name: Ash   Model: Mohr-Coulomb   Unit Weight: 112 pcf   Cohesion': 0 psf   Phi': 32 °   Phi-B: 0 °   Piezometric Line: 1
Name: Embankment Fill   Model: Shear/Normal Fn.   Unit Weight: 135 pcf   Strength Function: Embankment Fill   Phi-B: 0 °   Piezometric Line: 1
Name: Soft Clay Foundation   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 0 psf   Phi': 30 °   Phi-B: 0 °   Piezometric Line: 1
Name: Till   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion': 0 psf   Phi': 40 °   Phi-B: 0 °   Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU)   Model: Shear/Normal Fn.   Unit Weight: 125 pcf   Strength Function: Foundation Clay (Below Embankment - CIU)   Phi-B: 0 °   Piezometric Line: 1



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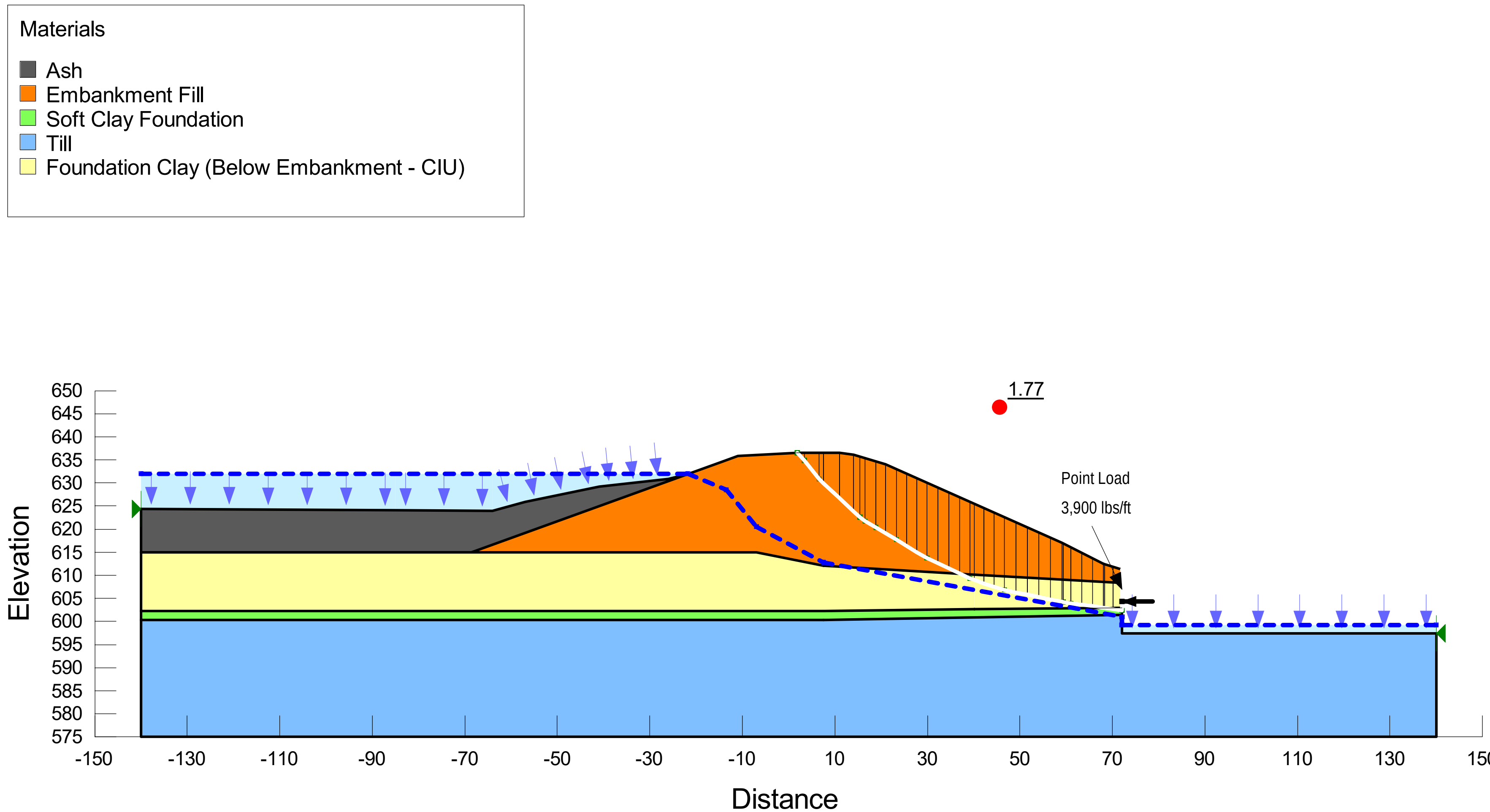
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Static Drained - Surcharge Pool - Block Specified - Point Load

Design by: ZJF
Date: 10/12/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1



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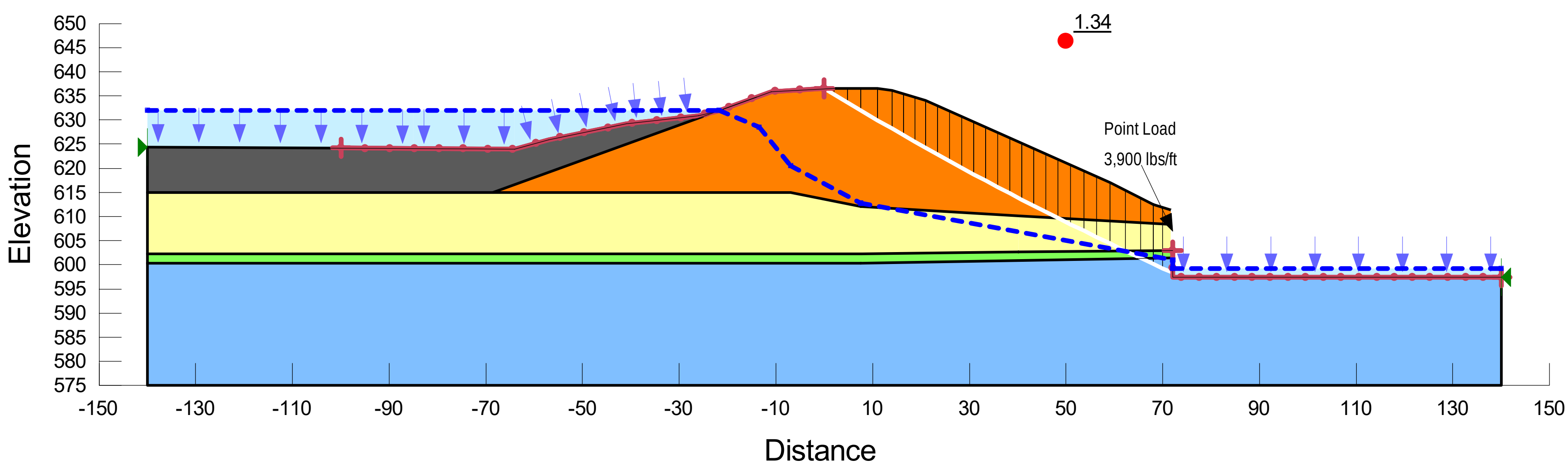
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Static Drained - Surcharge Pool - Entry-Exit

Design by: ZJF
Date: 10/12/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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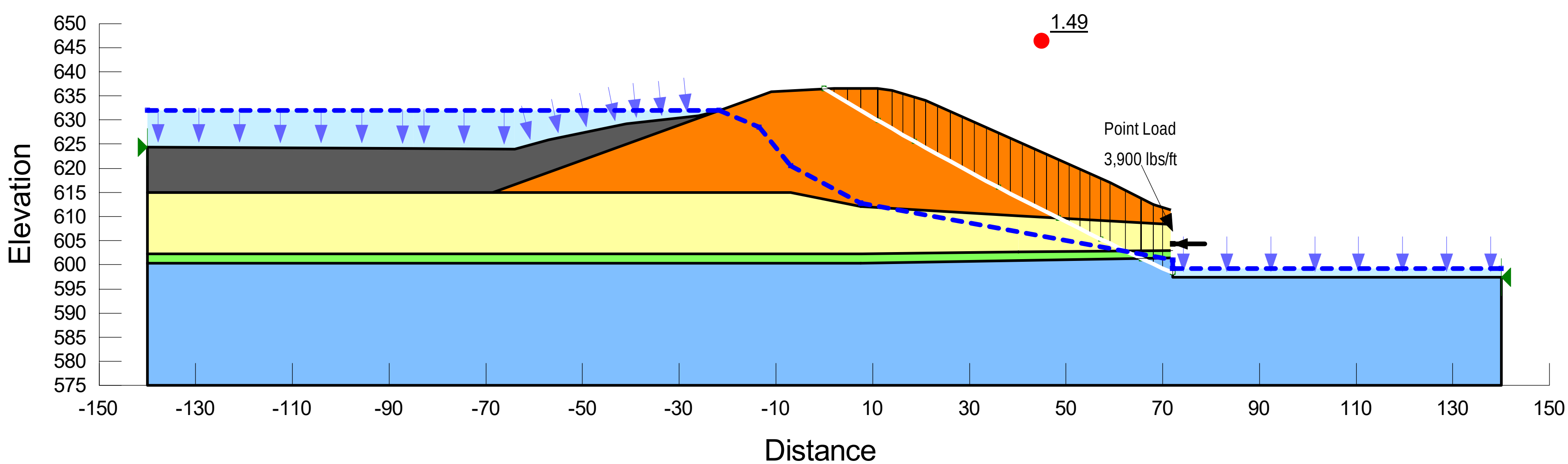
Dynegy Coffeen Ash Pond No. 1
Station 39+00
Slope Stability
Static Drained - Surcharge Pool - Entry-Exit Specified - Point Load

Design by: ZJF
Date: 10/12/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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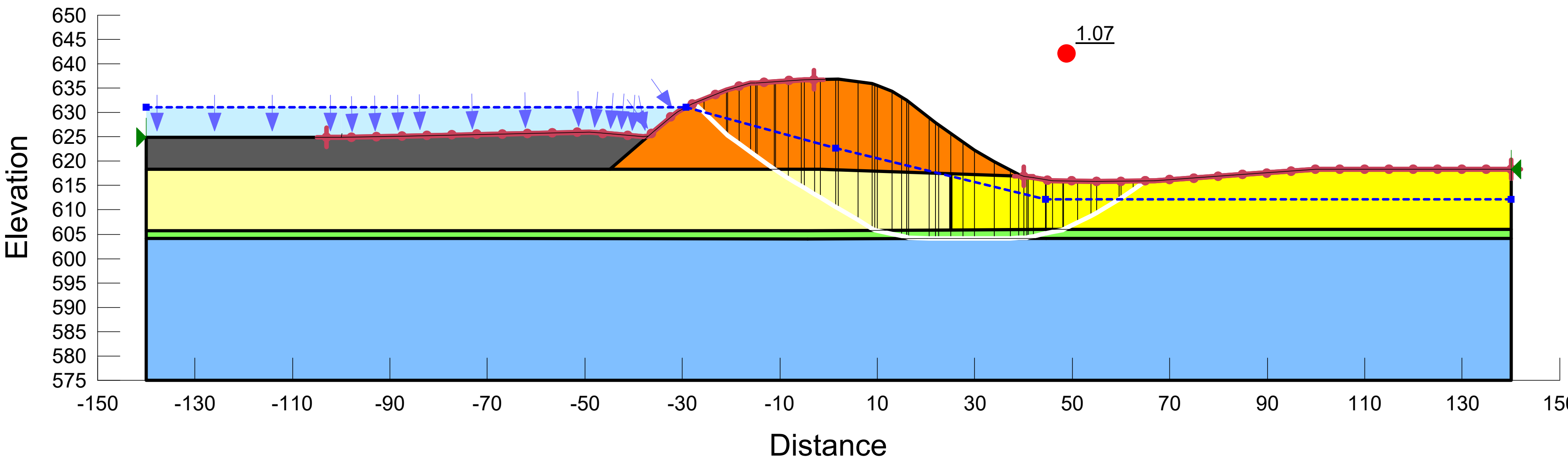
Dynegy Coffeen
Station 46+50
Peak Undrained Soil Strengths
Pseudostatic - Entry and Exit

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.4 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load:
kh = 0.14 g



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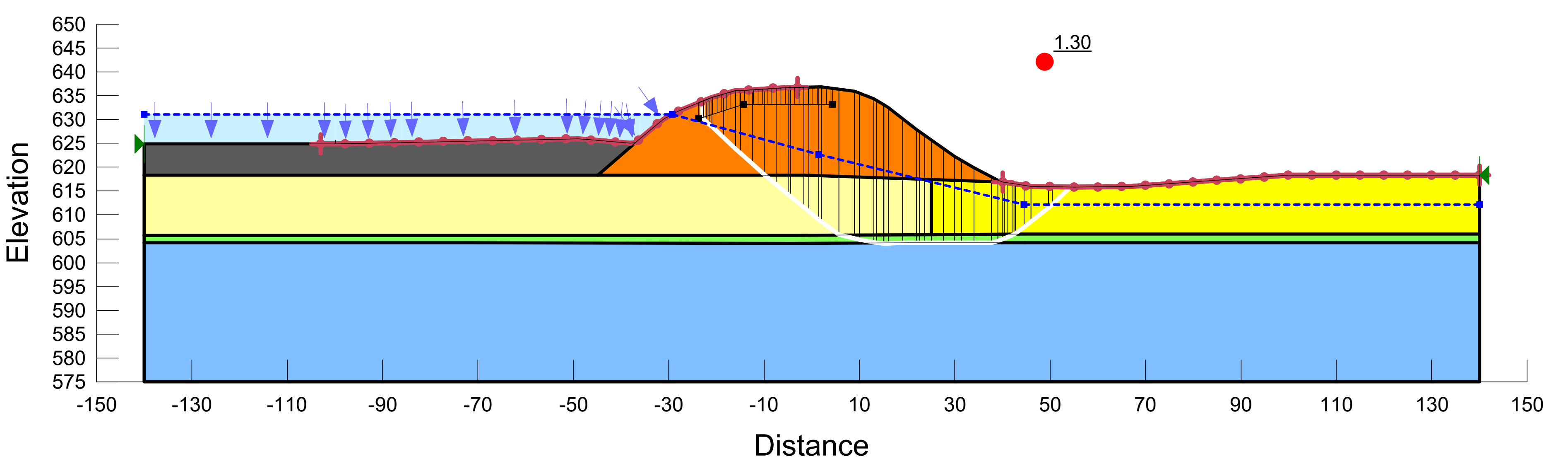
Dynegy Coffeen
Station 46+50
Slope Stability - Post Earthquake

Design by: Lucas Carr
Date: 2/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.1 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



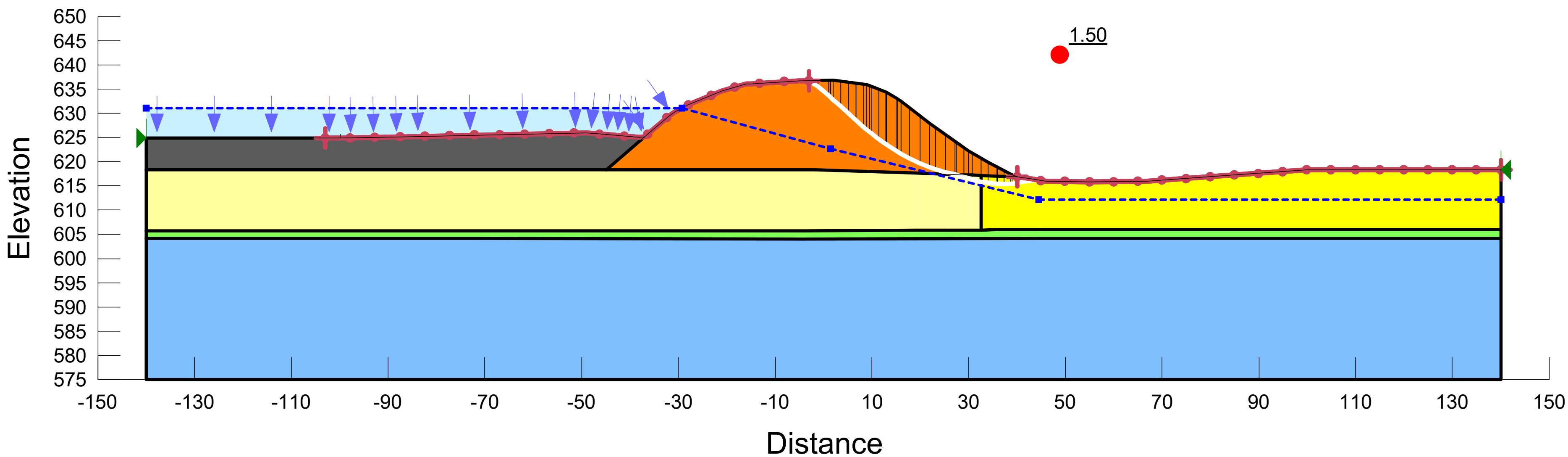
C:\Users\lucas_carr\Desktop\LOCAL\Dynegy\Coffeen\Rev2\Geotech\Stability\Slope Models\Coffeen_46+50_PostEQ_Undrained_LPC_20160207v4.gsz

Dynegy Coffeen
Station 46+50
Static Drained - Normal Pool

Design by: ZJF
Date: 10/1/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Shear/Normal Fn. Unit Weight: 135 pcf Strength Function: Embankment Fill Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Shear/Normal Fn. Unit Weight: 125 pcf Strength Function: Foundation Clay (Below Embankment - CIU) Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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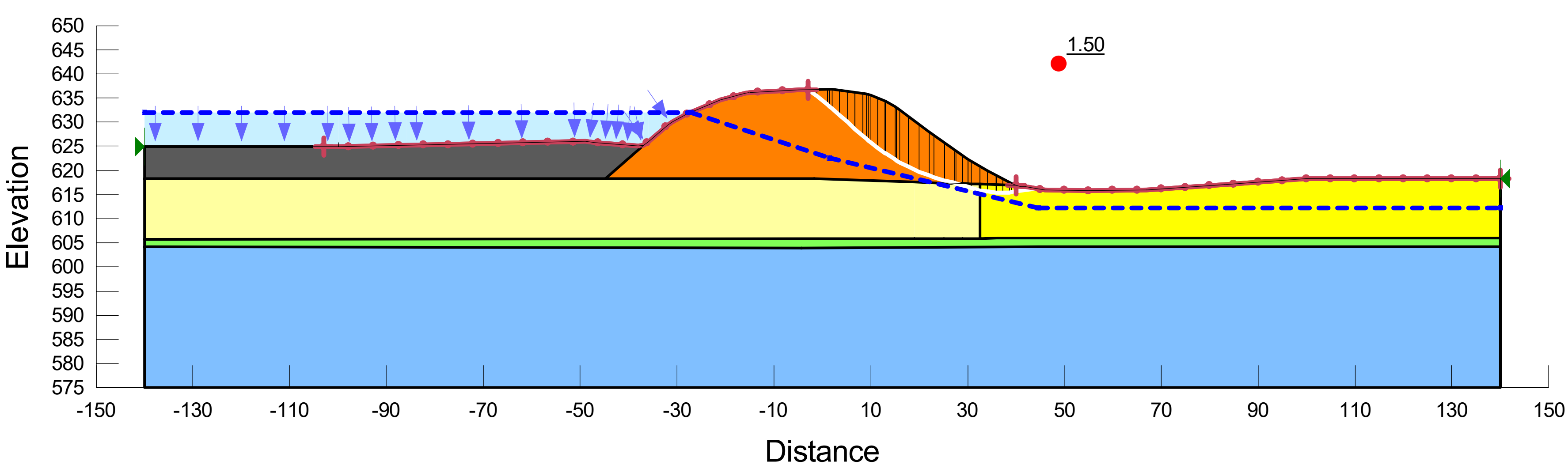
Dynegy Coffeen
Station 46+50
Static Drained - Surcharge Pool

Design by: ZJF
Date: 10/12/2016

Name: Ash   Model: Mohr-Coulomb   Unit Weight: 112 pcf   Cohesion': 0 psf   Phi': 32 °   Phi-B: 0 °   Piezometric Line: 1
Name: Embankment Fill   Model: Shear/Normal Fn.   Unit Weight: 135 pcf   Strength Function: Embankment Fill   Phi-B: 0 °   Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS)   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 0 psf   Phi': 30 °   Phi-B: 0 °   Piezometric Line: 1
Name: Soft Clay Foundation   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 0 psf   Phi': 30 °   Phi-B: 0 °   Piezometric Line: 1
Name: Till   Model: Mohr-Coulomb   Unit Weight: 135 pcf   Cohesion': 0 psf   Phi': 40 °   Phi-B: 0 °   Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU)   Model: Shear/Normal Fn.   Unit Weight: 125 pcf   Strength Function: Foundation Clay (Below Embankment - CIU)   Phi-B: 0 °   Piezometric Line: 1

Materials

- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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Calculation Notes

Subject: Coffeen Ash Pond No. 1 Slope Stability Analysis

Project Name: Dynegy CCR

By: Lucas Carr Date: 01/19/2016

Project No: 60480701

Checked By: Kevin Ritter Date: 02/09/2016

Task No.: 01

APPENDIX B

Sta. 39+00 Sheet Pile Evaluation

References:

[1] An Engineering Manual for Sheet Pile Walls, R. L. Allen, J.M. Duncan, R.T. Sancio, Virginia Tech, November 1987
[2] Coffeen Record Drawings
[3] Principles of Foundation Engineering (7th Edition), Braja Das
[4] Coffeen Cooling Lake Calculations, retrievied from: N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\5.0_Reference\Documents from Dynegy\Coffeen\Sharepoint Downloads\Cooling Water Basin

Assumptions:

-Drained static conditions @ Station 39+00.

Purpose:

-Determine the maximum static load from slide mass along the bottom of the foundation clay layer (El. 601.5) based on sheet pile embedment and strength limit states

Elevations:

$Pile_{top} := 611.3ft$ Sheet pile top (ft)

$Pile_{bottom} := 584.5ft$ Sheet pile bottom (ft) (Estimated from [4] pile driving logs)

$Till_{lefttop} := 601.5ft$ Till Layer Top Left (See Figure)

$Till_{righttop} := 597.5ft$ Till Layer Top Right (See Figure)

$Till_{leftbottom} := 584.5ft$ Till Layer Bottom Left (See Figure)

$Till_{rightbottom} := 584.5ft$ Till Layer Bottom Right (See Figure)

$Water_{Left} := 601ft$ Bouyant unit weight assumed for all soil below EL. 601.5

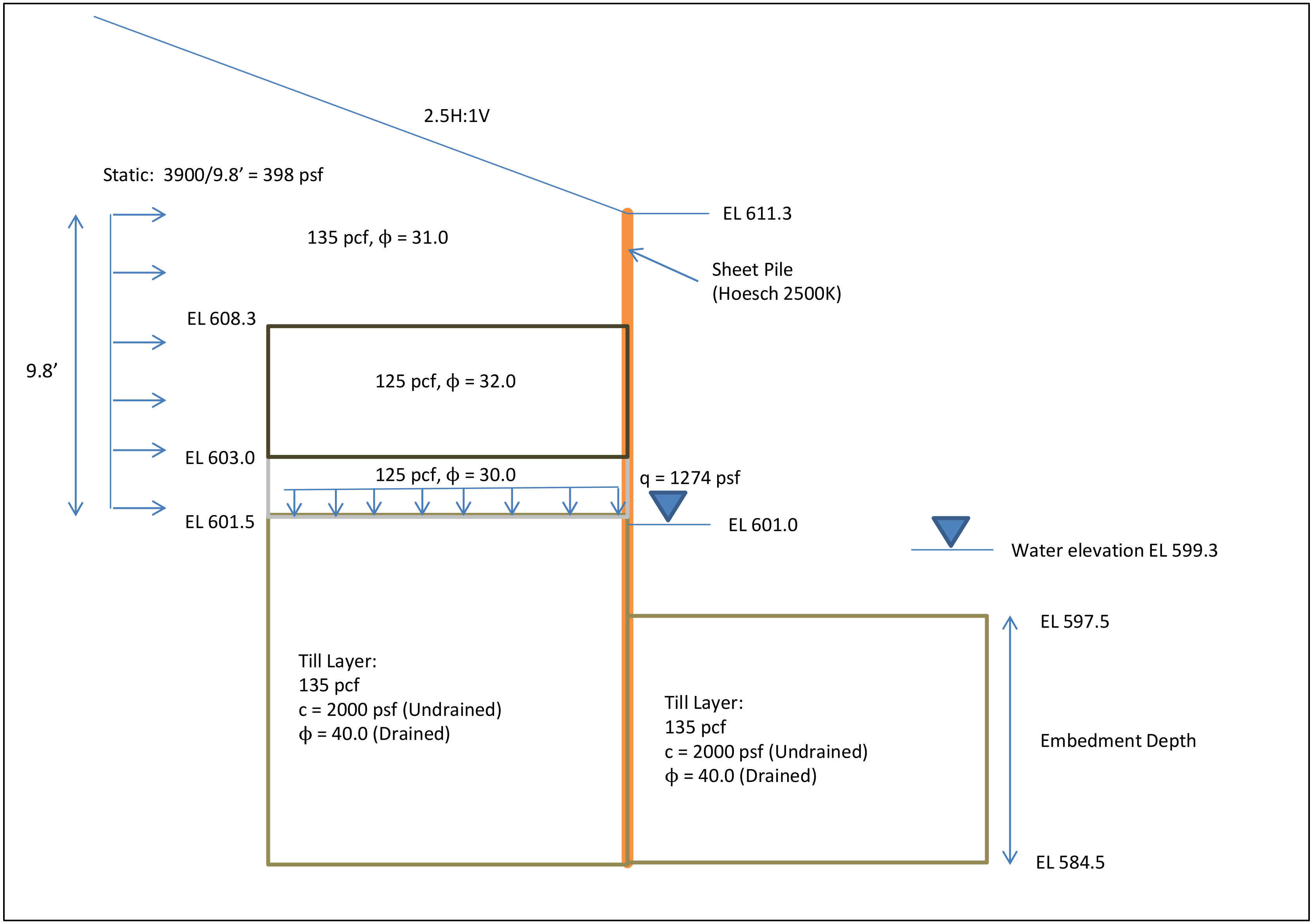
$\gamma_w := 62.4 \frac{lb}{ft^3}$

$Water_{Right} := 599.3ft$

$q := 1274 \frac{lb}{ft^2}$ Effective stress @ EL. 601.5

$$StaticF := \frac{3900 \frac{lb}{ft}}{Pile_{top} - Till_{lefttop}} = 397.959 \frac{lb}{ft^2}$$

Load from slide mass above bottom of foundation clay layer (El. 601.5), distributed even along sheet pile


2.5H:1V
Static: 3900/9.8' = 398 psf
EL 611.3
135 pcf, ϕ = 31.0
Sheet Pile
(Hoesch 2500K)
EL 608.3
9.8'
125 pcf, ϕ = 32.0
EL 603.0
125 pcf, ϕ = 30.0
q = 1274 psf
EL 601.5
EL 601.0
Water elevation EL 599.3
EL 597.5
Till Layer:
135 pcf
c = 2000 psf (Undrained)
ϕ = 40.0 (Drained)
Till Layer:
135 pcf
c = 2000 psf (Undrained)
ϕ = 40.0 (Drained)
Embedment Depth
EL 584.5

Material Properties:

Passive and Active Pressures
REF [1]

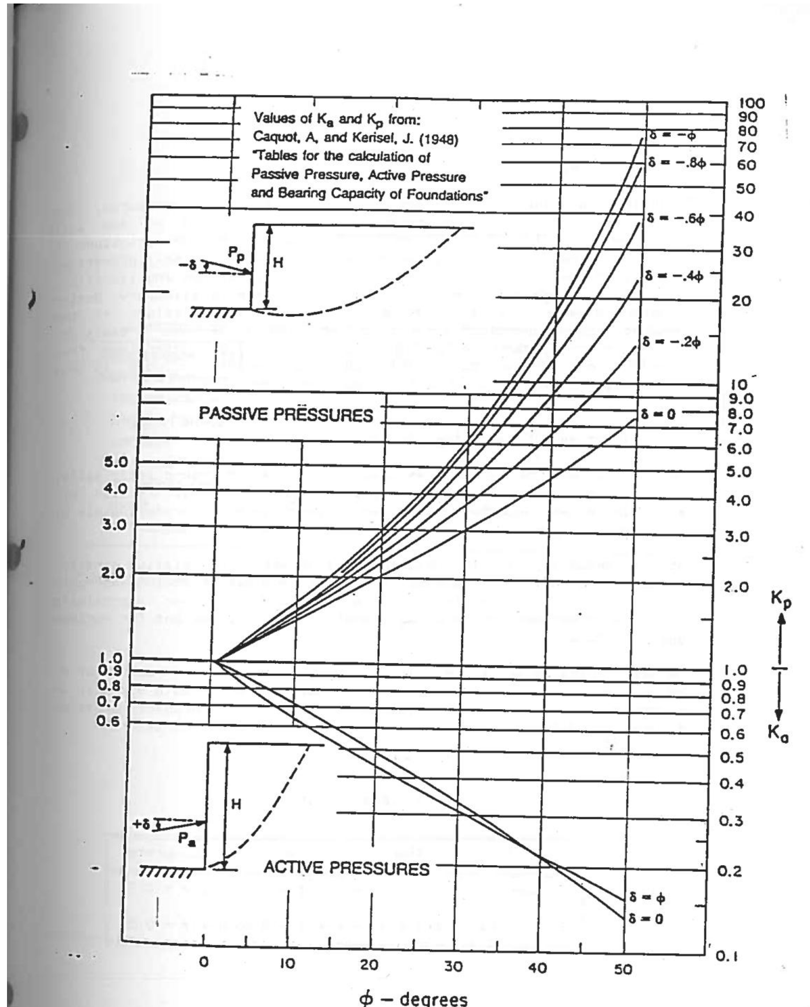


Fig. 10 – Active and Passive Earth Pressure Coefficients
For Log Spiral Theory

Material Properties:

Till Layer:

$\gamma_{till} := 135 \frac{lb}{ft^3}$ Till layer unit weight

$\phi_{till} := 40deg$ Internal friction angle

$\gamma_b := \gamma_{till} - \gamma_w = 72.6 \frac{lb}{ft^3}$ Till layer bouyant unit weight

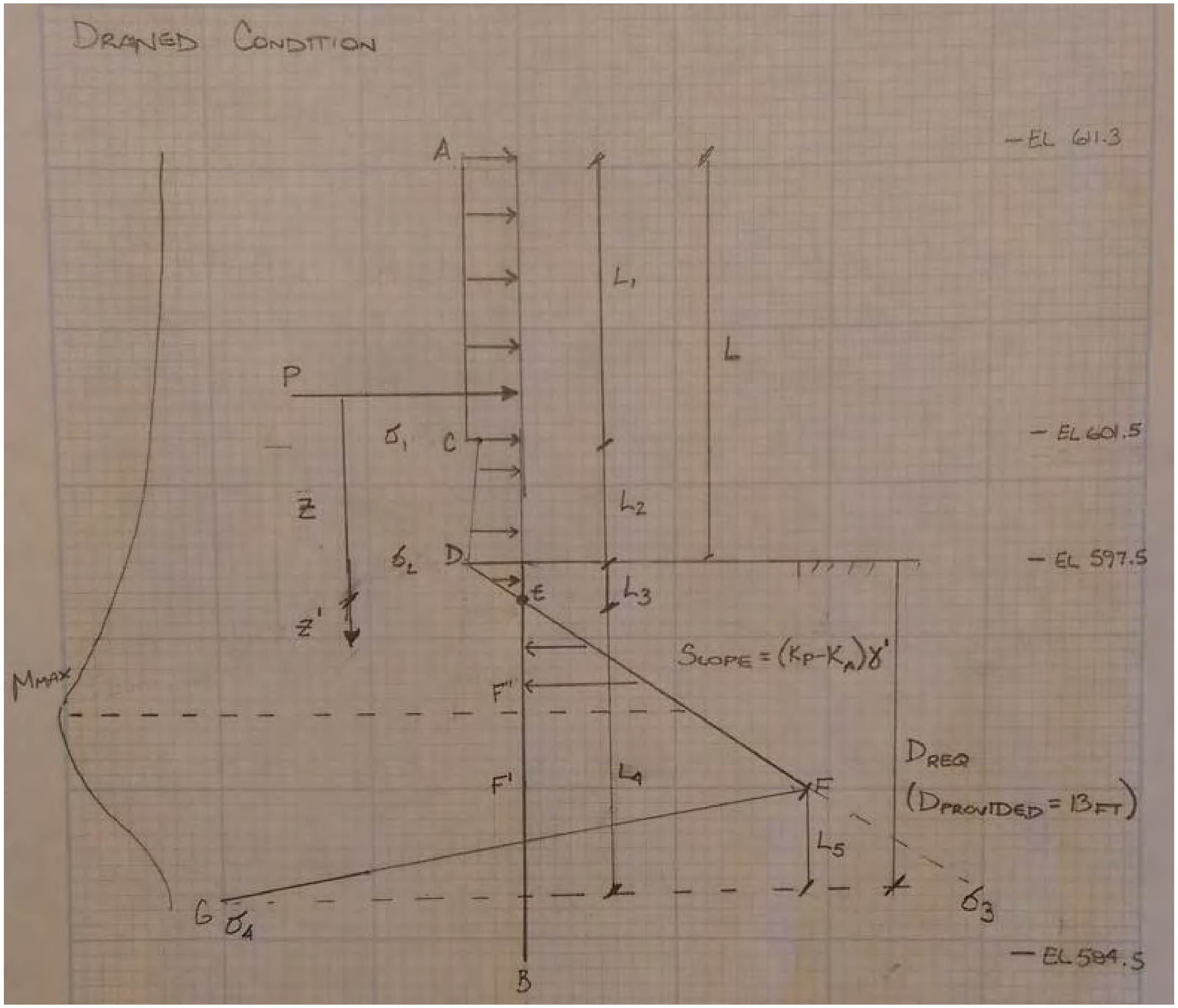
$\delta_{till} := \frac{\phi_{till}}{2} = 20\,deg$ Using Figure 10 [1]: $K_{act} := 0.25$ $K_{pas} := 10$

$K_a := K_{act} \cos(\delta_{till}) = 0.235$ Active coefficient

$K_p := K_{pas} \cos(\delta_{till}) = 9.397$ Passive coefficient

Stress Distribution:

Figure nomenclature and solution process adapted from [3]



From El. 611.3 to 601.5:

$$\sigma_1 := \text{StaticF} = 397.959\,\frac{\text{lb}}{\text{ft}^2}$$

$$L_1 := \text{Pile}_{top} - \text{Till}_{lefttop} = 9.8\,\text{ft}$$

Till Layer (From El. 601.5 to El. 597.5):

$$\sigma_{L601.5} := K_a\,q = 299.292\,\frac{\text{lb}}{\text{ft}^2}$$

$$\sigma_2 := K_a\left[\left[q + \gamma_b\left(\text{Till}_{lefttop} - \text{Till}_{righttop}\right)\right]\right] = 367.514\,\frac{\text{lb}}{\text{ft}^2}$$

$$L_2 := \text{Till}_{lefttop} - \text{Till}_{righttop} = 4\,\text{ft}$$

$$L_3 := \frac{\sigma_2}{\gamma_b\left(K_p - K_a\right)} = 0.553\,\text{ft}$$

Find the resultant and resultant location of active pressure above Point E:

$$Area_1 := \sigma_1 L_1 = 3.9 \times 10^3 \frac{lb}{ft}$$

$$Cent_1 := L_3 + L_2 + \frac{L_1}{2} = 9.453\, ft$$

$$Area_2 := \frac{\sigma_{L601.5} + \sigma_2}{2} L_2 = 1.334 \times 10^3 \frac{lb}{ft}$$

$$Cent_2 := L_3 + \frac{(L_2)(2\sigma_{L601.5} + \sigma_2)}{3(\sigma_{L601.5} + \sigma_2)} = 2.484\, ft$$

$$Area_3 := \frac{\sigma_2}{2} L_3 = 101.529 \frac{lb}{ft}$$

$$Cent_3 := \frac{2}{3} L_3 = 0.368\, ft$$

$$P := Area_1 + Area_2 + Area_3 = 5.335 \times 10^3 \frac{lb}{ft}$$

$$Z := \frac{Area_1\, Cent_1 + Area_2\, Cent_2 + Area_3\, Cent_3}{P} = 7.538\, ft$$

Calculate σ_5 at E (Retained soil is passive):

$$\sigma_5 := K_p\left[\left[q + \gamma_b\left(Till_{lefttop} - Till_{righttop}\right)\right]\right] + \left(K_p - K_a\right)\gamma_b L_3 = 1.507 \times 10^4 \frac{lb}{ft^2}$$

Find L_4, using fourth-degree polynomial from [3]:

$$L_4^{\,4} + A_1 L_4^{\,3} - A_2 L_4^{\,2} - A_3 L_4 - A_4 = 0$$

where,

$$A_1 := \frac{\sigma_5}{\left[\left(K_p - K_a\right)\gamma_b\right]} = 22.653\,ft$$

$$A_3 := \frac{6P\left[2Z\gamma_b\left(K_p - K_a\right) + \sigma_5\right]}{\left[\left(K_p - K_a\right)^2 \gamma_b^{\,2}\right]} = 1.816 \times 10^3\,ft^3$$

$$A_2 := \frac{8P}{\left[\left(K_p - K_a\right)\gamma_b\right]} = 64.167\,ft^2$$

$$A_4 := \frac{P\left(6Z\sigma_5 + 4P\right)}{\left[\left(K_p - K_a\right)^2 \gamma_b^{\,2}\right]} = 8.475 \times 10^3\,ft^4$$

$$L_4 := L_4^{\,4} + A_1 L_4^{\,3} - A_2 L_4^{\,2} - A_3 L_4 - A_4 = 0 \text{ solve}, L_4 \rightarrow$$

$$L_4 := Re\left(L_4\right) = \begin{pmatrix} -22.679 \\ -5.013 \\ -5.013 \\ 10.051 \end{pmatrix} ft$$

ORIGIN := 1

$$L_4 := L_{4_{4,1}} = 10\,ft$$

$$D_{req} := 1.3 L_4 = 13\,ft$$

30% Factor of Safety

$$D_{provided} := Till_{righttop} - Pile_{bottom} = 13\,ft$$

$$Embedment := \begin{cases} \text{"OK"} & \text{if } D_{provided} \ge D_{req} \\ \text{"NOTADEQUATE"} & \text{otherwise} \end{cases}$$

Embedment = "OK"

$$\frac{D_{req}}{D_{provided}} = 1$$

Find Maximum Moment:

Find z`:

$$z' := \sqrt{\frac{2P}{(K_p - K_a)\gamma_b}} = 4.005\,ft$$

$$M_{max} := P(Z + z') - \frac{1}{6}\left[(K_p - K_a)\gamma_b\right]z'^3 = 5.446 \times 10^4\,lb \qquad lb\frac{ft}{ft}$$

$$M_{max} := M_{max} 12in = 6.535 \times 10^5\,in\,lb$$

$$F_y := 50000\frac{lb}{in^2}$$ Strength of pile [4] (No reduction due to extreme load case)

$$S_{reqd} := \frac{M_{max}}{F_y} = 13.071\,in^3$$ Section modulus required per foot of sheet pile

Hoesch 2500 K Steel Sheet Piling

Reference [4]

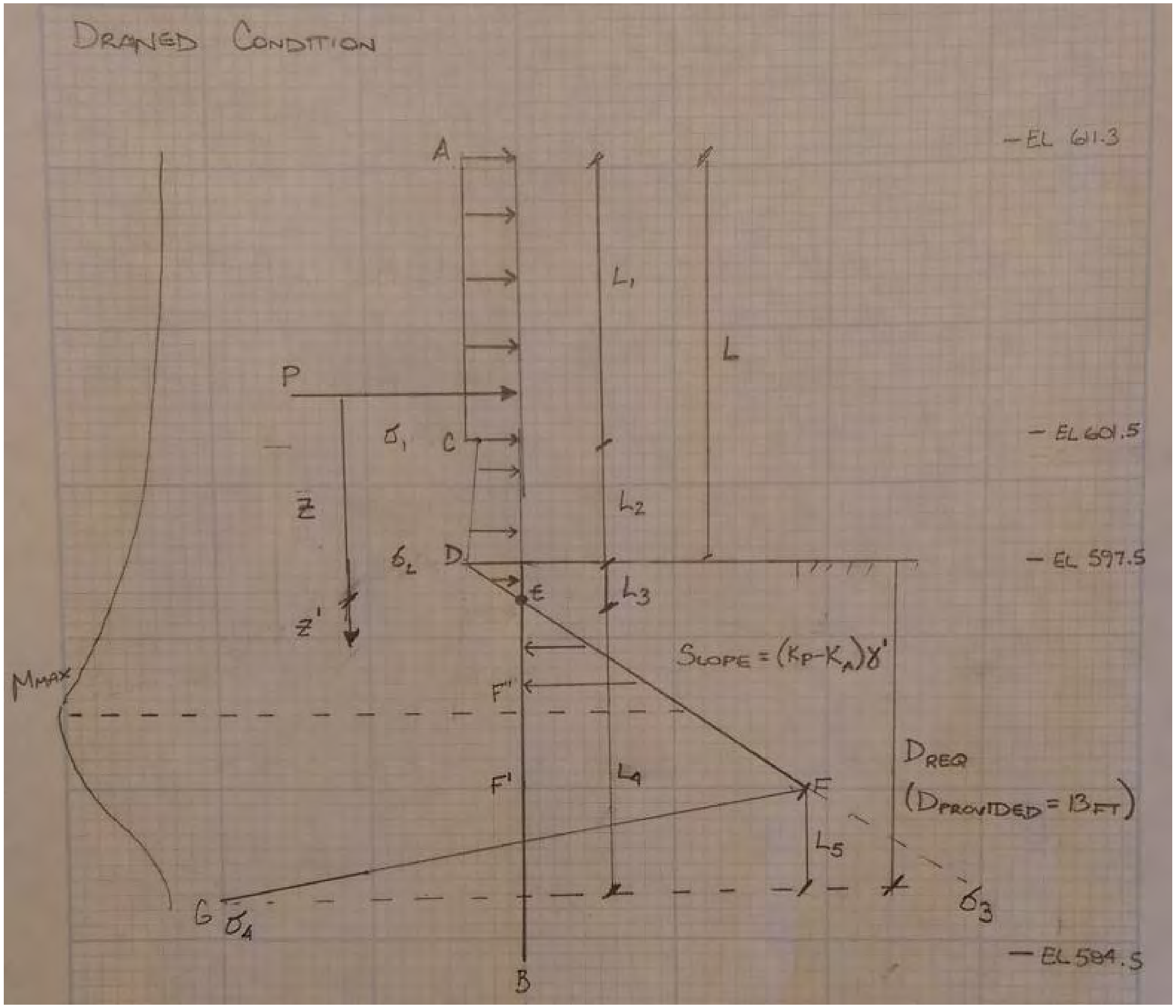
Dimensions and Properties								
Driving distance per pile	Depth	Thickness		Weight		Section Modulus		Moment of Inertia
		Web	Flange	per single pile	per sq. ft. of wall	per single pile	per ft. of wall	per ft. of wall
in.	in.	in.		lbs./ft.	lbs.	in.^{3}	in.^{3}	in.^{4}
22.64	13.78	0.394	0.504	59.88	31.74	89.06	47.24	323.53

$$S_{provided} := 47.24in^3$$

$$PileStrength := \begin{cases} \text{"OK "} & \text{if } S_{provided} \geq S_{reqd} \\ \text{"NOTADEQUATE"} & \text{otherwise} \end{cases}$$

PileStrength = "OK "

Check equlibrium:



Using [3] formulation above:

$\sigma_1 = 397.959 \frac{lb}{ft^2}$ $L_1 = 9.8\, ft$ $L_3 = 0.553\, ft$

$L_2 = 4\, ft$ $L_4 = 10.051\, ft$

$\sigma_{L601.5} = 299.292 \frac{lb}{ft^2}$

$\sigma_2 = 367.514 \frac{lb}{ft^2}$

$\sigma_5 = 1.507 \times 10^4 \frac{lb}{ft^2}$

$$\sigma_3 := \gamma_b L_4 (K_p - K_a) = 6.686 \times 10^3 \frac{lb}{ft^2}$$

$$\sigma_4 := \sigma_5 + \gamma_b L_4 (K_p - K_a) = 2.175 \times 10^4 \frac{lb}{ft^2}$$

$$L_5 := \frac{\sigma_3 L_4 - 2P}{(\sigma_3 + \sigma_4)} = 1.988\, ft$$

$$\sigma_F := \gamma_b (K_p - K_a)(L_4 - L_5) = 5.363 \times 10^3 \frac{lb}{ft^2}$$

$$x := \frac{\sigma_4}{\frac{\sigma_4 + \sigma_F}{L_5}} = 1.594\, ft$$

Location above Point G where net zero shear occurs

Sum of forces (Should equal 0):

$P_1 := P = 5.335 \times 10^3 \frac{lb}{ft}$ Top resultant (triangle above E)

$P_2 := \frac{\sigma_F (L_4 - x)}{2} = 2.268 \times 10^4 \frac{lb}{ft}$ Mid resultant (triangle below E)

$P_3 := \frac{\sigma_4 x}{2} = 1.734 \times 10^4 \frac{lb}{ft}$ Bottom resultant (triangle at bottom)

$\text{Resultant} := (P_1 + P_3) - P_2 = 0 \frac{lb}{ft}$

$$\text{SumForce} := \begin{cases} \text{"OK "} & \text{if } -1 \frac{lb}{ft} < \text{Resultant} < 1 \frac{lb}{ft} \\ \text{"NOTADEQUATE"} & \text{otherwise} \end{cases}$$

SumForce = "OK "

Sum of moments about bottom (Should equal 0):

$M_1 := P_1(L_4 + Z) = 9.384 \times 10^4\ \text{lb}$

Moment of top portion (triangle above E)

$$M_{2top} := \frac{\sigma_F(L_4 - L_5)}{2}\left[L_5 + \left[\frac{1}{3}(L_4 - L_5)\right]\right] = 1.011 \times 10^5\ \text{lb}$$

$\frac{\text{lb ft}}{\text{ft}}$

$$M_{2bottom} := \frac{\sigma_F(L_5 - x)}{2}\left[x + \left[\frac{2}{3}(L_5 - x)\right]\right] = 1.957 \times 10^3\ \text{lb}$$

$$M_3 := P_3\left(\frac{1}{3}x\right) = 9.218 \times 10^3\ \text{lb}$$

$SumM := M_1 + M_3 - M_{2top} - M_{2bottom} = 0\ \text{lb}$

$$SumMoment := \begin{cases} \text{"OK "} & \text{if } -1\text{lb} < SumM < 1\text{lb} \\ \text{"NOTADEQUATE"} & \text{otherwise} \end{cases}$$

SumMoment = "OK "

Design Summary:

A force of 3900 lbs is the upper limit on the static slide mass force. The controlling limit state is embedment depth of the pile, slightly above required embedment with an assumed drive depth of 13 ft [4.] and a 30% factor of safety applied to required embedment depth.

Embedment = "OK "

$$\frac{D_{req}}{D_{provided}} = 1$$

PileStrength = "OK "

$$\frac{S_{provided}}{S_{reqd}} = 3.614$$

SumForce = "OK "

SumMoment = "OK "

Attachment I. Probabilistic Seismic Hazard Analysis Report

Final Report

Site-Specific Probabilistic Seismic Hazard Analysis, Site Response Analysis and Development of Time Histories for the Coffeen Power Station in Southern Illinois

Prepared for

Dynegy
Houston, Texas

6 January 2016

Prepared by

AECOM
Eliza Nemser, Patricia Thomas, Mark Dober, and Ivan Wong
Seismic Hazards Group, AECOM
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AECOM
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856 Sea View Drive, El Cerrito, CA 94530

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Figures

A site-specific seismic hazard analysis has been performed for the Coffeen Power Station in southern Illinois to develop Safety Evaluation Earthquake (SEE) ground motions for use in liquefaction and dynamic deformation analyses of the facility. The SEE ground motions consist of acceleration response spectra and time histories. The power station is located in the Midcontinent of the U.S. away from active plate boundaries but in a region that exhibits a moderate level of historical seismicity. The site is capable of experiencing strong ground shaking from moderate to large earthquakes (moment magnitude [**M**] > 6) particularly from the adjacent New Madrid Seismic Zone (NMSZ) and the Wabash Valley Seismic Zone. The New Madrid fault system (NMFS) which is contained in the NMSZ produced the series of three **M** > 7 earthquakes in 1811 and 1812. These are the largest earthquakes known to have occurred in the central and eastern U.S. (CEUS).

In this study, four major tasks were performed: 1) seismic source characterization; 2) probabilistic seismic hazard analysis (PSHA); 3) site response analysis; and 4) development of the SEE ground motion parameters. The SEE ground motions are based on a probabilistic assessment of the seismic hazard at the site using the PSHA approach. The annual probability considered in this study was 1/2500 or a return period of 2,500 years. There are two major inputs into a PSHA: a characterization of all seismic sources that can generate significant ground shaking at the site and ground motion prediction models that relate primarily magnitude, distance, and site condition to levels of ground shaking at a site. For the seismic source characterization, we used the recently developed seismic source model developed for the CEUS by the Electric Power Research Institute (EPRI), the U.S. Department of Energy (DOE), and the U.S. Nuclear Regulatory Commission (NRC). This model is being used in the PSHAs for nuclear power plants and other critical facilities in the CEUS.

In a similar fashion, we used the EPRI ground motion prediction models developed in 2013 that are also being used in the PSHAs for nuclear power plants. A limitation of all existing ground motion models for the CEUS including the EPRI models is that they were developed for a hard rock site condition (shear-wave velocity [V_S] of 2,830 m/sec and greater).

The products of the PSHA are hard rock hazard curves and deaggregation information. The deaggregation indicated that the most important seismic sources to the power station site were the Illinois Basin Extended Basement Zone (IBEB) in which the site is located and the NMFS.

The power station is situated on Quaternary glacial till. Hard rock (in this case Precambrian basement rock), is at a depth of greater than 1,645 m. Hence a site response analysis was performed to estimate the ground motions at the top of the glacial till by accounting for any site effects of the geology beneath the site down to basement rock. The inputs required in a site response analysis are a best-estimate V_S profile and dynamic properties of the geologic units beneath the site. A V_S profile was developed from the ground surface down to basement rock based on available data, none of it being site-specific in nature. Dynamic properties were assigned to the unconsolidated materials and firm rock above the basement in the analysis. The hard rock hazard curves from the PSHA were adjusted to the top of the glacial till using amplification factors computed from the site response analysis.

Based on the results of the PSHA and site response analysis, a horizontal SEE Uniform Hazard Spectrum (UHS) was calculated. The SEE UHS is provided in the table below. The SEE peak horizontal ground acceleration (PGA) at the site is 0.19 g. Three sets of two-component horizontal time histories were spectrally matched to the SEE UHS.

2,500-Year Return Period Mean UHS for the Ground Surface

Period (sec)	SA (g)
0.01 (PGA)	0.19
0.02	0.22
0.03	0.25
0.04	0.27
0.10	0.40
0.20	0.42
0.40	0.23
1.0	0.12
2.0	0.07
3.0	0.05
4.0	0.04
5.0	0.03

At the request of Dynegy, a site-specific probabilistic seismic hazard analysis (PSHA) and site response analysis has been performed for the Coffeen Power Station in southern Illinois to develop Safety Evaluation Earthquake (SEE) ground motions (Figure 1). The SEE ground motions will be used to evaluate the seismic design of the station. Horizontal acceleration time histories were also developed. The hazard was defined at the top of the Quaternary till beneath the site and will be used in liquefaction and deformation analyses of the power station.

Coffeen Power Station is located in the Midcontinent region of the U.S. away from active plate boundaries in a region that exhibits a moderate level of historical seismicity (Figure 1). There have been six known earthquakes larger than moment magnitude (**M**) 5.0 within 200 km of the site. The region is capable of experiencing strong ground motions from moderate to large earthquakes (**M** > 6) particularly from the New Madrid Seismic Zone (NMSZ) to the south of the site and the Wabash Valley Seismic Zone (WVSZ) to the east of the site (Figure 1).

This report presents the results of the site-specific PSHA, the site response analysis, and development of the horizontal acceleration time histories consistent with the 2,500-year Uniform Hazard Spectrum (UHS) at the ground surface.

1.1 SCOPE OF WORK

In site-specific seismic hazard analyses, the available geologic and seismologic data are used to evaluate and characterize (1) potential seismic sources, (2) the likelihood of earthquakes of various magnitudes occurring on those sources, and (3) the likelihood of the earthquakes producing ground motions over a specified level. Based on a site-specific PSHA and site response analysis, SEE spectra and time histories were developed. The following tasks were performed:

Task 1 – Seismic Source Characterization

Seismic source parameters that are needed in order to characterize an active (seismogenic) fault for ground motion hazard assessments include: the geometry and rupture dimensions of the fault; the size of the maximum earthquake; the nature (style) and amount of slip on the fault expected for the maximum earthquake; and the rate and nature of earthquake recurrence. These parameters should be estimated for all significant seismic sources. In addition to the known active faults located in the region that can impact the site, the hazard from buried and unknown faults must also be accounted for. Hence, seismic sources will consist of active and potentially active faults and regional seismic source zones, which account for buried and unknown faults. In this study, we utilized the recently developed seismic source model developed for the central and eastern U.S. (CEUS) by the Electric Power Research Institute (EPRI), the U.S. Department of Energy (DOE), and the U.S. Nuclear Regulatory Commission (NRC). This model is being used in the seismic hazard analyses for nuclear power plants and other critical structures/facilities in the CEUS.

Task 2 – Probabilistic Seismic Hazard Analysis

Site-specific probabilistic ground motions were calculated for the project site for a 2,500-year return period. The PSHA methodology allows for the explicit inclusion of the range of possible interpretations in components of the seismic hazard model, including seismic source characterization and ground motion estimation. Uncertainties in models and parameters were incorporated into the hazard analysis through the use of logic trees. State-of-the-art ground motion prediction models were selected for the types of seismic sources considered in the PSHA. In this case, EPRI (2013) models for hard rock and the CEUS were used in the PSHA. Hard rock is defined by a V_S30 (time-averaged shear-wave velocity [V_S] in the top 30 m) greater than 2,830 m/sec.

Task 3 – Site Response Analysis

Site response analyses were performed consistent with NUREG/CR-6728 (McGuire *et al.*, 2001) to adjust the hard rock hazard to site-specific free-field ground surface conditions. The inputs into the analyses were V_S profiles representative of the site and non-linear dynamic properties. The V_S profiles were randomized using a correlation model to capture the variability in V_S across the site. Site response analyses were performed to calculate a suite of amplification factors at selected spectral frequencies i.e., PGA, 0.2 and 1.0 sec spectral acceleration and input motions. A state-of-the-art random-vibration-theory (RVT) methodology based on an equivalent-linear approach was used.

Task 4 – Development of SEE Ground Motion Parameters and Final Report

Horizontal design response spectra for a 2,500-year return period were developed and provided for the soil-structure interaction (SSI) analysis. A total of three time histories were developed. A final report was produced that describes and summarizes the above analyses.

1.2 ACKNOWLEDGMENTS

The seismic hazard analysis of Coffeen Power Station was performed by Eliza Nemser, Patricia Thomas, Mark Dober, and Ivan Wong of the Oakland Seismic Hazards Group, Earl Underwood, Denver of AECOM, and Walt Silva and Bob Darragh of Pacific Engineering and Analysis. Our appreciation to Tiffany Adams for project management support, Melinda Lee for her assistance in the preparation of this report, and to Ed Villano for his peer review of the report.

The PSHA approach used in this study is based on the model developed principally by Cornell (1968). The occurrence of earthquakes on a fault is assumed to be a Poisson process. The Poisson model is widely used and is a reasonable assumption in regions where data are sufficient to provide only an estimate of average recurrence rate (Cornell, 1968). The occurrence of ground motions at the site in excess of a specified level is also a Poisson process, if (1) the occurrence of earthquakes is a Poisson process, and (2) the probability that any one event will result in ground motions at the site in excess of a specified level is independent of the occurrence of other events.

The probability that a ground motion parameter "*Z*" exceeds a specified value "*z*" in a time period "t" is given by:

$$p(Z > z) = 1 - e^{-\nu(z) \bullet t} \quad (2\text{-}1)$$

where $\nu(z)$ is the annual mean number (or rate) of events in which Z exceeds z. It should be noted that the assumption of a Poisson process for the number of events is not critical. This is because the mean number of events in time t, $\nu(z) \bullet t$, can be shown to be a close upper bound on the probability $p(Z > z)$ for small probabilities (less than 0.10) that generally are of interest for engineering applications. The annual mean number of events is obtained by summing the contributions from all sources, that is:

$$\nu(z) = \sum_{n} \nu_n(z) \quad (2\text{-}2)$$

where $\nu_n(z)$ is the annual mean number (or rate) of events on source n for which Z exceeds z at the site. The parameter $\nu_n(z)$ is given by the expression:

$$\nu_n(z) = \sum_{i}\sum_{j} ß_n(m_i) \bullet p(R=r_j|m_i) \bullet p(Z>z|m_i,r_j) \quad (2\text{-}3)$$

where:

$ß_n(m_i)$ = annual mean rate of recurrence of earthquakes of magnitude increment m_i on source n;

$p(R=r_j|m_i)$ = probability that given the occurrence of an earthquake of magnitude m_i on source n, r_j is the closest distance increment from the rupture surface to the site;

$p(Z > z|m_i,r_j)$ = probability that given an earthquake of magnitude m_i at a distance of r_j, the ground motion exceeds the specified level z.

The calculations were made using the computer program HAZ38CEUS. The basic program (HAZ38) has been validated in the Pacific Earthquake Engineering Research (PEER) Center-sponsored "Validation of PSHA Computer Programs" Project (Thomas *et al.*, 2010). Modifications were made to HAZ38 to incorporate the CEUS-SSC model and the resulting revision, HAZ38CEUS, was validated by comparing hazard results with the test case results contained in EPRI/DOE/NRC (2012).

The following is a general overview of PSHA methodology used by AECOM. For this study, we have adopted the EPRI/DOE/NRC (2012) seismic source model, which required modifications to our general approach. For a detailed description, see EPRI/DOE/NRC (2012). A sample logic tree is shown on Figure 2. Logic trees such as shown on Figure 3 are used in the EPRI/DOE/NRC (2012) model.

2.1 SEISMIC SOURCE CHARACTERIZATION

Three types of earthquake sources are characterized in the CEUS-SSC model: (1) known fault sources; (2) seismotectonic zones; and (3) Mmax zones. Fault sources are modeled as three-dimensional fault surfaces and details of their behavior are incorporated into the source characterization. The inventory of fault sources in the CEUS is small and undoubtedly incomplete. Given this shortcoming, the historical seismicity is used as a proxy to address the hazard from those buried or unknown faults. The spatial density of the historical seismicity was assumed to be stationary; in this model the recurrence rates per area for each small area were smoothed using a Gaussian filter.

The geometric source parameters for faults include fault location, segmentation model, dip, and thickness of the seismogenic zone (Figure 3). The recurrence parameters include recurrence model, recurrence rate (slip rate or average recurrence interval for the maximum event), slope of the recurrence curve (*b*-value), and maximum magnitude. Clearly, the geometry and recurrence are not totally independent. For example, if a fault is modeled with several small segments instead of large segments, the maximum magnitude is lower, and a given slip rate requires many more small earthquakes to accommodate a cumulative seismic moment. For areal source zones, only the area, seismogenic thickness, maximum magnitude, and recurrence parameters (based on the historical earthquake record) need to be defined (Figure 2).

Uncertainties in the CEUS-SSC source parameters are modeled using logic trees. In this procedure, values of the source parameters are represented by the branches of logic trees with weights that define the distribution of values. Sample logic trees are shown on Figures 2 and 3. In general, three or five values for each parameter were weighted and used in the analysis. Note that the weights associated with the percentiles are not equivalent to probabilities for these values, but rather are weights assigned to define the distribution.

2.1.1 Source Geometry

In the PSHA, it is assumed that earthquakes of a certain magnitude may occur randomly along the length of a given fault or segment. The distance from an earthquake to the site is dependent on the source geometry, the size and shape of the rupture on the fault plane, and the likelihood of the earthquake occurring at different points along the fault length. The distance to the fault is defined to be consistent with the specific ground motion prediction model used to calculate the ground motions. The distance, therefore, is dependent on both the dip and depth of the fault plane, and a separate distance function is calculated for each geometry and each ground motion prediction model. The size and shape of the rupture on the fault plane are dependent on the magnitude of the earthquake, with larger events rupturing longer and wider portions of the fault plane. For a given magnitude, the associated rupture surface is uniformly distributed along the fault length and width. Ruptures are constrained to occur entirely on the defined fault plane.

The rupture dimensions are modeled using magnitude-rupture area and rupture width relationships.

2.1.2 Fault Recurrence

The recurrence relationships for faults are generally modeled using the exponentially truncated Gutenberg-Richter, characteristic earthquake, and the maximum moment (magnitude) recurrence models. These models are weighted to represent judgment on their applicability to the sources. For the areal source zones, only a truncated exponential recurrence relationship is assumed appropriate.

The general approach of Molnar (1979) and Anderson (1979) is often used to arrive at the recurrence for the exponentially truncated model. The number of events exceeding a given magnitude, *N(m)*, for the truncated exponential relationship is

$$N(m) = \alpha(m^o)\frac{10^{-b(m-m^o)} - 10^{-b(m^u-m^o)}}{1 - 10^{-b(m^u-m^o)}} \qquad (2\text{-}4)$$

where $\alpha(m^o)$ is the annual frequency of occurrence of earthquake greater than the minimum magnitude, m^o; b is the Gutenberg-Richter parameter defining the slope of the recurrence curve; and m^u is the upper-bound magnitude event that can occur on the source. A m^o of **M** 5.0 was used for the hazard calculations; this value is also used by the USGS in the National Hazard Maps (Frankel *et al*., 1996; Petersen *et al*., 2008).

A popular model often used in PSHA is where faults rupture with a "characteristic" magnitude on specific segments; this model is described by Aki (1983) and Schwartz and Coppersmith (1984). For the characteristic model, the numerical model of Youngs and Coppersmith (1985) is often used. In the characteristic model, the number of events exceeding a given magnitude is the sum of the characteristic events and the non-characteristic events. The characteristic events are distributed uniformly over a ± 0.25 magnitude unit around the characteristic magnitude and the remainder of the moment rate is distributed exponentially up to the characteristic range using the above equation (Youngs and Coppersmith, 1985).

The maximum moment model can be regarded as an extreme version of the characteristic model. The model proposed by Wesnousky (1986) is often used when there is no exponential portion of the recurrence curve, i.e., no events can occur between the minimum magnitude of **M** 5.0 and the distribution about the maximum magnitude.

The recurrence rates for the fault sources are defined by either the slip rate or the average return time for the maximum or characteristic event and the recurrence *b*-value. The slip rate is used to calculate the moment rate on the fault using the following equation defining the seismic moment:

$$M_o = \mu \, A \, D \qquad (2\text{-}5)$$

where M_o is the seismic moment, μ is the shear modulus, A is the area of the rupture plane, and D is the slip on the plane. Dividing both sides of the equation by time results in the moment rate as a function of slip rate:

$$\dot{M}_o = \mu A S \qquad (2\text{-}6)$$

where $\dot{M}_o$ is the moment rate and S is the slip rate. M_o has been related to moment magnitude, **M**, by Hanks and Kanamori (1979):

$$\mathbf{M} = 2/3 \log M_o - 10.7 \qquad (2\text{-}7)$$

Using this relationship and the relative frequency of different magnitude events from the recurrence model, the slip rate can be used to estimate the absolute frequency of different magnitude events.

The average return time for the characteristic or maximum magnitude event defines the high magnitude (low likelihood) end of the recurrence curve. When combined with the relative frequency of different magnitude events from the recurrence model, the recurrence curve is established.

2.2 GROUND MOTION PREDICTION

To characterize the ground motions at a specified site as a result of the seismic sources considered in the PSHA, we used ground motion prediction models for spectral accelerations (Figure 2; Section 4.2). Ground motion prediction models have at a minimum the variables of magnitude, distance, and site condition (e.g., rock, soil).

The uncertainty in ground motion models was included in the PSHA by using the log-normal distribution about the median values as defined by the standard deviation associated with each model. This distribution was truncated at five standard deviations above the median value predicted by the each model. We have tested our approach using the five sigma truncation against the test cases contained in EPRI/DOE/NRC (2012) where sigma was untruncated. The differences are insignificant.

In this section, we describe the seismotectonic setting and historical seismicity of the site region and the site geology.

3.1 SEISMOTECTONIC SETTING

Coffeen Power Station is located in southern Illinois, about 120 km west of the WVSZ and 200 km north of the NMSZ (Figure 4). Although the site is located within the continental interior and far from active plate boundaries, the preexisting structures formed in earlier tectonic settings are still capable of generating seismicity that can pose a hazard to the region. This seismicity has included several large historical earthquakes in the region (**M** > 7), e.g., the 1811 and 1812 New Madrid earthquakes (Figure 1).

The CEUS is part of a broad mid-plate compressive stress province that also includes most of Canada (Zoback and Zoback, 1991). Over this large region, the stress field is oriented with a relatively uniform east-northeast direction of maximum horizontal compression. This compression direction corresponds well to the direction of absolute plate motion of the North American Plate, which suggests that a far-field tectonic source such as ridge-push or basal drag at the Mid-Atlantic Ridge may be the primary source of stress in the mid-plate region (Zoback and Zoback, 1991).

3.2 HISTORICAL SEISMICITY

The following is a discussion of the historical seismicity and significant earthquakes in the region surrounding the Coffeen Power Station.

3.2.1 Historical Seismicity Catalog

A historical seismicity catalog was derived mainly from the CEUS Seismic Source Characterization (CEUS-SSC) catalog (EPRI/NRC/DOE, 2012) (Figure 4). This catalog includes data primarily from the catalog compiled by the U.S. Geological Survey (USGS) for the National Seismic Hazard Mapping Project (Mueller *et al*., 1997; Petersen *et al*., 2008) and from the Geological Survey of Canada (GSC) catalog for seismic hazard analyses (Adams and Halchuk, 2003). The main source for the USGS catalog was the NCEER-91 catalog (Seeber and Ambruster, 1991) which updated the original EPRI-SOG (EPRI 1988) catalog. The catalog was then updated using the National Earthquake Information Center's (NEIC) Preliminary Determination of Epicenters (PDE) and data from the National Earthquake Database (NEDB) of Canada. Researchers reviewed original catalogs and special earthquake studies to verify and if needed update original entries, and regional catalogs were incorporated into the continental scale catalogs described above (see EPRI/NRC/DOE, 2012 for details of special study references and list of regional catalogs used). The CEUS-SSC catalog spans the time period of 1568 to 2008. We updated this catalog with more recent data (up to May 2015) from the Advanced National Seismic System (ANSS) catalog as shown on Figure 1.

All of the events in the USGS catalog used to compile the CEUS-SSC catalog have body-wave (m_b) magnitude values, which were converted to **M** using the equations of Atkinson and Boore (1995):

$\mathbf{M} = -0.39 + 0.98Mn$ for magnitudes ≤ 5.5

$\mathbf{M} = 2.715 - 0.277Mn + 0.127(Mn^2)$ for magnitudes > 5.5

and Johnston (1996):

$\mathbf{M} = 1.14 + 0.24\ m_b + 0.0933\ m_b^2$

Mn (Nuttli magnitude) was considered to be equivalent to m_b. All events in the PDE catalog that we used to update the CEUS-SSC catalog were Mn or M_D. We converted the PDE Mn magnitudes to **M** using the average of Atkinson and Boore (1995) and Johnston (1996). For the M_D values, we used the same conversion used in the CEUS-SSC catalog to convert them to **M** values for the Midcontinent U.S. east of 100º W (EPRI/DOE/NRC, 2012).

$\mathbf{M} = 0.869 + 0.762\ M_D$

3.2.2 Significant Earthquakes

The most significant earthquakes to have occurred in the CEUS are the 1811-1812 **M** 7 to 8 New Madrid earthquake sequence and the 1886 **M** 6.8 Charleston, South Carolina, earthquake (Figure 1). The New Madrid earthquake sequence occurred over the winter of 1811-1812 in southeastern Missouri/northeastern Arkansas. This sequence, which was felt as far away as the East Coast (Figure 5), consisted of three principal events on 16 December 1811, 23 January 1812, and 7 February 1812 (referred to as NM1, NM2, and NM3, respectively in Hough *et al*., 2000) (Figure 6). Because the epicentral region was sparsely populated at the time of the events, little structural damage occurred, and the maximum Modified Mercalli (MM) intensity is IX (NM1) as reinterpreted by Hough *et al.* (2000). The Coffeen Power Station site probably underwent strong ground shaking of MM VI to VIII in the 16 December 1811 mainshock (Figure 5). The NMSZ is currently the most seismically active area in the CEUS (Figure 1).

The Wabash Valley, which encompasses southern Illinois and southwestern Indiana and is 120 km east of the Coffeen Power Station, has historically been seismically active with several earthquakes of **M** 4.5 and larger (Figure 1). Hence, the site has been strongly shaken numerous times after the 1811-1812 and 1886 earthquakes. An event on 27 September 1891 occurred near Mt. Vernon, Illinois, which caused chimney damage in the epicentral area (Stover and Coffman, 1993). The size of the earthquake was estimated to be a body-wave magnitude (m_b) 5.8 and the event was felt widely in several states (Figure 7). Shaking at the site could have been as strong as MM V.

On 31 October 1895, an earthquake of estimated surface wave magnitude (M_S) 6.7 struck the northern end of the NMSZ (Figures 1 and 8). This is the largest earthquake to have occurred in the central Mississippi Valley since 1811-1812 (Stover and Coffman, 1993). The event caused extensive damage in the town of Charleston, Missouri. Sand blows due to liquefaction were also reported in the epicentral area (Stover and Coffman, 1993). In the area of the site, the ground shaking was probably at MM V level (Figure 8).

On 9 November 1968, a m_b 5.5 earthquake struck southern Illinois and neighboring states with a maximum reported MM VII (Figures 1 and 9). Damage consisted of damaged chimneys, broken windows, cracked or fallen plaster, cracked foundations, and scattered instances of collapsed parapets (Stover and Coffman, 1993). The site was probably subjected to MM V ground shaking from this event. Another notable earthquake was the 18 April 2008 **M** 5.4 Southern Illinois earthquake southeast of the site (Figure 1).

On 27 July 1980, a **M** 5.1 earthquake struck the area near Sharpsburg, Kentucky. This event, the strongest in the history of Kentucky, occurred approximately 490 km southeast of the site and caused over $1 million in property damage (Stover and Coffman, 1993). The site was probably subjected to intensities of MM I to II (Figure 10).

3.3 SITE GEOLOGY

The site lies in the west-central portion of the Illinois Basin, a northwest-southeast oriented regional-scale structural depression that includes Illinois, Indiana, Kentucky and portions of Tennessee and Missouri. The bedrock in the site area dips gently to the southeast toward the center of the Illinois Basin which lies in southern Illinois. Underlying the region is thousands of meters of sedimentary bedrock deposited from Cambrian to Pennsylvanian periods. More recent Quaternary deposits of glacial, loess, and alluvial soils cover the bedrock at depths ranging from tens to hundreds of feet.

The regional bedrock consists of sequences of shale, siltstone, sandstone, coal, and limestone overlying Precambrian crystalline basement rock. The thickness of the sedimentary bedrock units varies and is controlled by depositional environment and geologic structure. The total thickness of the sedimentary rocks in the region is reported to be about 2,000 m based upon oil test borings and seismic profiles (Horberg, 1950).

Pleistocene-aged glacial and loess deposits cover the bedrock at the site. Glacial till deposits from the Illinoian Stage glaciation form dense, compact silts, sand, clay, and gravel mixtures (Frye *et al.*, 1968; Jacobs and Lineback, 1969). Windblown loess, silts blown from river valleys, cover the glacial deposits and are interbedded in select areas with modern alluvium. At the Coffeen site these unconsolidated deposits are approximately 105 ft thick.

Underlying the Quaternary deposits at the site is a ~545 ft-thick section of Pennsylvanian strata that includes sandstone, siltstone, shale, limestone, coal, and clay (Treworgy*et al.*, 1994; Treworgy and Whitaker, 1990). The Pennsylvanian System lies unconformably above the Mississippian strata, which are comprised mainly of limestones and siltstone and to a lesser extent shale, with a total thickness of ~1,200 feet (Treworgy *et al.*, 1994; Treworgy and Whitaker, 1990). A siltstone member of the Mississippian, the Borden Siltstone was interpreted to have lower strength than surrounding limestone rock and was assigned as a separate sub-unit. The Borden Siltstone was estimated from cross-section to be approximately 450 feet thick at the Coffeen site.

The Devonian System beneath the Mississippian only consists of the Lower Devonian Series at the Coffeen site: carbonate limestone and chert deposits generally 100 feet in thickness (Treworgy *et al.*, 1994; Treworgy and Whitaker, 1990). Beneath the Devonian, the Silurian System contains a reddish argillaceous limestone to calcareous siltstone, a homogeneous limestone, and a cherty limestone and is estimated to be 450 to 500 feet thick at the Coffeen site (Treworgy *et al.*, 1994; Treworgy and Whitaker, 1990).

Underlying the Silurian, the Ordovician System, approximately 700 feet thick at the site, contains several major groups: the Maquoketa Group, the Galena Group, the Platteville Group and the Joaquim Dolomite (Treworgy *et al.*, 1994; Treworgy and Whitaker, 1990; Horberg, 1950). Formations within these groups consist of the St. Peter Sandstone, the Galena-Platteville Limestone and Dolomite, and the Maquoketa Shale. The St. Peter Sandstone is a distinct, very well-sorted fine- and medium-grained quartz sandstone. The Galena-Platteville Group is comprised of numerous dolomite and limestone formations of varying composition. The Maquoketa Group consists of three shale formations and one limestone formation. The Maquoketa Group was estimated as having lower strength than the surrounding dolomite and limestone rock and was assigned as a separate sub-unit of the Ordovician System for the site stratigraphy.

The Cambrian System rocks, primarily siltstone, shale sandstone, and dolomite, are projected to be approximately 2,300 ft thick at the Coffeen site. Below the rocks of the Cambrian system lie stronger crystalline basement rocks, predominately granite with associated granodiorite and rhyolite.

The following section discusses the two major inputs into the PSHA: the seismic source model and the ground motion prediction models.

4.1 SEISMIC SOURCE MODEL

Seismic source characterization is concerned with three fundamental elements: (1) the location, geometry, and characteristics of significant sources of future earthquakes; (2) the maximum size of these earthquakes; and (3) the rate at which different size earthquakes occur. Two types of seismic sources were considered in this PSHA: discrete fault or fault zone sources and regional seismic source zones.

The seismic source characterization presented here is adopted from the comprehensive seismic source characterization of the CEUS, developed for nuclear facilities by EPRI/DOE/NRC (2012). Two zonation models that account for earthquakes associated with buried or generally unknown faults (background) were characterized and included in the PSHA; these models include multiple zones, many having alternative geometries (Figures 11 and 12). In addition, the source parameters for several fault sources or RLMEs (repeated large magnitude earthquakes) (Figure 11) were characterized for input into the PSHA.

A major challenge in understanding the earthquake potential in the CEUS has been associating the observed seismicity with specific geologic structures. Few active faults are known east of the Rocky Mountains. Thus the traditional approach in addressing the seismic hazard in the CEUS has been to rely on the historical earthquake record in conjunction with seismic source zones that separate regions of different seismotectonic characteristics and hence possibly different earthquake potential. Each seismic source zone is defined and characterized according to geologic, tectonic, and seismicity data. The zones comprise regions having a common geologic history that distinguishes them from neighboring areas. They may have a similar structure (e.g., faults or fractures of similar age, type, orientation), a similar pattern of seismicity, and/or a homogeneous stress regime. The EPRI/DOE/NRC (2012) model retains this methodology by dividing the CEUS into numerous "seismotectonic zones", defined by differences in various seismic source assessment criteria such as style of faulting, earthquake recurrence, maximum magnitude, seismogenic thickness, etc. The model includes an alternative approach to dividing the CEUS into source zones, which is based solely on the expected maximum magnitude in the zone. This alternative zonation approach divides the study area into "Mmax zones" (Figure 12). The seismotectonic zone approach receives slightly higher weight, 0.6, than the Mmax zone approach, 0.4.

Figures 11 and 12 show the locations of the seismotectonic and Mmax zones, respectively. There are three Mmax zones and 12 seismotectonic zones in the EPRI/DOE/NRC model. The Mmax zones and some seismotectonic zones have one or more alternate geometries. Table 1 summarizes the source zone parameters used in the analysis. (Not all seismic source zones are shown on Figure 11.) The Coffeen Power Station lies in the Illinois Basin Extended Basin Zone (IBEB) zone, 120 km from the Wabash Valley RLME, 190 km from the Commerce fault zone and 200 km from the New Madrid North fault (NMN) (Figures 6 and 11).

Table 1
Seismic Source Zones Incorporated Into Analysis

Source Zone	Symbol	Mmax (M)[1]	Seismogenic Depth[2] (km)	Area (km^2)
Seismotectonic Zones				
Atlantic Highly Extended Crust	AHEX	6.0 6.7 7.2 7.7 8.1	8 (0.5) 15 (0.5)	177683
Extended Continental Crust–Atlantic Margin Zone	ECC-AM	6.0 6.7 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	881480
Extended Continental Crust–Gulf Coast	ECC-GC	6.0 6.7 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	1239288
Gulf Highly Extended Crust	GHEX	6.0 6.7 7.2 7.7 8.1	8 (0.5) 15 (0.5)	509090
Great Meteor Hotspot Zone	GMH	6.0 6.7 7.2 7.7 8.1	25 (0.5) 30 (0.5)	32250
Illinois Basin Extended Basin Zone	IBEB	6.5 6.9 7.4 7.8 8.1	13 (0.4) 17 (0.4) 22 (0.2)	114526
Midcontinent Craton Zone (all alternatives)	MidC	5.6 6.1 6.6 7.2 8.0	13 (0.4) 17 (0.4) 22 (0.2)	4258598 4246625 4025001 4013028
Northern Appalachian Zone	NAP	6.1 6.7 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	378331
Oklahoma Aulacogen Zone	OKA	5.8 6.4 6.9 7.4 8.0	15 (0.5) 20 (0.5)	53583

Source Zone	Symbol	Mmax (M)[1]	Seismogenic Depth[2] (km)	Area (km^2)
Paleozoic Extended Crust (Narrow and Wide alternatives)	PEZ	5.9 6.4 6.8 7.2 7.9	13 (0.4) 17 (0.4) 22 (0.2)	365395 598992
Reelfoot Rift Zone	RR	6.2 6.7 7.2 7.7 8.1	13 (0.4) 15 (0.4) 17 (0.2)	69479
Reelfoot Rift with Rough Creek Graben Zone	RR and RR_RCG	6.1 6.6 7.1 7.6 8.1	13 (0.4) 15 (0.4) 17 (0.2)	81452
St. Lawrence Rift Zone	SLR	6.2 6.8 7.3 7.7 8.1	25 (0.5) 30 (0.5)	329322
Mmax Zones				
Mesozoic and Younger Extended Crust - Narrow	MESE-N	6.4 6.8 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	3616923
Mesozoic and Younger Extended Crust - Wide	MESE-W	6.5 6.9 7.3 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	4342413
Non-Mesozoic and Younger Extended Crust - Narrow	NMESE-N	6.4 6.8 7.1 7.5 8.0	13 (0.4) 17 (0.4) 22 (0.2)	4792101
Non-Mesozoic and Younger Extended Crust - Wide	NMESE-W	5.7 6.1 6.6 7.2 7.9	13 (0.4) 17 (0.4) 22 (0.2)	4066611
Study Region	Study Region	6.5 6.9 7.2 7.7 8.1	13 (0.4) 17 (0.4) 22 (0.2)	8409024

Notes:

1 Weights for all magnitude distributions are 0.101/0.244/0.310/0.244/0.101, a discrete five-point approximation to an arbitrary continuous distribution (EPRI/DOE/NRC, 2012).

2 Weights for depth in parentheses

The EPRI/DOE/NRC (2012) model includes sources defined based on RLMEs rather than only fault sources. Many of the RLMEs correlate with identified geologic faults, but some are defined solely by geographically clustered paleoliquefaction events that suggest a localized source even if the responsible fault has not been identified and characterized. The site lies approximately 120 km from the Wabash Valley RLME (Figure 11). Although quite distant from the site, we include the Charleston source (Figure 11) in the PSHA because its maximum earthquakes and relatively high activity rates often dominate the hazard in the CEUS, particularly at long-period ground motions. Tables 2 and 3 summarize the RLME (fault) source parameters used in the analysis.

4.1.1 Seismotectonic Zones

This section describes the seismotectonic characteristics of the most significant seismotectonic zones to the site, the basis for delineating the zones and for defining the model values for style of faulting, geometry, seismogenic depth, and Mmax. Recurrence for the zones is discussed in Section 4.1.3.

Illinois Basin Extended Basement Zone (IBEB)

The Illinois Basin Extended Basement (IBEB) zone encompasses southwestern Indiana and southeastern Illinois; the site is located in the IBEB zone (Figure 11). Southern Indiana and southern Illinois are characterized by several moderate-sized paleoearthquakes and by higher rates of seismicity than adjacent craton regions (Figure 4). Several characteristics combine to support the delineation of IBEB as a separate seismotectonic zone. The southern part of the Illinois basin is one of the most structurally complex areas of the Midcontinent (McBride *et al*., 2002), with a crust distinct from that of the neighboring craton. Numerous moderately dipping reflectors interpreted to be faults are present in the basement. Moderate-sized historical earthquakes that appear to be spatially associated with Precambrian basement faults and with Paleozoic faults suggest continued reactivation of older basement features as well as younger Paleozoic structures (McBride *et al*., 2002). Stresses induced by Mesozoic rifting possibly extend into the southern Illinois basin causing the reactivation of deep structures (Braile *et al*., 1984). The IBEB source zone is defined to characterize sources of moderate- to large-magnitude earthquakes (excluding those attributed to the Wabash Valley RLME source) that may occur on deep structures in the Precambrian basement and as Paleozoic faults that extend into the overlying Paleozoic sedimentary rocks (EPRI/DOE/NRC 2012).

Fault dips are generalized based on sense of slip, with strike-slip ruptures assigned steep dips between 70° and 90° and reverse ruptures assigned moderate dips between 40° and 70°. Seismogenic thickness ranges from 13 to 22 km, the default values for the entire study area (EPRI/NRC/DOE, 2012). The seismogenic thickness is based on reported depths of seismicity within the IBEB. The deepest well-constrained earthquake hypocenters in the deep part of the Illinois basin, are located at depths of 20 to 22 km (McBride *et al*., 2002; Yang *et al*., 2009). However, the average depth throughout the IBEB zone based on other historical earthquakes may be less (EPRI/DOE/NRC, 2012).

Table 2
New Madrid Fault System RLME Source Model

Cluster?	wt	Localizing Structures	Southern Fault Geometry	wt	Northern Fault Geometry	wt	Central Fault Geometry	wt	Thickness (km)	wt	Mmax	wt	Recurrence method	wt	Recurrence Data	wt	Earthquake Recurrence Model	wt	Repeat Time Coefficient of Variation	wt	Rate (yrs)	wt
All In	0.9	NMS NMN RFT	BA-BL	0.6	NMN-S	0.7	RFT-S	0.7	13	0.4	NMS, RFT, NMN 7.9, 7.8, 7.6	0.167	Intervals	1.0	1811-1812, 1450, and 900 AD	1.0	Poisson	0.75	NA		167	0.101
																					270	0.244
																					417	0.310
																					714	0.244
																					1613	0.101
											7.8, 7.7, 7.5	0.167	same as above				Renewal	0.25	0.3	0.2	286	0.101
											7.6, 7.8, 7.5	0.25									909	0.244
											7.2, 7.4, 7.2	0.085									3125	0.310
											6.9, 7.3, 7.0	0.25									15625	0.244
											6.7, 7.1, 6.8	0.085									212766	0.101
									15	0.4	same as above								0.5	0.5	208	0.101
									17	0.2											455	0.244
							RFT-L	0.3	same as above												1124	0.310
					NMN-L	0.3	same as above														3846	0.244
																					32258	0.101
			BA-BFZ	0.4	same as above														0.7	0.3	227	0.101
																					455	0.244
																					1000	0.310
																					2941	0.244
																					21277	0.101
All out except RFT	0.05	RFT	NA		NA		RFT-S	0.7	13	0.4	7.8	0.167	Intervals	1.0	2000 BC and 1000 AD	1.0	Poisson	1.0	NA		769	0.101
																					1389	0.244
																					2381	0.310
																					4545	0.244
																					12500	0.101
											7.7	0.167	same as above									
											7.8	0.25										
											7.4	0.085										
											7.3	0.25										
											7.1	0.085										
									15	0.4	same as above											
									17	0.2												
							RFT-L	0.3	same as above													
All Out	0.05	None	Revert to background																			

Table 3
RLME (Fault) Sources Incorporated Into Analysis

Fault	Geometry	Style of Faulting[1]	Mmax (M)	Dip (deg)	Seismogenic Thickness (km)	Recurrence Data[2]	Recurrence Interval (yr)[3]
Reelfoot Rift - Eastern Rift Margin Fault (ERM)							
ERM-N	ERM-N (1.0)	SS	6.7 (0.3) 6.9 (0.3) 7.1 (0.3) 7.4 (0.1)	90	13 (0.3) 15 (0.5) 17 (0.2)	1 event in 12-35 kyr (0.9)	3448 6667 12500 25000 71429
						2 events in 12-35 kyr (0.1)	2564 4545 7692 13889 31250
ERM-S	ERM-SCC (0.6)	SS	6.7 (0.15) 6.9 (0.2) 7.1 (0.2) 7.3 (0.2) 7.5 (0.2) 7.7 (0.05)	90	same as above	2 events in 17.7-21.7 kyr (0.333)	2857 4762 7143 12500 27778
						3 events in 17.7-21.7 kyr (0.334)	2326 3571 5263 8333 16129
						4 events in 17.7-21.7 kyr (0.333)	2000 2941 4167 6250 11111
	ERM-SRP (0.4)	same as above	same as above	same as above	same as above	same as above	same as above
Reelfoot Rift-Marianna In cluster (0.5) [Out of cluster (0.5) - default to background]	Marianna NW-strike (0.5)	SS	6.7 (0.15) 6.9 (0.2) 7.1 (0.2) 7.3 (0.2) 7.5 (0.2) 7.7 (0.05)	90	13 (0.3) 15 (0.5) 17 (0.2)	3 events in 9.6-10.2 kyr	1449 2381 3704 6250 13889
						4 events in 9.6-10.2 kyr	1190 1818 2703 4167 8333
	Marianna NE-strike (0.5)	same as above	same as above	same as above	same as above	same as above	same as above

Fault	Geometry	Style of Faulting[1]	Mmax (M)	Dip (deg)	Seismogenic Thickness (km)	Recurrence Data[2]	Recurrence Interval (yr)[3]
Reelfoot Rift - Commerce Fault Zone	Commerce fault (1.0)	SS	6.7 (0.15) 6.9 (0.35) 7.1 (0.35) 7.3 (0.1) 7.7 (0.05)	90	13 (0.3) 15 (0.5) 17 (0.2)	2 events in 18.9-23.6 kyr	4000 7143 12500 25000 71429
						3 events in 18.9-23.6 kyr	3030 5000 7692 13158 29412
Wabash Valley	Wabash Valley zone (1.0)	SS	6.75 (0.05) 7 (0.25) 7.25 (0.35) 7.5 (0.35)	90		2 events in 11-13 kyr	2273 4000 7143 13889 41667
Charleston	Local (0.5)	SS	6.7 (0.1) 6.9 (0.25) 7.1 (0.3) 7.3 (0.25) 7.5 (0.1)	90	13 (0.4) 17 (0.4) 22 (0.2)	2,000-yr record (0.8) 4 events in 2 kyr (1.0)	213 323 476 769 1471
						5,500-yr record (0.2) 4 events in 5.5 kyr (0.2)	213 323 476 769 1471
						5 events in 5.5 kyr (0.3)	370 526 769 1136 2000
						5 events in 5.5 kyr (0.2)	526 769 1086 1562 2941
						6 events in 5.5 kyr (0.3)	455 667 909 1282 2174
	Narrow (0.3)	SS	same as above	90	same as above	same as above	same as above
	Regional (0.2)	SS	same as above	90	same as above	same as above	same as above
New Madrid Fault System (NMFS)	see Table 2						

Note: Values in parentheses are weights. All faults are modeled with the Characteristic recurrence model

[1] SS Strike-slip

[2] "Recurrence Data" describes datasets used to calculate recurrence intervals.

[3] Weights for all distributions are: 0.101/0.244/0.310/0.244/0.101.

The largest earthquakes in the IBEB zone include an August 1891 **M** 5.5 event, a September 1891 **M** 5.0 event in eastern Nebraska, and a 2008 **M** 5.3 event. Four prehistoric earthquakes inferred from the paleoliquefaction studies have estimated magnitudes (**M** 6.2 to 6.3) that are larger than the historical earthquakes (EPRI/DOE/NRC, 2012). Maximum magnitudes modeled in the IBEB range from **M** 6.5 to 8.1, with a value of **M** 7.4 being preferred.

Reelfoot Rift Zone (RR)

The Reelfoot Rift (RR) is a north-northeast-trending major crustal rift located within the Mississippi Embayment of the south-central United States (Figure 11). The RR originally formed in late Precambrian to early Paleozoic time during the breakup of Rodinia and Iapetan rifting (Bond *et al*., 1971; Hildenbrand, 1985; Thomas, 2006), but experienced middle to late Paleozoic uplift and Mesozoic extension and deposition (Kolata and Nelson, 1991). Geologic evidence for faulting from post-Cretaceous to Holocene time in the RR and adjacent areas includes shallow seismic reflection data (Koffi *et al*., 1997; Schweig and Van Arsdale, 1996; Sexton *et al*., 1996); faulting and fault-related deformation exposed in exploratory trenches (Kelson *et al*., 1996); and regional paleoliquefaction features (Tuttle and Schweig, 1995; Tuttle *et al*., 1996a and 1996b; Tuttle and Schweig, 1996; Wolf *et al*., 1996).

The RR zone contains several RLME sources in the EPRI/DOE/NRC source model, including the New Madrid fault system, the Eastern Rift Margin (ERM), Marianna zone (MAR), and Commerce fault zone (CFZ) (Figure 6). The NMFS is discussed in detail in Section 4.1.4 because of its relatively high rate of activity.

The RR zone is characterized by having experienced Mesozoic extension and having a higher rate of seismicity than the surrounding MidC cratonic seismotectonic zone, as well as containing a unique concentration of Quaternary active faults. The RR zone has two alternative geometries, based on inclusion or exclusion of the east-west-trending Rough Creek graben. The Rough Creek graben was formed as part of the late Proterozoic-Cambrian Iapetan intracontinental rifting episode that created the RR. Some structures may have been reactivated during the Appalachian-Ouachita Orogeny (Kolata and Nelson, 1991) like the RR. However, due to the lack of associated igneous rocks, Wheeler (1997) infers that deeply penetrating faults were not reactivated. This coupled with the different strike of the major faults in the RCG compared to those in the RR leads EPRI/DOE/NRC (2012) to put lower weight (0.33) on the combined RR-RCG zone; rather, they prefer to include the RCG in the MidC zone.

The largest historical earthquakes in the RR zone are the 1811-1812 **M** 7.5 to 8 events, which are included in the characterization of the NMFS RLME (Figure 6). Large magnitude paleoseismic events are also included in nearby RLME characterizations. The largest non-RLME historical earthquakes include two approximately **M** 6 events in 1843 and 1895. The Mmax distribution for the RR zone ranges from **M** 6.1 to **M** 8.1, with a preferred value of **M** 7.1 (Table 1). Seismogenic depth in the RR zone, based on seismicity, ranges from 13 to 17 km.

Midcontinent-Craton Zone (MidC)

The MidC zone occupies most of the CEUS study area, dominating the central United States and encompassing most of the Great Plains area (Figure 11). The MidC zone includes those regions of the continent that have not occupied the Phanerozoic continental margin, specifically

Precambrian basement rocks of the Canadian shield and the platform (EPRI/DOE/NRC, 2012). The craton was formed by Paleoproterozoic accretion and now forms a cold, strong crustal core to the continent. Two orthogonal sets of structures, northeast-striking ductile shear zones and northwest-striking brittle-ductile faults dominate the Precambrian basement structure (Sims *et al*., 2005). Numerous geophysical anomalies have been observed within the MidC zone and may represent zones of crustal weakness that could localize future seismicity. Seismicity in the MidC zone is spatially variable and includes a few concentrations of activity that constitute seismic zones within the greater seismotectonic zone, such as the Anna seismic zone and Northeast Ohio seismic zone in Ohio, and the Nehama Ridge seismic zone in Kansas.

The fundamental distinguishing characteristic of the MidC zone is that it contains crust that has not experienced Mesozoic or younger extension, and generally not Paleozoic extension either. The characterization of the seismotectonic zone includes four alternative geometries, based on the inclusion or exclusion of smaller Mid-Continent regions. These smaller zones include a northeast-trending band of crust along the Appalachian Mountains that is included either within the PEZ or within the MidC zone, and the Rough Creek Graben, which is included either in the RR or in the MidC zone (Figure 11).

The largest earthquakes in the MidC zone include a 1909 **M** 5.7 event in eastern Montana, an 1877 **M** 5.5 event in eastern Nebraska, and a 1964 **M** 4.8 earthquake in eastern Ontario. Maximum magnitudes have a broader distribution in the MidC than most other seismotectonic zones, ranging from **M** 5.6 to 8.0, with a value of **M** 6.6 being preferred.

Few data exist to characterize independently the deep Precambrian structures within the intracratonic MidC region on which future earthquakes might be preferentially located. Thus the characterization of the MidC region is equivalent to what EPRI/DOE/NRC (2012) calls the "default" seismotectonic characteristics, representative of the entire study region. Thus both strike-slip and reverse mechanisms are included, with a 2/3 weight on strike-slip, reflecting the occurrence of both mechanisms in focal mechanism data, the state of stress, and the orientation of existing geologic structures in the region. Strikes include northwest, north-south, northeast and east-west orientations, determined based on focal mechanism data, tectonic stress, and structural grain within the study area. The dips are generalized based on sense of slip, with strike-slip ruptures assigned steep dips between 60° and 90° and reverse ruptures assigned moderate dips between 30° and 60°. Seismogenic thickness ranges from 13 to 22 km.

4.1.2 Mmax Zones

The Mmax zones are based on the observation that within the global catalogue of earthquakes within stable continental regions, there is little to distinguish any of them in a statistically significant way except that larger earthquakes seem to occur more commonly within those parts of the stable continental regions that have undergone extension, especially Mesozoic or younger extension (Johnston *et al*., 1994). Consequently, the zonation model is based on using global analogues to characterize the maximum magnitudes, with regions divided into extended and cratonic categories, each with a different distribution of maximum magnitudes. We adopt the zone boundaries and maximum magnitude distribution of EPRI/DOE/NRC (2012). The maximum magnitude distributions are used for the background seismicity.

The EPRI/DOE/NRC statistical analysis of the global database of earthquakes in stable continental regions (SCR) showed that the distinction between Mesozoic extended crust and non-extended crust noted by Johnston *et al*. (1994), while present, is only marginally significant. Therefore, within the Mmax zonation approach, two models are included: 1) the CEUS is divided into two Mmax zones, each with its own Mmax distribution, based on the presence or absence of Mesozoic-extended crust, and 2) the CEUS can be described by a single Mmax zone with a single Mmax distribution (Figure 12). The former model has slightly higher weight because of the marginally significant difference observed in the statistical analyses.

Mesozoic and Younger Extended Crust (MESE)

The Mesozoic extended zone (MESE) includes areas that underwent Paleozoic and Mesozoic or younger extension and includes the Atlantic and Gulf coastal regions as well as the failed rifts in the central U.S. (including the RR and southern Oklahoma aulocogen) (Figure 12). The site is located within the MESE-W and the NMESE-N (Figure 12).

Non-Mesozoic and Younger Extended Crust (NMESE)

The Non-Mesozoic and Younger extended crust (NMESE) includes that part of the CEUS stable continental region that has not undergone Mesozoic or younger extension. This includes primarily interior cratonic regions and overlaps significantly with the MidC seismotectonic zone (Figure 12).

The boundaries between the extended and non-extended Mmax zones have two alternatives, reflecting uncertainty in the geographic extent of extended crust (Figure 12). The MESE-N (N = “narrow”) zone includes regions that have definitively experienced Mesozoic extension as inferred based on the presence of certain distinguishing characteristics. These may include: Mesozoic grabens and rift basins, Mesozoic and younger plutons, Mesozoic and younger uplift and unroofing associated with normal faulting (EPRI/DOE/NRC, 2012). Generally, regions that meet most of these criteria are considered to be extended and are assigned to the MESE-N zone. Regions with less compelling evidence, such as localized Mesozoic and younger reactivation of older structures or the presence of structures favorably oriented for reactivation, are less certainly extended and are assigned to the MESE-W (W = “wide”) zone. The NMESE-N and NMESE-W zones include the rest of the CEUS region outside the MESE-N and MESE-W zones, respectively (Figure 12). The narrow boundary, dividing definitively extended crust from the rest of the craton receives most of the weight (0.8) due to the lack of clear evidence for extension in the MESE-W zone.

The narrow and wide geometry for each zone has its own maximum magnitude distribution for this region, based on the largest historical earthquake known in each zone. These appear in Table 1 (Table 6.3.2-1 in EPRI/DOE/NRC, 2012).

Study Region

The single-zone alternative of the Mmax zone model includes the Study Region (StudyR) source zone (Figure 12), which encompasses the entire study area, which is represented by a single Mmax distribution. The distributions for seismogenic depth and Mmax for this zone appear in Table 1.

4.1.3 Recurrence for Seismic Zonation

The CEUS-SSC model is based on the spatial stationarity of seismicity, which is defined from small- to moderate-magnitude earthquakes that have occurred during a relatively short historical and instrumental record (EPRI/DOE/NRC, 2012).

For the seismotectonic and Mmax source zones, the seismicity rates are determined from the historical seismicity catalog. All dependent earthquakes were removed from the catalog, and earthquakes associated with the RLME sources were also removed to avoid double-counting. The cell size for all seismotectonic source zones except MidC was 0.25 degrees; the cell size for MidC was set to 0.5 degrees. The spatial smoothing operation, a penalized-likelihood function, is based on calculations of earthquake recurrence within each cell. Both *a*- and *b*- values are allowed to vary, but the degree of variation has been optimized such that *b*-values vary little across the study region, and the *a*-values are neither too smooth or spikey. Also, the recurrence calculations consider weighting of magnitudes in the recurrence rate calculations, with moderate events assigned more weight than smaller events.

Five alternative cases were considered for weights, which affect the degree of smoothing, for various magnitude bins; Cases A, B, C, D, and E (EPRI/DOE/NRC, 2012). Case C was dropped as it is very similar to Case B, and Case D was considered too extreme. Thus for each source zone three magnitude weighted cases were used: A, B, and E, with weights of 0.3, 0.3, and 0.4, respectively.

Furthermore, more than point estimates of the recurrence parameters are needed as modern PSHA requires an assessment of the epistemic uncertainty associated with these estimates, including correlations between the recurrence parameters of cells in the same geographical region, which may jointly affect the hazard at one site. The approach used to generate alternative maps of the recurrence parameters uses a technique known as Markov Chain Monte Carlo (MCMC) (EPRI/DOE/NRC, 2012).

This resulted in eight alternative maps representing the uncertainty in recurrence parameters that result from the limited duration of the catalog. If the smoothing parameters are treated as uncertain and estimated objectively from the data, the eight alternative maps also include the uncertainty about the appropriate values of the smoothing parameters. The eight realizations are equally weighted. For computational efficiency, the mean of the eight realizations was utilized in these calculations.

4.1.4 RLME

The following describes the Wabash Valley and New Madrid fault system RLMEs, which are the most significant RLMEs to the site.

Wabash Valley Fault Zone

The north-northeast-trending Wabash Valley fault system (WVFS) consists of numerous high-angle oblique-slip faults that comprise a broad 80-km-long zone located within the limits of the Grayville graben. The Wabash Valley RLME as defined in the CEUS-SSC model is significantly longer than the WVFS proper and extends north to include the Vincennes, Indiana area (Figures 6 and 11). The Grayville graben formed during Iapetan rifting (Hildenbrand and Ravat, 1997;

EPRI/DOE/NRC, 2012). Direct evidence for neotectonic activity, including exposures of Quaternary displacement, was documented along the WVFS by Woolery (2005). He interpreted offset of a reflector, identified as a late Quaternary (ca 37,000 years old) sand, revealed in high-resolution seismic reflection profiles as due to displacement across the Hovey Lake fault at the south end of the WVFS. More recent work by Counts *et al*. (2009) and Van Arsdale *et al*. (2009) has identified Holocene deformation across the Uniontown scarp, part of the Hovey Lake fault. Van Arsdale *et al*. (2009) excavated a trench exposing 3500-year-old Ohio River alluvium that had been folded in a monocline with a 3-m amplitude, and also observed fractures within a younger unit that indicate possible activity within the last 295 years. For the most part, activity of the WVFS is indicated by historical seismicity and the aforementioned paleoliquefaction features. The historic seismicity includes five slightly damaging earthquakes of body-wave magnitude (mb) 5.0 to 5.8 during 200 years of historical time (Figure 4).

The maximum magnitude estimates adopted from the EPRI/DOE/NRC (2012) CEUS source characterization of the Wabash Valley RLME are based on analysis of paleoliquefaction features in the vicinity of the lower Wabash Valley of southern Illinois and Indiana. The magnitude of the largest paleoearthquake in the lower Wabash Valley (the Vincennes-Bridgeport earthquake), which occurred 6,011 ± 200 yr BP, was estimated to be ≥ **M** 7.5 using the magnitude-bound method (Obermeier, 1998). Use of a more recently developed magnitude-bound curve for the CEUS gives a lower estimate of **M** 7.1 to 7.3 (Olsen *et al*. (2005). The lower-bound relationship developed by Castilla and Audermard (2007) from a worldwide database gives a range of **M** 7.0 to 7.3. Estimates based on a suite of geotechnical analyses (cyclic stress and energy stress methods) range from **M** 7.5 to 7.8 (summarized in Obermeier *et al*., 1993). The next largest earthquake, the Skelton paleoearthquake, occurred 12,000 ± 1,000 yr BP (Obermeier, 1998). Lower and upperbound magnitude range from **M** 6.3 to 7.3 based on estimates by Munson *et al*. 1997, Olsen *et al*., 2005 and Castilla and Audemard (2007). The magnitude distribution of the EPRI/DOE/NRC (2012) CEUS source model (Table 3) incorporates the range of estimated sizes of the Vincennes-Bridgeport and Skelton paleoearthquakes as representative of both the aleatory variability in the size of individual Wabash Valley RLMEs and the epistemic uncertainty in the approaches and data used to estimate the magnitudes of prehistoric earthquakes.

The recurrence rates for the Wabash Valley RLME (Table 3) are based on the estimated ages for the Vincennes-Bridgeport and Skeleton paleoearthquakes using a Poisson model (EPRI/DOE/NRC, 2012).

New Madrid Fault System (NMFS) RLME

The New Madrid Seismic Zone (NMSZ) is the most likely site of the 1811-1812 New Madrid earthquake sequence, which includes three of the largest earthquakes to have occurred within the North American plate in historical times (Johnston and Shedlock, 1992) (Figure 6). The pattern of seismicity and surface uplift is generally interpreted as delineating a left-stepping, right-lateral, strike-slip fault system (Cox *et al*., 2001; Johnston and Schweig, 1996). Johnston and Schweig (1996) developed faulting models for the 1811-1812 sequence based on geological, geophysical, seismological, and historical data. They concur with the commonly held assumption that the current seismicity is illuminating the most active faults; i.e., those that ruptured in 1811–1812 and also prior to 1811.

Schweig and Ellis (1994) and Johnston and Schweig (1996) provide summaries of the seismological, geodetic, and paleoseismologic data that have been used to assess the repeat times of large-magnitude events in the New Madrid region. In addition, Wheeler and Perkins (2000) provide additional information from the 2002 USGS National Hazard Maps for the CEUS. Correlation of dated liquefaction features suggest that widespread liquefaction occurred within the zone in A.D. 1811-1812, 1450, 900, 300 as well as about 2350 B.C. (Tuttle *et al*., 2005). Liquefaction deposits can constrain the ages of prehistoric events but not the causative faults. However, several of the prehistoric liquefaction deposits are composite, indicating they were formed in multiple episodes within a short period and thus may have occurred in a rapid sequence of large earthquakes similar to the 1811-1812 sequence.

The occurrence of two large events in A.D. ~900 and 2500-1400 B.C. is supported by recent studies of Mississippi River channel morphology that suggest that the Mississippi River changed its course in response to a sudden localized change in base level at those times (Holbrook *et al*., 2006). That change in base level is attributed to uplift of the downstream side of the channel across the Reelfoot reverse fault (described below).

These paleoseismic results indicate a recurrence interval of about 500 years for large earthquakes or earthquake sequences in the NMSZ over the past 2,000 years. The absence of paleoseismic evidence for earthquakes between 300 A.D. and 2200-2350 B.C. has been cited as indicative of temporal clustering of earthquakes in the NMSZ, with large earthquakes or earthquake sequences happening every few hundred years over a period of time followed by a long hiatus in activity (Holbrook *et al*., 2006). However, at this point it remains uncertain if the lack of events documented between A.D. 300 and 2200 B.C. in New Madrid is due to clustering or an incomplete paleoseismic record.

The possibly clustered behavior in the NMSZ, coupled with the discovery of paleoliquefaction features in the Reelfoot Rift southwest of the New Madrid zone (indicative of large earthquakes between about 5,000 and 7,000 years ago but not during the New Madrid cycles), has led to the suggestion that the locus of earthquake activity moves around the Reelfoot Rift on time scales of 5 to 15 kyr. In this model, the New Madrid region is the current, or most recent, locus of activity, but other areas have been so in the past, and the locus may shift again.

In the seismic source model, the elevated seismicity in the NMSZ is included in the RR seismotectonic zone, whereas large historical and paleoseismic events that likely occurred on the structures that ruptured in 1811-1812 are modeled as part of the NMFS RLME, in keeping with the CEUS-SSC model. The source zone accommodates the hazard from background seismicity; the NMFS contributes an additional hazard (Tables 1 and 2). In the seismic source model, the NMFS comprises three distinct fault zones, located within the NMSZ source zone (Figure 6). The three NMFS faults, defined after the models of Van Arsdale (2000) and Johnston and Schwieg (1996), include: 1) the southern section (NMS), comprising the Blytheville arch (BA), extending into the Blytheville fault zone (BFZ) and Bootheel lineament (BL) area, 2) the central section, comprising the Reelfoot reverse fault (RFT), and 3) the northern section, comprising the New Madrid North fault and the Northwestern Seismicity Arm (NMN) (Figure 6; Table 2). Each of these sections ruptured to produce the 1811 and 1812 earthquakes.

The faults of the NMFS are defined primarily based on concentrations of seismicity as geomorphic expression of faulting is poor; only the Reelfoot reverse fault is well expressed as a definitively tectonic feature. Several different geologic faults have been postulated as the source of the events but there remains considerable uncertainty in defining the causative faults. The southern and northern sections of the fault system are northeast-striking features that are probably ancient faults related to rifting that have been reactivated in the modern stress regime as primarily right-lateral strike-slip faults. Focal mechanisms from these areas are consistent with predominantly dextral motion. The Reelfoot reverse fault strikes northwest and dips southwest; earthquakes associated with it have a variety of focal mechanisms. The fault has been described as a cross-structure in a compressional left step between right-lateral strike-slip faults.

Van Arsdale (2000) reports that the first of the 1811 and 1812 earthquakes, the NM1 event in December 1811, occurred on the southern section (NMS), which extends about 110 km from northeastern Arkansas to the southeastern bootheel of Missouri (EOI, 2008). The rupture occurred along the Blytheville arch, a 10 to 15-km wide northeast-trending Paleozoic upwarp that lies along the axis of the Reelfoot Rift, and extended northeast of the arch proper. Van Arsdale (2000) considers that the event may have resulted from rupture of the 65-km long, steeply dipping to vertical, dextral-oblique Cottonwood Grove-Ridgely fault. Johnston and Schweig (1996) assign the northern extension of the rupture to the Blytheville fault, a 55-km long structure that continues on trend with the Blytheville arch and lies about 4 km east of the Cottonwood Grove fault. However, they suggest the Blytheville fault and the Cottonwood Grove fault may be essentially the same structure.

Johnston and Schweig (1996) propose two alternative rupture scenarios for the December earthquake: (1) the Blytheville Arch region ruptured along with its extension to the northeast, the Blytheville fault (NMS: BA-BFZ) and (2) the Blytheville Arch ruptured, but the rupture branched onto the Bootheel lineament and ruptured the northernmost 70 km of that structure (NMS: BA-BL) (Figure 6). In each scenario, the structure that did not rupture in the main event was the source of one of more of the large aftershocks, which have been proposed as smaller mainshocks (Johnston and Schweig, 1996). In other words, the Bootheel lineament and Blytheville fault sustained the aftershocks in the first and second scenarios, respectively.

The second mainshock of the New Madrid 1811-1812 sequence was the NM2 earthquake, in January 1812, on the northern margin of the fault system (NMN; Figure 6). The source of this event is also uncertain. The region is delineated by a line of seismicity, the Northwestern Seismicity Arm. Concentrated seismicity extends about 40 km, with more sparse seismicity extending another 20 km to near the Illinois border. This seismicity has been postulated to be correlated with the New Madrid North fault (sometimes the East Prairie fault), which has been seen in the subsurface, geomorphically, and in trench exposures (Baldwin *et al*., 2005; Johnston and Schweig, 1996). That fault is at least 30 km long; the seismicity extends beyond the known fault. Wheeler (1997) postulated that the structure continued still farther north to merge with the Rough Creek graben in western Kentucky; he considered this extent, about 100 km, to be the maximum extent of Reelfoot Rift faults. There is little in the sparse distribution of seismicity and lack of significant Quaternary faulting in the northern extent to support that assertion, and based on surface and subsurface expression as well as focal mechanisms, this fault is likely a steeply dipping dextral fault (DTEE, 2011).

The last of the three 1811-1812 mainshocks, NM3, occurred in February 1812, on the central section, the Reelfoot reverse fault (RFT), the proposed cross-structure in a compressional step-over between the dextral southern and northern sections of the system (Figure 6). The Reelfoot fault is a south-dipping blind reverse fault that has a dip that varies laterally and down dip. The dip can be as steep as 45°-75° in the upper few kilometers and as shallow as 25°-30° at depth (Mueller and Pujol 2001; Csontos and Van Arsdale, 2008). This fault is well-expressed geomorphically with a pronounced scarp, but its extent is also uncertain because seismicity extends beyond the scarp in both directions, beyond the strike-slip faults of the postulated stepover. Johnston and Schweig (1996) define three distinct fault segments: (1) the central Reelfoot fault, defined by its mapped surface extent of about 32 km (Van Arsdale *et al*., 1995); (2) the Reelfoot South seismicity trend, extending 35 km east of the Reelfoot fault; and (3) the New Madrid West seismicity trend, extending about 40 km west of the Reelfoot fault. Their proposed rupture scenarios include rupture of the Reelfoot fault with one or the other of the flanking seismicity trends in the NM3 mainshock.

The third event may have served to accommodate the strain produced by the previous two bounding events (Van Arsdale, 2000). Van Arsdale (2000) also suggests that this sequence of multiple, temporally-clustered events may not be unusual for the NMFS. He cites evidence from subsurface analyses that suggests that these three faults may have identical displacement histories since the Late Cretaceous. Thus, he suggests that the paleoseismic history for the Reelfoot reverse fault can serve as a proxy for the other two faults. Trench exposures of the Reelfoot reverse fault indicate that deformation occurs primarily as folding rather than faulting at the surface and that the structure has experienced at least three earthquakes in the past 2400 years at times consistent with those determined from regional paleoliquefaction studies (Kelson *et al*., 1996). This interpretation is supported by paleoliquefaction studies, which indicate that large magnitude earthquakes on the faults of the New Madrid system have occurred in clusters like those of 1811-1812 (e.g., Tuttle *et al*., 2002; 2005).

There is significant uncertainty regarding the exact identification and geometry of the faults that ruptured in the 1811-1812 and earlier earthquakes, and some models of rupture (e.g., EPRI/DOE/NRC, 2012; STNOC 2011; USNRC, 2006) include weighted alternative geometries for each of the three faults. We adopt the characterization of EPRI/DOE/NRC (2012; Table 2). We include two alternative geometries for the northern extent of the southern section, the Blytheville fault zone (NMS: BA-BL), weighted 0.4, and the Bootheel Lineament (NMS: BA-BFZ), weighted 0.6. For the central and northern sections, we include two alternatives: short and long (RFT-S, RFT-L, NMN-S, NMN-L). The short central section (RFT-S) includes only that part of the Reelfoot reverse fault that is defined by the Reelfoot scarp and extends from the Blytheville fault to the New Madrid North fault; the long alternative (RFT-L) extends both east and west, based on continued seismicity. The short alternative for the New Madrid north fault (NMN-S) is the fault as defined by Johnston and Schweig (1996); the long alternative (NMN-L) extends the source along northward continuations of seismicity identified by Wheeler (1997). Because the causative faults are not well understood, the dips are not well constrained. The northern and southern sections of the system are modeled as vertical. The Reelfoot reverse fault is modeled with a 40-degree southwest dip.

The EPRI/DOE/NRC (2012) characterization also addresses the apparent clustering of activity along the NMFS faults using the approach of Toro and Silva (2001). The rate of earthquakes and geomorphic expression of faulting on the RFT in the late Holocene suggests that the system is or has recently been in a cluster. However, geodetic data gathered over the last decade or so suggest that little or no interseismic deformation is occurring across the NMSZ, which some researchers have interpreted as evidence that the system is shutting down and entering an inter-cluster period of quiescence (e.g., Calais *et al*., 2005; Calais and Stein, 2009). The EPRI/DOE/NRC model strongly favors the interpretation that the system is currently in a cluster (0.9), based on the recent history of activity and the unlikelihood that we have just happened upon the exact moment the system is shutting down. However, they, and we, give some weight to two alternative models: 1) only the RFT is currently in a cluster, and the other faults are quiescent (0.5), and 2) the entire system is out of a cluster (0.5) (Table 3). In the former case, the RFT is active, but at a lower rate than the in-cluster case; in the latter case, no faults are active and the system defaults to the RR background zone characterization.

Considerable debate has gone on over the past several years regarding the magnitude of the 1811-1812 earthquakes and thus maximum magnitude estimates for source characterization. Most of the studies in which magnitudes have been inferred depend on assessments of intensities derived from felt reports documented in archival material. Since much of the area was lightly populated, there is considerable uncertainty in these estimations. These uncertainties are complicated by a lack of data for constraining attenuation relations for large magnitude earthquakes, which have not been instrumentally recorded in the central and eastern U.S., and poorly known site response effects. Early estimates by Nuttli (1973; 1979) included values of mb 7.2, 7.1 and 7.4 for the southern (NM1), northern (NM2), and central (NM3) earthquakes, respectively. Johnston (1996), using isoseismal area regression, estimated magnitudes of **M** 8.1, 7.8, and 8.0 for these events. Reexamining felt reports, Hough *et al*. (2000) estimated noticeably lower magnitudes of **M** 7.2 to 7.3, **M** 7.0, and **M** 7.4 to 7.5 for the NM1, NM2, and NM3 events, respectively. Bakun and Hopper (2004b) modeled intensities and determined magnitudes of **M** 7.6, 7.5, and 7.8 for the three earthquakes. More recently, Hough and Page (2011) have reduced estimates even further using intensities and consideration of low regional strain rates with a model of postglacial rebound. Their preferred magnitudes are **M** 6.7 to 6.9, **M** 6.8 to 7.0, and **M** 7.1 to 7.3 for NM1, NM2, and NM3, respectively, with the different values dependent on models of earthquake recurrence and strain accumulation and release. However, these low magnitudes are not universally accepted. Holzer *et al*. (2011) argue that magnitudes must be mid-**M** 7s, not less than **M** 7, based on magnitude and extent of liquefaction deposits. Cramer and Boyd (2011) compare the earthquake intensities in New Madrid with those of the 1929 **M** 7.2 Grand Banks earthquake and argue that NM1 and NM3 must be larger than Grand Banks and NM2 comparable in size. They conclude that the New Madrid earthquakes are best fit with magnitudes between **M** 7 and 8. Cramer also used the 2001 Bhuj earthquake to compare to New Madrid; those comparisons yield preferred values for the New Madrid magnitudes of about **M** 7.6, 7.2 to 7.6, and about **M** 7.6 (NEPEC, 2011).

Several recent hazard analyses have developed source characterizations for the New Madrid faults. The USGS National Seismic Hazard Maps (Petersen *et al*., 2008) compiled recent data to develop a model with lower weighted mean magnitudes for the faults than in previous models, and with a recurrence model reflecting possibly clustered timing of events. Their magnitudes range from **M** 7.3 to 8.0 for the southern and central sections, with a preferred magnitude of **M** 7.7 and weighted mean of **M** 7.6, and from **M** 7.1 to 7.8 for the northern section, with a preferred value of **M** 7.5 and weighted mean of **M** 7.4. Models developed for the Site Safety Analysis for Exelon Generation Company in Illinois (USNRC, 2006) include a lower magnitude distribution, with **M** 7.2 to 7.9 (weighted mean **M** 7.5), **M** 7.4 to 7.8 (weighted mean of **M** 7.6), and **M** 7.0 to 7.6 (weighted mean of **M** 7.3) for the southern, central, and northern faults, respectively.

EPRI/DOE/NRC (2012) include distributions for the NMS, RFT, and NMN sections of the NMFS of **M** 6.7 to 7.9, **M** 7.1 to 7.8, and **M** 6.8 to 7.6, respectively. In our model, we adopt the EPRI/DOE/NRC distribution of maximum magnitudes. The preferred values and weighted means are similar to those developed in the nuclear studies described above.

4.2 EPRI GROUND MOTION PREDICTION MODELS

Several factors control the level and character of earthquake ground shaking. These factors are in general: (1) rupture dimensions, geometry, and orientation of the causative fault; (2) distance from the causative fault; (3) magnitude of the earthquake; (4) the rate of attenuation of the seismic waves along the propagation path from the source to site; and (5) site factors, including the effects of near-surface geology, particularly from soils and unconsolidated sediments. Other factors, which vary in their significance depending on specific conditions, include slip distribution along the fault, rupture process, footwall/hanging-wall effects, and the effects of crustal structure such as basin effects.

Several parameters may be used to characterize earthquake ground motions. The common parameters include: peak ground acceleration, velocity, and displacement; response spectral accelerations or velocities, duration, and time histories in acceleration, velocity, or displacement. In this analysis, we have estimated peak horizontal ground acceleration (PGA) and horizontal spectral accelerations (SA) at 0.04, 0.1, 0.2, 0.4, 1.0, and 2.0 sec.

Crustal ground motion prediction models for tectonically active regions like the western U.S. are empirical in nature and derived from strong motion data from such areas as California, Taiwan, Japan, and Italy. In contrast, few useable strong motion records exist for earthquakes in the Central and Eastern North America (CENA). Thus ground motion prediction models for the CENA have been developed, in large part, using seismological-based numerical models. During the past decade, ground motion models for the CENA have been derived using three different approaches: the stochastic method, the Green's function method, and the complex/empirical source method.

Recent efforts have been made to update the ground motion models for the CENA. One project is called the Next Generation of Attenuation (NGA) – East sponsored by Pacific Earthquake Engineering Research (PEER) Center. The objective of the project is to develop a new suite of ground motion prediction model for the CENA. The median ground motion models were just released but no standard deviations for the models were specified. There are 20 new NGA-East models and we expect it will be several months before the models become vetted.

In a second project, EPRI (2013) updated the 2004/2006 EPRI models in the near-term so that preliminary Ground Motion Response Spectra (GMRS) could be developed for existing nuclear power plant sites as required by the NRC's Recommendation 2.1 pending completion of the NGA East Project. The models were used in this study. The EPRI Ground-Motion Model (GMM) Review Project (EPRI, 2013), an enhanced SSHAC Level 2 assessment process, established a methodology to evaluate the existing 2004 EPRI GMM and determine if it should be updated. After reviewing the current literature and conducting interviews and convening a workshop with ground-motion experts and seismologists it was decided to update the 2004 GMM because (1) seven of the thirteen developers of the 2004 EPRI GMM recommended that their models be replaced; (2) three new models have been developed for the CENA by ground-motion experts; (3) 80% of the earthquake records in a new ground-motion database provided by the NGA-East Project are from earthquakes that occurred after the development of the 2004 EPRI GMM; (4) comparisons to the updated CENA database indicate the 2004 EPRI GMM overpredicts ground motions at some magnitude-distance and structural frequency ranges that are important to nuclear power plant PSHA; and (5) the models used to develop the aleatory portion of the 2006 EPRI GMM have been superseded.

The 2013 EPRI GMM retains the structure of the 2004 EPRI GMM, grouping the candidate individual models into four clusters according to their seismological characteristics, weighting the models within each cluster according to their consistency with the data, representing each cluster by three fitted relationships (5^{th} percentile, median, and 95^{th} percentile), and assessing cluster weights based on consistency with observed data and seismological attributes of the models within each cluster. The GMM Review Project identified new candidate models for the updated GMM clusters, models and weights, as shown in Table 4; a summary of the overall elements of the model are listed in Table 5.

For reference, the ground motion prediction models used by the USGS to develop the 2014 National Seismic Hazard Maps include Toro *et al.* (1997), Frankel *et al.* (1996), Silva *et al.* (2002), Atkinson and Boore (2006), Atkinson (2008), Campbell (2003), Tavakoli and Pezeshk (2005), Pezeshk *et al.* (2011), and Somerville *et al*. (2001). The versions of Atkinson and Boore (2006) and Atkinson (2008) in the EPRI study have been updated with Atkinson and Boore (2011). All the ground motion prediction models are for hard rock characterized by a time-averaged shear-wave (V_S) in the top 30 m (V_S30) of 2,800 m/sec. There are no vetted CENA GMMs for soil at present.

Comparisons indicate that the 2013 GMM is somewhat lower than 2004 EPRI GMM when the two models are taken as a whole, but these differences are moderate, given the broad uncertainty range spanned by both GMMs. The greater differences occur at low frequencies. For PGA the bulk of the curves are consistent between the two GMMs. In addition, there is a substantial overlap in the 10 to 200 km range indicating that the updated GMM does not represent a radical departure from the 2004 EPRI GMM. The observed differences are the result of possessing and using substantially more data and having acquired additional insights from other regions over a period of nearly 10 years.

The 2006 EPRI model for aleatory uncertainty (sigma) was based on preliminary NGA-West1 models for sigma from active tectonic regions, adjusted to account for differences in properties of the earth's crust between active (western North America [WNA]) and stable tectonic regions (i.e., CENA) (EPRI, 2006). The EPRI GMM Review Project updated the model to incorporate the nearly final NGA-West 2 aleatory models, with the same adjustments for differences between WNA and CENA. The updated sigma model is frequency and magnitude dependent, with inter-event and intra-event components. There is additional aleatory variability for distances of $R_{JB} < 20$ km. The updated aleatory variability model has higher values of total sigma than the 2006 EPRI model for **M** 5 earthquakes, and lower values for **M** 6 and 7 earthquakes for motions at 2.5 Hz and higher. At 1 Hz, the values of sigma are comparable in the two models and at 0.5 Hz, the updated GMM has slightly higher sigma than the 2006 EPRI model.

Table 4

EPRI (2013) GMM Clusters and Models

Cluster	Model Types and Cluster Weights (repeated large-magnitude earthquake sources/area earthquake sources)	Models
1	Single-corner Brune source (0.15/0.185)	Silva *et al*. (2002) – SC-CS-Sat[1] Silva *et al*. (2002) – SC-VS[1] Toro *et al*. (1997) Frankel et al. (1996)
2	Complex/Empirical Source ~R^{-1} geometrical spreading (0.31/0.383)	Silva *et al*. (2002) – DC-Sat Atkinson (2008) with 2011 modifications (A08′)
3	Complex/Empirical Source ~$R^{-1.3}$ geometrical spreading (0.35/0.432)	Atkinson-Boore (2006) with 2011 modifications (AB06′) Pezeshk *et al*. (2011)
4	Finite-source /Green's function (0.19/0)	Somerville *et al*. (2001); slightly different models for rifted and nonrifted (not used for distributed seismicity sources with large contribution from **M** < 6)

SC = single-corner; DC = double-corner; CS = constant stress; VS = variable stress; Sat = saturation.
[1] Treated as one model for calculation of weights.

Table 5

Elements of the CENA Ground Motion Models

Feature	Attribute
Ground Motion Measure	Peak ground acceleration Spectral acceleration at frequencies of 0.5, 1, 2.5, 5, 10, 25 Hz
Site Conditions	Hard rock (V_S 2.8 km/sec, 9200 ft/sec)
Regions	Midcontinent (includes east coast) Gulf Coast
Ground Motion Model Types	Four types included: • Single-corner Brune source • Complex/empirical source ~R^{-1} geometrical spreading • Complex/empirical source ~$R^{-1.3}$ geometrical spreading • Finite-source/Green’s function
Aleatory Variability	Magnitude and frequency dependent Includes additional variability for distances of R_{JB} < 20 km

4.3 SITE CONDITIONS

Subsurface investigations for the site have been limited to shallow soil borings in the upper Quaternary soils. Stratigraphic profiles for bedrock at the site were developed by researching available information which included data provided by Dynegy, geologic and mining reports, and various structural, isopach, lithofacies, and bedrock geology maps collected from the Illinois Geologic Survey (ISGS).

Specifically, the thickness of overlying soil (overburden) was determined from geotechnical soil borings completed by AECOM in 2015 and others (Hanson, 2007; 2008), drilled water well logs, and the nearest referenced 7.5 minute geologic quad maps (ISGS, 2011; USGS), when available. Bedrock stratigraphy was developed primarily using detailed cross-sections compiled by the ISGS utilizing data from drilled oil exploration wells (Treworgy and Whitaker, 1990; Treworgy *et al*., 1994). Based on the cross-sections, structural contours identified using the compiled topography of the Mt. Simon Sandstone (MGSC, 2005) were projected to the Coffeen site. The nearest oil exploration test hole along the contour interval was used to measure the thicknesses of bedrock units and the proper scaled thicknesses of bedrock units were then projected to the site. These thicknesses and projections were cross-checked using known depths to specific coal seams in Pennsylvanian bedrock, particularly the Herrin Coal, and matching the depth(s) to the information in the cross sections (Treworgy and Whitaker, 1990; Treworgy *et al*., 1994). Errors in estimates of bedrock thickness due to structural variations and map projection are likely in the range of 100 to 200 feet, and may compound with increasing depth or in areas of greater subsurface topography.

Site response analysis requires detailed information on subsurface stratigraphy and accurate representation of V_S characteristics for rock and soil. *In situ* measurements of V_S and deep exploration of bedrock at the Coffeen site were not within the scope of this project. A summary of V_S data from the Clinton Nuclear Power Station (130 km to the north) (Exelon, 2014) was used to correlate V_S for bedrock units at the site. Measurements at the Clinton site consisted of refraction, uphole, and downhole surveys as well as recent ESP measurements of unspecified proximity to the site. The measured velocities for lithofacies reported from the Clinton site were assigned to the same rock and soil units at the Coffeen site with thicknesses developed using the methods described above. Table 6 illustrates a set of estimated bedrock thicknesses and V_S for specific rock types at the site used to develop the V_S profile.

Based on Table 6, the mean basecase V_S profile used in the site response analysis (Section 6) was developed by combining layers of identical V_S (Figure 13). The mean value in the V_S ranges given in Table 6 were adopted in the mean basecase profile and the variability about that mean value was considered in developing the lower-range and upper-range basecase models.

Classification for site stratigraphy was based on the Clinton Nuclear Power Station report (Exelon, 2014), where rock groups were aggregated and classified according to geologic systems that each contain various rock types with thicknesses. Ranges for V_S are given to reflect the range of rocks included in each geologic system. In cases where weaker rock is thought to have an appreciable thickness that could affect the site response model, the layer was reported separately in the geologic system and assigned the lower range of values for V_S.

Table 6
V_S Profile

Formation Bottom Depth at Site* (ft)	Thickness of Unit/Formation at Site* (ft)	Age- System	Soil/Rock Description	Estimated V_S (ft/sec)[1]
0-13	13	**Quaternary**	EMBANKMENT FILL	600-1,200[2]
13-50	37		Illinoian TILL (Glasford Fm)	1100-3250
50-105	55		Pre-Illinoian TILL (Banner Fm)	1190-3310
105-650	545	**Pennsylvanian**	limestone, shale, sandstone, coal, and siltstone	3250-5700
650-1400	750	**Mississippian**	limestone, wlth lesser siltstone and shale	4500-6500
1400-1850	450		Siltstone[3]	4500[3]
1850-1950	100	**Devonian**	shale and limestone	4500-8500
1950-2400	450	**Silurian**	carbonates	4500-8500
2400-2550	150	**Ordovician**	shale, clacareous shales, and interbedded limestone	6500[3]
2550-3100	550		dolomite, sandstone, limestone and shales	6500-10500
3100-5400	2,300	**Cambrian**	siltstone, shale, sandstone and dolomite	6500-10500
>5400		**Precambrian**	igneous rocks, dominantly granite with associated granodiorite, rhyolite	> 9200

* Depths and thicknesses of bedrock statigraphic units are estimated from structural maps and cross-sections for the Illinois Basin (ISGS) and considered accurate within 200-400 ft

[1] V_S taken from Sesmic Hazard Screening Report data Clinton Station

[2] V_S value estimated from SPT blow count information in 2015 borings

[3] V_S estimated to be the lower bound limit of recorded velocity at Clinton Station

The results of the PSHA are presented in terms of ground motion for hard rock site conditions as a function of annual frequency of exceedance (AFE). AFE is the reciprocal of the average return period. Figure 14 shows the mean, median (50th percentile), 5th, 15th, 85th, and 95th percentile hazard curves for PGA. (PGA is defined as the 0.01 sec spectral acceleration.) These fractiles indicate the range of epistemic uncertainties about the mean hazard. The uncertainties are large due to both the large uncertainties in the ground motion prediction models and the source parameters of the controlling seismic source. The 1.0 sec horizontal spectral acceleration (SA) hazard is shown in Figure 15. The 2,500 year return period mean PGA is 0.19 g (Table 7).

The contributions of the various seismic sources to the mean PGA hazard are shown on Figure 16. The major contributors to the hazard at the site for a return period of 2,500 years are the IBEB zone in which the site is located and the NMFS RLME. The NMFS contributes up to 21 percent of the PGA hazard at 2,500-year return period with the background seismicity contributing 75 percent (Figure 17). At 1.0 sec SA, the NMFS RLME relative contribution increases up to 69 percent of the hazard at 2,500 years (Figures 18 and 19).

By deaggregating the PGA and 1.0 sec SA hazard by magnitude, distance and epsilon bins, we can illustrate the contributions by events at a return period of 2,500 years (Figures 20 and 21). Epsilon is the difference between the logarithm of the ground motion amplitude and the mean logarithm of ground motion (for that M and R) measured in units of the standard deviation (σ) of the logarithm of the ground motion. As shown on Figure 20, a majority of the PGA hazard at the site is coming from background events (**M** 5 to 6.5 within 50 km); the RLME also contributes to the PGA hazard. As shown on Figure 21, a majority of the 1.0 sec SA hazard at the site is coming from the NMFS RLME **M** 7.5 to 8.25 at 200 to 300 km with a small contribution from background events and from the Wabash Valley RLME.

The deaggregation shown in Figures 20 and 21 also provides the modal magnitude M*, modal distance D*, and modal epsilon ε*, which represent the largest contributor to the hazard at the defined return period. The M* and D* for the 2,500-year return period for PGA and 1.0 sec horizontal SA are listed in Table 8.

A horizontal Uniform Hazard Spectrum (UHS) on hard rock computed at 7 spectral periods for the 2,500-year return period is shown on Figure 22. A UHS shows the hazard across all periods for the same annual exceedance probability or return period. The SA hazard has been calculated at 0.01 (PGA), 0.04, 0.1, 0.2, 0.4, 1.0 and 2.0 sec. These are the spectral periods specified in the EPRI (2013) ground motion models.

Table 7

2,500-Year Return Period Mean UHS for Hard Rock

Period (sec)	SA (g)
0.01 (PGA)	0.185
0.04	0.380
0.10	0.322
0.20	0.225
0.40	0.147
1.00	0.071
2.00	0.041

Table 8

Modal M* and D* at 2,500-year Return Period

	M*	D*
PGA	5.1	12.5
1.0 Sec SA	7.9	275

The PSHA results are for hard rock and so we performed a site response analysis to adjust the ground motions to the ground surface. Traditionally in the estimation of site-specific probabilistic ground motions for a soil site, a rock ground motion is calculated and modified by deterministic site response analyses derived for the soil column to arrive at the ground motions at the soil surface. In doing so, the annual exceedance probability of that soil motion is generally unknown, varies with period, and may be of a higher probability than the control (rock) motion. If a risk analysis is desired, the surface motions must be hazard consistent, i.e., the annual exceedance probability of the soil ground motion should be the same as the rock ground motion.

In NUREG/CR-6728 (McGuire *et al.*, 2001), several site response approaches are recommended to produce soil motions consistent with the rock outcrop hazard. The approaches also incorporate the aleatory variabilities in the soil properties into the soil motions. McGuire *et al.* (2001) identified four basic approaches for determining the ground motions at a soil site. The approaches range from a PSHA using ground motion prediction models for the specific site (or location) of interest (Approach 4) to scaling the rock motion on the basis of a site response analysis using a broadband input motion (Approach 1). Conceptually, Approach 4 is the ideal approach and other approaches are approximations to it. However, Approach 4 is seldom used because rarely are data sufficient to develop site-specific ground motion models.

To compute the ground motions for the Coffeen Station site, we implemented Approach 3 as it is called (McGuire *et al.*, 2001; Bazzurro and Cornell, 2004). Approach 3 is a fully probabilistic analysis procedure which moves the site response, in an approximate way, into the hazard integral. The approach is described by Bazzurro and Cornell (2004) and NUREG/CR-6769 (McGuire *et al*., 2002). In this approach, the hazard at the surface is computed by integrating the site-specific hazard curve at generic rock or soil level with the probability distribution of the amplification factors (Lee *et al*., 1998; 1999). The site-specific amplification, relative to a reference rock, in this case hard rock, is characterized by a suite of frequency-dependent amplification factors that can account for nonlinearity in soil/rock response. Approach 3 involves approximations to the hazard integration using suites of transfer functions, which result in complete hazard curves at the ground surface for specific ground motion parameters (e.g., spectral accelerations) and a range of frequencies.

The basis for Approach 3 is a modification of the standard PSHA integration:

$$P[A_S > z] = \iiint P\left[AF > \frac{z}{a} \middle| m, r, a\right] f_{M,R|A}\,(m,r;a) f_A(a)\,dm\,dr\,da \qquad (6\text{-}1)$$

where A_S is the random ground-motion amplitude on soil at a certain natural frequency; z is a specific level of A_S; m is earthquake magnitude; r is distance; a is an amplitude level of the random rock ground motion, A, at the same frequency as A_S; $f_A(a)$ is derived from the rock hazard curve for this same frequency (namely it is the absolute value of its derivative); and $f_{M,R|A}$ is the deaggregated hazard (i.e., the joint distribution of M and R, given that the rock amplitude is level a). AF is an amplification factor defined as:

$$AF = A_S/a \qquad (6\text{-}2)$$

where AF is a random variable with a distribution that can be a function of m, r, and a. To accommodate epistemic uncertainties in site dynamic material properties, multiple suites of AF may be used and the resulting hazard curves combined with weights to properly reflect mean hazard and fractiles.

The ground surface response is controlled primarily by the level of rock motion and m, so Equation 6-1 can be approximated by:

$$P[A_S>z] = \int\int P[AF > \frac{z}{a}(m,a)]f_{M|A}(m;a)f_A(a)dmda \qquad (6\text{-}3)$$

where r is dropped because it has an insignificant effect in most applications (McGuire *et al.*, 2001). To implement Equation 6-3, only the conditional magnitude distribution for relevant amplitudes of a is needed. $f_{M|A}(m;a)$ can be represented (with successively less accuracy) by a continuous function, with three discrete values or with a single point, (e.g., $m^1(a)$, the mean magnitude given a). With the latter, Equation 6-3 can be simplified to:

$$P[A>z] = \int\int P[AF > \frac{z}{a}|a,m^1(a)]f_A(a)da \qquad (6\text{-}4)$$

where, $f_{M|A}(m;a)$ has been replaced with m^1 derived from deaggregation. With this equation, one can integrate over the rock acceleration, a, to calculate $P[A_S>z]$ for a range of surface amplitudes, z.

6.1 IMPLEMENTATION OF APPROACH 3

In Approach 3, the following steps were performed:

- Randomization of base case site-dynamic material properties to produce a suite of velocity profiles as well as G/Gmax and hysteretic damping curves that incorporate site randomness.
- Computation of transfer functions (hereafter termed amplification factors) as characterized by a mean and distribution for each set of base case site properties using the RVT-based equivalent-linear site response model.
- Full integration of the fractile and mean hazard curves for the generic site condition in this case hard rock and amplification factors to arrive at a distribution of site-specific hazard curves.

Specifically, the suites of rock hazard curves are first combined into a single suite and site-specific amplification factors applied using Approach 3. Combining the empirical hazard curves, rather than applying Approach 3 to each suite independently, results in the same mean hazard—the desired product—but does not properly preserve the full epistemic variability in the fractile estimates. As a result, the range in probability reflected in the resulting fractiles is likely somewhat underestimated. Although the fractiles are likely not significantly in error since the differences in hazard fractiles between the empirical relations are not large, the site-specific hazard fractiles should not be used for hazard or risk assessment.

Approach 3 is implemented through a number of computer programs. The computation of the amplification factors is the first phase of the calculations and is similar to what is done in other site-response approaches.

6.1.1 RVT-Based Equivalent-Linear Site Response Approach

The conventional site response approach in quantifying the effects of soil and other unconsolidated sediments on strong ground motions involves the use of time histories compatible with the specified outcrop response spectra to serve as control (input) motions. The control motions are then used to drive a nonlinear computational formulation to transmit the motions through the profile.

The computational formulation that has been most widely employed to evaluate 1D site response assumes vertically-propagating plane S-waves. Departures of soil response from a linear constitutive relation are treated in an approximate manner through the use of the equivalent-linear formulation. The equivalent-linear formulation, in its present form, was introduced by Idriss and Seed (1968). A stepwise analysis approach was formalized into a 1D, vertically propagating S-wave code called SHAKE (Schnabel *et al*., 1972). Subsequently, this code has become the most widely used and validated analysis package for 1D site response calculations.

The computational scheme employed to compute the amplification factors in this study uses an alternative approach employing RVT (Silva and Lee, 1987). In this approach, as embodied in the computer program RASCALS, the control motion power spectrum is propagated through the 1D soil profile using the plane-wave propagators of Silva (1976). The power spectrum is derived from the uniform hazard spectrum by spectral matching assuming the controlling earthquake. In this formulation only SH waves are considered. Arbitrary angles of incidence may be specified. In this case, vertical incidence was assumed.

Inputs to RASCALS are as follows:

- Location of input and output motions within the site profile.
- Input (control) motions characterized by earthquake power spectra.
- Incidence angles of input motion.
- A vertical profile consisting of homogeneous layers with specified thickness, seismic velocity, and density.
- Dynamic properties of the material at the site, consisting of strain-dependent shear modulus and damping curves for each layer.

Control motions (power spectral density) must be calculated for input into the site response analysis that are representative of the earthquake magnitude and distance dominating the hazard at the desired rate of exceedance. The basis for the control motions are the magnitude and distances specified by the hazard deaggregation.

Evaluation of site-response using the equivalent-linear site response model is based on convolution of appropriate control motions through randomized velocity profiles combined with randomized G/Gmax and hysteretic damping curves. The randomized profiles and curves are generated from base case velocity and nonlinear dynamic properties. The convolutions yield amplification factors for 5%-damped response spectra and peak ground velocity (PGV).

6.1.2 Inputs and Analysis

To perform the site response analysis, representative V_S profiles of the site and shear modulus (G/Gmax) reduction and damping curves are required.

For the computation of spectra for a site with uncertain properties and exhibiting a degree of lateral variability, a best-estimate (mean) basecase velocity profile (or profiles) (Table 10; Figure 13) is developed and used to simulate a number of V_S profiles. To address the epistemic uncertainty in the basecase V_S profile, an upper-range and lower-range basecase profiles were computed by using a factor of 1.57 (Figure 13). This factor was adopted from EPRI (2013) for sites where there are no site-specific V_S data. The upper-range basecase V_S profile was constrained to not exceed 2,800 m/sec (hard rock). Additionally, strain-dependent shear modulus and hysteretic damping are also randomized about best-estimate basecases. A large number of simulations can be required to achieve stable statistics on the response. To achieve statistical stability, 30 randomizations were produced using the velocity correlation models for each basecase velocity profile and each basecase nonlinear dynamic property curve. In order to randomly vary the V_S profile, a profile randomization scheme has been developed which varies both layer velocity and thickness. The randomization is based on a correlation model developed from an analysis of variance on about 500 measured V_S velocity profiles (EPRI, 1993; Silva *et al.*, 1996). Profile depth (depth to competent material) is also varied on a site specific basis using a uniform distribution. The depth range is generally selected to reflect expected variability over the structural foundation as well as uncertainty in the estimation of depth to competent material.

Associated with each of the 30 randomized profiles was also a set of randomized dynamic material property curves. For the dynamic material properties, the EPRI (1993) and Peninsular Range curves for cohesionless soils (Silva *et al.*, 1996) were used to approximate a nonlinear response over the top 250 ft, with linear response below (Silva *et al*., 1996). To accommodate the large uncertainty in nonlinear dynamic material properties, two sets of curves were used in the site-specific analyses. In addition to the EPRI (1993) curves, a subset of the EPRI (1993) curves was also used for each profile to account for the possibility that the site may behave more linearly. The second set, termed Peninsular Range curves, use the EPRI (1993) 51 to 120 ft curves for 0 to 50 ft and the 501 to 1,000 ft curves for deeper materials and reflect much more linear response than the EPRI curves. The two sets of curves were given equal weights and are considered to cover the range in nonlinear dynamic material properties.

Based on the RASCALS runs for the 30 V_S profiles for the two base case profiles, a probability distribution of amplification factors was calculated. Input control motions are computed using RASCALS for each set of 30 V_S profiles and dynamic property curves. RASCALS is used for horizontal spectra using normally-incident and inclined SH-waves. For each control motion, mean and standard deviation are computed from the 30 response spectra (from 30 randomized profiles). Thirty realizations result in stable estimates. The mean response spectrum from the 30 convolutions is divided by the mean (log) spectrum for hard rock spectrum to produce the amplification factors. The amplification factors include the effects of the inherent aleatory variability (randomness) of the site properties about each base case and any possible effects of magnitude of the control motions. Epistemic variability (uncertainty) is captured in consideration of alternate base case (mean) profiles and properties.

Table 10
Simplified V_S Profile Used in Analysis

Depth (ft)	Lithology	V_S (ft/sec)
0 – 92	Quaternary till	2,250
92 – 637	Limestone, shale, sandstone	4,500
637 – 1,387	Limestone, shale, sandstone	5,500
1,387 – 1,837	Siltstone	4,500
1,837 – 2,537	Shale, limestone	6,500
2,537 – 5,387	Dolomite, sandstone, limestone	8,500
> 5,387	Precambrian basement	> 9,200

RASCALS was used to generate control motions and acceleration power response spectra for two earthquakes, **M** 5.5 and 7.5, which approximately represents the range of magnitudes for events contributing to the hazard at the site at short- and long-period ground motions. The events were placed at a suite of distances to produce expected median rock peak accelerations of 0.01, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.75, 1.00, 1.25 and 1.50 g. The amplification factors (the ratios of the response spectra at the top of the site profiles to the hard rock profiles) are a function of the reference (hard rock) peak acceleration (or SA), spectral frequency, and nonlinear soil response.

6.2 SITE-SPECIFIC HORIZONTAL RESULTS

The hard rock hazard curves derived from the PSHA and the amplification factors relative to hard rock were multiplied to arrive at site-specific amplified hazard curves. The hazard curves calculated using the amplification factors from the **M** 5.5 and 7.5 earthquakes were weighted based on their contributions to the hazard at each spectral frequency. The uncertainty or epistemic variability in seismic hazard is typically represented by a set of weighted hazard curves. Using these sets of curves as discrete probability distributions, they can be sorted by the frequency of exceedance at each ground-motion level and summed into a cumulative probability mass function. When the cumulative probability mass function for a particular exceedance frequency equals or exceeds fractile y, then the exceedance frequency represents the y^{th} fractile. The weighted-mean hazard curve is the weighted average of the exceedance frequency values. This approach is a standard practice in PSHA.

Figure 23 shows the SEE UHS for the return period of 2,500 years at the ground surface (assumed to be the top of till) resulting from the site response analysis (Table 9). Also shown is the input hard rock UHS for the same return period. The amplification is significant at spectral periods greater than about 0.07 seconds.

6.3 COMPARISON WITH USGS NATIONAL HAZARD MAPS

In 1996, the USGS released a “landmark” set of NSHMs for earthquake ground shaking, which was a significant improvement from previous maps they had developed (Frankel *et al.*, 1996). These maps were the result of the most comprehensive analyses of seismic sources and ground motion prediction ever undertaken on a national scale. The maps are the basis for the NEHRP

Maximum Considered Earthquake (MCE_R) maps, which are used in the International Building Code. The maps are for NEHRP site class B/C (firm rock) (V_S30 760 m/sec).

For a 2,500-year return period, the 2014 NSHMs indicate firm rock (site class B/C) PGA, 0.2 sec SA and 1.0 sec SA values of 0.21, 0.38, and 0.12 g, respectively (USGS website). The site-specific ground surface values of 0.19, 0.42, and 0.12 g for PGA, 0.2 and 1.0 sec SA, respectively, are comparable. The minor differences are likely due to the differences in the site conditions.

Table 9

2,500-Year Return Period Mean SEE UHS for the Ground Surface

Period (sec)	SA (g)
0.01 (PGA)	0.19
0.02	0.22
0.03	0.25
0.04	0.27
0.10	0.40
0.20	0.42
0.40	0.23
1.0	0.12
2.0	0.07
3.0	0.05
4.0	0.04
5.0	0.03

Three sets of two-component time histories were spectrally-matched to a 2,500-year return period ground surface SEE UHS. At short periods the 2,500-year hazard is primarily from background events and at long periods the hazard is primarily from large events from the New Madrid fault system RLME (Figures 20 and 21). Hence, three sets of time histories were selected: one to represent a **M** ≤ 6.5 event at distances less than 50 km and two sets to represent a large NMFS event at greater distances (Table 11).

Because the response spectrum of a time history has peaks and valleys that deviate from the design response spectrum (target spectrum), it is necessary to modify the motion to improve its response spectrum compatibility. The procedure proposed by Lilhanand and Tseng (1988), as modified by Al Atik and Abrahamson (2010) and contained in the computer code RSPMatch09 (Fouad and Rathje, 2012), was used to develop the acceleration time histories through spectral matching to the target (seed) spectrum. This time-domain procedure has been shown to be superior to previous frequency-domain approaches because the adjustments to the time history are only done at the time at which the spectral response occurs resulting in only localized perturbations on both the time history and the spectra (Lilhanand and Tseng, 1988).

To match the design (target) spectrum, seed time histories should be from events of similar magnitude and distance (for duration) and most importantly, spectral shape as the earthquake dominating the spectrum. Figure 24 shows the spectra from the seed time histories scaled to the target spectrum at PGA. The seed acceleration time history series are shown on Figures 25 to 27. The spectral matches and resulting SEE time histories are shown on Figures 28 to 39. Arias intensities and durations of the SEE time histories are provided in Table 12.

Table 11

Seed Time Histories

Record Sequence Number	Year	Earthquake Name	Station Name	Earthquake Magnitude (M)	ClstD (km)	V_S30 (m/sec)	Comp	PGA(g)	PGV (cm/sec)	PGD (cm)	5-95% AI (m/sec)	5-95% Dur (sec)
172	1979	Imperial Valley	El Centro Array #1	6.5	21.7	237.3	140	0.141	16.06	9.82	0.287	15.02
							230	0.136	10.98	7.10	0.224	19.53
1404	1999	Chi-Chi, Taiwan	PNG	7.6	110.3	465.9	E	0.029	1.52	0.47	0.030	31.99
							N	0.034	2.27	0.66	0.033	28.10
2112	2002	Denali, Alaska	TAPS Pump Station #08	7.9	104.9	424.9	049	0.046	4.62	2.15	0.049	30.78
							319	0.036	4.22	2.52	0.043	36.28

ClstD Closest distance
Comp Component
PGA peak horizontal ground acceleration
PGV peak horizontal ground velocity
PGD peak horizontal ground displacement
AI Arias intensity
Dur Duration

Table 12

Spectrally-Matched Time Histories

Record Sequence Number	Year	Earthquake Name	Station Name	Earthquake Magnitude (M)	ClstD (km)	V_S30 (m/sec)	Comp	PGA(g)	PGV (cm/sec)	PGD (cm)	5-95% AI (m/sec)	5-95% Dur (sec)
172	1979	Imperial Valley	El Centro Array #1	6.5	21.7	237.3	140	0.183	13.35	9.41	0.366	20.04
							230	0.186	15.98	14.61	0.402	19.59
1404	1999	Chi-Chi, Taiwan	PNG	7.6	110.3	465.9	E	0.185	9.79	3.70	0.900	34.02
							N	0.187	13.63	4.97	0.758	29.81
2112	2002	Denali, Alaska	TAPS Pump Station #08	7.9	104.9	424.9	049	0.187	12.31	11.66	0.554	35.99
							319	0.186	13.83	10.36	0.815	39.70

ClstD Closest distance
Comp Component
PGA peak horizontal ground acceleration
PGV peak horizontal ground velocity
PGD peak horizontal ground displacement
AI Arias intensity
Dur Duration

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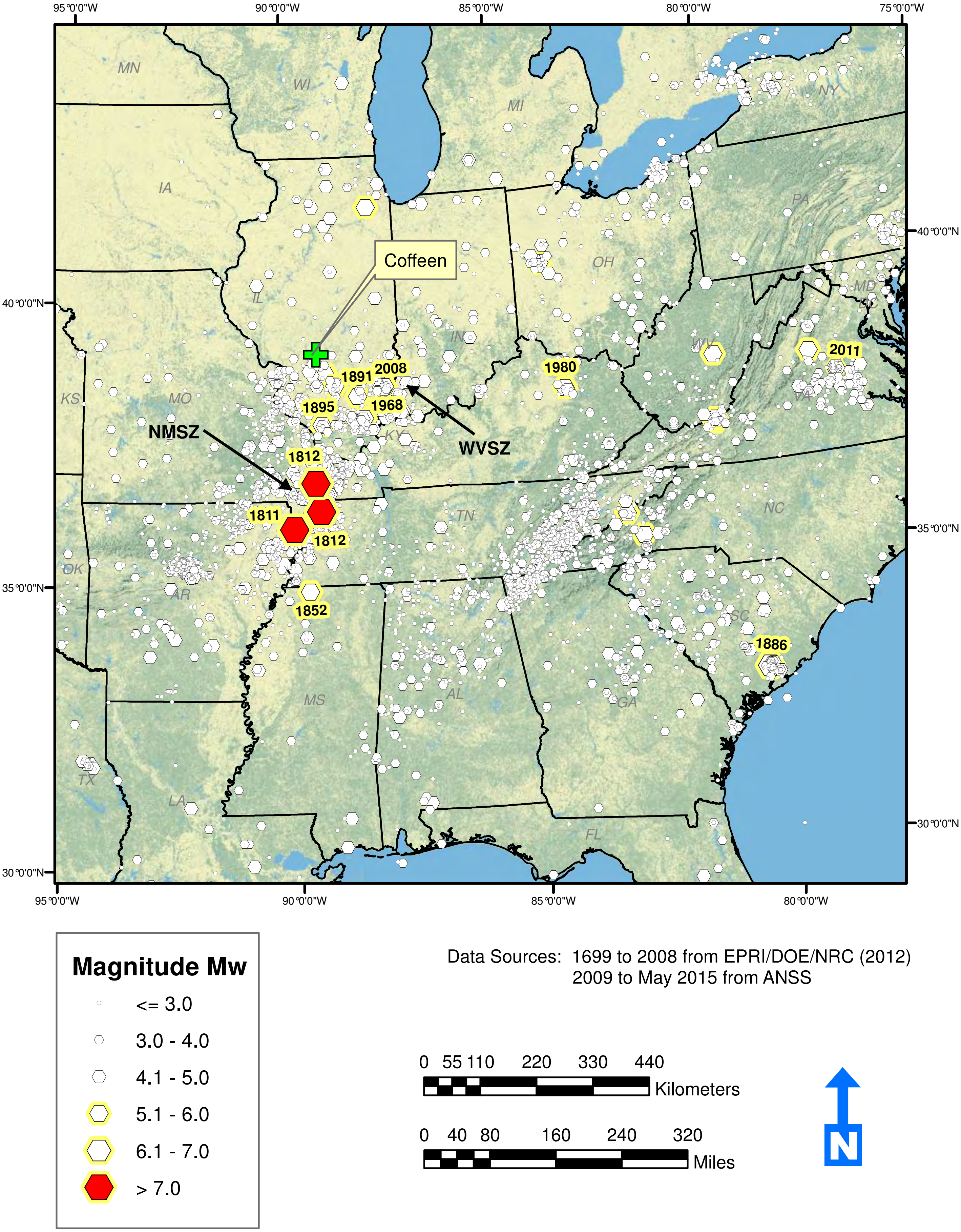
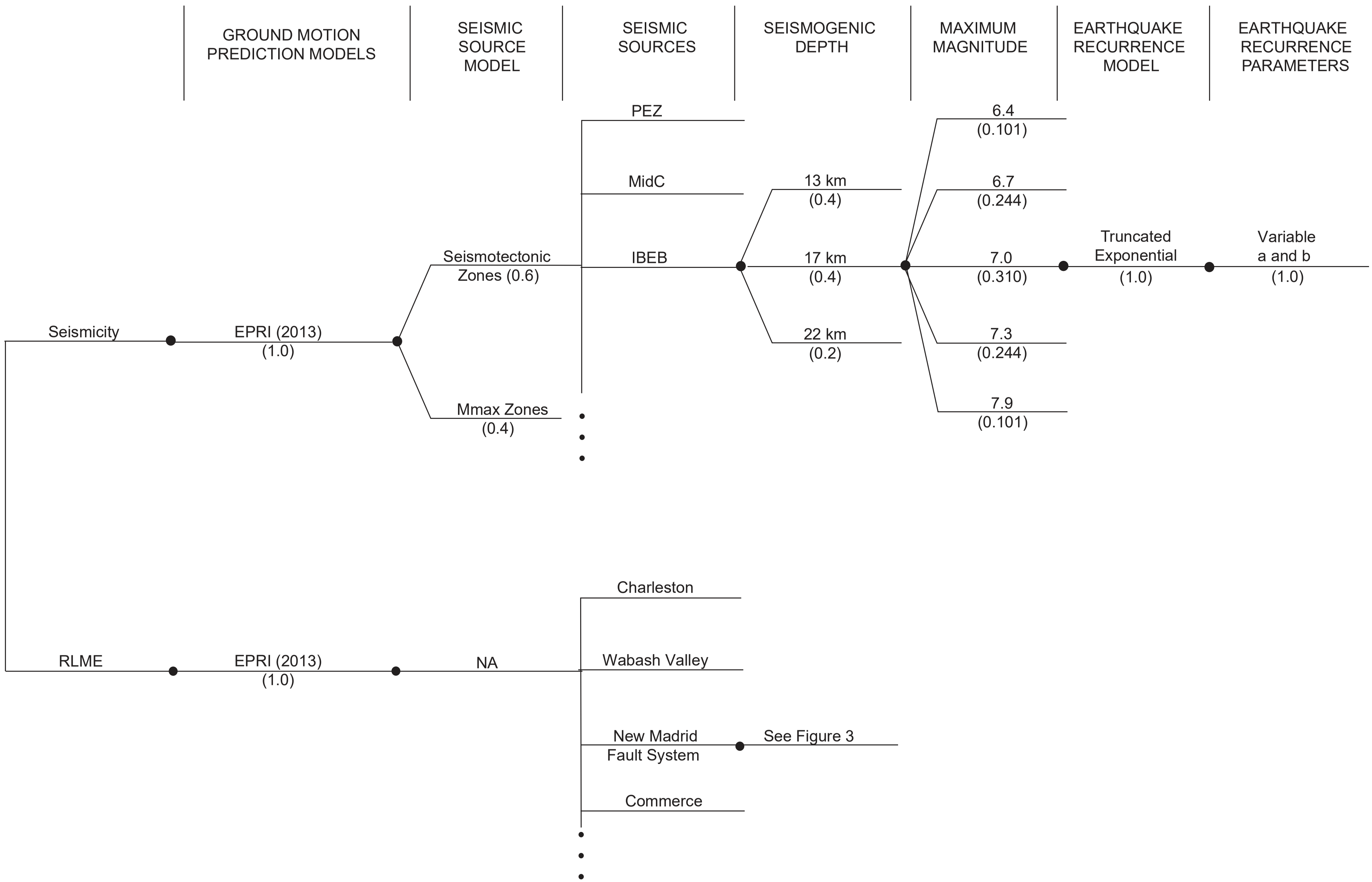


AECOM	Project No. 60440742 Coffeen Power Station Dynegy	HISTORICAL SEISMICITY OF CENTRAL AND EASTERN UNITED STATES (1699 - 2015)	Figure 1

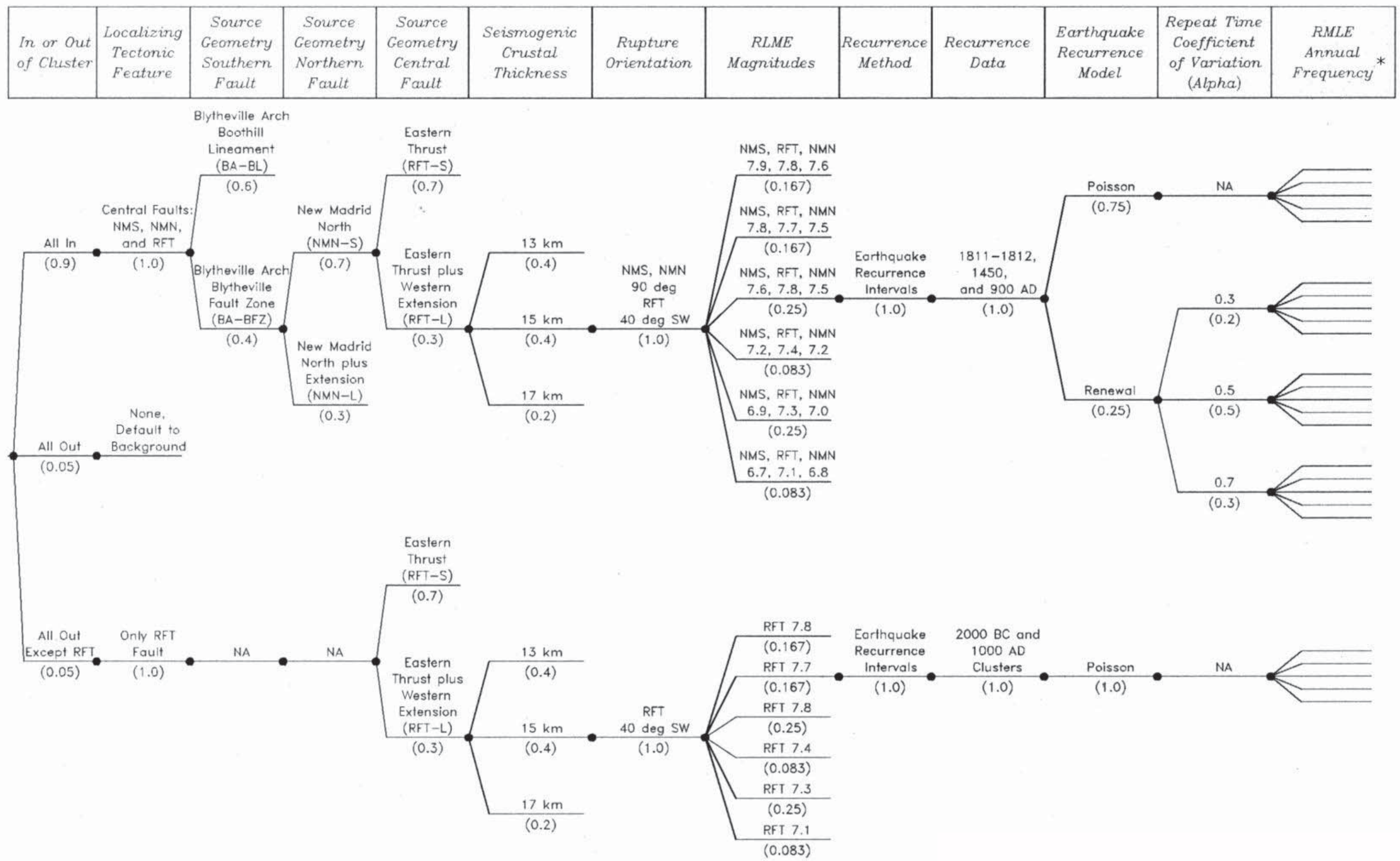


Project No. 60440742

Coffeen Power Station
Dynegy

EXAMPLE SEISMIC HAZARD MODEL LOGIC TREE

Figure 2



* See EPRI/DOE/NRC (2012)

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Project No. 60440742

Coffeen Power Station
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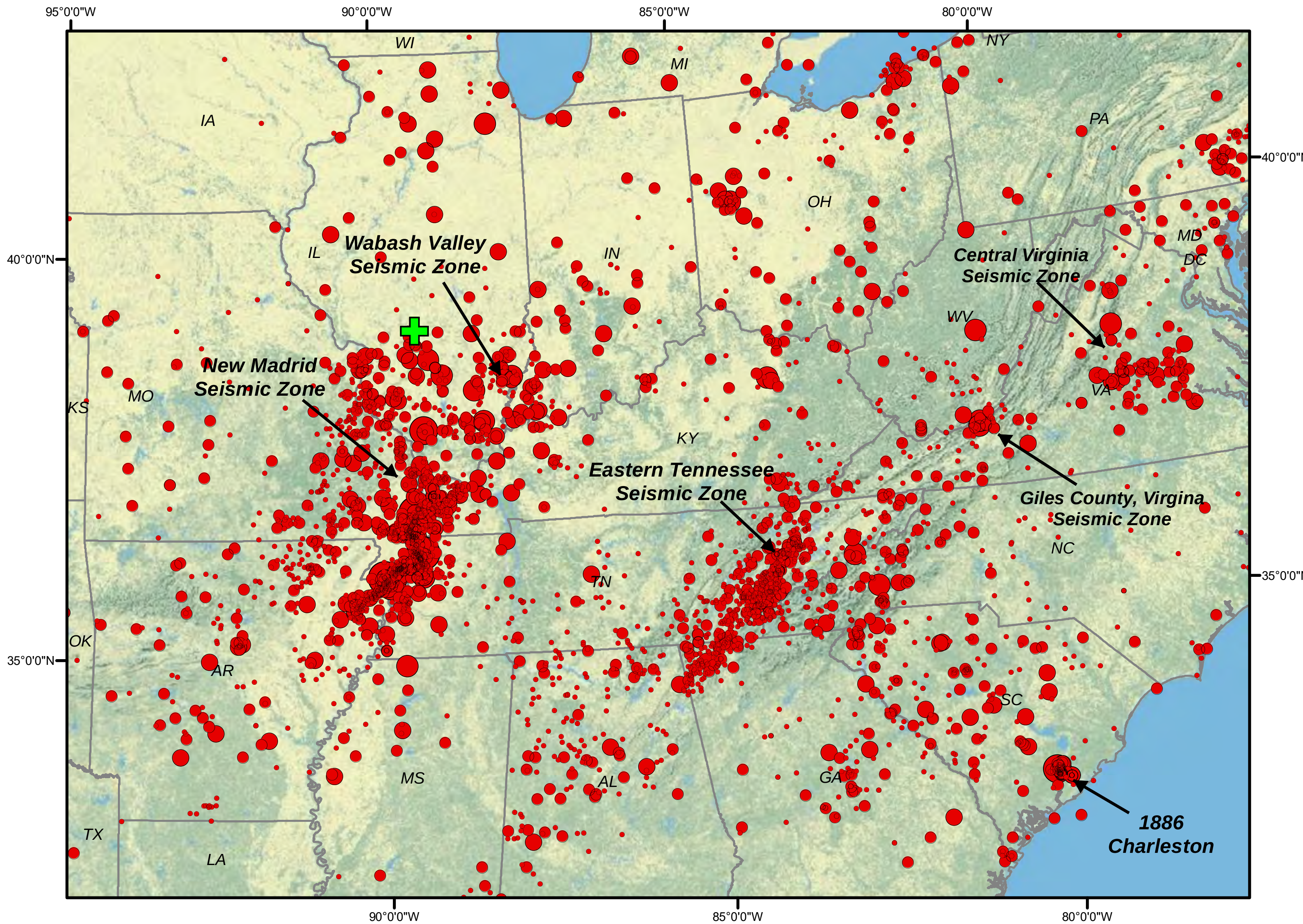
NEW MADRID RLME LOGIC TREE

Figure 3

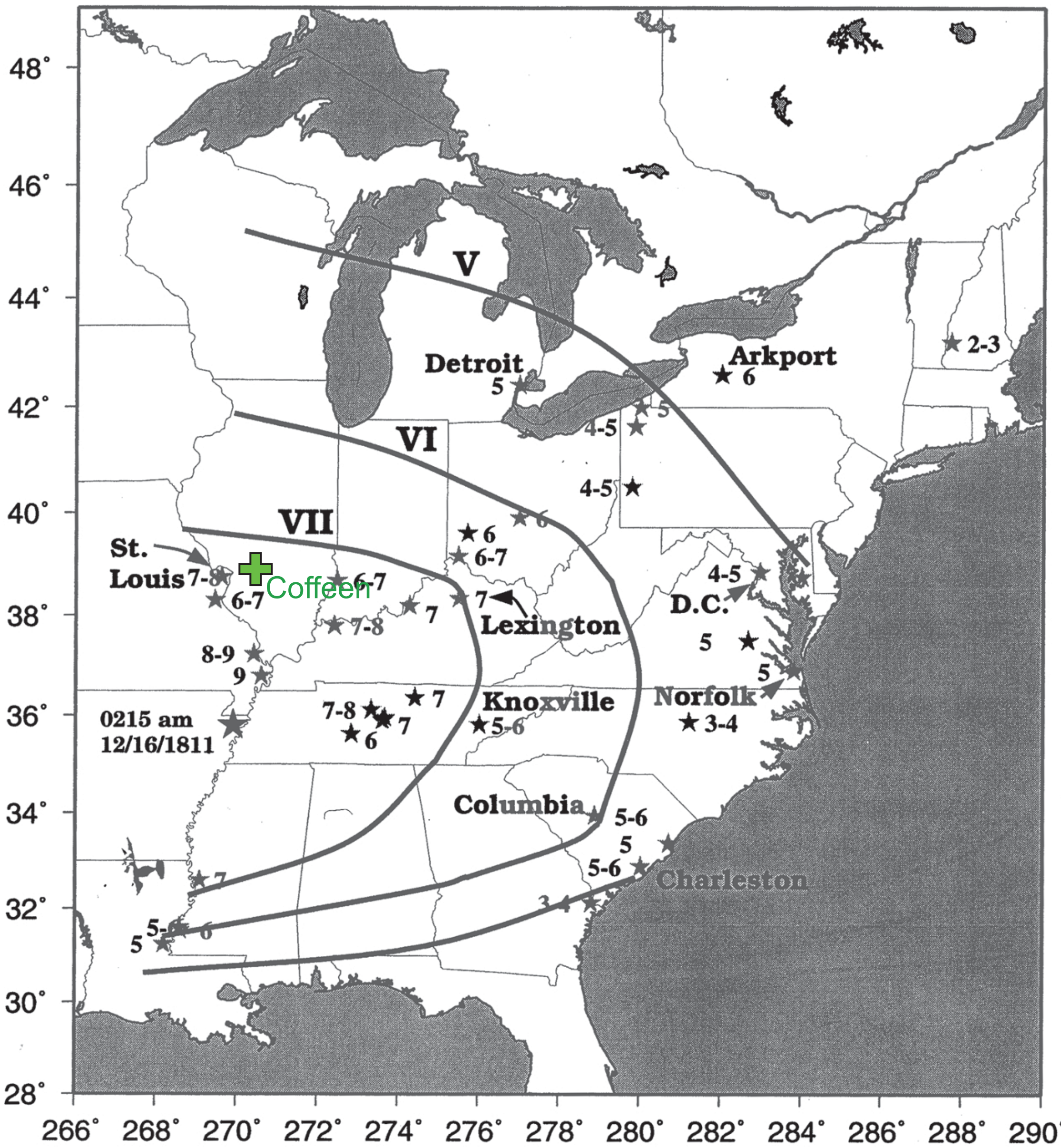


Project Site

Earthquake Epicenters

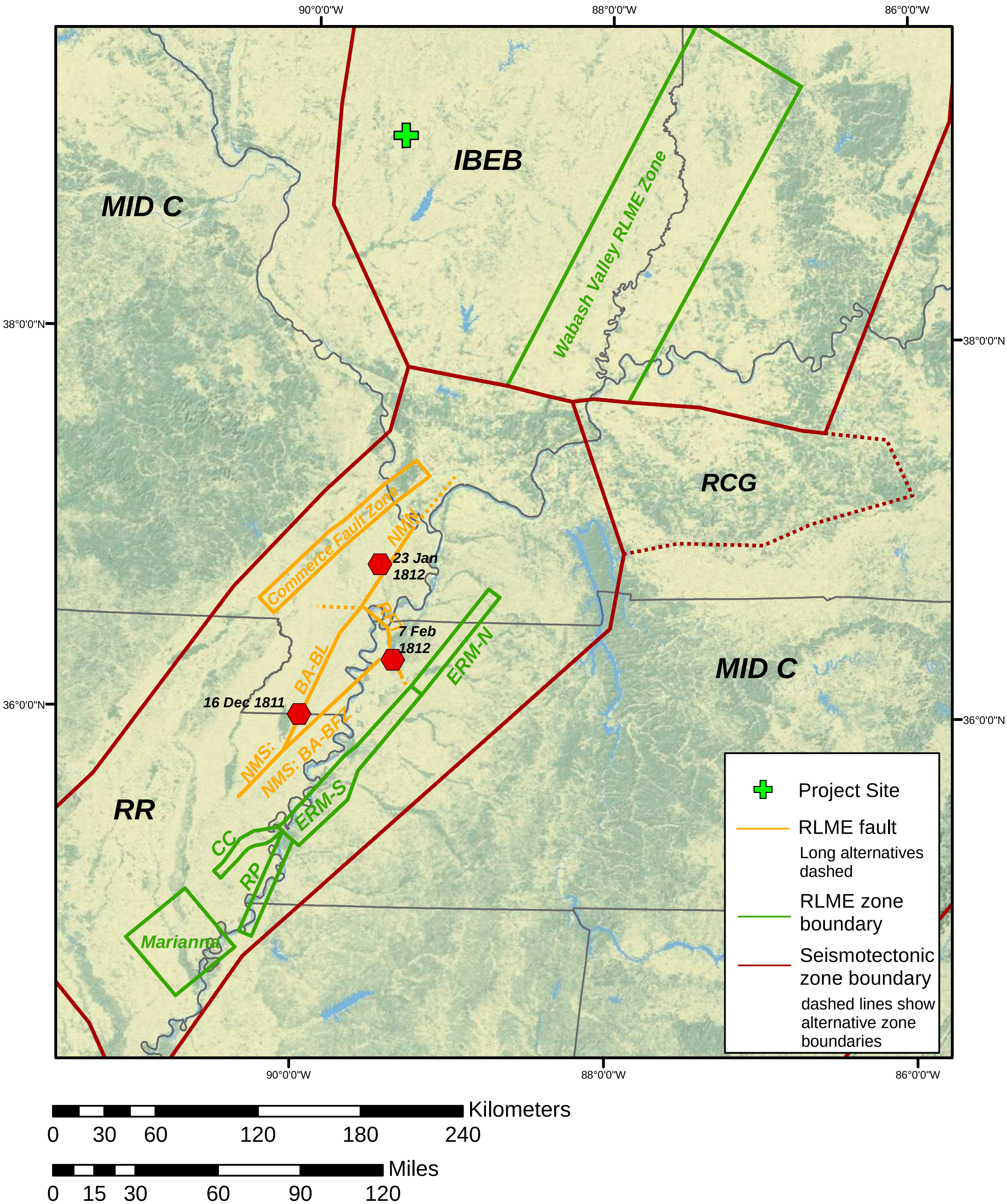
Seismicity from:
EPRI/DOE/NRC (2012)

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	HISTORICAL SEISMICITY AND SEISMIC ZONES IN THE CENTRAL AND EASTERN U.S.	Figure 4

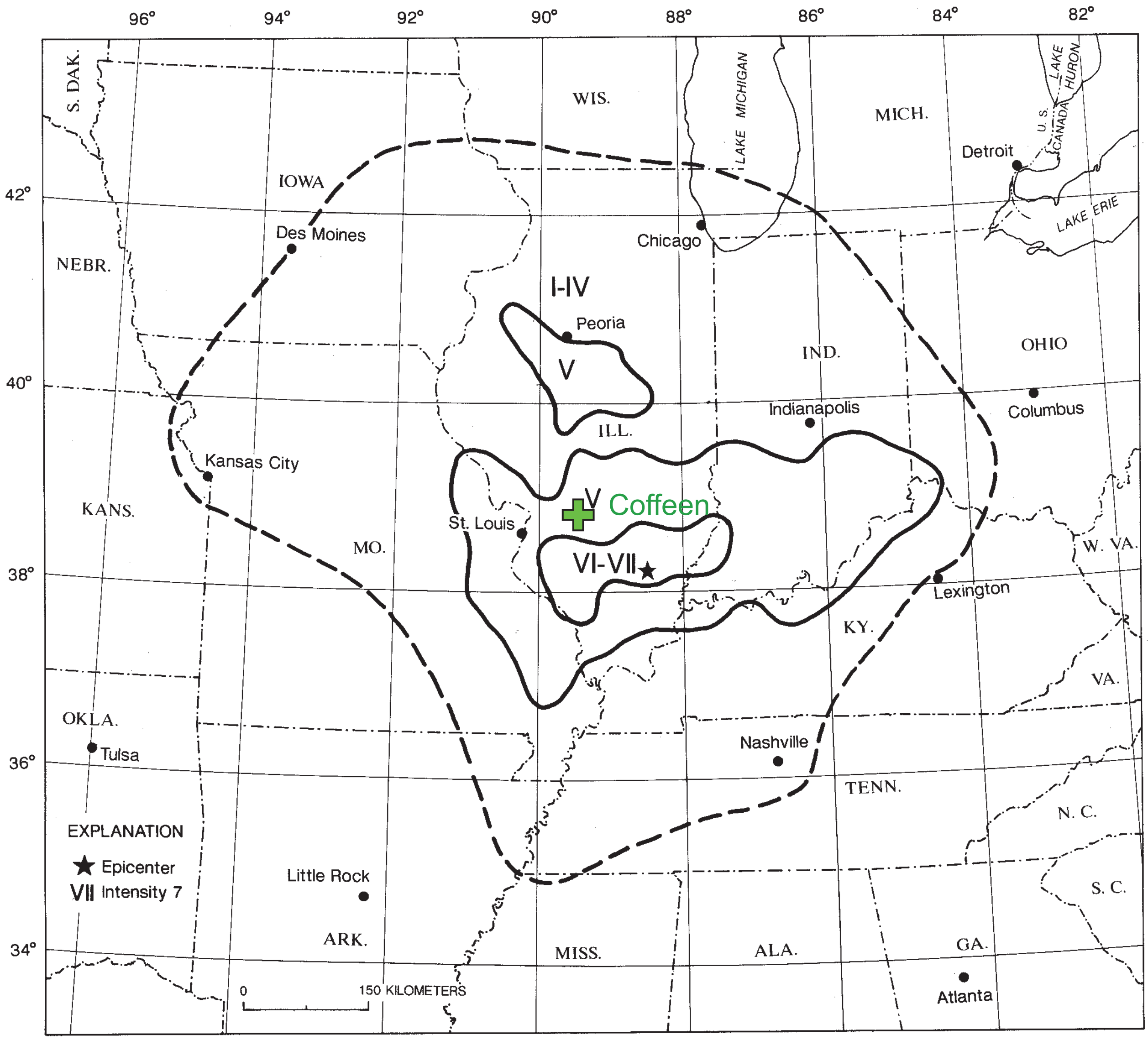


Source: Hough *et al*. (2000)

	Project No. 60440742	ISOSEISMAL MAP OF THE 16 DECEMBER 1811 **M** 7.2-7.3 NEW MADRID EARTHQUAKE	Figure 5
AECOM	Coffeen Power Station Dynegy		

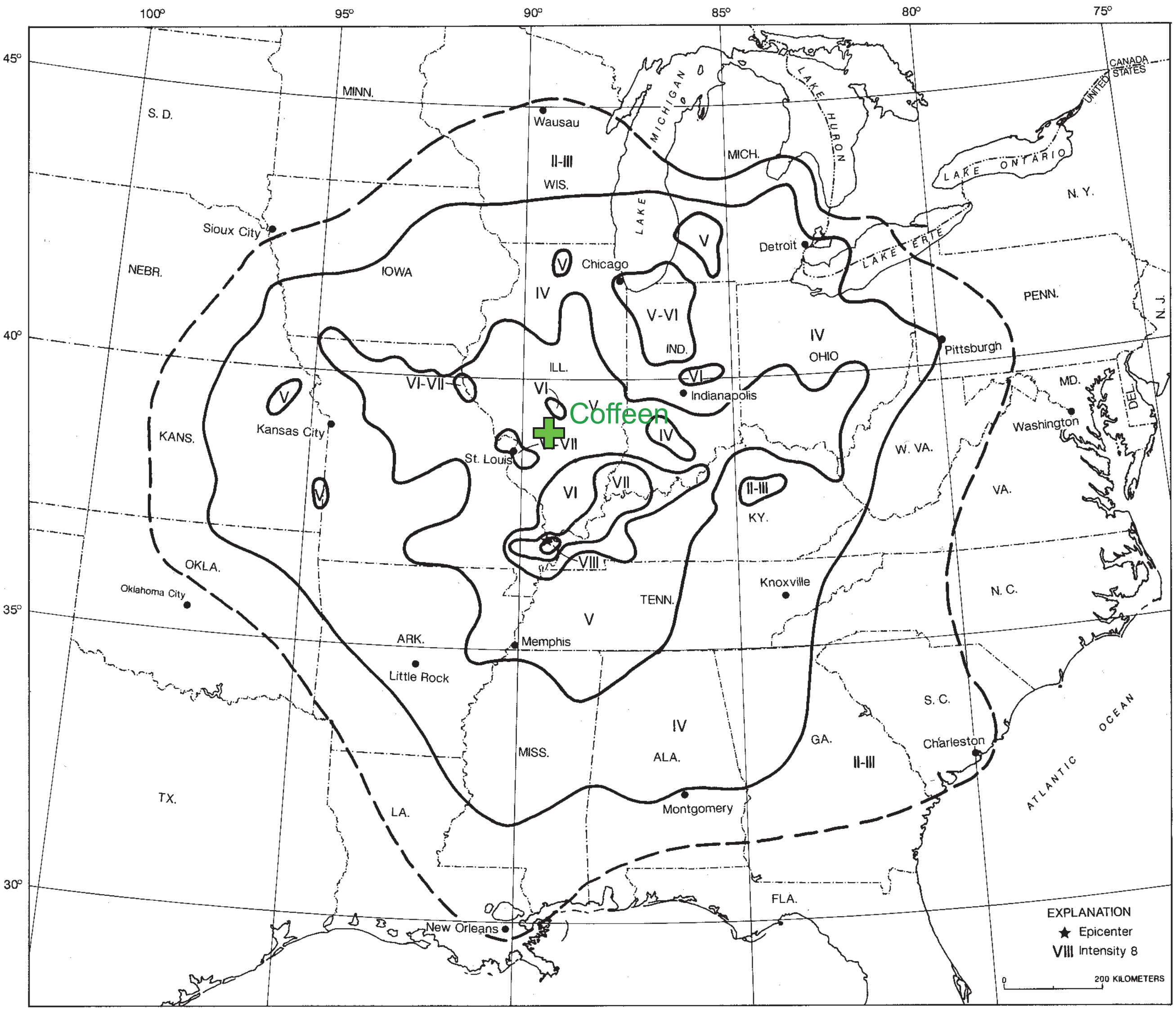


AECOM	Project No. 60440742 Coffeen Power Station Dynegy	NEW MADRID FAULT SYSTEM, 1811-1812 NMFS EARTHQUAKES, AND NEIGHBORING RLMEs	Figure 6



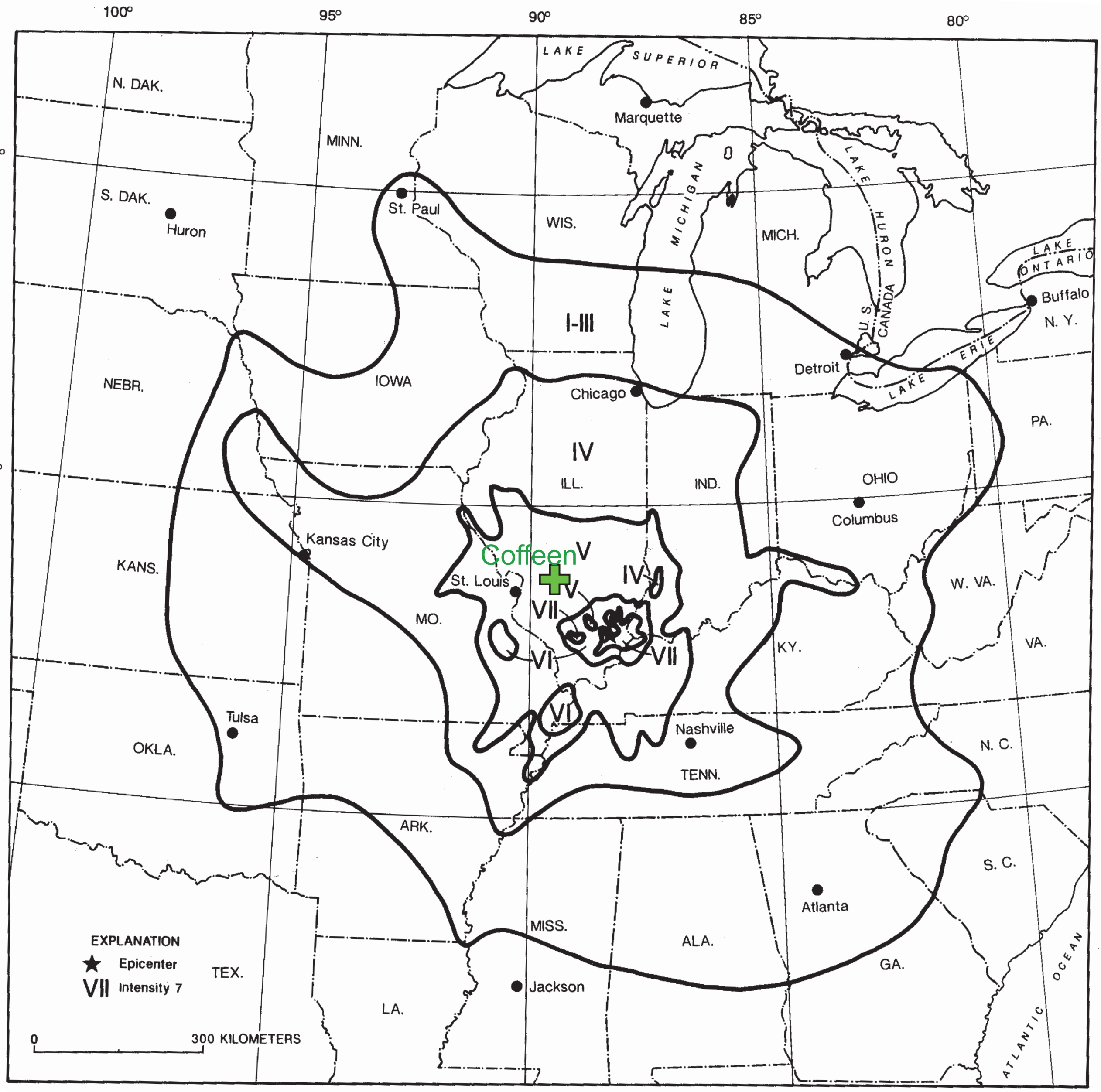
Source: Stover and Coffman (1993)

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	ISOSEISMAL MAP OF THE 27 SEPTEMBER 1891 m_b 5.8 SOUTHERN ILLINOIS EARTHQUAKE	Figure 7



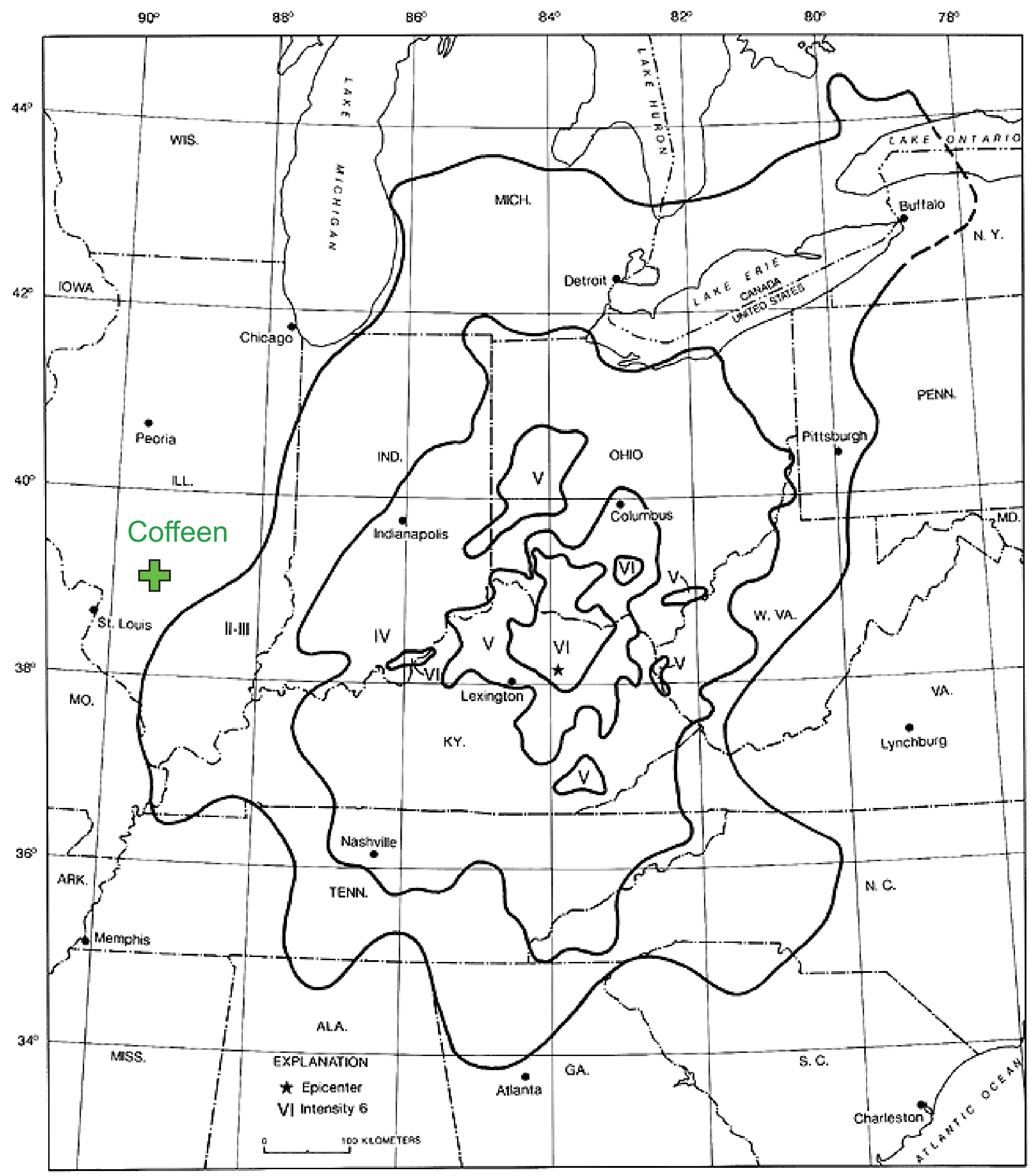
Source: Stover and Coffman (1993)

AECOM	Project No. 60440742	ISOSEISMAL MAP OF THE 31 OCTOBER 1895 M_S 6.7 CHARLESTON, MISSOURI EARTHQUAKE	Figure 8
	Coffeen Power Station Dynegy		



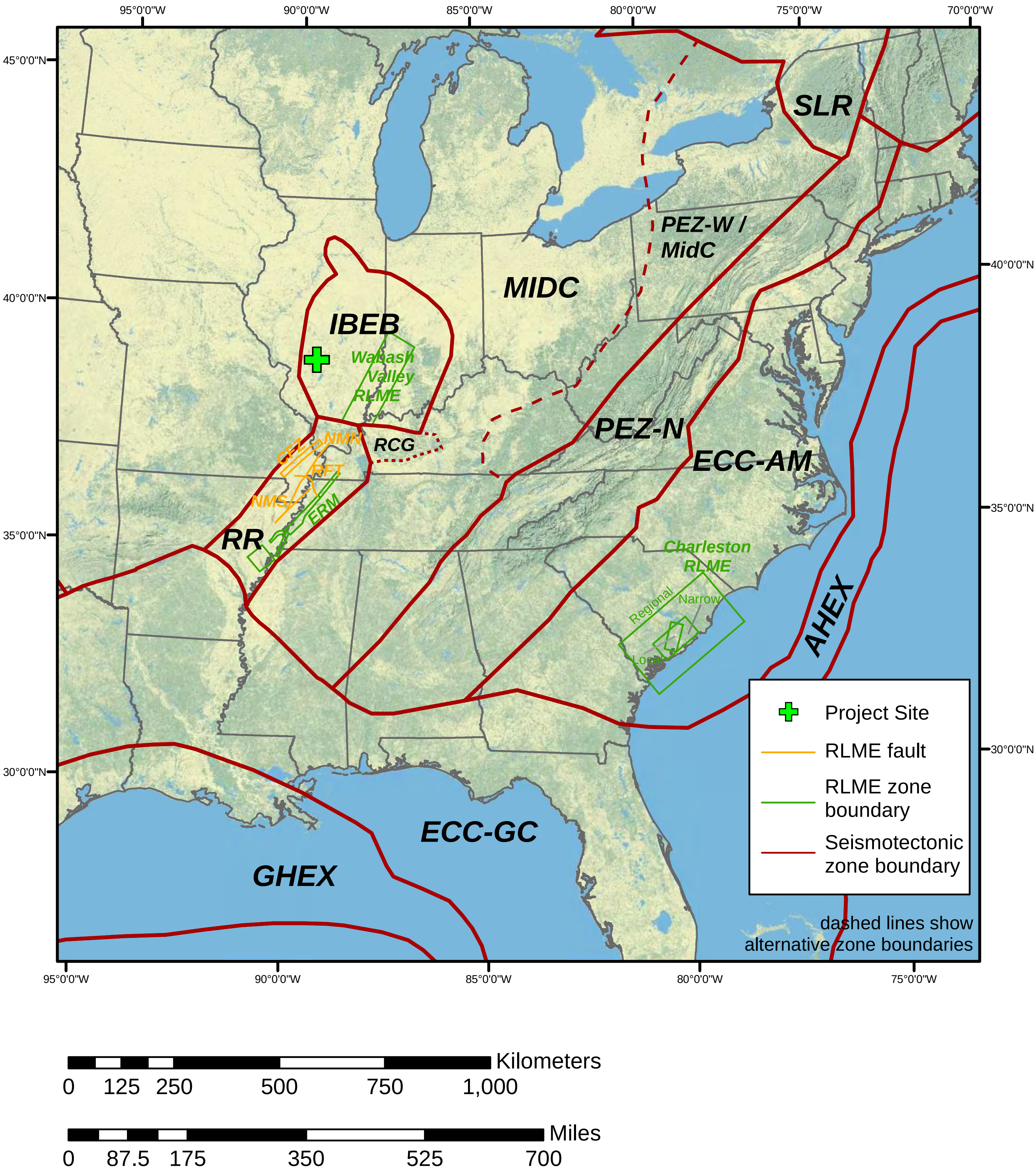
Source: Stover and Coffman (1993)

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	ISOSEISMAL MAP OF THE 9 NOVEMBER 1968 m_b 5.5 SOUTHERN ILLINOIS EARTHQUAKE	Figure 9



Source: Stover and Coffman (1993)

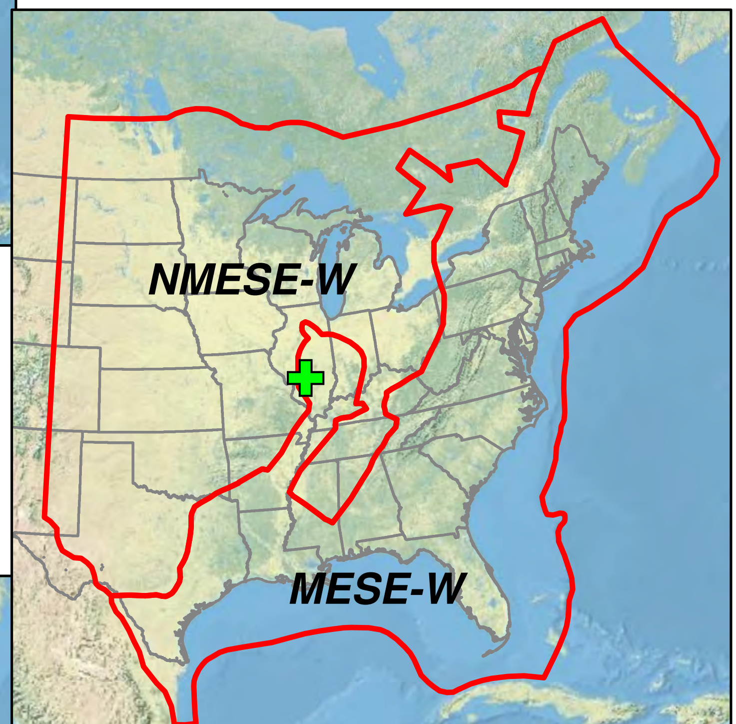
AECOM	Project No. 60440742	ISOSEISMAL MAP FOR THE 27 JULY 1980 M 5.1 SHARPSBURG, KENTUCKY EARTHQUAKE	Figure 10
	Coffeen Power Station Dynegy		

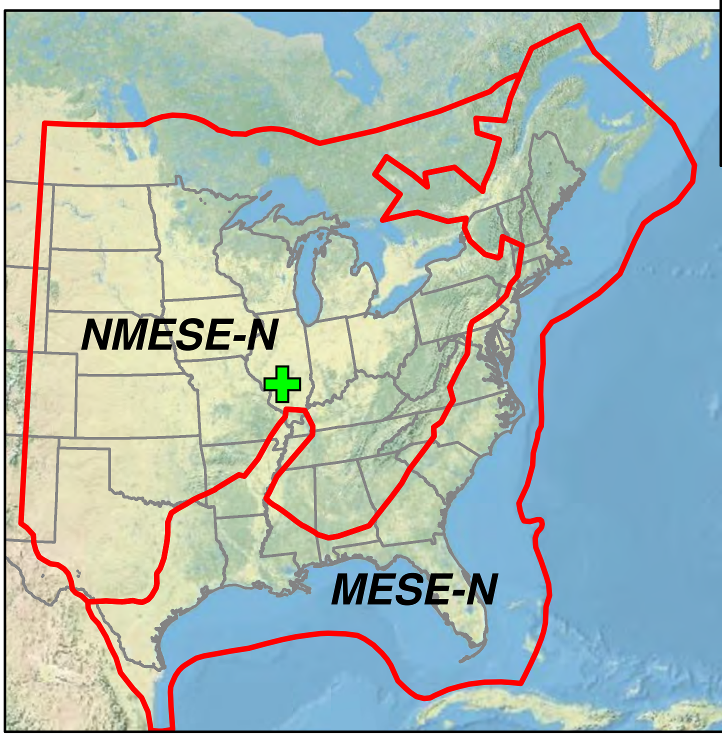


AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEISMOTECTONIC ZONES AND RLMES	Figure 11

1-Zone Model

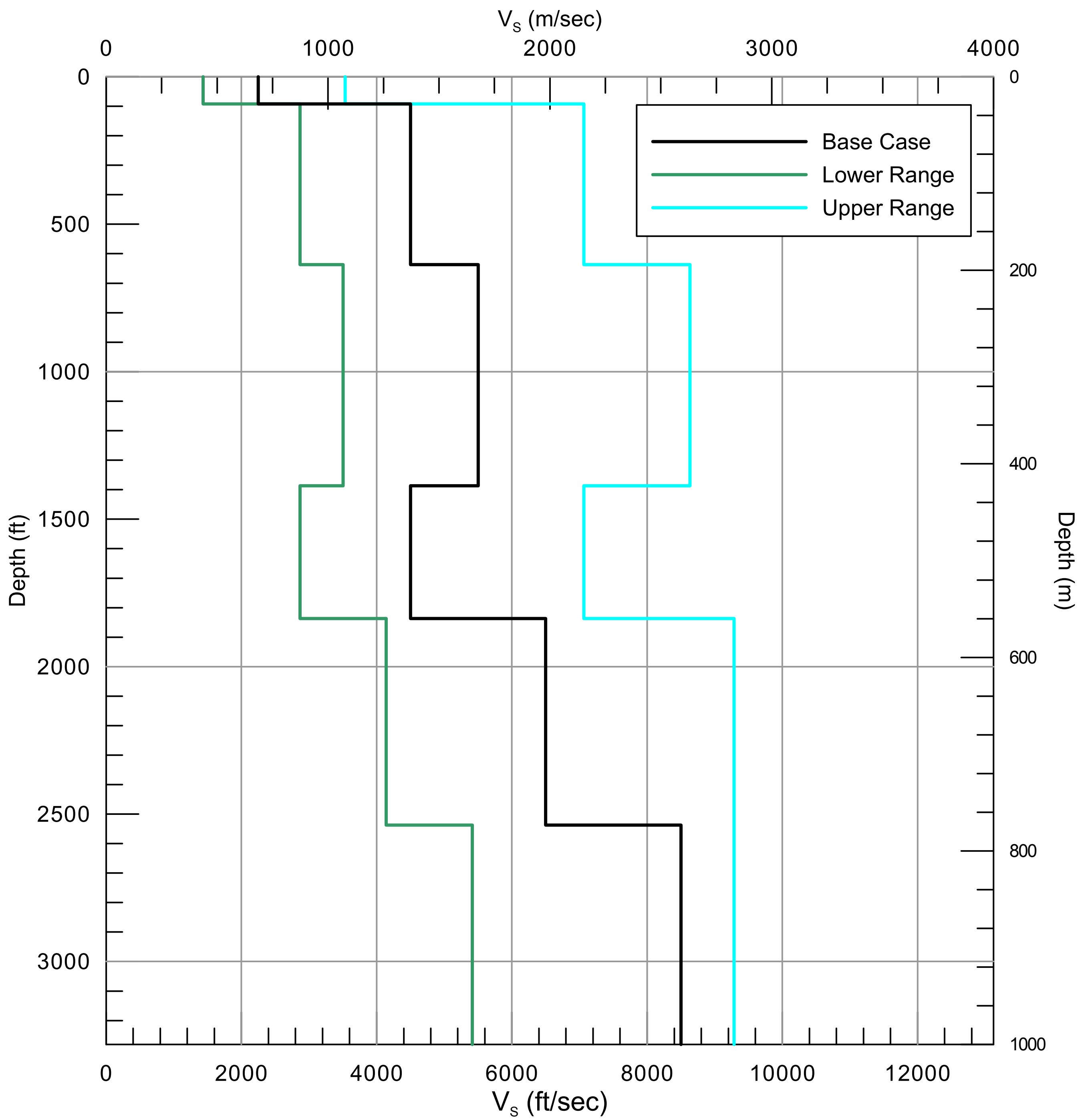
2-Zone Model
MESE-Wide



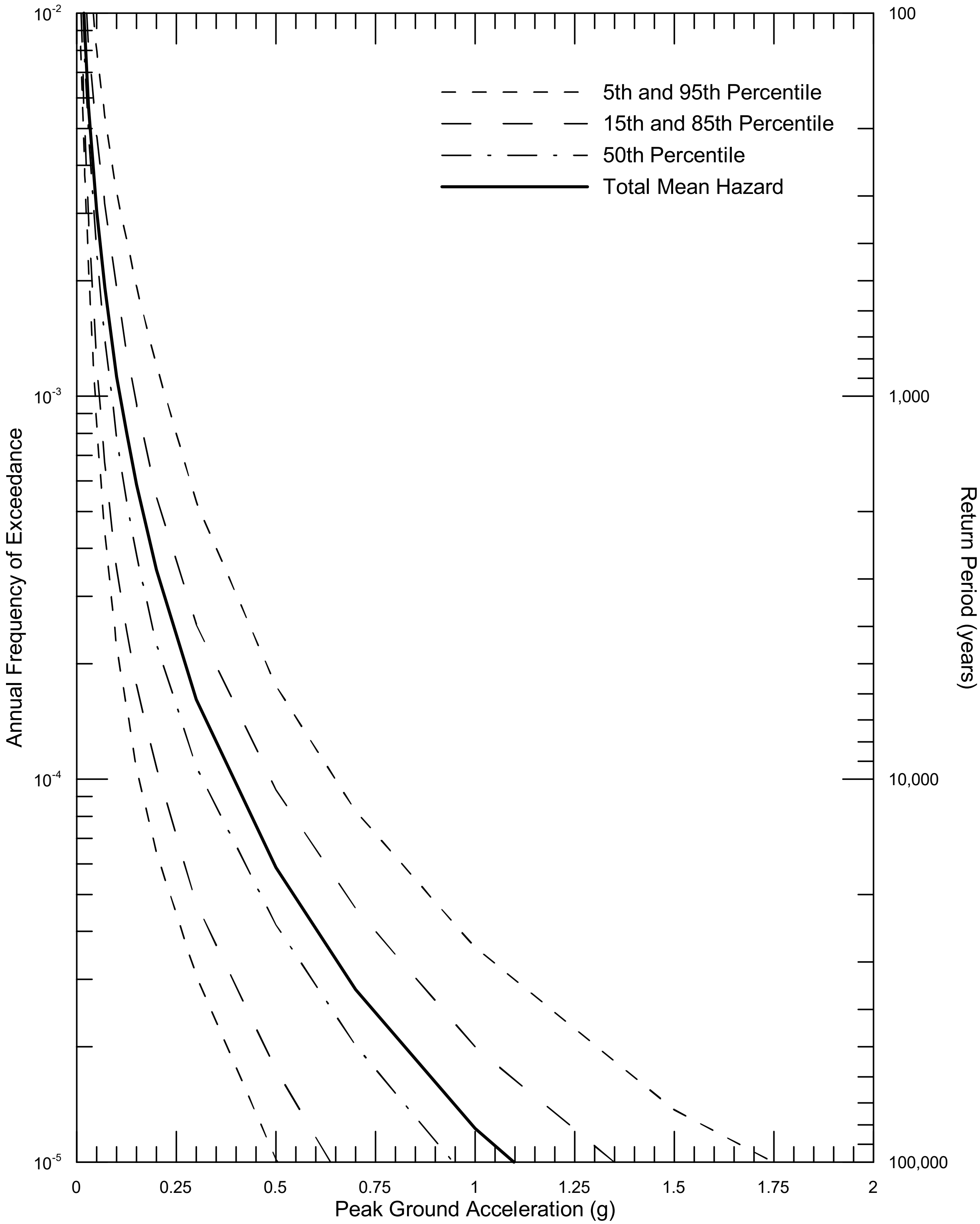


2-Zone Model
MESE-Narrow

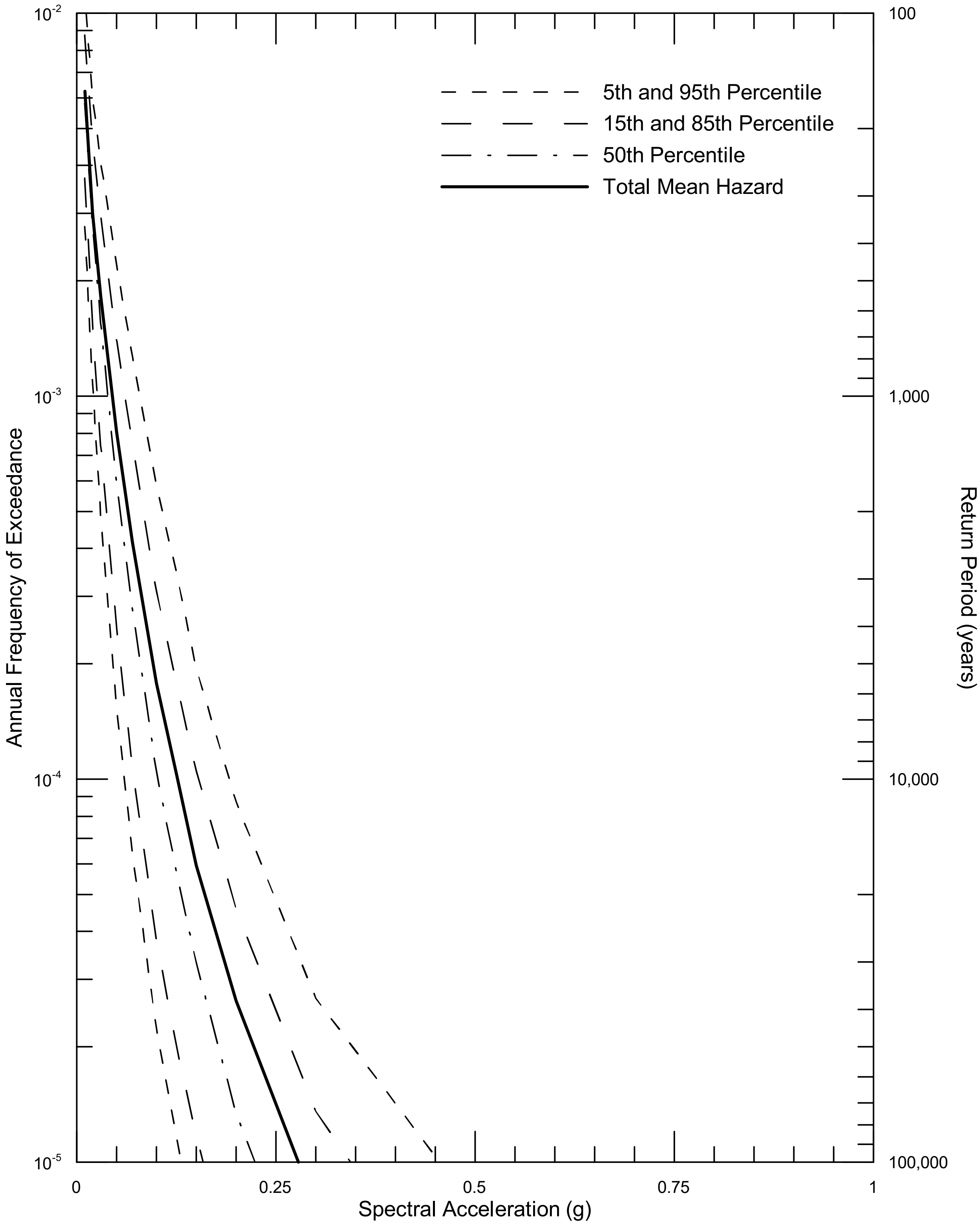
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	Mmax ZONES	Figure 12



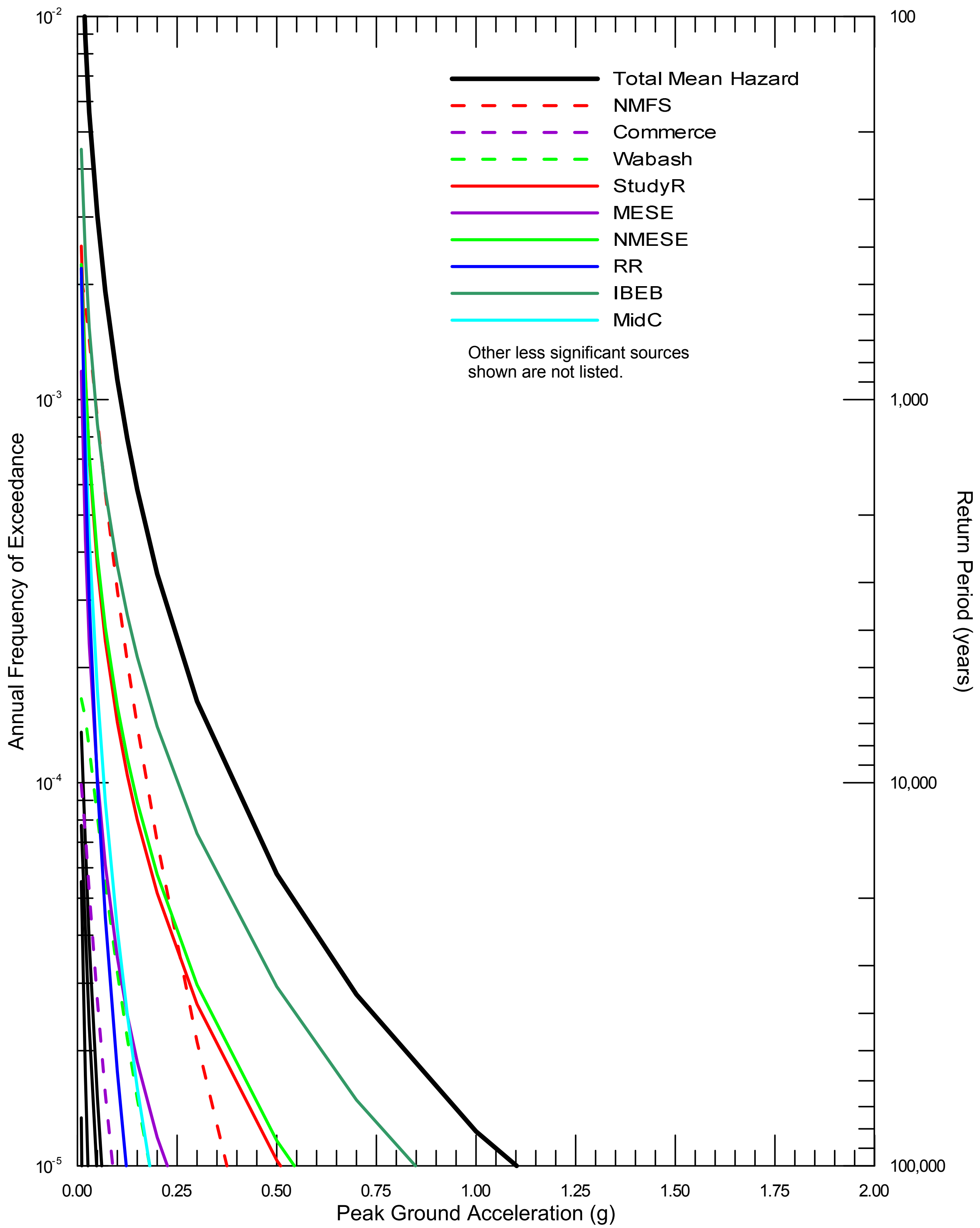
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SIMPLIFIED V_S PROFILES USED IN ANALYSIS	Figure 13



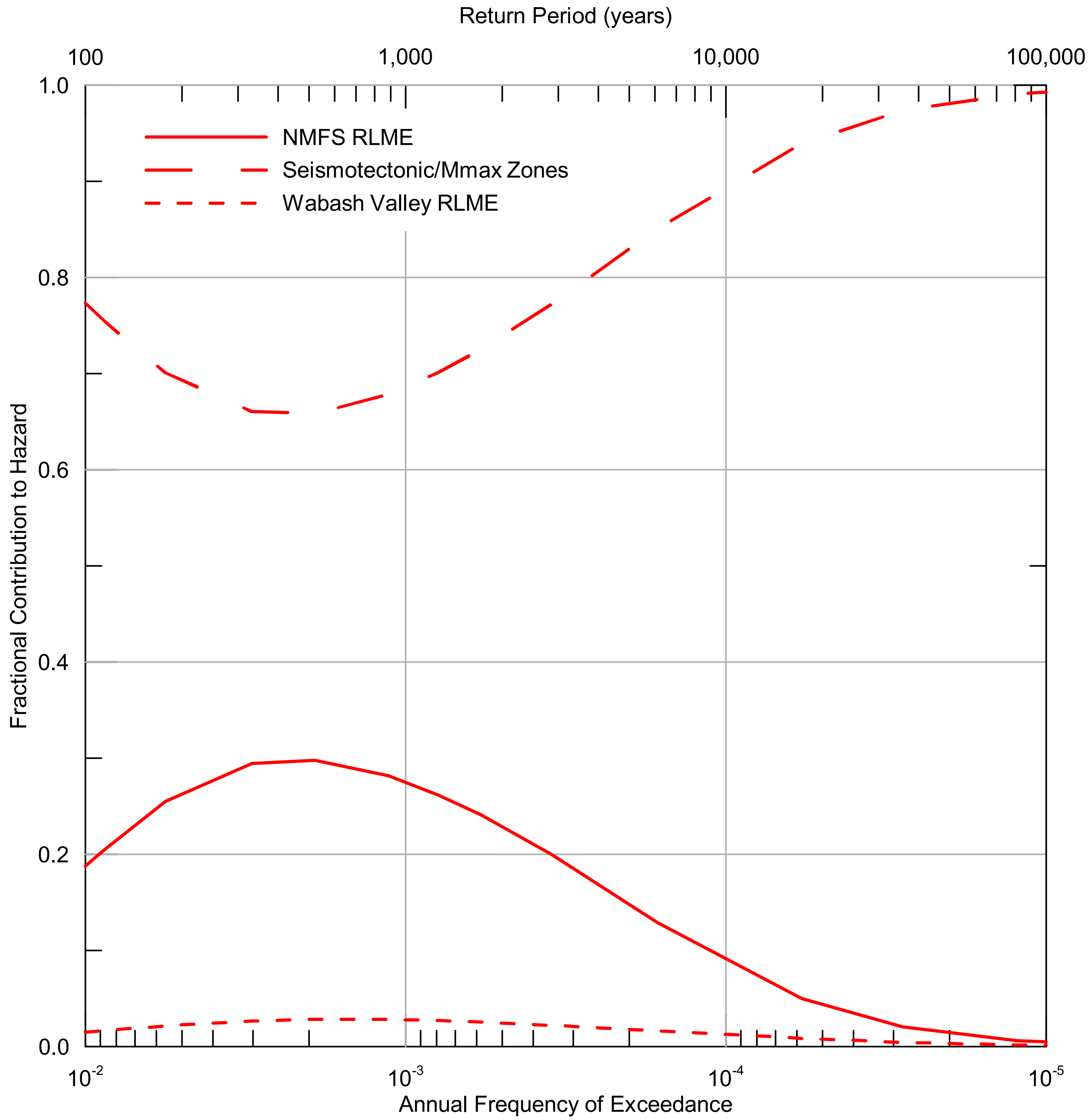
AECOM	Project No. 60440742	SEISMIC HAZARD CURVES FOR PEAK HORIZONTAL ACCELERATION ON HARD ROCK	Figure 14
	Coffeen Power Station Dynegy		



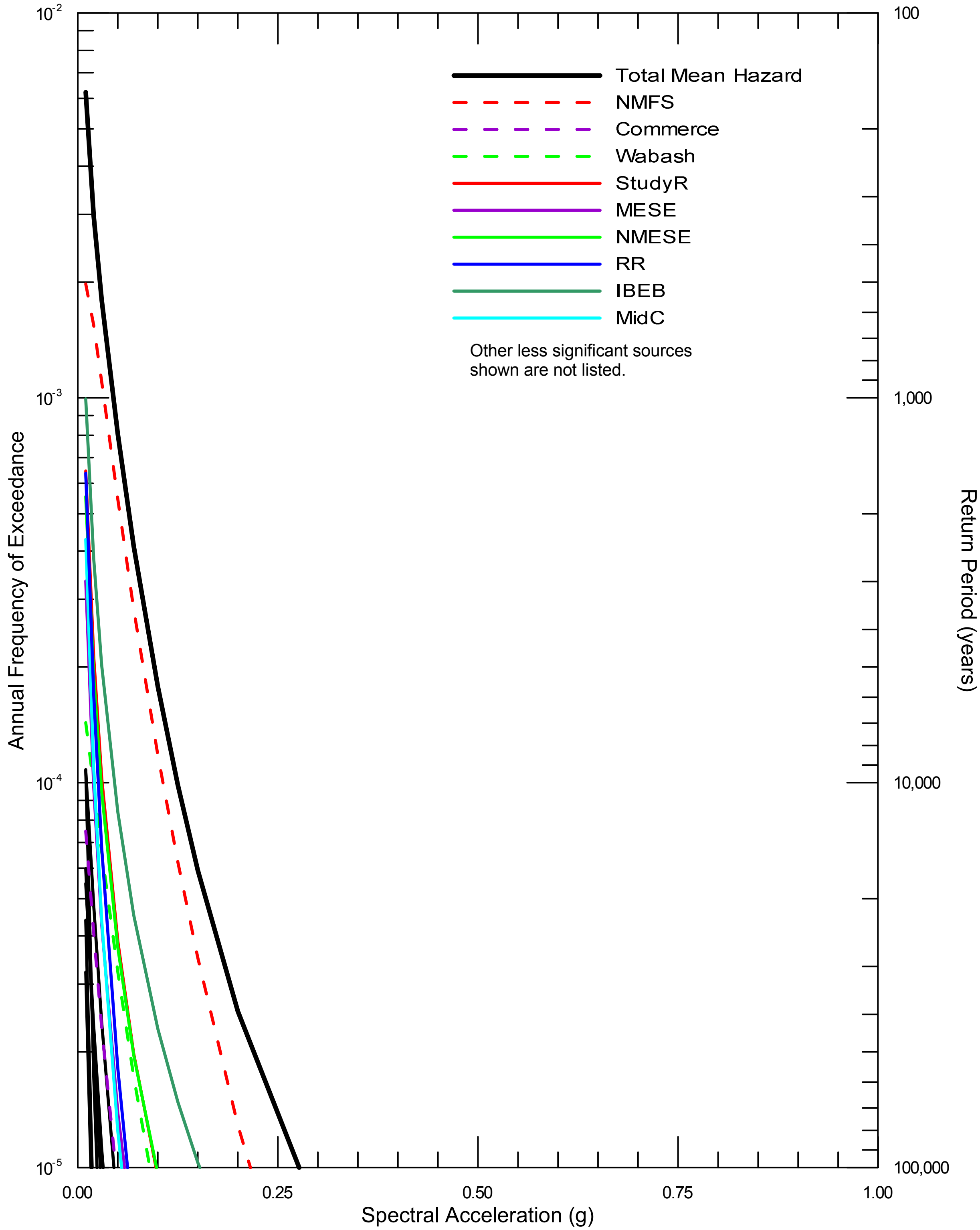
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEISMIC HAZARD CURVES FOR 1.0 SEC HORIZONTAL SPECTRAL ACCELERATION ON HARD ROCK	Figure 15



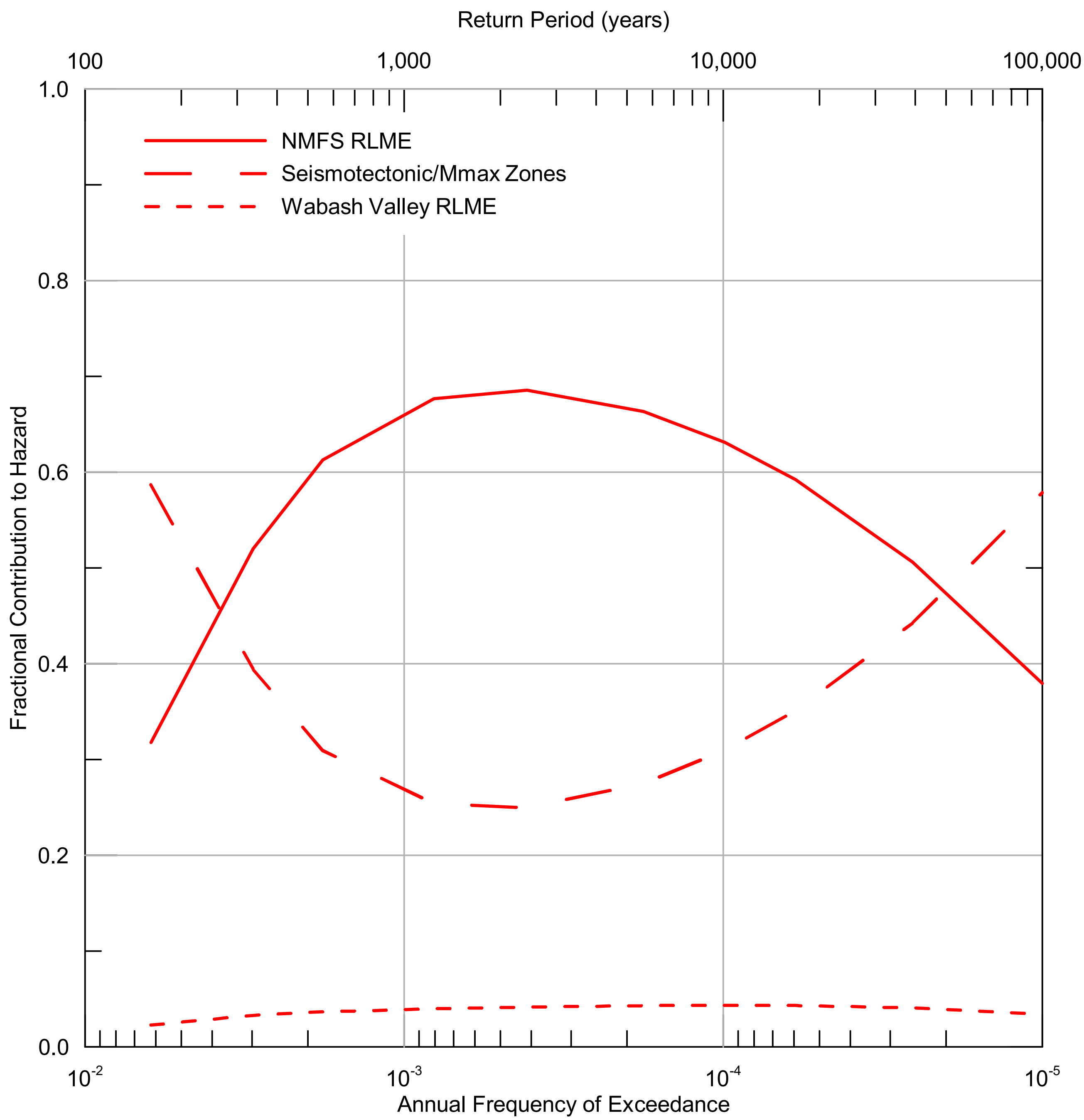
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEISMIC SOURCE CONTRIBUTIONS TO MEAN PEAK HORIZONTAL ACCELERATION HAZARD ON HARD ROCK	Figure 16



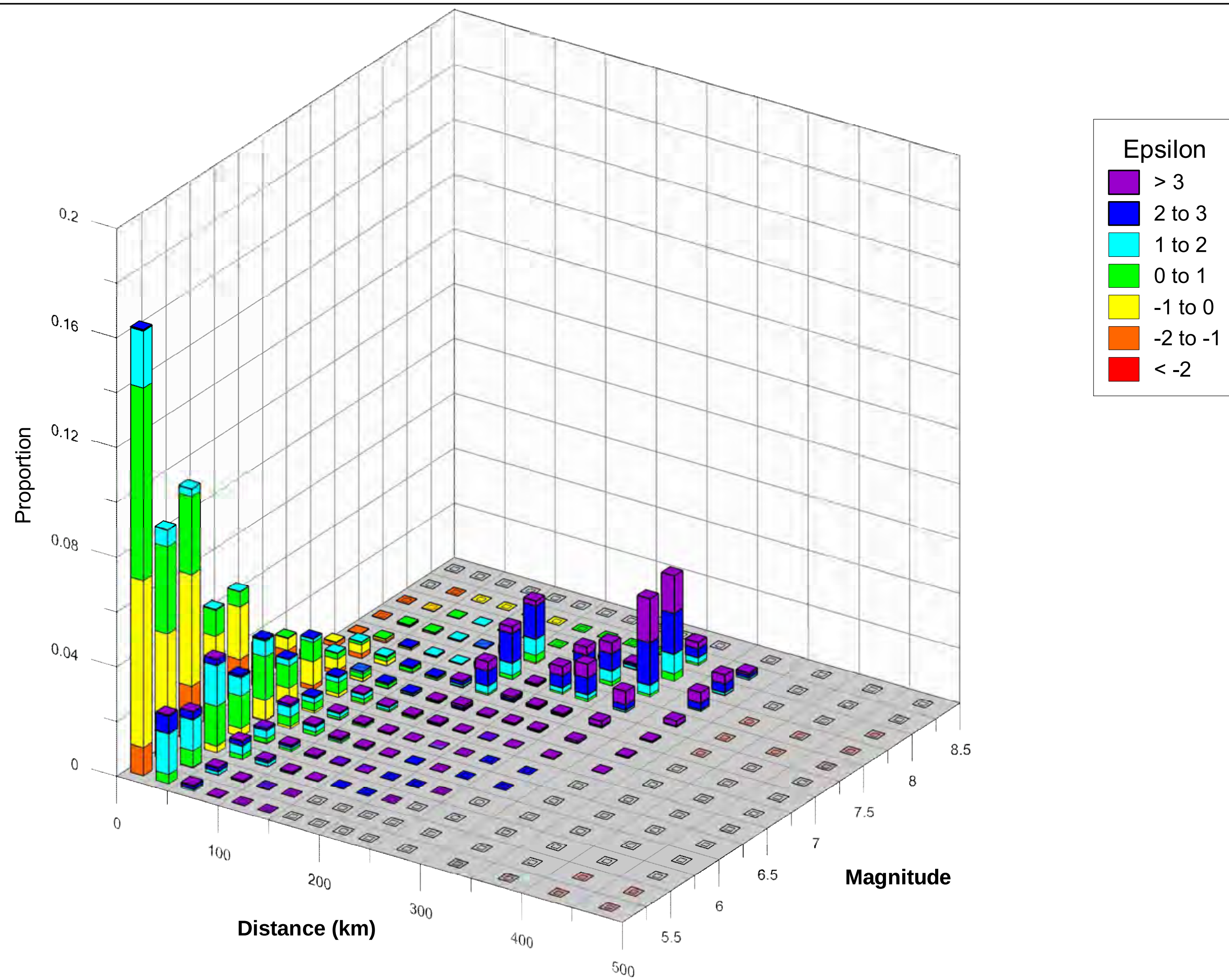
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEISMIC SOURCE FRACTIONAL CONTRIBUTION TO MEAN PEAK HORIZONTAL ACCELERATION HAZARD ON HARD ROCK	Figure 17



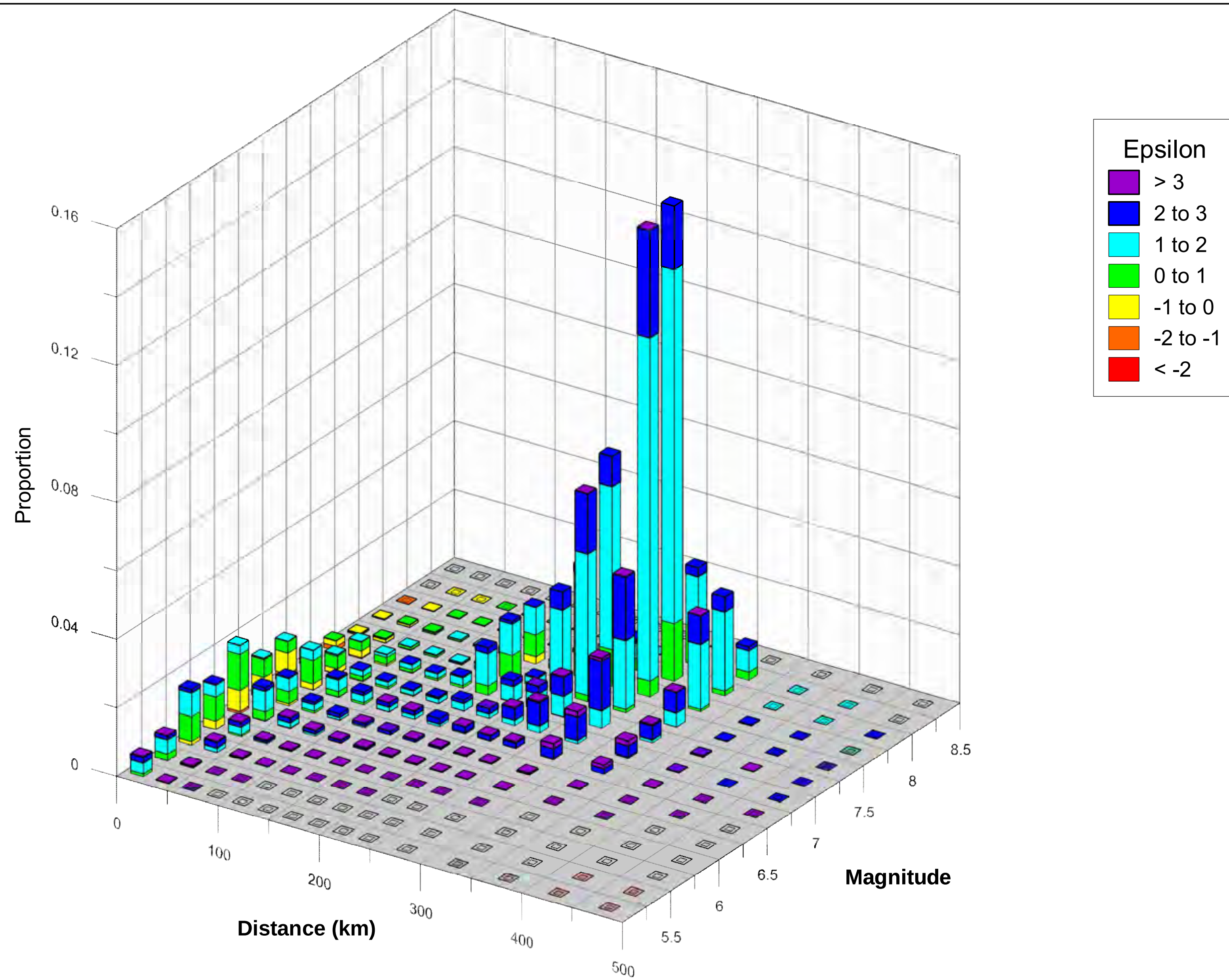
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEISMIC SOURCE CONTRIBUTIONS TO MEAN 1.0 SEC HORIZONTAL SEPCTRAL ACCELERATION HAZARD ON HARD ROCK	Figure 18



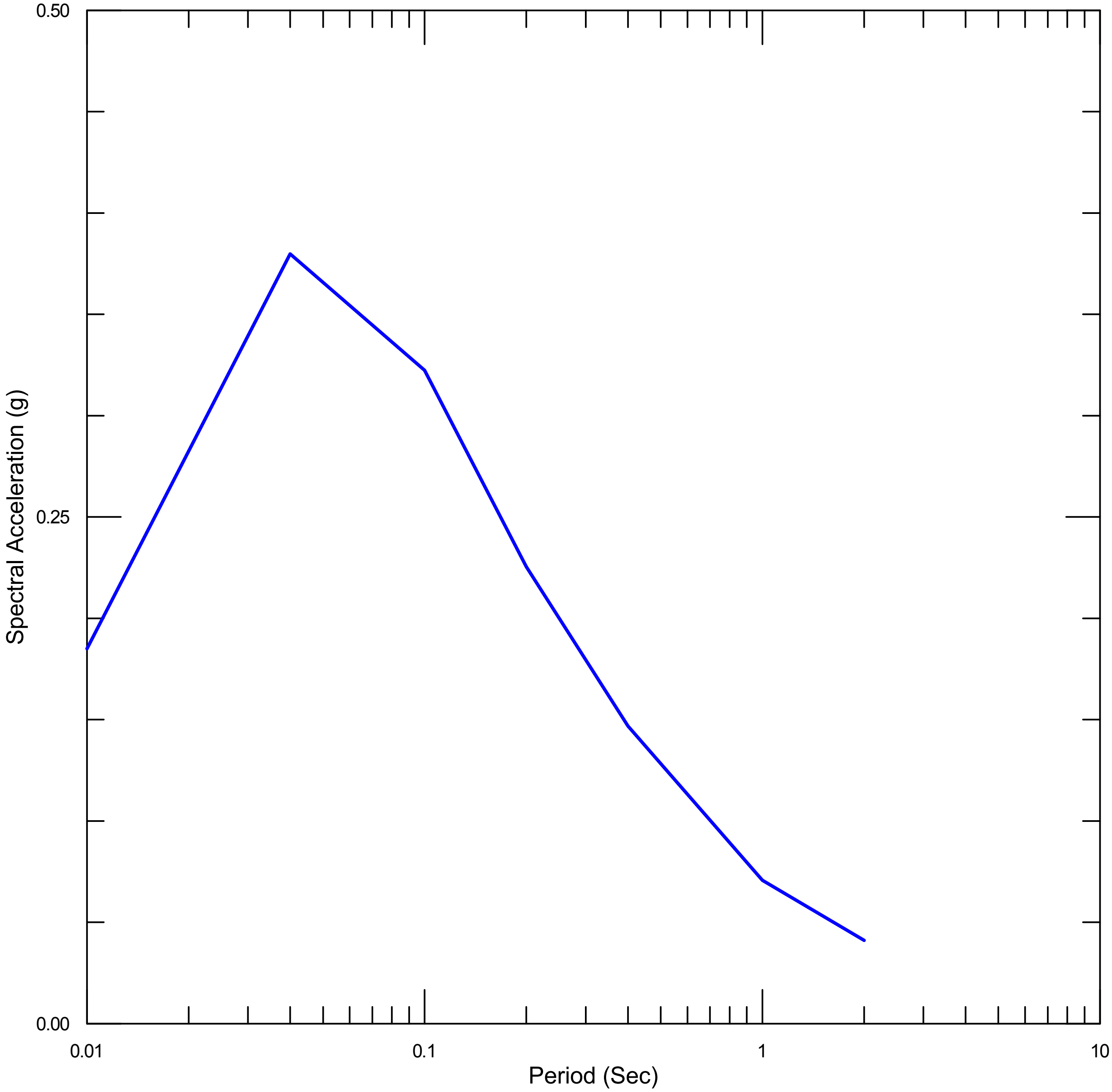
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEISMIC SOURCE FRACTIONAL CONTRIBUTION TO MEAN 1.0 SEC HORIZONTAL SPECTRAL ACCELERATION HAZARD ON HARD ROCK	Figure 19



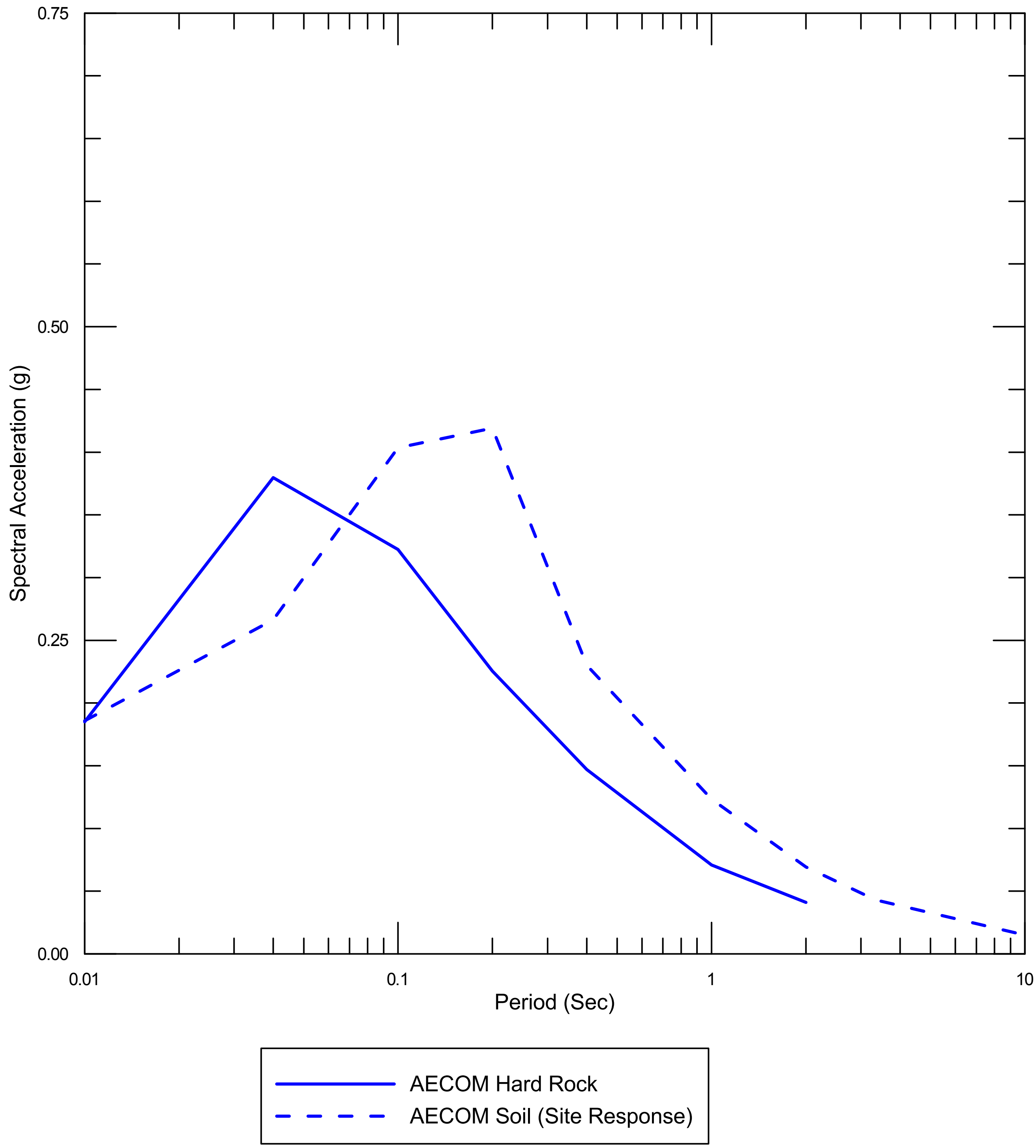
	Project No. 60440742	MAGNITUDE, DISTANCE AND EPSILON CONTRIBUTIONS TO THE MEAN PEAK HORIZONTAL ACCELERATIONHAZARD AT 2,475-YEAR RETURN PERIOD ON HARD ROCK	Figure 20
AECOM	Coffeen Power Station Dynegy		



AECOM	Project No. 60440742 Coffeen Power Station Dynegy	MAGNITUDE, DISTANCE AND EPSILON CONTRIBUTIONS TO THE MEAN 1.0 SEC HORIZONTAL SPECTRAL ACCELERATIONHAZARD AT 2,475-YEAR RETURN PERIOD ON HARD ROCK	Figure 21



AECOM	Project No. 60440742	5%-DAMPED MEAN HORIZONTAL UHS AT 2,475-YEAR RETURN PERIOD ON HARD ROCK	Figure 22
	Coffeen Power Station Dynegy		



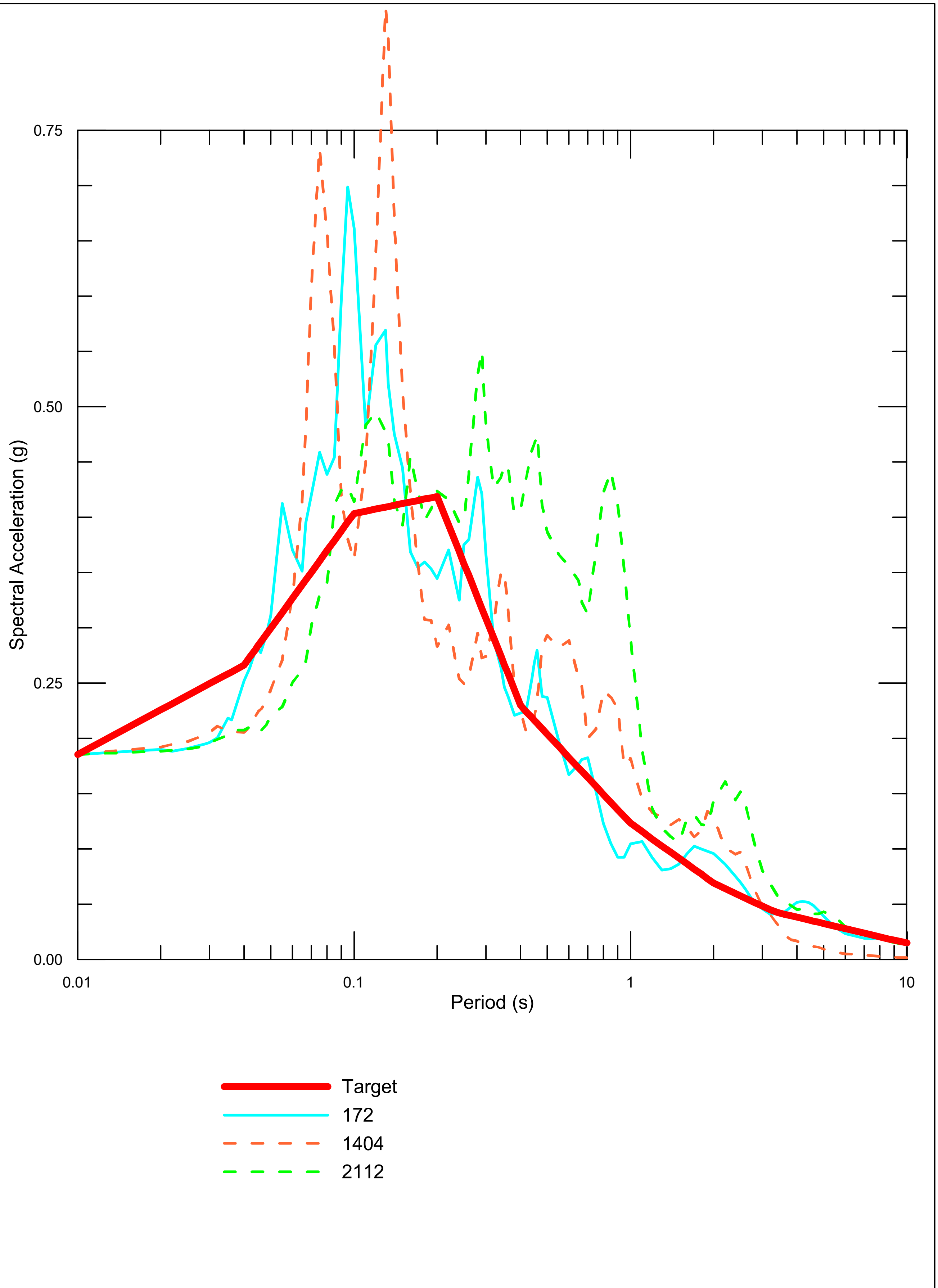
AECOM

Project No. 60440742

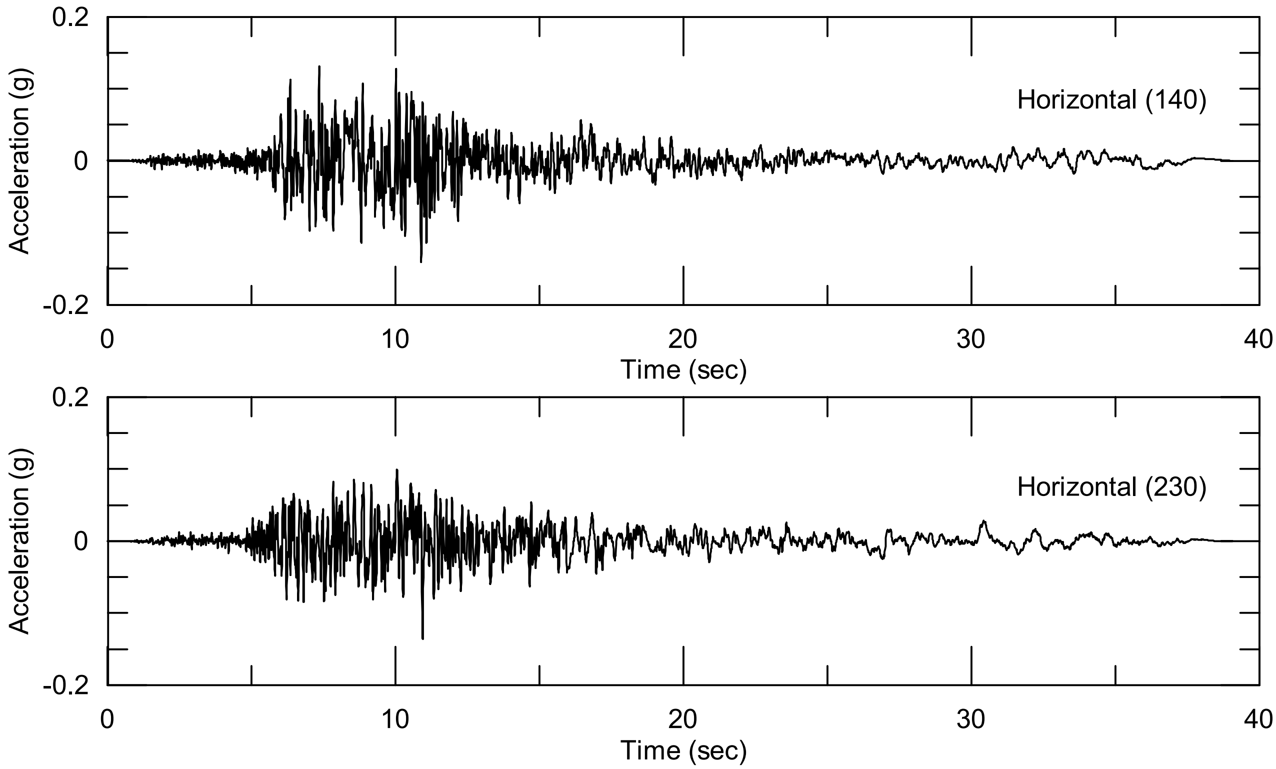
Coffeen Power Station
Dynegy

COMPARISON OF HORIZONTAL MEAN UHS
ON HARD ROCK AND GROUND SURFACE
AT 2,475-YEAR RETURN PERIOD

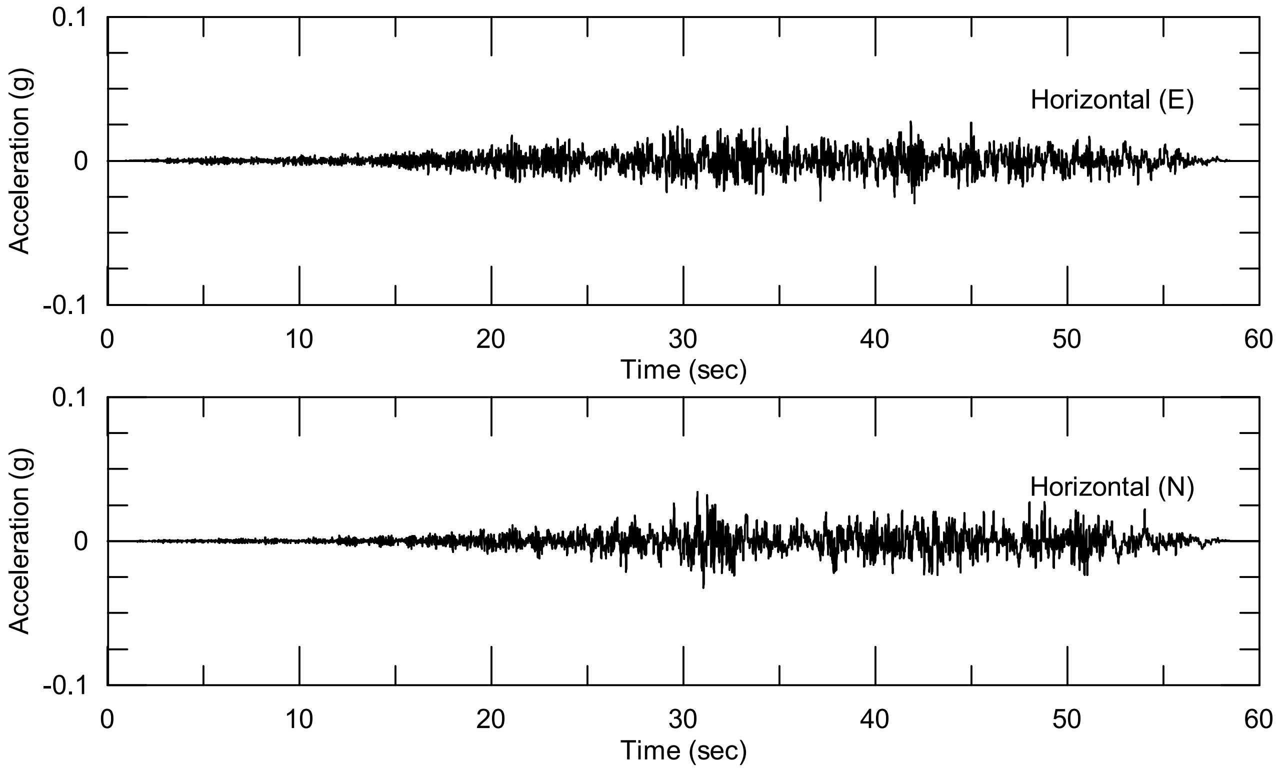
Figure
23



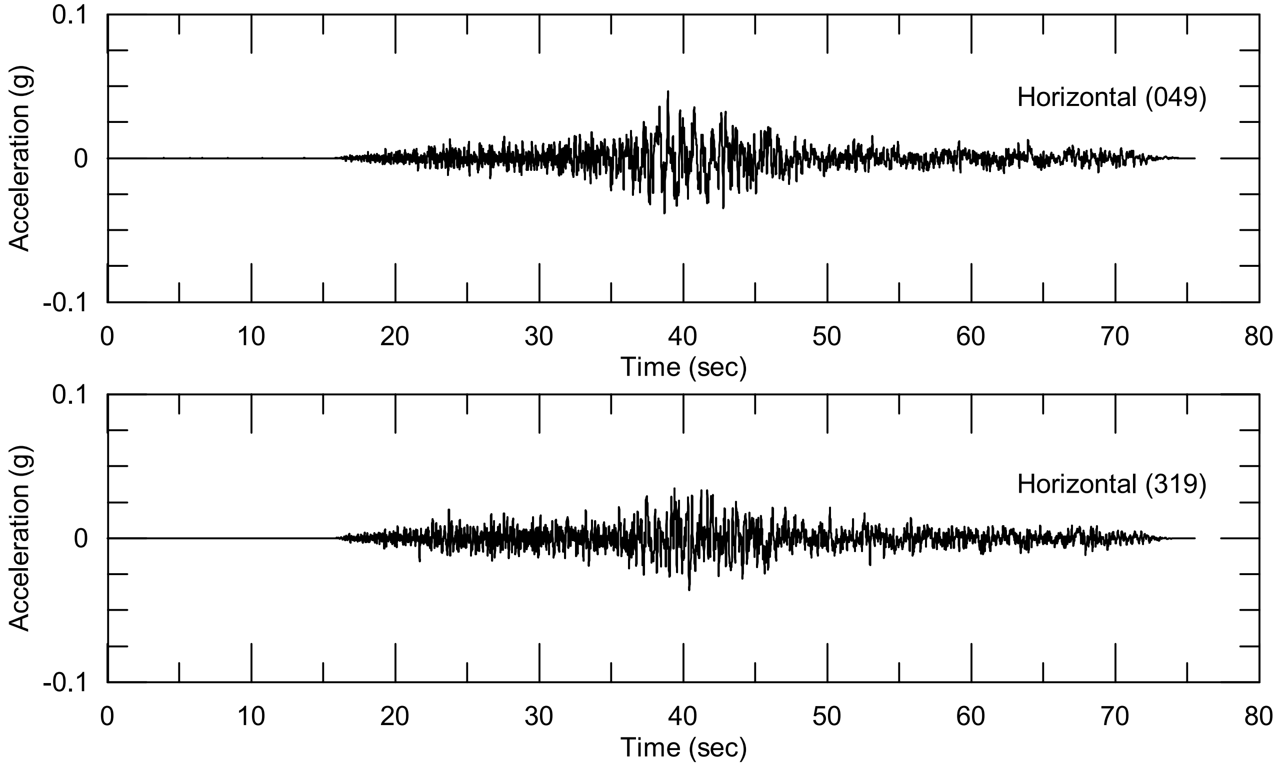
	Project No. 60440742	HORIZONTAL TARGET AND SELECTED SEED RESPONSE SPECTRA	Figure 24
AECOM	Coffeen Power Station Dynegy		



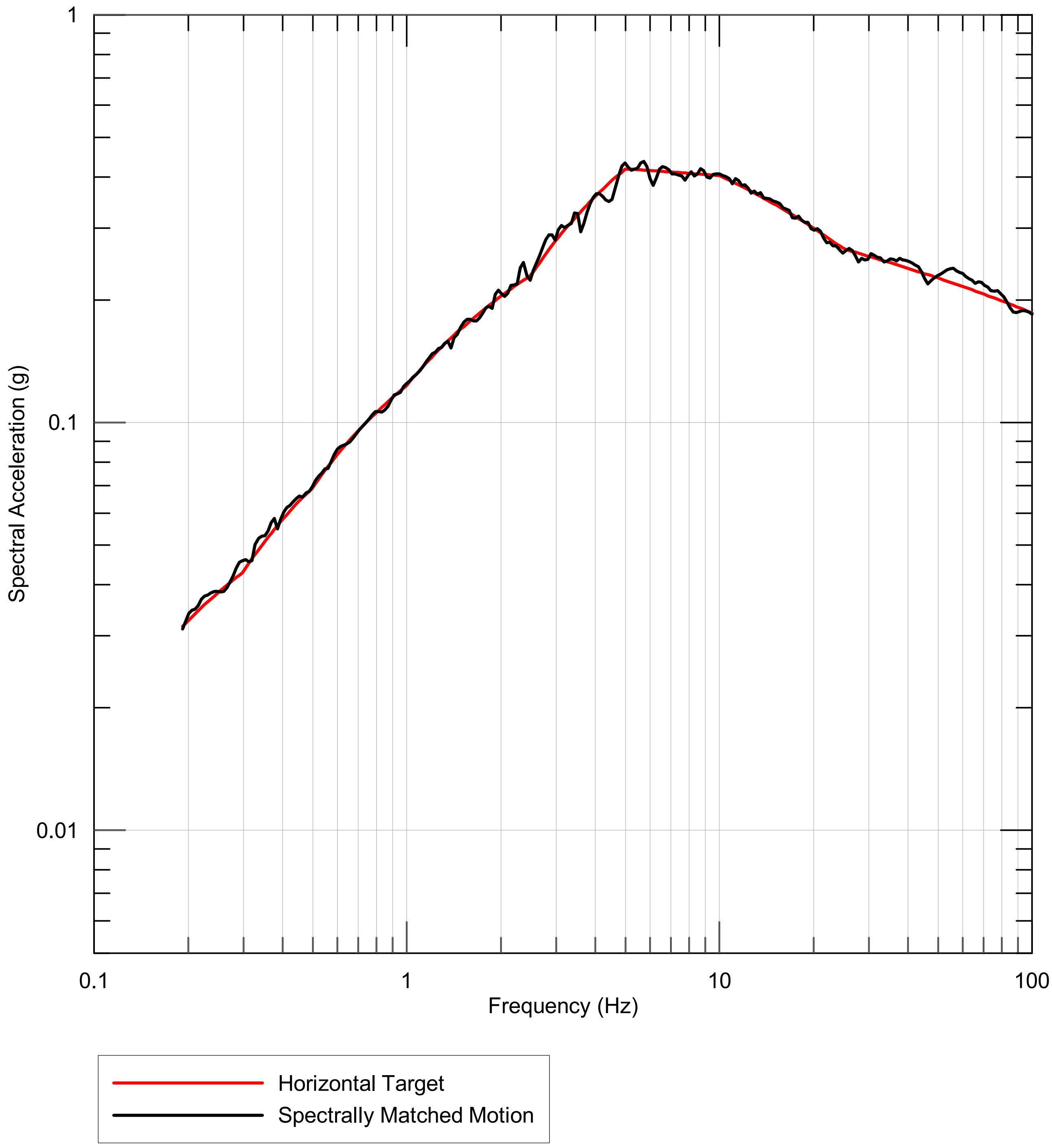
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEED TIME HISTORIES RSN0172 - 1979 IMPERIAL VALLEY EL CENTRO ARRAY #1	Figure 25



AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEED TIME HISTORIES RSN1404 - 1999 CHI CHI PNG	Figure 26

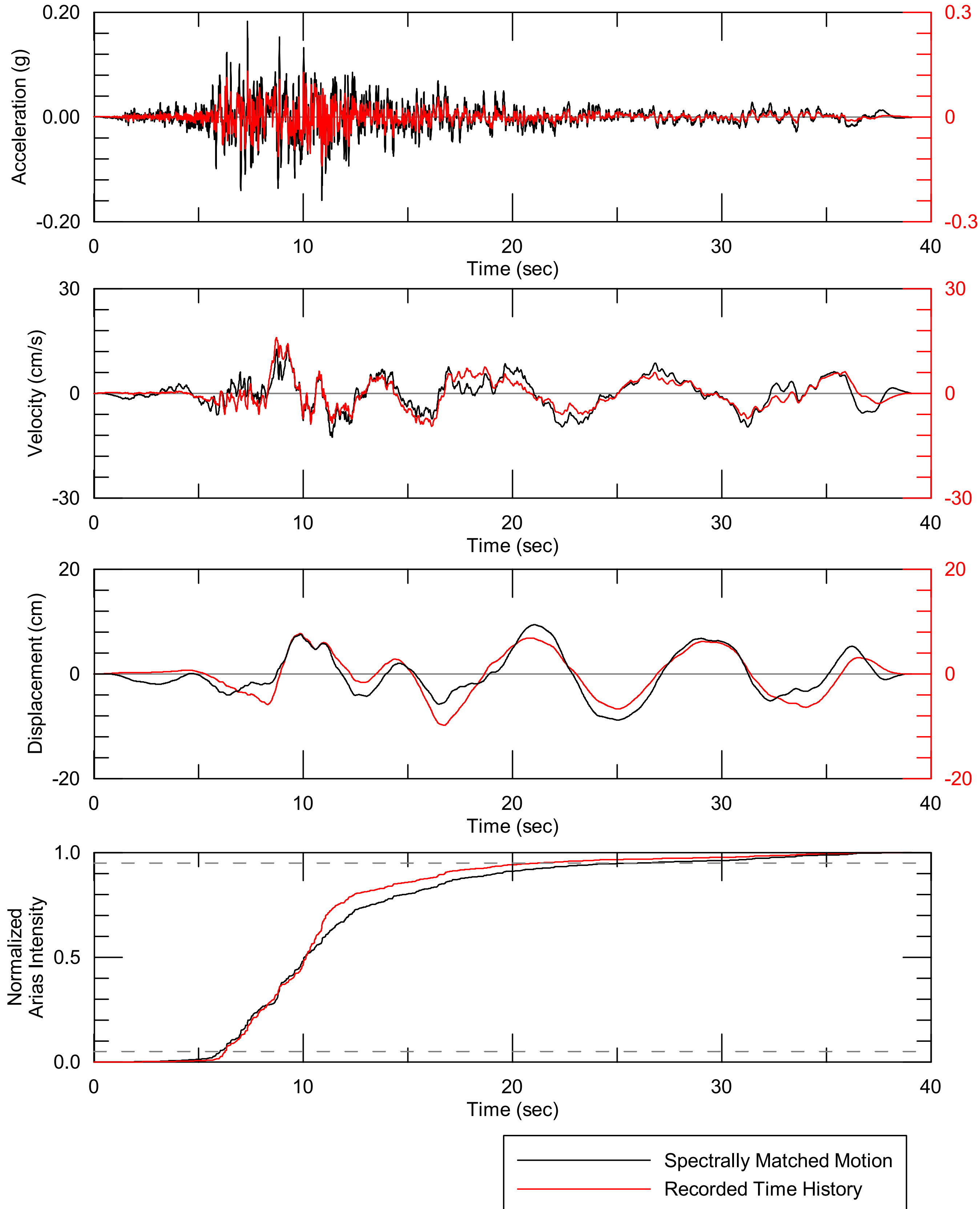


AECOM	Project No. 60440742 Coffeen Power Station Dynegy	SEED TIME HISTORIES RSN2112 - 2002 DENALI TAPS PUMP STATION #08	Figure 27



SEED: PEER RSN0172

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1979 IMPERIAL VALLEY - ECA #1 (140) SEED	Figure 28



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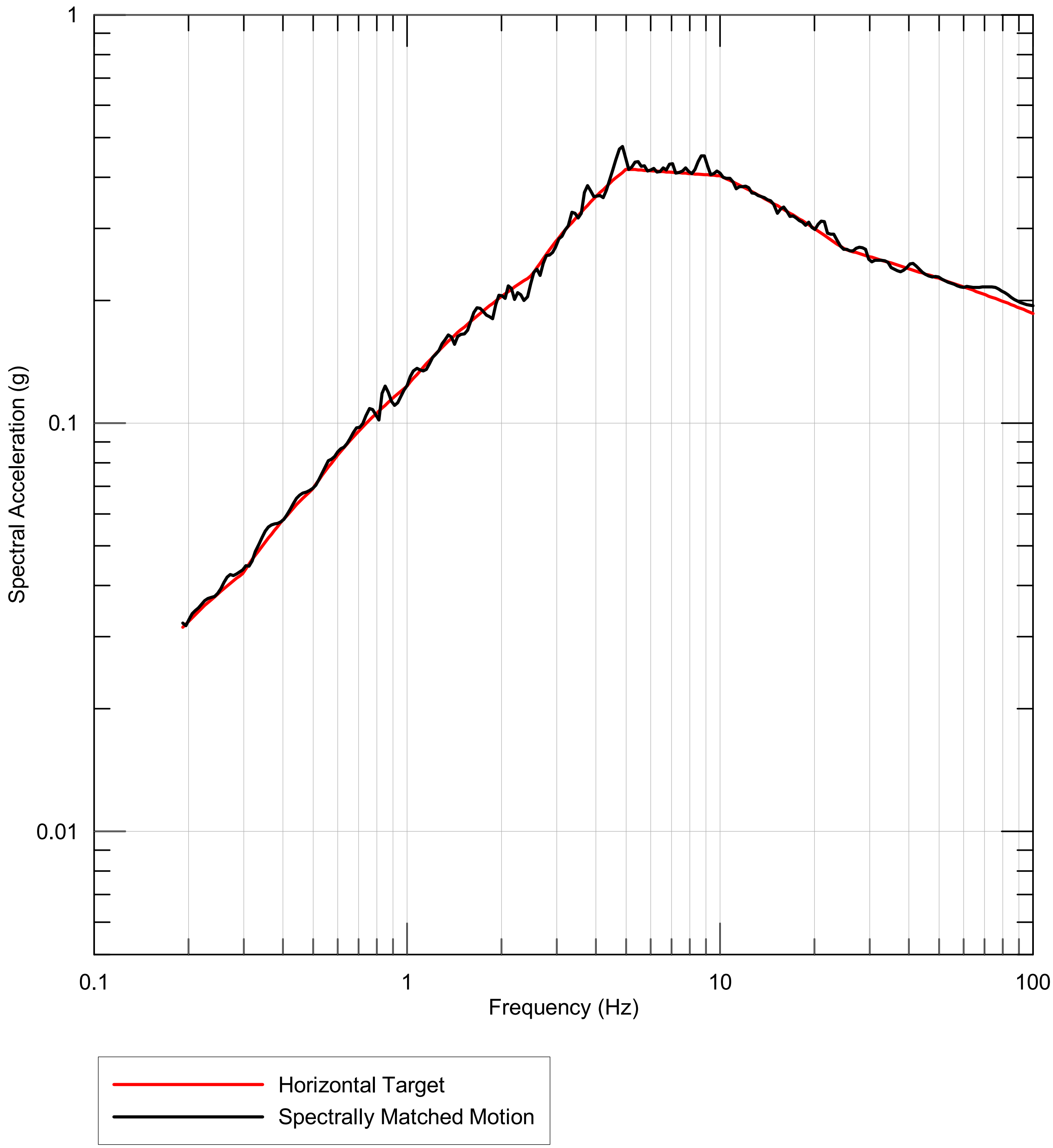
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1979 IMPERIAL VALLEY - ECA #1 (140) SEED	Figure 29



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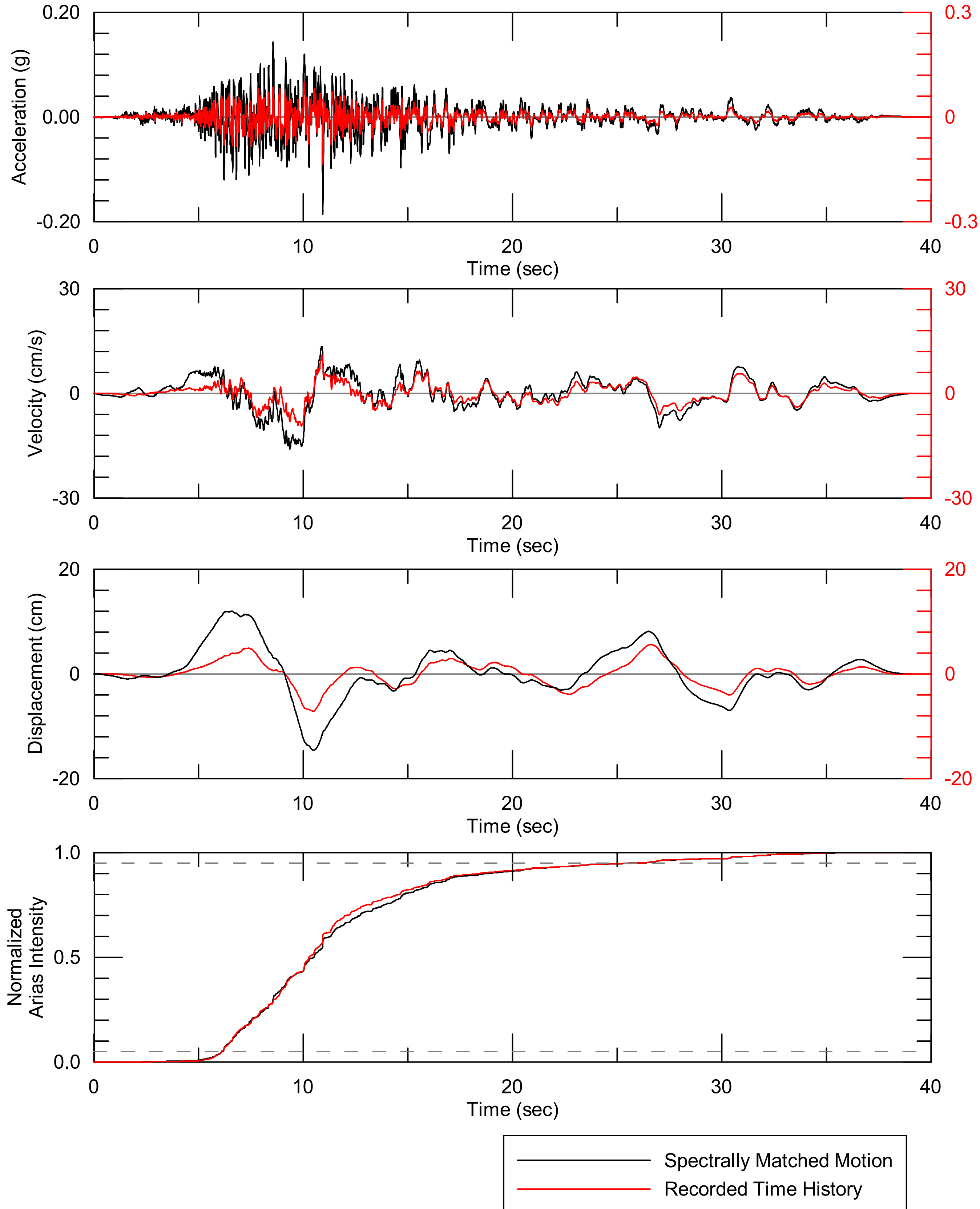
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1979 IMPERIAL VALLEY - ECA #1 (230) SEED	Figure 30



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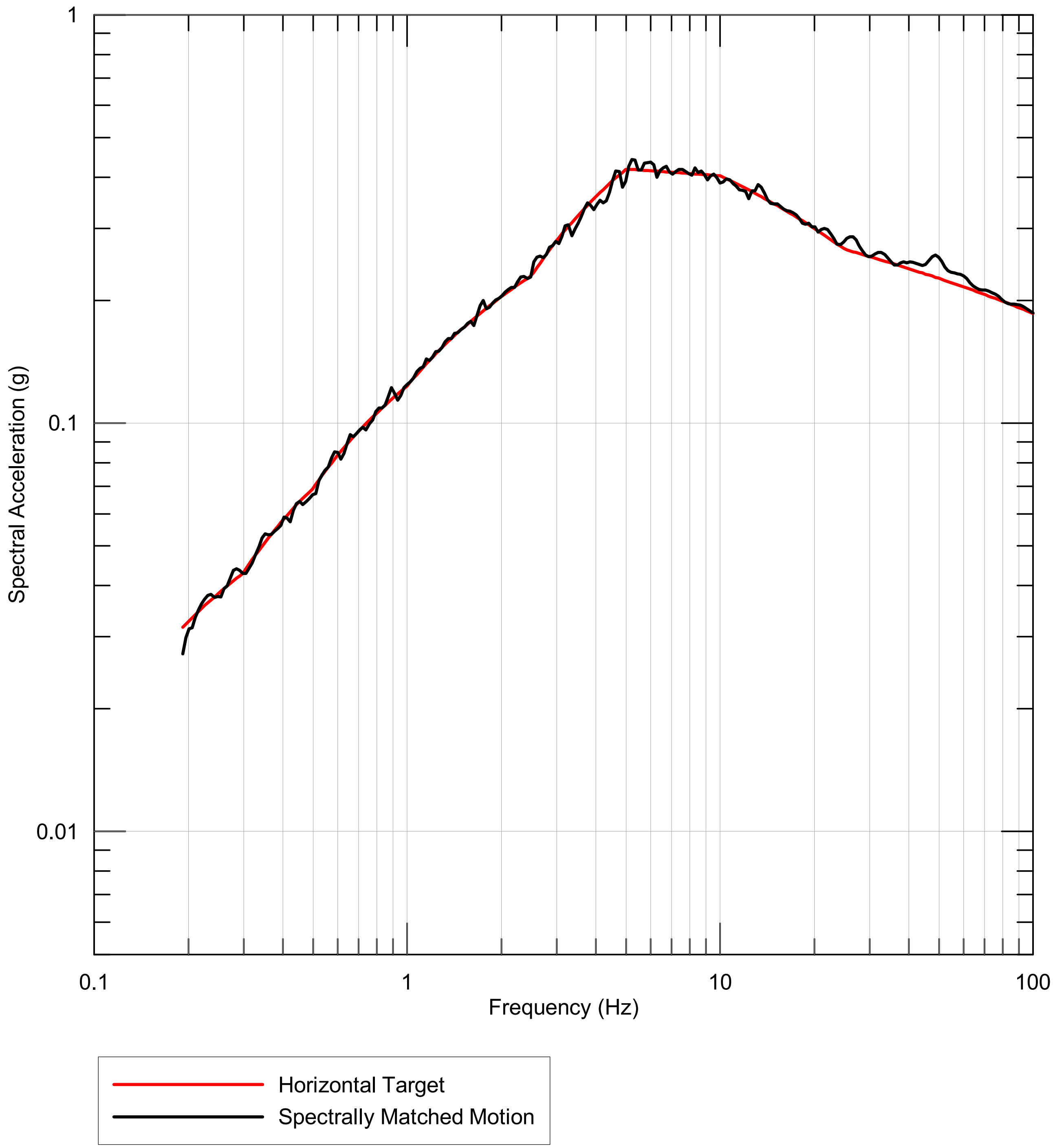
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1979 IMPERIAL VALLEY - ECA #1 (230) SEED	Figure 31



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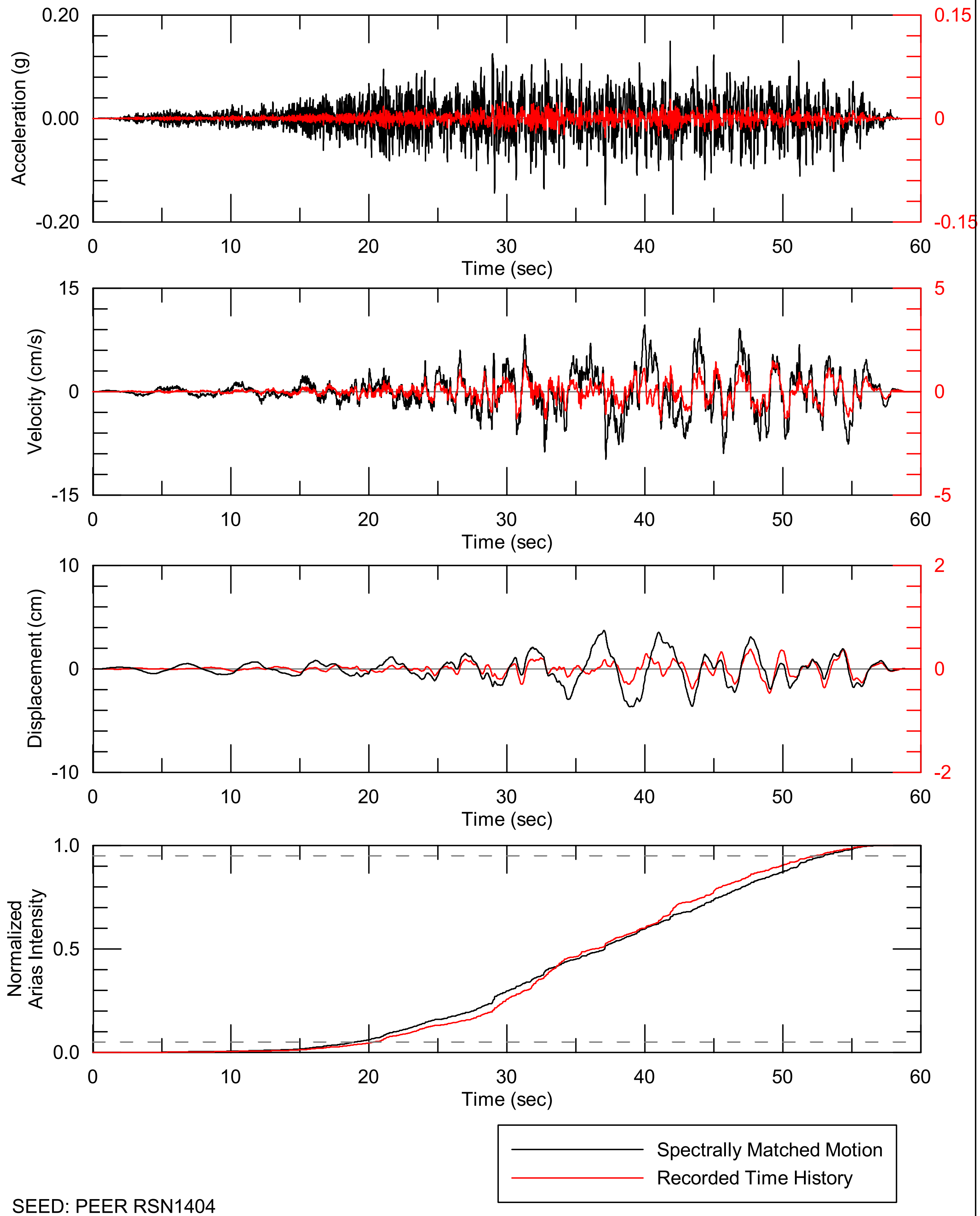
AECOM	Project No. 60440742 Coffeen Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 CHI CHI - PNG (E) SEED	Figure 32



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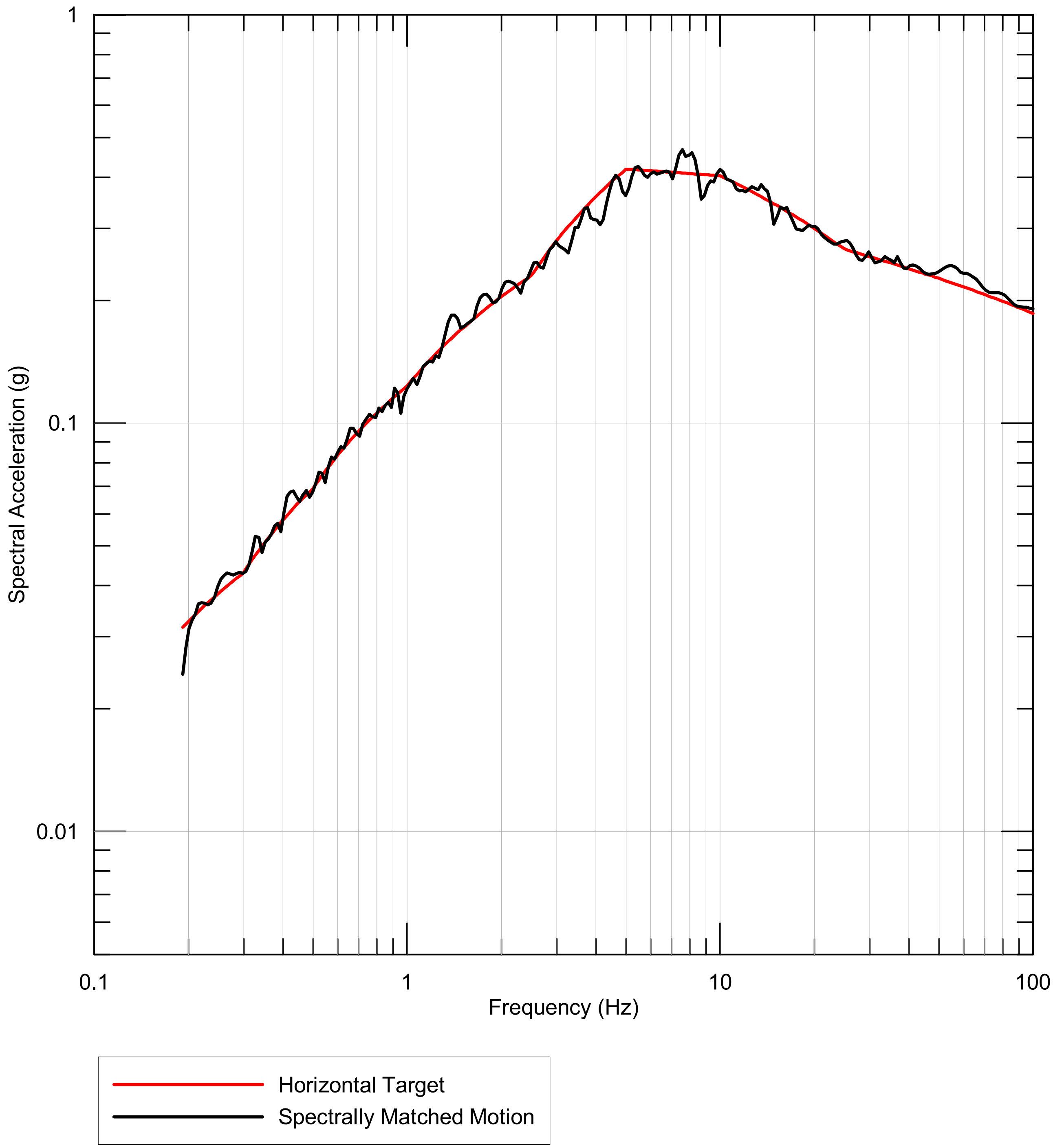
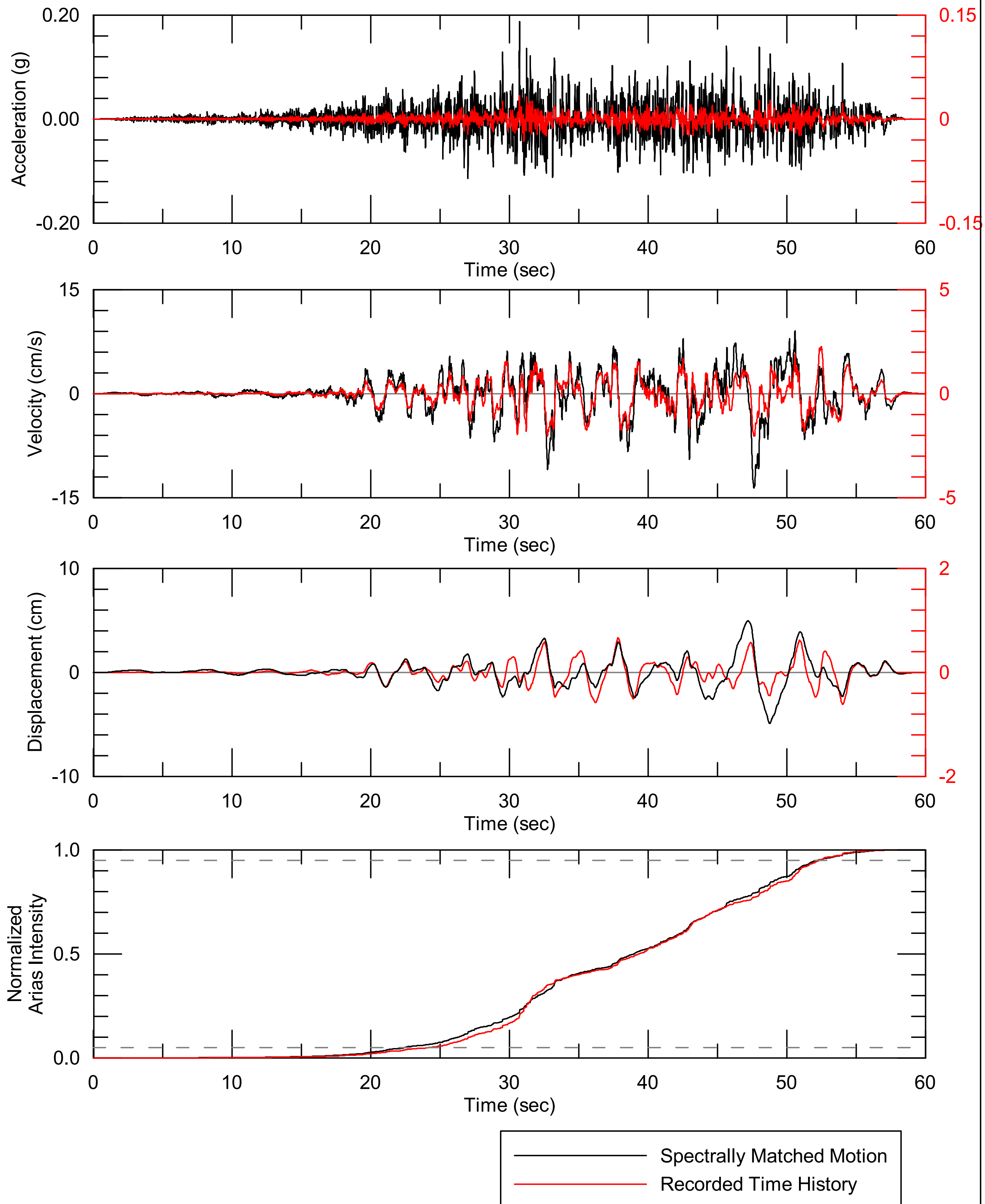


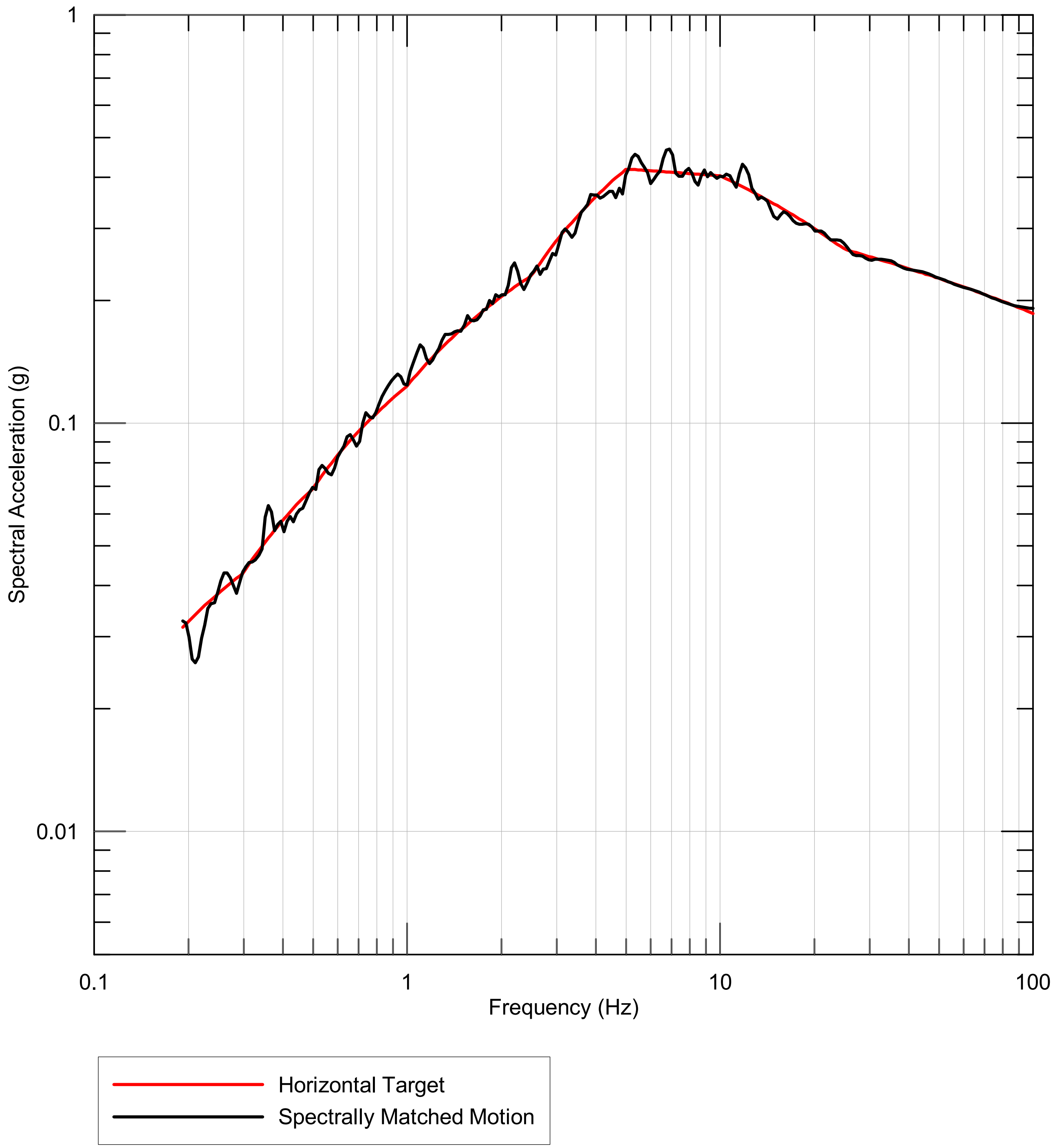
SEED: PEER RSN1404

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 CHI CHI - PNG (N) SEED	Figure 34



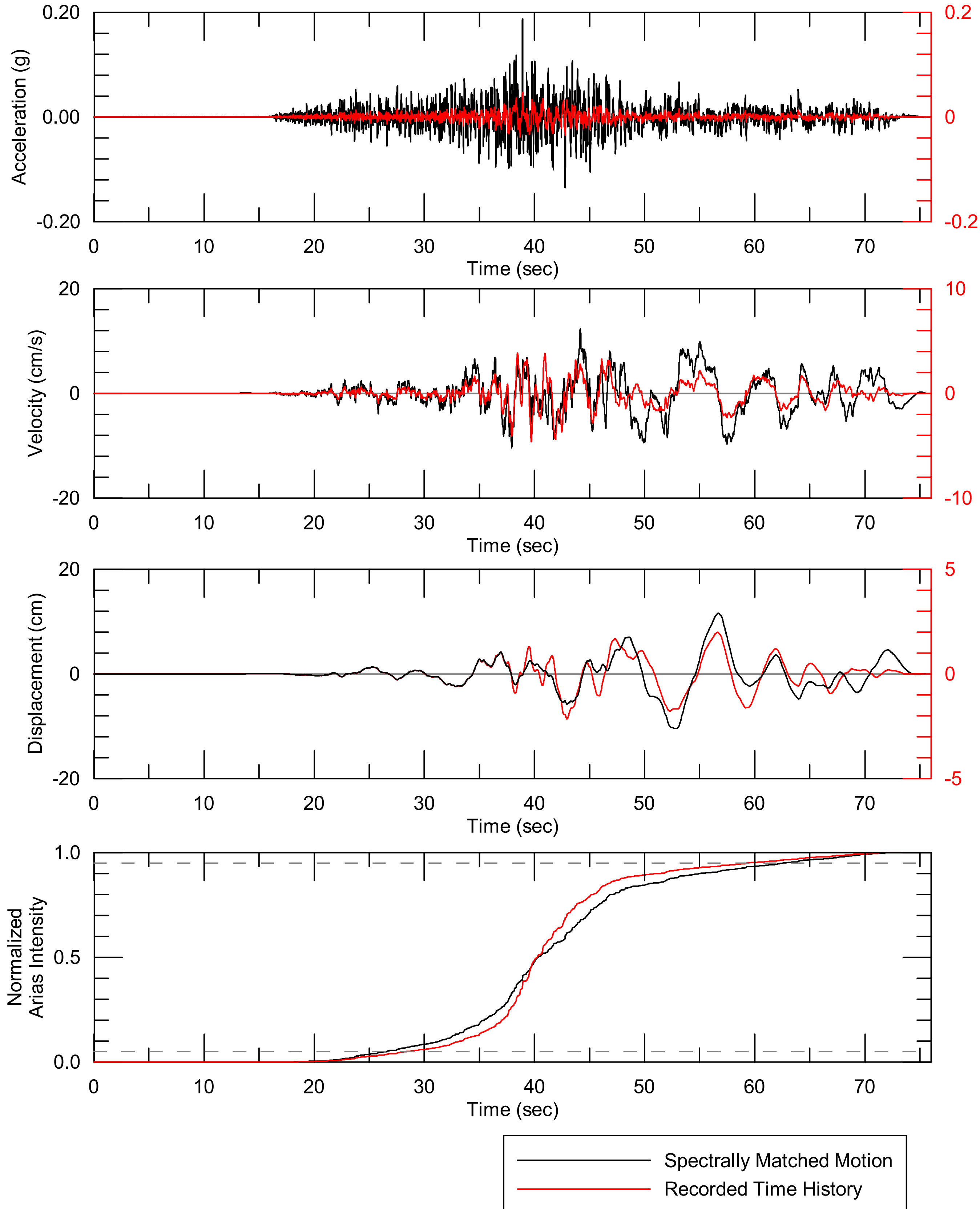
SEED: PEER RSN1404

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 CHI CHI - PNG (N) SEED	Figure 35



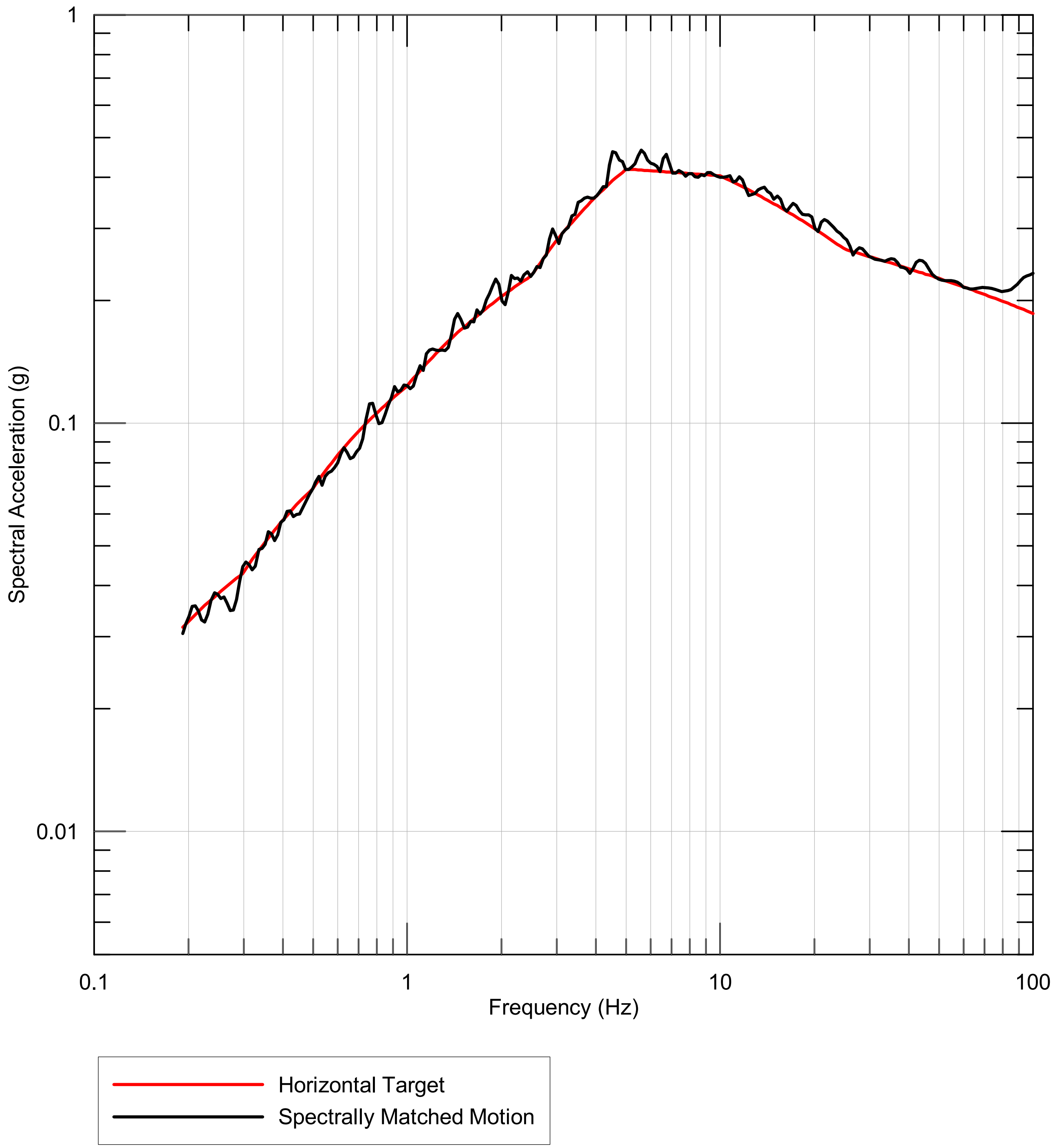
SEED: PEER RSN2112

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 2002 DENALI - TAPS PUMP STATION #8 (049) SEED	Figure 36



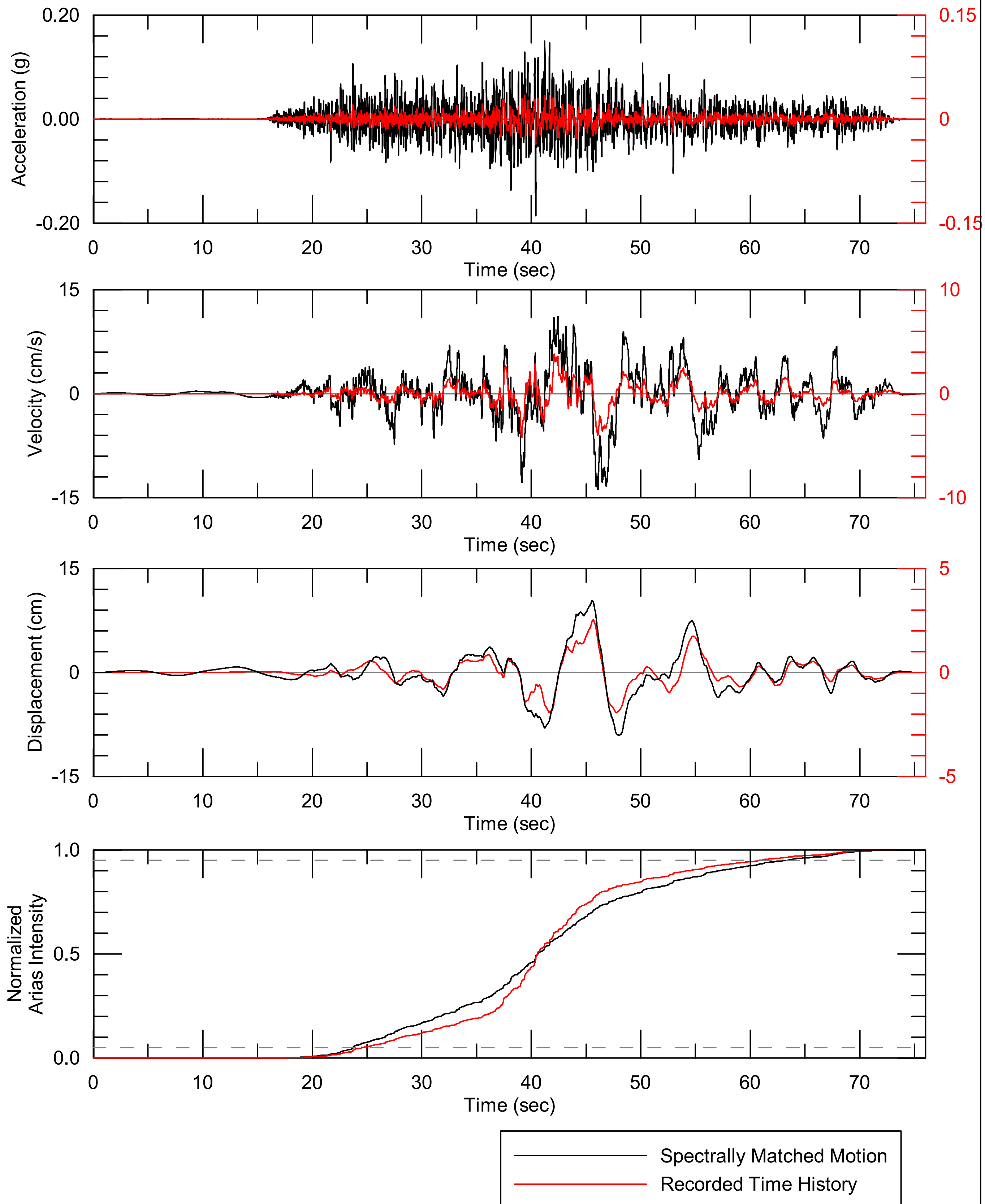
SEED: PEER RSN2112

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 2002 DENALI - TAPS PUMP STATION #8 (049) SEED	Figure 37



SEED: PEER RSN2112

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	RESPONSE SPECTRA FOR TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 2002 DENALI - TAPS PUMP STATION #8 (319) SEED	Figure 38



SEED: PEER RSN2112

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 2002 DENALI - TAPS PUMP STATION #8 (319) SEED	Figure 39

Attachment J. Dynamic Response Analysis Calculations

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Dynamic Response Analysis

Project Name: Dynegy CCR

By: Tiffany Adams Date: 01/21/2016

Project No: 60480701

Checked By: Masood Kafash Date: 01/22/2016

Task No.: 01

Objective

The purpose of this calculation is to perform 2-D site response analyses using the QUAD4M software program to estimate the seismic loads under the design, 2,500-year event.

Given:

- QUAD4TB, QUAD4MU, "A computer Program to Evaluate Seismic Response of Soil Structures Using Finite Element Procedures Incorporating a Compliant Base." Hudson, M., Idriss, I.M., and Beikae, M.
- Model geometry and material densities for Stations 30+00, 39+00, 46+50
- Shear wave velocity testing from the CPT investigations
- Earthquake motions developed through seismic hazard analysis

APPROACH AND ASSUMPTIONS:

The goal of this study is to estimate the peak ground surface accelerations (PGA) at the embankment crest and the embankment toe at Coffeen Ash Pond No. 1. These PGA values will be used as inputs to define the seismic load for the liquefaction triggering evaluation and to estimate a site-specific seismic coefficient for use in the seismic stability analyses (presented under separate cover) . Analyses were performed by using QUAD4M software program for the cross-sections at Station 30+00, 39+00, and 46+50 . Figure 1 provides an approximate location of each section. The general geometry of each of above mentioned cross sections are provided in Attachment A. Earthquake motions have been developed for Coffeen Ash Pond No.1 as part of the 2016 seismic hazard analysis for the top of the glacial till layer underneath the embankment (Vs = 2,250 ft/sec). Appendix B provides a summary and a comparison of the characteristics of above mentioned time histories. Cross sections, material properties and pore pressures used in analysis are mainly based and selected from slope stability analysis.

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Dynamic Response Analysis Project Name: Dynegy CCR

By: Tiffany Adams Date: 01/21/2016 Project No: 60480701

Checked By: Masood Kafash Date: 01/22/2016 Task No.: 01

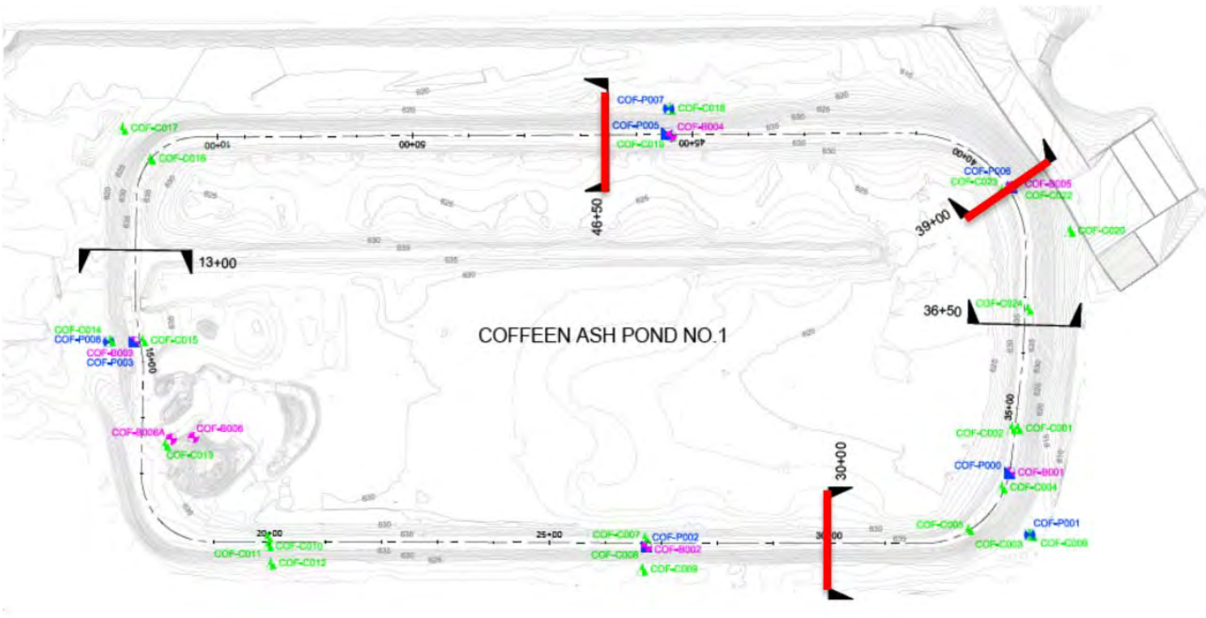


Figure 1. Location of QUAD4 Analysis Sections

Methodology

Due to the size and complexity of the section model, it is not practical to create a model mesh by hand. For time and practicality sake we used the FLAC program to develop the mesh and input properties under gravity at an elastic condition. A FLAC model for each section was developed and used. FISH and utility functions were used to convert the FLAC Model mesh and properties to the correct format for input into QUAD4.

Cross section

As discussed before, three cross sections developed in limit equilibrium slope stability analysis were used in site response analysis. In general cross sections have been developed based on the,2015 CPT soundings as discussed in the analysis section development calculation package. Five types of material were encountered during geotechnical investigation, including compacted embankment fill, foundation clay, glacial till, and a thin soft clay/silt/sand layer on top of the glacial till, directly below the foundation clay layer. Fly ash consisting of sand-size bottom ash material is impounded behind the embankment dam.

The QUAD4 model geometry was extended slightly into the glacial till layer, (Vs of 22500 ft/sec), as the earthquake motions have been developed as outcrop motion for the top of till.

Material Properties:

Elastic material properties including shear and bulk modulus of material are needed for QUAD4 analyses. The following provides a summary of parameters used in the analysis.

Shear stiffness parameters

Maximum shear modulus (Gmax) represents the stiffness of a material at very small strain levels. Shear modulus equation proposed in this table are based on a fit to the shear wave velocities obtained from CPT soundings. Average shear wave velocities for the embankment, foundation clay, and upper till were calculated based on the shear wave velocity tests in the CPT sounding, and are listed in Table 1. The shear wave velocity in the ash was estimated based on experience with similar bottom ash materials and the shear wave velocity of the soft clay layer was estimated to be the same as the overlying foundation clay layer, consistent with the material characterization for density and drained strength.

Shear Modulus and Damping Variations with Strains

As strains increase in the soil mass as a result of the intensity of earthquake shaking, the soils progressively start behaving nonlinearly and show a decrease in shear modulus and an increase in intergranular material damping. The reduction in shear modulus with increasing shear strains are typically normalized with respect to Gmax and expressed as a normalized modulus (G/Gmax) reduction versus strain relationship, which is dependent on the material type.

Vucetic and Dobry modulus and damping curves were selected for use with the clay materials at the site. The PI=15 curve was selected for the embankment and foundation clay based on their average PI values of 15 to 20, as determined from the laboratory testing program. The PI=0 curve was selected for the soft clay/silt/sand material based on the description of this material as being more granular and less plastic than the overlying clay. The EPRI sand curve for depths less than 20ft was selected for the bottom ash material, and Schnabel's curve for weathered rock was selected for the glacial till based on the high stiffness and strength of this material.

Table 1. Elastic material properties

Material	Unit Weight (pcf)	Dynamic Properties	
		Shear Wave Velocity (Vs) and Maximum Shear Modulus (Gmax)	Modulus and Damping Curves
Ash	112	*Vs=700 ft/s* Gmax = 1.7 x 10^6 psf	EPRI Sand (0-20ft), Idriss 1999 Modification
Embankment	135	*Vs=670 ft/s* Gmax = 1.9 x 10^6 psf	Vucetic and Dobry (PI=15)
Foundation Clay	125	*Vs=725 ft/s* Gmax = 2.0 x 10^6 psf	Vucetic and Dobry (PI=15)
Soft Clay	125	*Vs=725 ft/s* Gmax = 2.0 x 10^6 psf	Vucetic and Dobry (PI=0)
Glacial Till	135	*Vs=1300 ft/s* Gmax = 7.1 x 10^6 psf	Schnabel Weathered Rock

Time histories

The Chi-Chi east motion was selected as the most critical motion for use in the QUAD 4 analysis based on the Arias Intensity, duration and specific energy of the 6 ground motions provided with the PSHA. The 2500-yr design event has a PGA (at top of till) of 0.19g and Magnitude of 6.5

FILE LOCATIONS

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RESULTS

Crest and toe acceleration time histories for Station 30+00 and 46+50, and the crest acceleration time history from 39+00 are provided in attachment C. The peak ground acceleration (PGA) for the acceleration time histories at the crest is 0.40g and the PGA for the acceleration time histories at the dam toe is 0.21g.These site-specific PGAs are appropriate for use in the liquefaction triggering analysis, and the crest PGA is appropriate for use in determining the appropriate seismic coefficient for use in pseudo-static stability analysis.

REFERENCES:

Fast Lagrangian Analysis of Continua (FLAC). Version 7.0 Finite Difference Software, Itasca, 2011.

Vucetic, M. and Dobry, r., 1991, “Effect of Soil Plasticity on Cyclic Response,” Journal of Geotechnical Engineering, 117(no. 1): 89-107 .

Electric Power Research Institute (1993). Guidelines for determining design basis ground motions. Palo Alto, California: Electric Power Research Institute, vol. 1-5, EPRI TR-102293.

Schnabel, P. B., Lysmer, J., and Seed, H. B. (1972) “ SHAKE: A Computer Program for Earthquake Response Analysis of Horizontally Layered Sites”, Report No. UCB/EERC-72/12, Earthquake Engineering Research Center, University of California, Berkeley, December, 102p.

ATTACHMENTS:

- Attachment A –Cross sections
- Attachment B – Time histories
- Attachment C – Results.

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Dynamic Response Analysis

Project Name: Dynegy CCR

By: Tiffany Adams Date: 01/21/2016

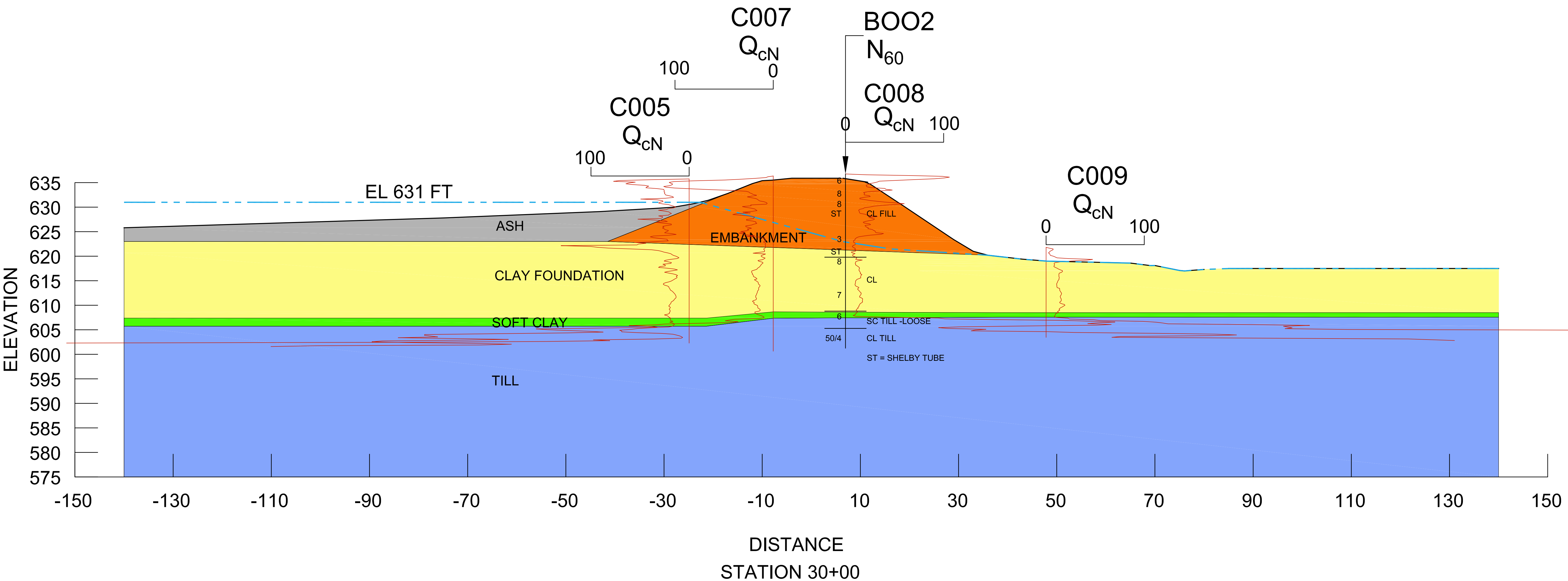
Project No: 60480701

Checked By: Masood Kafash Date: 01/22/2016

Task No.: 01

APPENDIX A

Cross Sections



PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 30+00	FIGURE 5-2
	AECOM		

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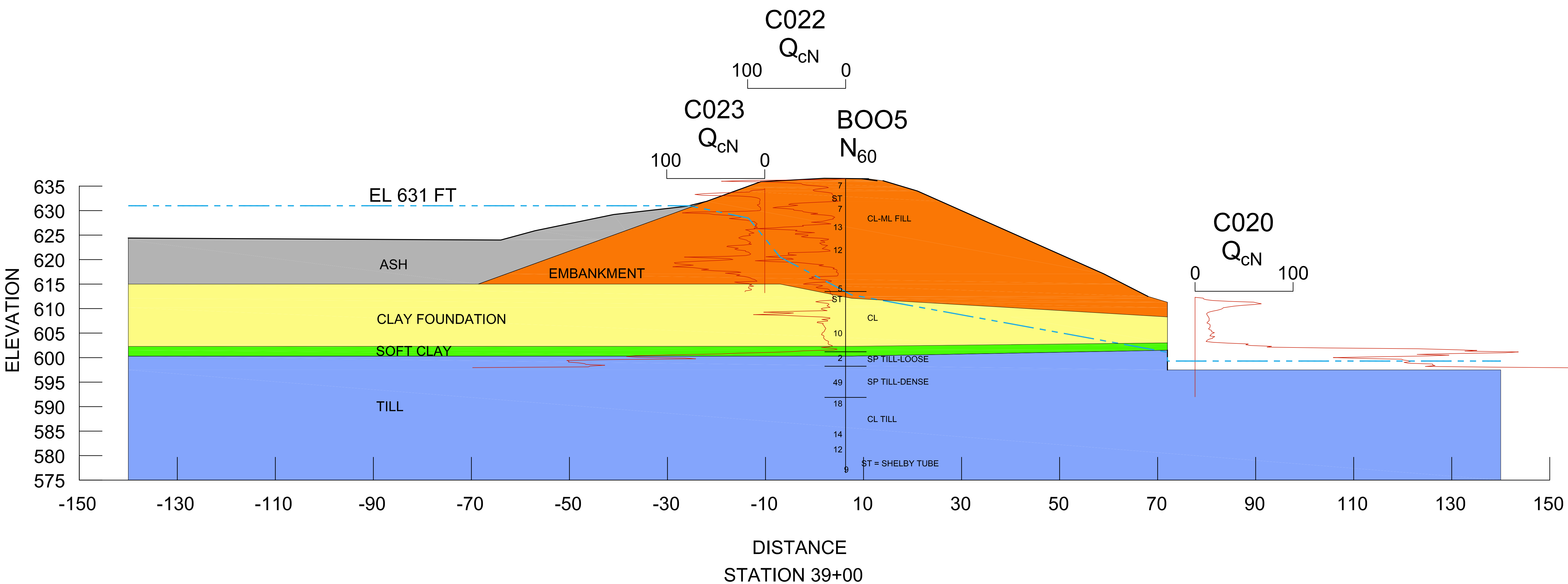

PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 39+00	FIGURE 5-4
	AECOM		

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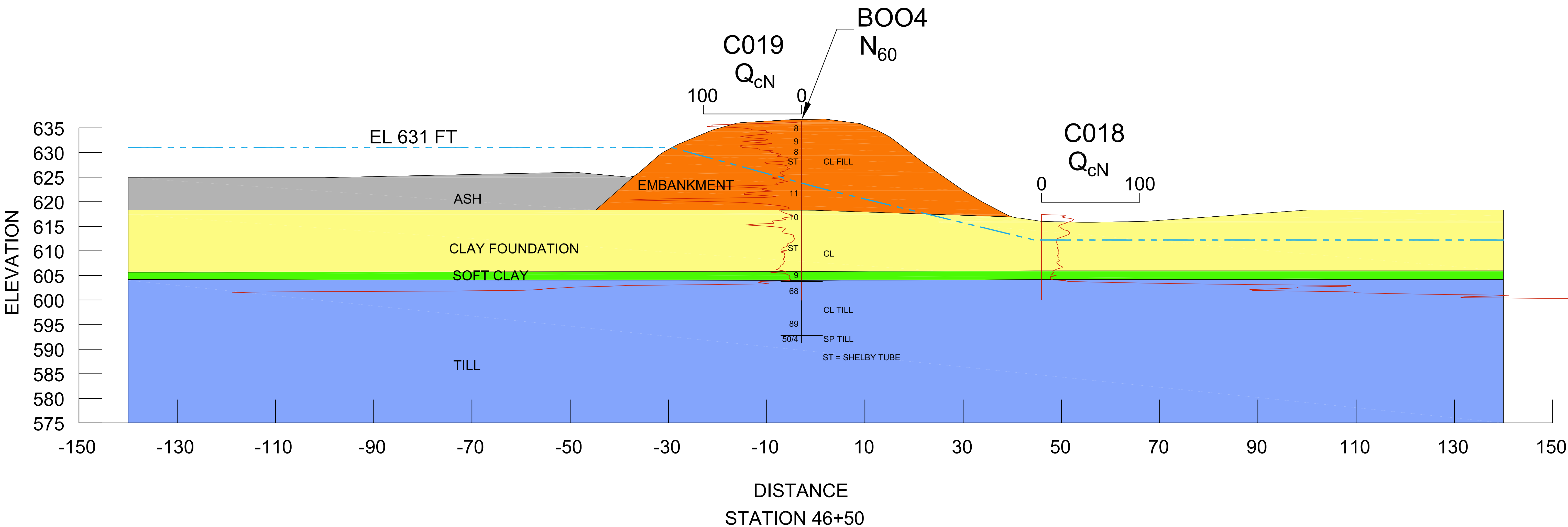

PROJECT NO. 60480701	DYNEGY CCR COFFEEN ASH POND NO. 1	SECTION STATION 46+50	FIGURE 5-5
	AECOM		

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Calculation Notes

Subject: Coffeen Ash Pond No. 1 Dynamic Response Analysis | Project Name: Dynegy CCR

By: Tiffany Adams | Date: 01/21/2016 | Project No: 60480701

Checked By: Masood Kafash | Date: 01/22/2016 | Task No.: 01

APPENDIX B

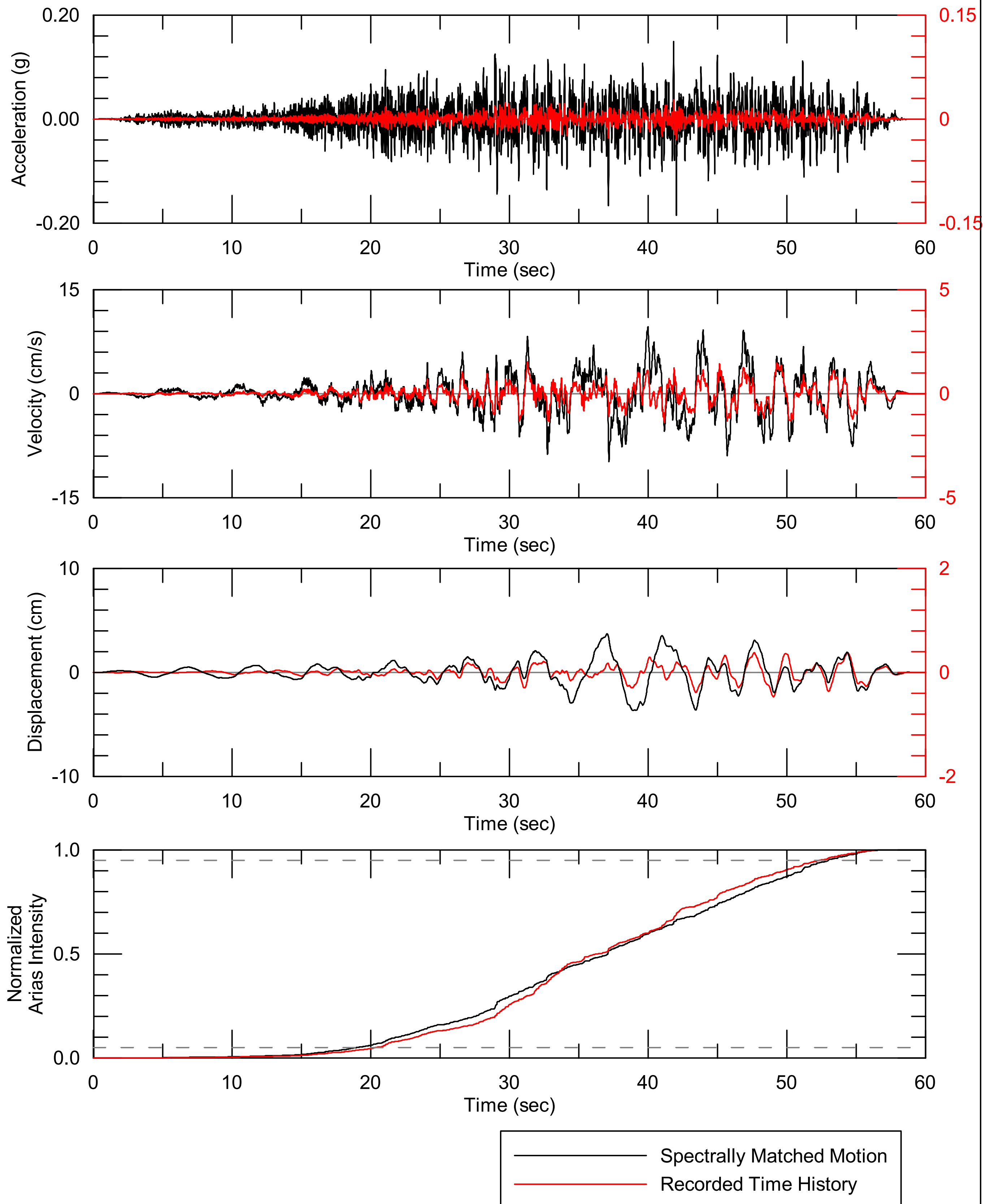
Time Histories

Table 12

Spectrally-Matched Time Histories

Record Sequence Number	Year	Earthquake Name	Station Name	Earthquake Magnitude (M)	ClstD (km)	V_S30 (m/sec)	Comp	PGA(g)	PGV (cm/sec)	PGD (cm)	5-95% AI (m/sec)	5-95% Dur (sec)
172	1979	Imperial Valley	El Centro Array #1	6.5	21.7	237.3	140	0.183	13.35	9.41	0.366	20.04
							230	0.186	15.98	14.61	0.402	19.59
1404	1999	Chi-Chi, Taiwan	PNG	7.6	110.3	465.9	E	0.185	9.79	3.70	0.900	34.02
							N	0.187	13.63	4.97	0.758	29.81
2112	2002	Denali, Alaska	TAPS Pump Station #08	7.9	104.9	424.9	049	0.187	12.31	11.66	0.554	35.99
							319	0.186	13.83	10.36	0.815	39.70

ClstD Closest distance
Comp Component
PGA peak horizontal ground acceleration
PGV peak horizontal ground velocity
PGD peak horizontal ground displacement
AI Arias intensity
Dur Duration



SEED: PEER RSN1404

AECOM	Project No. 60440742 Coffeen Power Station Dynegy	TIME HISTORY SPECTRALLY MATCHED TO 2,500-YEAR RETURN PERIOD UHS HORIZONTAL TARGET 1999 CHI CHI - PNG (E) SEED	Figure 33

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Dynamic Response Analysis

Project Name: Dynegy CCR

By: Tiffany Adams Date: 01/21/2016

Project No: 60480701

Checked By: Masood Kafash Date: 01/22/2016

Task No.: 01

APPENDIX C

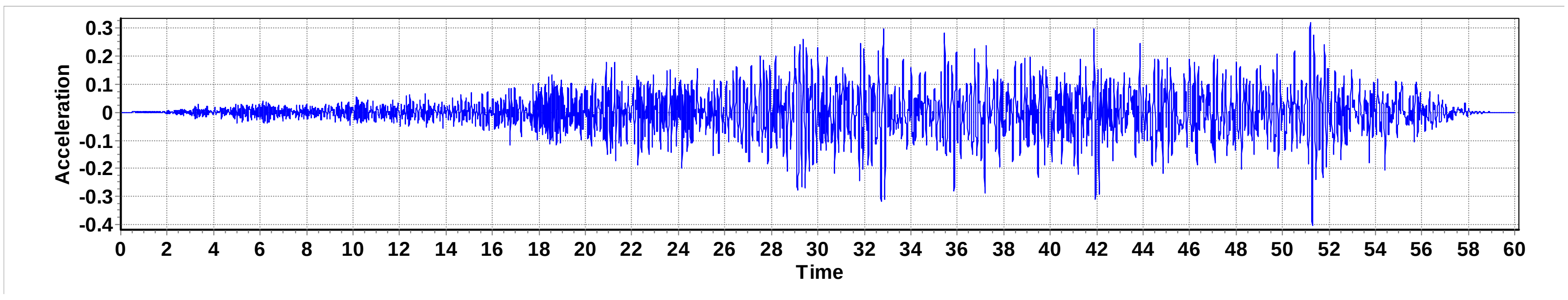
Results

QUAD4 RESULTS – ACCELERATION TIME HISTORIES

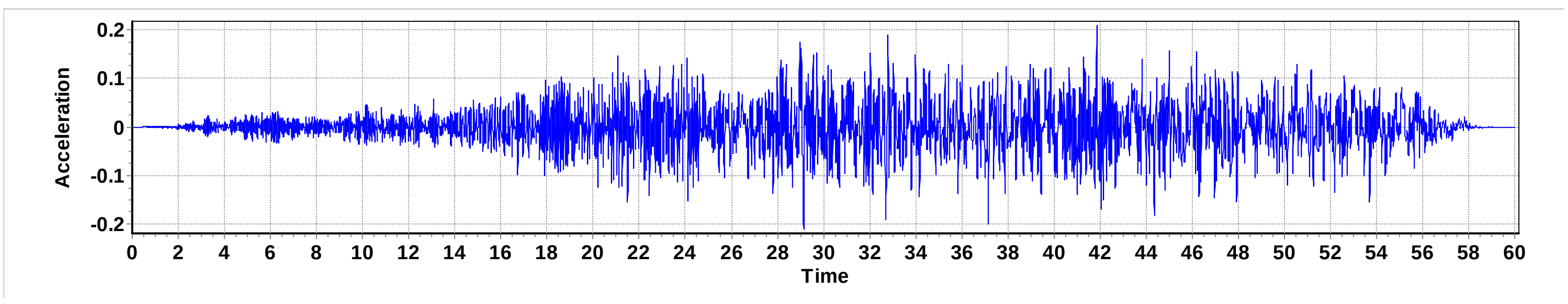
Input Motion: Chi Chi E spectrally matched to 2,500-year event (PGA=0.19g, M=6.5), top of Glacial Till

Station 30+00

Acceleration Time History at the Crest (PGA = 0.40g)

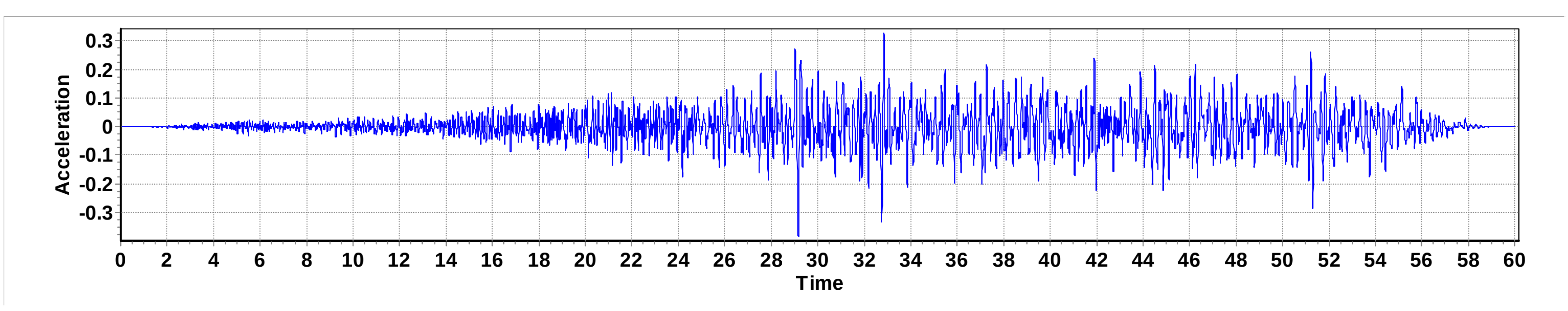


Acceleration Time History at the Toe(PGA = 0.21g)



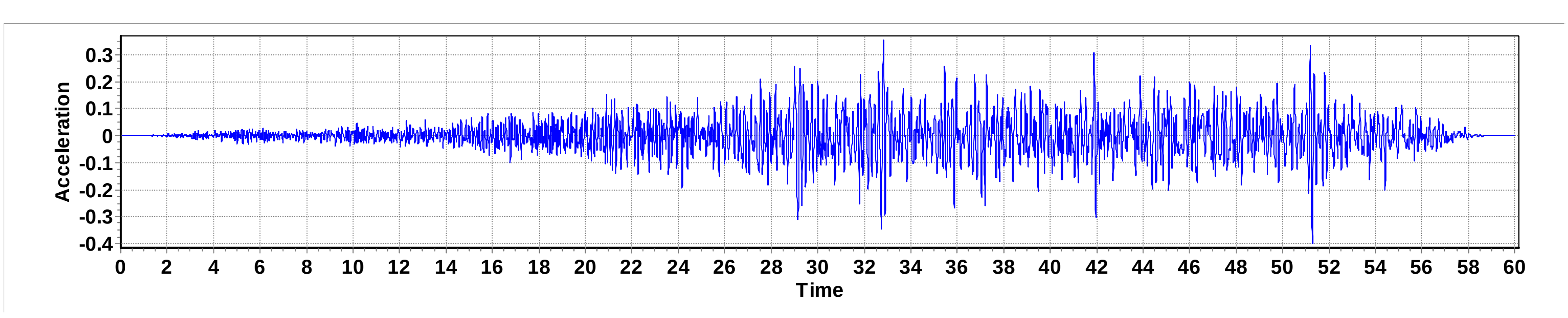
Station 39+00

Acceleration Time History at the Crest (PGA = 0.38g)

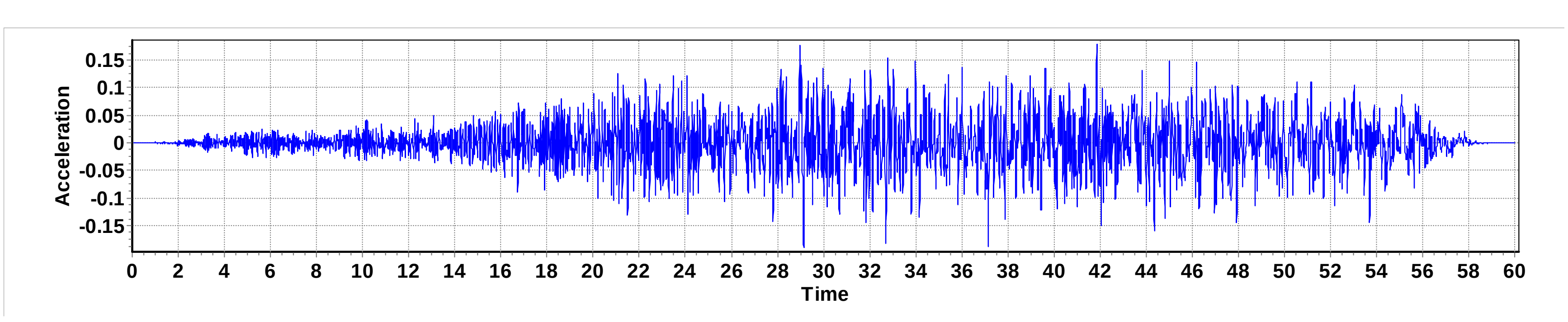


Station 46+50

Acceleration Time History at the Crest (PGA = 0.40g)



Acceleration Time History at the Toe (PGA = 0.19g)



Attachment K. Liquefaction Analysis Calculations

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Liquefaction Analysis

Project Name: Dynegy CCR

By: Brian Gomez / Meaghan Kenna Date: 01/22/2016

Project No: 60480701

Checked By: Julie Heitland Date: 01/22/2016

Task No.: 01

Objective

Determine the liquefaction potential of the Coffeen Ash Pond No. 1 impoundment using CPT-based triggering assessment. Liquefaction triggering analyses were evaluated using Idriss and Boulanger (2008).

Subsurface Conditions

A subsurface investigation was conducted at Coffeen Ash Pond No. 1 in August 2015 by AECOM. The investigation included 6 soil borings and 22 Cone Penetration Test (CPT) soundings. Borings and CPTs were drilled or pushed through the ash deposit and along the crest and toe of the existing embankments. CPT soundings used in the liquefaction triggering analysis are included in the Coffeen Ash Pond No. 1 Material Characterization calculation package.

Based on results of the investigation, five stratigraphic materials were identified at the site:

- **Impounded Ash**: Well-graded or medium- to coarse-grained SAND (cinders), with trace of silt or clay, very loose to medium dense, moist to wet, and black.
- **Embankment Fill**: Generally classified as silty CLAY, sandy CLAY, or CLAY with sand (CL), with a trace of fine gravel, soft to very stiff, low to medium plasticity, moist to wet, and brown to gray. Trace amounts of organic material and ash were sometimes encountered.
- **Foundation Clay**: Native clay of wind-blown origin (loess), with some coarse-grained layers. The fine-grained soils (clays) encountered in the borings were generally classified as low to medium plasticity silty CLAY, sandy CLAY, or CLAY with sand (CL) often with a trace of gravel; or high plasticity clay (CH), often with a trace of sand. The CL and CH soils were soft to very stiff, very moist to saturated, and brown to gray. The coarse-grained soils encountered in the borings were classified as clayey SAND (SC), silty SAND (SM), or fine- to coarse-grained SAND (SP), with a trace of gravel, loose to dense, wet to very wet, and brown to gray.
- **Soft Foundation Clay**: A thin layer of native silty or sandy clay (CL) was encountered in several borings and in CPT soundings between the foundation clay and underlying glacial till deposits. The clay was very soft to medium stiff, low to medium plasticity, very wet, and orange brown to gray.
- **Till:** Generally classified as CLAY, or silty to sandy CLAY (CL), with a trace of fine gravel, hard, low plasticity, moist to very wet, and brown to gray. In one boring, the till was classified as silty, fine- to coarse-grained sand (SP) underlain by clayey, fine to coarse grained sand (SC), with a trace of gravel, very dense, very wet, and brown.

ANALYSIS

The evaluation of liquefaction susceptibility of soils included a conventional triggering analysis calculating the factor of safety against liquefaction and a CPT-based liquefaction evaluation. The liquefaction triggering analysis is further described below.

CPT-Based Liquefaction Evaluation

The CPT-based state characterization of the soundings advanced at Coffeen Ash Pond No.1 provides an independent "first principles" approach to soils material behavior under dynamic and static loading conditions. The characterization provides an independent state assessment of whether the materials would behave in a dilative or contractive manner during loading. Materials that exhibit dilative behavior are typically denser, have a lower dynamic pore pressure response, and are less susceptible to liquefaction while materials that show contractive behavior are typically looser, have a higher dynamic pore pressure response, and are more susceptible to liquefaction.

The CPT-based state characterization included four different methods to evaluate the state of the embankment and foundation soils. The four methods include:

- Comparison between recorded static and dynamic pore pressures;
- Development of a normalized pore pressure parameter (P-value);
- Development of normalized CPT plots with state parameter lines; and
- Development of state parameter difference plots.

Each method is described in more detail below.

Static and Dynamic Pore Pressures

The static pore pressures in the CPT soundings obtained from the pore pressure dissipation tests were compared to the dynamic pore pressures recorded during cone advancement to evaluate potentially contractive or dilative material behavior as follows:

- Materials that show dynamic pore pressures greater than the static pore pressures indicate potentially contractive behavior during shearing; and
- Materials that show dynamic pore pressures less than static pore pressures indicate potentially dilative behavior during shearing.

Normalized Pore Pressure Parameter

The pore pressure difference value (P-value) was calculated by subtracting the static from the dynamic pore pressures (u_{dyn}-u_{static}) and normalizing the difference to the vertical effective stress, reflecting the effects of depth. If the P-value is negative, the dynamic pore pressures are less than the static pore pressures and the material shows potentially dilative behavior during shearing. If the P-value is positive, the dynamic pore pressures are greater than the static pore pressures and the material shows potentially contractive behavior during shearing.

Normalized Material Properties and State Parameter

Normalized CPT soil behavior type charts (SBTn chart) were created for the CPT soundings following the Robertson (2010) method to evaluate material behavior. The normalized CPT data were plotted as normalized tip resistance (Q_{tn}) versus normalized friction ratio (F_r). The approximate boundary between dilative and contractive material behavior is provided by the state parameter Ψ = -0.05 line plotted on the SBTn charts. The state parameter, Ψ, is the difference between the initial void ratio and the critical void ratio line.

The SBTn chart and data from liquefaction case histories (Robertson, 2010) is shown in Figure 1. The data shows that most flow liquefaction failures have CPT data that plots in zones 4 and 5 below the $Q_{tn,cs}$ = 70 line. The $Q_{tn,cs}$ = 70 line is similar to the state parameter Ψ = -0.05 line. The state parameter line for Ψ = 0.00 and Ψ = -0.10 were also shown on the charts to evaluate the sensitivity of the state parameter. The CPT soundings were normalized based on the phreatic surface at the time of sounding advancement.

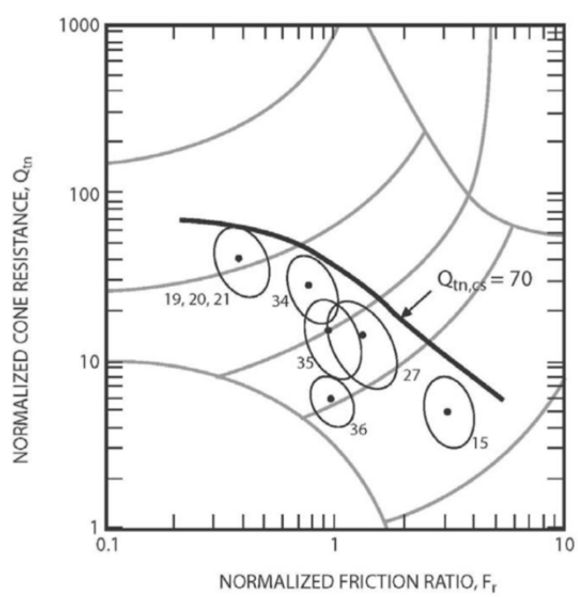


Figure 1: Robertson (2010) Liquefaction Case Histories

Generally, zones of dilative soils plot above the state parameter Ψ = -0.05 line of the SBTn chart and contractive soils plot below the state parameter Ψ = -0.05 line. Materials that plot in zones 2 and 3 of the SBTn chart generally indicate plastic or clay-like behavior and may not be susceptible to liquefaction.

State Parameter Difference

The state parameter difference plot combines the evaluation of the normalized pore pressure difference (P-value) and the normalized CPT data soil behavior plots to provide an additional tool to help characterize the material as potentially contractive or dilative.

Negative P-values indicate potentially dilative behavior and positive values indicate potentially contractive behavior, as described above, and are plotted on the y-axis on the state parameter difference plot. The perpendicular distance from the state parameter Ψ = -0.05 line for each data point was calculated and plotted on the x-axis on this plot. Recognizing that data plotting above the state parameter Ψ = -0.05 line on the normalized CPT soil behavior plot indicate dilative behavior, the horizontal distance calculated to a point above this line was given a negative value to remain consistent with the convention that negative values indicate dilative behavior. Therefore, a point that plots below the state parameter Ψ = -0.05 line on the normalized CPT soil behavior plot is positive, indicating contractive behavior.

The state parameter difference plot was broken into quadrants, with quadrant number one in the upper right corner progressing counterclockwise to quadrant number four in the lower right corner. Material that showed dilative behavior on both the normalized pore pressure difference plot and normalized CPT soil behavior plot can be found in quadrant three. Material that showed potentially contractive behavior in both the normalized pore pressure difference plot and on the normalized CPT soil behavior plot will plot in quadrant one.

Results

The CPT-based state characterization analysis is typically used to evaluate the liquefaction potential of sands. Since the embankment and foundation clay materials at Coffeen Ash Pond No. 1 are clay-like, they are not susceptible to liquefaction. Therefore, the CPT-based state characterization does not provide indication of potential for strength loss in these materials. However, the trend toward more dilative response in the upper portion of the soundings is consistent with the compacted clay embankment and the upper over-consolidated portion of the foundation clay.

CPT sounding COF-C013 was advanced through the ash material. The CPT-based state characterization analysis on this CPT indicates the saturated sand-like material as primarily dilative. A liquefaction triggering analysis was performed to assess the liquefaction potential of this material. However, the dilative behavior of this material is consistent with cyclic mobility and therefore may not behave as a liquefaction flow failure.

Liquefaction Triggering Analysis

An earthquake triggering analysis is used to assess the liquefaction potential of saturated soils under a design event. The analysis consists of comparing the calculated cyclic resistance ratio (CRR) from the CPT soundings to the cyclic stress ratio (CSR) calculated from a simplified site response analysis as described in Idriss and Boulanger (2008). All the CPT soundings performed were evaluated for liquefaction triggering potential.

The factor of safety against liquefaction is computed as:

$$FS = \frac{CRR}{CSR}$$

If the calculated factor of safety is less than 1.2, the material is considered to be potentially liquefiable. If the calculated factor of safety is greater than 1.2, the material is considered to be not susceptible to liquefaction. A detailed description of the procedure can be found in Idriss and Boulanger (2008).

Based on the 2016 PSHA, the design event for the Coffeen Ash Pond No.1 site is a 2,500-year, 6.5 magnitude event with a PGA of 0.19g. A dynamic response analysis was performed (discussed in a separate calculation package) using QUAD4 to determine the PGA at the crest and toe of the embankment. For this site, the PGA_{crest} = 0.40g and the PGA_{toe} = 0.21g.

Results

The CPT liquefaction triggering plots generally show factors of safety greater than 1.2, except for the soft clay layer above the till and the ash material. Factors of safety were less than 1.2 in some portions of the sounding where the I_c index values were less than 2.6. These portions were calculated consistently with liquefaction triggering evaluation of sand-like material.

While the I_c index for the embankment and foundation clay materials at the Coffeen Ash Pond No. 1 site vary from somewhat above (clay-like) and below (sand-like) the 2.6 index value, the materials encountered during the field investigation classify as clay. To illustrate how this affects the liquefaction triggering factor of safety, CPT COF-C006 was reinterpreted using the Idriss and Boulanger cyclic softening evaluation criteria for clay-like materials (Figure 2 below), and results in factors of safety well above 1.2. Therefore, the triggering analysis indicates that the embankment and foundation clay above the soft layer do not have a potential for cyclic softening during the design earthquake event; only the soft clay layer has factors of safety indicative of potential cyclic softening during the design earthquake event.

The liquefaction triggering analysis completed on cone penetration sounding COF-C013 was pushed within the ash material. This cone shows about 17 feet of ash material underlain by native soils. Based on the simplified liquefaction analysis, the saturated sand-like material indicates factors of safety against liquefaction less than 1.2, and thus the potential for liquefaction.

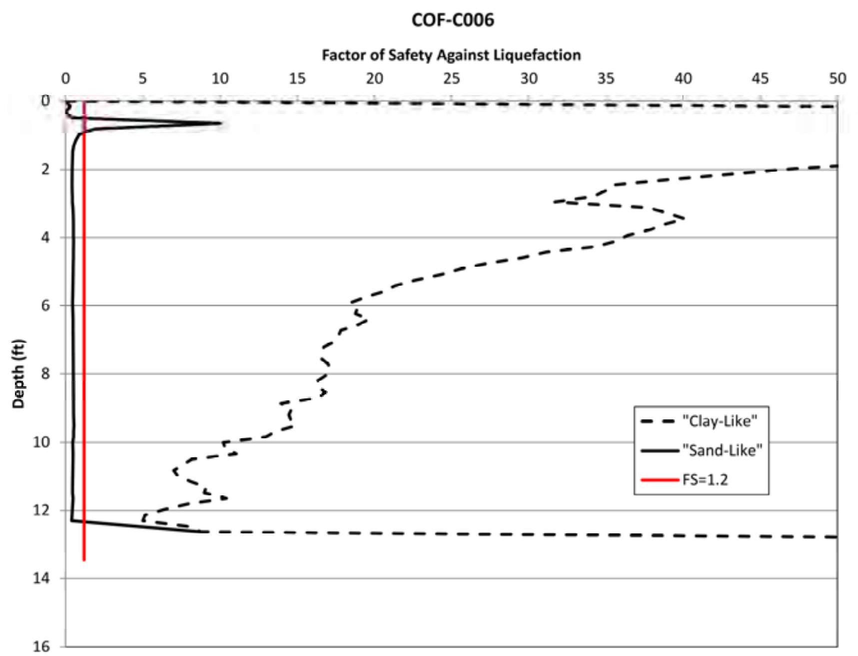


Figure 2: CPT COF-C006 Factors of Safety for Sand-Like and Clay-Like Evaluations

Calculation Notes

AECOM

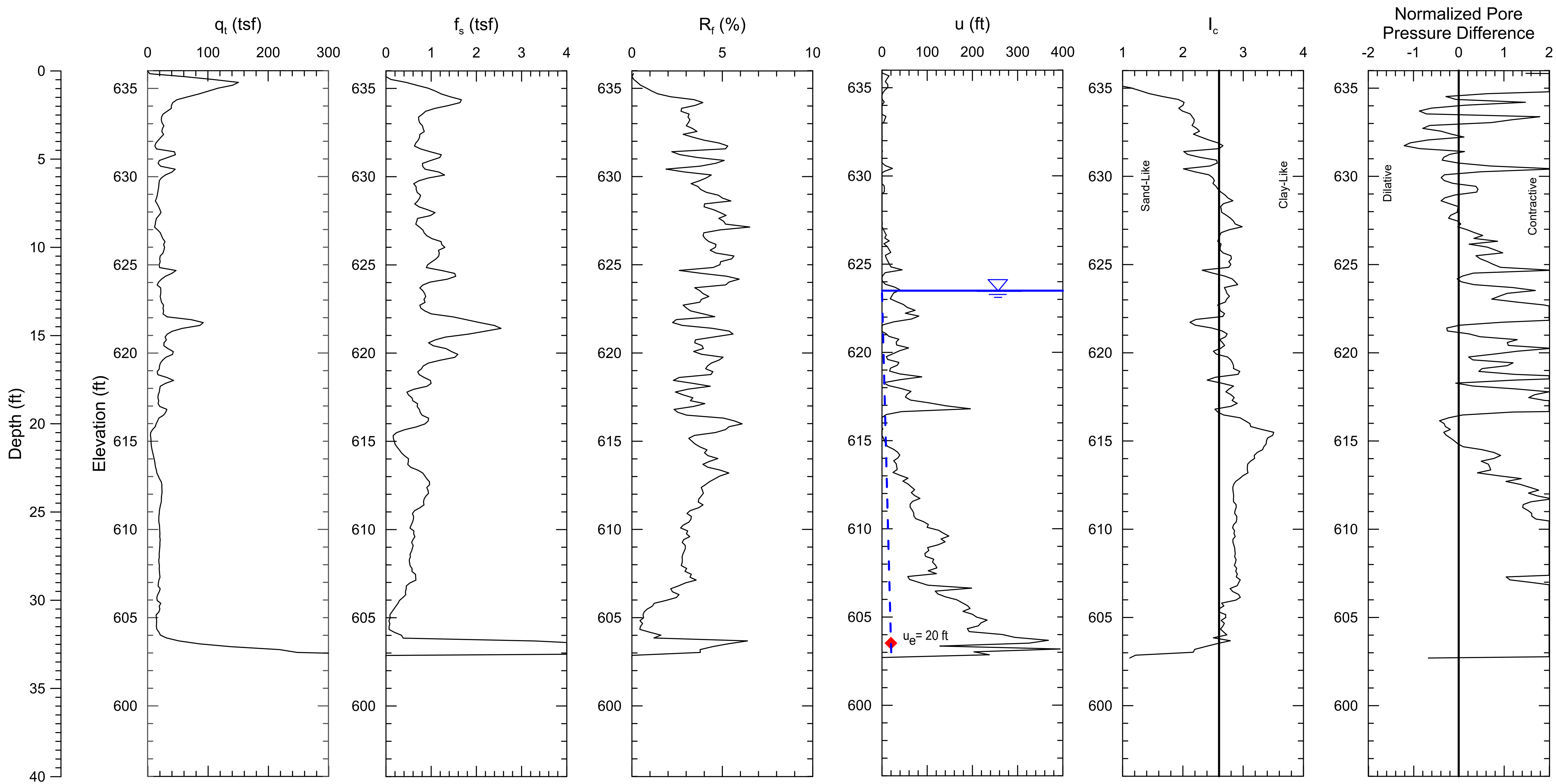
Subject: Coffeen Ash Pond No. 1 Liquefaction Analysis
Project Name: Dynegy CCR

By: Brian Gomez / Meaghan Kenna Date: 01/22/2016
Project No: 60480701

Checked By: Julie Heitland Date: 01/22/2016
Task No.: 01

APPENDIX A

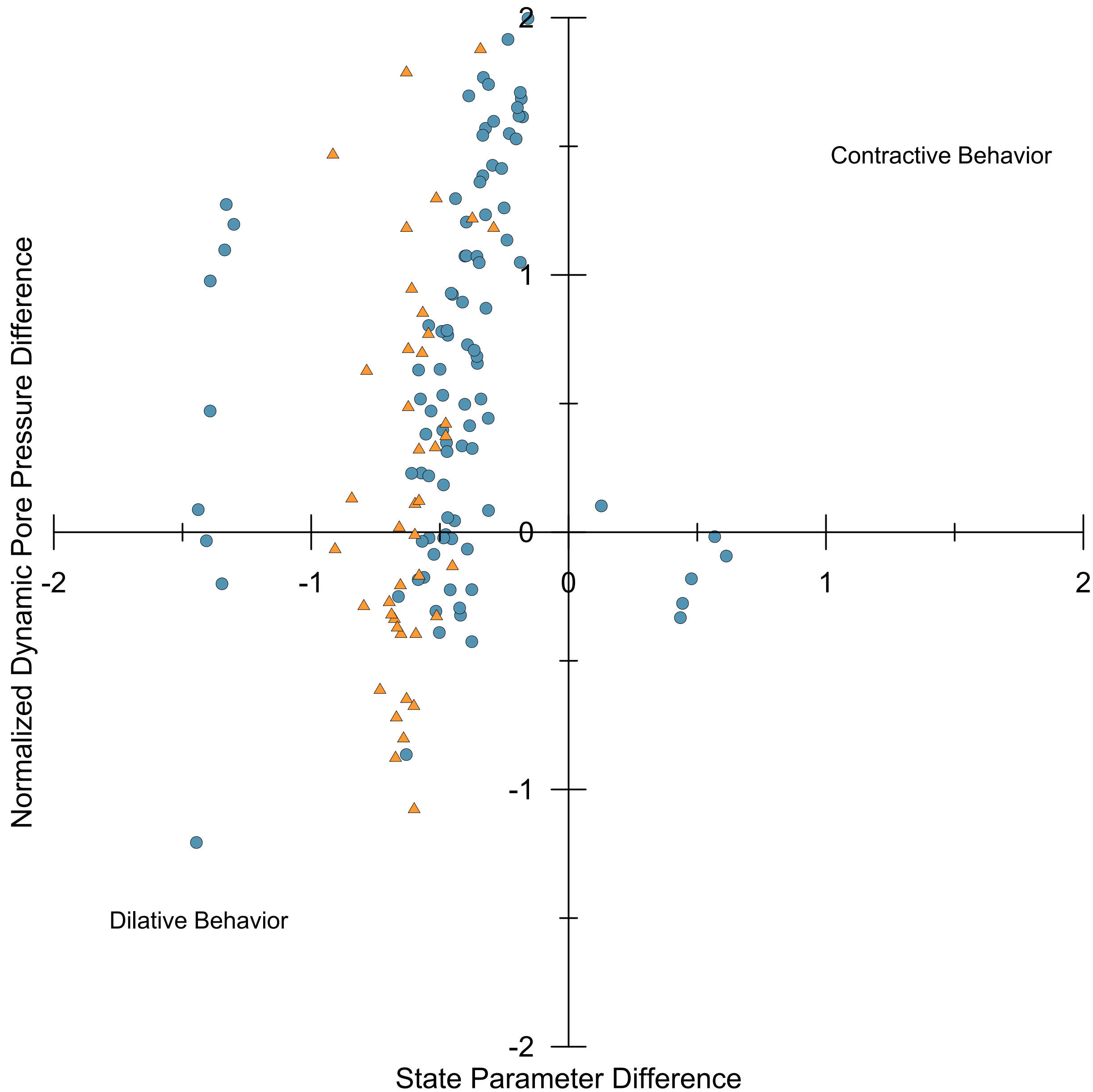
CPT-Based State Characterization Plots



◆ Pore Pressure Dissipation Test
– – – 100% Hydrostatic Pore Pressure Line

Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-001 Coffeen Ash Pond No. 1	FIGURE
AECOM			



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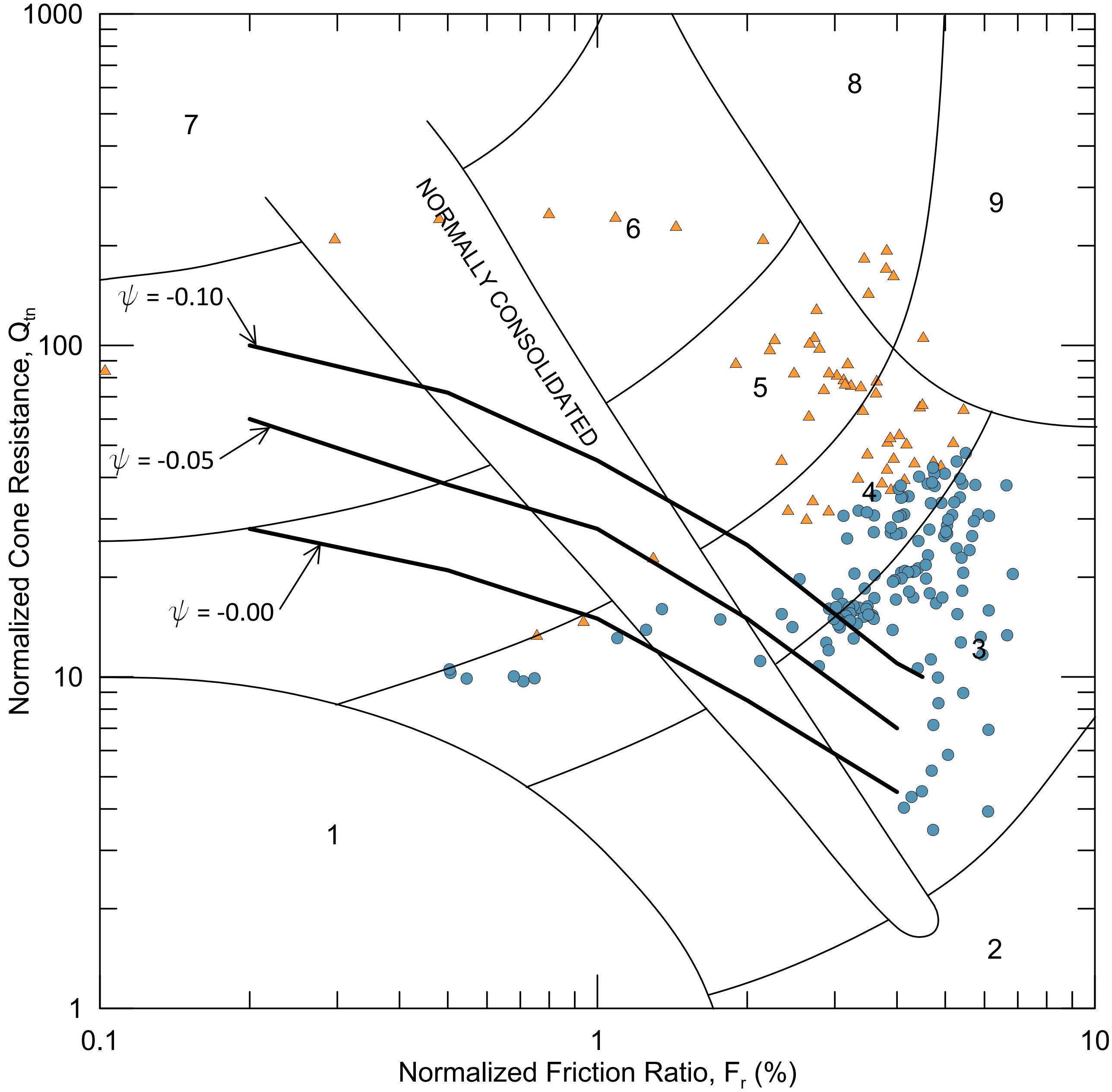
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-001 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

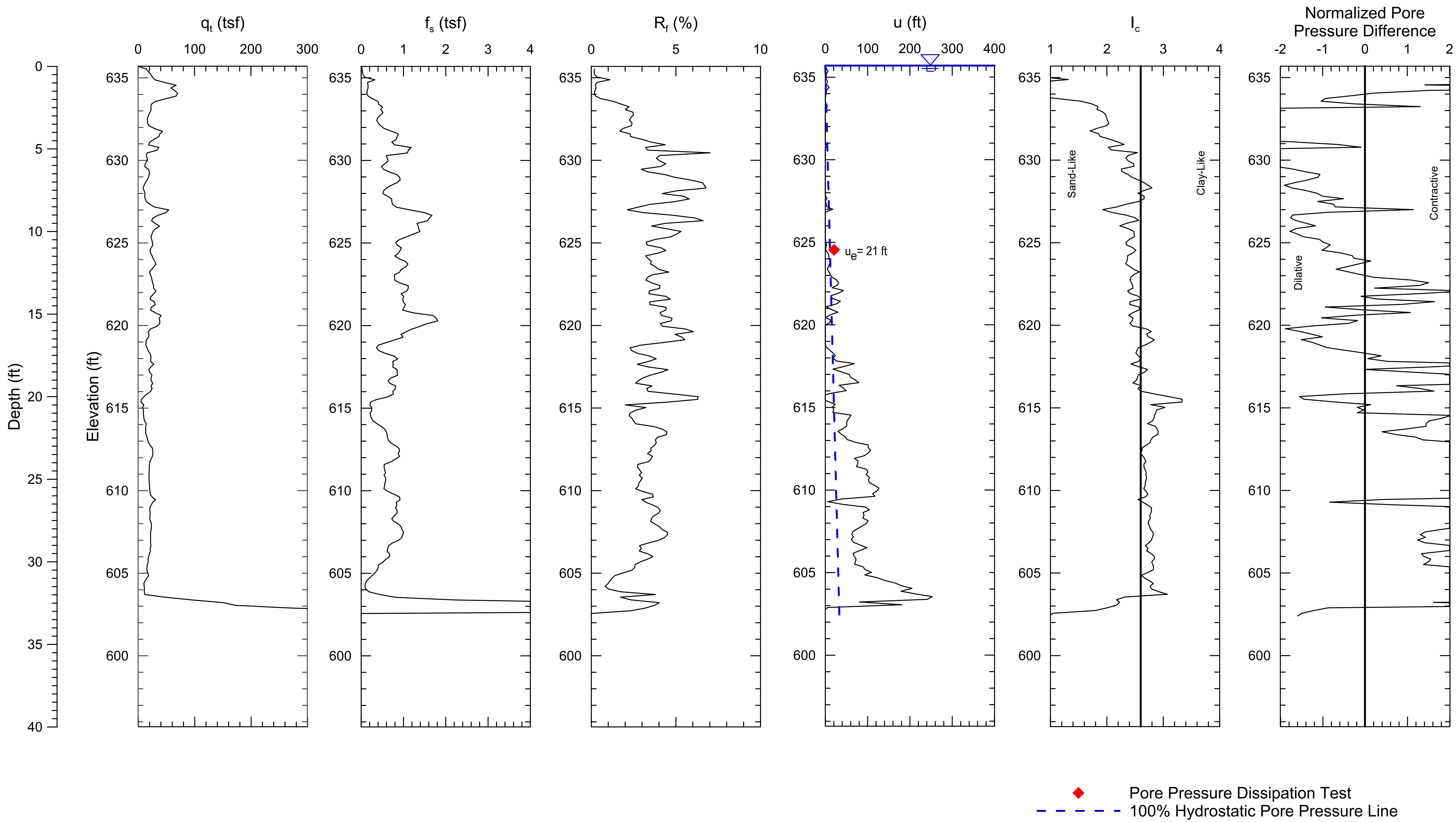


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

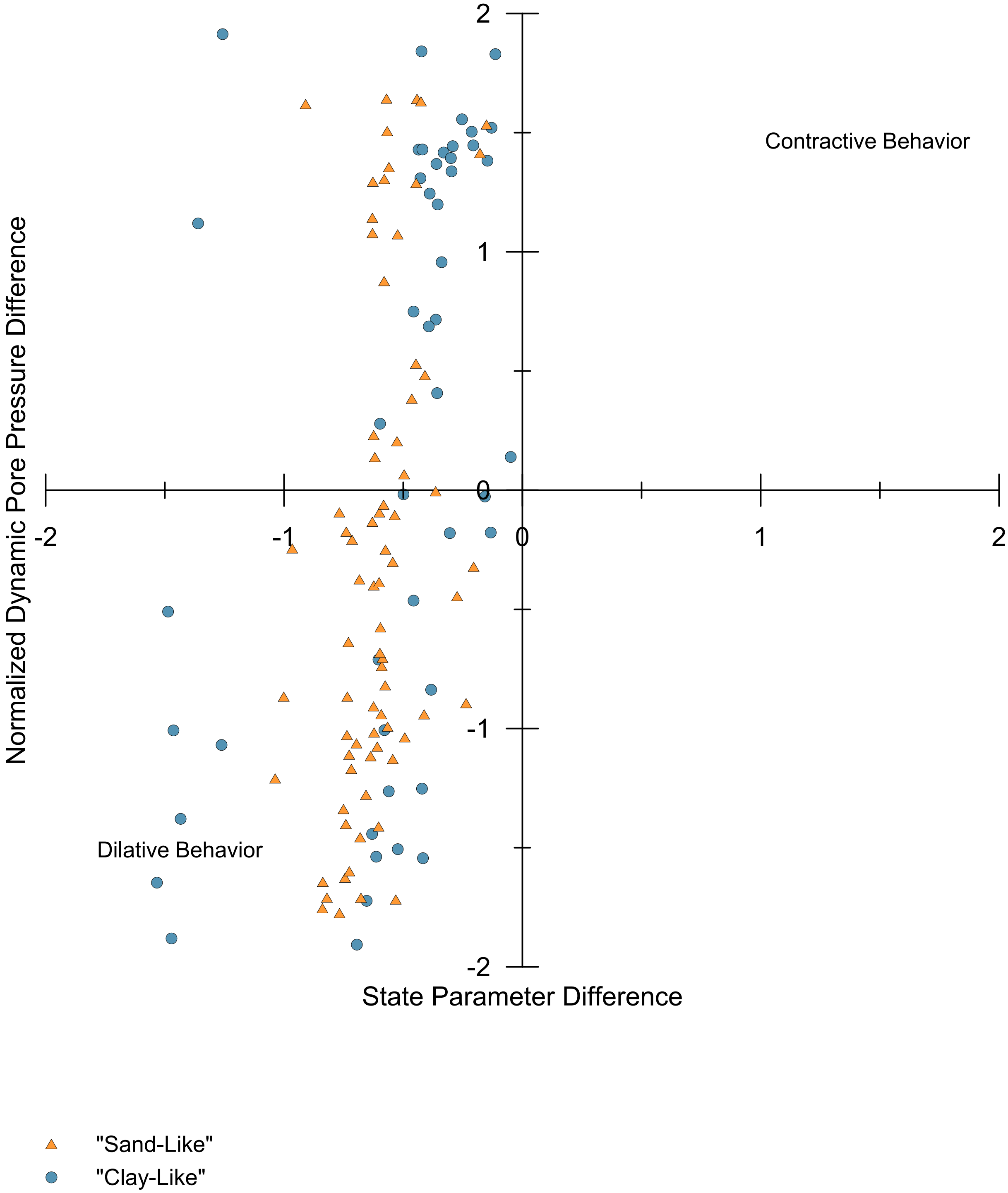
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-001_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-001 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-002 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



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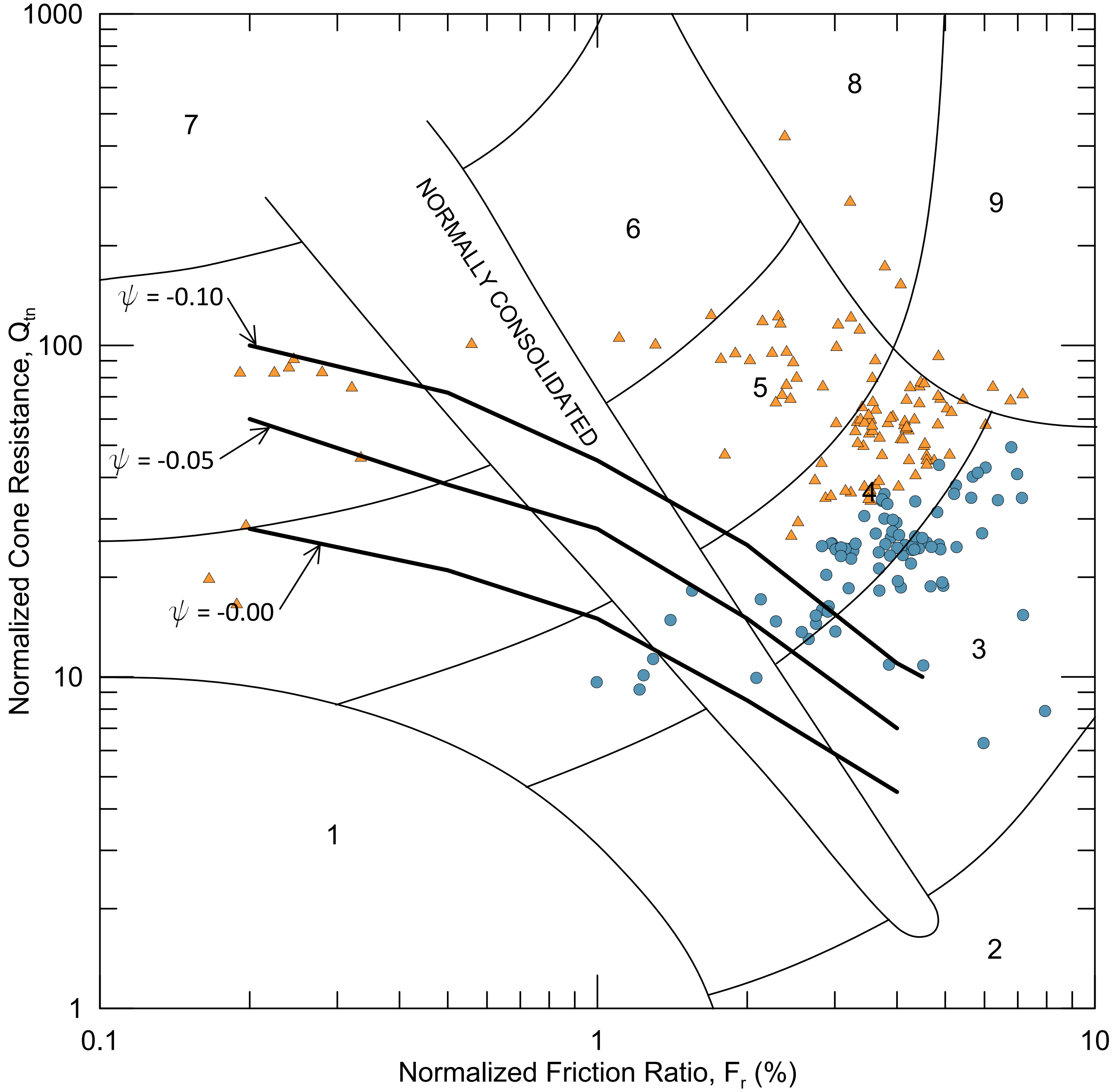
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-002 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

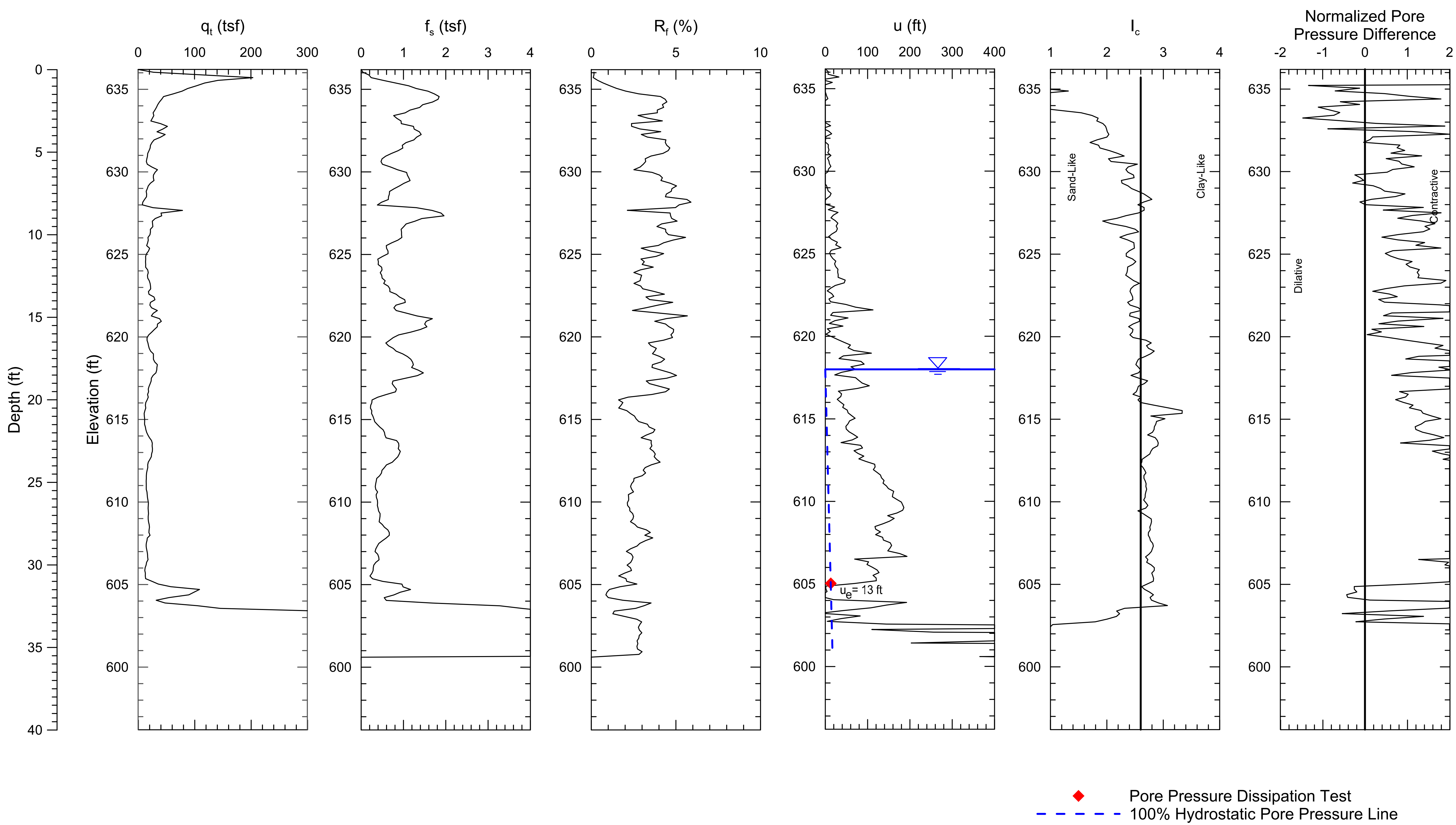


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-002 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-002_DC_Normalized State.grf

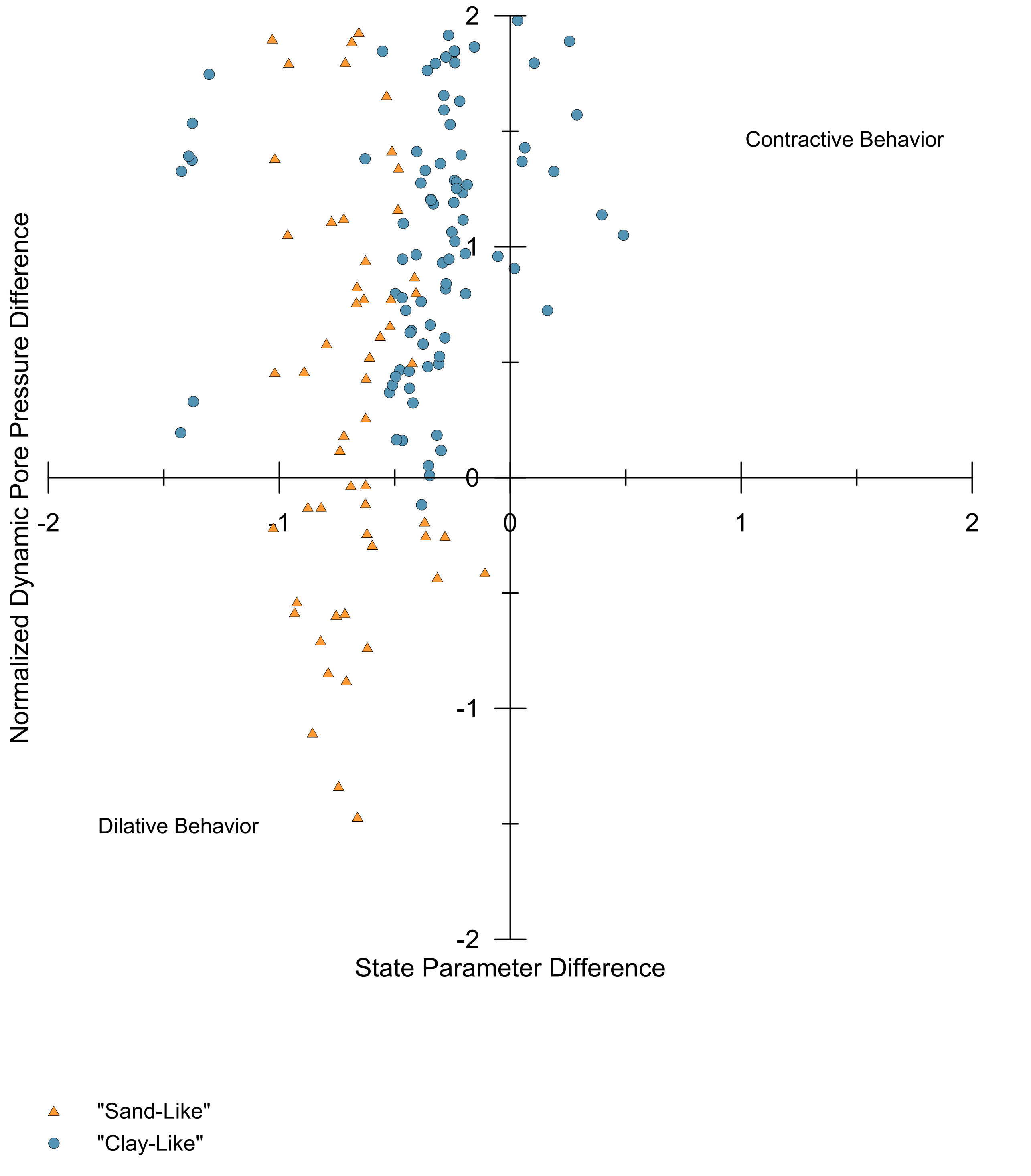


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-004 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



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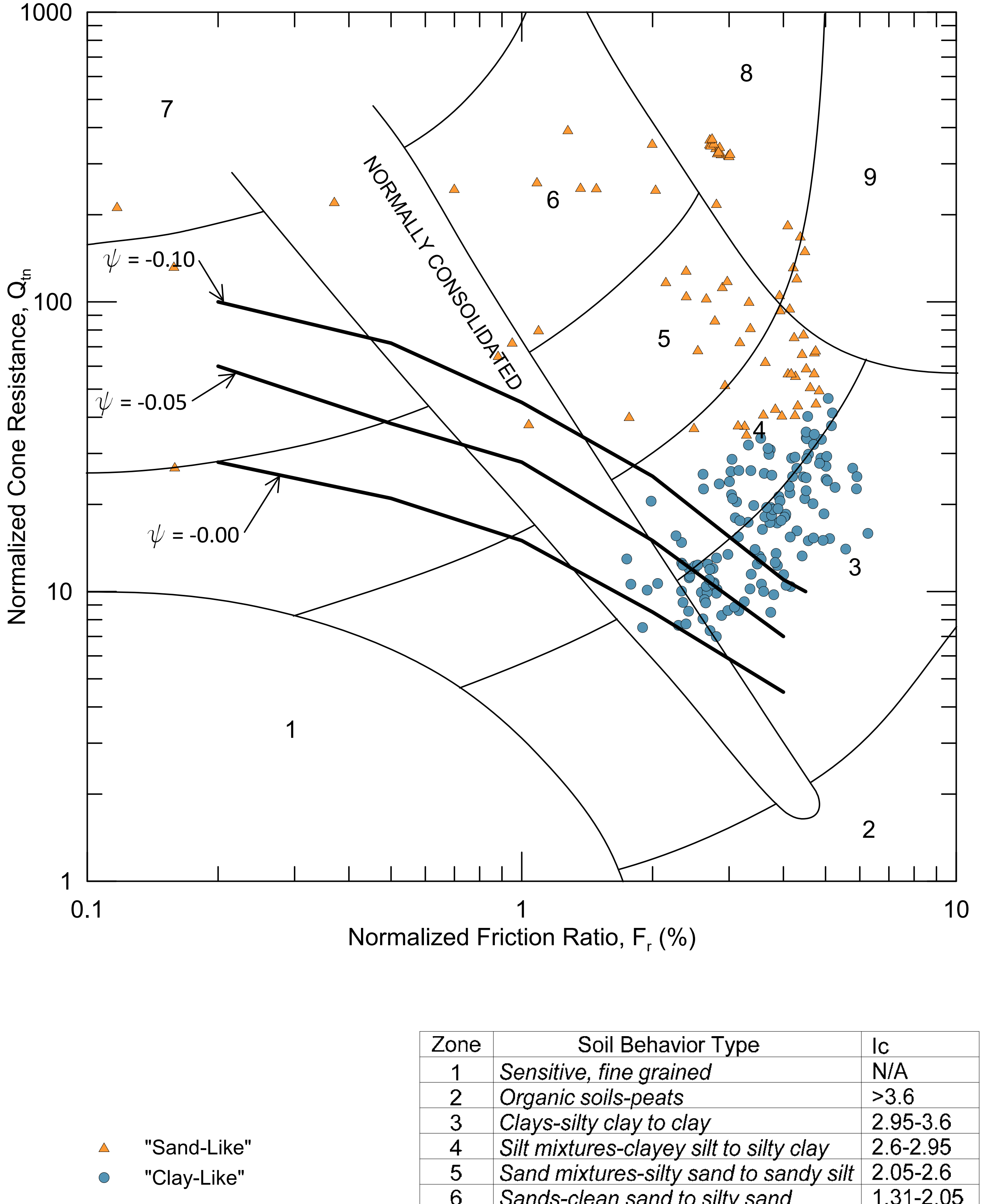
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-004 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

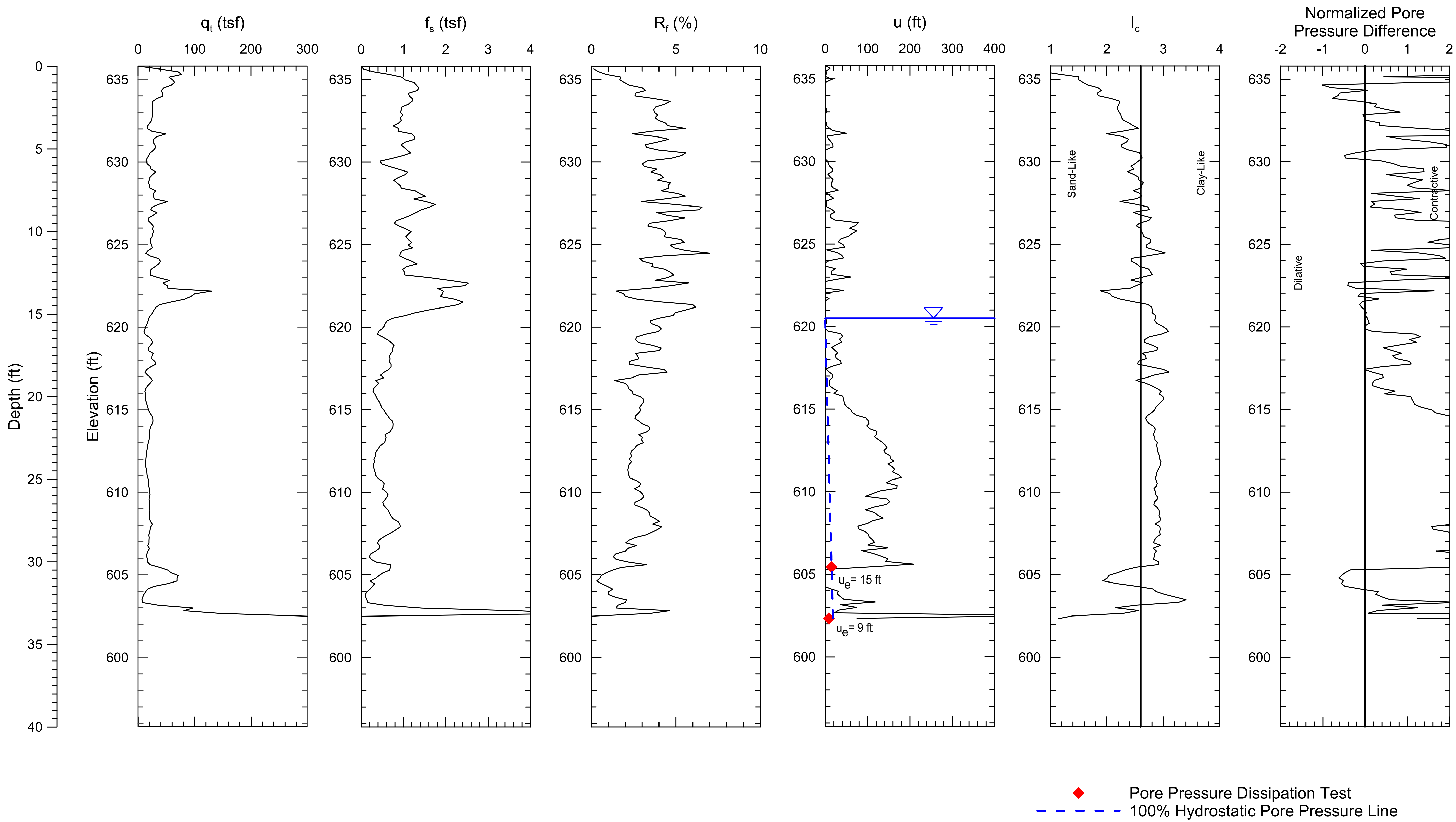


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

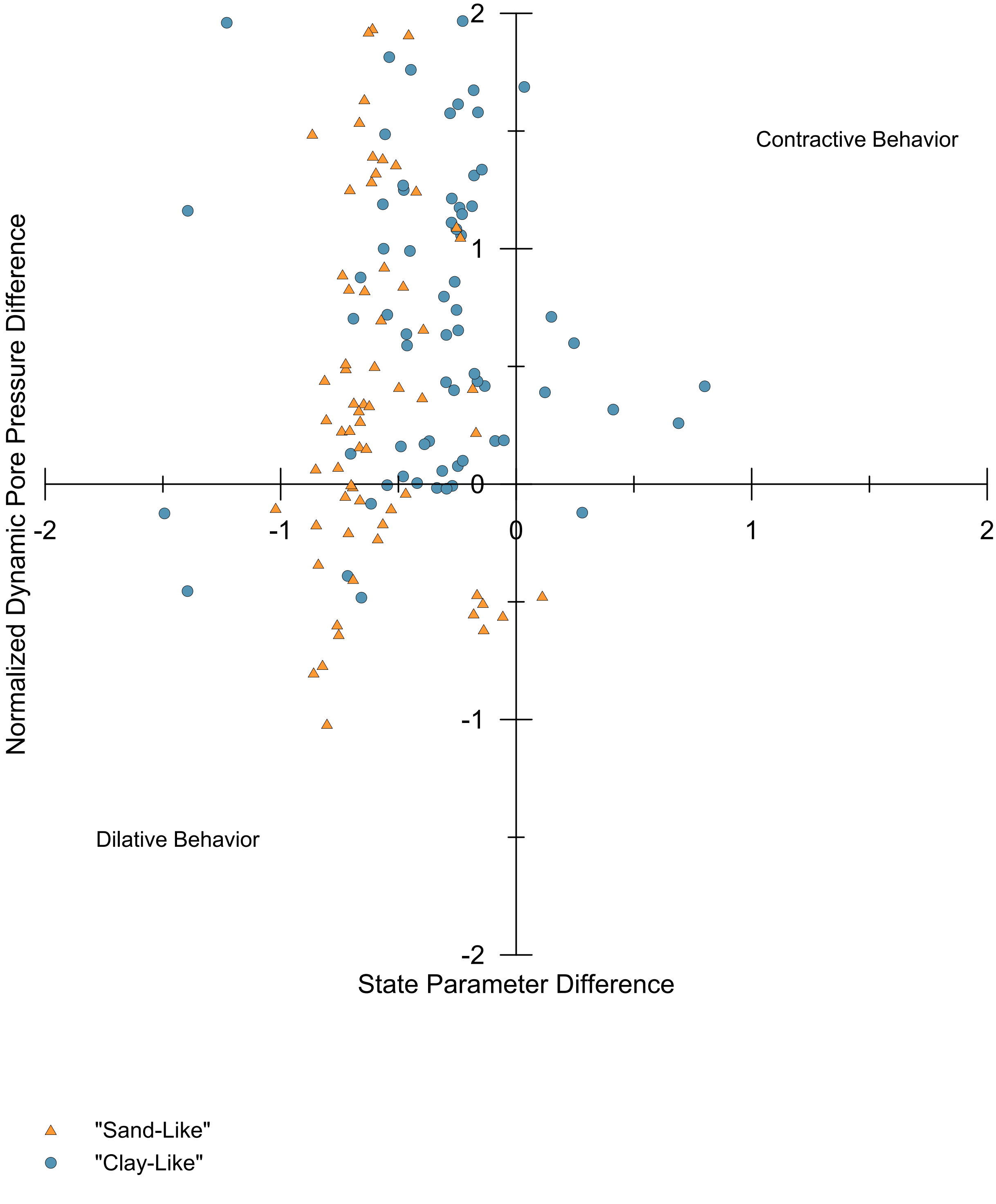
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-004 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-004_DC_Normalized State.grf



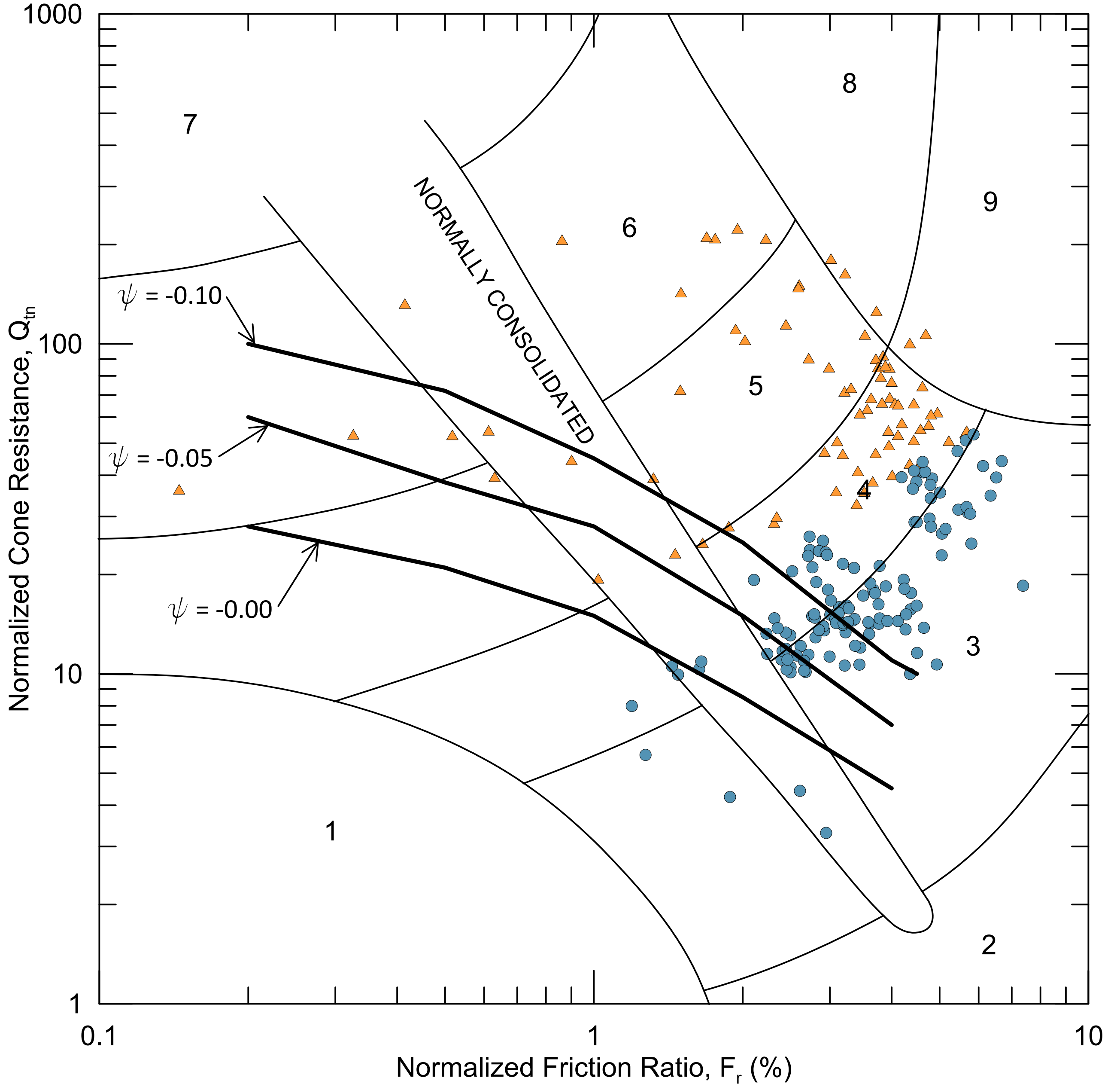
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-005 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-005 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-005_DC_ State Parameter Difference.grf

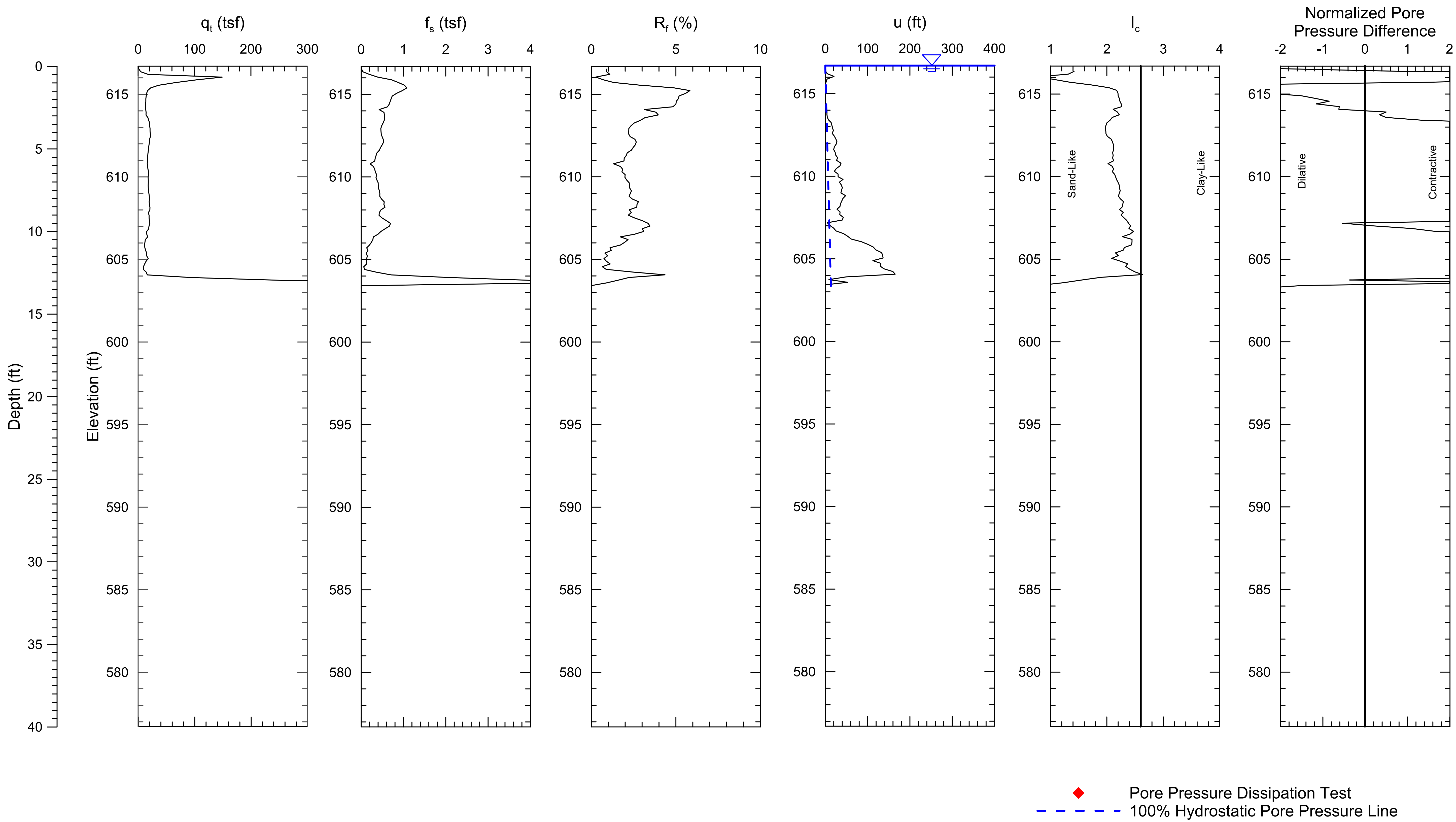


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-005_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-005 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-006 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

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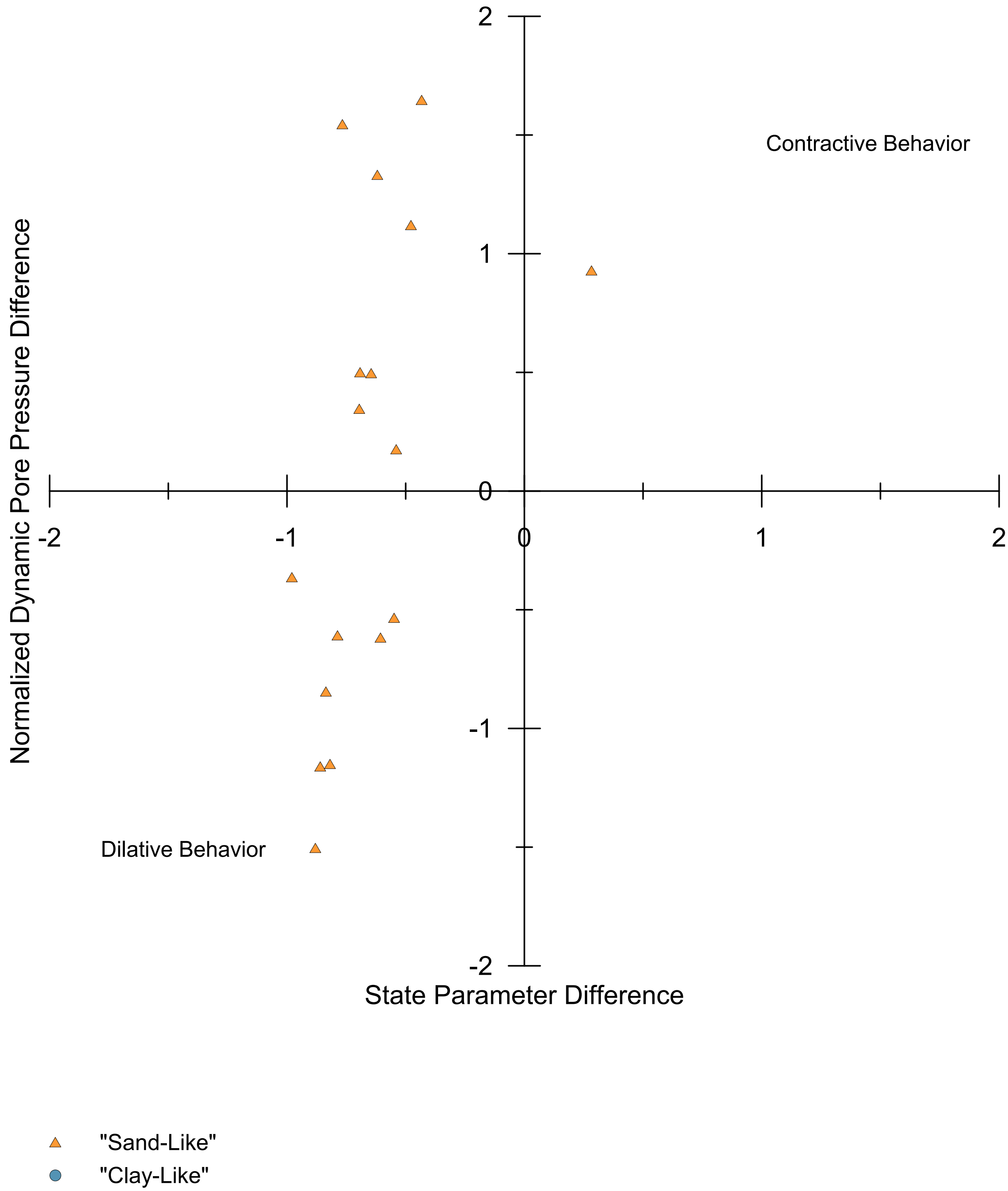
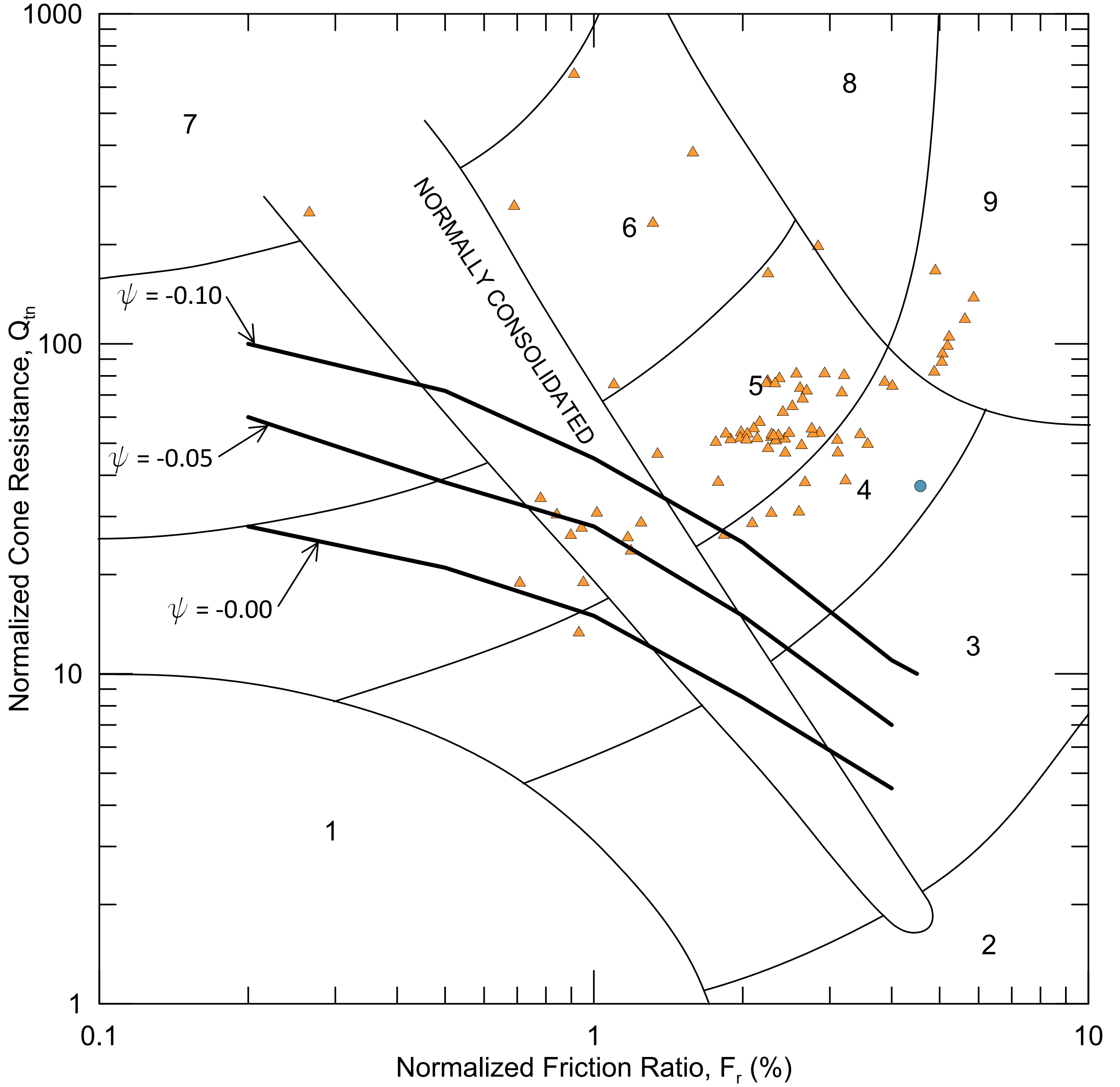


PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-006 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		



Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-006 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			

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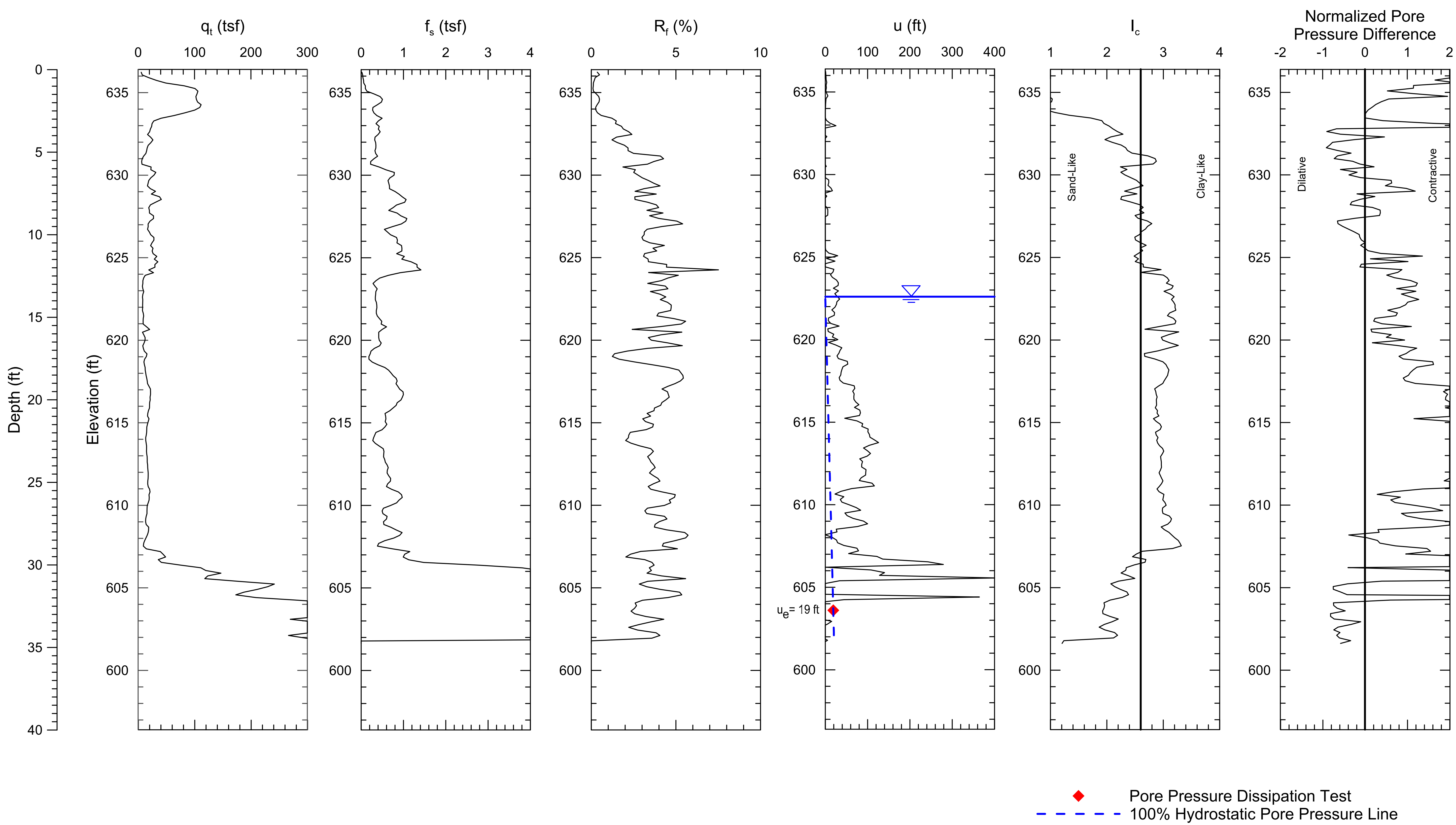
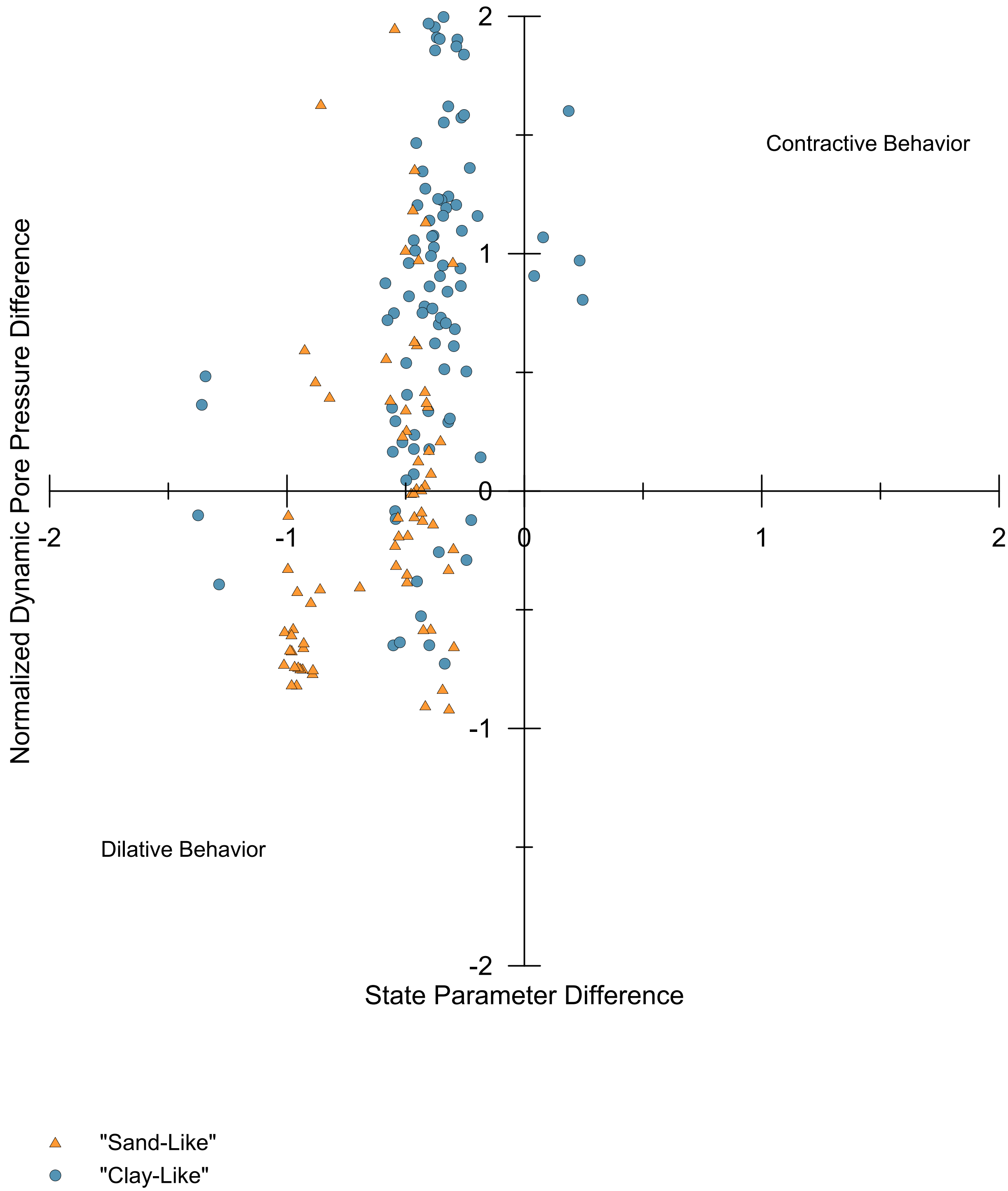


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-007 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



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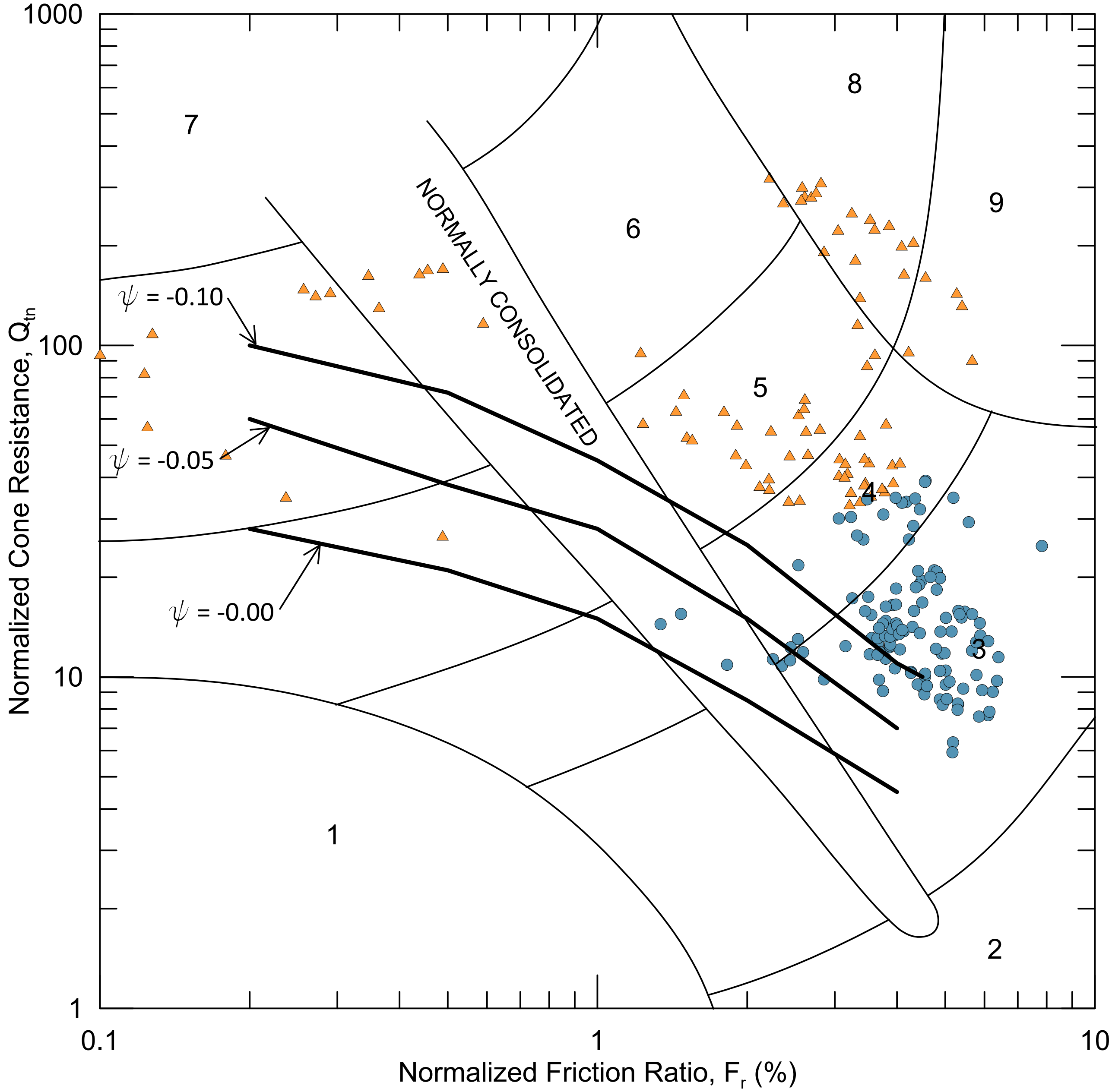
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-007 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

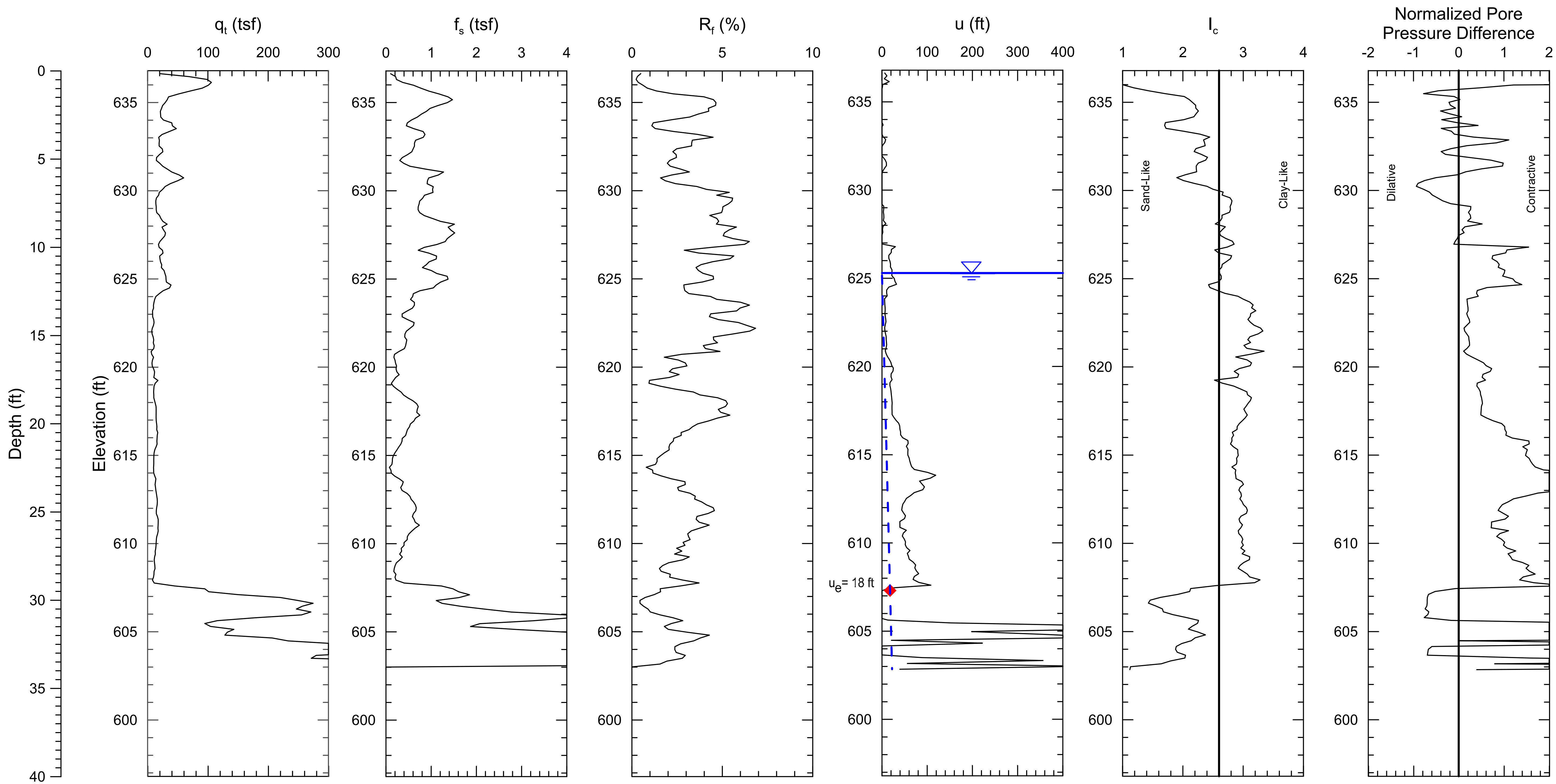


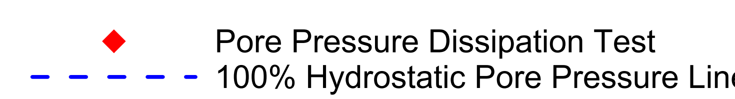
Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-007 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
	AECOM		

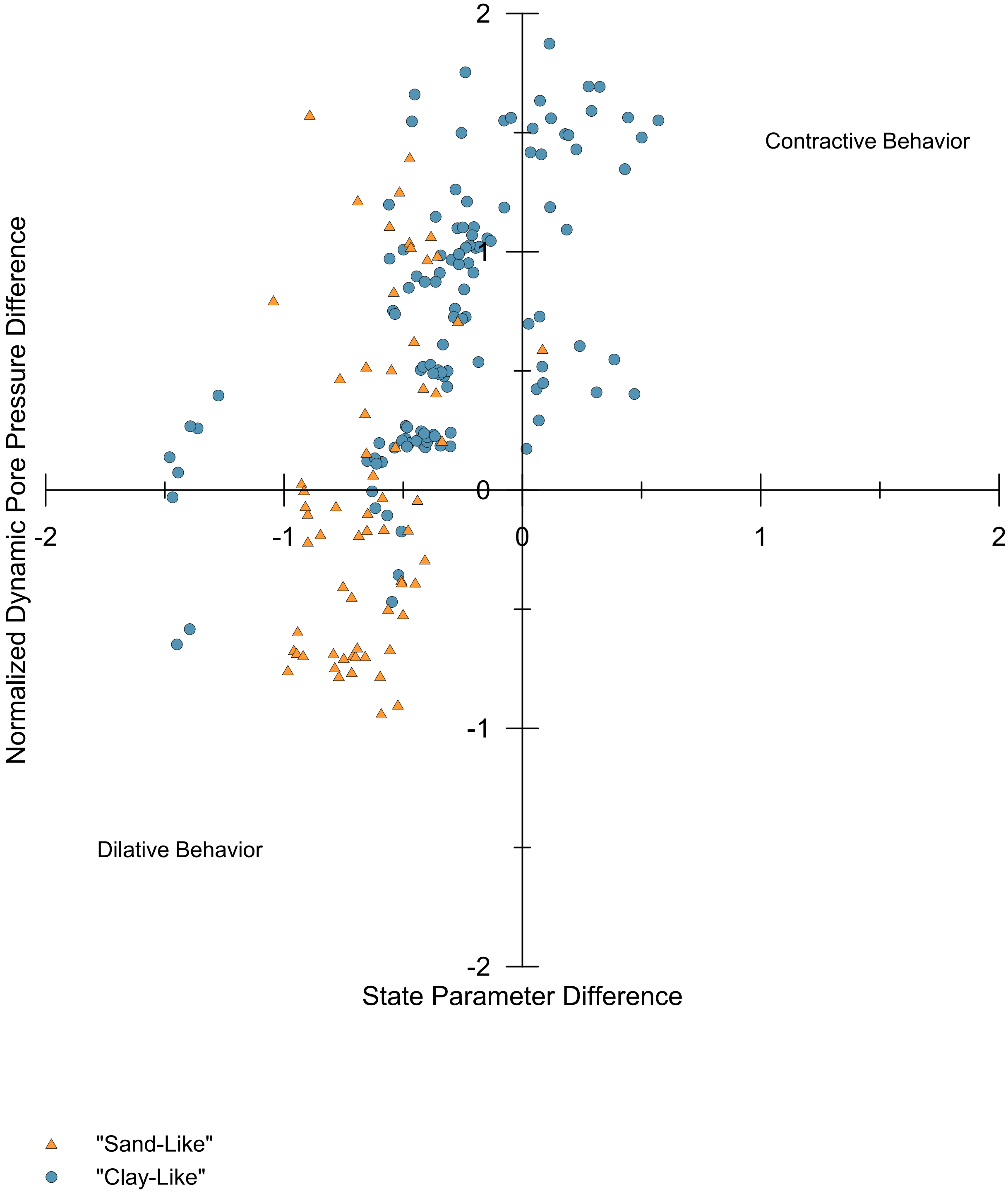
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-007_DC_Normalized State.grf





Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-008 Coffeen Ash Pond No. 1	FIGURE
AECOM			



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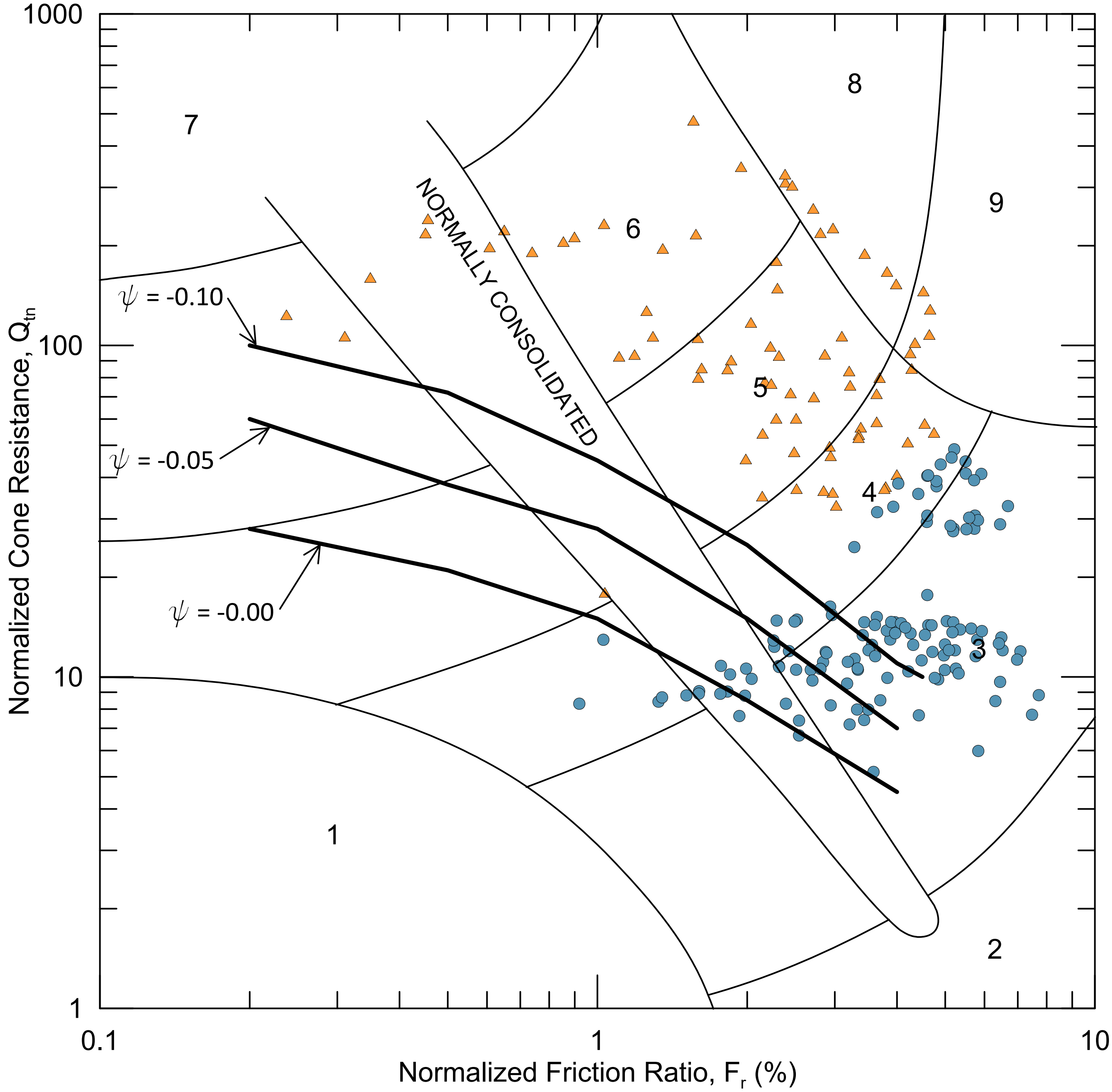
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-008 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
AECOM			

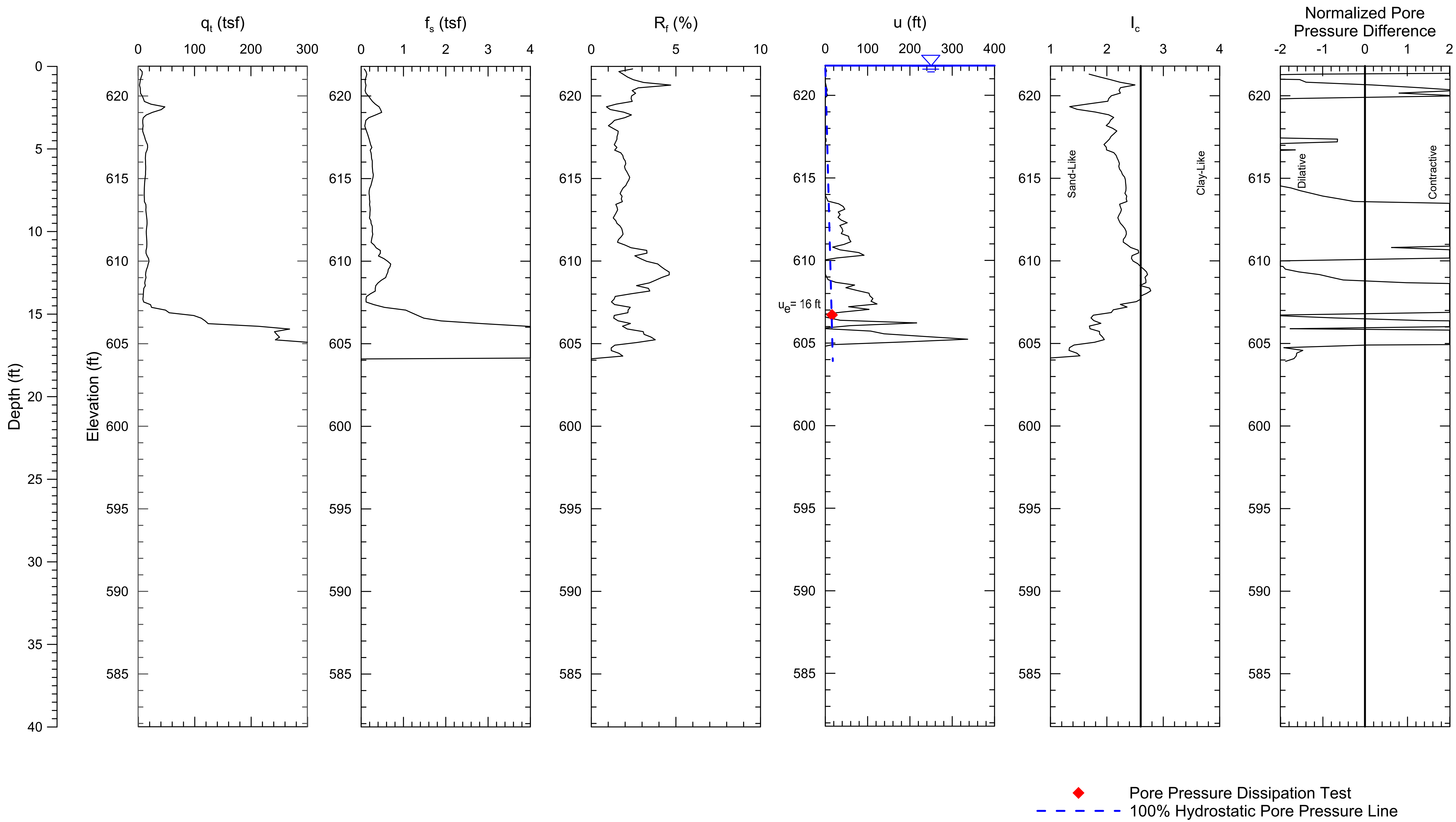


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

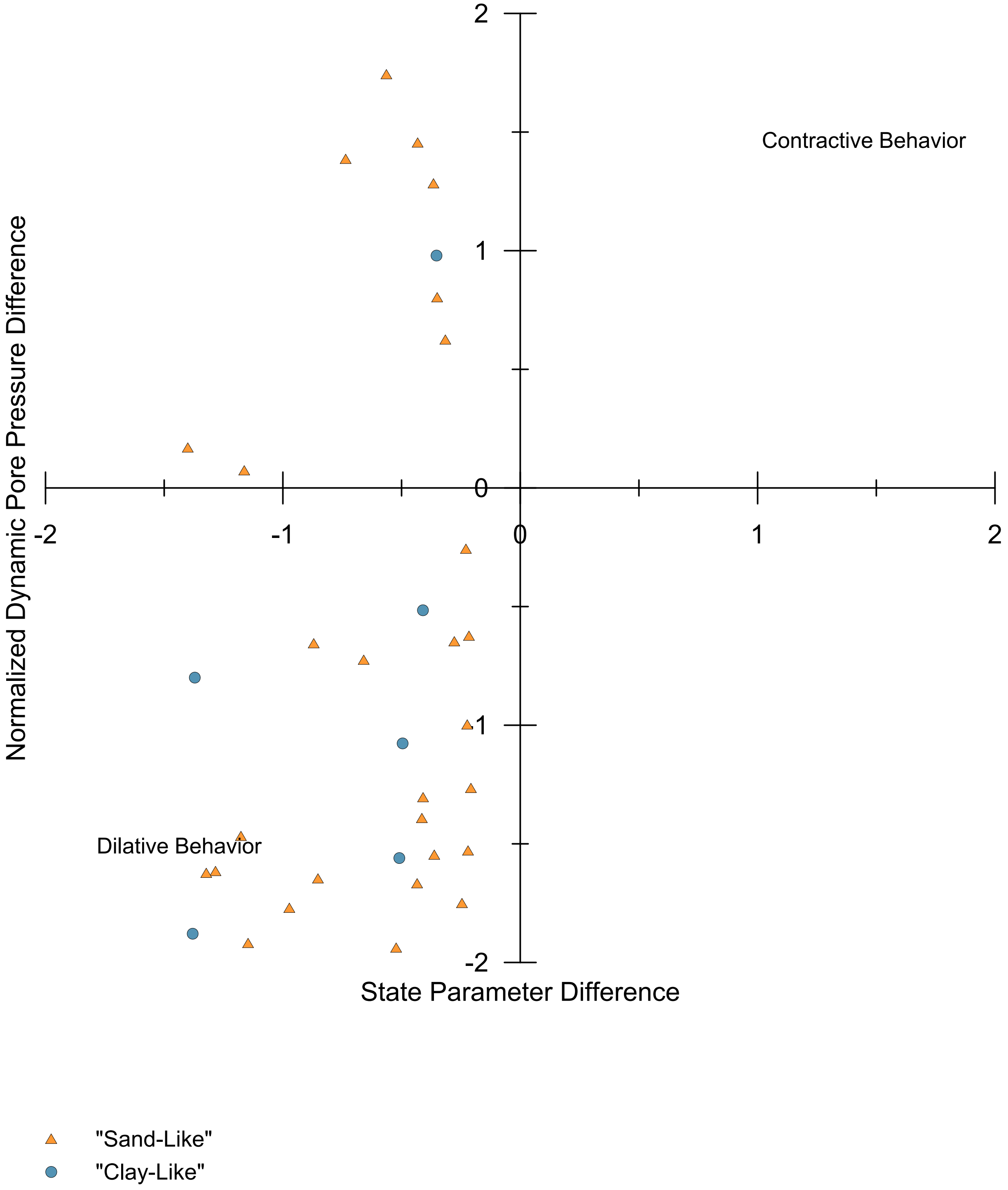
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-008 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-008_DC_Normalized State.grf



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-009 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



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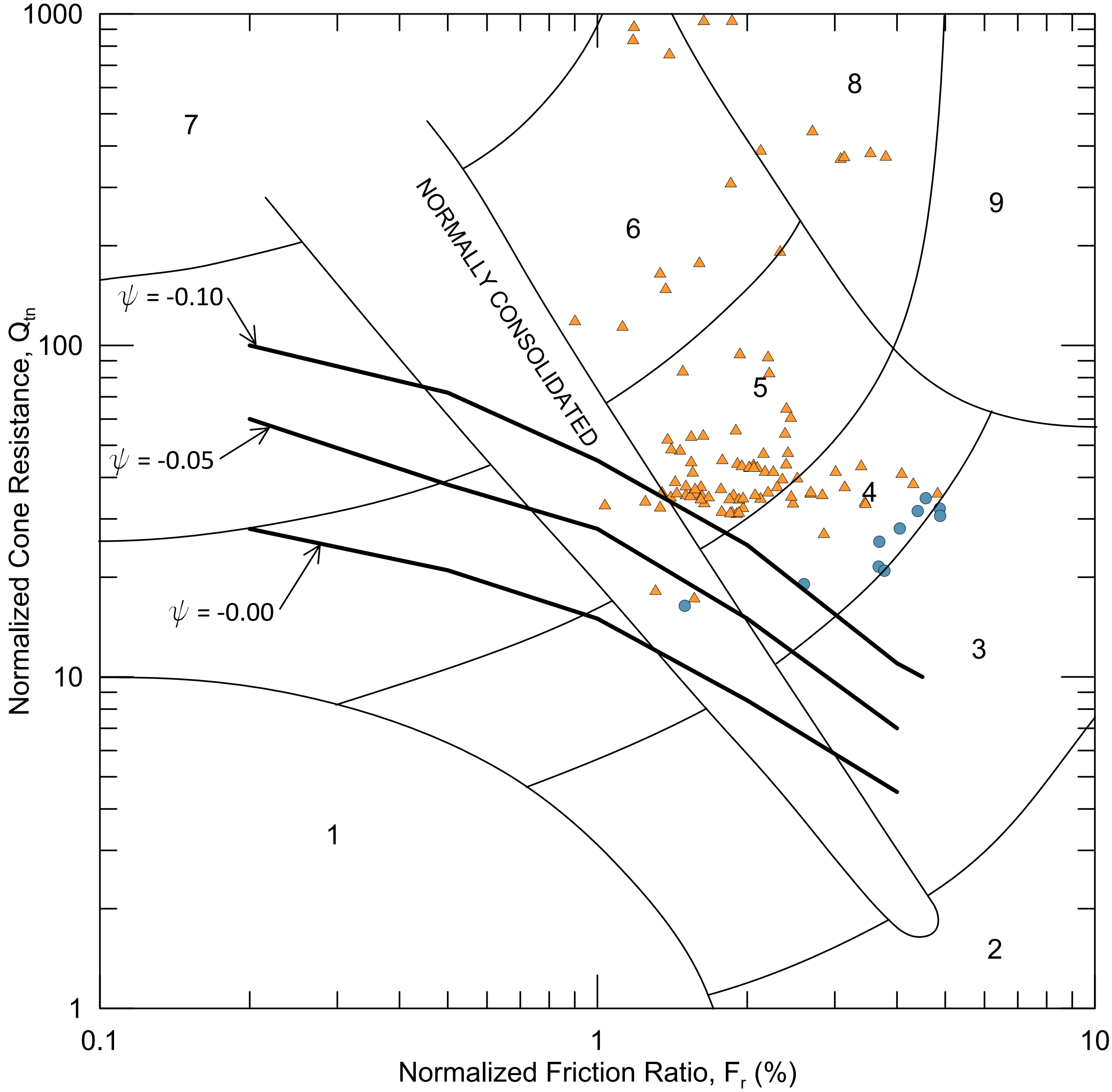
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-009 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		



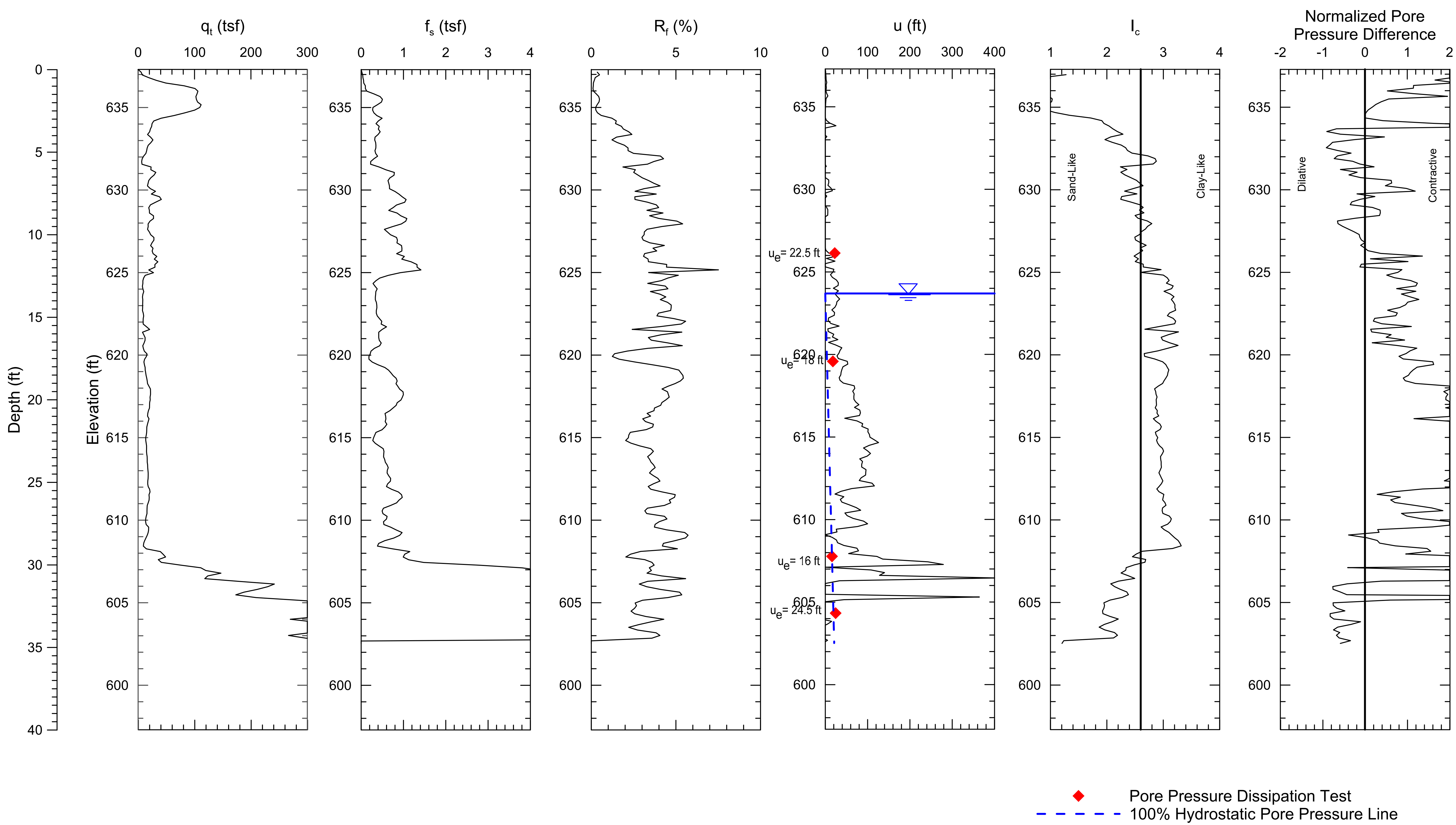
Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

"Sand-Like"
"Clay-Like"

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-009_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-009 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
	AECOM		

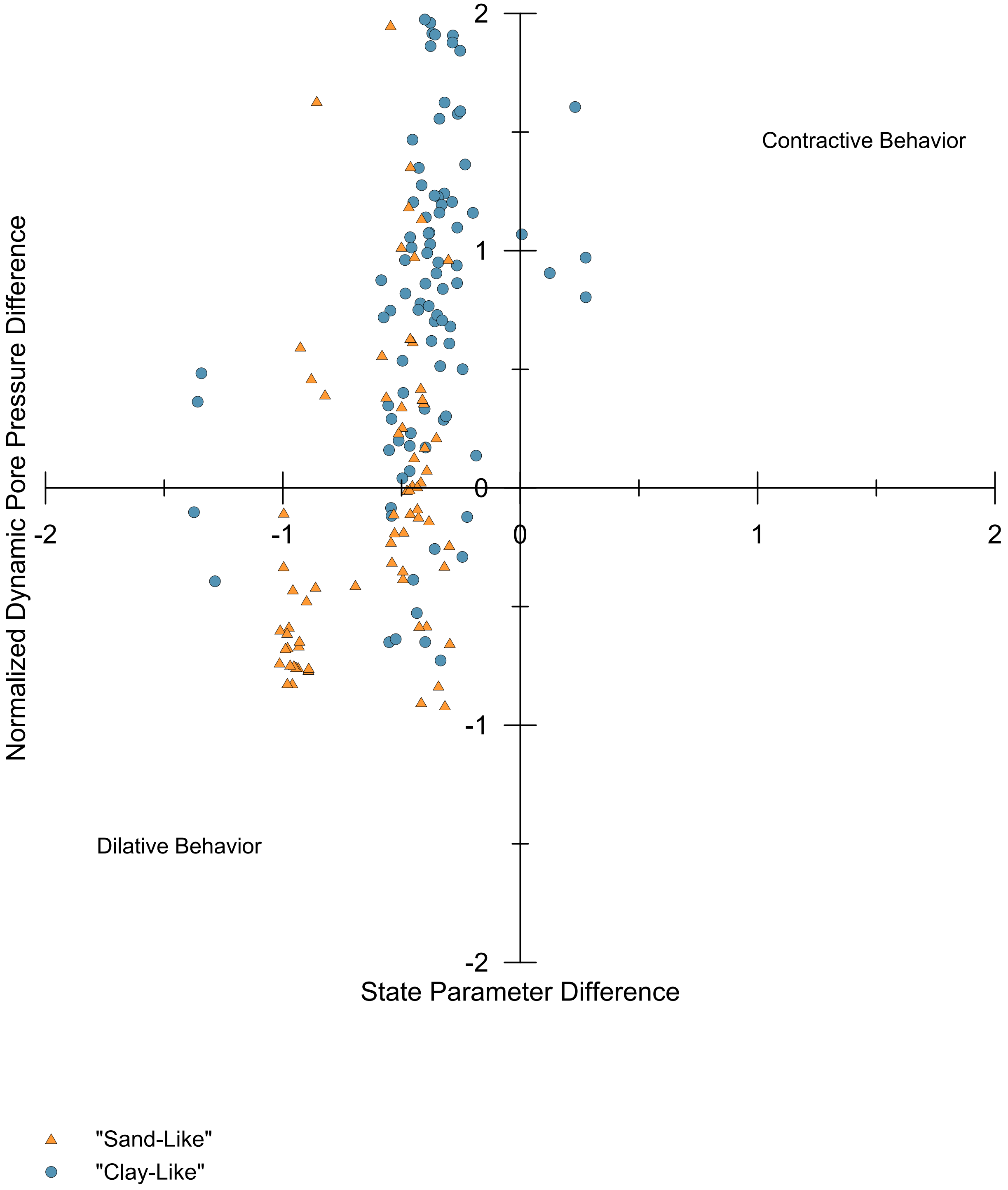


Notes:

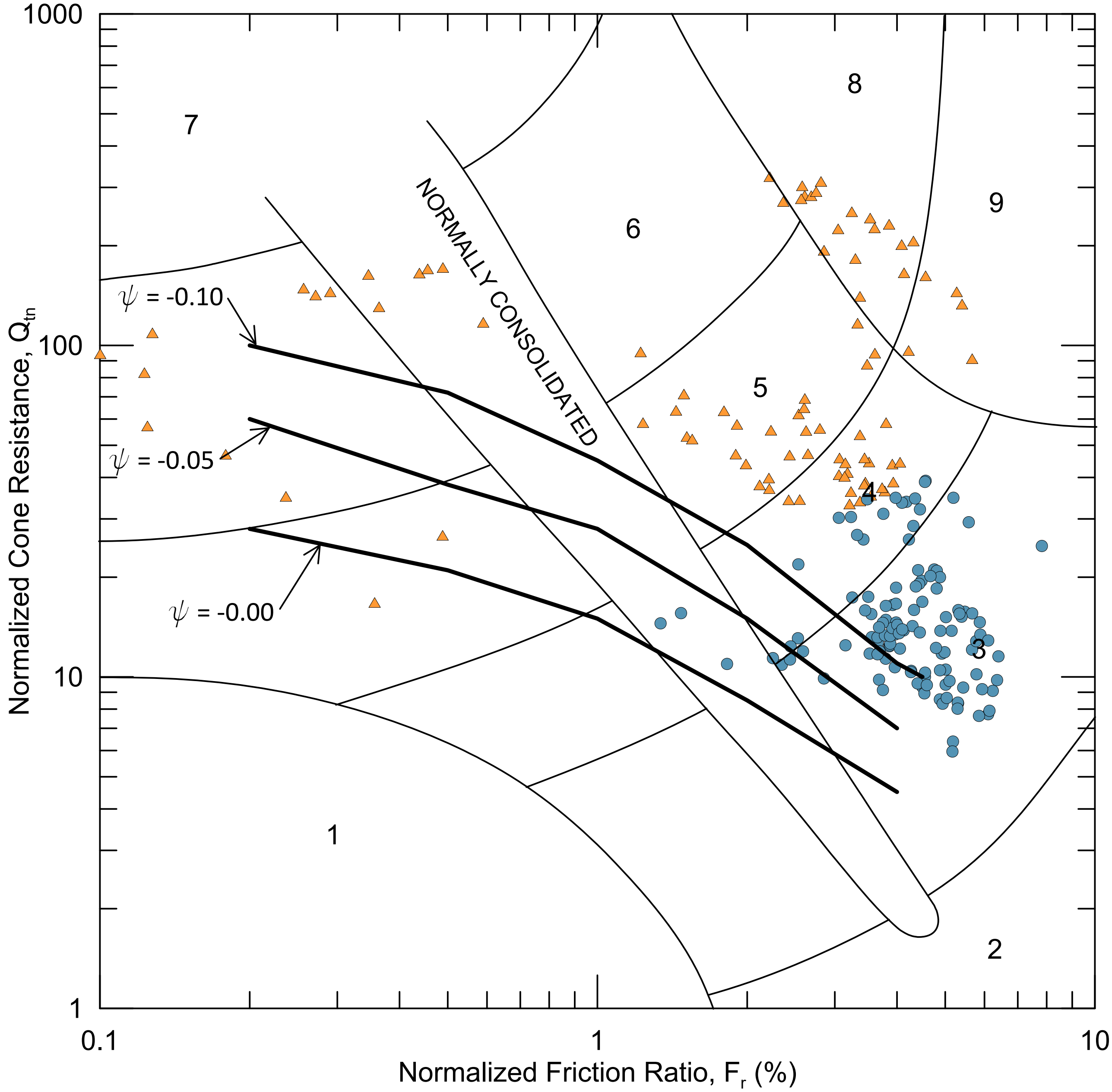
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-010 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-010 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

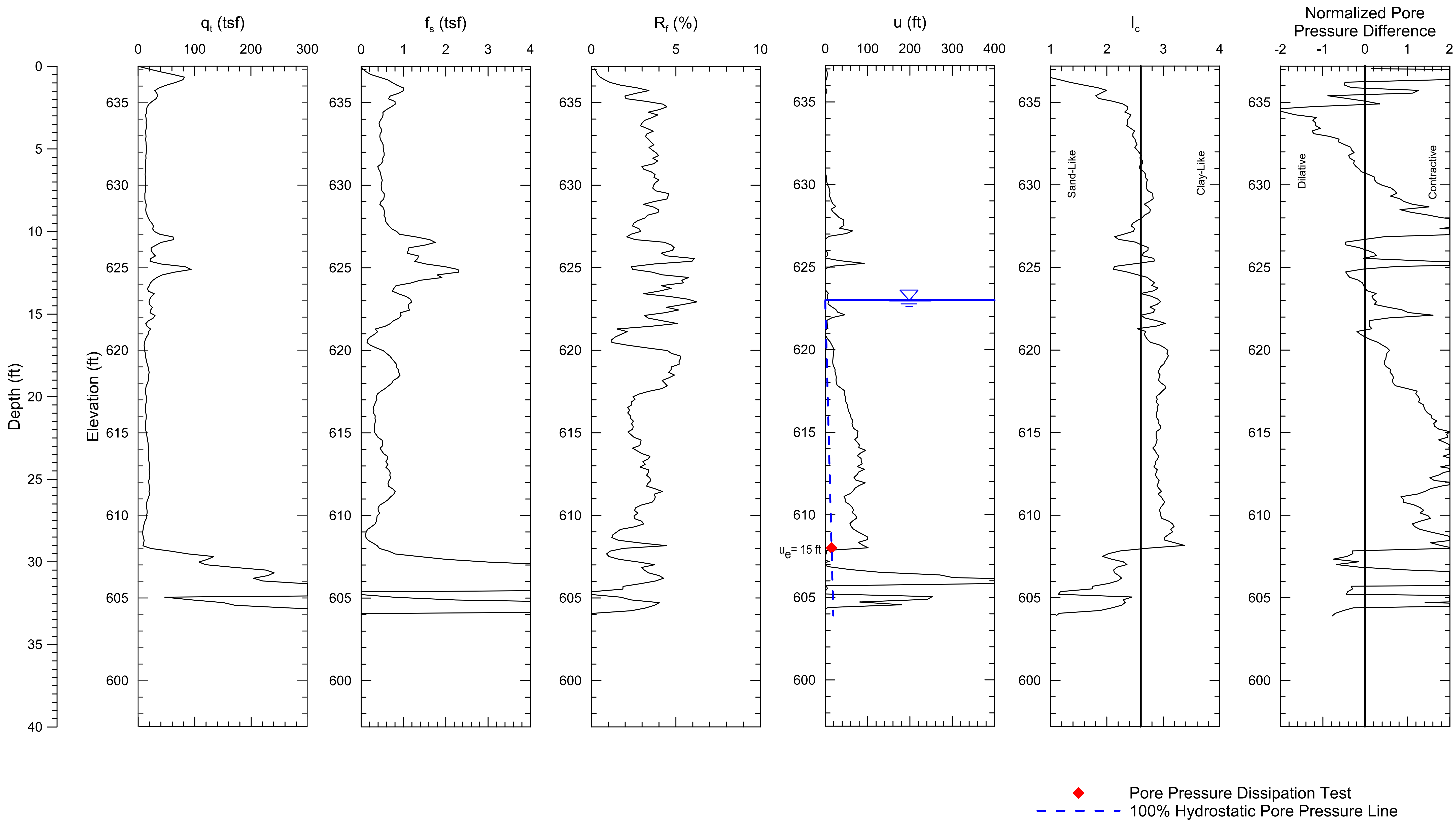


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

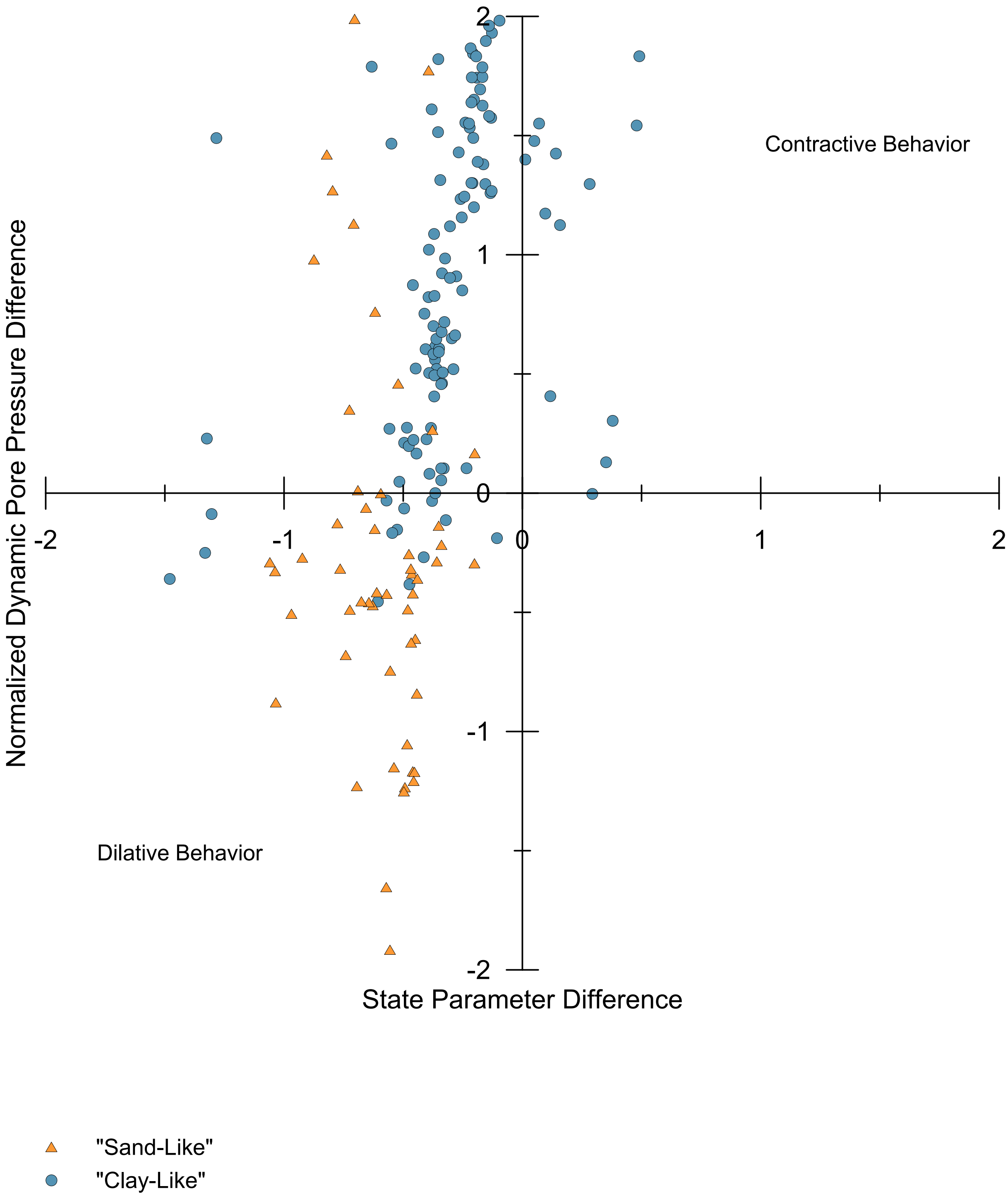
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-010_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-010 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			



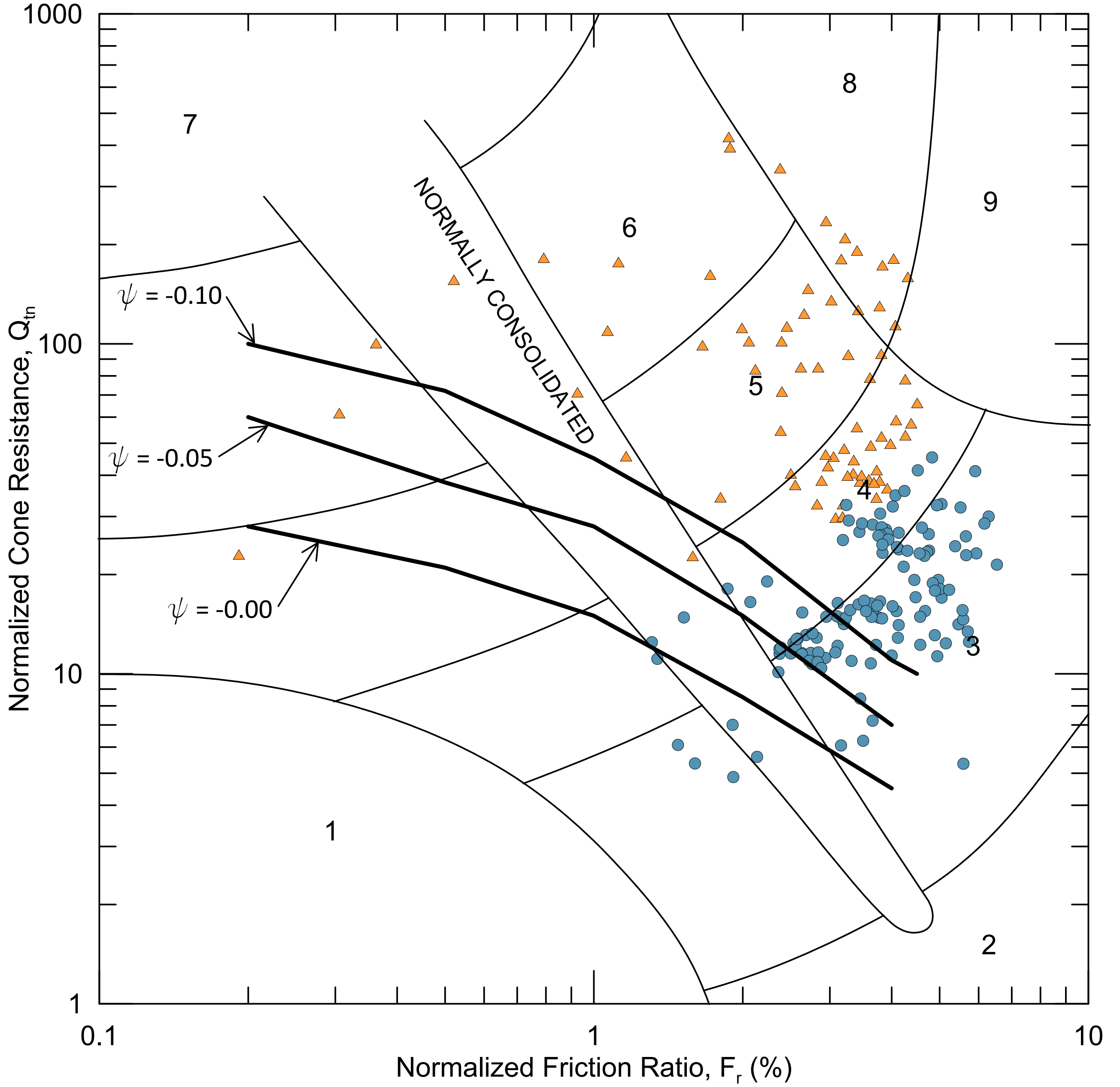
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-011 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-011_DC_ State Parameter Difference.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-011 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

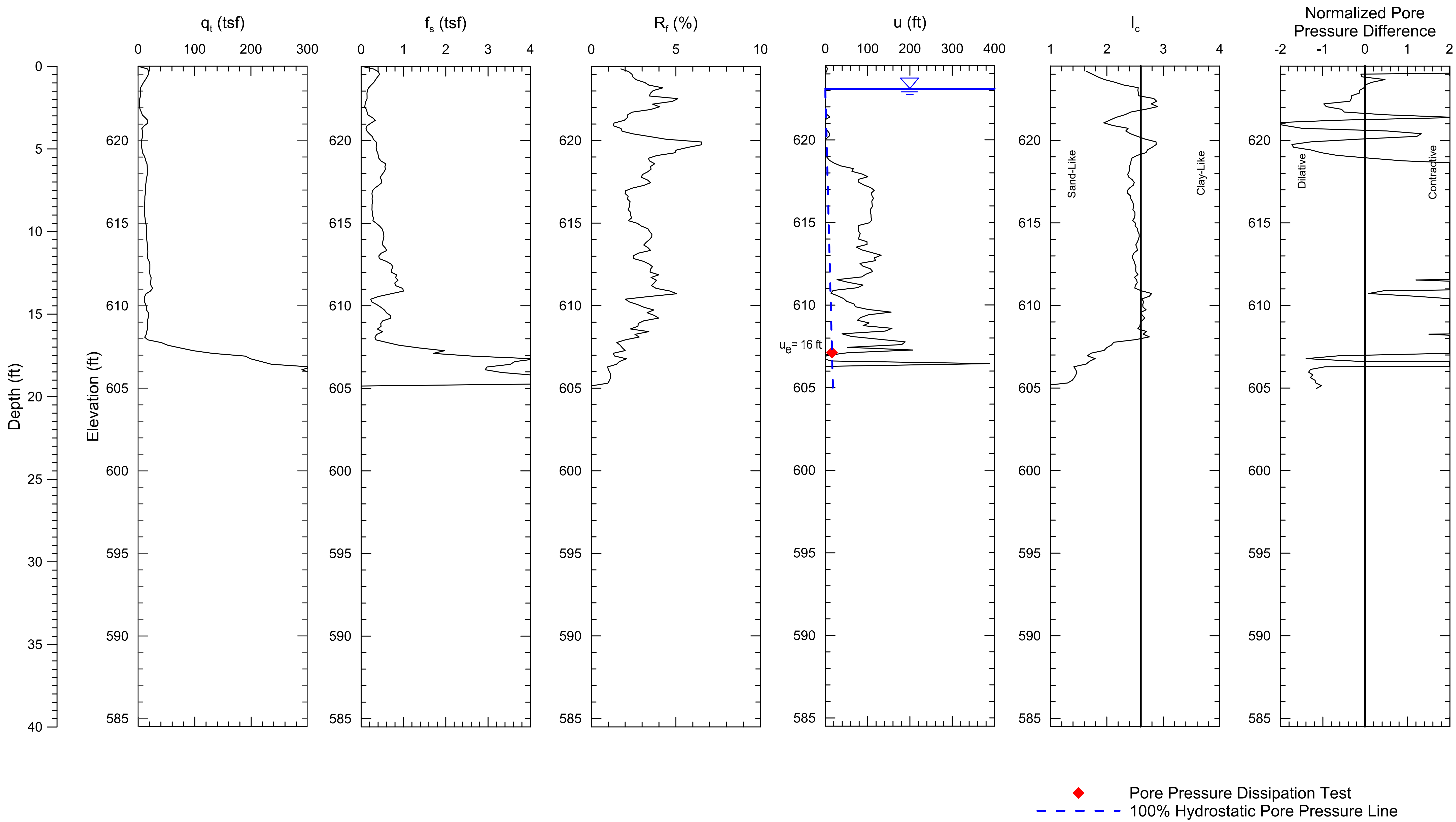


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

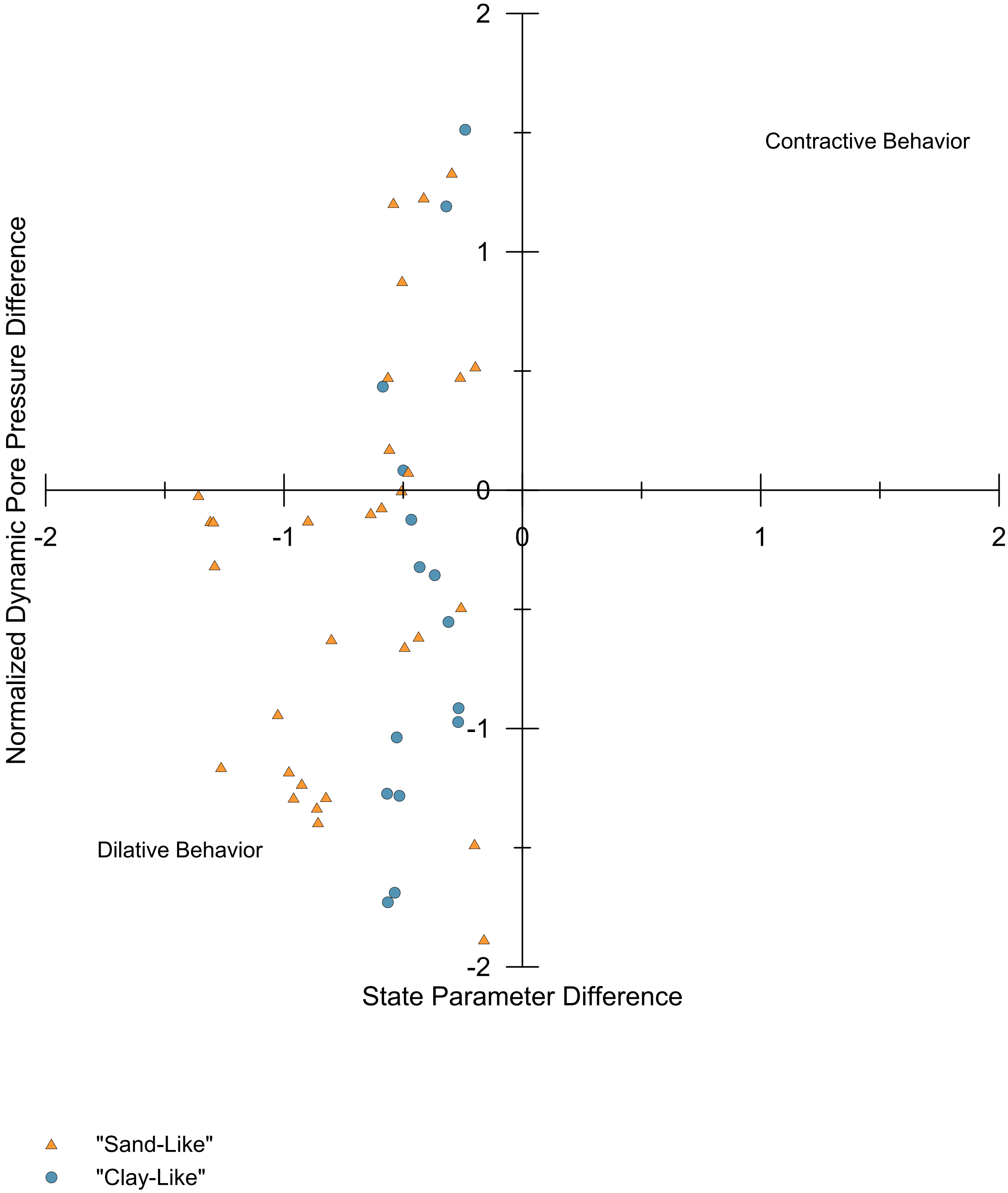
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-011_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-011 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			



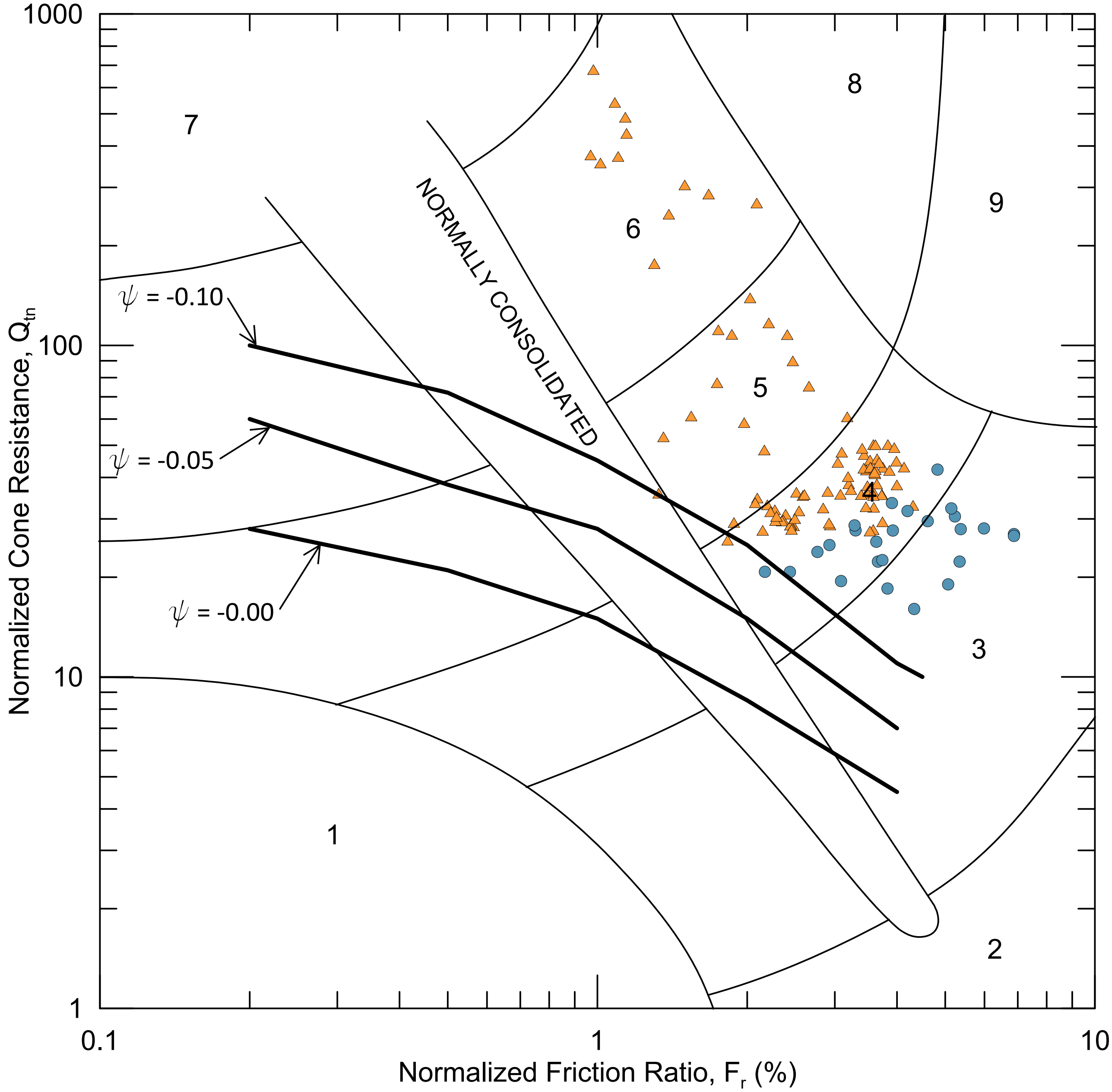
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-012 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-012_DC_ State Parameter Difference.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-012 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

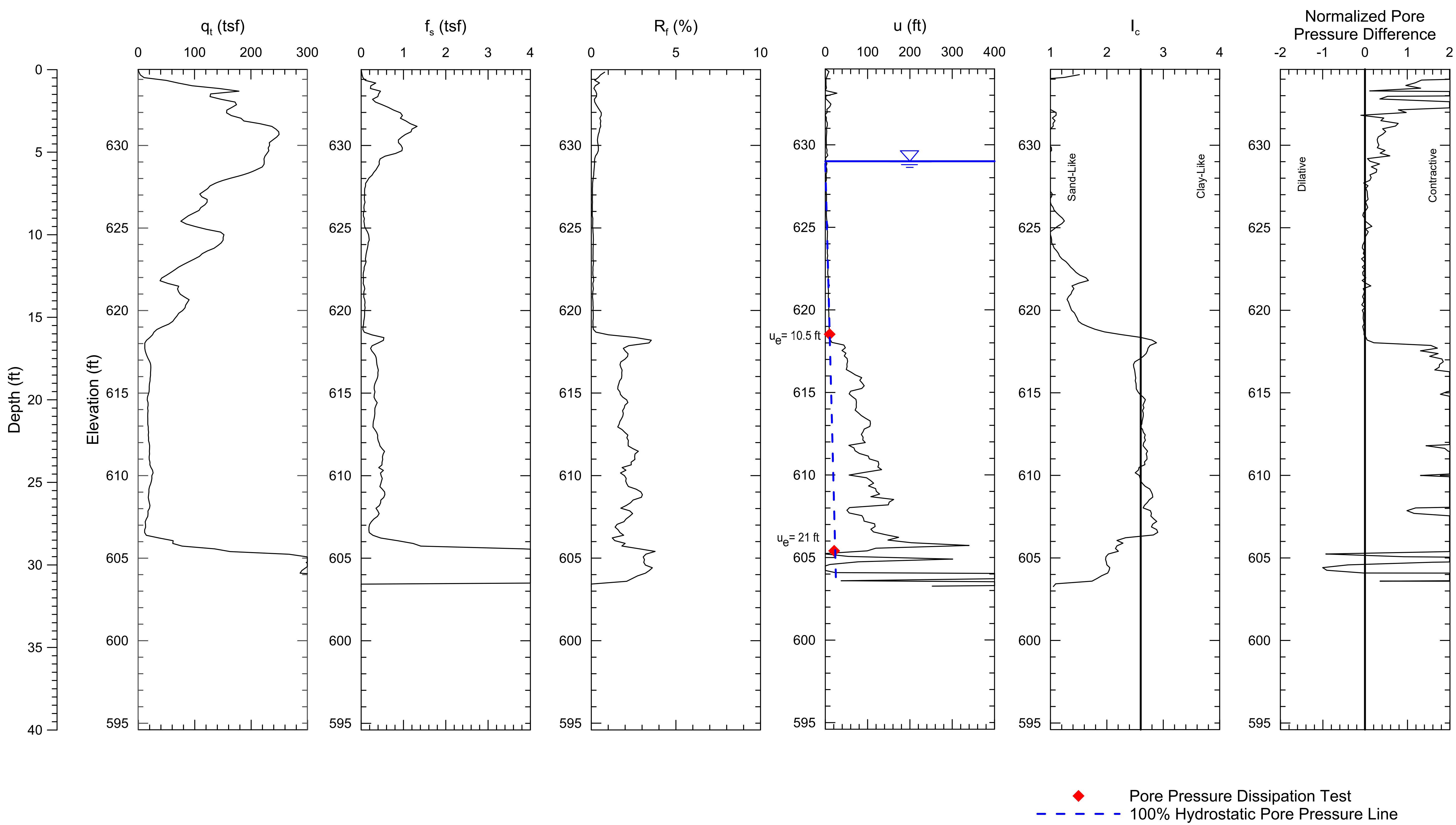


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

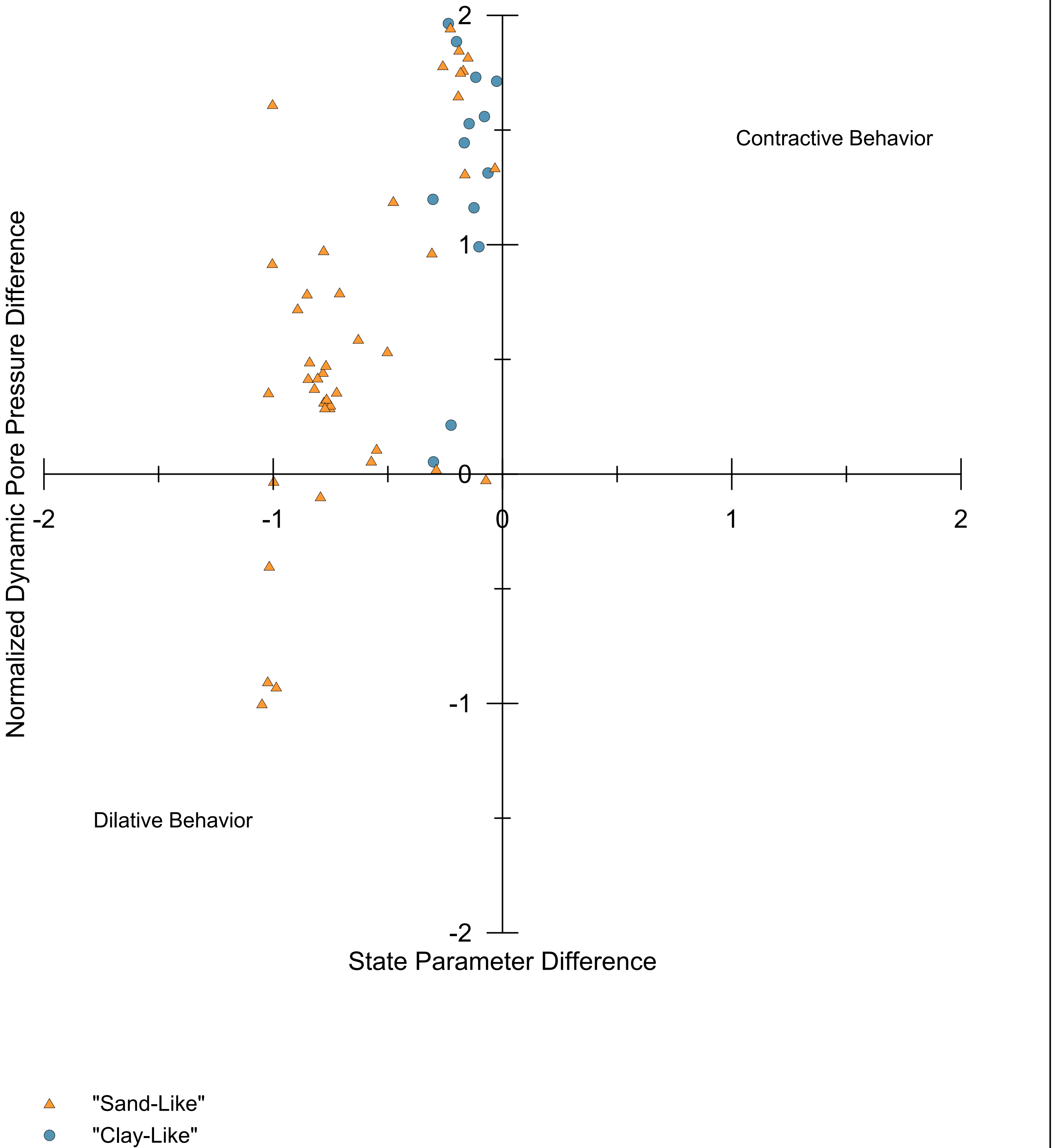
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-012_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-012 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			

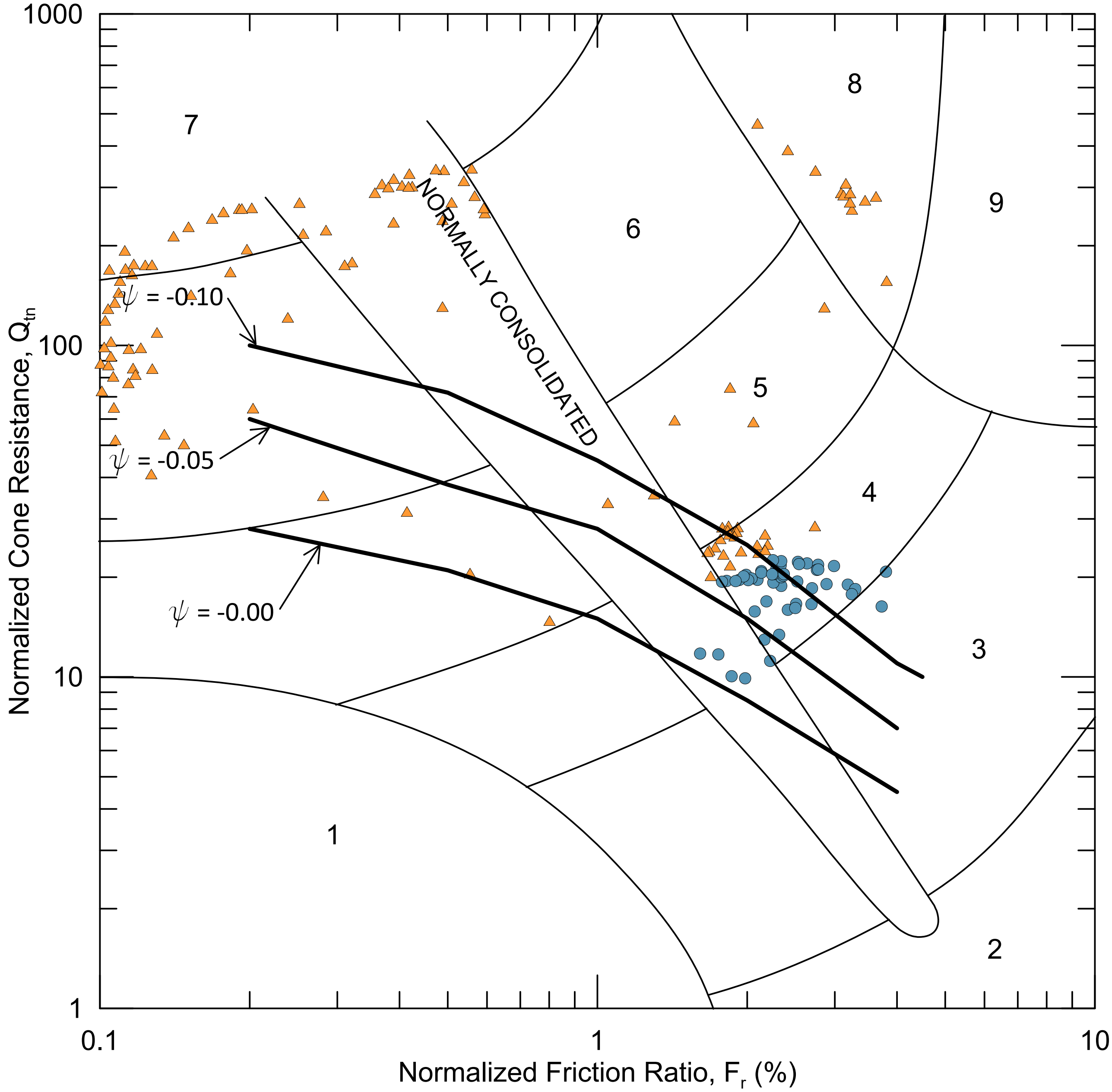


Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-013 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-013 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

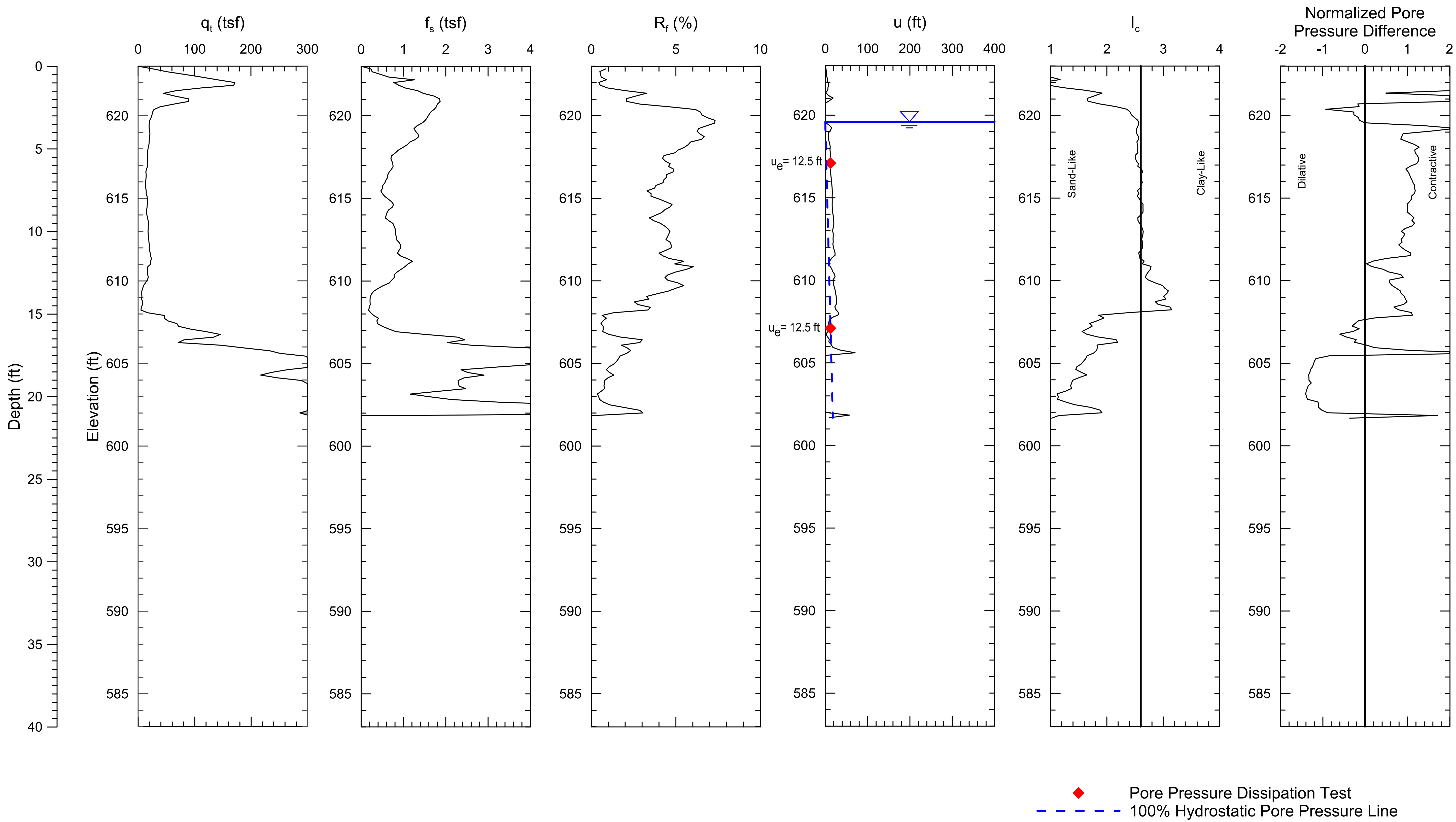


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

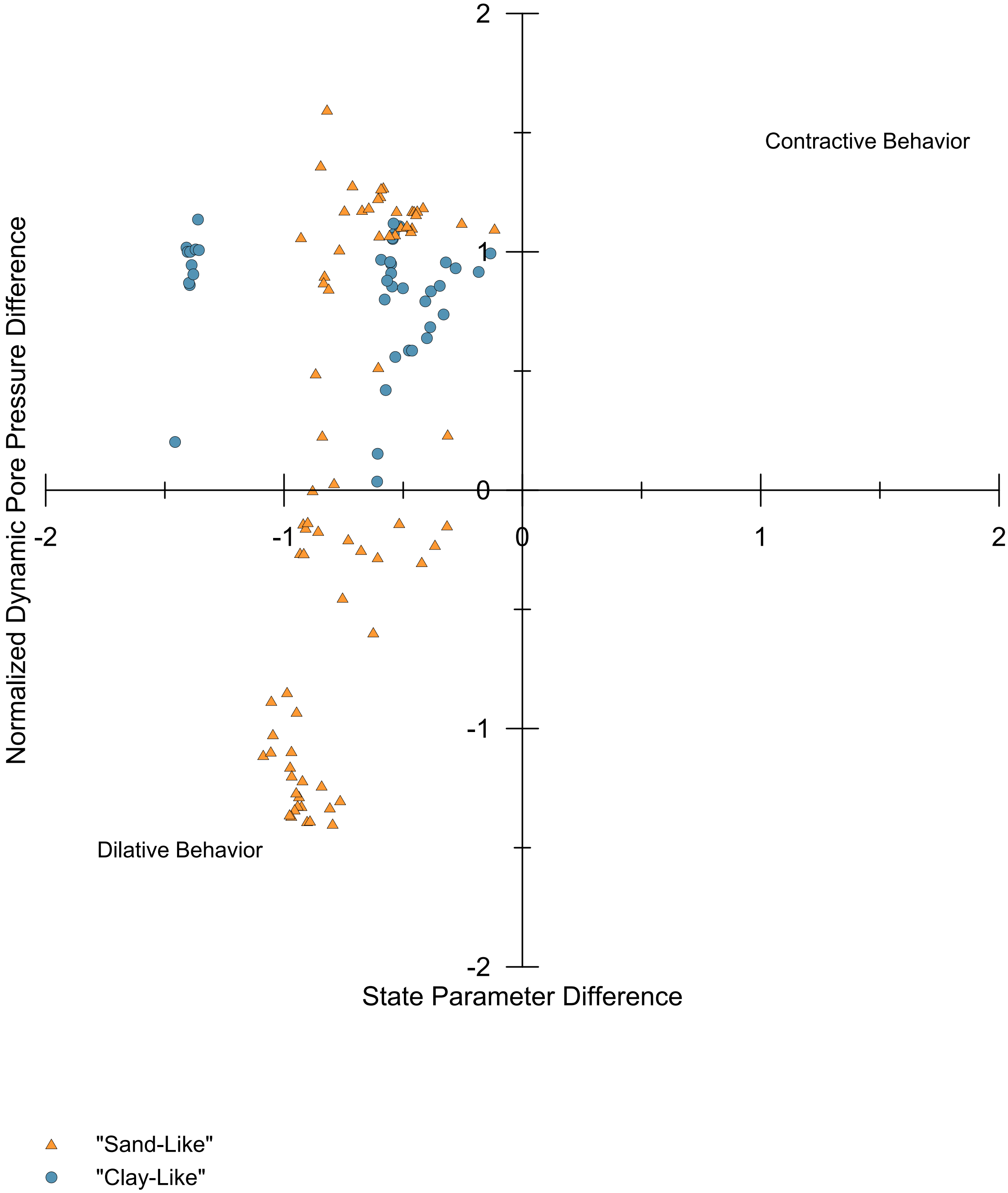
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-013_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-013 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			



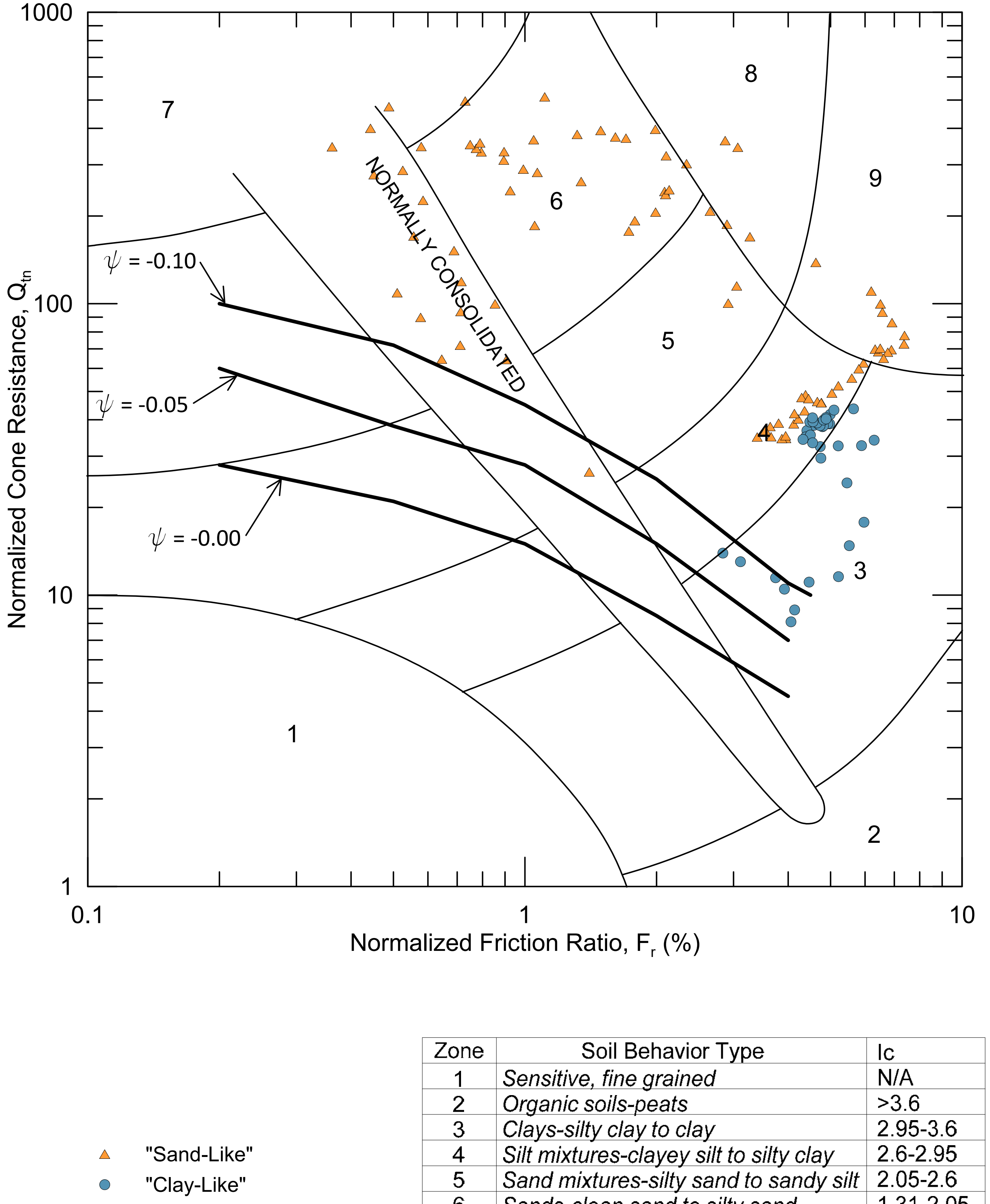
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-014 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-014_DC_ State Parameter Difference.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-014 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
AECOM			

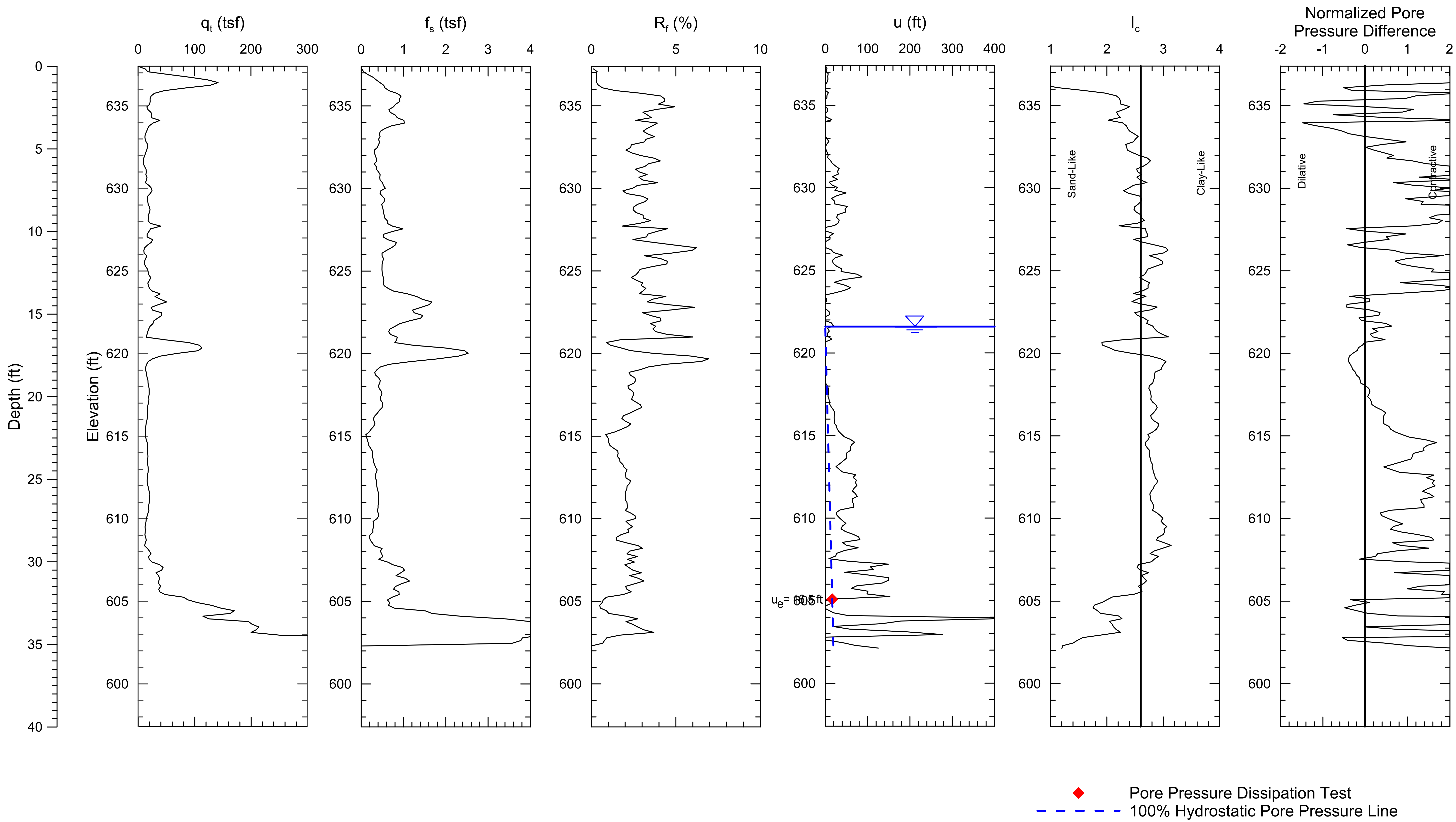


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-014_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-014 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			

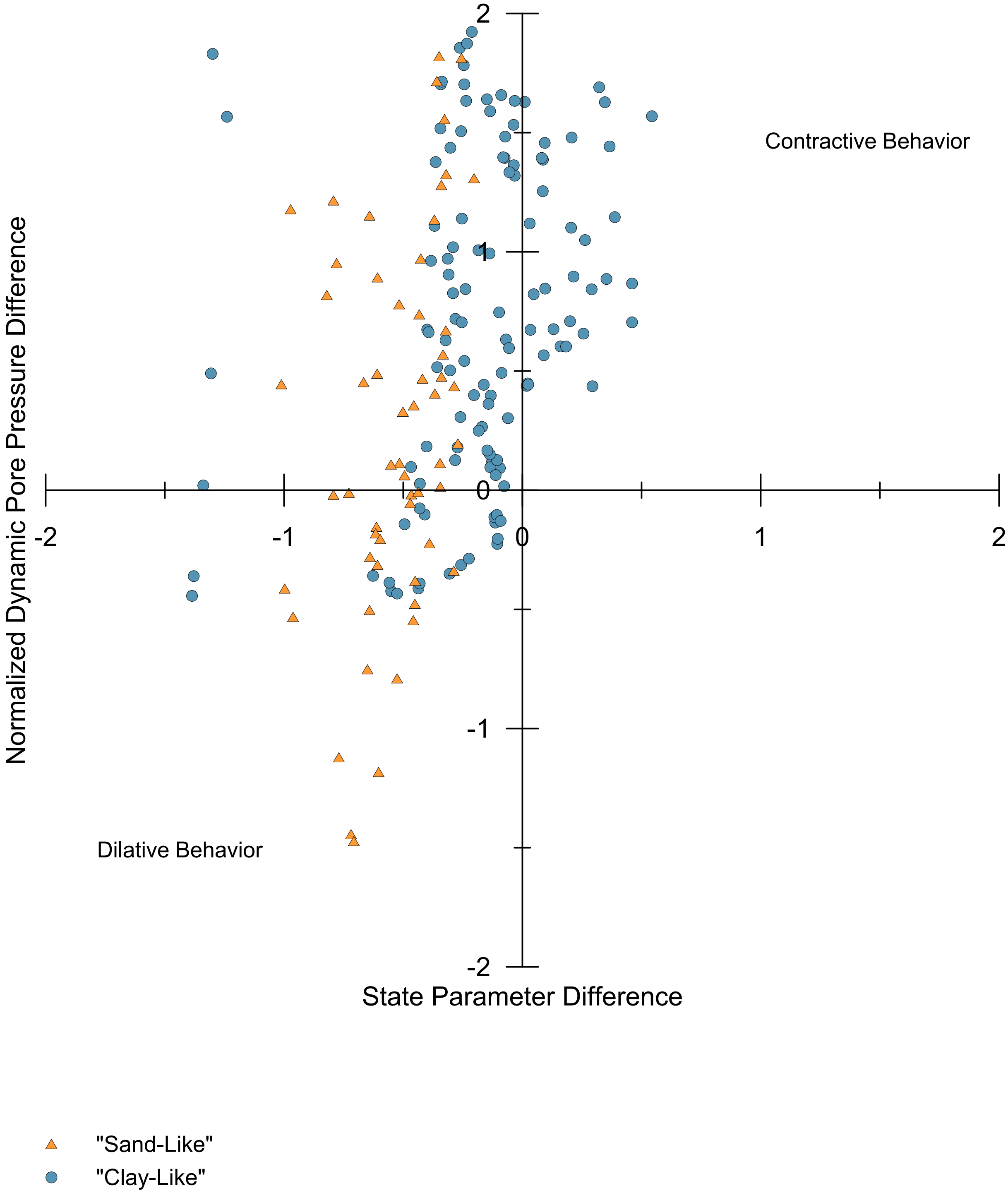


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

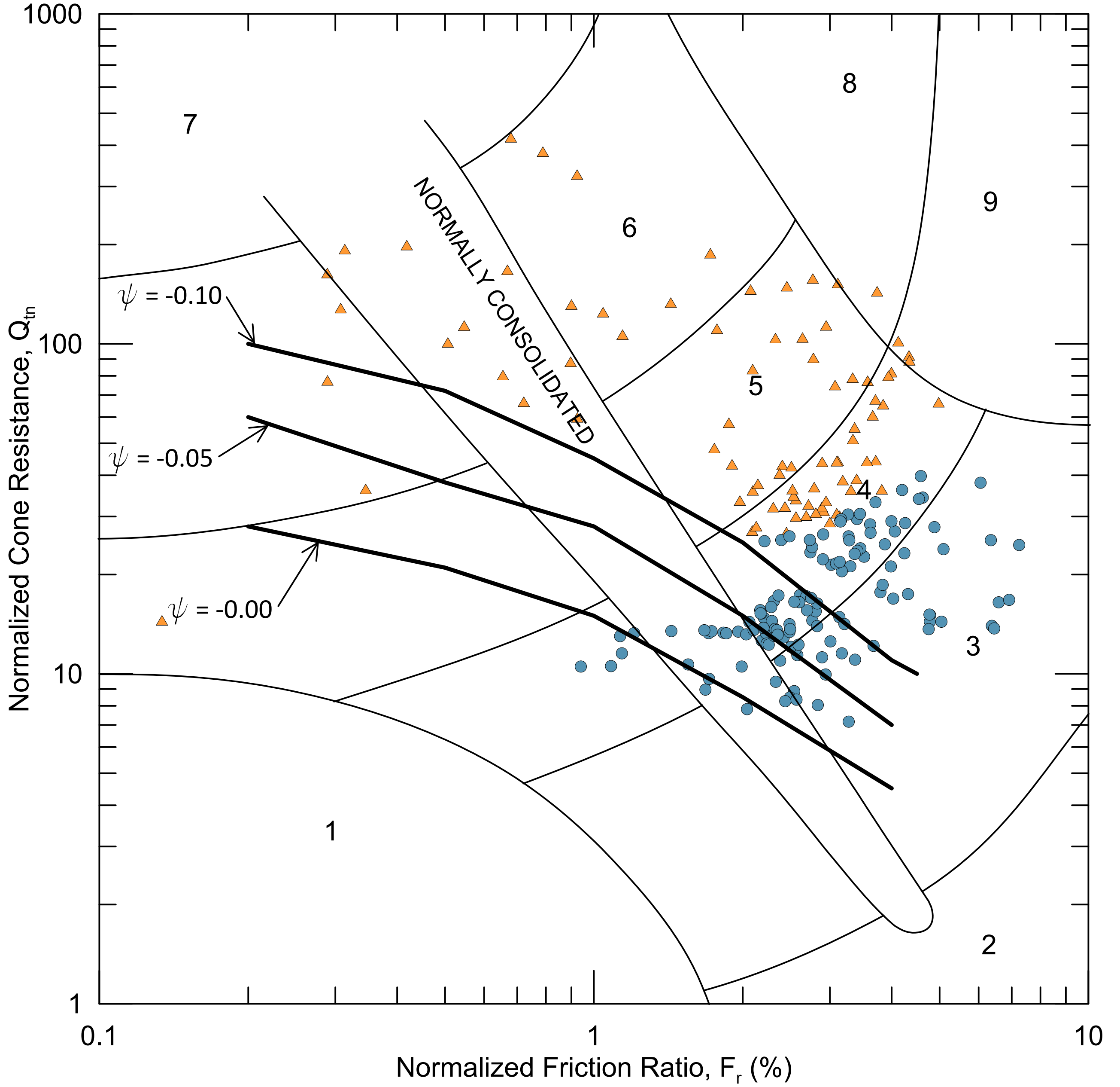
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-015 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-015_DC_ State Parameter Difference.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-015 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		



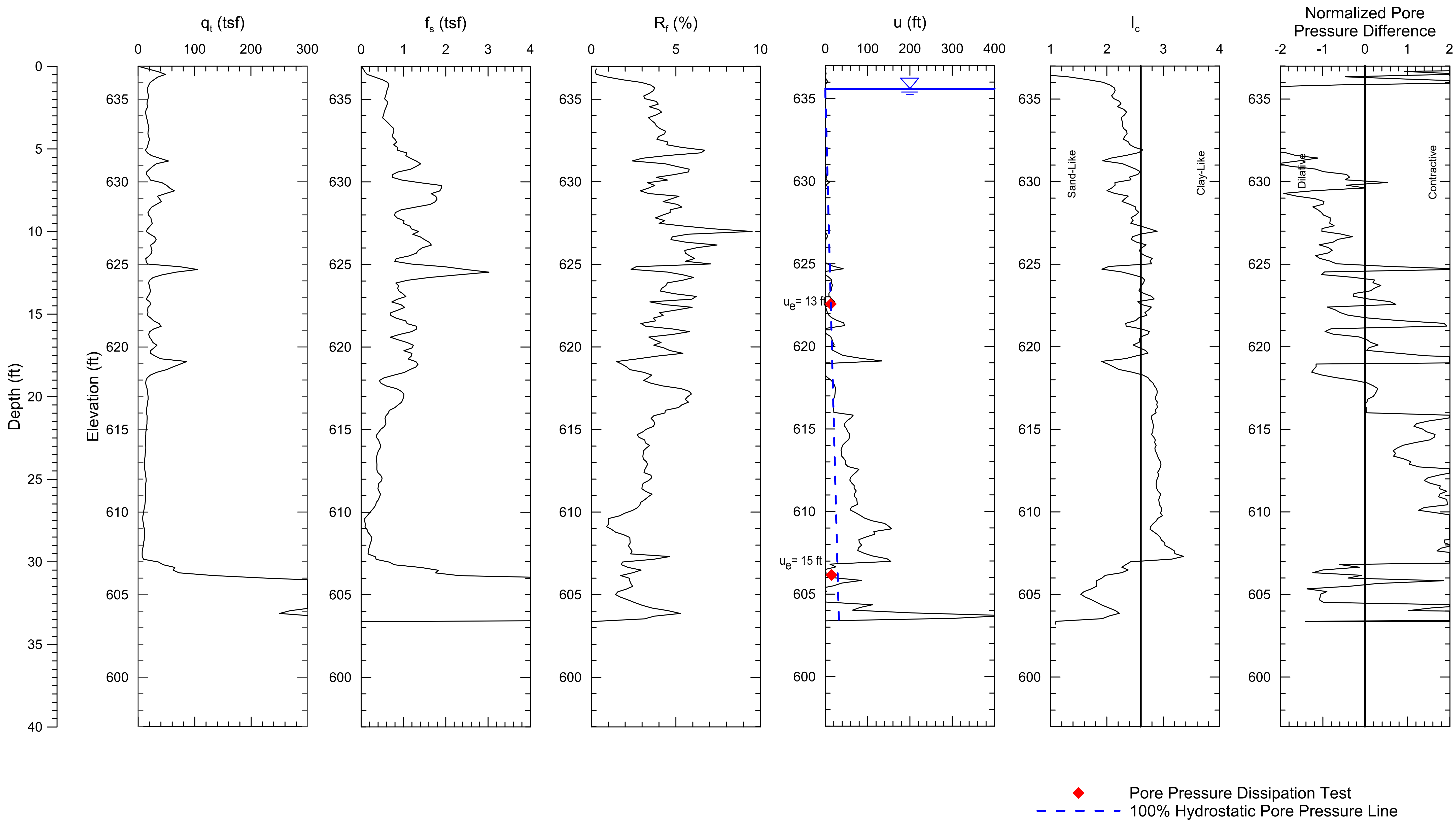
Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

"Sand-Like"
"Clay-Like"

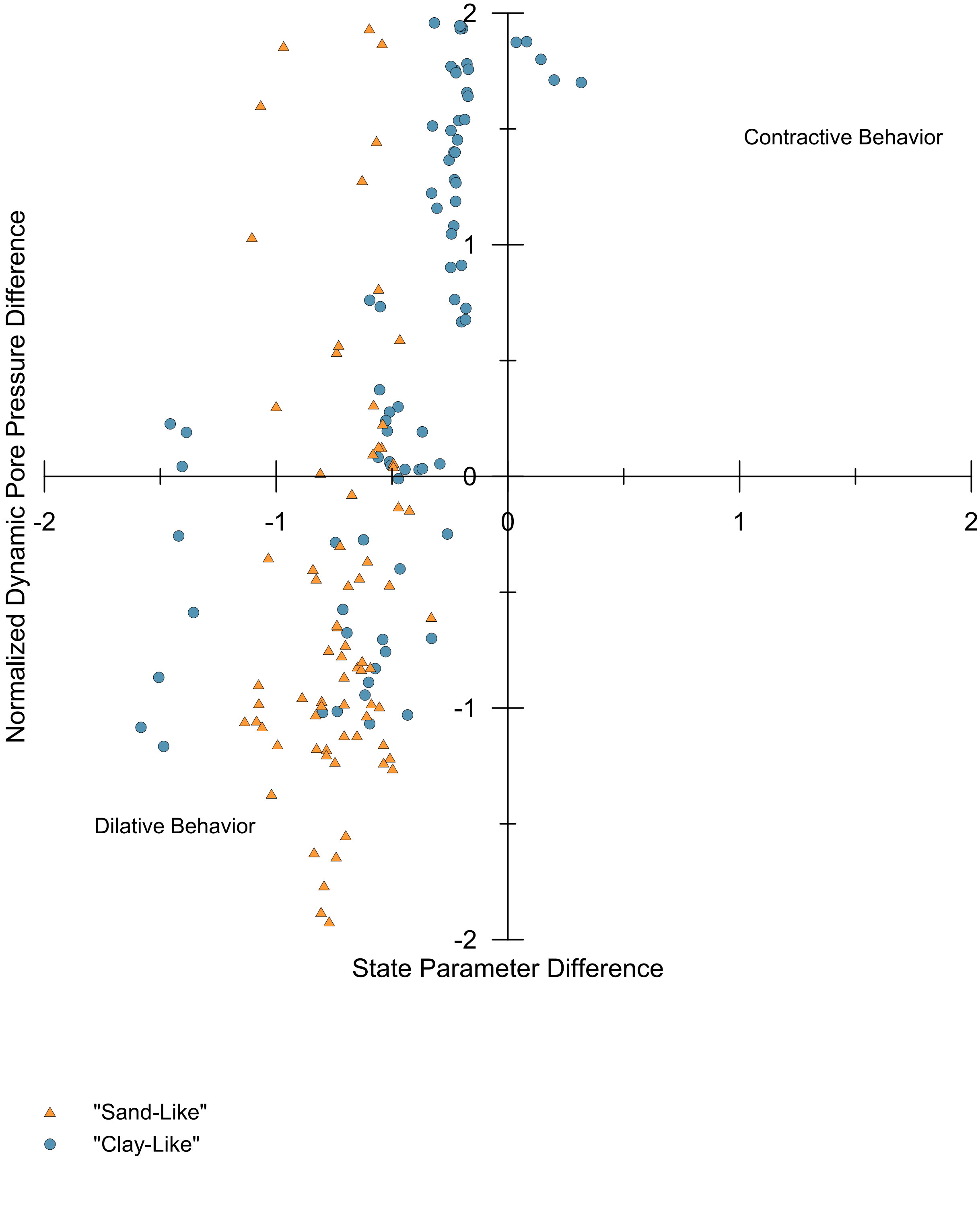
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-015_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-015 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
	AECOM		



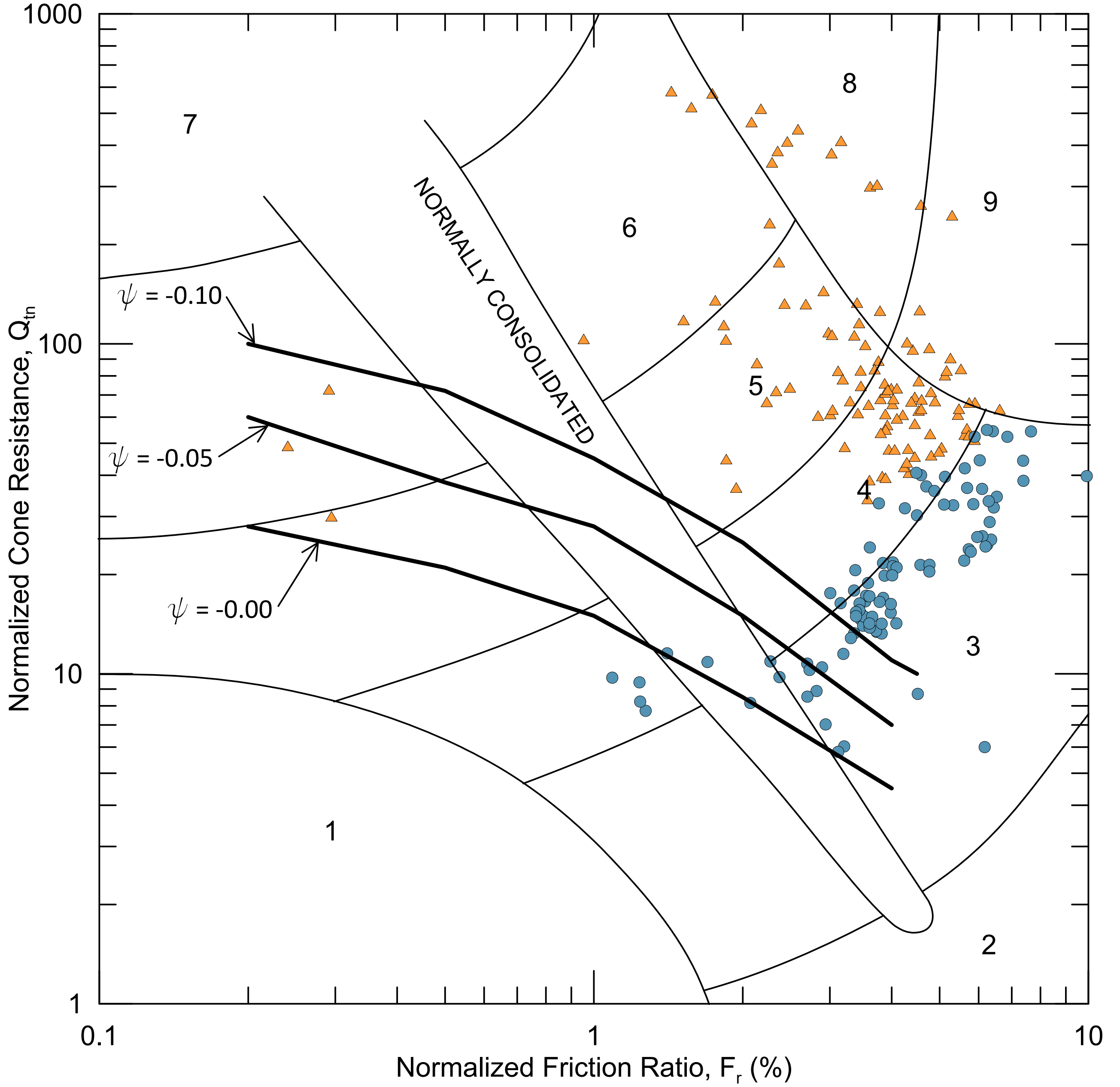
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-016 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-016_DC_ State Parameter Difference.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-016 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

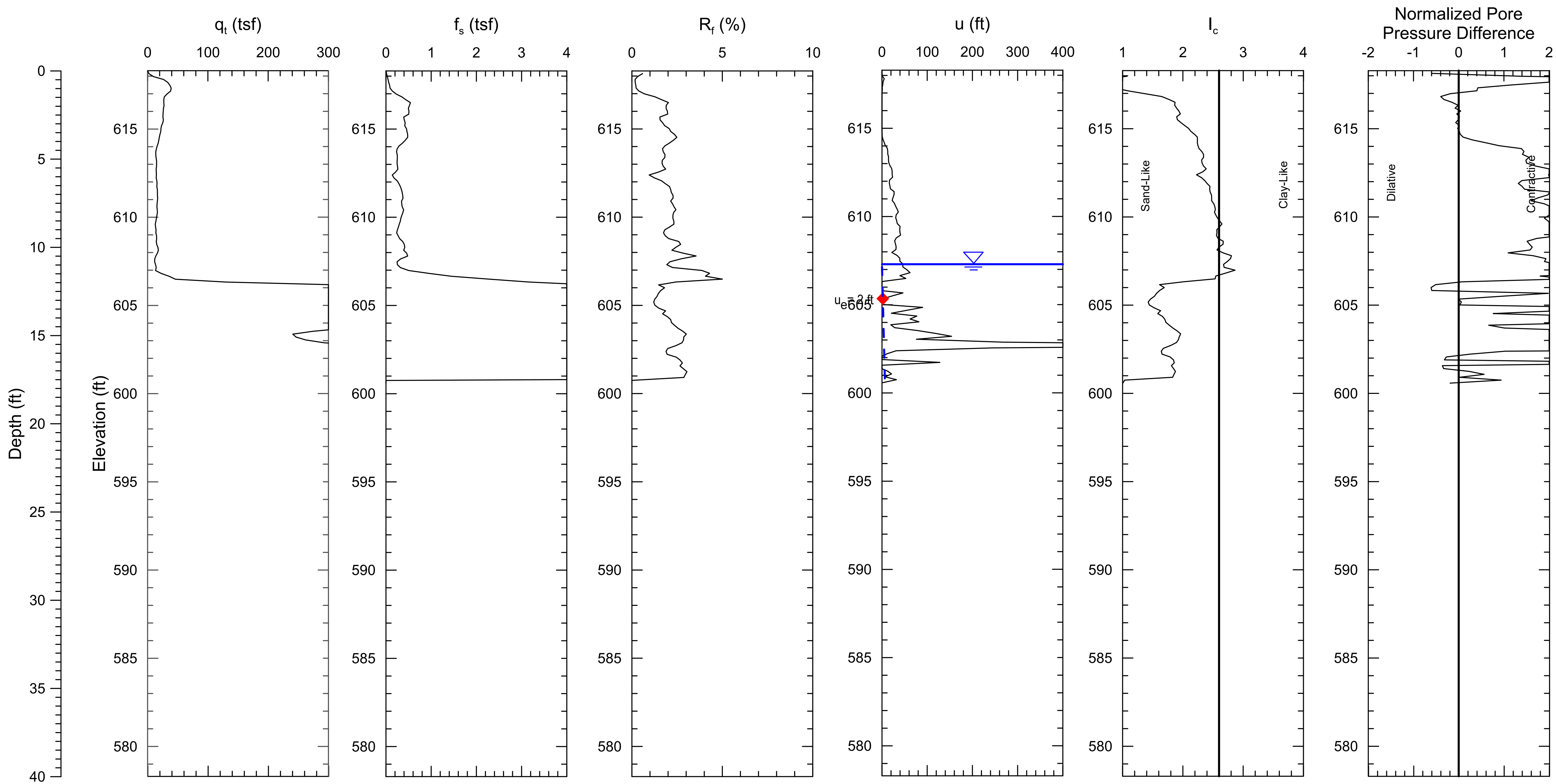


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-016 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-016_DC_Normalized State.grf



Pore Pressure Dissipation Test

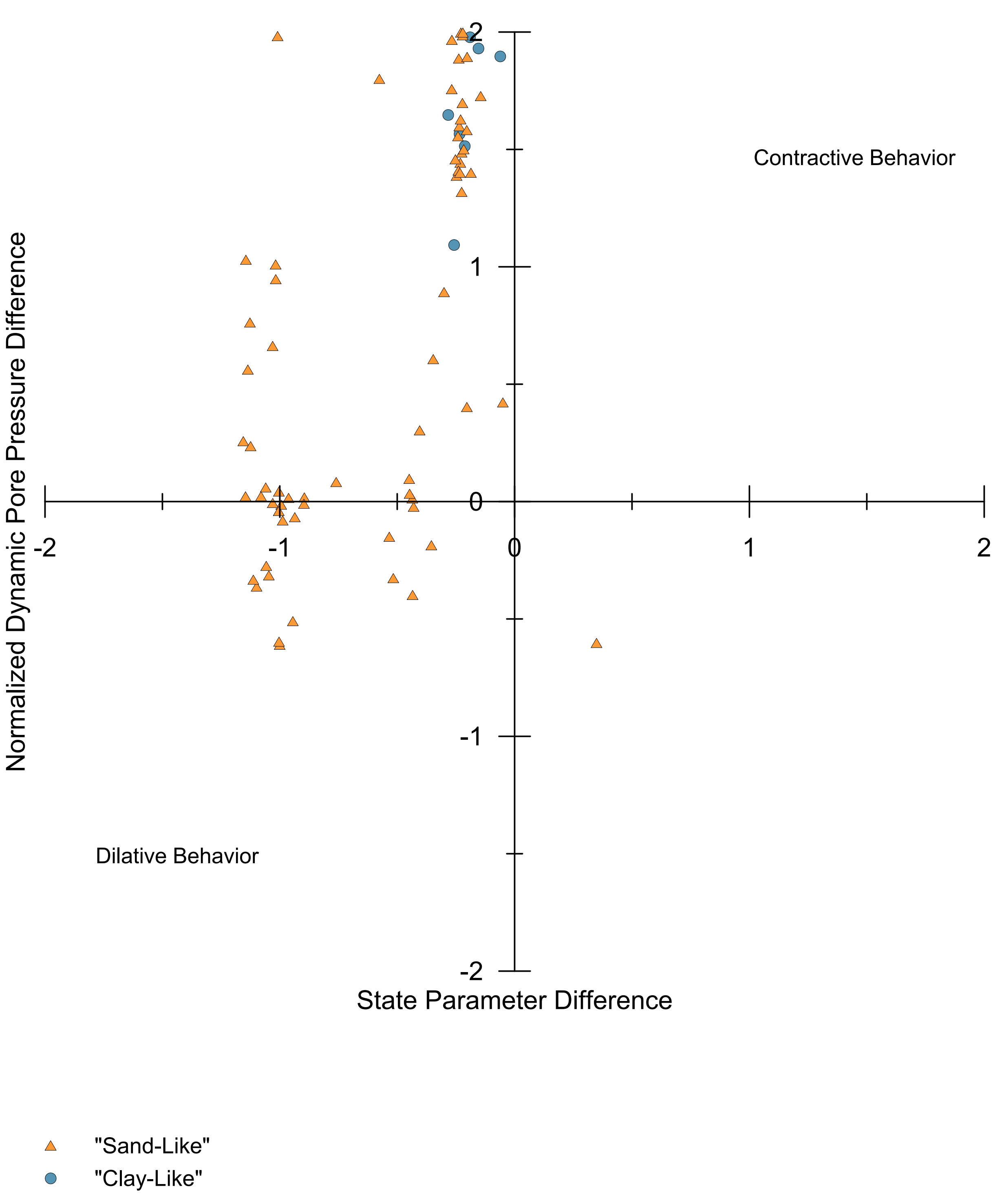
100% Hydrostatic Pore Pressure Line

Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

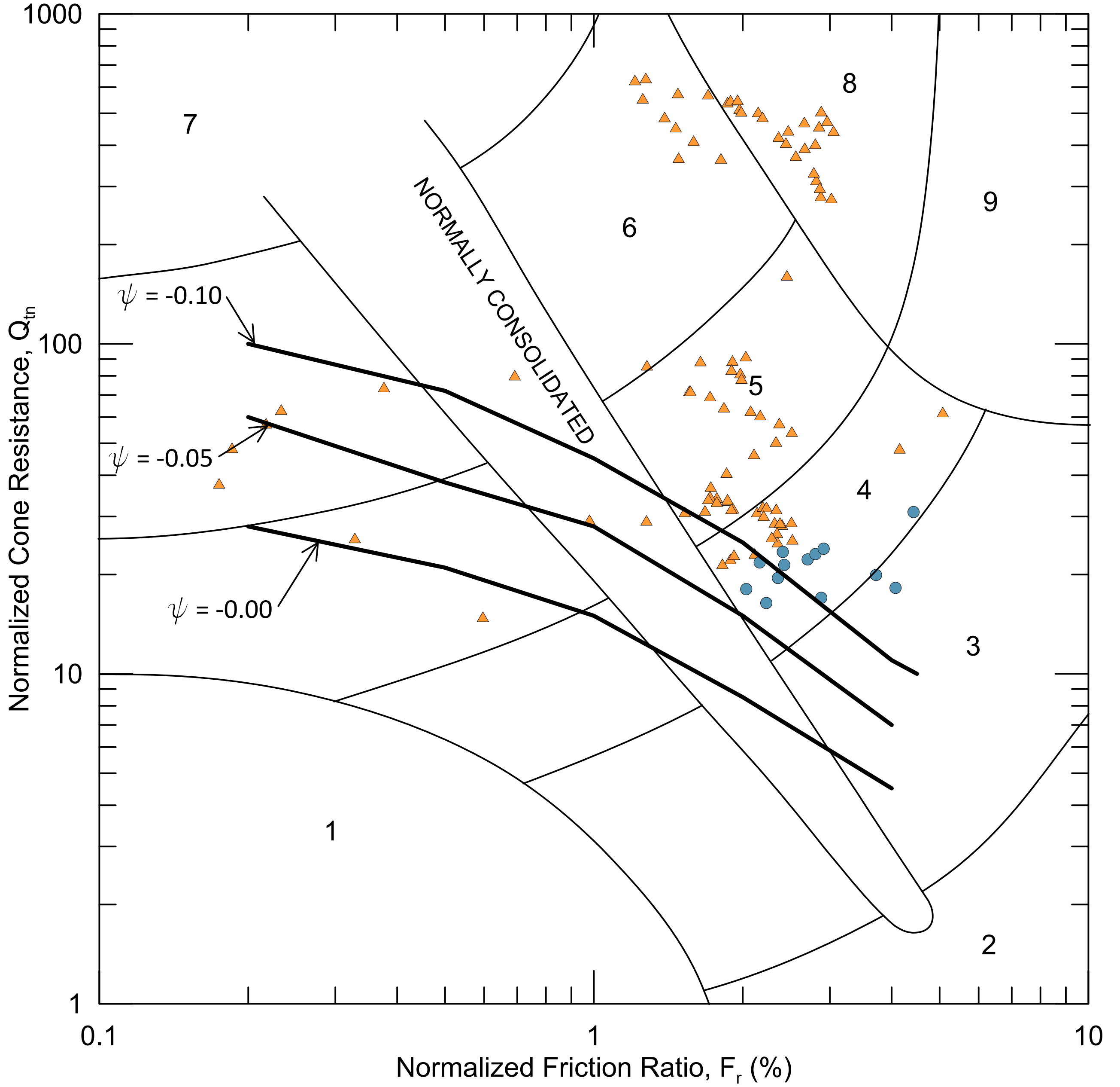
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-017 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-017_DC_ State Parameter Difference.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-017 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
AECOM			

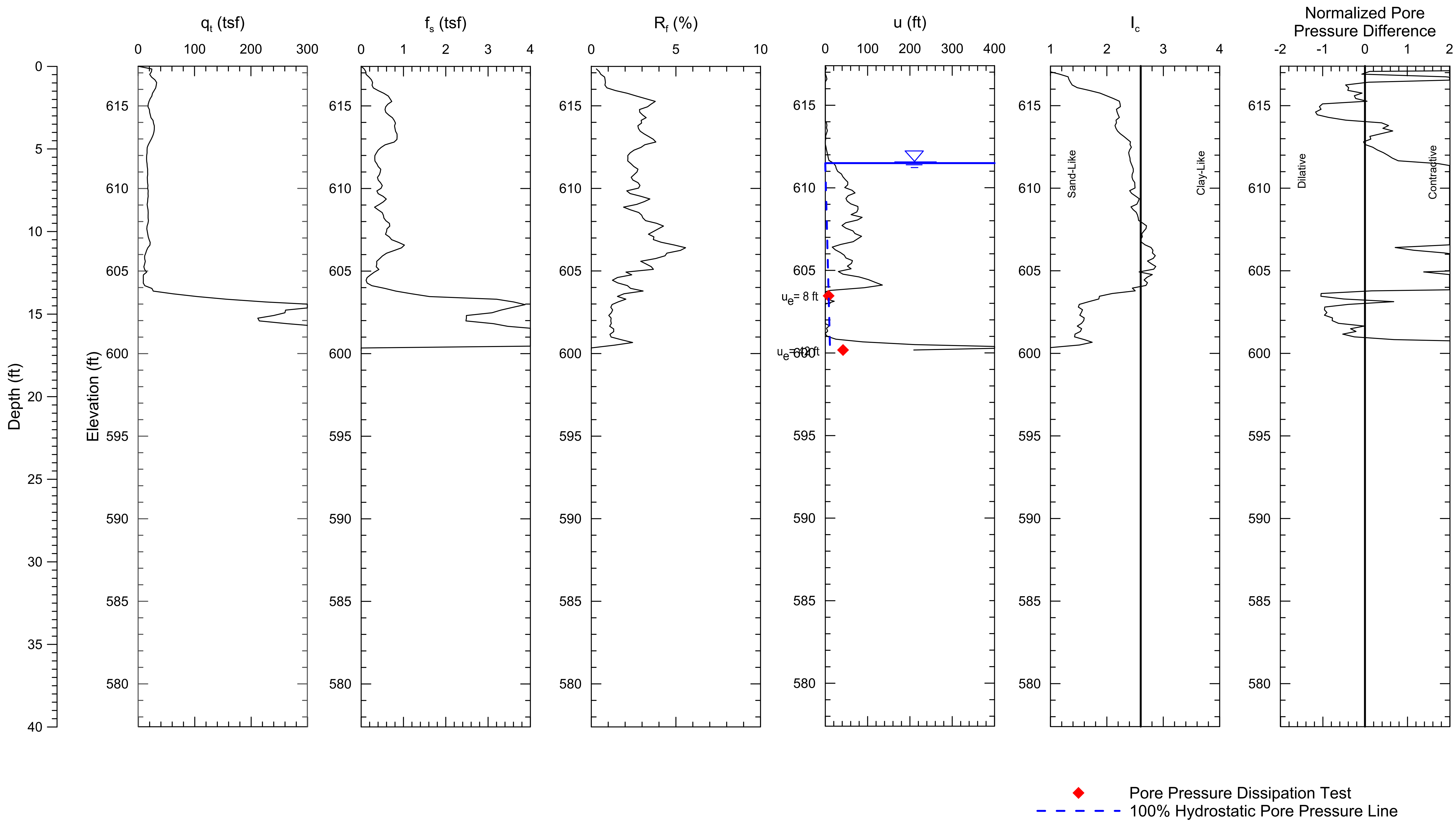


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

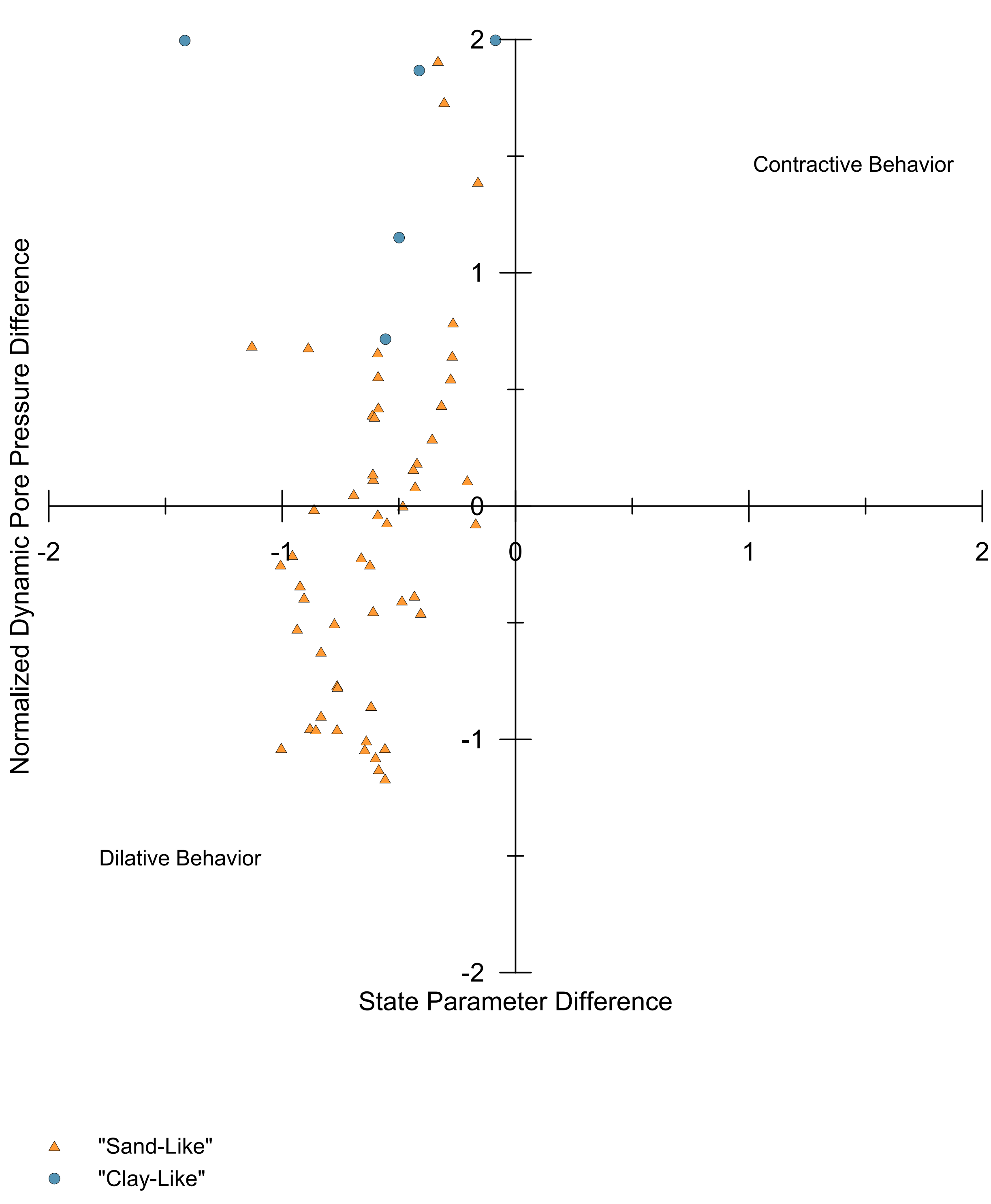
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-017 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-017_DC_Normalized State.grf



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-018 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



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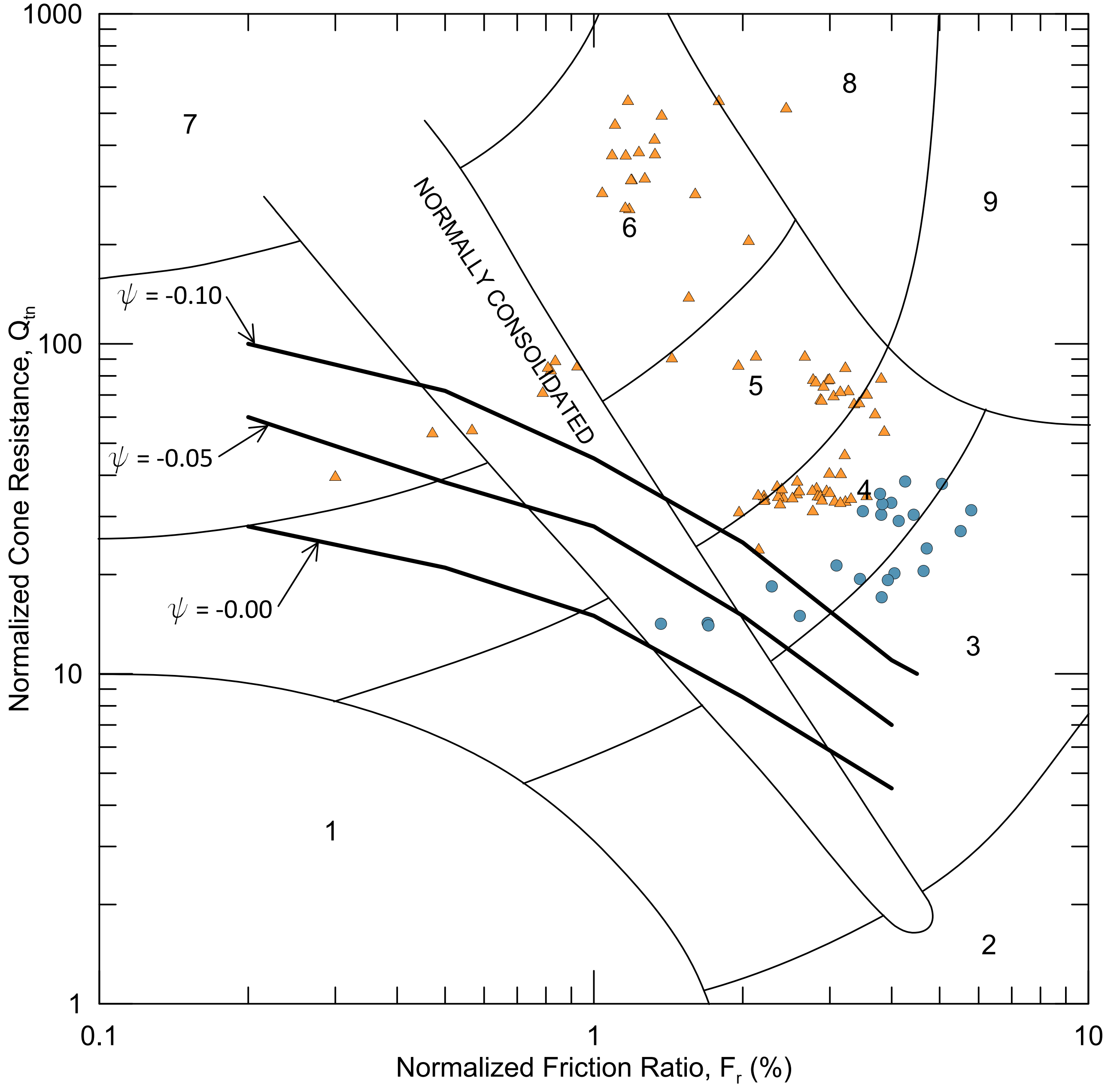
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-018 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		



Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

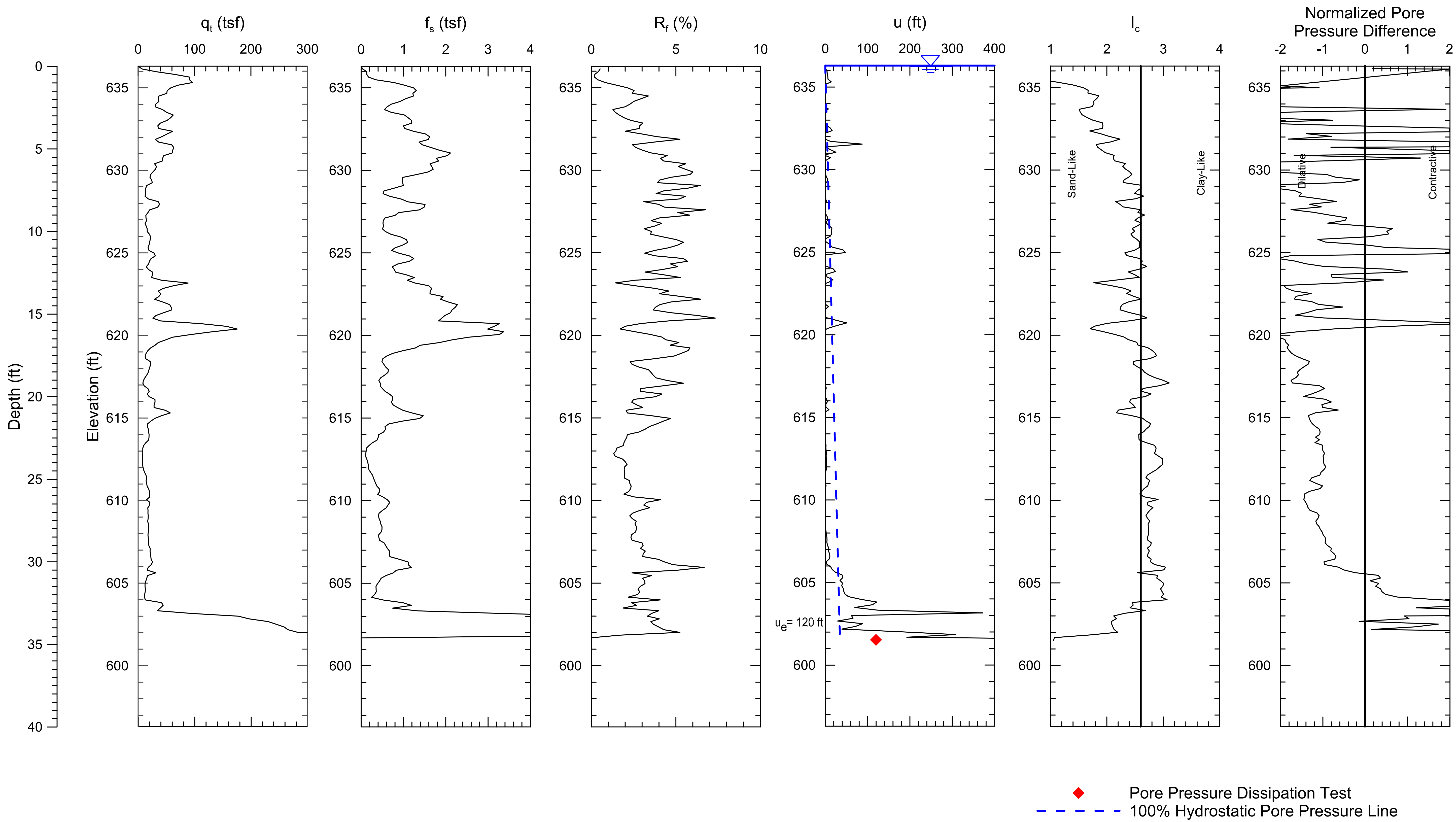
**Heavily overconsolidated or cemented*

▲ "Sand-Like"

● "Clay-Like"

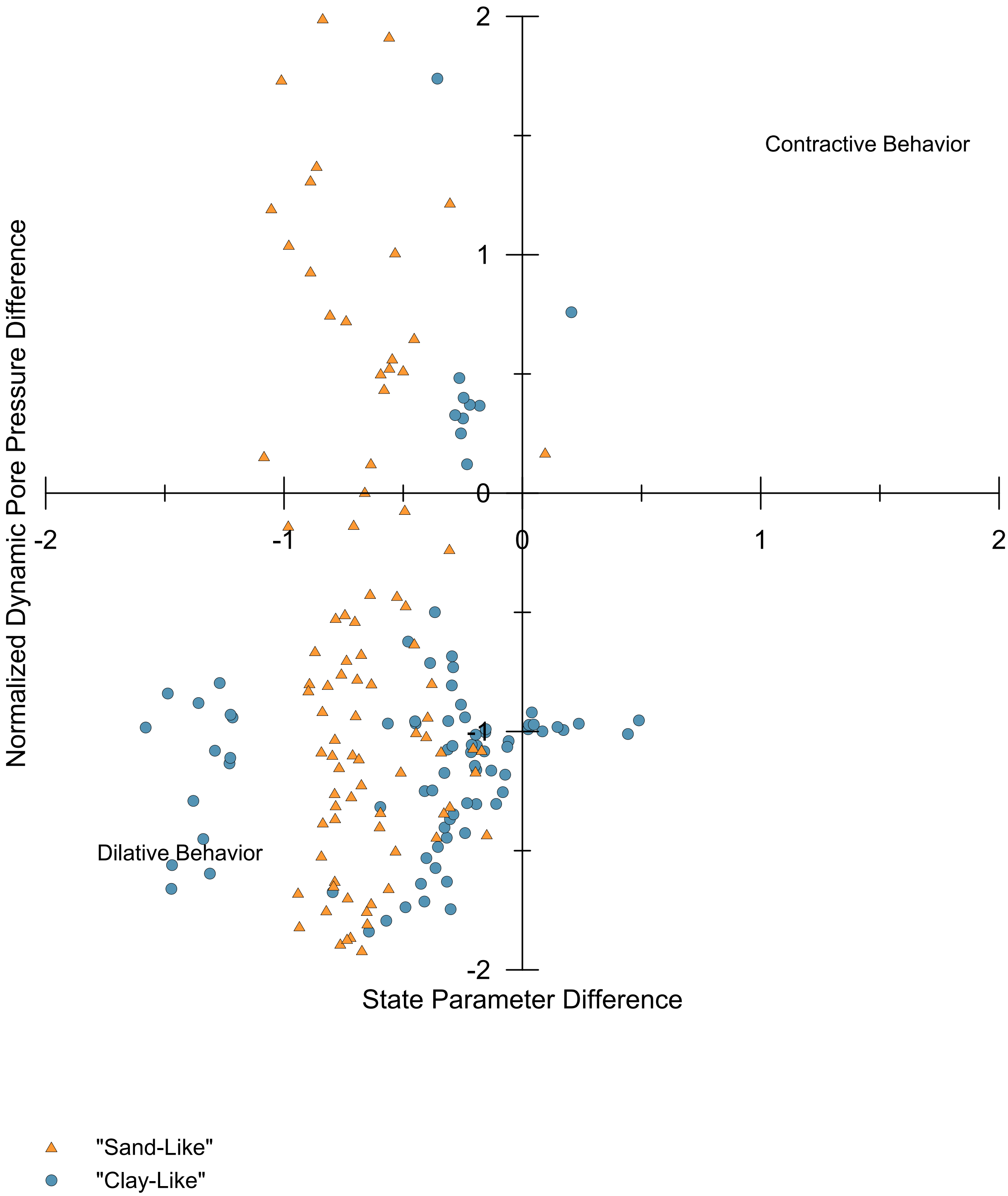
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-018_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-018 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			



Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-019 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



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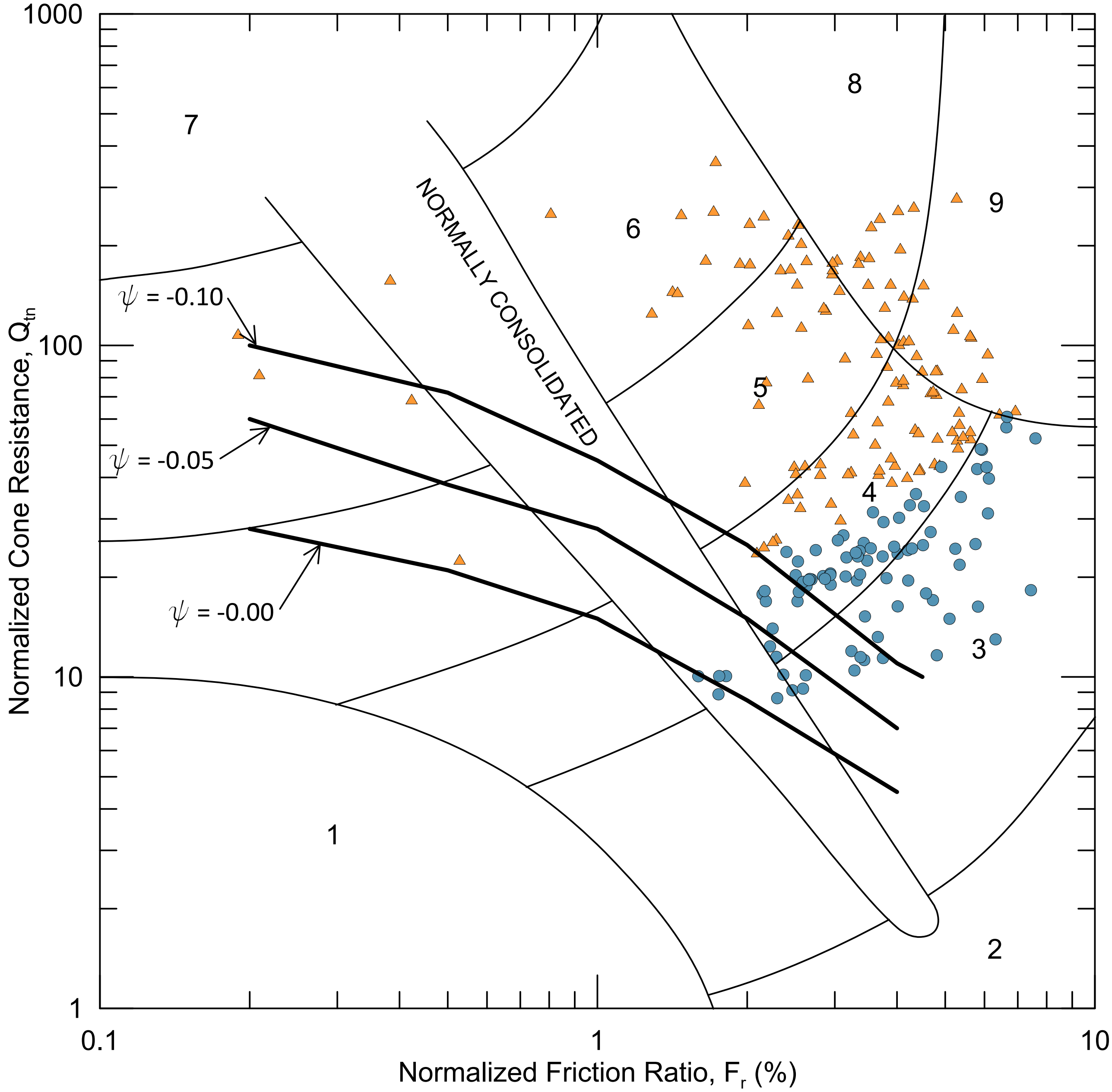
PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-019 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		



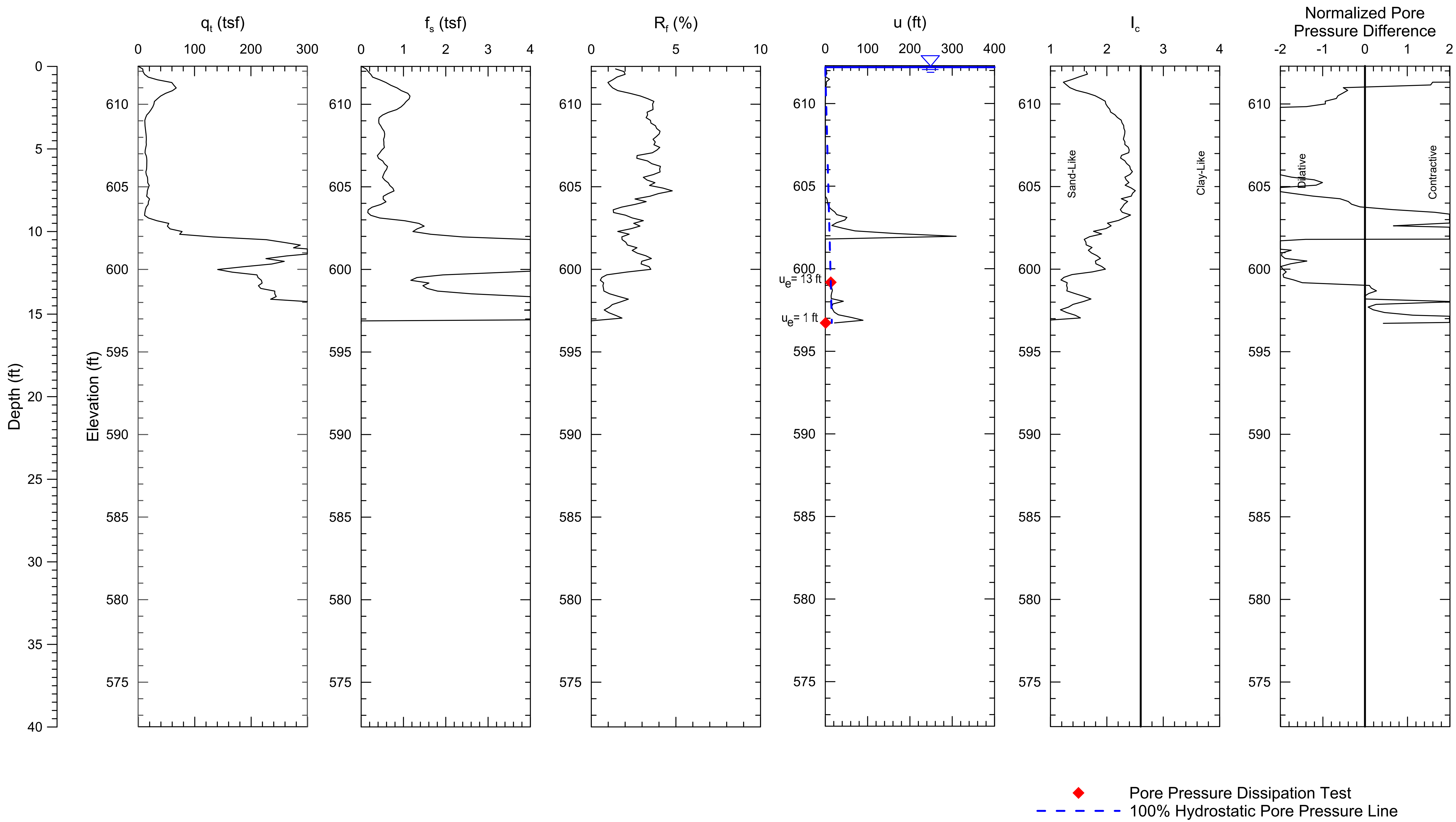
▲ "Sand-Like"

● "Clay-Like"

Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-019 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
	AECOM		

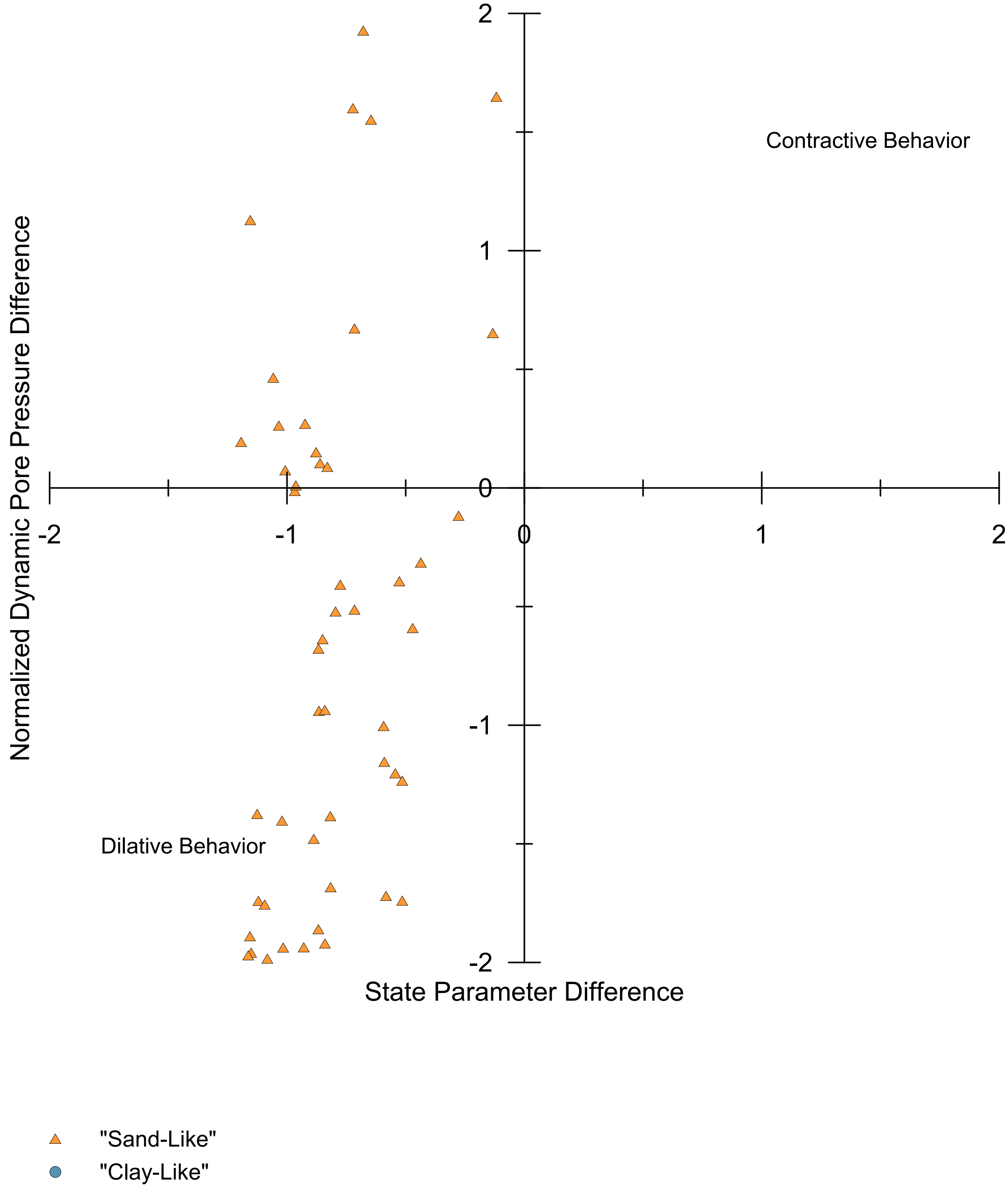


Notes:

1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).

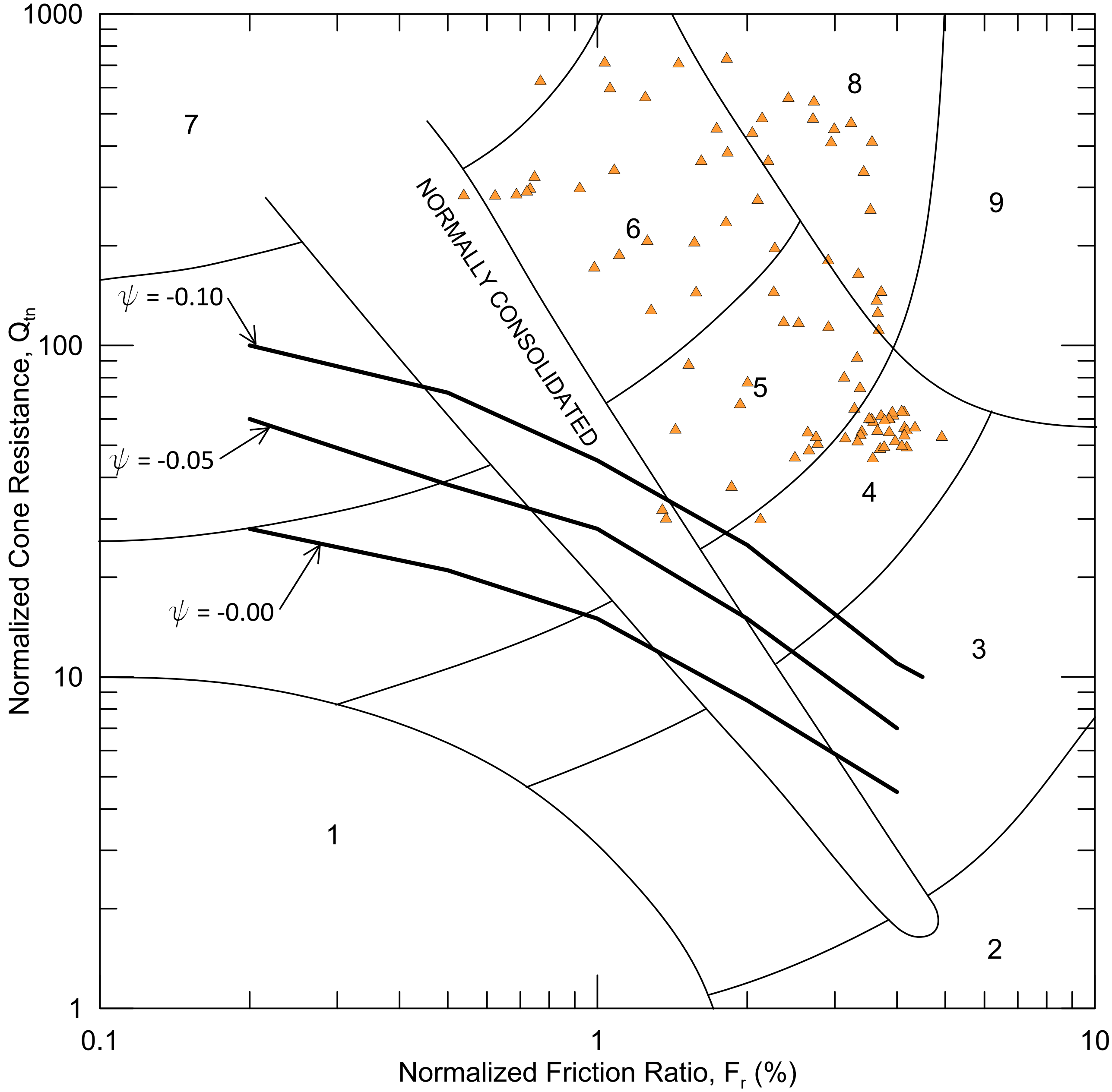
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-020 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-020_DC_ State Parameter Difference.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-020 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

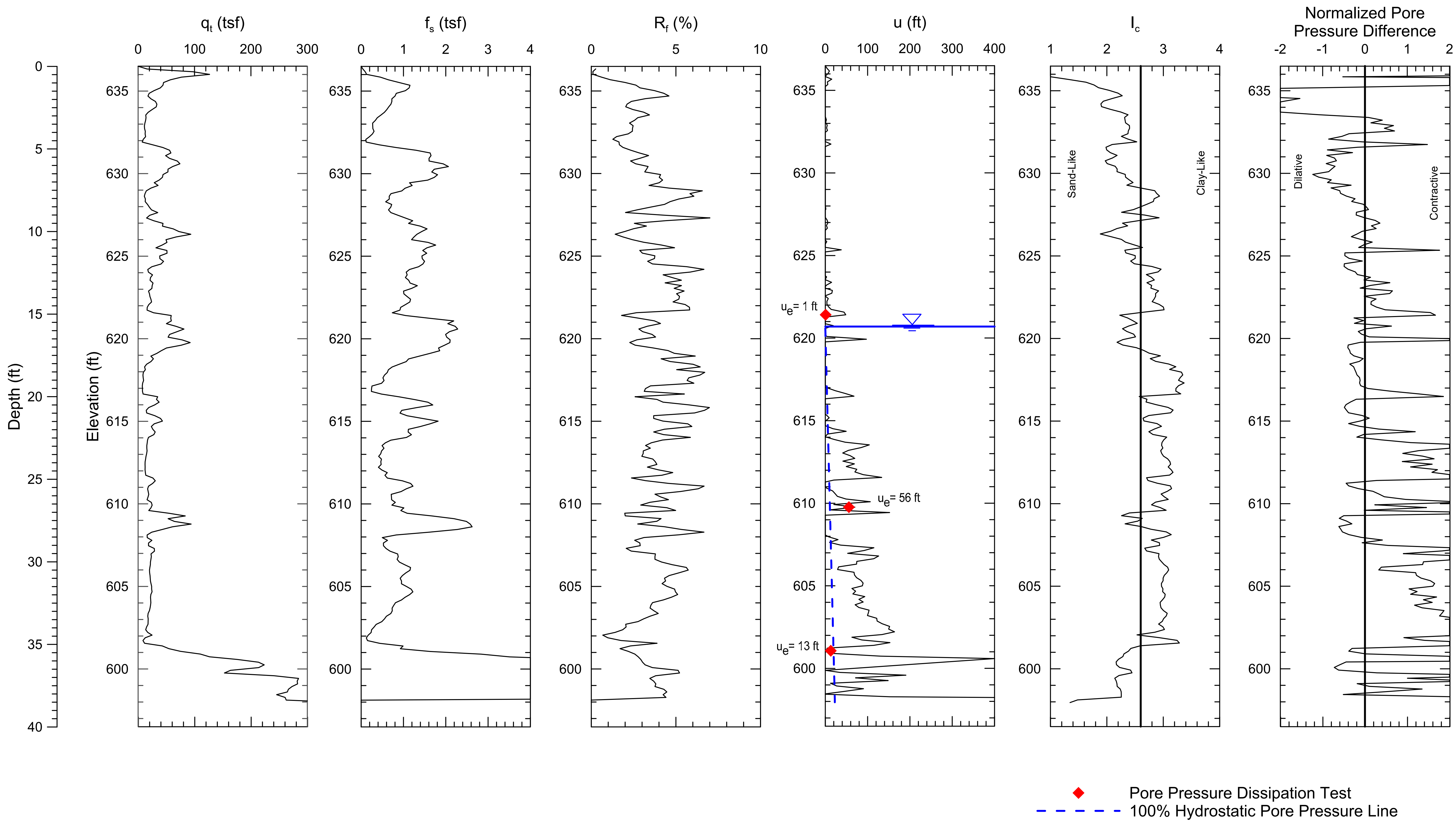


Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

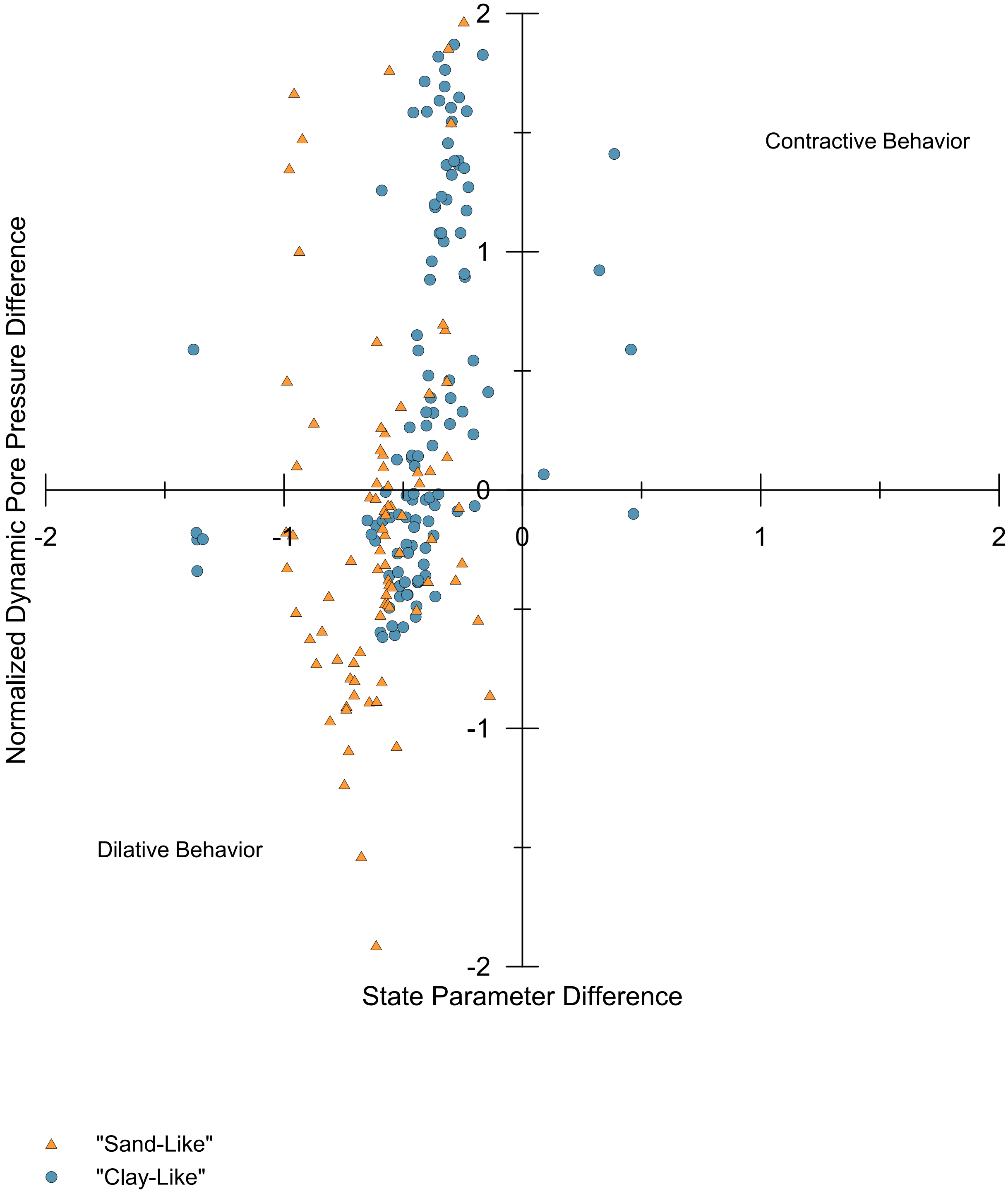
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-020_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-020 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			



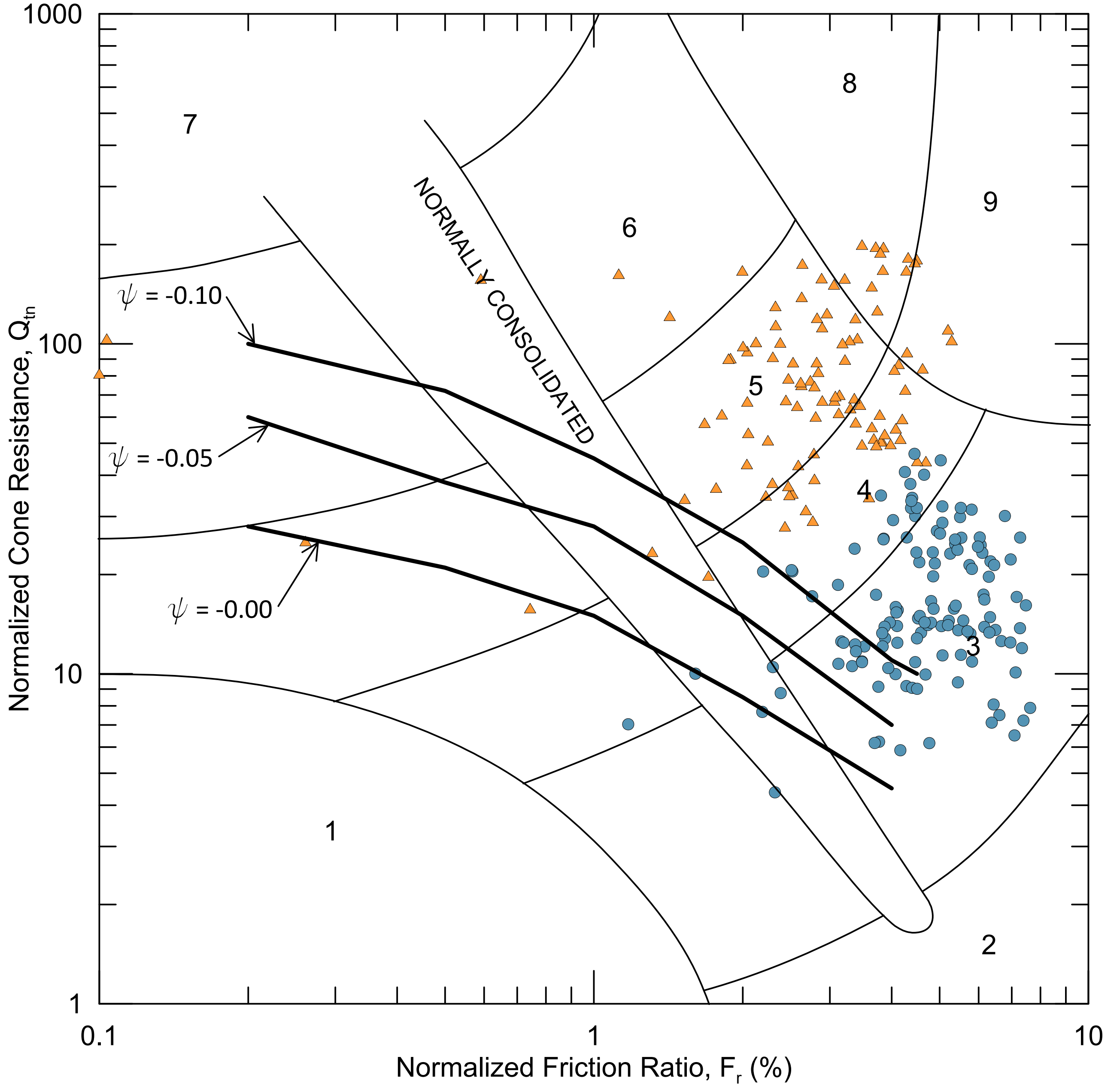
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-022 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-022 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-022_DC_ State Parameter Difference.grf



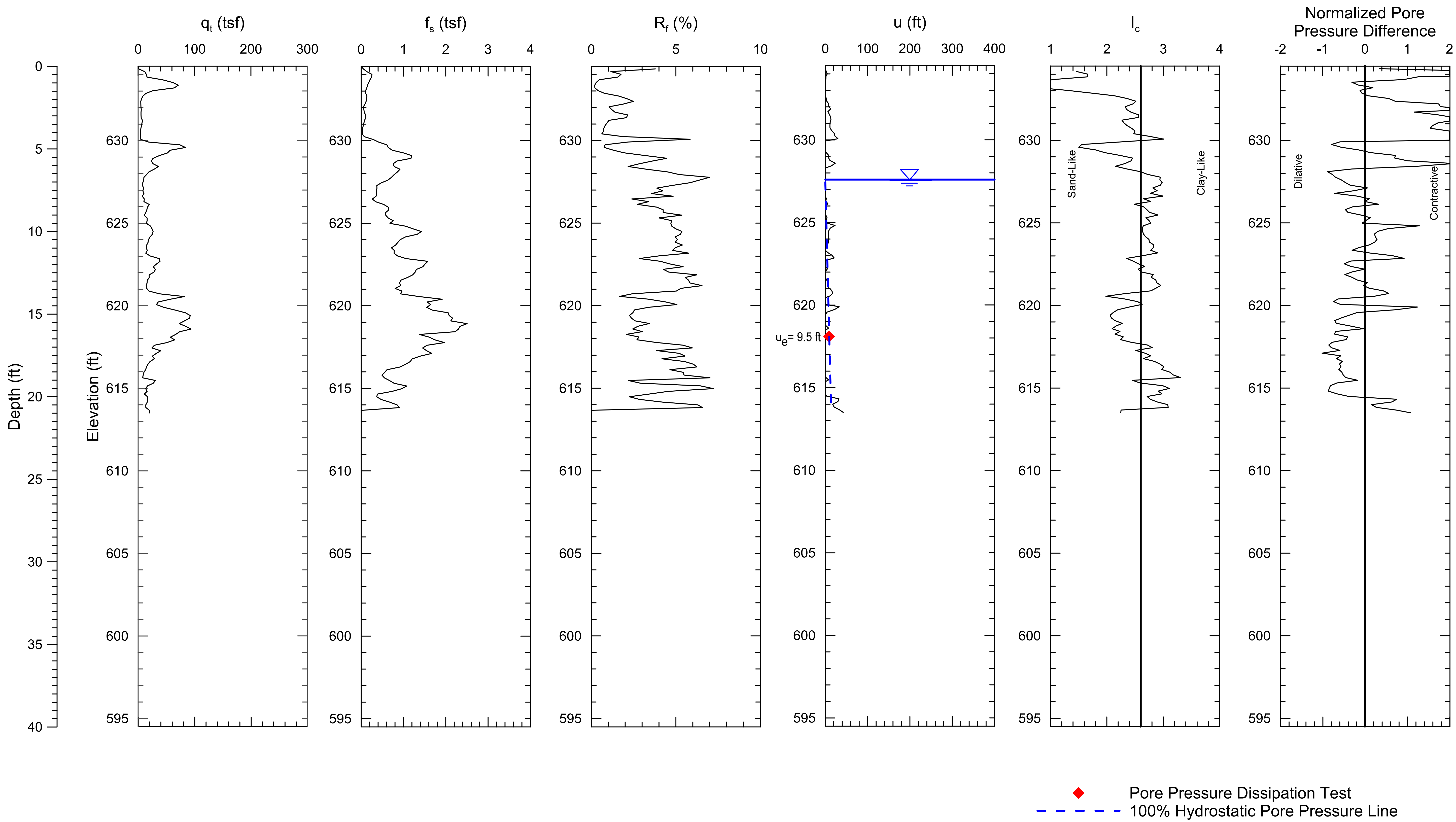
Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

"Sand-Like"
"Clay-Like"

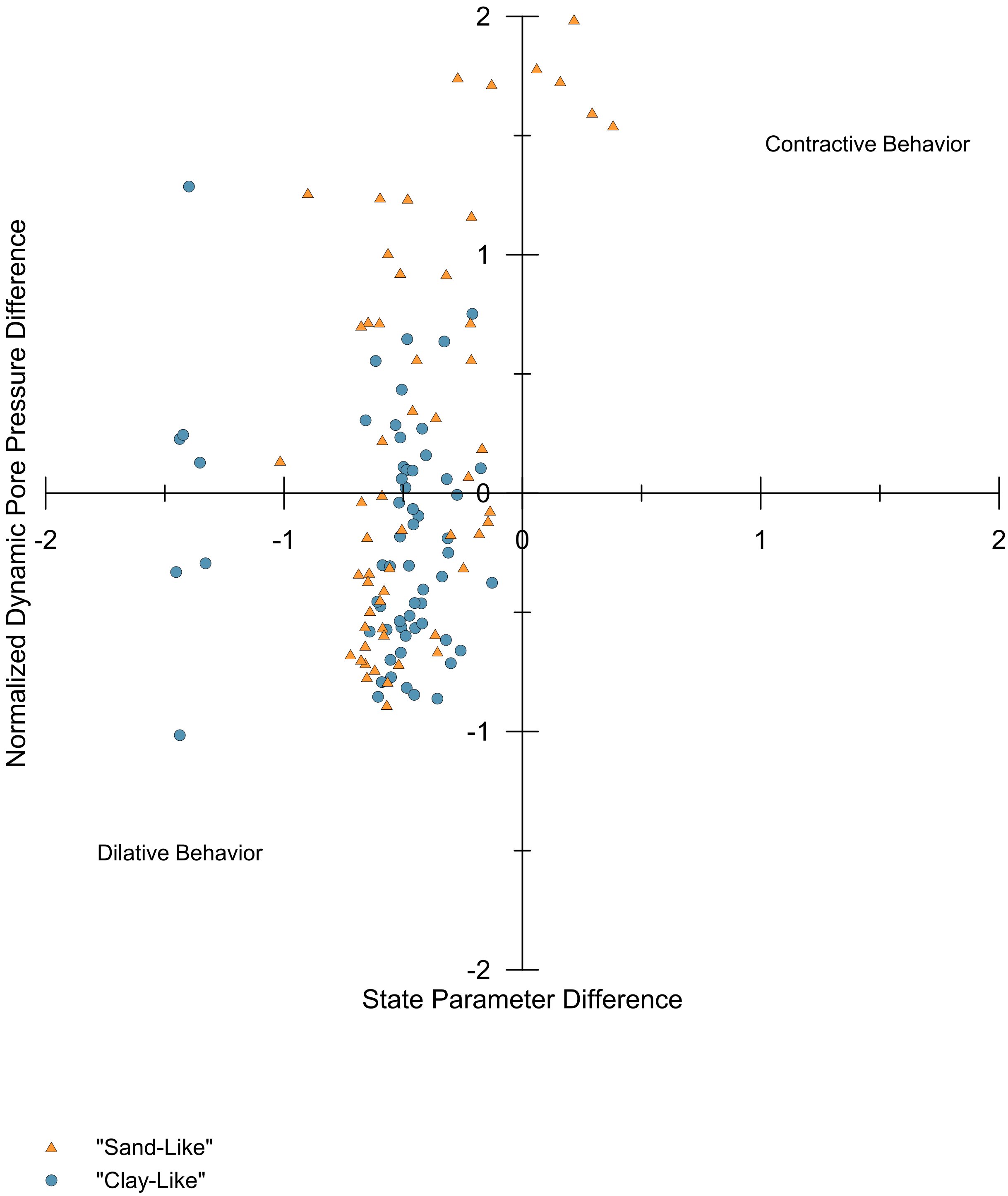
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-022_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-022 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
AECOM			



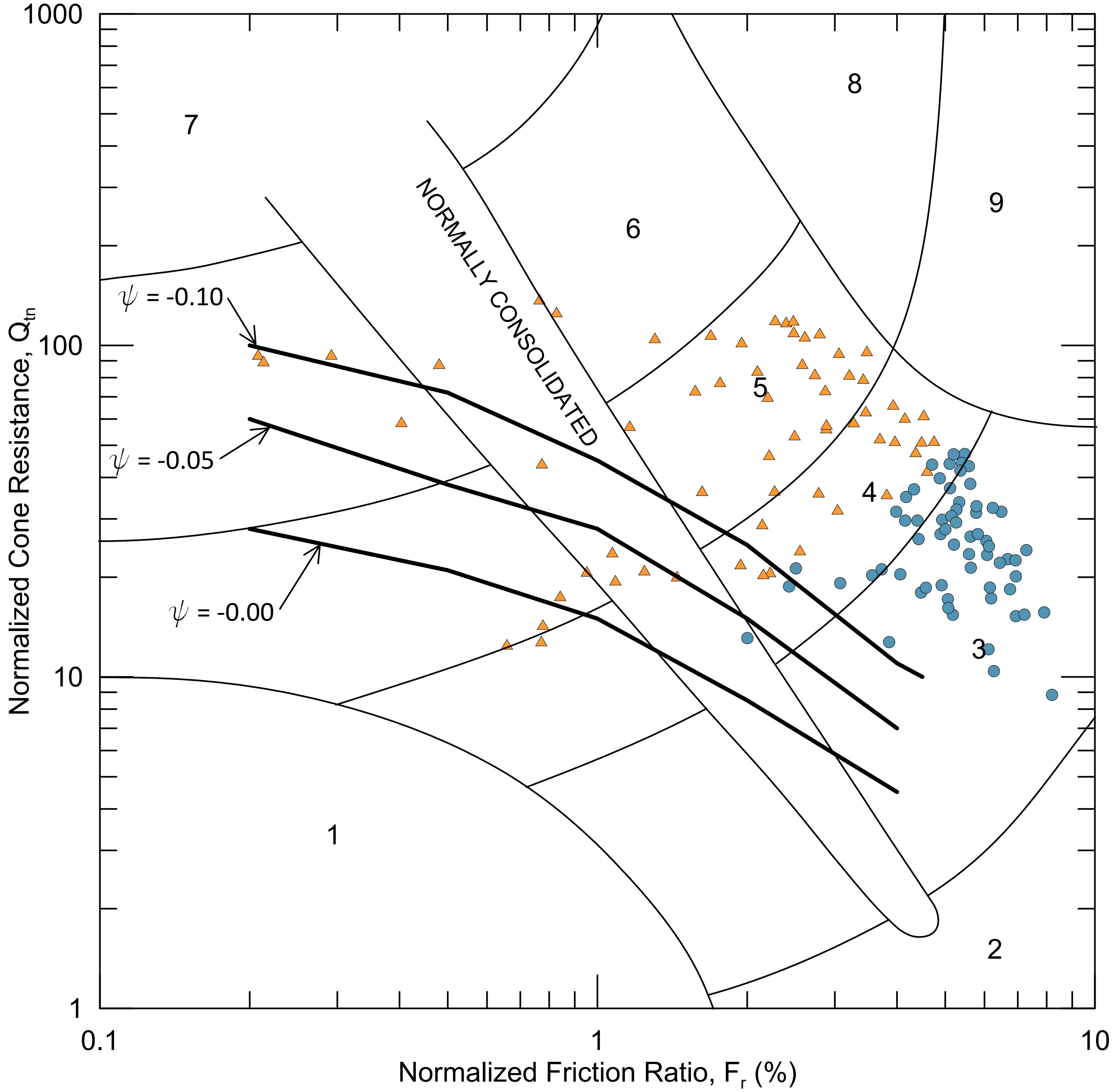
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-023 Coffeen Ash Pond No. 1	FIGURE
	AECOM		



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-023_DC_ State Parameter Difference.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-023 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		



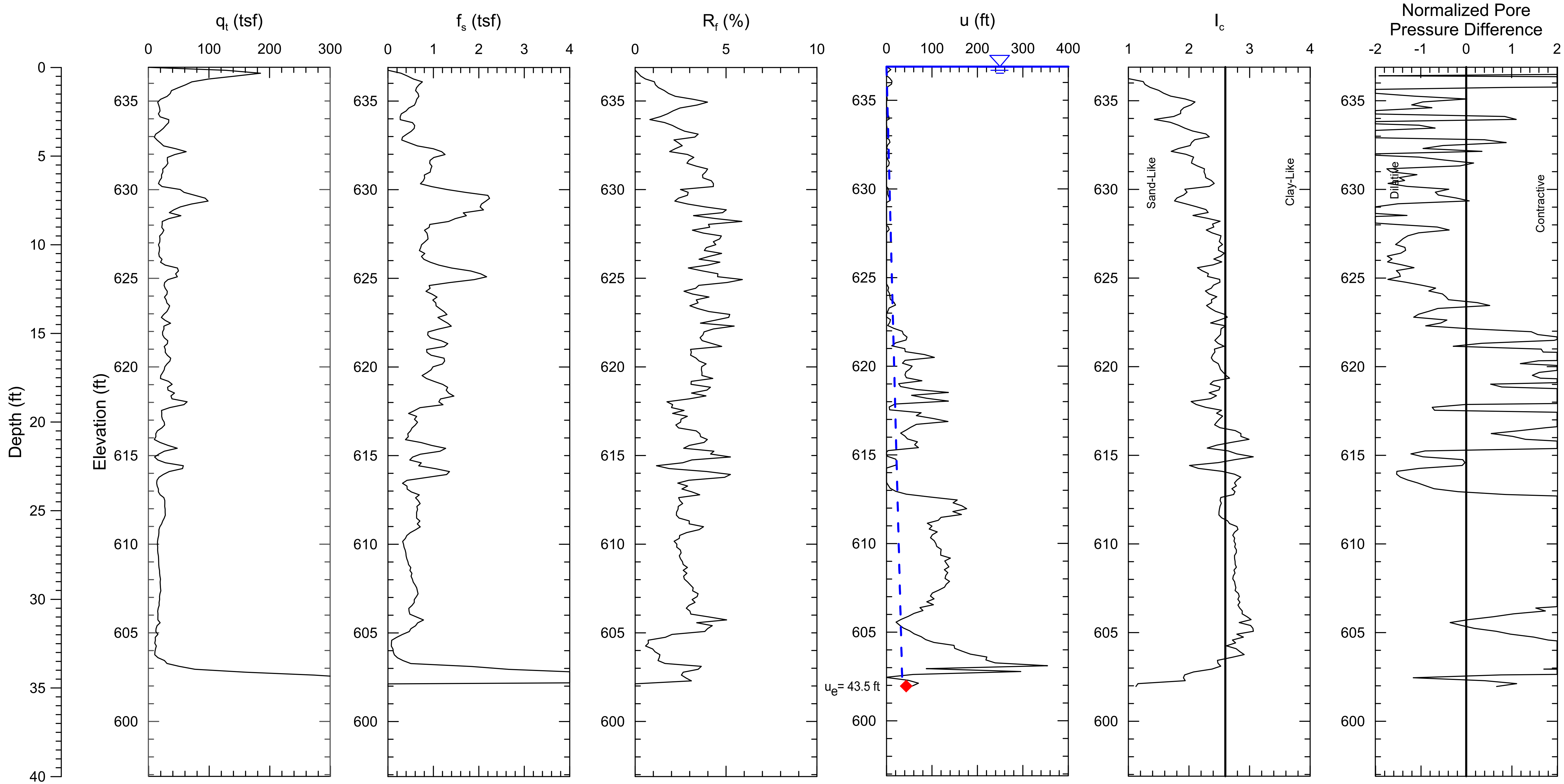
Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

▲ "Sand-Like"
● "Clay-Like"

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-023_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-023 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
	AECOM		

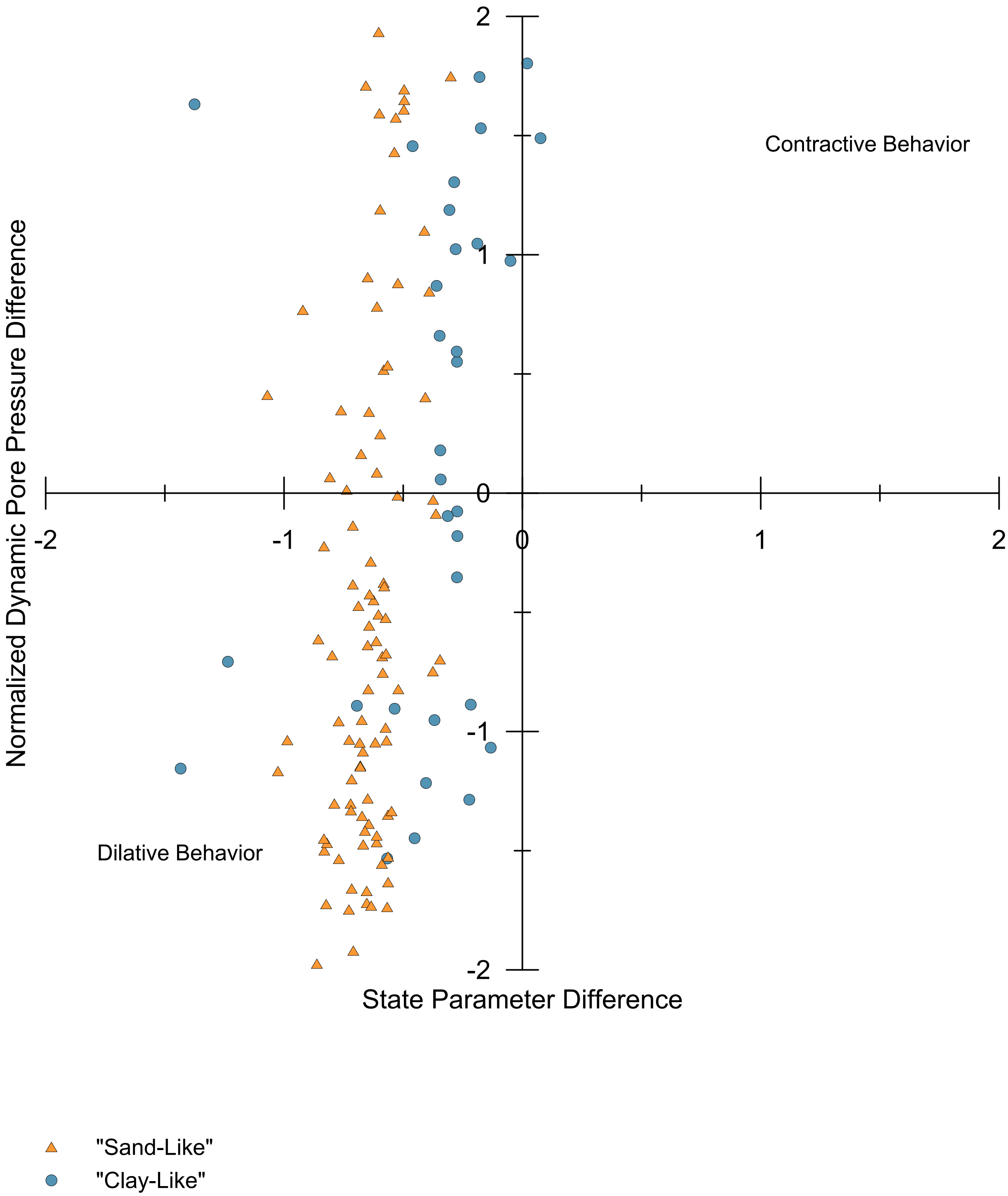


Pore Pressure Dissipation Test
100% Hydrostatic Pore Pressure Line

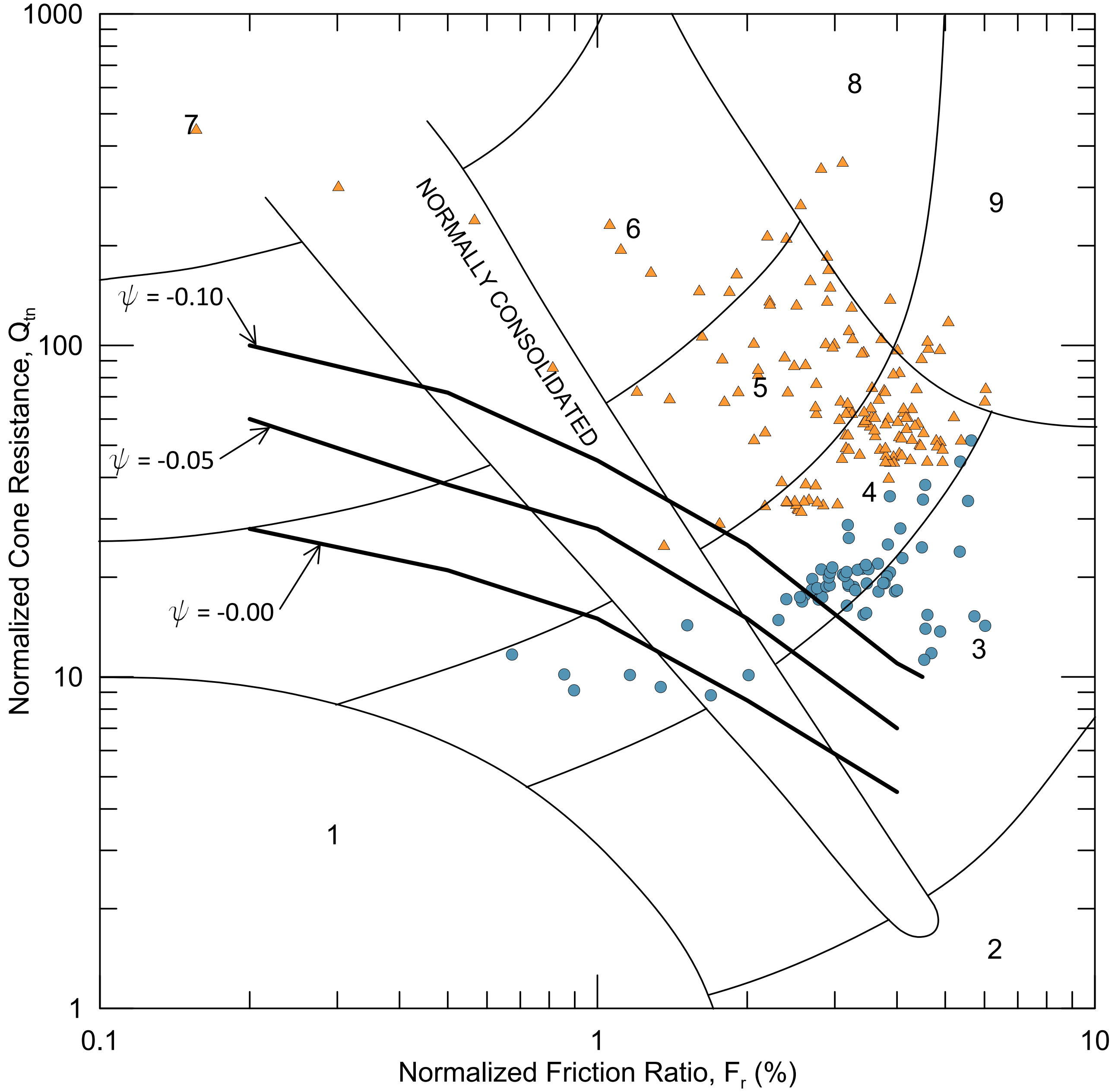
Notes:
1) Soil behavior type index, I_C, values based on correlations in Guide to Cone Penetration Testing for Geotechnical Engineering (Robertson, 2012).
2) CPT soundings performed by ConeTec, Inc. in August 2015.

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-024 Coffeen Ash Pond No. 1	FIGURE
	AECOM		

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-024_DC_ State Parameter Difference.grf



PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-024 Normalized Dynamic Pore Pressure Difference vs State Parameter Difference	FIGURE
	AECOM		



Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\COF-024_DC_Normalized State.grf

PROJECT NO. 60480701	Dynegy - Coffeen Site	COF-024 Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters	FIGURE
	AECOM		

Calculation Notes

Subject: Coffeen Ash Pond No. 1 Liquefaction Analysis | Project Name: Dynegy CCR

By: Brian Gomez / Meaghan Kenna | Date: 01/22/2016 | Project No: 60480701

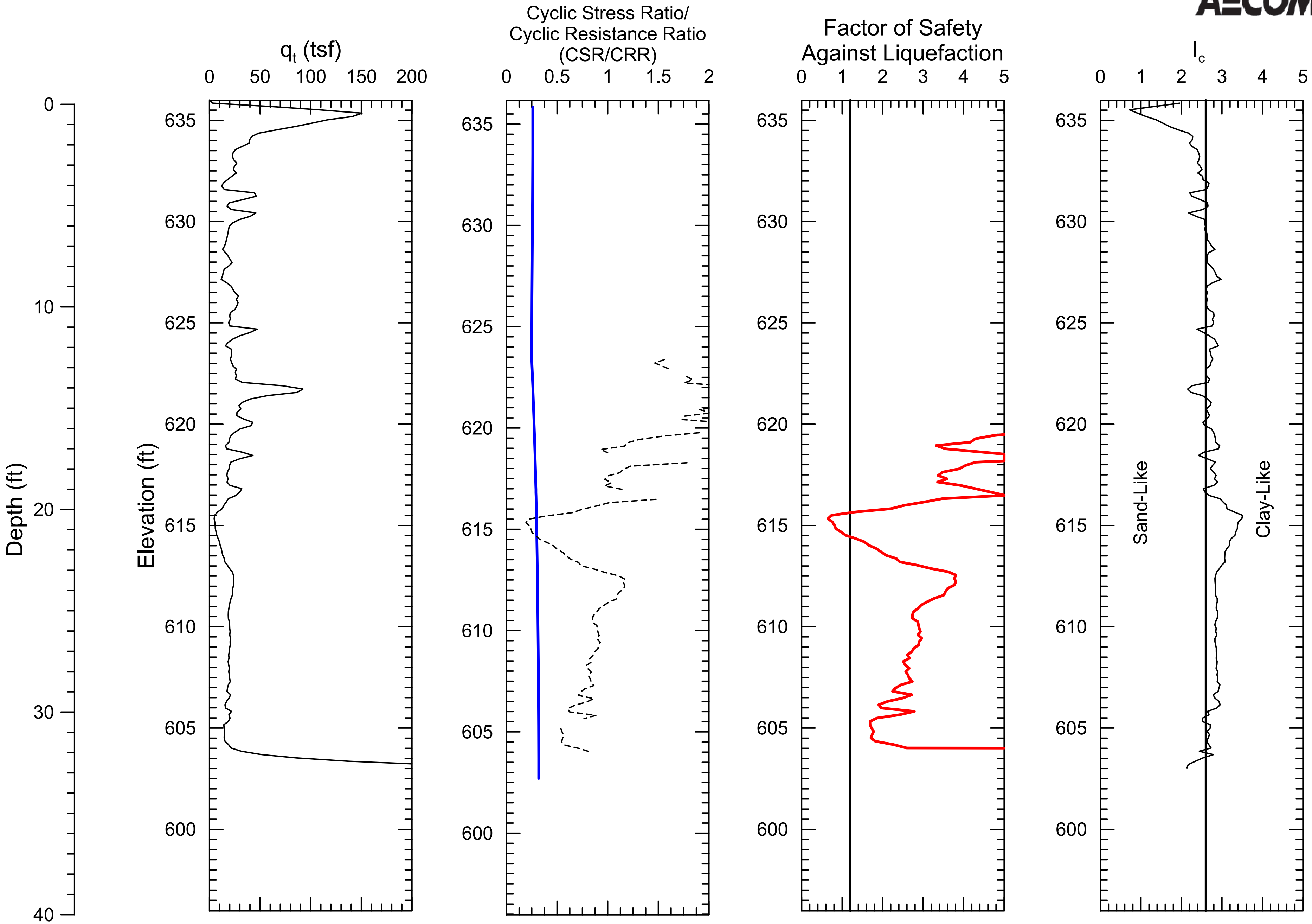
Checked By: Julie Heitland | Date: 01/22/2016 | Task No.: 01

APPENDIX B

Liquefaction Triggering Plots

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_0010.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-001 Triggering.grf

AECOM

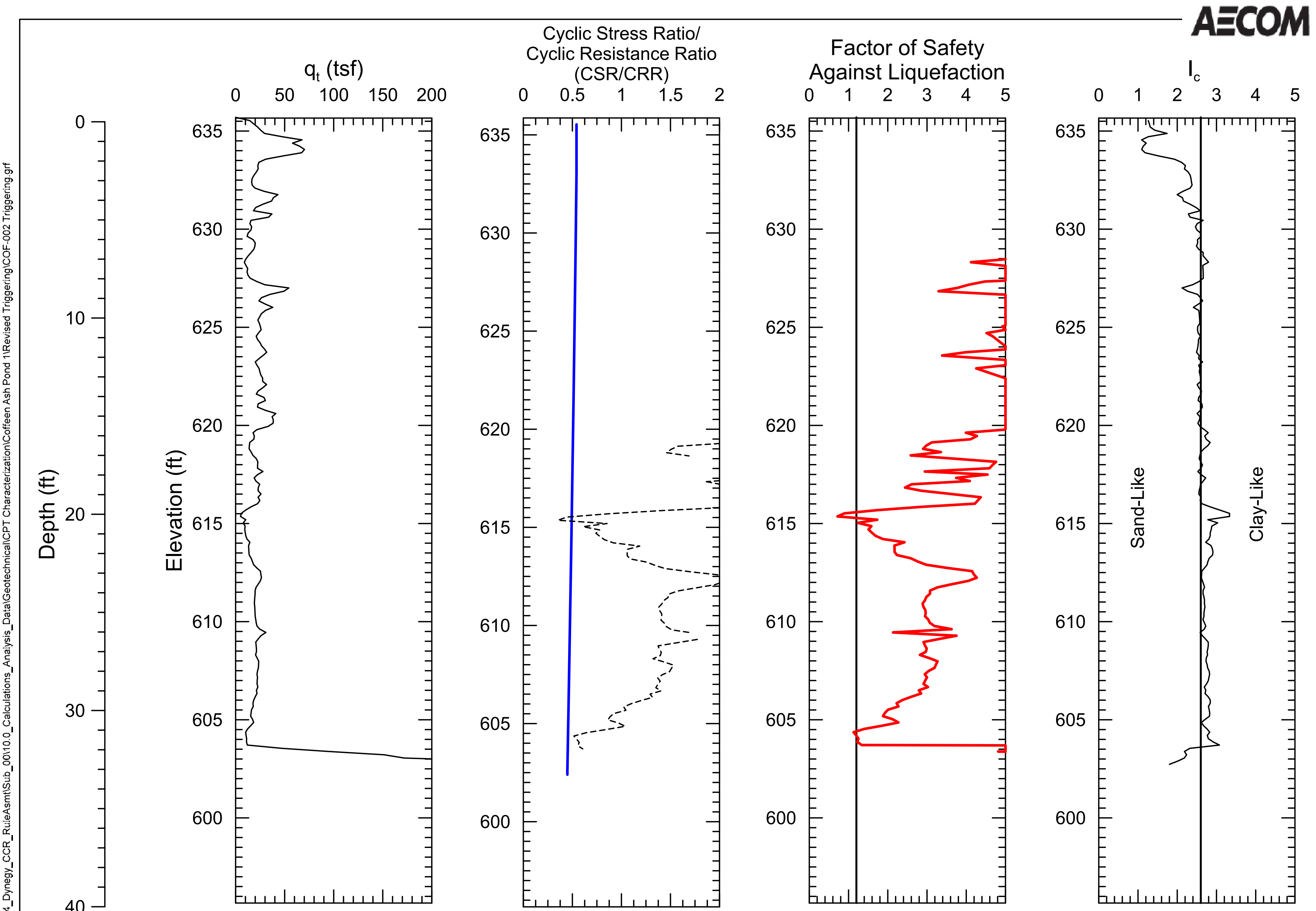


Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 636.0 FT

Project No. 60480698	COF-C001 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

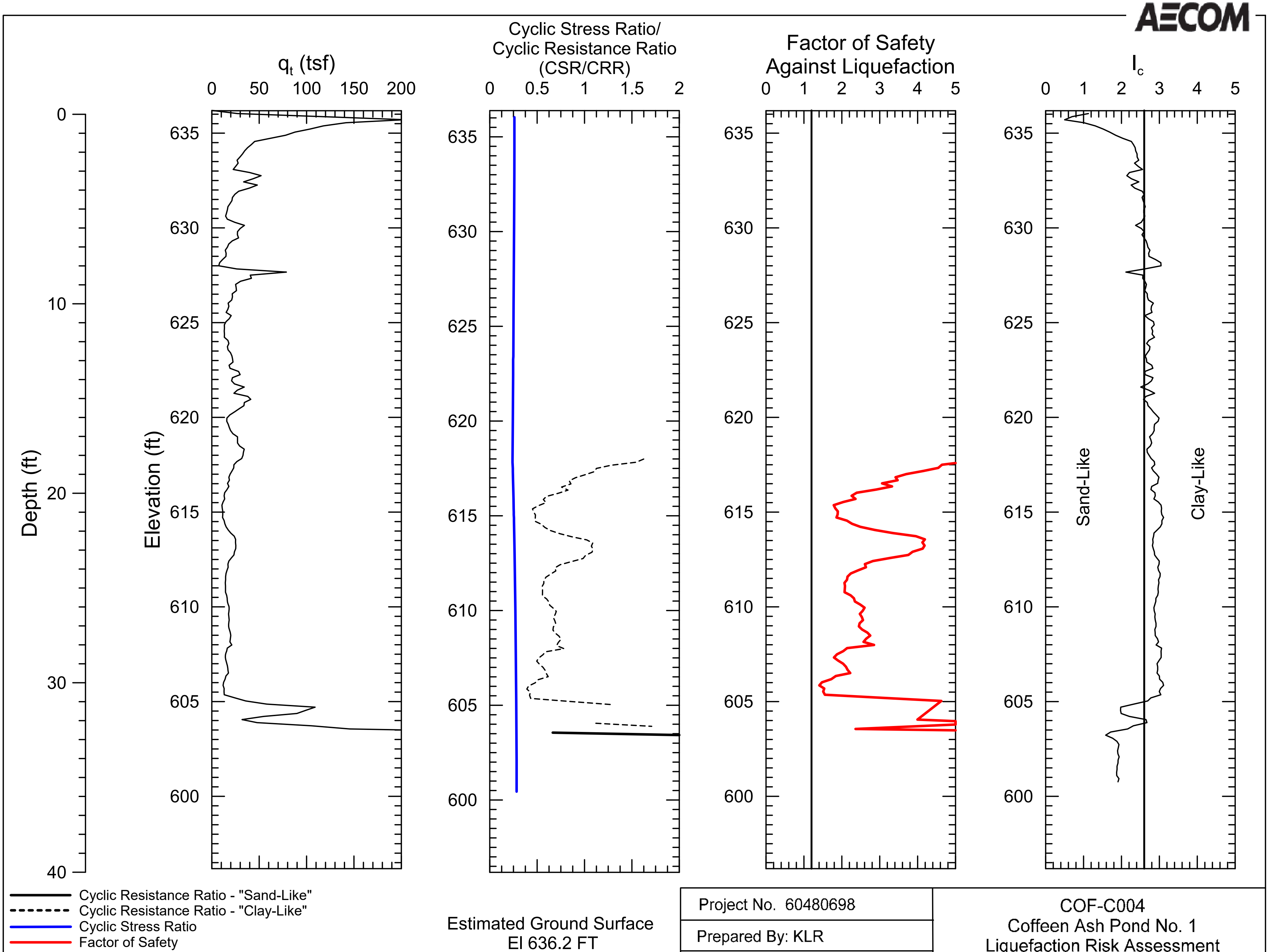


Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 635.7 FT

Project No. 60480698	COF-C002 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX



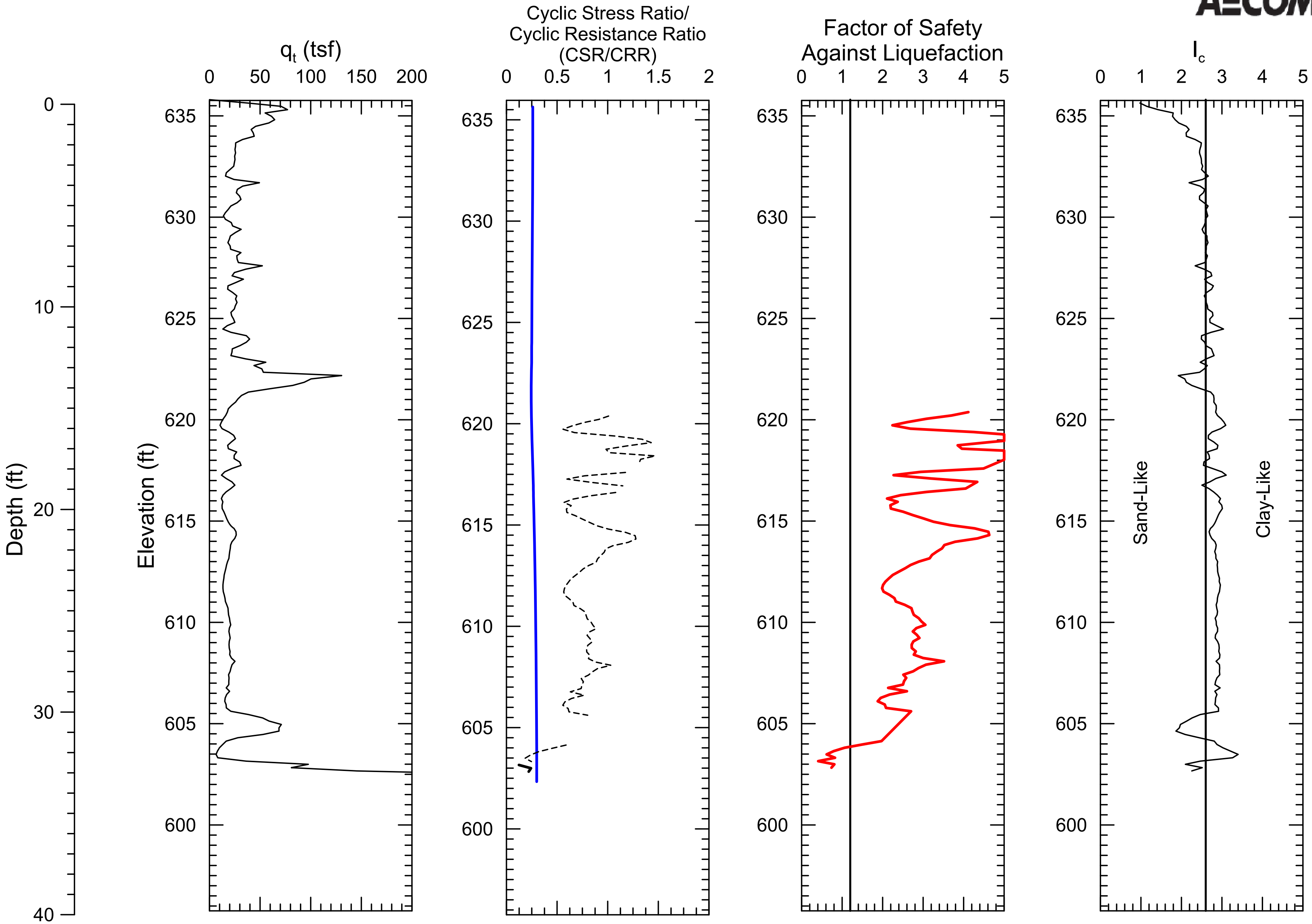
Estimated Ground Surface
El 636.2 FT

Project No. 60480698	COF-C004 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_0010.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-004 Triggering.grf

AECOM

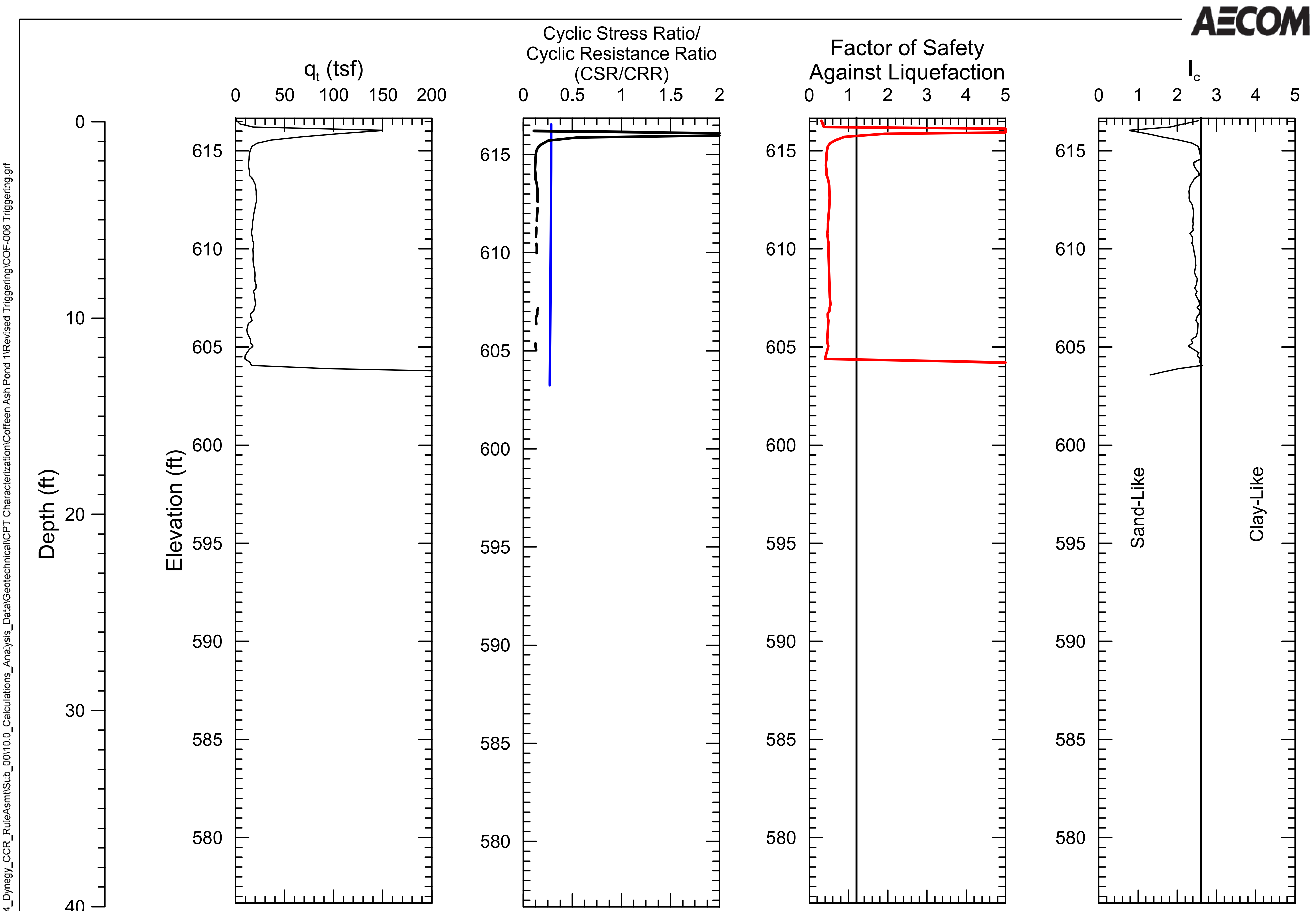


Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 635.8 FT

Project No. 60480698	COF-C005 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

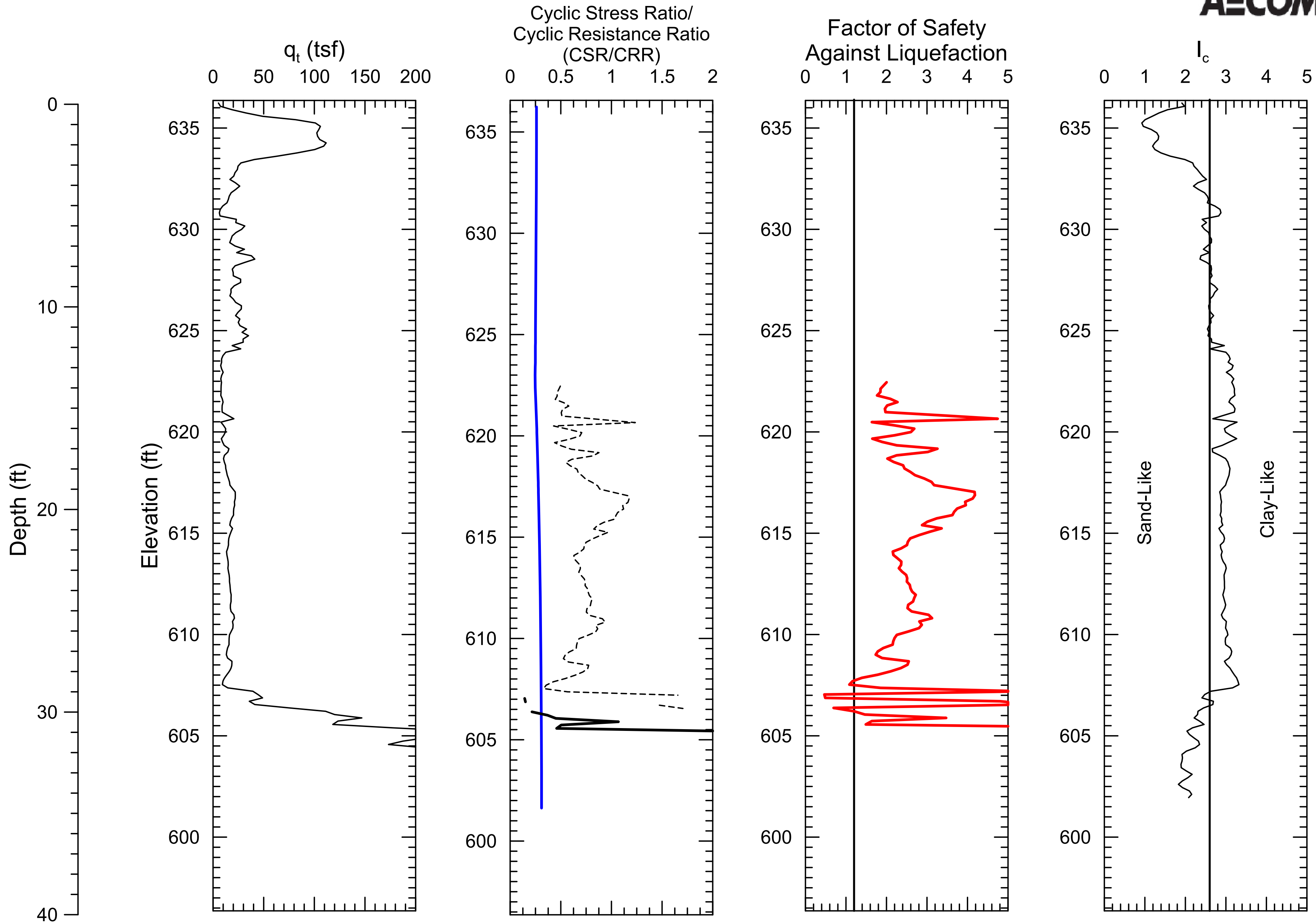


Estimated Ground Surface
El 616.7 FT

Project No. 60480698	COF-C006 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

AECOM

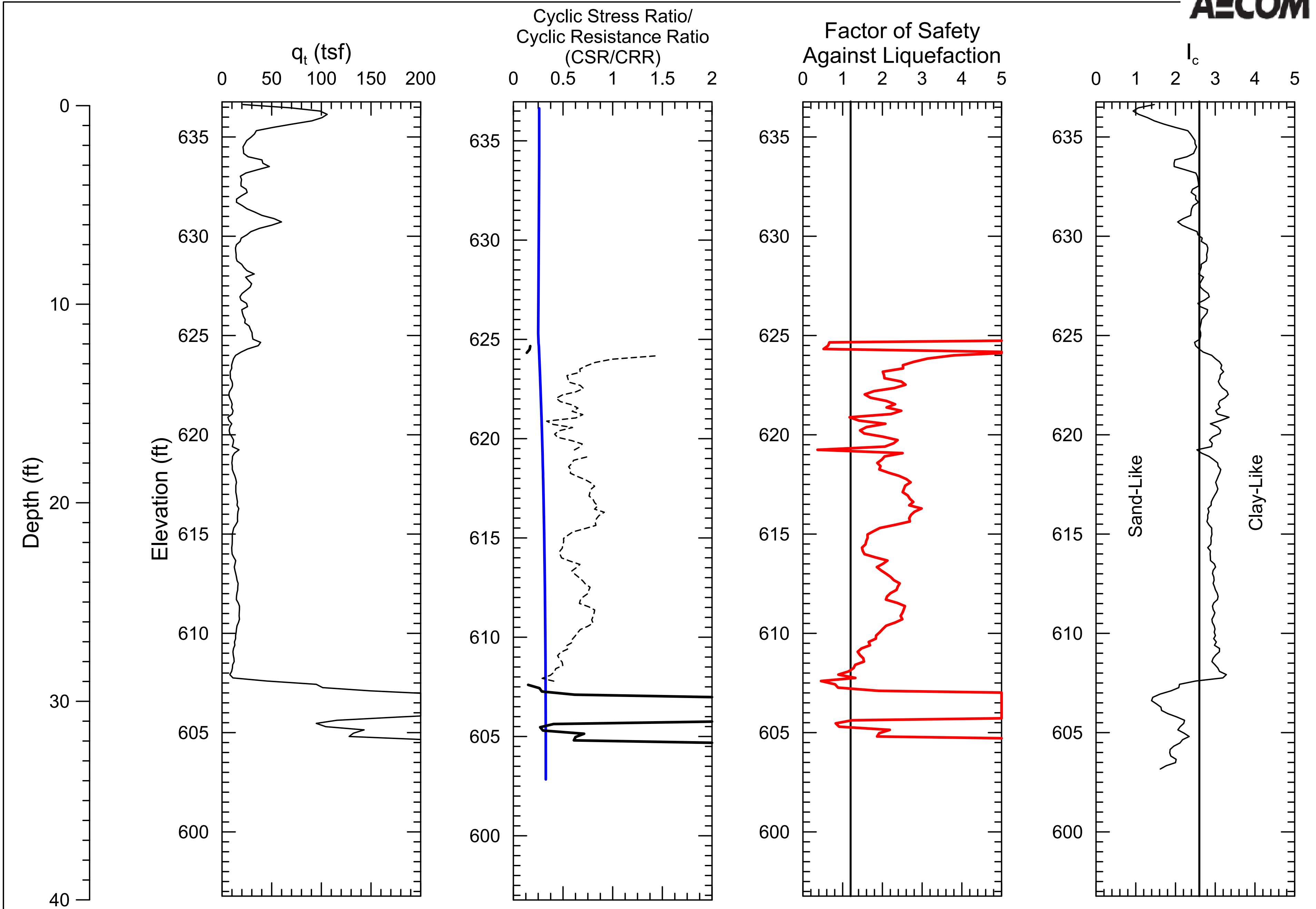


Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 636.4 FT

Project No. 60480698	COF-C007 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX



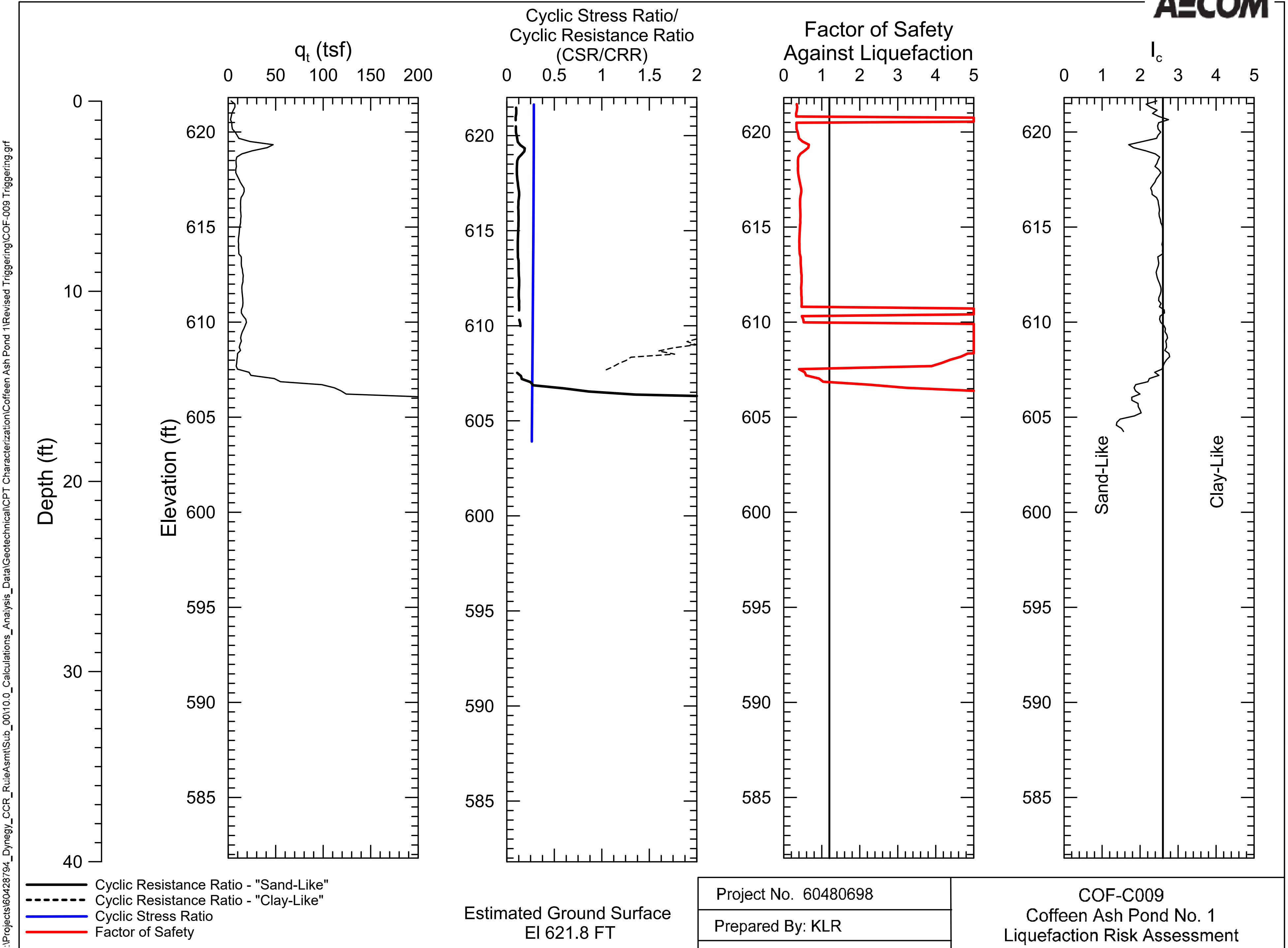
Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 636.8 FT

Project No. 60480698	COF-C008 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_0010.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-008 Triggering.grf

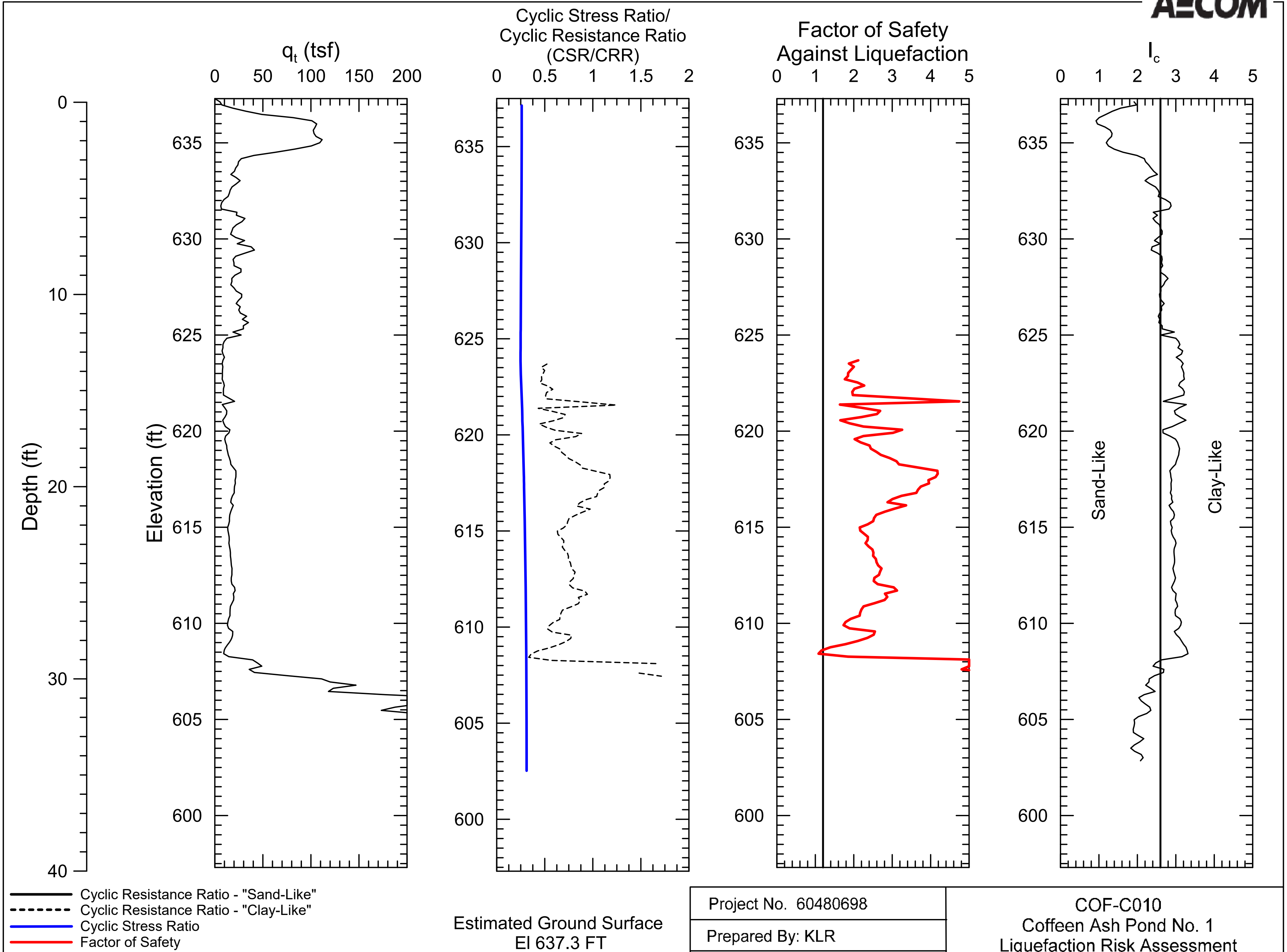


AECOM

Estimated Ground Surface
El 621.8 FT

Project No. 60480698	COF-C009 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX



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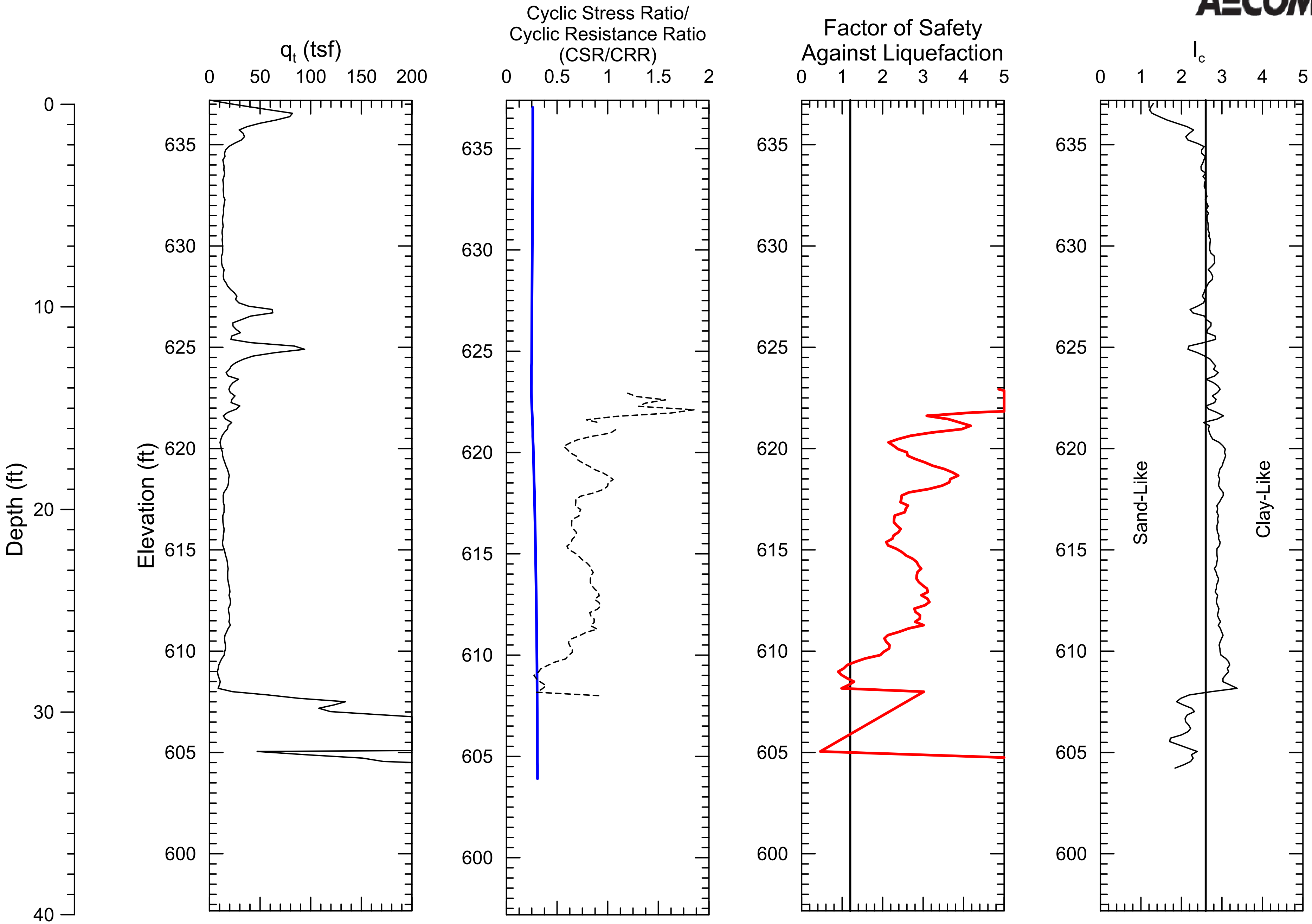
AECOM

Estimated Ground Surface
El 637.3 FT

Project No. 60480698	COF-C010 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX



N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-011 Triggering.grf

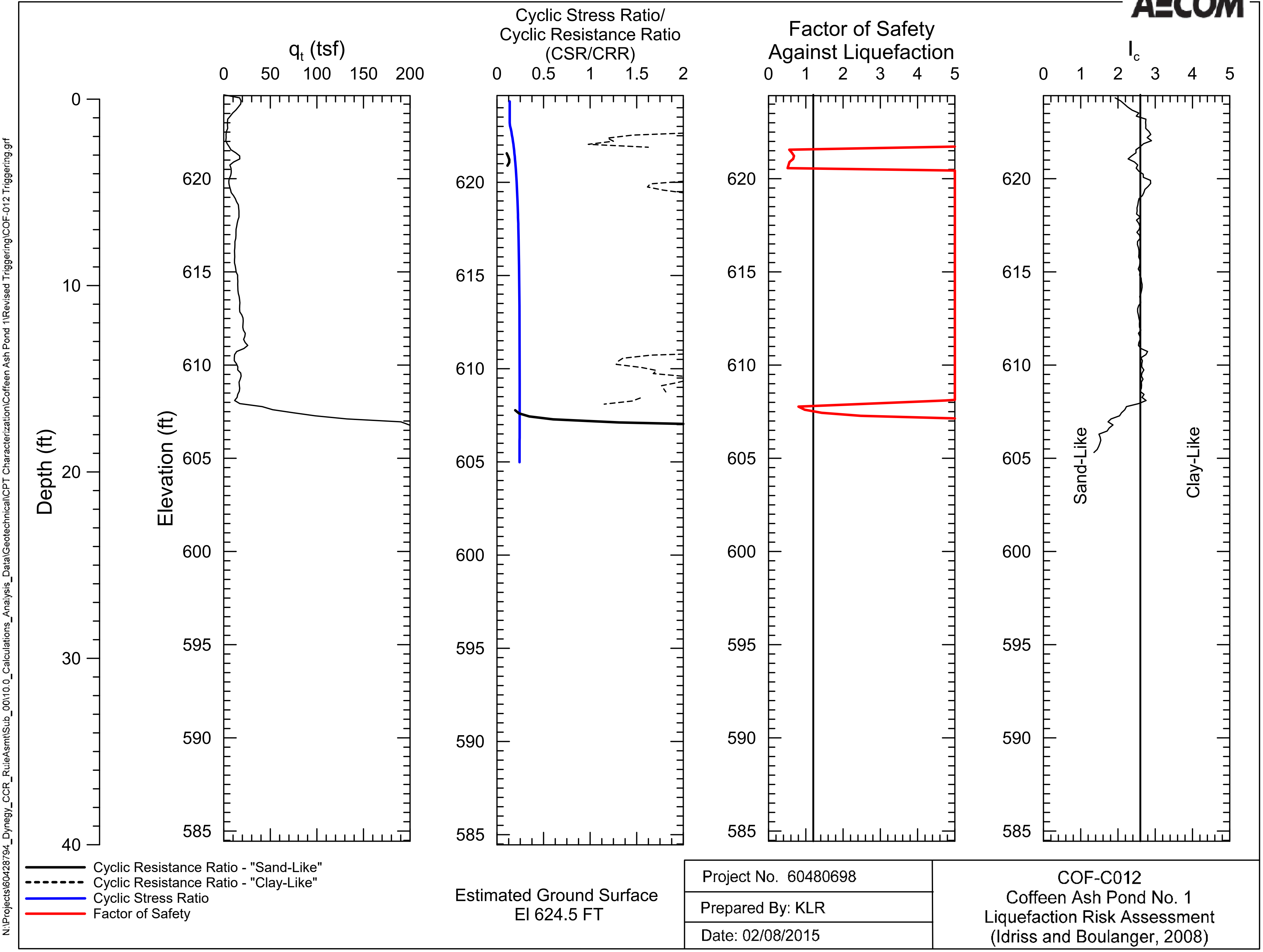
AECOM

- Cyclic Resistance Ratio - "Sand-Like"
- Cyclic Resistance Ratio - "Clay-Like"
- Cyclic Stress Ratio
- Factor of Safety

Estimated Ground Surface
El 637.2 FT

Project No. 60480698	COF-C011 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

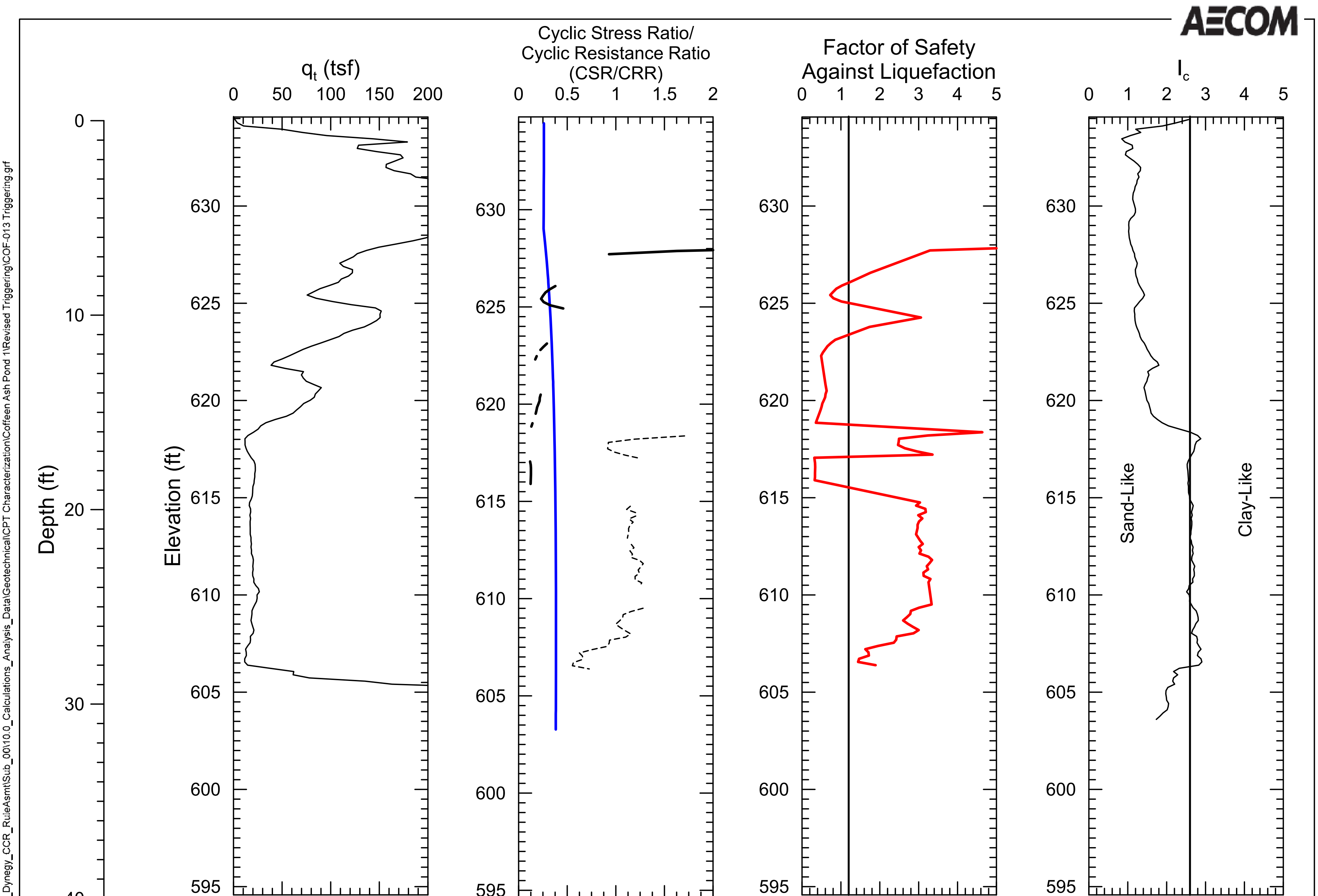
FIG. XXXX



Estimated Ground Surface
El 624.5 FT

Project No. 60480698	COF-C012 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

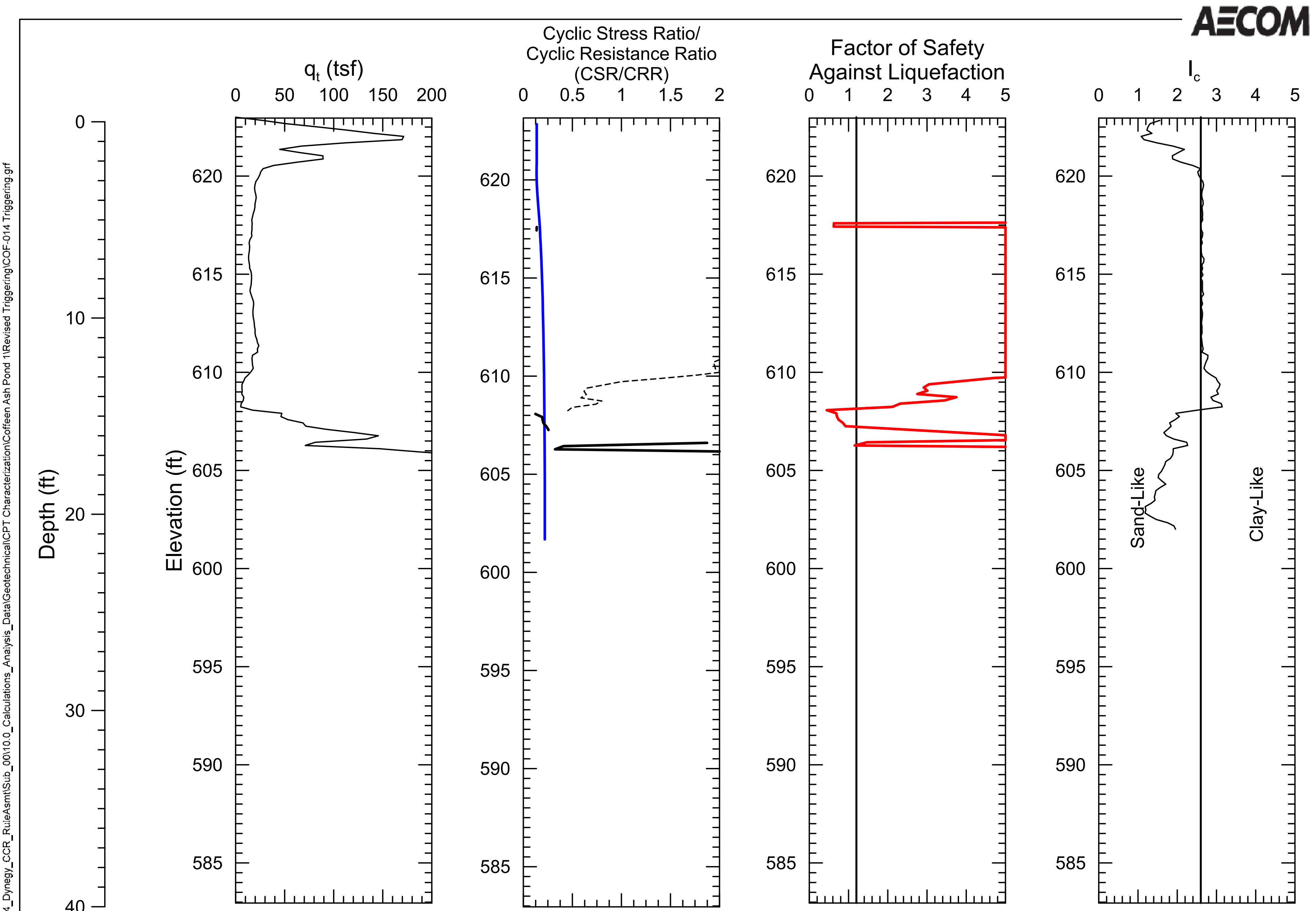


- Cyclic Resistance Ratio - "Sand-Like"
- Cyclic Resistance Ratio - "Clay-Like"
- Cyclic Stress Ratio
- Factor of Safety

Estimated Ground Surface
El 634.6 FT

Project No. 60480698	COF-C013 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

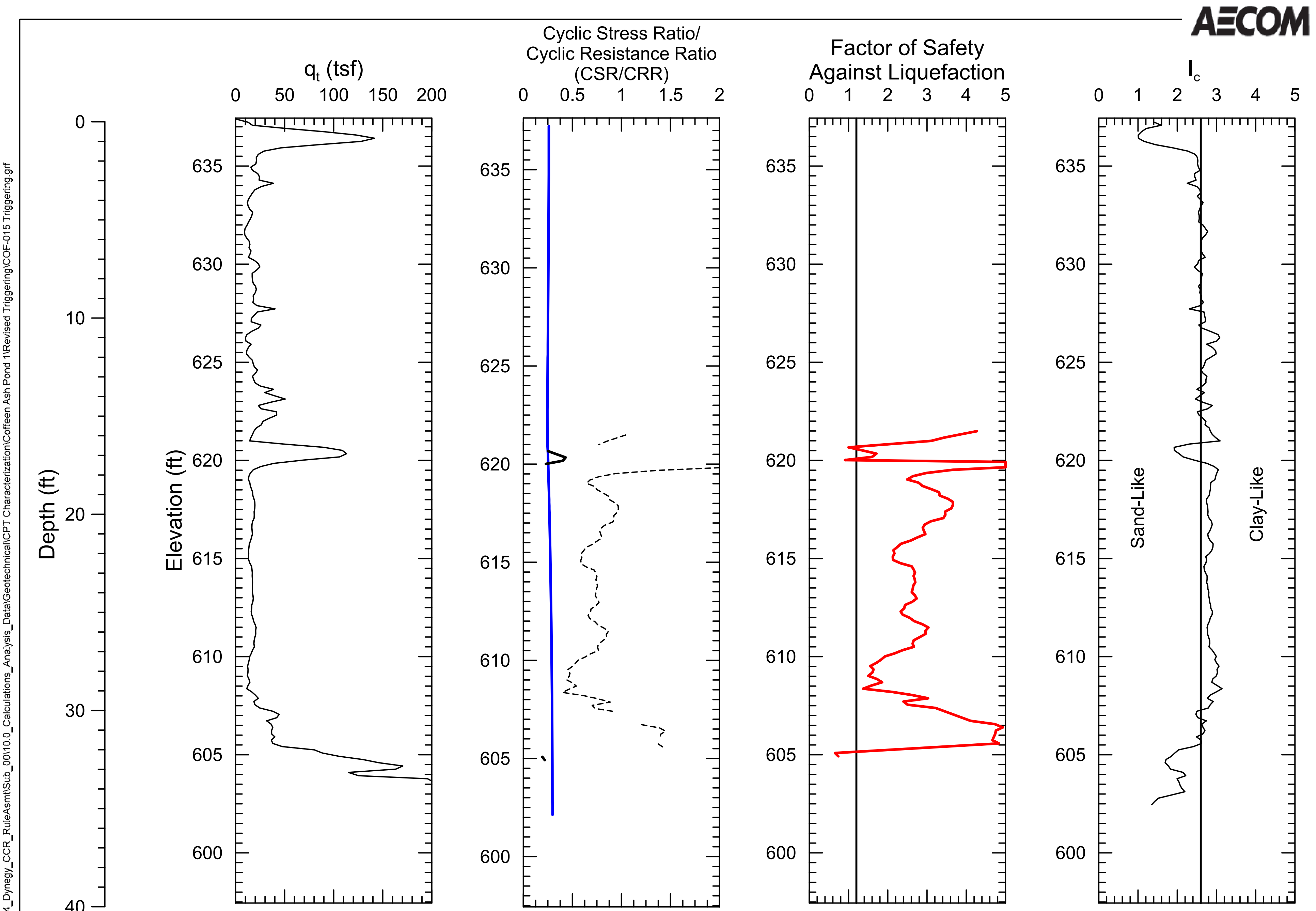


- Cyclic Resistance Ratio - "Sand-Like"
- Cyclic Resistance Ratio - "Clay-Like"
- Cyclic Stress Ratio
- Factor of Safety

Estimated Ground Surface
El 623.0 FT

Project No. 60480698	COF-C014 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

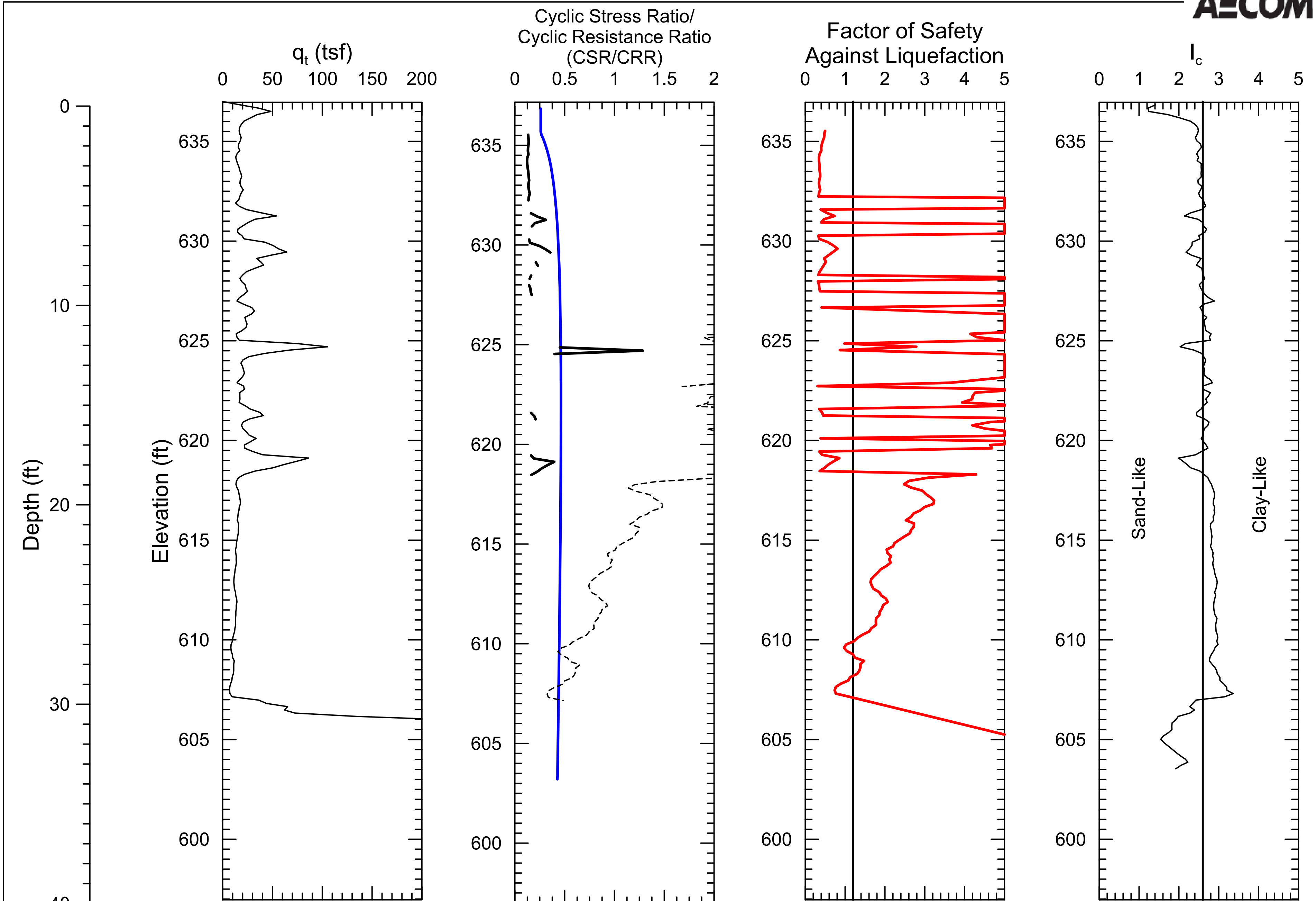
FIG. XXXX



Estimated Ground Surface
El 637.4 FT

Project No. 60480698	COF-C015 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX



AECOM

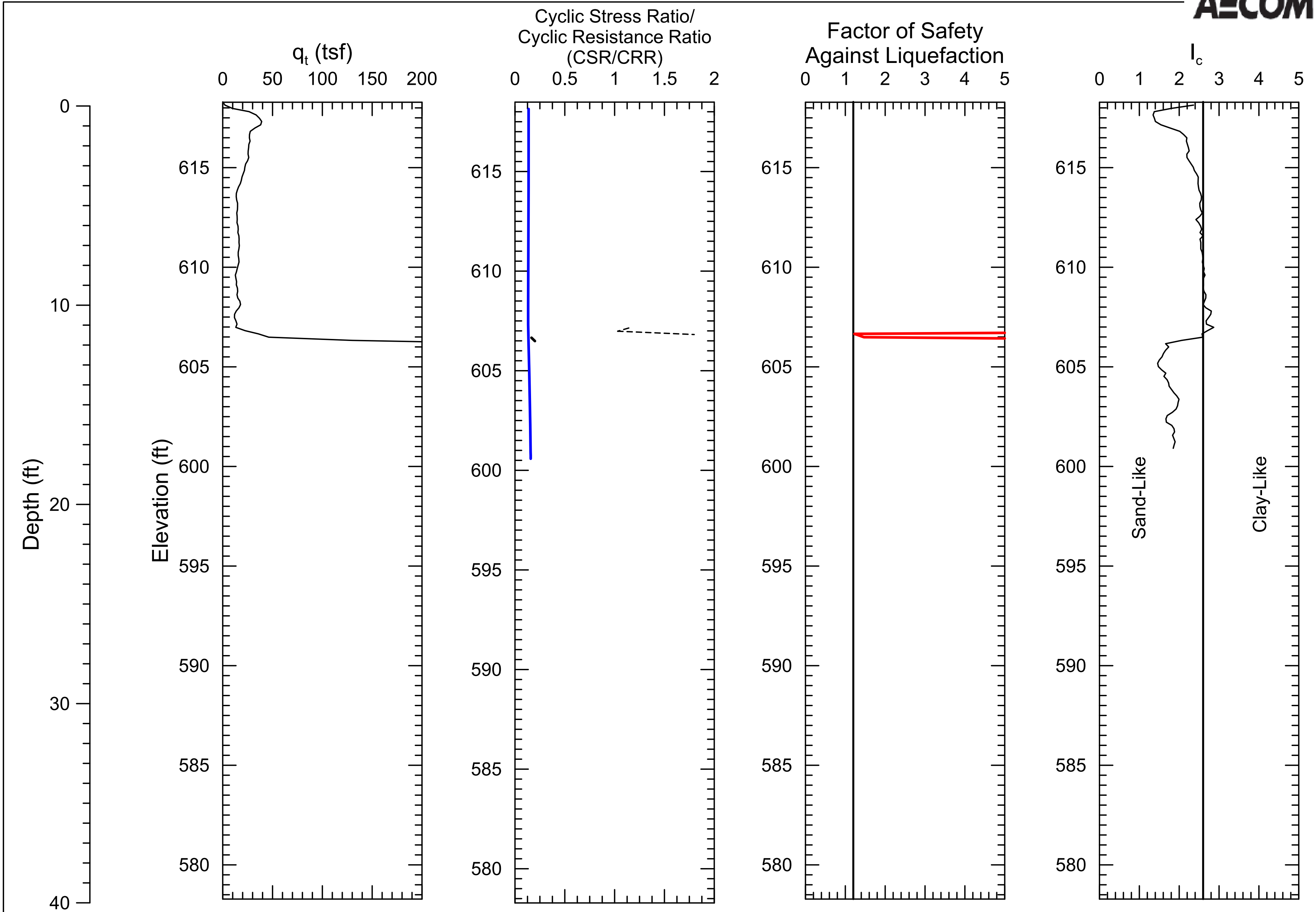
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-016 Triggering.grf

Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 637.0 FT

Project No. 60480698	COF-C016 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX



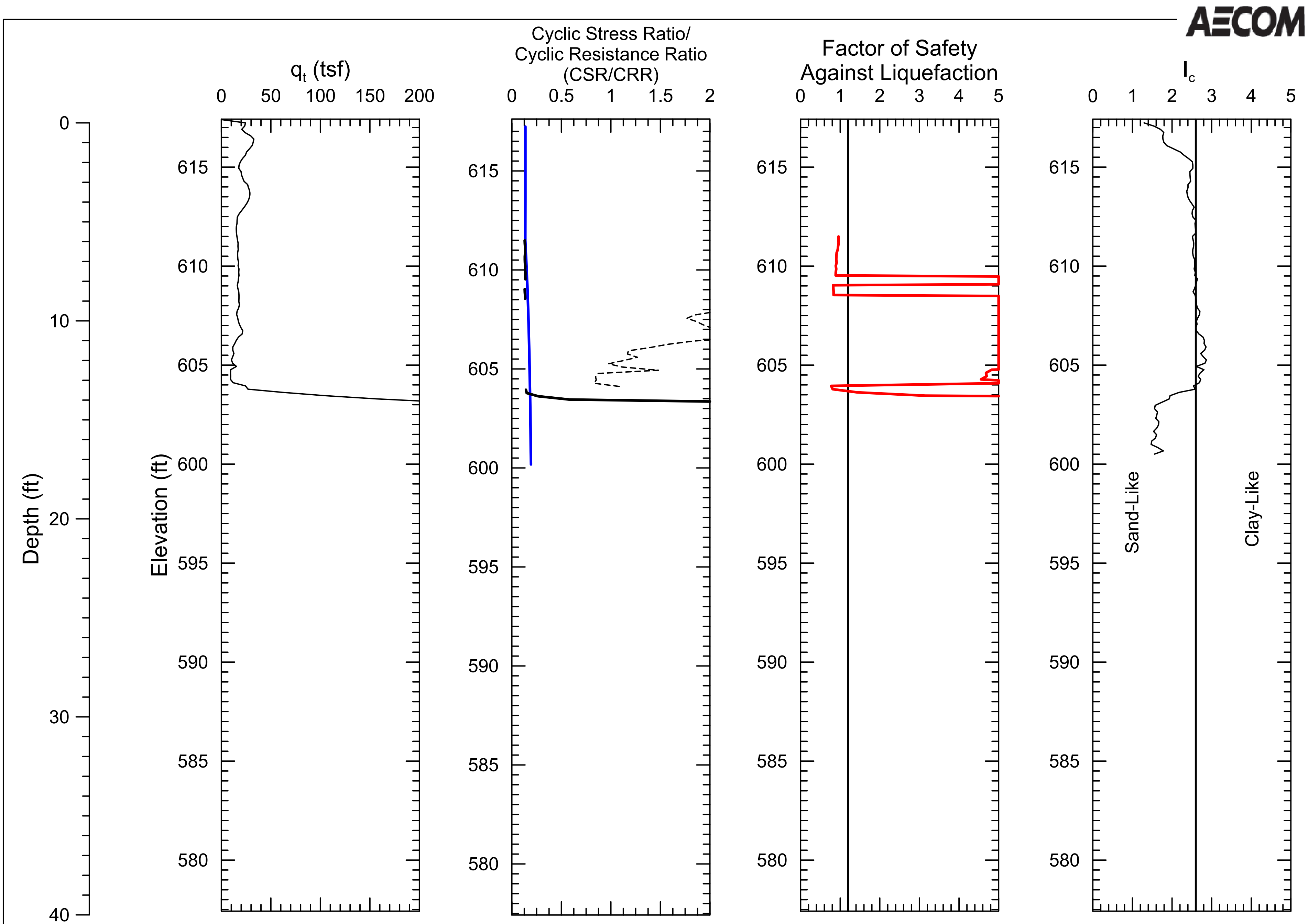
Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 618.3 FT

Project No. 60480698	COF-C017 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

N:\Projects\60428794_Dynegy_CCR_RiskAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-017 Triggering.grf



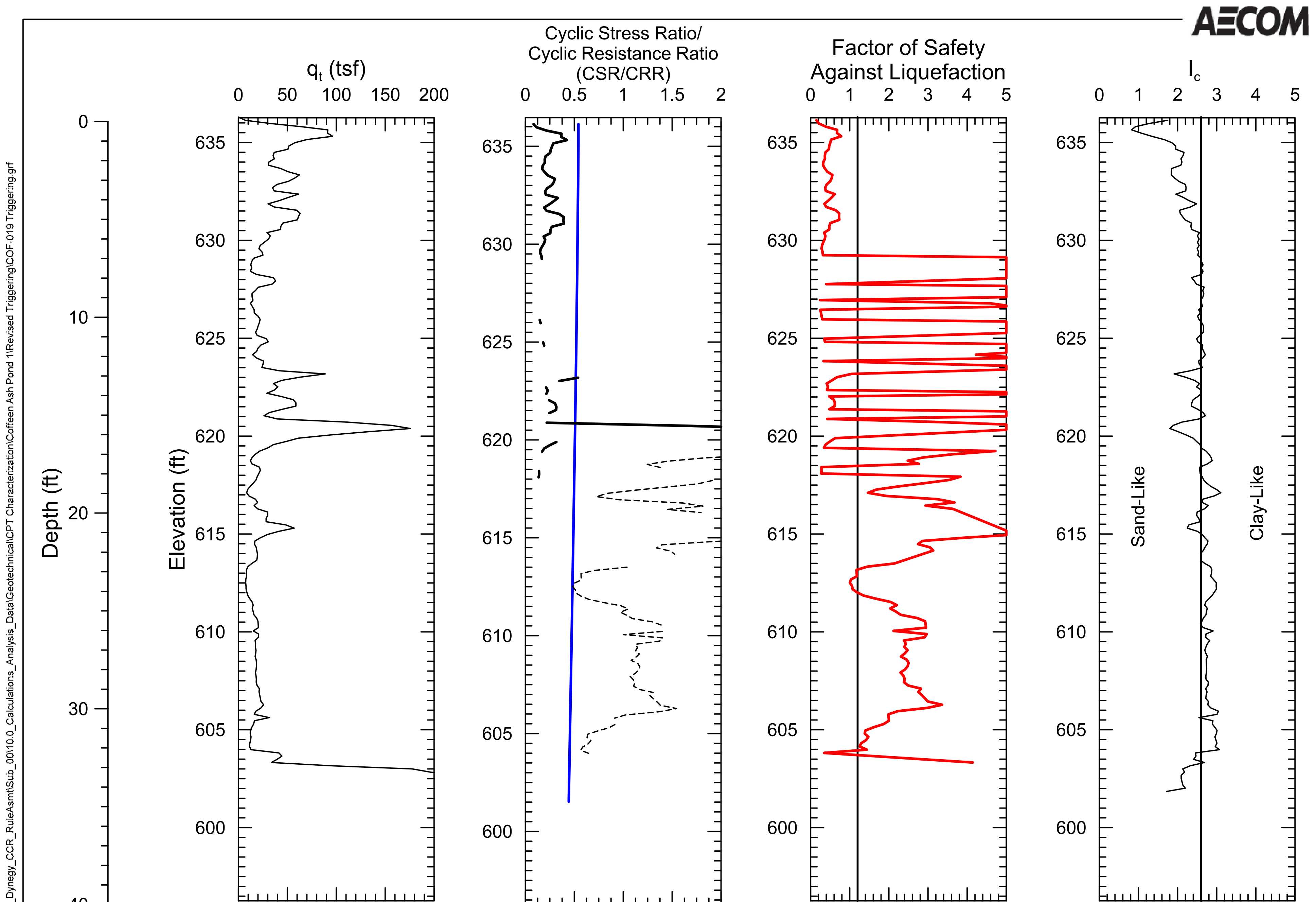
N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-018 Triggering.grf

Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 617.4 FT

Project No. 60480698	COF-C018 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX



Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

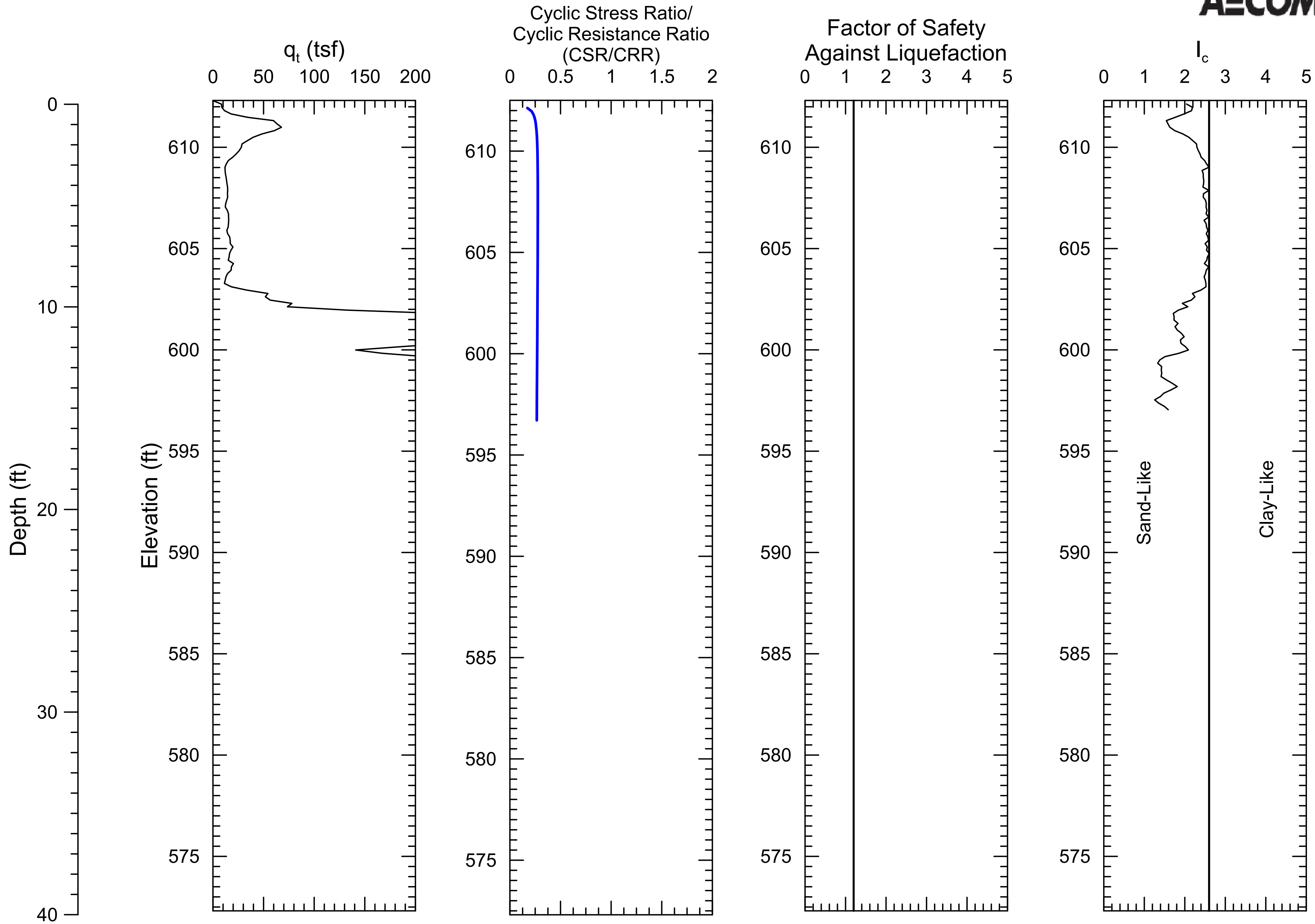
Estimated Ground Surface
El 636.3 FT

Project No. 60480698	COF-C019 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-020 Triggering.grf

AECOM

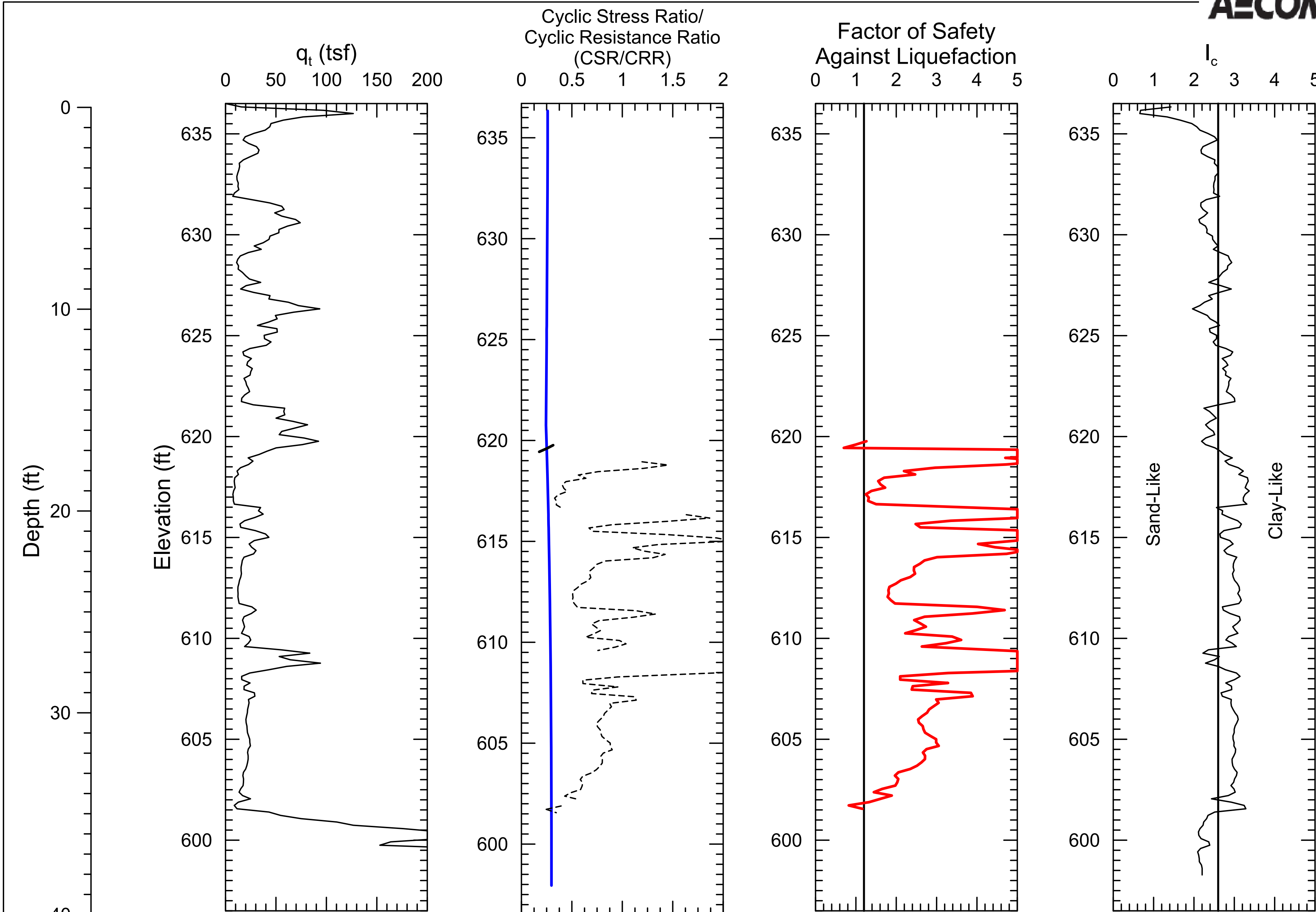


Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 612.3 FT

Project No. 60480698	COF-C020 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX



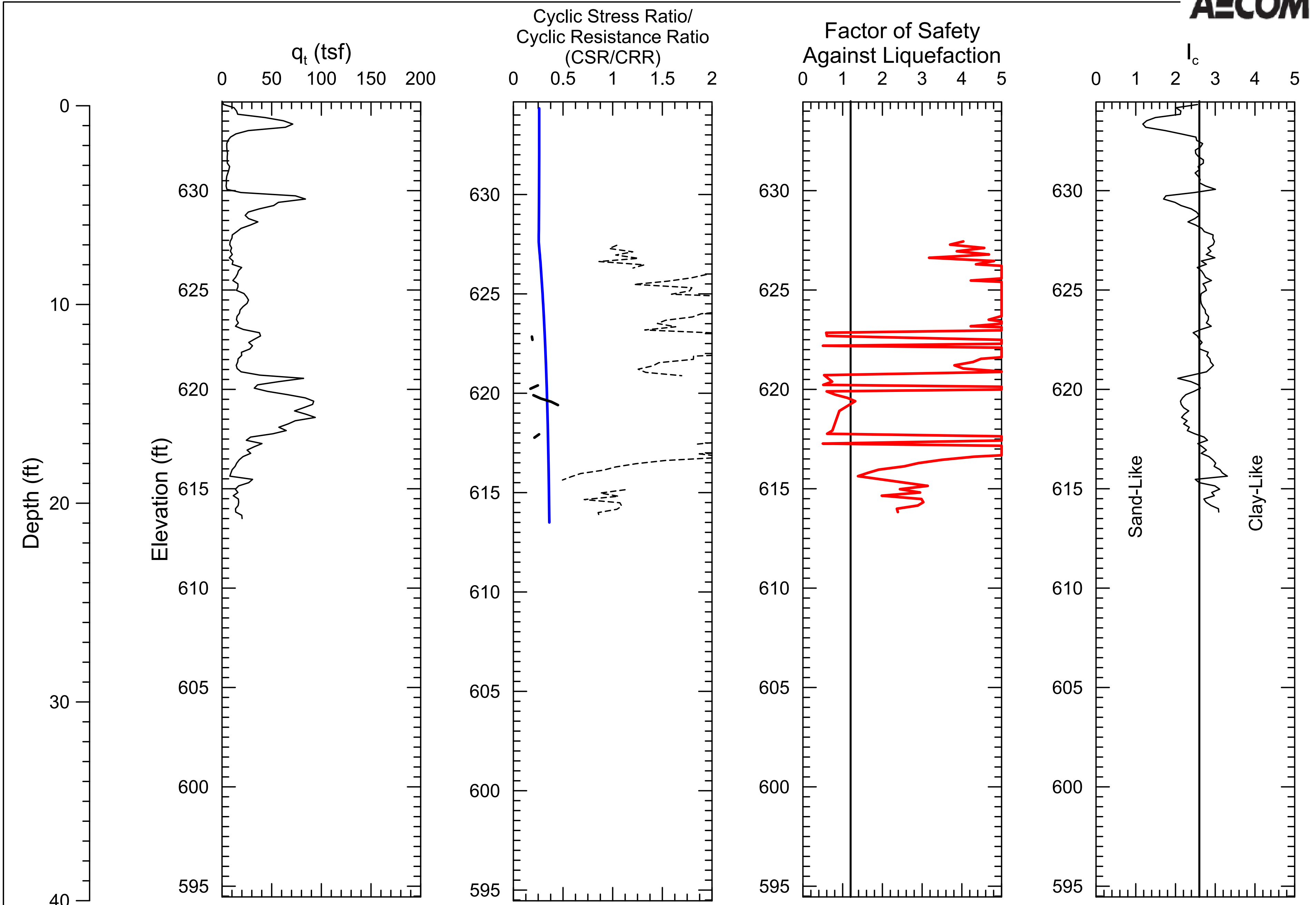
Cyclic Resistance Ratio - "Sand-Like"
Cyclic Resistance Ratio - "Clay-Like"
Cyclic Stress Ratio
Factor of Safety

Estimated Ground Surface
El 636.5 FT

Project No. 60480698	COF-C022 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

N:\Projects\60428794_Dynegy_CCR_RiskAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-022 Triggering.grf

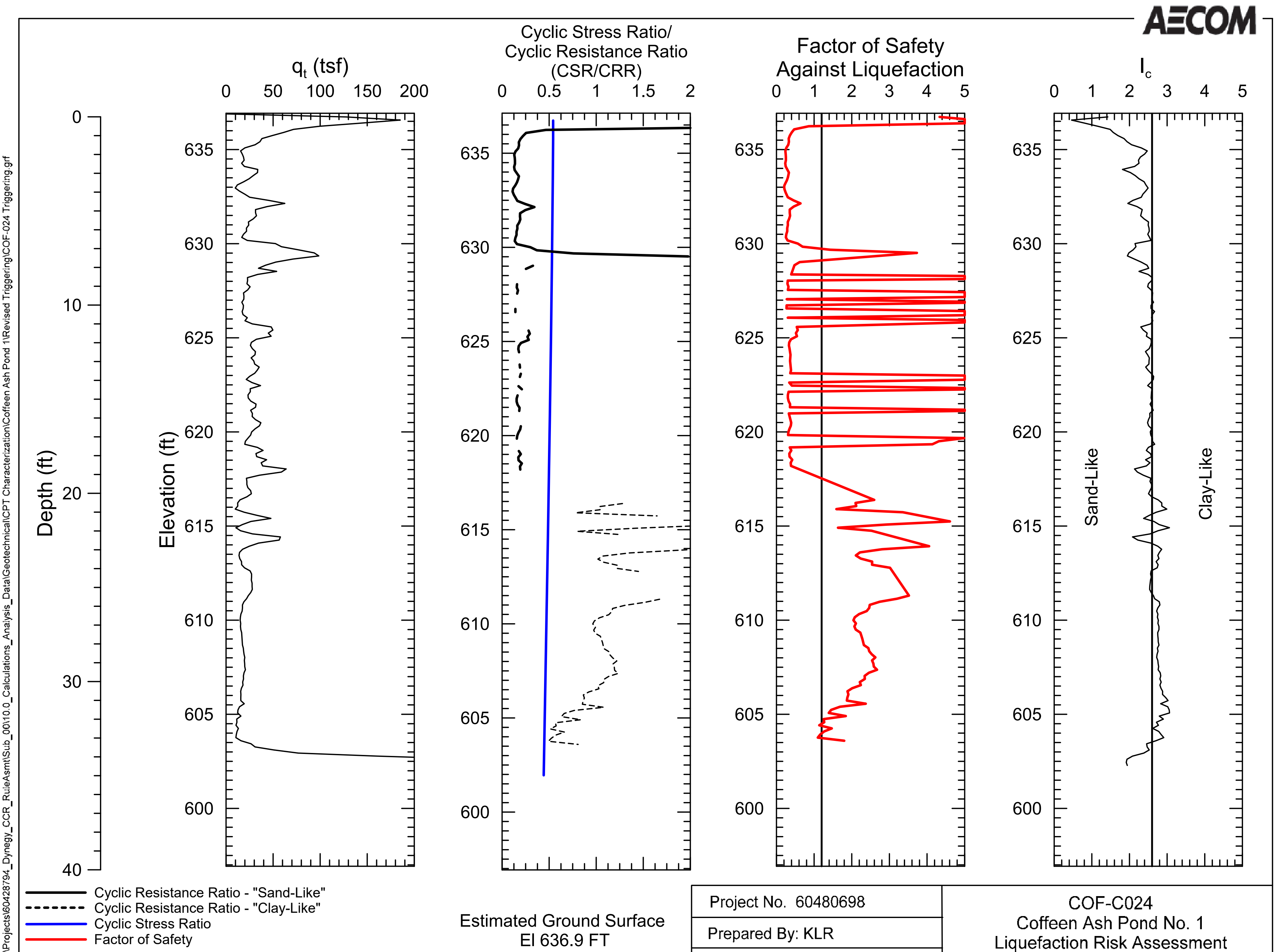


Estimated Ground Surface
El 634.5 FT

Project No. 60480698	COF-C023 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

N:\Projects\60428794_Dynegy_CCR_RuleAsmt\Sub_00\10.0_Calculations_Analysis_Data\Geotechnical\CPT Characterization\Coffeen Ash Pond 1\Revised Triggering\COF-023 Triggering.grf



Estimated Ground Surface
El 636.9 FT

Project No. 60480698	COF-C024 Coffeen Ash Pond No. 1 Liquefaction Risk Assessment (Idriss and Boulanger, 2008)
Prepared By: KLR	
Date: 02/08/2015	

FIG. XXXX

Appendix C. Hydrologic and Hydraulic Report

AECOM

AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110-1337
www.aecom.com

314.429.0100 tel
314.429.0462 fax

October 7, 2016

Mr. Matt Ballance, PE
Senior Project Engineer
Dynegy Inc.
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

RE: Hydrologic and Hydraulic Summary Report
Coffeen Power Station
Ash Pond No. 1

Dear Mr. Ballance:

AECOM is pleased to provide this Summary Report of Hydrologic and Hydraulic Modeling for the Illinois Power Generating Company (IPGC) Coffeen Ash Pond No. 1 Coal Combustion Residual (CCR) Unit. This analysis was performed to document that the facility meets the requirements of 40 CFR §257.82(a) with regard to the Inflow Design Flood Control Plan. Based on AECOM's analysis, the Ash Pond meets all hydraulic requirements for certification per 40 CFR §257.82(a).

AECOM looks forward to providing continued support to IPGC and working together on this important program. Please do not hesitate to call Ron Hager at 314-429-0100 (office) / 440-591-7868 (mobile), if you have any questions.

Sincerely,

AECOM

Victor Modeer, PE, D.GE
Site Manager
victor.modeer@aecom.com

Ronald Hager
Program Manager
Ronald.hager@aecom.com

cc: Mark Rokoff, PE – AECOM

Attachments:

A. Location Map
B. Hydrologic and Hydraulic Analysis

1. INTRODUCTION

1.1. *Purpose Of This Memorandum*

This report presents the results of the hydrologic and hydraulic analysis prepared by AECOM for the Illinois Power Generating Company (IPGC)[1] Ash Pond No. 1 Coal Combustion Residual (CCR) Unit at the Coffeen Power Station, located approximately 2.4 miles south-southwest of Coffeen, Illinois in Montgomery County (See Attachment A for Location Map). This analysis was completed in accordance with the Environmental Protection Agency (EPA) 40 CFR Part §257, Subpart D, regulations for the disposal of CCR. As required by §257.82(a), by October 17, 2016, owners and operators of existing CCR surface impoundments must develop an Inflow Design Flood Control Plan that documents how the inflow design flood control system has been designed and constructed to meet the following requirements:

- *(40 CFR 257.82, (a)(1)* - The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood.
- *(40 CFR 257.82, (a)(2)* - The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood.

Ash Pond No. 1 has a significant hazard potential, based on the initial hazard potential classification assessment performed by Stantec in 2016, in accordance with §257.73(a)(2).

1.2. *Brief Description of Impoundments*

The embankment forms a ring dike that is approximately 4,350 feet in length and forms a complete perimeter around the impoundment. The elevation of the embankment crest ranges from approximately 635 to 638 ft. Unless otherwise noted, this and all elevations listed in this report are in the NAVD88 datum.

The Coffeen Ash Pond No. 1 is operated as a zero-discharge facility during normal conditions and receives and impounds sluiced ash from the plant as well as providing recycle water necessary for sluicing ash back into the pond and for plant operation. Ash Pond 1 is operated such that the outflow from pond is essentially equal to the inflow from plant processes, as there is virtually no storage capacity between the outflow and the inflow pipes. This unit is indispensable to the operation of the Coffeen Power Station. The total surface area of theimpoundment is approximately 26.2 acres, including the embankments.

There is an overflow pipe located in the northwest corner of the unit which discharges pond water back into the recycle pipe during high water conditions. The overflow pipe is at an invert of 631.0 ft, based on design drawings, and consists of a 24-inch corrugated

---

[1] Although the Coffeen Power Station and Ash Pond No. 1 are owned and operated by IPGC, Dynegy Administrative Services Company (*Dynegy*) contracted AECOM to develop this Report on behalf of IPGC. Therefore, “Dynegy” is referenced in materials attached to this Report.

metal pipe that transitions into a steel pipe that is connected to the top of the 48-inch recycle pipe within the embankment.

2. POND CAPACITY / IMPOUNDMENT COMPUTATIONS

The elevation/areas for Ash Pond No. 1 were determined using a computer- aided design (CAD) analysis of topographic and bathymetric surveys of the interior of Ash Pond No. 1 completed by Weaver Consultants 2015. The starting water surface for the analysis was assumed to be 631.0 feet, which is the invert elevation of the overflow pipe and is intended to represent a maximum operating pool based on the characteristics of the outfall structure, and is 1.1 ft higher than the pool elevation of 629.9 feet surveyed by Weaver Consultants in 2015. Please refer to Attachment B for further details.

3. HYDROLOGIC AND HYDRAULIC ANALYSIS OF WOOD RIVER PONDS

3.1. *Rainfall Data*

The rainfall information used in the HydroCAD modeling was based on the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2 (Reference 10) which provides rainfall data for storm events with average recurrence intervals ranging from 1 to 1,000 years and durations ranging from 5 minutes to 60 days. The maximum estimated rainfall depths for the 24-hour storms were used in the modeling to be conservative.

The 1,000-year flood rainfall depth of **9.13** inches was distributed according to the National Resources Conservation Service (NRCS) Type II distribution.

3.2. *Runoff Computations*

To assess the capacity of the pond to store and convey the storm flows, a hydraulic model was created in HydroCAD 10.00-12. HydroCAD has the capability to evaluate each pond within the network, to respond to variable tailwater, pumping rates, permit flow loops, and reversing flows. HydroCAD routing calculations reevaluate the pond systems' discharge capability at each time increment, making the program an efficient and dynamic tool for this evaluation. Runoff was calculated using the SCS Curve Number Method, where curve numbers were assigned to each subcatchment based on the type of land cover and soil type present.

Please refer to Attachment B for further details and modeling results.

4. CONCLUSIONS

- The H&H evaluation under the described scenario indicates that Coffeen Ash Pond No. 1 will not overtop during the 1,000-year storm event. Results of the model are summarized below in Table 4.1.

Table 4.1
Coffeen Ash Pond No. 1 Summary of Hydrologic and Hydraulic Analysis, 1,000-Year, 24-Hour Storm

CCR Unit	Beginning WSE[1] (ft)	Peak WSE (ft)	Minimum Crest Elevation (ft)
Ash Pond No. 1	631.0	632.0	635.0

Notes:
[1] WSE = Water Surface Elevation

- The Coffeen Ash Pond No. 1 is certified to be able to pass the Inflow Design Flood (IDF) per §257.82(a) the CCR Rule.

5. LIMITATIONS

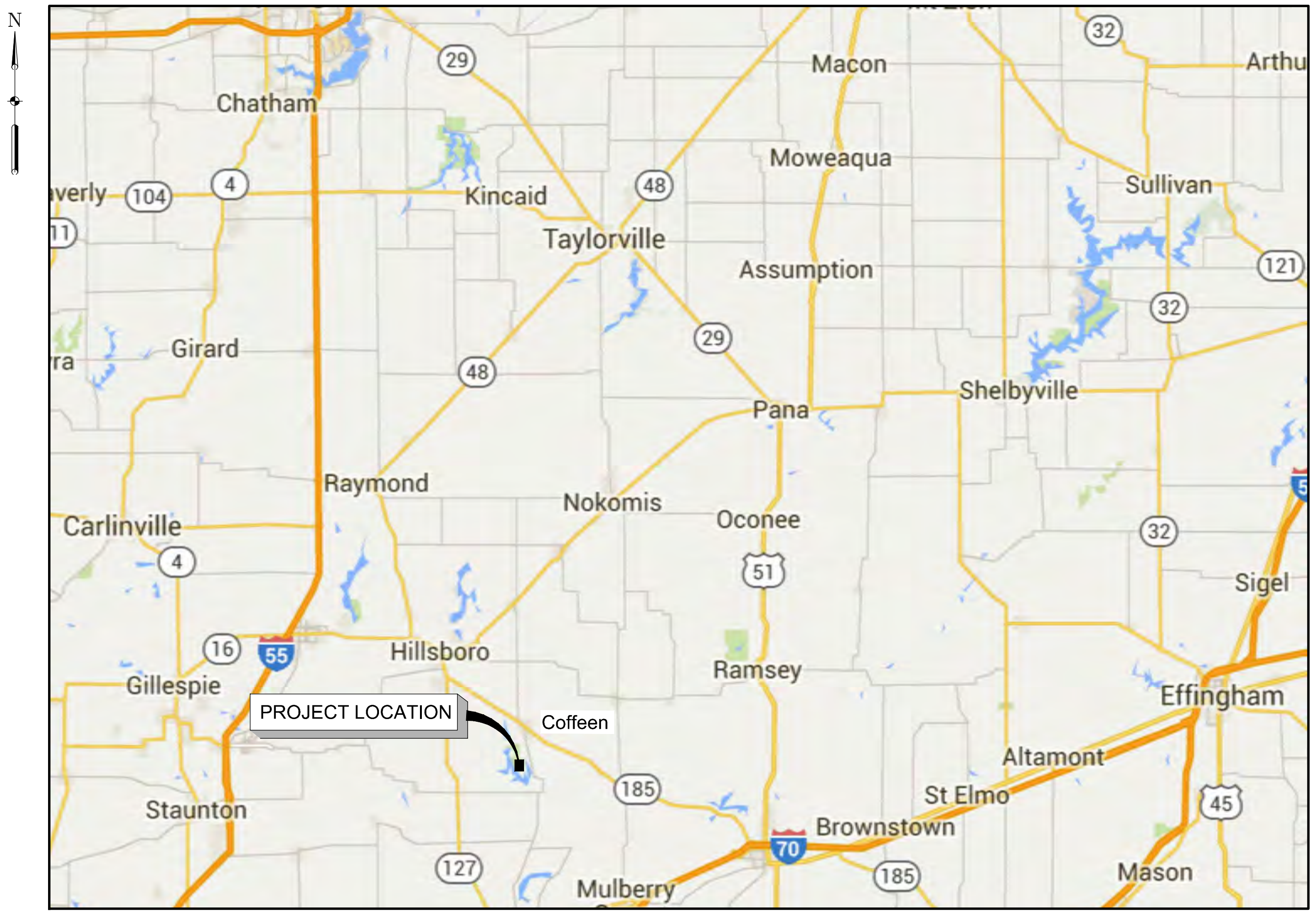
Background information, design basis, and other data, which AECOM has used in preparing this report have been furnished to AECOM by IPGC. AECOM has relied on this information as furnished, and is not responsible for the accuracy of this information. Our recommendations are based on available information from previous and current investigations. These recommendations may be updated as future investigations are performed.

The conclusions presented in this report are intended only for the purpose, site location, and project indicated. The recommendations presented in this report should not be used for other projects or purposes. Conclusions or recommendations made from these data by others are their responsibility. The conclusions and recommendations are based on AECOM's understanding of current plant operations, maintenance, stormwater handling, and ash handling procedures at the station, as provided by IPGC. Changes in any of these operations or procedures may invalidate the findings in this report until AECOM has had the opportunity to review the findings, and revise the report if necessary.

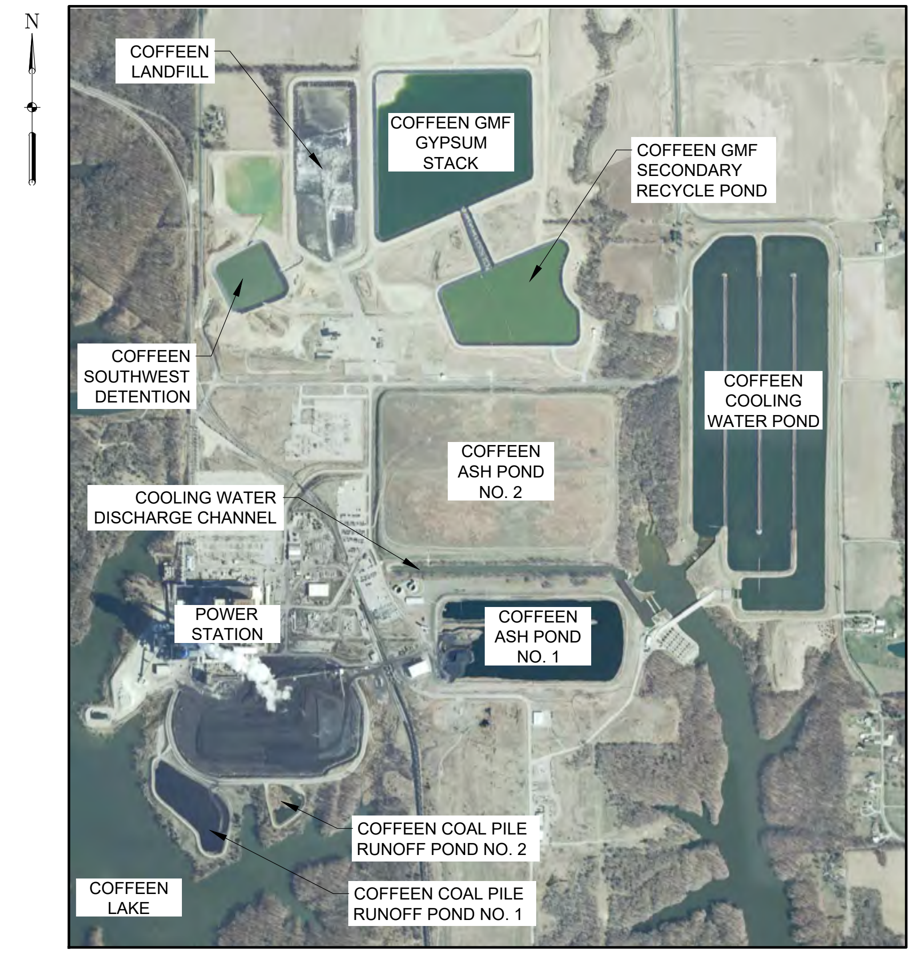
This hydrologic and hydraulic analysis was performed in accordance with the standard of care commonly used as state-of-practice in our profession. Specifically, our services have been performed in accordance with accepted principles and practices of the engineering profession. The conclusions presented in this report are professional opinions based on the indicated project criteria and data available at the time this report was prepared. Our services were provided in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation is intended.

Attachment A – Location Map

SMITH, CURT, 2/9/2016 11:40 AM



LOCATION MAP
NOT TO SCALE



VICINITY MAP
NOT TO SCALE

AECOM
1001 Highlands Plaza Drive, Suite 300
St. Louis, Mo. 63110
314 429-0100 (phone)
314-429-0462 (fax)

DYNEGY
Dynegy Inc.
1500 East Port Plaza Drive
Collinsville, IL 62234

CCR RULE ASSESSMENT OF PLANTS

COFFEEN POWER PLANT
COFFEEN, ILLINOIS

H&H REPORT
ASH POND NO. 1

ISSUED FOR BIDDING DATE BY

ISSUED FOR CONSTRUCTION DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	
DRAWN BY:	GJH
DESIGNED BY:	EJV
CHECKED BY:	MCR
DATE CREATED:	12/23/2015
PLOT DATE:	2/9/2016
SCALE:	AS SHOWN
ACAD VER:	2014

SHEET TITLE

LOCATION MAP &
SITE VICINITY MAP

1-1

SHEET 1 OF 4

DRAWING PATH: P:\Projects\Geotech\60428794_Dynegy\CCR\04Tasks\01 Coffeen Tasks\7.0_CAD_GIS\7.09_Exhibits\Exploration Location Plans\COF-POND-1-EXPLORATION_02072016.dwg

Attachment B - Hydrologic and Hydraulic Analysis Report

Dynegy
Coffeen Ash Pond 1
11/16/2015

Stage Storage
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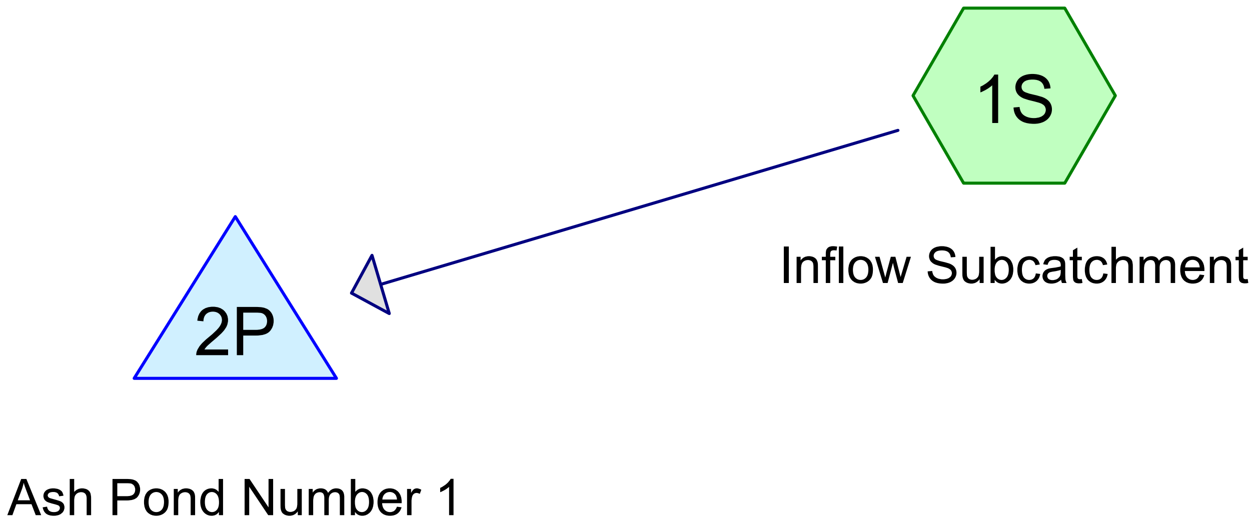
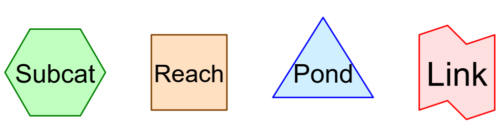
Elevation

Coffeen Ash Pond 1							
Elevation	Area		Depth	Incremental Volume		Cumulative Volume	
				Conic		Conic	
(ft-amsl)	(sq. ft)	(acres)	(ft)	(cu. ft)	(ac-ft)	(cu. ft)	(ac-ft)
630.00	759933	17.45	-	N/A	0.00	0.00	0
631.00	823039	18.89	1	791276.21	18.17	791276.21	18.17
632.00	889619	20.42	1	856113.26	19.65	1647389.48	37.82
633.00	934593	21.46	1	912013.37	20.94	2559402.85	58.76
634.00	974196	22.36	1	954325.96	21.91	3513728.81	80.66
635.00	1024742	23.52	1	999362.42	22.94	4513091.23	103.61
636.00	1063389	24.41	1	1044005.74	23.97	5557096.97	127.57





Routing Diagram for Dynegy Coffeen H&H Model CCR Requirements - Zero Outflow
Prepared by AECOM, Printed 1/28/2016
HydroCAD® 10.00 s/n 04760 © 2011 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
26.200	98	Water Surface and Ash (1S)
26.200	**98**	**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	2P	624.00	607.00	100.0	0.1700	0.012	48.0	0.0	0.0

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Inflow Subcatchment Runoff Area=26.200 ac 100.00% Impervious Runoff Depth=8.92"
Tc=5.0 min CN=98 Runoff=345.41 cfs 19.480 af

Pond 2P: Ash Pond Number 1 Peak Elev=631.99' Storage=848,545 cf Inflow=345.41 cfs 19.480 af
Outflow=0.00 cfs 0.000 af

Total Runoff Area = 26.200 ac Runoff Volume = 19.480 af Average Runoff Depth = 8.92"
0.00% Pervious = 0.000 ac 100.00% Impervious = 26.200 ac

Summary for Subcatchment 1S: Inflow Subcatchment

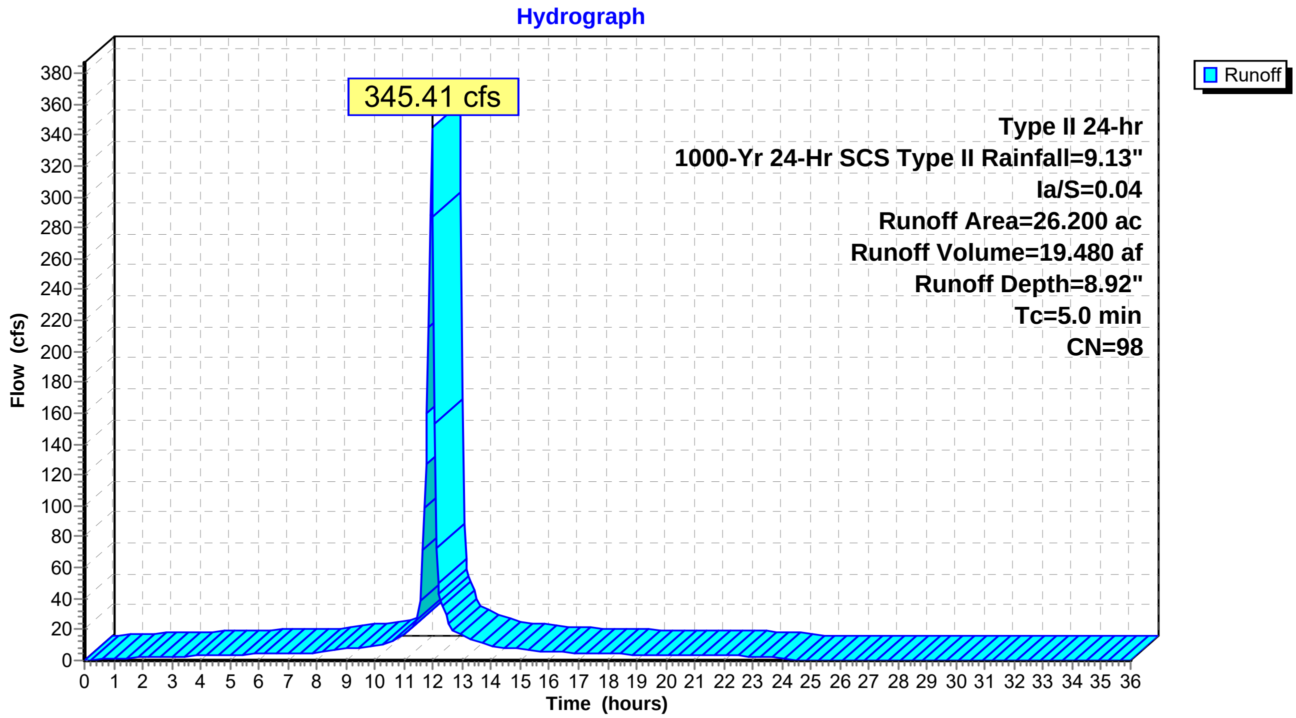
Runoff = 345.41 cfs @ 11.95 hrs, Volume= 19.480 af, Depth= 8.92"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-Yr 24-Hr SCS Type II Rainfall=9.13", Ia/S=0.04

	Area (ac)	CN	Description
*	26.200	98	Water Surface and Ash
	26.200		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Minimal - Direct Entry into Impoundment**

Subcatchment 1S: Inflow Subcatchment



Hydrograph for Subcatchment 1S: Inflow Subcatchment

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	0.05	0.01	0.62
1.00	0.10	0.03	1.27
1.50	0.15	0.06	1.73
2.00	0.20	0.09	2.08
2.50	0.26	0.14	2.36
3.00	0.31	0.18	2.60
3.50	0.38	0.24	2.81
4.00	0.44	0.29	3.00
4.50	0.50	0.35	3.27
5.00	0.58	0.42	3.55
5.50	0.65	0.49	3.82
6.00	0.73	0.56	4.09
6.50	0.81	0.64	4.36
7.00	0.90	0.73	4.62
7.50	1.00	0.82	4.88
8.00	1.10	0.92	5.13
8.50	1.21	1.02	6.19
9.00	1.34	1.16	7.40
9.50	1.49	1.30	7.60
10.00	1.65	1.46	9.23
10.50	1.86	1.67	11.97
11.00	2.15	1.95	16.49
11.50	2.58	2.39	**27.01**
12.00	6.05	5.85	**287.56**
12.50	6.71	6.50	25.21
13.00	7.05	6.84	15.67
13.50	7.29	7.09	11.85
14.00	7.49	7.28	9.29
14.50	7.65	7.44	8.20
15.00	7.79	7.59	7.36
15.50	7.92	7.71	6.52
16.00	8.03	7.83	5.67
16.50	8.14	7.93	5.29
17.00	8.23	8.03	4.99
17.50	8.32	8.12	4.69
18.00	8.41	8.20	4.39
18.50	8.49	8.28	4.08
19.00	8.56	8.35	3.78
19.50	8.63	8.42	3.48
20.00	8.69	8.48	3.18
20.50	8.75	8.54	3.08
21.00	8.81	8.60	3.02
21.50	8.86	8.66	2.96
22.00	8.92	8.71	2.90
22.50	8.97	8.77	2.84
23.00	9.03	8.82	2.78
23.50	9.08	8.87	2.72
24.00	**9.13**	**8.92**	2.65
24.50	9.13	8.92	0.00
25.00	9.13	8.92	0.00
25.50	9.13	8.92	0.00
26.00	9.13	8.92	0.00
26.50	9.13	8.92	0.00
27.00	9.13	8.92	0.00
27.50	9.13	8.92	0.00
28.00	9.13	8.92	0.00
28.50	9.13	8.92	0.00
29.00	9.13	8.92	0.00
29.50	9.13	8.92	0.00
30.00	9.13	8.92	0.00
30.50	9.13	8.92	0.00
31.00	9.13	8.92	0.00
31.50	9.13	8.92	0.00
32.00	9.13	8.92	0.00
32.50	9.13	8.92	0.00
33.00	9.13	8.92	0.00
33.50	9.13	8.92	0.00
34.00	9.13	8.92	0.00
34.50	9.13	8.92	0.00
35.00	9.13	8.92	0.00
35.50	9.13	8.92	0.00
36.00	9.13	8.92	0.00

Summary for Pond 2P: Ash Pond Number 1

Inflow Area = 26.200 ac,100.00% Impervious, Inflow Depth = 8.92" for 1000-Yr 24-Hr SCS Type II event
Inflow = 345.41 cfs @ 11.95 hrs, Volume= 19.480 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 631.99' @ 24.35 hrs Surf.Area= 889,036 sf Storage= 848,545 cf

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= (not calculated: no outflow)

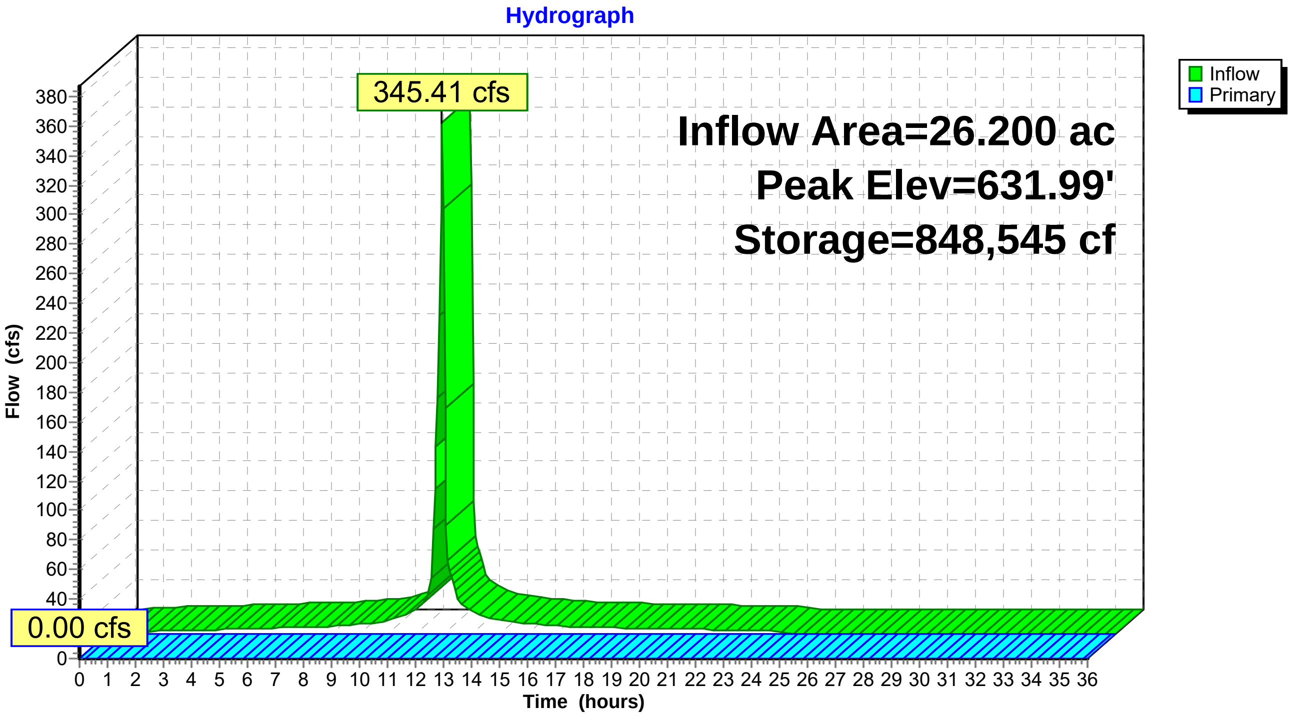
Volume	Invert	Avail.Storage	Storage Description
#1	631.00'	4,766,364 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
631.00	823,039	0	0
632.00	889,619	856,329	856,329
633.00	934,593	912,106	1,768,435
634.00	974,196	954,395	2,722,830
635.00	1,024,742	999,469	3,722,299
636.00	1,063,389	1,044,066	4,766,364

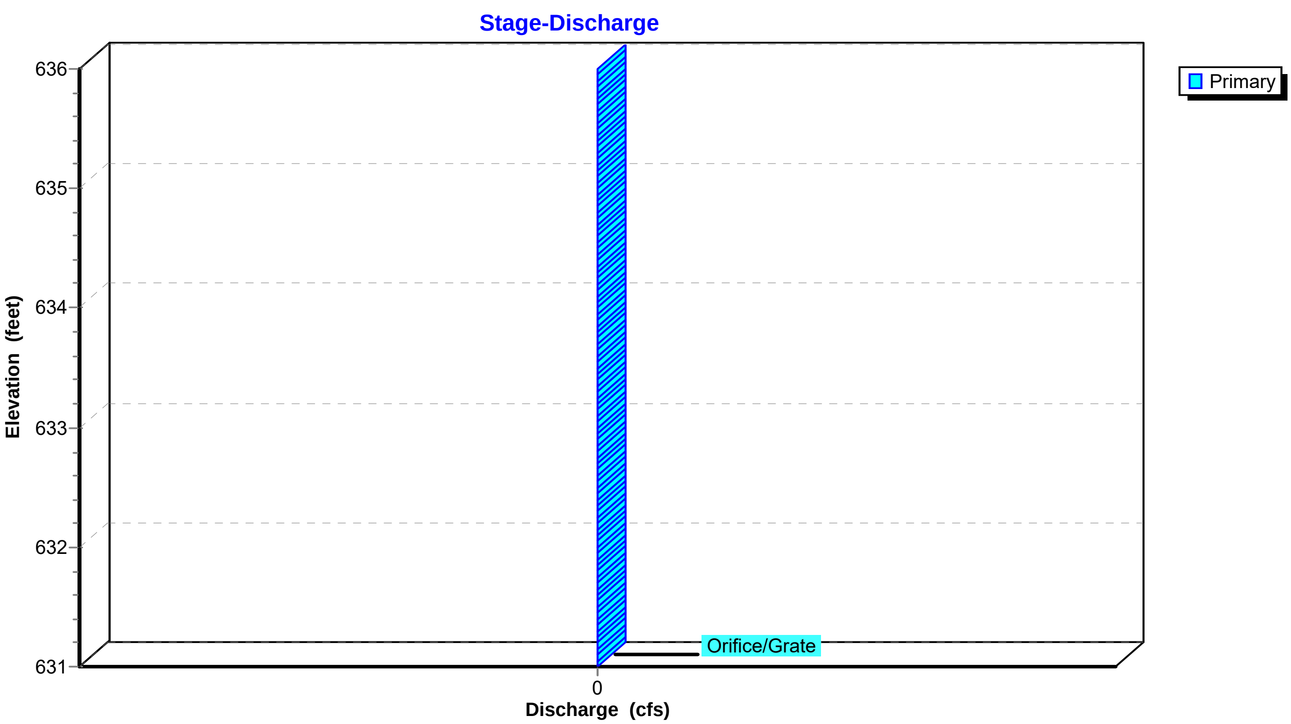
Device	Routing	Invert	Outlet Devices
#1	Primary	624.00'	**48.0" Round Culvert** L= 100.0' Ke= 1.000 Inlet / Outlet Invert= 624.00' / 607.00' S= 0.1700 '/' Cc= 0.900 n= 0.012 Steel, smooth, Flow Area= 12.57 sf
#2	Device 1	631.00'	**24.0" Horiz. Orifice/Grate X 0.00** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=631.00' (Free Discharge)
└─**1=Culvert** (Passes 0.00 cfs of 101.47 cfs potential flow)
  └─**2=Orifice/Grate** (Controls 0.00 cfs)

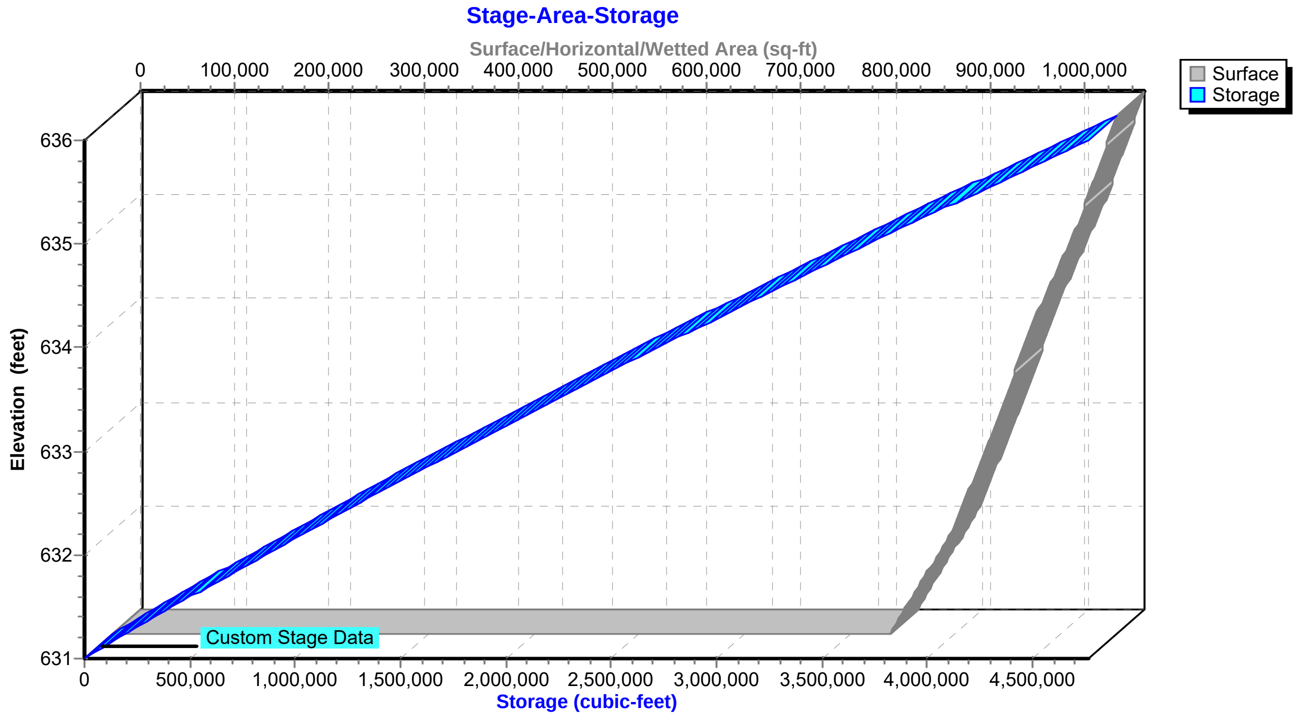
Pond 2P: Ash Pond Number 1



Pond 2P: Ash Pond Number 1



Pond 2P: Ash Pond Number 1



Hydrograph for Pond 2P: Ash Pond Number 1

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Primary (cfs)
0.00	0.00	0	631.00	**0.00**
1.00	1.27	2,145	631.00	0.00
2.00	2.08	8,317	631.01	0.00
3.00	2.60	16,797	631.02	0.00
4.00	3.00	26,903	631.03	0.00
5.00	3.55	38,665	631.05	0.00
6.00	4.09	52,414	631.06	0.00
7.00	4.62	68,091	631.08	0.00
8.00	5.13	85,647	631.10	0.00
9.00	7.40	107,958	631.13	0.00
10.00	9.23	136,527	631.16	0.00
11.00	**16.49**	180,904	631.22	0.00
12.00	**287.56**	496,298	631.59	0.00
13.00	15.67	646,433	631.76	0.00
14.00	9.29	689,800	631.81	0.00
15.00	7.36	719,383	631.85	0.00
16.00	5.67	742,849	631.87	0.00
17.00	4.99	761,906	631.89	0.00
18.00	4.39	778,779	631.91	0.00
19.00	3.78	793,483	631.93	0.00
20.00	3.18	806,018	631.94	0.00
21.00	3.02	817,124	631.96	0.00
22.00	2.90	827,789	631.97	0.00
23.00	2.78	838,020	631.98	0.00
24.00	2.65	**847,817**	**631.99**	0.00
25.00	0.00	**848,557**	**631.99**	0.00
26.00	0.00	848,557	631.99	0.00
27.00	0.00	848,557	631.99	0.00
28.00	0.00	848,557	631.99	0.00
29.00	0.00	848,557	631.99	0.00
30.00	0.00	848,557	631.99	0.00
31.00	0.00	848,557	631.99	0.00
32.00	0.00	848,557	631.99	0.00
33.00	0.00	848,557	631.99	0.00
34.00	0.00	848,557	631.99	0.00
35.00	0.00	848,557	631.99	0.00
36.00	0.00	848,557	631.99	0.00

Stage-Discharge for Pond 2P: Ash Pond Number 1

Elevation (feet)	Primary (cfs)	Elevation (feet)	Primary (cfs)
631.00	**0.00**	633.60	0.00
631.05	0.00	633.65	0.00
631.10	0.00	633.70	0.00
631.15	0.00	633.75	0.00
631.20	0.00	633.80	0.00
631.25	0.00	633.85	0.00
631.30	0.00	633.90	0.00
631.35	0.00	633.95	0.00
631.40	0.00	634.00	0.00
631.45	0.00	634.05	0.00
631.50	0.00	634.10	0.00
631.55	0.00	634.15	0.00
631.60	0.00	634.20	0.00
631.65	0.00	634.25	0.00
631.70	0.00	634.30	0.00
631.75	0.00	634.35	0.00
631.80	0.00	634.40	0.00
631.85	0.00	634.45	0.00
631.90	0.00	634.50	0.00
631.95	0.00	634.55	0.00
632.00	0.00	634.60	0.00
632.05	0.00	634.65	0.00
632.10	0.00	634.70	0.00
632.15	0.00	634.75	0.00
632.20	0.00	634.80	0.00
632.25	0.00	634.85	0.00
632.30	0.00	634.90	0.00
632.35	0.00	634.95	0.00
632.40	0.00	635.00	0.00
632.45	0.00	635.05	0.00
632.50	0.00	635.10	0.00
632.55	0.00	635.15	0.00
632.60	0.00	635.20	0.00
632.65	0.00	635.25	0.00
632.70	0.00	635.30	0.00
632.75	0.00	635.35	0.00
632.80	0.00	635.40	0.00
632.85	0.00	635.45	0.00
632.90	0.00	635.50	0.00
632.95	0.00	635.55	0.00
633.00	0.00	635.60	0.00
633.05	0.00	635.65	0.00
633.10	0.00	635.70	0.00
633.15	0.00	635.75	0.00
633.20	0.00	635.80	0.00
633.25	0.00	635.85	0.00
633.30	0.00	635.90	0.00
633.35	0.00	635.95	0.00
633.40	0.00	636.00	0.00
633.45	0.00		
633.50	0.00		
633.55	0.00		

Stage-Area-Storage for Pond 2P: Ash Pond Number 1

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
631.00	823,039	0	633.60	958,355	2,336,319
631.05	826,368	41,235	633.65	960,335	2,384,287
631.10	829,697	82,637	633.70	962,315	2,432,353
631.15	833,026	124,205	633.75	964,295	2,480,518
631.20	836,355	165,939	633.80	966,275	2,528,782
631.25	839,684	207,840	633.85	968,256	2,577,146
631.30	843,013	249,908	633.90	970,236	2,625,608
631.35	846,342	292,142	633.95	972,216	2,674,169
631.40	849,671	334,542	634.00	974,196	2,722,830
631.45	853,000	377,109	634.05	976,723	2,771,602
631.50	856,329	419,842	634.10	979,251	2,820,502
631.55	859,658	462,742	634.15	981,778	2,869,528
631.60	862,987	505,808	634.20	984,305	2,918,680
631.65	866,316	549,040	634.25	986,833	2,967,958
631.70	869,645	592,439	634.30	989,360	3,017,363
631.75	872,974	636,005	634.35	991,887	3,066,894
631.80	876,303	679,737	634.40	994,414	3,116,552
631.85	879,632	723,635	634.45	996,942	3,166,335
631.90	882,961	767,700	634.50	999,469	3,216,246
631.95	886,290	811,931	634.55	1,001,996	3,266,282
632.00	889,619	856,329	634.60	1,004,524	3,316,445
632.05	891,868	900,866	634.65	1,007,051	3,366,735
632.10	894,116	945,516	634.70	1,009,578	3,417,150
632.15	896,365	990,278	634.75	1,012,106	3,467,693
632.20	898,614	1,035,152	634.80	1,014,633	3,518,361
632.25	900,863	1,080,139	634.85	1,017,160	3,569,156
632.30	903,111	1,125,239	634.90	1,019,687	3,620,077
632.35	905,360	1,170,450	634.95	1,022,215	3,671,125
632.40	907,609	1,215,775	635.00	1,024,742	3,722,299
632.45	909,857	1,261,211	635.05	1,026,674	3,773,584
632.50	912,106	1,306,760	635.10	1,028,607	3,824,966
632.55	914,355	1,352,422	635.15	1,030,539	3,876,445
632.60	916,603	1,398,196	635.20	1,032,471	3,928,020
632.65	918,852	1,444,082	635.25	1,034,404	3,979,692
632.70	921,101	1,490,081	635.30	1,036,336	4,031,460
632.75	923,350	1,536,192	635.35	1,038,268	4,083,325
632.80	925,598	1,582,416	635.40	1,040,201	4,135,287
632.85	927,847	1,628,752	635.45	1,042,133	4,187,345
632.90	930,096	1,675,201	635.50	1,044,066	4,239,500
632.95	932,344	1,721,762	635.55	1,045,998	4,291,752
633.00	934,593	1,768,435	635.60	1,047,930	4,344,100
633.05	936,573	1,815,214	635.65	1,049,863	4,396,545
633.10	938,553	1,862,092	635.70	1,051,795	4,449,086
633.15	940,533	1,909,069	635.75	1,053,727	4,501,724
633.20	942,514	1,956,146	635.80	1,055,660	4,554,459
633.25	944,494	2,003,321	635.85	1,057,592	4,607,290
633.30	946,474	2,050,595	635.90	1,059,524	4,660,218
633.35	948,454	2,097,968	635.95	1,061,457	4,713,243
633.40	950,434	2,145,440	636.00	**1,063,389**	**4,766,364**
633.45	952,414	2,193,012			
633.50	954,395	2,240,682			
633.55	956,375	2,288,451			

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October 2016

CCR Certification Report: Initial Structural Stability Assessment, Initial Safety Factor Assessment, and Initial Inflow Design Flood Control System Plan

For

GMF Pond

At Coffeen Power Station

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Executive Summary

The initial structural stability assessment, initial safety factor assessment, and initial inflow design flood control system plan for the GMF Pond at the Coffeen Power Station have been prepared in accordance with the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule 40 Code of Federal Regulations (CFR) §257.73(d), §257.73(e), and §257.82, respectively. These regulations require that the specified structural stability, safety factor, and hydrologic and hydraulic (supporting the inflow design flood control system plan) assessments for an existing CCR surface impoundment be completed by October 17, 2016.

The engineering investigations, analyses, and evaluations determined that the GMF Pond meets all requirements for the structural stability assessment, safety factor assessment, and hydrologic and hydraulic analysis, as summarized in **Table ES-1**.

Table ES-1 – Certification Summary

Report Section	CCR Rule Reference	Requirement Summary	Requirement Met?	Comments
Initial Structural Stability Assessment				
3.1	§257.73(d)(1)(i)	Stable foundations and abutments	Yes	Foundations were found to be stable. Abutments are not present.
3.2	§257.73(d)(1)(ii)	Adequate slope protection	Yes	Slope protection is adequate.
3.3	§257.73(d)(1)(iii)	Sufficiency of dike compaction	Yes	Dike compaction is sufficient for expected ranges in loading conditions.
3.4	§257.73(d)(1)(iv)	Presence and condition of slope vegetation	Yes	Vegetation is present on exterior slopes and is maintained. Interior slopes have alternate protection (geomembrane liner).
3.5	§257.73(d)(1)(v)(A) and (B)	Adequacy of spillway design and management	Yes	Spillways are adequately designed and constructed and adequately manage flow during the probable maximum flood (PMF).
3.6	§257.73(d)(1)(vi)	Structural integrity of hydraulic structures	Not Applicable	Hydraulic structures penetrating the dikes of or underlying the base of the GMF Pond are not present.
3.7	§257.73(d)(1)(vii)	Stability of downstream slopes inundated by water body	Not Applicable	Inundation of exterior slopes is not expected. This requirement is not applicable.
Initial Safety Factor Assessment				
4.1	§257.73(e)(1)(i)	Maximum storage pool safety factor must be at least 1.50	Yes	Safety factors were calculated to be 3.45 and higher.
4.2	§257.73(e)(1)(ii)	Maximum surcharge pool safety factor must be at least 1.40	Yes	Safety factors were calculated to be 3.45 and higher.
4.3	§257.73(e)(1)(iii)	Seismic safety factor must be at least 1.00	Yes	Safety factors were calculated to be 1.47 and higher.
4.4	§257.73(e)(1)(iv)	For dikes constructed of soils that have susceptibility to liquefaction safety factor must be at least 1.20	Not Applicable	Dike soils are not susceptible to liquefaction.
Initial Inflow Design Flood Control System Plan				
5.1	§257.82(a)(1), (2), (3)	Adequacy of inflow design flood control system	Yes	Flood control system adequately manages inflow and peak discharge during the 1,000-year, 24-hour, Inflow Design Flood conditions.
5.2	§257.82(b)	Discharge from the CCR Unit	Yes	Discharges into Waters of the United States are not expected to occur during normal and 1,000-year, 24-hour, Inflow Design Flood conditions.

1 Introduction

This report documents that the structural stability assessment, safety factor assessment, and inflow design flood control system plan meet the requirements specified in 40 CFR §257.73(d), §257.73(e), and §257.82, respectively, to support the certification required under each of those regulatory provisions for the Coffeen Power Station Gypsum Management Facility Pond (GMF Pond). The GMF Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the specified initial structural stability assessment, initial safety factor assessment, and initial inflow design flood control system plan (i.e., hydrologic and hydraulic analysis) for an existing CCR surface impoundment be completed by October 17, 2016.

The Coffeen Power Station has three existing CCR surface impoundments, the GMF Pond, the GMF Recycle Pond, and Ash Pond No. 1. The GMF Pond has been evaluated to determine whether the structural stability, safety factor, and inflow design flood control system plan requirements are met. The following sections describe the evaluations performed and the results from the analyses, as supported by the underlying data and analyses included in the appendices.

2 Facility Description and Location Map

2.1 Overview of Existing Surface Impoundments

The Coffeen Power Station is a coal-fired power plant located approximately 2.4 miles south-southwest of Coffeen, Illinois in Montgomery County. The Coffeen Power Station is located on a peninsula extending into Coffeen Lake, and the GMF Pond is located approximately 0.6 miles north of the station. A site location map showing the Coffeen Power Station is in **Figure 1**. **Figure 2** presents the Coffeen Power Station site plan.

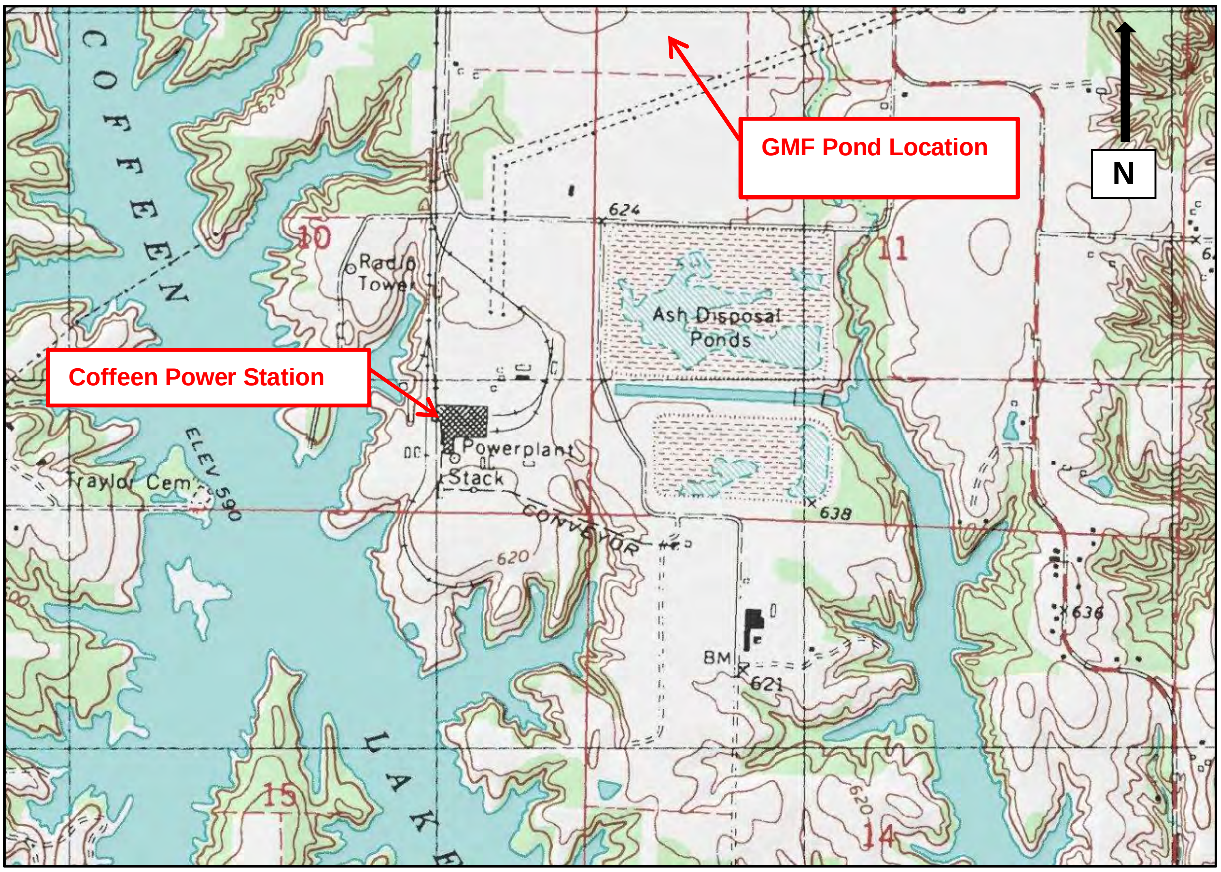

Figure 1 – Coffeen Power Station Location Map
(from United States Geological Survey Coffeen, Illinois 7.5' Topographic Maps, 1977)

Three active CCR surface impoundments – the GMF Pond, the GMF Recycle Pond, and Ash Pond No. 1 – are utilized for managing CCRs generated by the Coffeen Power Station. This certification report only pertains to the GMF Pond. The GMF Pond has a high hazard potential, based on the initial hazard potential classification assessment performed by Stantec in 2016 in accordance with §257.73(a)(2).

Figure 2 – Coffeen Power Station Site Plan
(Imagery from Google Earth Pro, 2016)

The GMF Pond serves as the primary wet impoundment basin for gypsum produced by the wet scrubber system at the Coffeen Power Station. The GMF Pond was constructed between 2008 and 2009 and receives inflow from two pairs of high-density polyethylene (HDPE) gypsum slurry pipes. Clear water discharge from the GMF Pond flows downstream into the GMF Recycle Pond via a lined channel (transfer channel) and 14-inch HDPE low-flow pipe buried beneath the transfer channel. The transfer channel effectively acts as a gap in the dike of the GMF Pond, as the bottom elevation of the transfer channel is equal to the adjacent exterior toe elevation of the dike. The transfer channel is approximately 580 feet in length, trapezoidal in shape, lined with 60-mil HDPE, has 3H:1V (horizontal to vertical) side slopes, and the bottom elevation decreases from 624 feet (all elevations in this report are in the NAVD88 datum, unless sated otherwise) at the upstream end to 622 feet at the downstream end. The 14-inch low flow pipe has an invert of 619.0 feet at the upstream end and 617.6 feet at the downstream end. The GMF Recycle Pond acts as a polishing pond, and outflow is pumped to the station to be recycled for use in the wet scrubber system.

The GMF Pond has a composite liner system that extends up to elevation 630.5 feet (all elevations in this report are in the NAVD88 datum, unless stated otherwise) and is present underneath the entire footprint of the pond. The liner system includes a 3-foot thick layer of compacted clay that is overlain by 60-mil textured HDPE geomembrane. The geomembrane liner is exposed at the pond bottom and side slopes. **Figure 3** shows a typical section of the composite liner section.

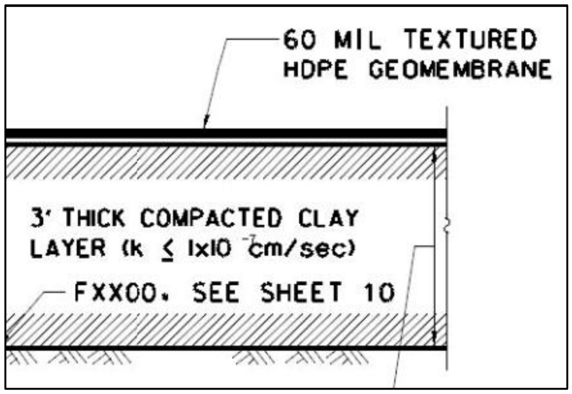

Figure 3 – GMF Pond Liner System Typical Section

(from Ameren Energy Generating Drawing C-10206, Rev 0, 2011)

As currently operated, the normal pool elevation of the GMF Pond was observed to be 621.2 feet in the 2015 Weaver Consultants survey of the site, as controlled by the 14-inch low-level outlet structure and recycle water inflow and outflow pumping rates. The GMF Pond is approximately 36.2 acres in size and was formed with a continuous embankment, a ring dike, which has a total perimeter length of approximately 5,000 feet. The perimeter dike was constructed to include a crest width of approximately 15 to 25 feet and crest height from 5 feet at the north embankment to 9 feet at the east embankment. The interior of the pond extends deeper than the exterior slopes, and the maximum interior slope height is approximately 25 feet in the southeast corner of the pond. The elevation of the embankment crest ranges from 631 to 632 feet. Both interior and exterior slopes have an orientation of 3H:1V (horizontal to vertical). Additional details about the geometry and configuration of the pond is provided in the Geotechnical Report in **Appendix A.**

3 Initial Structural Stability Assessment

40 CFR §257.73(d)(1)
The owner or operator of the CCR unit must conduct initial and periodic structural stability assessments and document whether the design, construction, operation, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater which can be impounded therein. The assessment must, at a minimum, document whether the CCR unit has been designed, constructed, operated, and maintained with [the standards in (d)(1)(i)-(vii)].

Analyses completed for the initial structural stability assessment of the Coffeen Power Station's GMF Pond are described in this section. Data and analysis results in the following subsections were developed using recent and historical data provided by Illinois Power Generating Company (IPGC), including impoundment design information, spillway design information, survey data, historical data, analysis reports, and information about operational and maintenance procedures. These data were supplemented with subsurface investigation and laboratory data collected by AECOM in 2015.

IPGC's operation of the GMF Pond is consistent with the design and construction of the CCR unit. IPGC follows an established maintenance program that quickly identifies and resolves issues of concern.

3.1 Foundations and Abutments (§257.73(d)(1)(i))

CCR unit designed, constructed, operated, and maintained with stable foundations and abutments.

Stability of the foundations of the GMF Pond was evaluated by reviewing soil consistencies and phreatic data estimated from Cone Penetration Test (CPT) tip resistances, side frictions and pore pressures; and collected soil laboratory test data from the 2015 AECOM field investigation for Ash Pond 1 and Ash Pond 2, which is discussed in more detail in **Section 4**. Based on these data, foundation materials generally consist of approximately 10 feet of medium stiff to stiff weathered loess (clay) and 2 to 5 feet of soft to very soft clay which overlies glacial till that is comprised of very stiff to hard clay with some dense sand. Phreatic water is typically near the embankment/foundation interface at the GMF Pond. As the GMF Pond is a ring dike structure, abutments are not present.

This information was used to perform slope stability analyses as required by §257.73(e)(1), which is discussed in more detail in **Section 4**. Safety factors for slip surfaces passing through the dike and foundation were found to meet or exceed the minimum requirements required by §257.73(e)(1), which indicates that the foundation of the GMF Pond is stable.

In order to evaluate the stability of the foundation under post-seismic conditions, liquefaction/cyclic softening analyses as well as post-earthquake (i.e. "liquefaction") slope stability analyses were also performed. The liquefaction and cyclic softening triggering analyses were performed for the 2,500-year return period design seismic event in order to delineate soils susceptible to liquefaction within the foundations of the GMF Pond. The analyses were performed using CPTs advanced into the foundations of the GMF Pond, the methodology presented by Idriss and Boulanger (2008), and laboratory index and cyclic shear strength test data. The analyses found that the soft clay material and transition zone between the soft clay and underlying glacial till within the foundation of the GMF Pond is susceptible to liquefaction or cyclic softening, depending on the fines content of the material. This material is present between the bottom of the foundation clay and top of the glacial till. All other foundation soils evaluated at the site were not found to be susceptible to liquefaction or cyclic softening during the design seismic event.

Post-earthquake ("liquefaction" or post-cyclic softening) slope stability analyses were performed assuming residual strengths in the soft clay and soft clay/glacial till transition zone and peak undrained shear strengths in all other embankment and foundation soils. Horizontal seismic loads are not included in this analysis, as it is intended to model the conditions immediately after earthquake shaking stops. The pool elevation and phreatic conditions were assumed to be the same as the Maximum Storage Pool case (**Section 4.1**), and correspond to normal operating conditions at the GMF Pond. Resulting factors of safety were compared to the criteria presented in §257.73(e)(1)(iv). The factors of safety for slip surfaces passing through the foundation were found to meet the minimum factors of safety listed in §257.73(e)(1)(iv), which only applies to dike soils. The calculated factors of safety are listed in **Table 1.**

Table 1 – Summary of Factors of Safety – Post-Earthquake Conditions

Cross Section	Calculated Factor of Safety (§257.73 Minimum = 1.20)
13+50	2.46*
22+50	2.46*
46+50	3.02
58+00	2.61

*Indicates critical cross section (i.e., lowest calculated factor of safety out of the 4 cross sections analyzed)

Based on this evaluation, the GMF Pond meets the requirements presented in §257.73(d)(1)(i). A detailed presentation of the field and laboratory data collected for the foundations and the completed slope stability analyses can be found in **Appendix A**.

3.2 Slope Protection (§257.73(d)(1)(ii))

CCR unit designed, constructed, operated, and maintained with adequate slope protection to protect against surface erosion, wave action and adverse effects of sudden drawdown.

The adequacy of slope protection present at the GMF Pond was evaluated by reviewing design drawings, operational and maintenance procedures, and conditions observed in the field during AECOM's June 12, 2015 site visit.

The exterior dike slopes have a 3H:1V orientation and are covered with vegetation for slope protection. IPGC regularly maintains the slopes, including repairing observed surface erosion and addressing areas of poor vegetation growth, as required. As the exterior slopes are not adjacent to a downstream water body, they are not susceptible to wave action or sudden drawdown. AECOM observed the vegetation to be adequately protecting against surface erosion.

The interior dike slopes have a 3H:1V orientation and are covered with an exposed 60-mil HDPE textured geomembrane liner. The liner extends to up to the interior crest of the dike and is under the full extents of the normal pool level footprint. IPGC maintains the liner by repairing tears or rips if they occur. As the liner isolates the pool from the dike soils, it protects the dike against surface erosion and wave action. Sudden drawdown is not applicable to the GMF Pond, as the liner serves to prevent saturation of the dike's soils below the normal pool.

Based on this evaluation, the GMF Pond meets the requirements in §257.73(d)(1)(ii).

3.3 Dike Compaction (§257.73(d)(1)(iii))

CCR unit designed, constructed, operated, and maintained with dikes mechanically compacted to a density sufficient to withstand the range of loading conditions in the CCR unit.

Compaction of the GMF Pond dikes was evaluated using field data obtained from the 2015 AECOM geotechnical investigation and by reviewing design drawings and operational and maintenance procedures.. Based on the 2015 AECOM data, the dike materials consist of clay. CPT tip resistances indicate that the dike material is medium stiff to stiff, which is indicative of mechanically compacted dikes. Slope stability analyses as required by §257.73(e)(1) found acceptable safety factors for each required loading condition, as presented in **Section 4**. Therefore, the dike compaction and density is sufficient for withstanding required ranges in loading conditions.

Based on this evaluation, the GMF Pond meets the requirements in §257.73(d)(1)(iii). A detailed presentation of the field and laboratory data collected for the dikes and the completed slope stability analyses can be found in **Appendix A**.

3.4 Vegetated Slopes (§257.73(d)(1)(iv))[1]

CCR unit designed, constructed, operated, and maintained with vegetated slopes of dikes and surrounding areas, except for slopes which have an alternate form or forms of slope protection.

The adequacy of slope vegetation at the GMF Pond was evaluated by reviewing conditions observed in the field during AECOM's June 12, 2015 site visit and by reviewing design drawings and operational and maintenance procedures. At the time of the site visit, the exterior slopes were vegetated and the interior slopes were covered with exposed geomembrane, which is an alternate form of slope protection. The vegetation on the exterior slopes is well-maintained. Regular maintenance manages the vegetation as described in this section.

Based on this evaluation, the GMF Pond meets the requirements in §257.73(d)(1)(iv).

3.5 Spillways (§257.73(d)(1)(v))

CCR unit designed, constructed, operated, and maintained with a single spillway or a combination of spillways configured as specified in [paragraph (A) and (B)]:

- *(A) All spillways must be either:*
  - *(1) of non-erodible construction and designed to carry sustained flows; or*
  - *(2) earth- or grass-lined and designed to carry short-term, infrequent flows at non-erosive velocities where sustained flows are not expected.*
- *(B) The combined capacity of all spillways must adequately manage flow during and following the peak discharge from a:*
  - *(1) Probable maximum flood (PMF) for a high hazard potential CCR surface impoundment; or*
  - *(2) 1000-year flood for a significant hazard potential CCR surface impoundment; or*
  - *(3) 100-year flood for a low hazard potential CCR surface impoundment.*

The spillway system at the GMF Pond was evaluated using hydrologic and hydraulic analyses, conditions observed during AECOM's June 12, 2015 site visit, and historic design and construction information provided by IPGC, and operational and maintenance procedures. The GMF Pond has a high hazard potential; therefore, the probable maximum flood (PMF) is the design flood event for the GMF Pond, per §257.73(d)(1)(v)(B).

The spillway system for the GMF Pond includes a HDPE-lined overflow channel and 14-inch diameter HDPE low-level pipe, which are both non-erodible materials designed to carry sustained flows. The capacity of the spillway system was evaluated using hydrologic and hydraulic analyses. The analysis found that the spillway system can adequately manage flow during peak discharge resulting from the PMF event without overtopping of the embankments, as discussed in more detail in **Section 5**.

Based on these evaluations, the GMF Pond meets the requirements in §257.73(d)(1)(v). A detailed presentation of the hydraulic and hydrologic analyses can be found in **Appendix B**.

3.6 Stability and Structural Integrity of Hydraulic Structures (§257.73(d)(1)(vi))

CCR unit designed, constructed, operated, and maintained with hydraulic structures underlying the base of the CCR unit or passing through the dike of the CCR unit that maintain structural integrity and are free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris which may negatively affect the operation of the hydraulic structure.

Based on an evaluation of design drawings, operational and maintenance procedures, and conditions observed in the field by AECOM, no hydraulic structures are present that underlie the base or pass through the dike of the GMF Pond. The 14-inch diameter spillway pipe that underlies the transfer channel was not evaluated as it does not pass through the GMF Pond dike, or underlie the base of the GMF Pond. As discussed in Section 2.1, the GMF Pond dike has a gap where the transfer channel is located, which forms the transfer channel. Therefore, the §257.73(d)(1)(vi) requirements are not applicable to the GMF Pond.

[1] As modified by court order issued June 14, 2016, Utility Solid Waste Activities Group v. EPA, D.C. Cir. No. 15-1219 (order granting remand and vacatur of specific regulatory provisions).

3.7 Downstream Slope Inundation/Stability (§257.73(d)(1)(vii))

CCR unit designed, constructed, operated, and maintained with, for CCR units with downstream slopes which can be inundated by the pool of an adjacent water body, such as a river, stream or lake, downstream slopes that maintain structural stability during low pool of the adjacent water body or sudden drawdown of the adjacent water body.

The structural stability of the downstream slope of the GMF Pond was evaluated by comparing the location of the GMF Pond relative to published flood maps for the area. The nearest downstream water body is the GMF Recycle Pond, which is approximately 500 lateral feet beyond the downstream slopes of the GMF Pond; however, the GMF Recycle Pond is a CCR unit and not a river, lake, or stream. Coffeen Lake is also located in the vicinity of the GMF Pond, but the GMF Pond is outside the flood zone shown on the FEMA Federal Insurance Rate Map (FIRM) for Montgomery County, Illinois. Therefore, adjacent water bodies that can inundate the downstream slopes of the GMF Pond are not present. **Figure 4** shows the footprint of the GMF Pond within the FIRM map (FEMA, 1981).

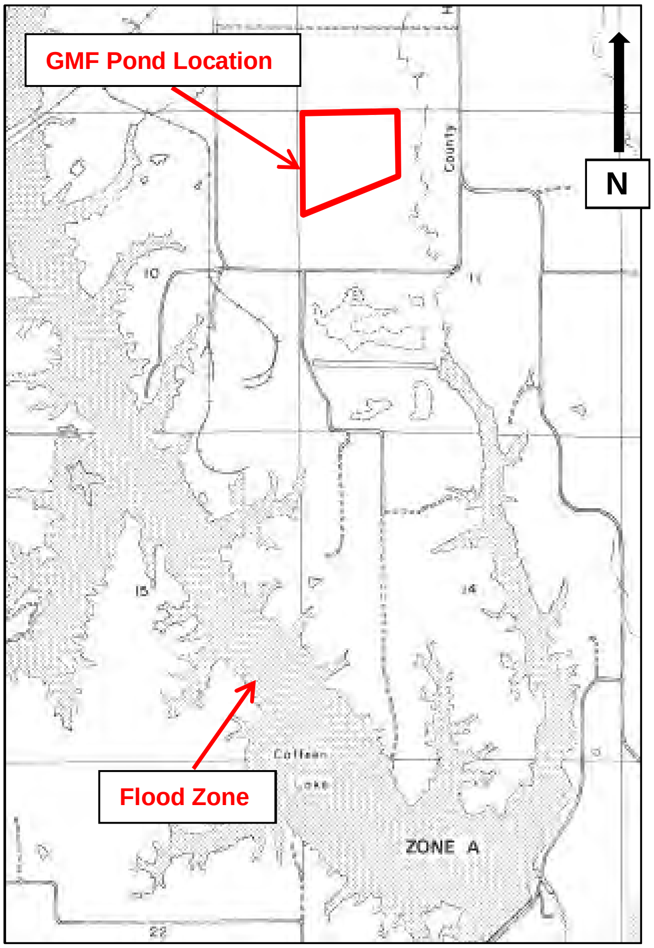

Figure 4 - GMF Pond Flood Zone Map
(from FEMA Flood Hazard Boundary Map, Montgomery County, Illinois, 1981)

Based on this evaluation, the requirements in §257.73(d)(1)(vii) are not applicable to the GMF Pond, as inundation of the downstream slopes is not expected to occur.

4 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

A geotechnical investigation program and stability analyses were performed by AECOM in 2015 to evaluate the design, performance, and condition of the earthen dikes of the GMF Pond. The exploration consisted of 8 cone penetration tests (CPTs), although boring and laboratory test data collected by AECOM for Ash Pond 1 and Ash Pond 2 were also used for the GMF Pond. Data collected from the 2015 AECOM investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at the GMF Pond consist of a compacted medium stiff to stiff clay dike overlying weathered loess and glacial till foundation materials. The foundation materials consist of around 10 feet of medium stiff to stiff lean to fat clay overlying 2 to 5 feet of very soft to soft clay, which in turn overlies glacial till consisting of stiff to hard clay with dense to very dense sand and gravel. Explorations were terminated at refusal in the glacial till and did not reach bedrock. The phreatic surface within the subsurface is typically 8 to 10 feet below the ground surface at the toe of the embankment and at the embankment/foundation interface beneath the crest.

Four (4) representative cross sections (13+50, 22+50, 46+50, and 58+00) were analyzed using GeoStudio SLOPE/W limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. Slip surface search routines in SLOPE/W relied on circular slip surfaces using the entry and exit-point based method to define the initial critical slip surface. The slip surface was then optimized to find a critical, non-circular slip surface, and factors of safety were calculated using the Spencer method. This methodology was selected as it evaluates a wide range of slip surface geometries through the dike system and foundation, and the Spencer method satisfies both moment and force equilibrium. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Sections were generally selected to include the most critical configurations of the dike system along each side of the dike system, in terms of embankment height and slope and subsurface conditions. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The results of the initial safety factor assessment are summarized in the following sub-sections. A detailed presentation of the analyses performed, including development of site stratigraphy, strength parameters, stability analysis methodology, and figures showing cross-section and exploration plans can be found in **Appendix A**.

4.1 Factor of Safety: Maximum Storage Pool Loading (§257.73(e)(1)(i))

The calculated static factor of safety under long-term, maximum storage pool loading condition must equal or exceed 1.50.

This calculation models the dike stability under static, long-term conditions, under the normal storage water level (El. 621.2 feet) within the impoundments, which corresponds to the water level measured during the September 22, 2015 survey of the site performed by Weaver Consultants. Drained (effective stress) shear strength parameters were used for all materials, and phreatic conditions were estimated based on available piezometer and boring data. The calculated minimum factors of safety are identified in **Table 2.**

Table 2 – Summary of Factors of Safety – Maximum Storage Pool Loading Condition

Cross Section	Calculated Factor of Safety (§257.73(e)(1)(i) Minimum = 1.50)
13+50	3.45*
22+50	3.48
46+50	4.19
58+00	3.57

*Indicates critical cross section (i.e., lowest calculated factor of safety out of the 4 cross sections analyzed)

The calculated factors of safety exceed 1.50 for all cross sections analyzed, which meets the requirements in §257.73(e)(1)(i).

4.2 Factor of Safety: Maximum Surcharge Pool Loading (§257.73(e)(1)(ii))

The calculated static factor of safety under maximum surcharge pool loading condition must equal or exceed 1.40.

This calculation models the dike stability under short-term, surcharge pool conditions. The pool level for analysis was modeled at elevation 623.8 feet, which is the PMF pool (**Section 5.1**). Drained soil strengths were used for analysis, as the relatively small increase in pool level is not expected to result in the development of undrained conditions in the downstream embankment slopes or foundation soils. Pore pressures in the embankment were assumed to be similar to the static drained conditions; however, the pool level in the GMF Pond was increased to model additional loading from the surcharge pool. The calculated factors of safety are identified in **Table 3**.

Table 3 – Summary of Factors of Safety – Maximum Surcharge Pool Loading Condition

Cross Section	Calculated Factor of Safety (§257.73(e)(1)(ii) Minimum = 1.40)
13+50	3.45*
22+50	3.48
46+50	4.19
58+00	3.57

*Indicates critical cross section (i.e., lowest calculated factor of safety out of the 4 cross sections analyzed)

The calculated factors of safety exceed 1.40 for all cross sections analyzed, which meets the requirements in §257.73(e)(1)(ii).

4.3 Factor of Safety: Seismic (§257.73(e)(1)(iii))

The calculated seismic factor of safety must equal or exceed 1.00.

This calculation models the dike stability under short-term, seismic loading conditions during the design 2,500-year return period seismic event. Seismic loading is modeled as a horizontal force acting outward on the dike and foundation. This analysis is intended to model conditions during earthquake shaking, when seismically-induced material strength losses have not yet occurred. Therefore, peak undrained (total stress) shear strength parameters were used for this analysis, due to the short duration of the loading and the fine-grained, slow-draining nature of the embankment and foundation soils. The pool elevation and phreatic conditions were assumed to be the same as the Maximum Storage Pool case (**Section 4.1**), and correspond to normal operating conditions at the GMF Pond. The calculated factors of safety are identified in **Table 4**.

Table 4 – Summary of Factors of Safety – Seismic Loading Condition

Cross Section	Calculated Factor of Safety (§257.73(e)(1)(iii) Minimum = 1.00)
13+50	1.61
22+50	1.47*
46+50	1.76
58+00	1.66

*Indicates critical cross section (i.e., lowest calculated factor of safety out of the 4 cross sections analyzed)

The calculated factors of safety exceed 1.00 for all cross sections analyzed, which meets the requirements in §257.73(e)(1)(iii).

4.4 Factor of Safety: Soils Susceptible to Liquefaction (§257.73(e)(1)(iv))

For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A liquefaction triggering analysis was performed to evaluate the requirements of §257.73(e)(1)(iv).

Liquefaction triggering analyses were performed for the 2,500-year return period design seismic even in order to delineate soils susceptible to liquefaction within the dike. The analyses were performed using CPTs advanced through the dike of the GMF Pond, the methodology presented by Idriss and Boulanger (2008), and laboratory index test data. The analyses found that the materials comprising the GMF Pond dikes were not susceptible to liquefaction during the design seismic event.

Based on this evaluation, the requirements in §257.73(e)(1)(iv) are not applicable to the GMF Pond, as the dikes are not susceptible to liquefaction.

5 Initial Inflow Design Flood Control System Plan

40 CFR §257.82

(a) The owner or operator of an existing … CCR surface impoundment … must design, construct, operate, and maintain an inflow design flood control system as specified in paragraphs (a)(1) and (2) of this section.

(1) The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood specified in paragraph (a)(3) of this section.

(2) The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood specified in paragraph (a)(3) of this section.

(3) The inflow design flood is:

(i) For a high hazard potential CCR surface impoundment, …, the probable maximum flood;

(ii) For a significant hazard potential CCR surface impoundment, …, the 1,000-year flood;

(iii) For a low hazard potential CCR surface impoundment, …, the 100-year flood; or

(iv) For an incised CCR surface impoundment, the 25-year flood.

(b) Discharge from the CCR unit must be handled in accordance with the surface water requirements under §257.3-3.

Analyses completed for the initial inflow design flood control system plan of the GMF Pond are described in the following subsections. Data and analysis results in the following subsection are based on spillway design information shown on design drawings, construction information, topographic surveys, information about operational and maintenance procedures provided by IPGC and field measurements collected by AECOM. The analysis approach and results of the hydrologic and hydraulic analyses are presented in the following subsections. A detailed presentation of the analyses performed can be found in **Appendix B**.

The GMF Pond has a high hazard potential; therefore, the inflow design flood (IDF) is the PMF.

5.1 Initial Inflow Design Flood Control Systems (§257.82(a))

An initial inflow design flood control system plan, supported by a hydraulic and hydrologic analysis, was developed for the GMF Pond by evaluating the effects of a 24-hour duration design storm for the PMF IDF using a hydraulic HydroCAD (Version 10) computer model and a starting water surface elevation of 621.2 feet, based on the pool level in the GMF Pond surveyed by Weaver Consultants in 2015. This was assumed to be the normal pool at the GMF Pond as it is 2.2 feet above the invert of the low-flow spillway and therefore represents a process flow condition at the GMF Pond. The computer model evaluated the GMF Pond's ability to collect and control the PMF IDF under existing operational and maintenance procedures. Rainfall data for the PMF IDF, which corresponds to the probable maximum precipitation rainfall event, was obtained from the National Weather Service Hydrometeorological Report No. 51 (HMR 51). The HMR 51 rainfall depth is 34.25 inches.

The HydroCAD model results for the GMF Pond indicate that the CCR unit has sufficient storage capacity and spillway structures to adequately manage (1) flow into the CCR unit during and following the peak discharge of the PMF IDF and (2) flow from the CCR unit to collect and control the peak discharge resulting from the PMF IDF. The peak water surface elevation is 623.8 feet during the IDF, and the minimum crest elevation of the GMF Pond dike is 631 feet. Therefore, overtopping is not expected.

Based on this evaluation, the GMF Pond meets the requirements in §257.82(a). The hydrologic and hydraulic analysis is presented in **Appendix B**.

5.2 Discharge from the CCR Unit (§257.82(b))

40 CFR §257.82(b) provides that the discharge from the CCR unit must be handled in accordance with the surface water requirements under 40 CFR §257.3-3, which states the following:

(a) For purposes of section 4004(a) of the Act, a facility shall not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES) under section 402 of the Clean Water Act, as amended.

(b) For purposes of section 4004(a) of the Act, a facility shall not cause a discharge of dredged material or fill material to waters of the United States that is in violation of the requirements under section 404 of the Clean Water Act, as amended.

(c) A facility or practice shall not cause non-point source pollution of waters of the United States that violates applicable legal requirements implementing an areawide or Statewide water quality management plan that has been approved by the Administrator under section 208 of the Clean Water Act, as amended.

(d) Definitions of the terms Discharge of dredged material, Point source, Pollutant, Waters of the United States, and Wetlands can be found in the Clean Water Act, as amended, 33 U.S.C. 1251 et seq., and implementing regulations, specifically 33 CFR part 323 (42 FR 37122, July 19, 1977).

The handling of discharge was evaluated by reviewing design drawings, operational and maintenance procedures, conditions observed in the field by AECOM, and the inflow design flood control system plan developed per §257.82(a).

Based on this evaluation, the GMF Pond does not discharge into waters of the United States. Clear water from the GMF Pond flows downstream into the GMF Recycle Pond. Hydraulic and hydrologic analyses performed as part of the initial inflow design flood control system plan found the GMF Pond adequately manages outflow during the PMF IDF, as overtopping of the GMF Pond embankments is not expected.

Therefore, discharge into waters of the United States is not expected during both normal and IDF conditions, and the GMF Pond meets the requirements in §257.82(b).

6 Conclusions

The GMF Pond at the Coffeen Power Station was evaluated relative to the USEPA CCR Rule requirements for initial structural stability assessments (§257.73(d)), initial safety factor assessments (§257.73(e)), and initial inflow design flood control system plan (§257.82). Based on the evaluations presented herein, the referenced requirements are satisfied.

7 References

AECOM (2016). *Hydrologic and Hydraulic Summary Report-Coffeen Power Station, GMF Pond.* Coffeen, Illinois.

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Federal Emergency Management Agency (FEMA). (1981). Flood Hazard Boundary Map, Montgomery County, Illinois, Unincorporated Area, Panel 9 of 9. Community-Panel Number 170992 0009 A.

U.S. Environmental Protection Agency [USEPA]. (2015). *Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments.* 40 CFR Part 257, Subpart D. 80 Fed. Reg. 21468 April 17, 2015.

Weaver Consultants Group. (2015). Coffeen 2015 Aerial Topography, Existing Site Conditions, Coffeen, Illinois. December 1, 2015.

8 Appendices

A. Geotechnical Report

B. Hydrologic and Hydraulic Report

Appendix A. Geotechnical Report

AECOM
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October 7, 2016

Mr. Matt Ballance, PE
Senior Project Engineer
Dynegy Inc.
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

RE: Geotechnical Report
Coffeen Power Station
GMF Pond

Dear Mr. Ballance:

AECOM is pleased to provide this Geotechnical Report for the Illinois Power Generating Company, LLC (IPGC) Gypsum Management Facility (GMF) Pond Coal Combustion Residuals (CCR) unit at the Coffeen Power Station located in Montgomery County, Illinois. This Geotechnical Report has been prepared to document the analyses performed to check that the facility meets the geotechnical stability requirements including Factors of Safety required by 40 CFR § 257.73.

AECOM looks forward to providing continued support to the Illinois Power Generating Company, LLC (IPGC) and working together on this important program. Please do not hesitate to call Ron Hager at 314-429-0100 (office) / 440-591-7868 (mobile), if you have any questions or comments on this Geotechnical Report.

Sincerely,

AECOM

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Site Manager
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Program Manager
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cc: Mark Rokoff, PE – AECOM

Attachments:

A. Figures
B. GMF Pond CPT Soundings
C. Slope Stability Analysis Calculations
D. Liquefaction Analysis Calculations

1. INTRODUCTION

1.1. *Purpose of this Report*

This report presents the results of geotechnical analyses prepared by AECOM for the Illinois Power Generating Company, LLC (IPGC)[1] GMF Pond CCR Unit at the Coffeen Power Station located in Montgomery County, Illinois (see **Figure 1**, **Attachment A** for Location Map). The purpose of the geotechnical investigation and analyses performed is to evaluate the design, performance, and condition of the impoundment and associated structures using the data collected from surface and subsurface investigations, available design drawings, previous engineering investigations, and other pertinent historic documents provided to AECOM by IPGC. This information was then used to evaluate the design and operation of the surface impoundment against regulatory standards set in 40 CFR § 257.73.

The geotechnical field evaluation for the GMF Pond was conducted between August 7 and August 11, 2015, as part of the Geotechnical Evaluation for Coffeen Ash Pond No. 1 (AP1) and Coffeen Ash Pond No. 2 (AP2), as the GMF Pond is located nearby AP1 and AP2. The field program consisted of 8 Cone Penetration Tests (CPT) supplemented with the geotechnical boring, CPT, and laboratory testing data collected at AP1 and AP2, as foundation and embankment conditions at the GMF Pond were found to be very similar. Stability analyses were performed by AECOM to evaluate the potential for slope instabilities, in accordance with 40 CFR § 257.73(d) and (e).

A summary of the geotechnical field program and stability evaluations are presented herein. Data from the AP1 and AP2 investigations used for the GMF Pond evaluations is referenced and can be found in the AP1 Geotechnical Report (AECOM, 2016). Detailed interpretations, calculations, and presentations of analysis results are provided in the Attachments to this report.

1.2. *Description of Impoundment*

The GMF Pond is a approximately 36.2-acre CCR unit located north-northeast of the Coffeen Power Station (see **Attachment A, Figure 1** for site location and vicinity maps). A continuous earthen embankment forms the perimeter (approximately 5,000 ft) of the pond. The unit was designed as a storage impoundment for gypsum CCR material produced by the Coffeen Power Station (Hanson, 2007).

Based on the 2015 survey performed by Weaver Consultants Group (Weaver, 2015) the embankment height ranges from approximately 5 feet (north embankment) to 9 feet (east embankment), as referenced to the downstream toe. Embankment slopes were built at 3H:1V (horizontal to vertical) slopes on the upstream and downstream sides. Embankment crest width ranges from approximately 15 to 25 feet. The crest elevation of the GMF Pond is approximately 631 to 632 feet (elevation datum in this report is NAVD88, unless stated otherwise). The liner system consists of the following, starting from foundation grade: 3 feet of compacted clay ($k \leq 1 \times 10^{-7}$ cm/sec) covered with a 60 mil textured high-density polyethylene (HDPE) geomembrane (Ameren Energy Generating, 2008).

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[1] Although the Coffeen Power Station is owned and operated by IPGC, Dynegy Administrative Services Company, (*Dynegy*) contracted AECOM to develop this Geotechnical Report on behalf of IPGC. Therefore, “Dynegy” is referenced in materials attached to this geotechnical report.

2. SUMMARY OF FIELD INVESTIGATIONS

A subsurface exploration consisting of 8 cone penetration tests (CPT) with seismic wave velocity measurements and pore pressure dissipation (PPD) testing was performed at the GMF Pond. CPT soundings were performed by AECOM's subcontractor ConeTec, Inc. with full-time oversight by AECOM personnel. Surface elevations at the CPT soundings varied from 622 to 631 feet while termination depths varied from 19 to 66 feet below ground surface. A summary of the CPT tests can be found in **Table 1**. Logs of the CPT soundings and PPD tests provided by ConeTec can be found in **Attachment B** and CPT locations can be seen on **Figure 2** in **Attachment A**. The complete ConeTec CPT report can be found in the Geotechnical Report for Coffeen AP1 (AECOM, 2016)

Table 1 – CPT Exploration Location Data for GMF Pond

Exploration ID	Location	Northing [1] (ft., NAD83)	Easting [1] (ft., NAD83)	Surface Elevation [2] (ft., NAVD88)
COF-C048	East Dike Toe	876163	2516007	622.4
COF-C049	North Dike Crest	876622	2515991	631.3
COF-C050	West Dike Crest	875753	2514594	631.3
COF-C051	West Dike Toe	875751	2514544	627.0
COF-C052	South Dike Crest	875284	2515063	631.0
COF-C053	East Dike Crest	876172	2515958	630.9
COF-C054	South Dike Toe	875244	2515068	626.1
COF-C055	North Dike Toe	876652	2515343	623.9

1. Easting and northing coordinates were collected using a handheld GPS Receiver by ConeTec, at the time of CPT advancement. Assumed accuracy is ±6 ft.
2. Elevations are based site topographic LIDAR survey provided by Weaver Consultants (August 17, 2015). Assumed accuracy is ±2 ft,

Additional subsurface investigations were performed at the Coffeen Station around AP1 and AP2, and information from these investigations were used for the analysis of the GMF Pond. AP1 and AP2 are located approximately 4,000 and 3,000 feet south of the GMF Pond, respectively, and the subsurface conditions are similar at all three ponds. Boring logs, laboratory data, and associated strength characterizations for these structures can be found in the geotechnical report for AP1 (AECOM, 2016).

3. SUMMARY OF SITE-SPECIFIC SUBSURFACE CONDITIONS

The subsurface profile over the site included cohesive embankment fill materials and foundation materials consisting of weathered loess (foundation clay), soft clay, and glacial till. The phreatic water within the subsurface is typically confined to the foundation soils.

3.1. *Site Stratigraphy*

Based on CPT data including tip resistance, side friction, and pore pressures, the subsurface conditions at the GMF Pond are very similar to those found at AP1 and AP2. Therefore, information from the lab data obtained from soil samples at AP1 and AP2 was used in conjunction with CPT data to classify and assign properties to the subsurface stratigraphy at the GMF Pond. Five representative material horizons were identified at the GMF Pond and used in the subsurface profiles. These material horizons are similar to the materials used for AP1 and AP2. Each material is discussed below:

- Embankment Fill: Embankment fill encountered in the borings at AP1 and AP2 typically classified as silty clay, sandy lean clay, or lean clay with sand (CL), with trace amounts of fine gravel, soft to very stiff, low to medium plasticity, moist to wet, and brown to gray. Trace amounts of organic material and ash were sometimes encountered. The embankment fill generally appeared to be well-compacted. Based on AECOM's interpretation of CPTs advanced at the GMF Pond, the materials are similar.

- Impounded CCR Materials: Investigations within the impounded gypsum were not performed by AECOM due to the potential for liner system damage during sampling. Conservative, lower-bound shear strengths were assigned for this material based on AECOM's experience.

- Foundation Clay: The Coffeen site is underlain predominantly by a native clay of wind-blown origin (loess), with some coarse-grained layers. The fine-grained soils (clays) encountered in the borings at AP1 and AP2 were typically classified as low- to medium-plasticity silty clay, sandy lean clay, or lean clay with sand (CL) often with trace amounts of gravel; or high plasticity fat clay (CH), often with trace amounts of sand. The CL and CH soils were soft to very stiff, moist to wet, and brown to gray. The coarse-grained soils encountered in the borings were classified as clayey sand (SC), silty sand (SM), or fine to coarse sand (SP), with a trace of gravel, loose to dense, wet to very wet, and brown to gray. Based on AECOM's interpretation of CPTs advanced at the GMF Pond, the foundation materials appeared similar.

- Soft Foundation Clay: A thin layer of native silty or sandy lean clay (CL) was encountered in some CPT soundings and borings at AP1 and AP2, between the foundation clay and underlying glacial till deposits. The clay was very soft to medium stiff, low to medium plasticity, wet, and orange brown to gray. At the GMF Pond, a similar layer was also encountered in most CPTs, identified by a localized reduction in tip resistance and side friction above the top of the glacial till. However, the transition from the soft foundation clay to the glacial till was more gradual at the GMF Pond than at AP1 and AP2. The transition zone was typically around 1 to 2 feet thick and consisted of a gradual increase in CPT tip resistance from the top to the bottom of the zone.

- Glacial Till: Glacial material encountered in the borings at AP1 and AP2 was typically classified as lean clay, or silty to sandy lean clay (CL), with trace amounts of fine gravel, hard, low plasticity, moist to wet, and brown to gray. At the GMF Pond, the glacial till material appears to be similar, although a slightly more sandy zone was likely present at the top of the till than was found at AP1 and AP2. CPT tip resistances in the glacial till were relatively high at AP1, AP2, and the GMF Pond, typically exceeding 200 tons per square foot (tsf). However, at the GMF Pond, the glacial till was more clayey in CPTs COF-C053 and COF-C054 than at AP1 and AP2, and tip resistances were on the order of 50 tsf beneath the sandy zone at the top of the till.

3.2. *Phreatic Water Conditions*

Phreatic water conditions at the GMF Pond were estimated from CPT pore pressure data. The phreatic water was assumed to be encountered when pore pressures exceeded zero and began increasing at a consistent rate. Based on the PPD test estimates, it appears that phreatic water is generally confined to the foundations of the GMF Pond embankment. A summary of phreatic conditions is presented in **Table 2**.

Table 2 – Phreatic Water Conditions

Exploration ID	Surface Elevation (ft. NAVD88)[1]	Phreatic Water Depth (ft.)[2]
COF-C048	622.4	10
COF-C049	631.3	11
COF-C050	631.3	8
COF-C051	627.0	7.5
COF-C052	631.0	11
COF-C053	630.9	8.8
COF-C054	626.1	12.2
COF-C055	623.9	7.8

1. Elevations are estimated, and assumed accurate to ±2 ft
2. Depths are below ground surface

4. SUMMARY OF LABORATORY TESTING

Laboratory testing was not performed for soils at the GMF Pond. Based on an evaluation of the CPT soundings, the embankment and foundation soils at the GMF Pond were judged by AECOM to be very similar to the soils at AP1 and AP2, where AECOM did conduct laboratory testing. To develop soils strength properties for analysis, AECOM evaluated undrained shear strengths from the GMF Pond CPTs and compared them to the design shear strengths developed at AP1. This correlation generally showed similar or higher shear strengths at the GMF Pond than at AP1. However, potentially lower shear strengths were identified in some localized areas in the GMF Pond foundation, and the design shear strengths for these areas were reduced as appropriate.

Laboratory data and material characterization for AP1 and AP2 can be found in the geotechnical reports for those CCR Units. The correlation and development of design shear strength values for the GMF Pond can be found in **Attachment C**.

5. SLOPE STABILITY ANALYSES

Slope stability analyses were performed for varying loading conditions at selected cross-sections, as described in the following sub-sections. Analysis section development, soil material properties, and seismic analyses related to the slope stability analysis are also discussed in the following sub-sections.

5.1. ***Cross-Sections for Analysis***

Four cross sections were identified for the stability evaluation of the GMF Pond perimeter embankments. Because the foundation conditions underneath the embankments were fairly uniform, the analysis section for each embankment was selected based on the maximum height of the embankment along each of the four sides of the GMF Pond. The location of each analysis section is listed below and shown on **Figure 2** in **Attachment A**.

- Station 13+50: East embankment
- Station 22+50: North embankment
- Station 46+50: West embankment
- Station 58+00: South embankment

The section geometry for each analysis cross-section was determined based on the ground surface topographic and bathymetric contours shown on **Figure 2 (Attachment A)** and subsurface information from the CPT soundings. The piezometric surfaces for each analysis section were estimated based on PPD tests from the CPT soundings

5.2. *Stability Analysis Conditions Considered*

Consistent with the criteria provided in the USEPA CRR Rule § 257.73(e), the stability of the GMF Pond embankment was evaluated for four load cases:

Static, Steady-State, Normal Pool Condition*:* This case models the embankment under static, long-term conditions, at normal water elevation within the impoundment of El. 621.2 feet, as listed in AECOM's hydrologic and hydraulic report (AECOM, 2016) for the GMF Pond. Drained (effective stress) shear strength parameters were used for all materials, and phreatic conditions were estimated based on available piezometer and CPT pore pressure data. ***Target Factor of Safety of 1.50.***

Static, Maximum Surcharge Pool Condition: This case models the conditions under a short-term surcharge pool elevation of 623.8 feet, as listed in AECOM's hydrologic and hydraulic report (AECOM, 2016) for the GMF Pond. Drained (effective stress) shear strength parameters were used for all materials in this analysis. This is because the increase in flood pool is relatively small (2.6 feet) and is not expected to result in the development of undrained conditions in the downstream embankment slope or foundation soils, which is where the critical slip surface from the normal pool condition was found. Therefore, the use of drained soil strengths is appropriate. Due to the presence of a liner, the phreatic surface within the embankment and foundation was assumed to be the same as the steady-state condition analysis; however, the pool level within the GMF Pond was increased to model the additional surcharge. ***Target Factor of Safety of 1.40.***

Seismic Slope Stability Analysis: These analyses incorporate a horizontal seismic coefficient k_h selected to be representative of expected loading during the design earthquake event (i.e., a "pseudostatic" analysis). Seismic loads were taken from a probabilistic seismic hazard analysis (PSHA) and dynamic response analyses performed by AECOM for Coffeen Ash Pond No. 1, as the embankments are similar and located close to the GMF Pond. The analyses utilized peak undrained strength parameters for the embankment and foundation soils due to the fine grained nature of these materials. The phreatic surface and pore water pressures corresponding to the steady state pool from the static analyses were utilized. ***Target Factor of Safety of 1.00***.

Post-Liquefaction Condition: Liquefaction triggering analyses (see **Section 5.4.3**) identified the presence of soils susceptible to cyclic softening within the foundation at the GMF Pond. The triggering analyses did not identify soils susceptible to liquefaction or cyclic softening within the GMF Pond dikes. Therefore, a post-earthquake (i.e. liquefaction triggering) slope stability analysis is not required per §257.73(e), as the dike soils are not susceptible to liquefaction. However, a post-earthquake slope stability analysis was performed to evaluate the effects of cyclic softening within the foundation at the GMF Pond, in order to support the evaluation of foundation stability, per §257.73(d)(1)(i). The target factor of safety for post-earthquake analysis listed in §257.73(e) of 1.20 was also used as the target factor of safety for this analysis, as §257.73(d)(1)(i) does not specify a minimum factor of safety for post-earthquake slope stability analysis. No horizontal seismic coefficient is included in these analyses, but selection of strength parameters for the analyses takes into account the potential for softening/ weakening of the soils as a result of cyclic softening in clay-like materials due to the earthquake shaking. Sluiced CCRs retained by the dikes were assumed to liquefy for this analysis, although these materials are not located within the dikes themselves or within the foundation. ***Target Factor of Safety of 1.20.***

5.3. ***Material Properties***

Material properties for the GMF Pond were based on material properties for AP1, which were based on laboratory test data. In order to evaluate potential variations in shear strength between the GMF Pond and AP1, AECOM developed profiles of undrained shear strength vs. depth, based on CPTs advanced at the GMF Pond. The resulting undrained shear strengths were then compared, vs. depth, to the design shear strengths developed for AP1.

Typically, the correlated shear strengths at the GMF Pond were similar to or higher than the shear strengths for the same materials at AP1. Zones of potential lower-strength material were identified at CPTs COF-C049 and COF-C052 (used at cross-sections 22+50 and 58+00, respectively), in the foundation clay and soft clay. At these locations, the design peak undrained and post-earthquake undrained shear strengths were reduced as appropriate to better match undrained shear strength correlated from the CPTs.

Design drained shear strengths were taken directly from AP1. However, the AP1 strengths for embankment fill and foundation clay (under embankment) used a nonlinear failure envelope at lower effective stresses in order to account for the effects of overconsolidation. These nonlinear failure envelopes, based on laboratory test data, predict higher shear strengths at lower effective stresses than a typical linear failure envelope. As laboratory testing was not performed for the GMF Pond by AECOM in 2015, the same drained strength friction angles as were used from AP1, but were assumed to be fully linear with no cohesion. Shear strength reduction factors developed from the CPTs were not applied to drained shear strengths, as the use of the linear failure envelope was assumed to be sufficient to account for variations in drained shear strength between the GMF Pond and AP1. The specified dike compaction for construction of the GMF Pond was 95% of the standard Proctor (ASTM D698), per the construction specifications for the facility (Hanson, 2008), which is supported by the high tip resistances in the CPT data collected by AECOM.

Design shear strength values for cross-sections 13+50 and 46+50 are listed in **Table 3**. Design shear strength values for cross-section 22+50 are listed in **Table 4** and design shear strengths for cross-section 58+00 are listed in **Table 5**.

As discussed in the AP1 geotechnical report, separate shear strengths were used for the foundation clay beneath the embankment (based on CIU' triaxial tests) and the foundation clay near and beyond the toe of the embankment (based on direct simple shear [DSS] tests). Within the foundation clay, the boundary between the two different strengths was iterated during the slope stability analysis based on the orientation of the slip surface. DSS strengths were assigned for the near-horizontal portions of the slip surface under and downstream of the embankment while CIU strengths were assigned for inclined portions of the slip surface where it is dipping into the foundation clay.

Table 3 – Design Shear Strengths, Sta. 13+50 and 46+50

		Peak Drained Shear Strength		Peak Undrained Shear Strength	Post-Earthquake Shear Strength
Material	Unit weight (pcf)	Cohesion, c' (psf)	Friction Angle, ϕ' (degrees)	Su/P'	Su/P'
Ash	112	0	31	0.40	0.05
Embankment	135	0	31	Su/p' = 0.60 Minimum Su = 450 psf	Peak Undrained
Foundation Clay	125	0	Below Embankment: ϕ' = 32 Free-Field: ϕ' = 30	Below Embankment: Su/p' = 0.45 Minimum Su = 700 psf Free-Field: Su/p' = 0.28 Minimum Su = 450 psf	Peak Undrained
Soft Clay Foundation	125	0	30	Su/p' = 0.28 Minimum Su = 275 psf	Su/p' = 0.16 Minimum Su = 200 psf
Till	135	0	40	Su/p' = 0.45 Minimum Su = 700 psf	Peak Undrained

Table 4 – Design Shear Strengths, Sta. 22+50

		Peak Drained Shear Strength		Peak Undrained Shear Strength	Post-Earthquake Shear Strength
Material	Unit weight (pcf)	Cohesion, c' (psf)	Friction Angle, ϕ' (degrees)	Su/P'	Su/P'
Ash	112	0	31	0.40	0.05
Embankment	135	0	31	Su/p' = 0.60 Minimum Su = 450 psf	Peak Undrained
Foundation Clay	125	0	Below Embankment: ϕ' = 32 Free-Field: ϕ' = 30	Below Embankment: Su/p' = 0.39 Minimum Su = 700 psf Free-Field: Su/p' = 0.24 Minimum Su = 450 psf	Peak Undrained
Soft Clay Foundation	125	0	30	Su/p' = 0.22 Minimum Su = 275 psf	Su/p' = 0.13 Minimum Su = 200 psf
Till	135	0	40	Su/p' = 0.45 Minimum Su = 700 psf	Peak Undrained

Table 5 – Design Shear Strengths, Sta. 58+00

		Peak Drained Shear Strength		Peak Undrained Shear Strength	Post-Earthquake Shear Strength
Material	Unit weight (pcf)	Cohesion, c' (psf)	Friction Angle, ϕ' (degrees)	Su/P'	Su/P'
Ash	112	0	31	0.40	0.05
Embankment	135	0	31	Su/p' = 0.60 Minimum Su = 450 psf	Peak Undrained
Foundation Clay	125	0	Below Embankment: ϕ' = 32 Free-Field: ϕ' = 30	Below Embankment: Su/p' = 0.39 Minimum Su = 700 psf Free-Field: Su/p' = 0.24 Minimum Su = 450 psf	Peak Undrained
Soft Clay Foundation	125	0	30	Su/p' = 0.23 Minimum Su = 275 psf	Su/p' = 0.13 Minimum Su = 200 psf
Till	135	0	40	Su/p' = 0.45 Minimum Su = 700 psf	Peak Undrained

5.4. ***Methodology of Analyses***

Limit equilibrium stability analysis was completed using the two-dimensional Slope/W (v. 8.15.1.11236 by GeoStudio) computer program. Factors of safety were calculated with Spencer's method circular search routines to determine the critical failure surface for each analysis section and load case. The circular search routines included the optimization option, which allows the program to develop non-circular sliding planes through soft layers for the final solution. Slip surfaces which intersected the embankment crest and could result in a release of CCR materials were analyzed. Pore pressures were assigned as hydrostatic pressure under the piezometric line.

A brief summary of the analyses is presented in the following sections.

5.4.1. *Static Analysis Conditions*

Static stability was evaluated for steady-state conditions using a normal pool elevation of 621.2 feet, as found from the August 17th, 2015 LIDAR survey data for the GMF Pond performed by Weaver Consultants. A pool elevation of 623.8 feet was assumed for maximum surcharge pool loading, which corresponds to the Probable Maximum Flood pool level for the GMF Pond. Both pool levels are discussed in more detail in AECOM's hydrologic and hydraulic report for the GMF Pond (AECOM, 2016).

Conditions analyzed for slope stability analyses are summarized in **Section 5.2**. A more detailed description can be found in **Attachment C**.

5.4.2. *Earthquake Analysis Conditions*

Seismic conditions for the GMF Pond were the same as those used for AP1. As previously mentioned, a PSHA and dynamic response analysis were performed for AP1 to estimate seismic accelerations. The PSHA is applicable to the entire Coffeen site, including the GMF Pond, as seismic hazard is unlikely to vary appreciably over the short distance between Ash Pond No. 1 and the GMF Pond. Based on the 2015 CPT soundings, the foundation and embankment materials of the GMF Pond were judged to be similar to those found at AP1, while the embankment heights of the GMF Pond are considerably lower than AP1. Therefore, results obtained from the AP1 dynamic response analysis can be reasonably applied the GMF Pond, as the lower embankment height of the GMF Pond likely results in less amplification of ground motions than AP1. Details of these analyses can be found in AECOM's AP1 geotechnical report.

5.4.3. *Liquefaction Triggering Analysis*

A liquefaction triggering analysis was conducted to evaluate the potential for liquefaction or cyclic softening under the 2,500-year event in the dike and foundation soils. The analysis consists of comparing the calculated cyclic resistance ratio (CRR) from the CPT soundings to the cyclic stress ratio (CSR) calculated from a simplified site response analysis as described in Idriss and Boulanger (2008, 2014). The ratio of CRR to CSR is the triggering factor of safety. CRR values were calculated for liquefaction resistance of sand-like materials or for cyclic softening resistance of clay-like materials. CSR values were calculated using empirical correlations in the triggering analysis based on earthquake magnitude and site-specific PGA values at the ground surface. All of the CPT soundings advanced at the GMF Pond were evaluated for liquefaction triggering potential.

Details of the liquefaction triggering analysis are provided in **Attachment D**.

6. RESULTS

6.1. *Results of Static Stability Analyses*

The results of the limit equilibrium slope stability analyses for the static load cases are summarized in **Table 6**. The Slope/W output figures showing the slip surfaces and details of the analyses are included in **Attachment C**.

Table 6 – Summary of Minimum Slope Stability Factors of Safety for Static Load Cases

Load Case	Program Criteria	Station 13+50	Station 22+50	Station 46+50	Station 58+00
Steady State (Normal Pool)	FS ≥ 1.50	3.45	3.48	4.19	3.57
Surcharge Pool (Flood Pool)	FS ≥ 1.40	3.45	3.48	4.19	3.57

6.2. *Results of Earthquake Stability Analyses*

6.2.1. *Liquefaction Triggering Analysis*

The liquefaction triggering analysis found that the embankment fill, foundation clay, and glacial till soils are not susceptible to liquefaction or cyclic softening during the design seismic event. This means that the soils comprising the dike are not susceptible to liquefaction.

However, the liquefaction triggering analysis found that the soft clay layer, and the transition zone between the soft clay layer and underlying glacial till, is susceptible to cyclic softening or liquefaction during the design seismic event. The soft clay layer and transition zone are located within the foundation of the GMF Pond, between the bottom of the foundation clay and the top of the glacial till. The fines content of this material varies, and thus it may be susceptible to either liquefaction or cyclic softening, both of which represent post-earthquake strength losses. In addition, the CPT data indicate residual undrained strengths for this material that are well below the correlated peak undrained strengths, which confirms the potential for cyclic softening. This material was therefore assigned residual strengths in the post-liquefaction slope stability analysis load case.

Retained gypsum within the impoundment was assumed to liquefy during the design seismic event. A post-liquefaction residual shear strength ratio (S_r/s'_{vo}) of 0.05 was assigned for this material, based on AECOM's experience. This corresponds to a lower-bound residual shear strength for a granular material. As subsurface explorations were not performed in the gypsum, due to the potential for damaging the pond's liner system during sampling, the actual liquefaction susceptibility of the material is not known, and the conservative lower-bound strengths were selected for analysis.

Based on the results of the liquefaction triggering analyses, post-earthquake (i.e. liquefaction) slope stability analyses were performed using peak undrained strengths in the embankment fill, foundation clay, and glacial till (as these soils are not susceptible to liquefaction), residual strengths in the soft clay layer and transition layer within the foundation (as this soil is susceptible to either liquefaction or cyclic softening), and residual strengths in the gypsum within the GMF Pond.

6.2.2. *Seismic and Post-Liquefaction Stability Analysis*

The results of the slope stability analyses for the seismic load cases are summarized in **Table 7**. The Slope/W output figures showing the slip surfaces and details of the analyses are included in **Attachment C**.

Table 7 – Summary of Minimum Slope Stability Factors of Safety for Earthquake Load Cases

Load Case	Program Criteria	Station 13+50	Station 22+50	Station 46+50	Station 58+00
Seismic (Pseudostatic)	FS ≥ 1.00	1.61	1.47	1.76	1.66
Post-Liquefaction	FS ≥ 1.20	2.46	2.46	3.02	2.61

7. CONCLUSIONS

The calculated factors of safety from the limit equilibrium slope stability analysis satisfy the USEPA CCR Rule § 257.73(e) requirements for all the load cases analyzed at the critical analysis sections for each of the embankments that comprise the perimeter of the GMF Pond. Load cases analyzed for this study included static (steady-state) normal pool, maximum flood surcharge pool, seismic (pseudo-static), and static post-liquefaction.

8. LIMITATIONS

Background information, design basis, and other data have been furnished to AECOM by the CCR unit owner. AECOM has used this data in preparing this report. AECOM has relied on this information as furnished, and is not responsible for the accuracy of this information.

Borings and CPT soundings have been spaced as closely as economically feasible, but variations in soil properties between borings, that may become evident at a later date, are possible. The conclusions developed in this report are based on the assumption that the subsurface soil, rock, and phreatic water conditions do not deviate appreciably from those encountered in the site-specific exploratory borings. If any variations or undesirable conditions are encountered in any future exploration, we should be notified so that additional analyses can be made, if necessary.

The conclusions presented in this report are intended only for the purpose, site location, and project indicated. The recommendations presented in this report should not be used for other projects or purposes. Conclusions or recommendations made from these data by others are their responsibility. The conclusions and recommendations are based on AECOM's understanding of current plant operations, maintenance, stormwater handling, and ash handling procedures at the station, as provided by the CCR unit owner. Changes in any of these operations or procedures may invalidate the findings in this report until AECOM has had the opportunity to review the changes, and revise the report if necessary.

This geotechnical investigation was performed in accordance with the standard of care commonly used as state-of-practice in our profession. Specifically, our services have been performed in accordance with accepted principles and practices of the geological and geotechnical engineering profession. The conclusions presented in this report are professional opinions based on the indicated project criteria and data available at the time this report was prepared. Our services were provided in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation is intended.

9. REFERENCES

AECOM (2016). *Geotechnical Report for Coffeen Power Station, Ash Pond No. 1.*

Ameren Energy Generating Company (2008). *Coffeen Power Plant Gypsum Management Facility Dam Permit Application.*

Hanson Professional Services (2007). *Project Specifications, Gypsum Stack and recycle Pond Construction, Gypsum Management Facility, Coffeen Power Station, Montgomery County, Illinois.* January, 2008.

Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction during Earthquakes.* Earthquake Engineering Research Institute, MNO-12.

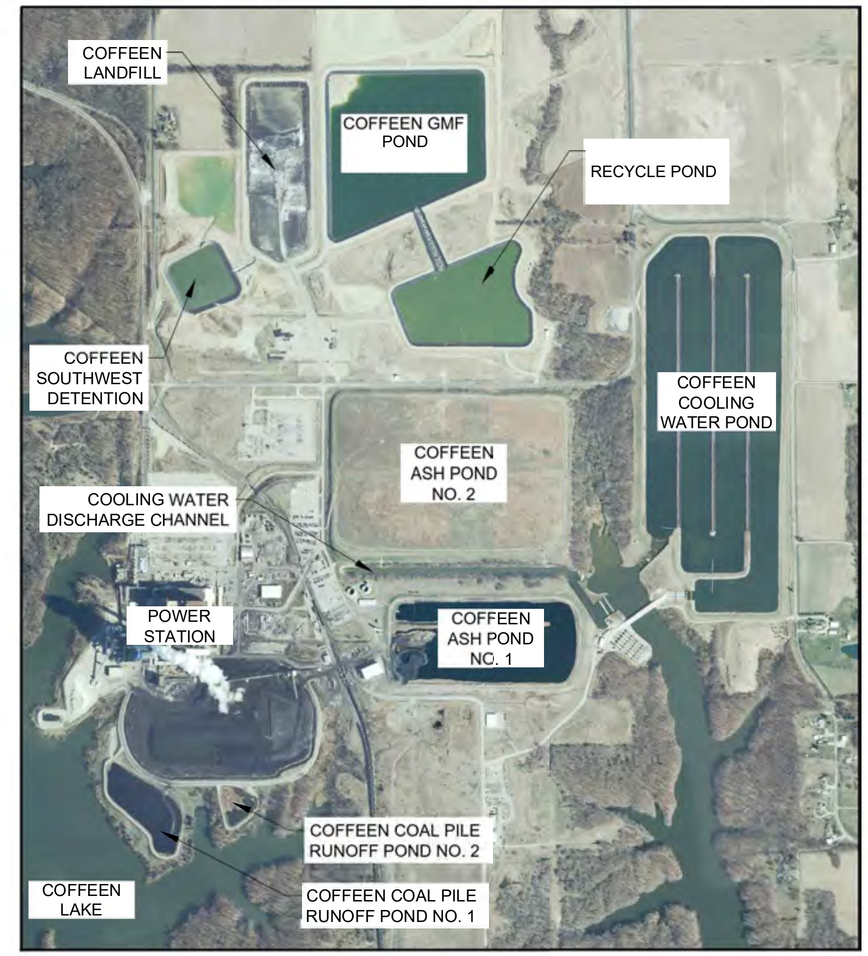
Weaver Consultants Group (2015). *Coffeen 2015 Aerial Topography, Existing Site Conditions*

Hanson Professional Services Inc. (2007), *Application for Development Permit Water Treatment Devices Coal Combustion By-Product Management Facility, Ameren Coffeen Power Station, Montgomery County, Illinois*

Ameren Energy Generating (2008), *Gypsum Stack, Cell G-1, Coal Combustion By-Product Management Facility, Ameren Coffeen Power Station, Montgomery County, Illinois*

Attachment A. Figures

LOCATION MAP
NOT TO SCALE



VICINITY MAP
NOT TO SCALE

AECOM
1001 Highlands Plaza Drive, Suite 300
St. Louis, Mo. 63110
314 429-0100 (phone)
314-429-0462 (fax)

DYNEGY
Dynegy Inc.
1500 East Port Plaza Drive
Collinsville, IL 62234

CCR RULE ASSESSMENT OF PLANTS

COFFEEN STATION
MONTGOMERY COUNTY, ILLINOIS

GEOTECHNICAL REPORT
GMF POND

ISSUED FOR BIDDING — DATE BY

ISSUED FOR CONSTRUCTION — DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	
DRAWN BY:	GJH
DESIGNED BY:	EJV
CHECKED BY:	MCR
DATE CREATED:	12/23/2015
PLOT DATE:	2/9/2016
SCALE:	AS SHOWN
ACAD VER:	2014

SHEET TITLE

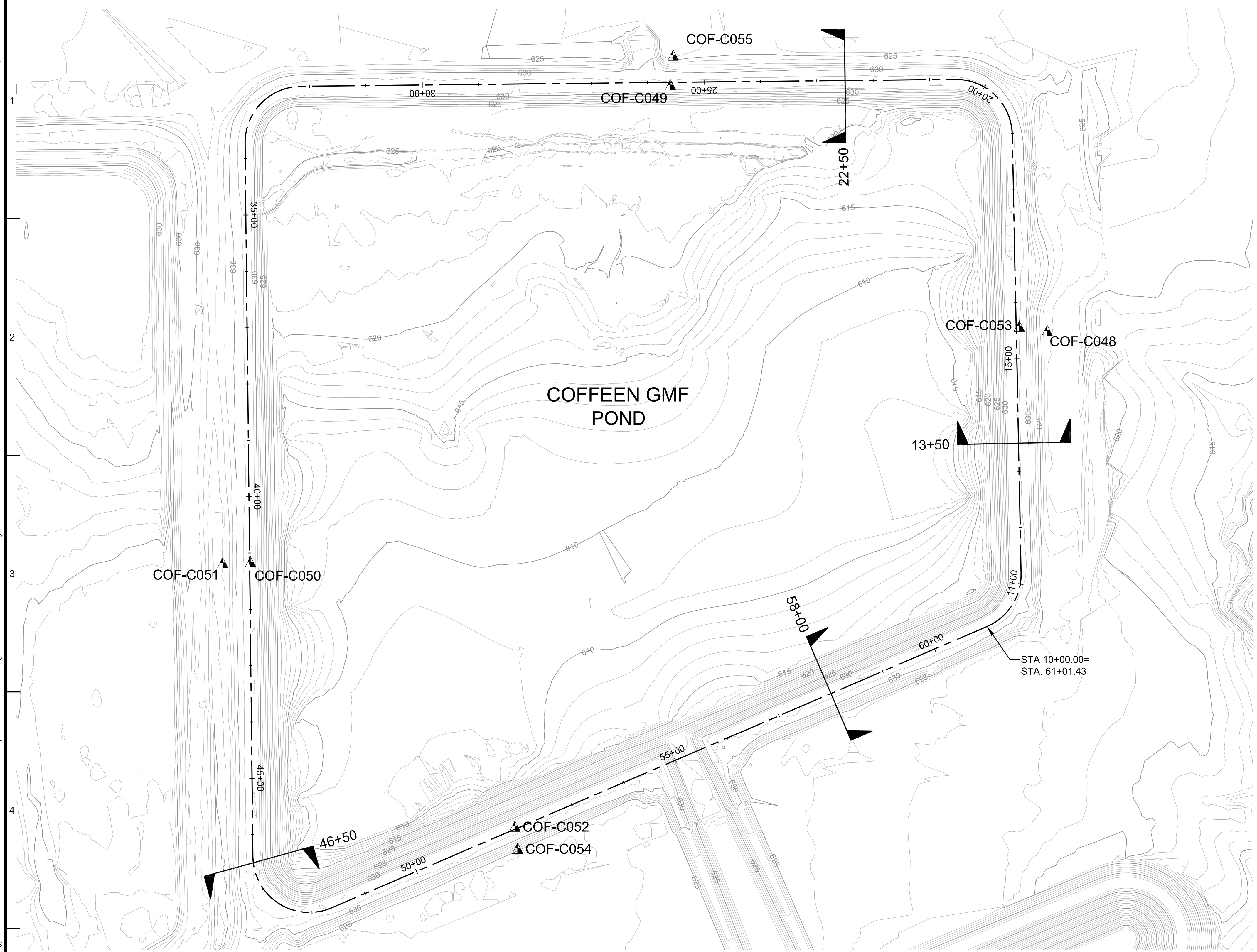
LOCATION MAP & SITE VICINITY MAP

Figure 1

SHEET OF

SMITH, CURT 2/9/2016 11:40 AM

DRAWING PATH: P:\Projects\Geotech\60427794_Dynegy\CCR\04Tasks\01 Coffeen Tasks\7.0_CAD_GIS\7.09_Exhibits\Exploration Location Plans\COF-POND-1-EXPLORATION_02072016.dwg



NOTES:

1. CONTOURS ARE 1 FOOT ELEVATION INTERVALS.
2. SURVEY BENCHMARKS WILL BE PROVIDED BY THE OWNER.
3. GROUND CONTOURS SOURCES: FINAL RESULTS OF SURVEY BY WEAVER CONSULTANTS DATED AUGUST 17 2015
4. BATHYMETRIC CONTOURS SOURCE: SURVEY BY WEAVER CONSULTANTS GROUP DATED SEPTEMBER 2015.

LEGEND

COF-C000 — AECOM CONE PENETROMETER TESTING LOCATION

STUDY SECTION

N

0 100 200 300
SCALE IN FEET

AECOM
8181 East Tufts Avenue
Denver, Co. 80237-2579
303 694-2770 (phone)
303-694-3946 (fax)

DYNEGY
Dynegy Inc.
1500 East Port Plaza Drive
Collinsville, IL 62234

CCR RULE ASSESSMENT OF PLANTS

COFFEEN STATION
MONTGOMERY COUNTY, ILLINOIS

GEOTECHNICAL REPORT
GMF POND

ISSUED FOR BIDDING — DATE BY

ISSUED FOR CONSTRUCTION — DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	60440742
DRAWN BY:	GJH
DESIGNED BY:	EJV
CHECKED BY:	MCR
DATE CREATED:	12/23/2015
PLOT DATE:	11/18/2015
SCALE:	AS SHOWN
ACAD VER:	2014

SHEET TITLE

EXPLORATION AND CROSS SECTION LOCATIONS

Figure 2

SHEET OF

Attachment B. GMF Pond CPT Soundings

Cone Penetration Test Summary and

Standard Cone Penetration Test Plots

ConeTec report modified by AECOM to include
only CPT data relating to Coffeen GMF Stack Pond

Job No:	15-53063
Client:	AECOM
Project:	Coffeen Power Station, Coffeen, IL
Start Date:	04-Aug-2015
End Date:	11-Aug-2015

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (ft)	Final Depth (ft)	Shear Wave Velocity Tests	Northing[2] (m)	Easting (m)	Refer to Notation Number
COF-C048	15-53063_CP48	11-Aug-2015	374:T1500F15U500	0.0	20.01		4327303	292909	5
COF-C049	15-53063_SP49	07-Aug-2015	335:T1500F15U500	9.5	25.75	2	4327443	292710	
COF-C050	15-53063_CP50	07-Aug-2015	335:T1500F15U500	9.7	23.95		4327193	292474	
COF-C051	15-53063_SP51	11-Aug-2015	374:T1500F15U500	4.3	20.18	3	4327193	292459	
COF-C052	15-53063_SP52	07-Aug-2015	335:T1500F15U500	9.6	26.90	3	4327045	292612	5
COF-C053	15-53063_SP53	07-Aug-2015	335:T1500F15U500	12.8	53.64	10	4327306	292894	
COF-C054	15-53063_CP54	11-Aug-2015	374:T1500F15U500	2.2	65.62		4327033	292613	5
COF-C055	15-53063_SP55	11-Aug-2015	374:T1500F15U500	2.3	18.87	3	4327459	292712	

ConeTec

AECOM

Job No: 15-53063
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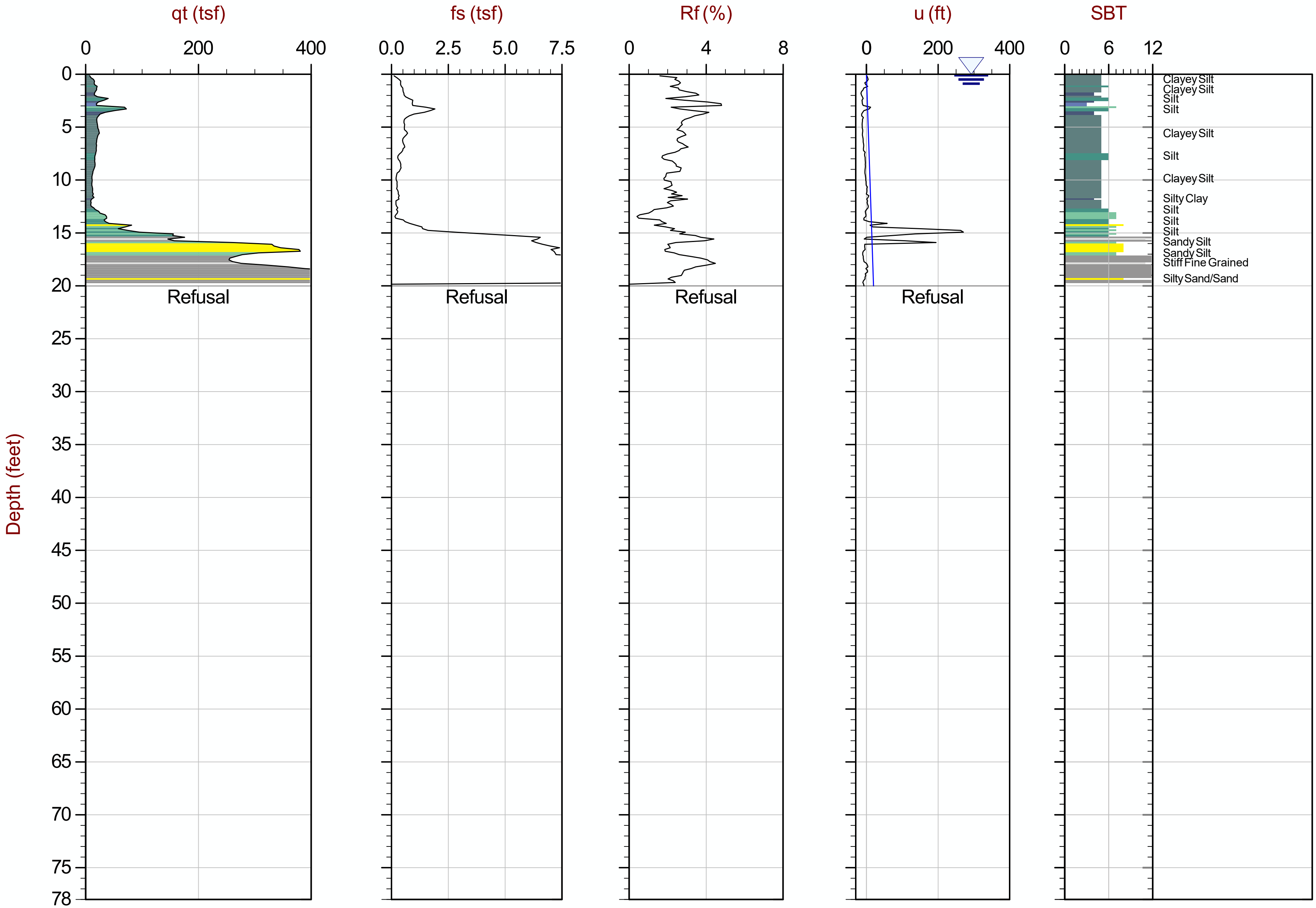
Sounding: COF-C048
Cone: 374:T1500F15U500



Max Depth: 6.100 m / 20.01 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP48.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327303m E: 292909m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

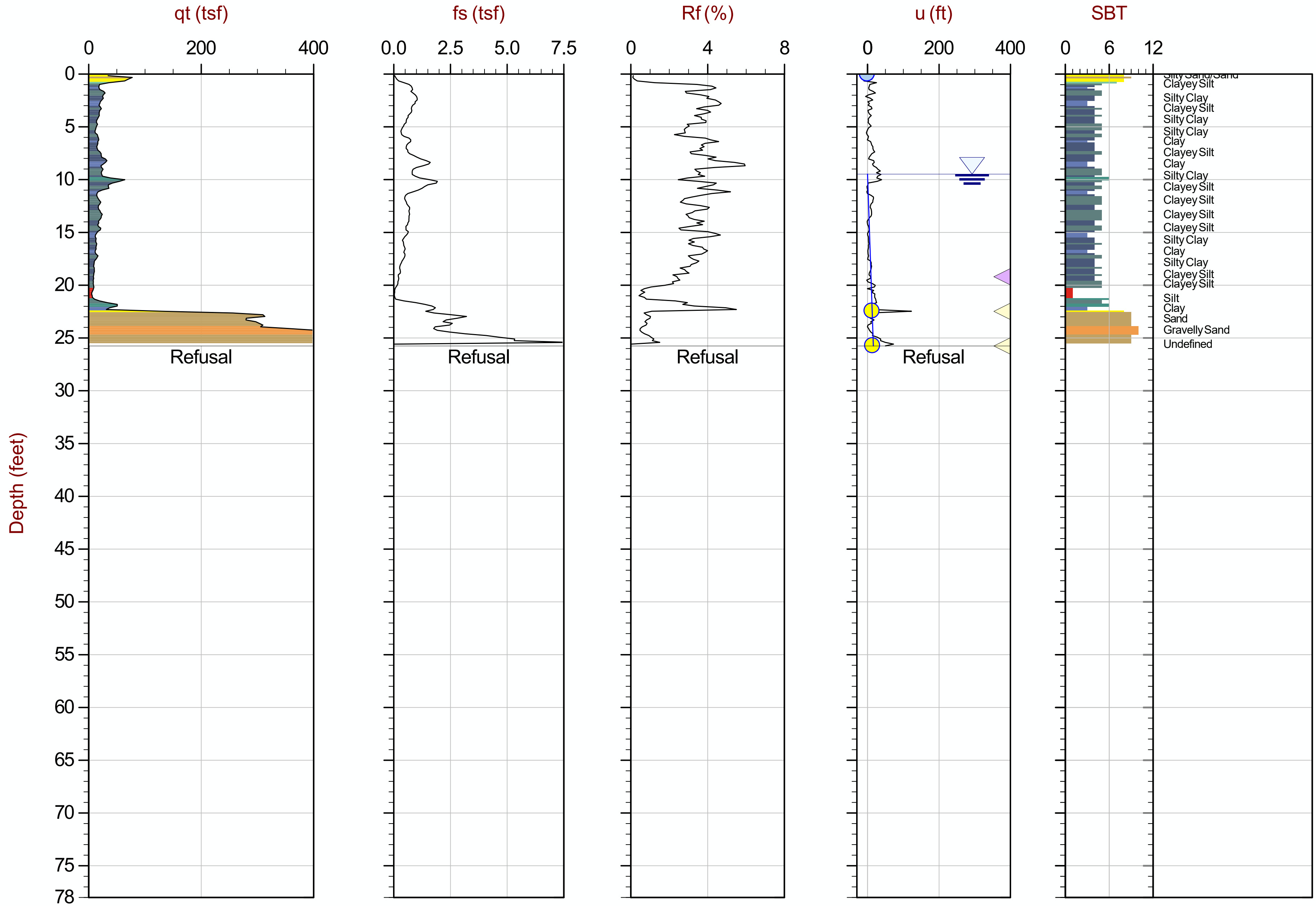
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:07:15 12:14
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335:T1500F15U500



Max Depth: 7.850 m / 25.75 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP49.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327443m E: 292710m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

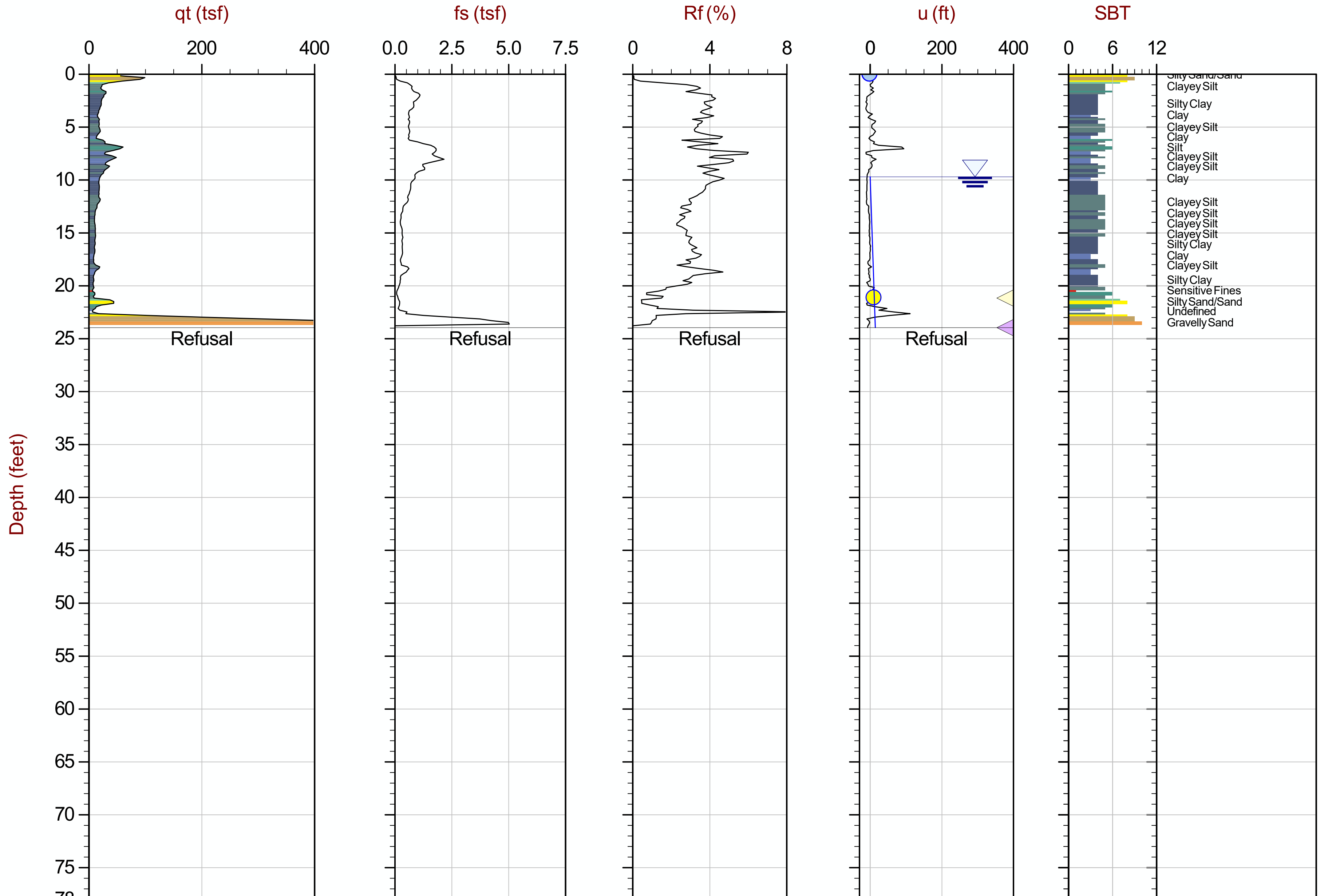
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 13:50
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C050
Cone: 335:T1500F15U500



Max Depth: 7.300 m / 23.95 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP50.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327193m E: 292474m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

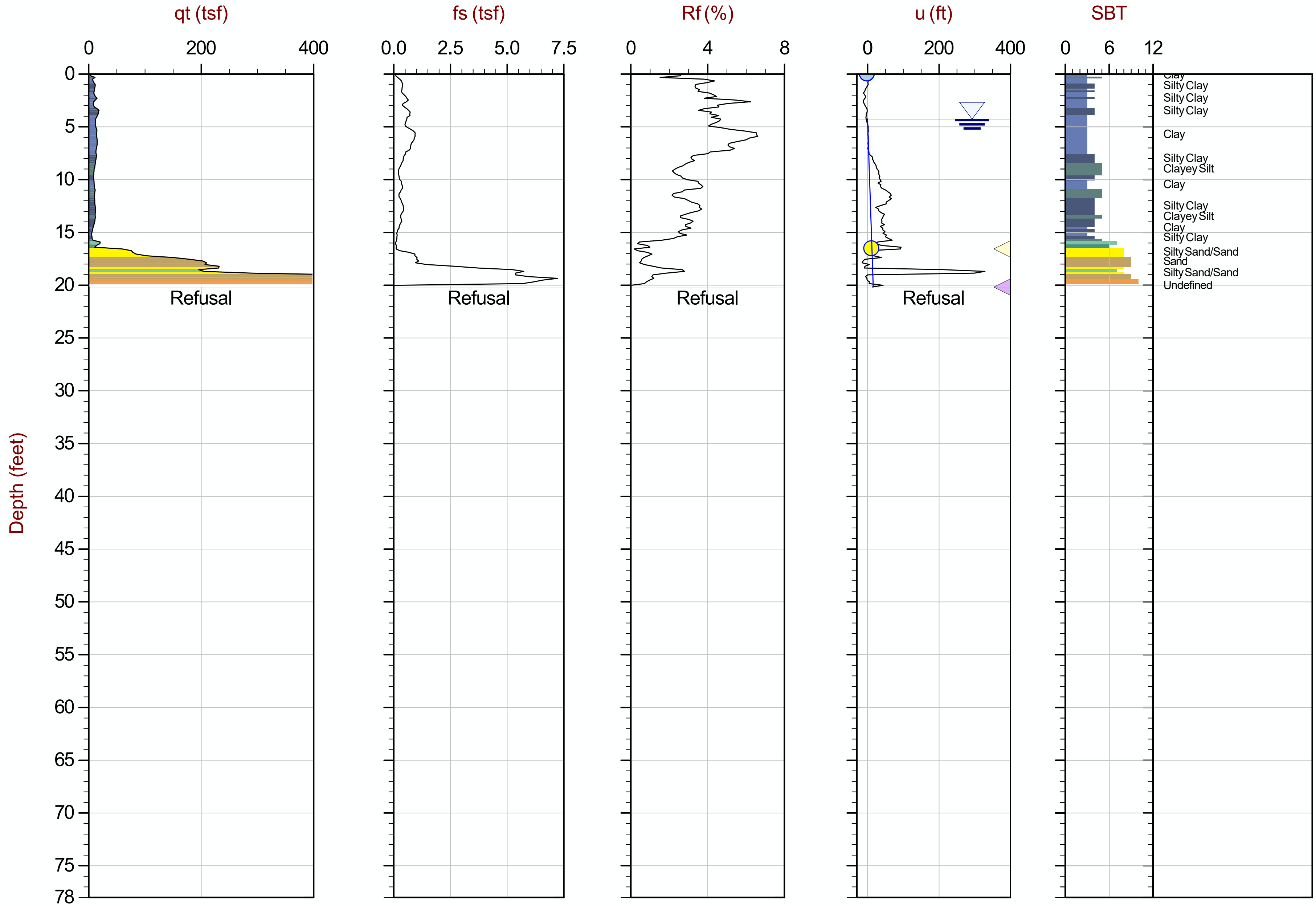
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:11:15 08:45
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C051
Cone: 374:T1500F15U500



Max Depth: 6.150 m / 20.18 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP51.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327193m E: 292459m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

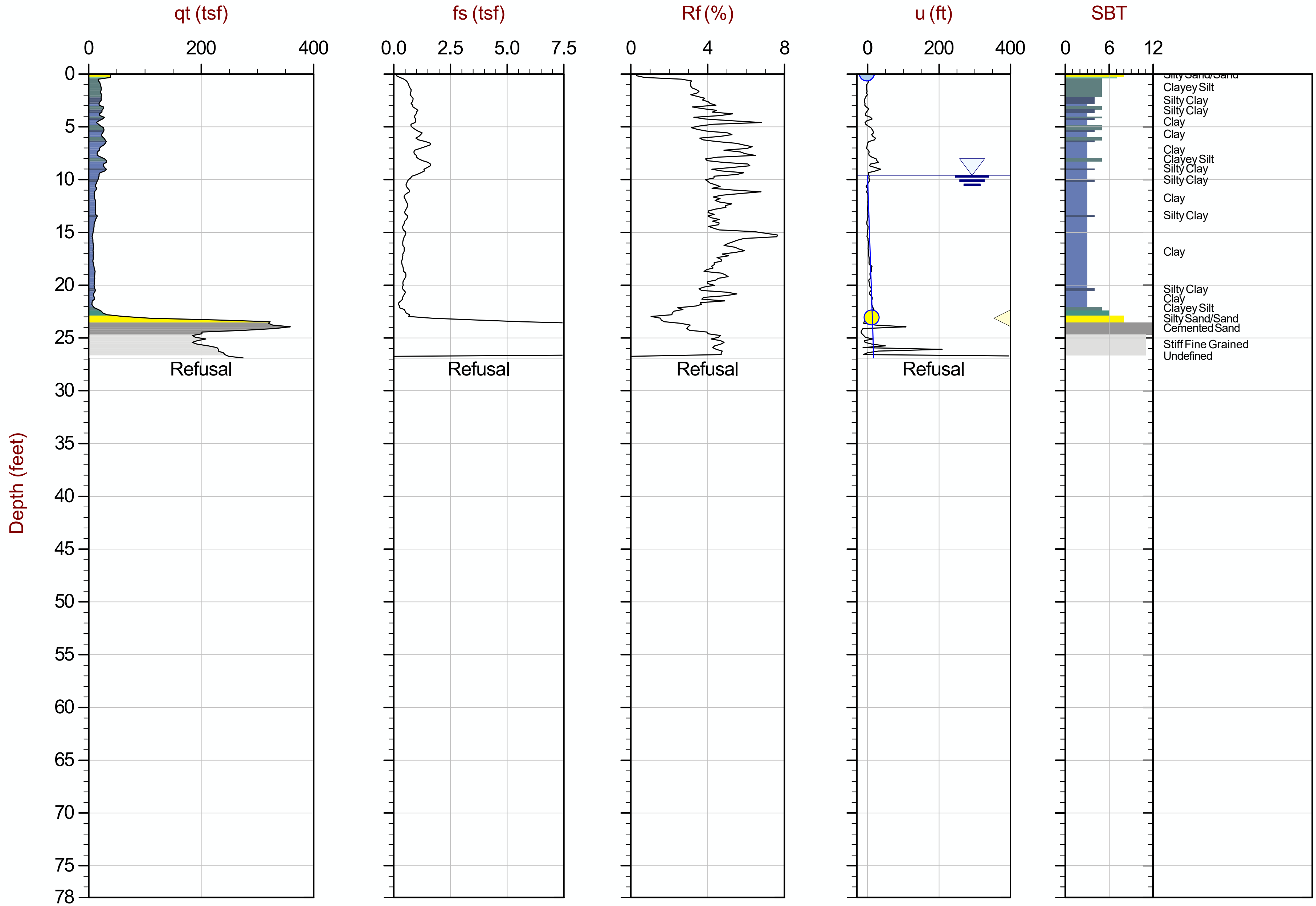
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 15:53
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C052
Cone: 335:T1500F15U500



Max Depth: 8.200 m / 26.90 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP52.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327045m E: 292612m

Hydrostatic Line Ueq Assumed Ueq PPD, Ueq achieved PPD, Ueq not achieved

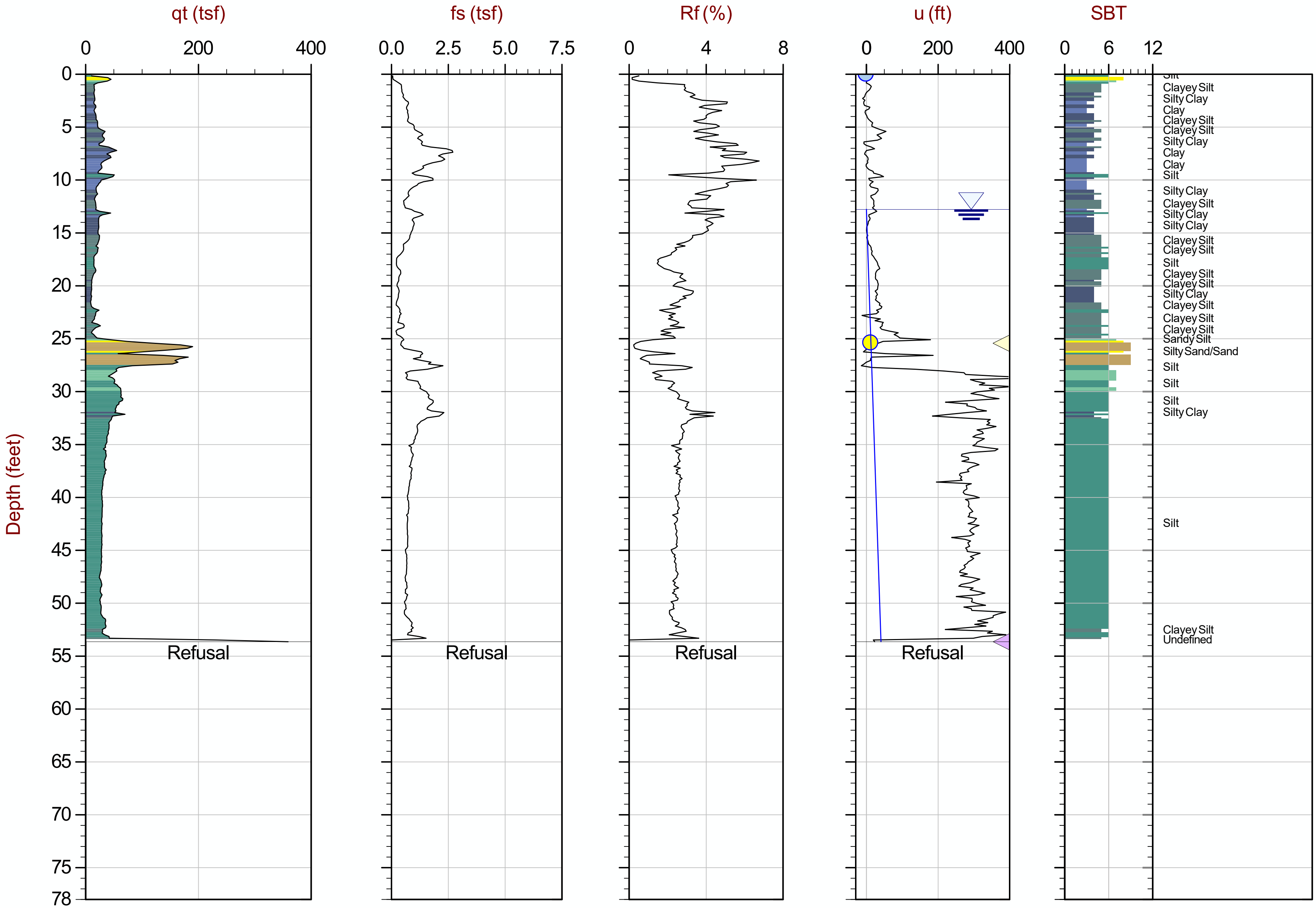
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 10:02
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C053
Cone: 335:T1500F15U500



Max Depth: 16.350 m / 53.64 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP53.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327306m E: 292894m

Hydrostatic Line ● Ueq ● Assumed Ueq ◁ PPD, Ueq achieved ◁ PPD, Ueq not achieved

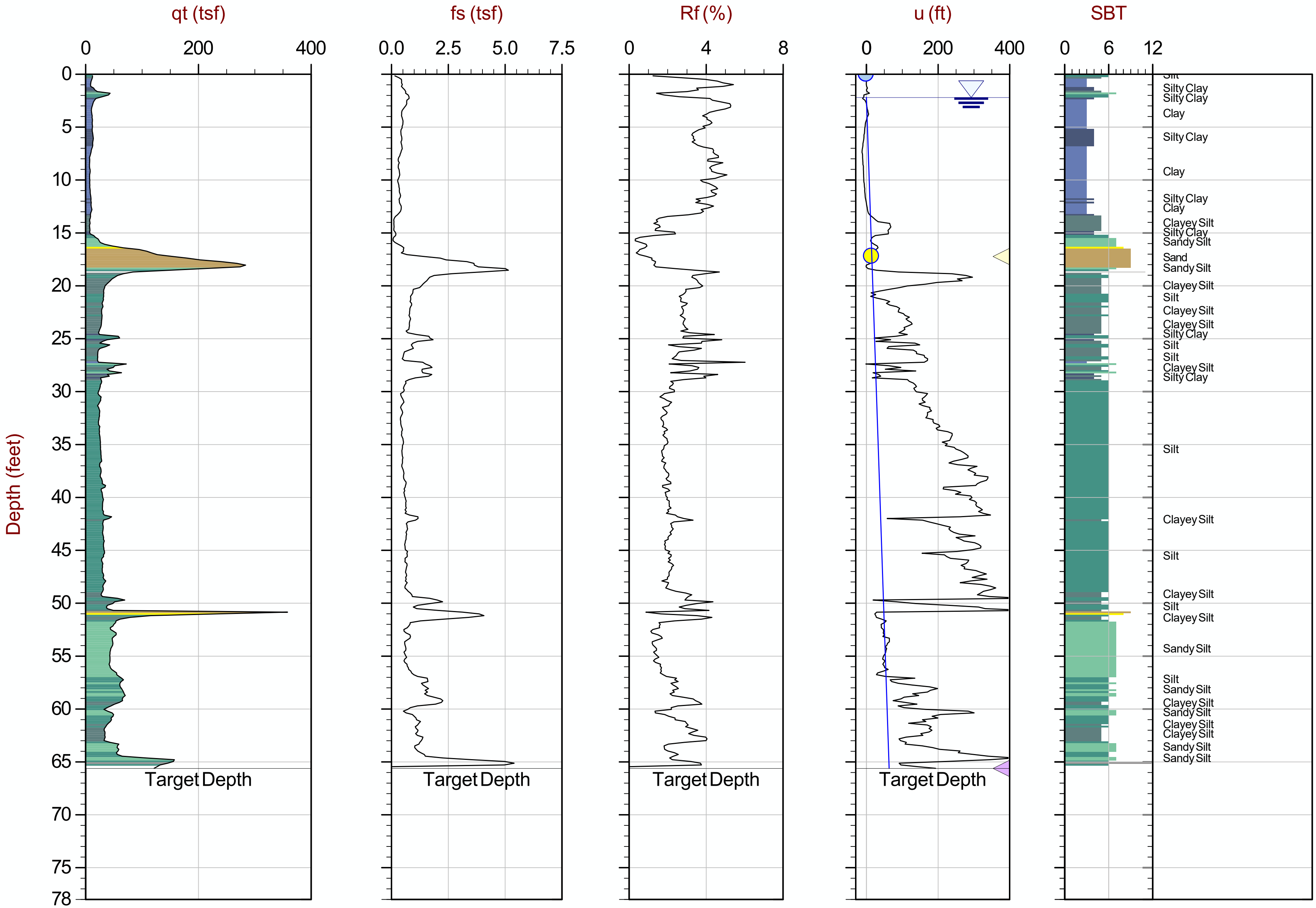
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

AECOM

Job No: 15-53063
Date: 08:11:15 13:04
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C054
Cone: 374:T1500F15U500



Max Depth: 20.000 m / 65.62 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_CP54.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327033m E: 292613m

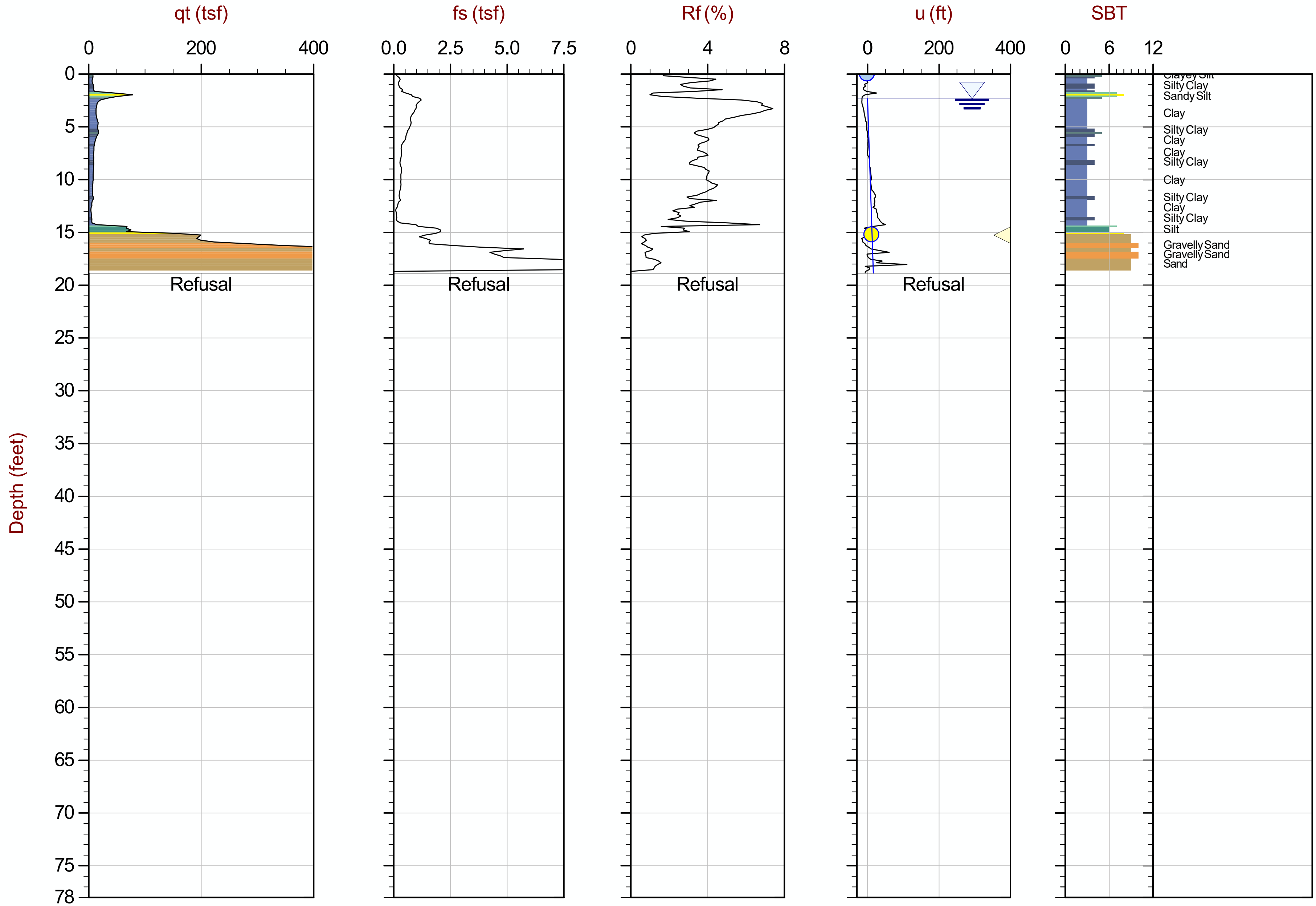
Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:11:15 10:39
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C055
Cone: 374:T1500F15U500



Max Depth: 5.750 m / 18.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP55.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327459m E: 292712m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

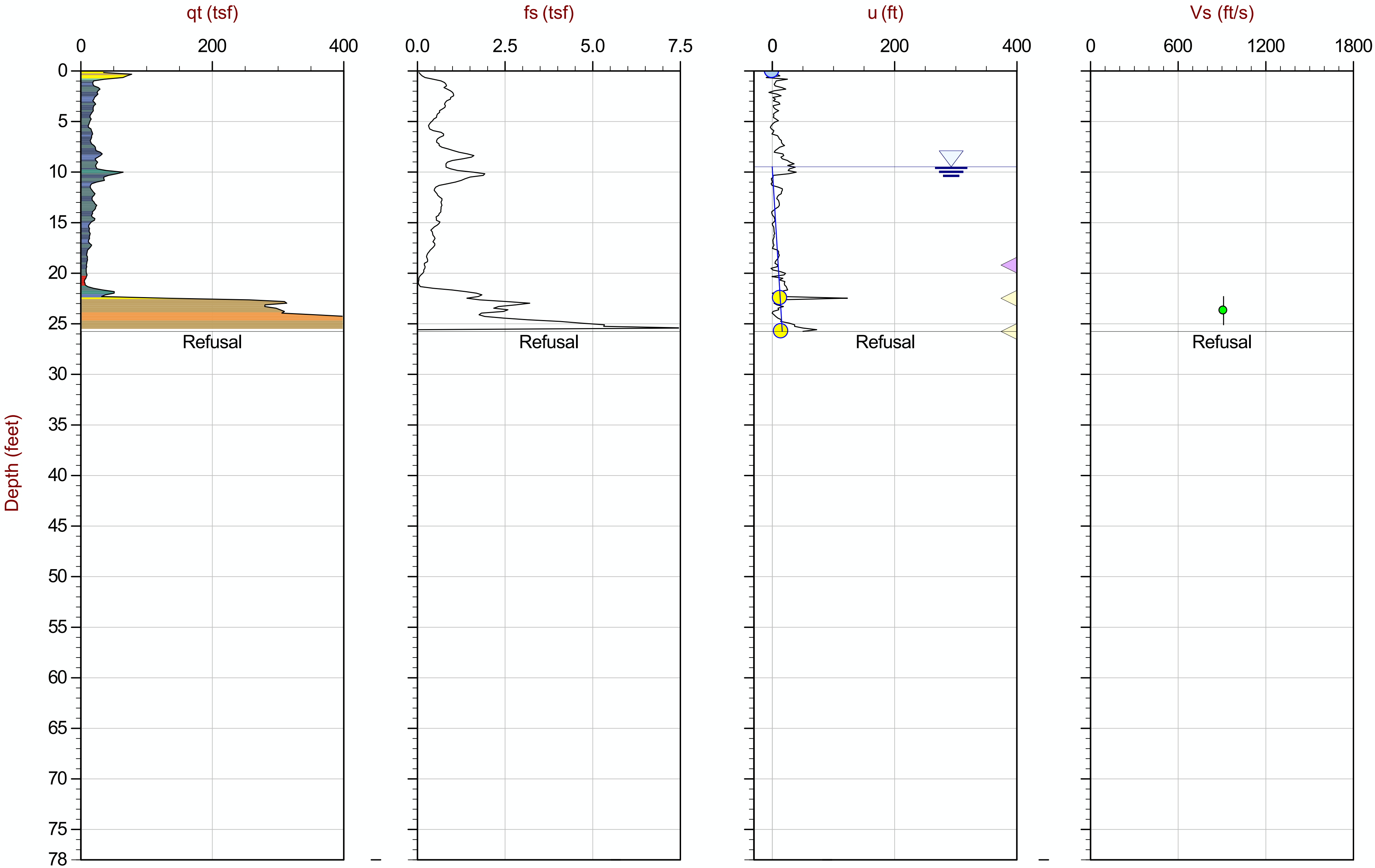
Seismic Cone Penetration Test Plots

ConeTec

AECOM

Job No: 15-53063
Date: 08:07:15 12:14
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335:T1500F15U500



Max Depth: 7.850 m / 25.75 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP49.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327443m E: 292710m

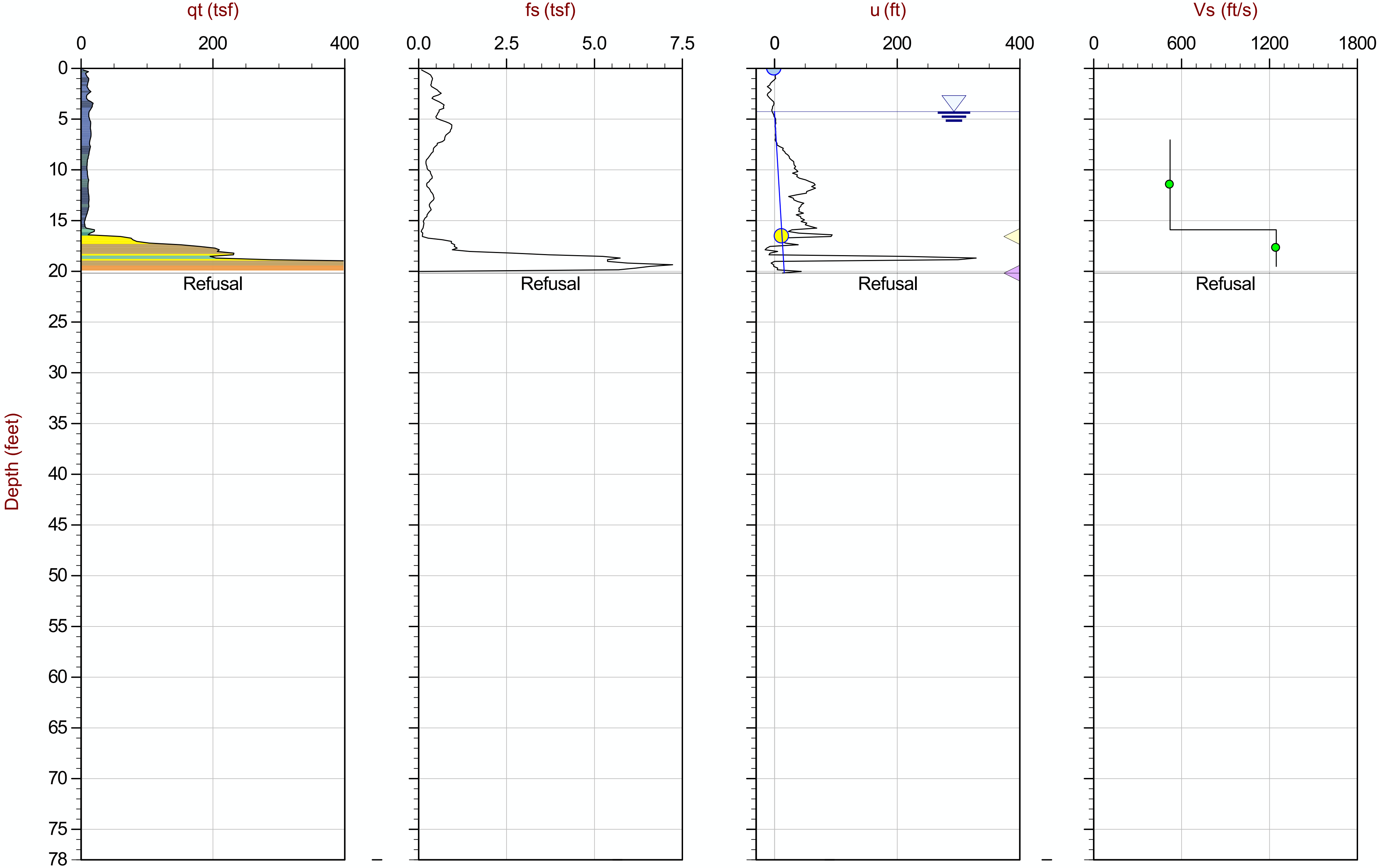
Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM

Job No: 15-53063
Date: 08:11:15 08:45
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C051
Cone: 374:T1500F15U500



Max Depth: 6.150 m / 20.18 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP51.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327193m E: 292459m

Hydrostatic Line | Ueq | Assumed Ueq | PPD, Ueq achieved | PPD, Ueq not achieved

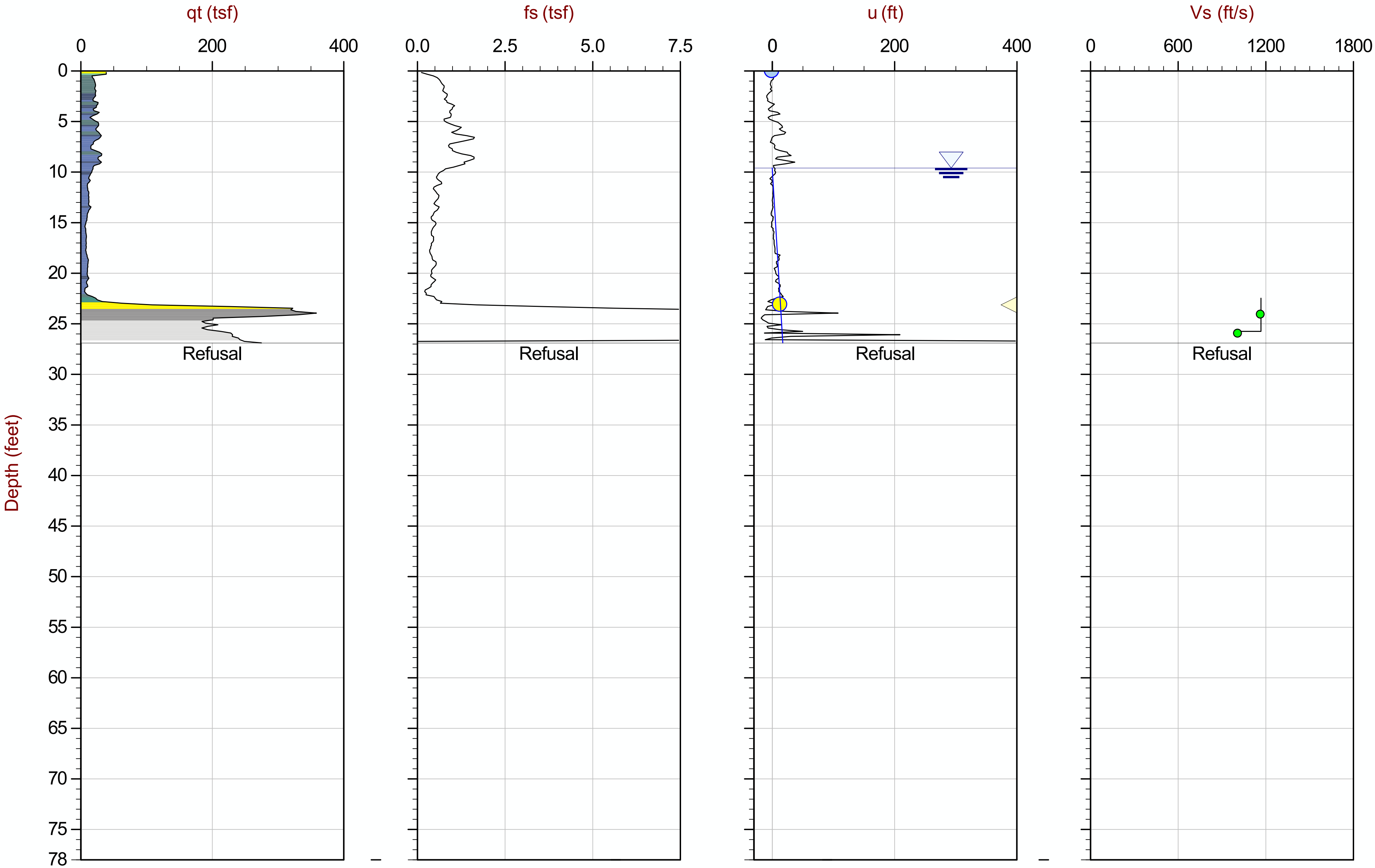
The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

AECOM

Job No: 15-53063
Date: 08:07:15 15:53
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C052
Cone: 335:T1500F15U500



Max Depth: 8.200 m / 26.90 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

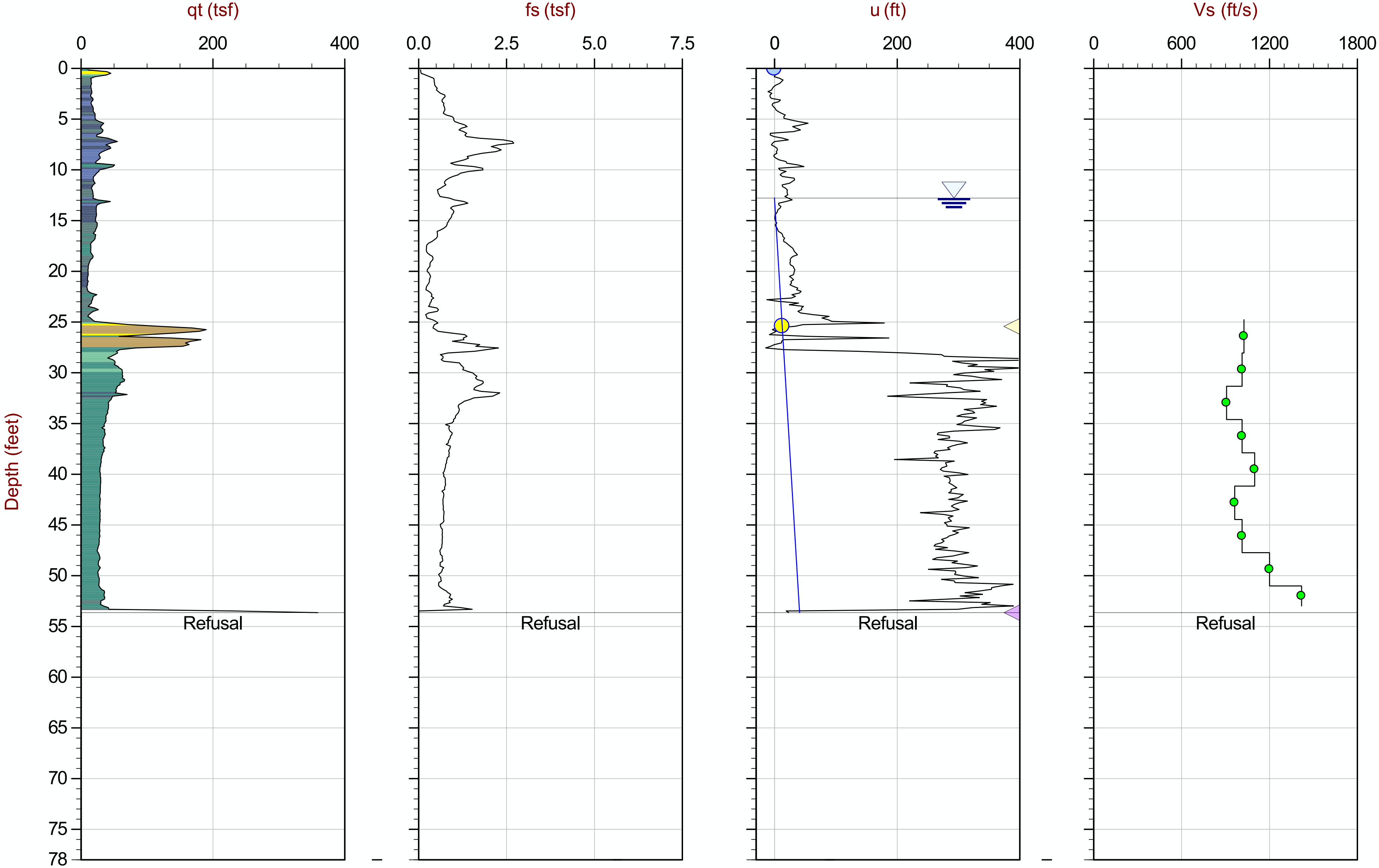
File: 15-53063_SP52.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327045m E: 292612m

Hydrostatic Line · Ueq · Assumed Ueq · PPD, Ueq achieved · PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

AECOM	Job No: 15-53063	Sounding: COF-C053
	Date: 08:07:15 10:02	Cone: 335:T1500F15U500
	Site: Coffeen Power Station, Coffeen, IL	



Max Depth: 16.350 m / 53.64 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP53.COR

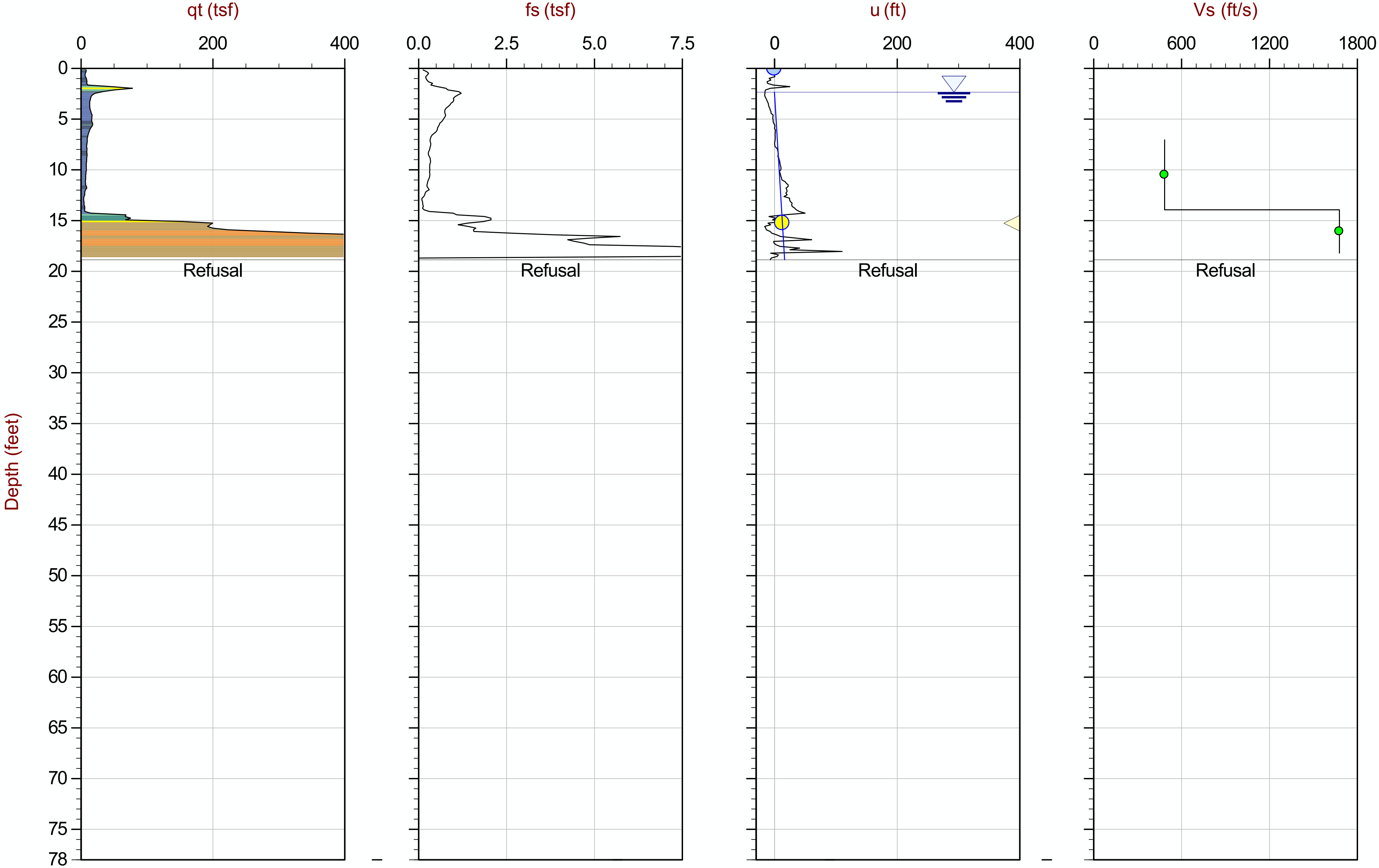
SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327306m E: 292894m

Hydrostatic Line   Ueq   Assumed Ueq   PPD, Ueq achieved   PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Job No: 15-53063	Sounding: COF-C055
Date: 08:11:15 10:39	Cone: 374:T1500F15U500
Site: Coffeen Power Plant, Coffeen, IL	

AECOM



Max Depth: 5.750 m / 18.86 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: Every Point

File: 15-53063_SP55.COR

SBT: Robertson and Campanella, 1986
Coords: UTM Zone 16 N: 4327459m E: 292712m

Hydrostatic Line · Ueq · Assumed Ueq · PPD, Ueq achieved · PPD, Ueq not achieved

The reported coordinates were acquired from consumer-grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Tabular Results (Vs)

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C049
Date: 07-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
22.97	22.31	22.36			
25.75	25.10	25.14	2.78	3.05	911

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C051
Date: 11-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.71	7.05	10.09			
16.57	15.91	17.47	7.38	14.14	522
20.18	19.52	20.81	3.34	2.68	1246

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C052
Date: 07-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
23.13	22.47	22.52			
26.41	25.75	25.80	3.27	2.81	1167
26.90	26.25	26.29	0.49	0.49	1011

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C053
Date: 07-Aug-2015

Seismic Source: Beam
Source Offset (ft): 1.50
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
25.43	24.77	24.82			
28.71	28.05	28.09	3.28	3.19	1026
31.99	31.33	31.37	3.28	3.24	1013
35.27	34.61	34.65	3.28	3.61	907
38.55	37.89	37.92	3.28	3.24	1013
41.83	41.17	41.20	3.28	2.98	1099
45.11	44.46	44.48	3.28	3.40	963
48.39	47.74	47.76	3.28	3.24	1013
51.67	51.02	51.04	3.28	2.73	1201
53.64	52.99	53.01	1.97	1.39	1419

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station
Sounding ID: COF-C055
Date: 11-Aug-2015

Seismic Source: Beam
Source Offset (ft): 7.21
Source Depth (ft): 0.00
Geophone Offset (ft): 0.66

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Ray Path Difference (ft)	Travel Time Interval (ms)	Interval Velocity (ft/s)
7.71	7.05	10.09			
14.60	13.94	15.70	5.61	11.58	484
18.86	18.21	19.58	3.89	2.32	1678

Pore Pressure Dissipation Summary and

Pore Pressure Dissipation Plots

Job No: 15-53063
Client: AECOM
Project: Coffeen Power Station, Coffeen, IL
Start Date: 04-Aug-2015
End Date: 11-Aug-2015

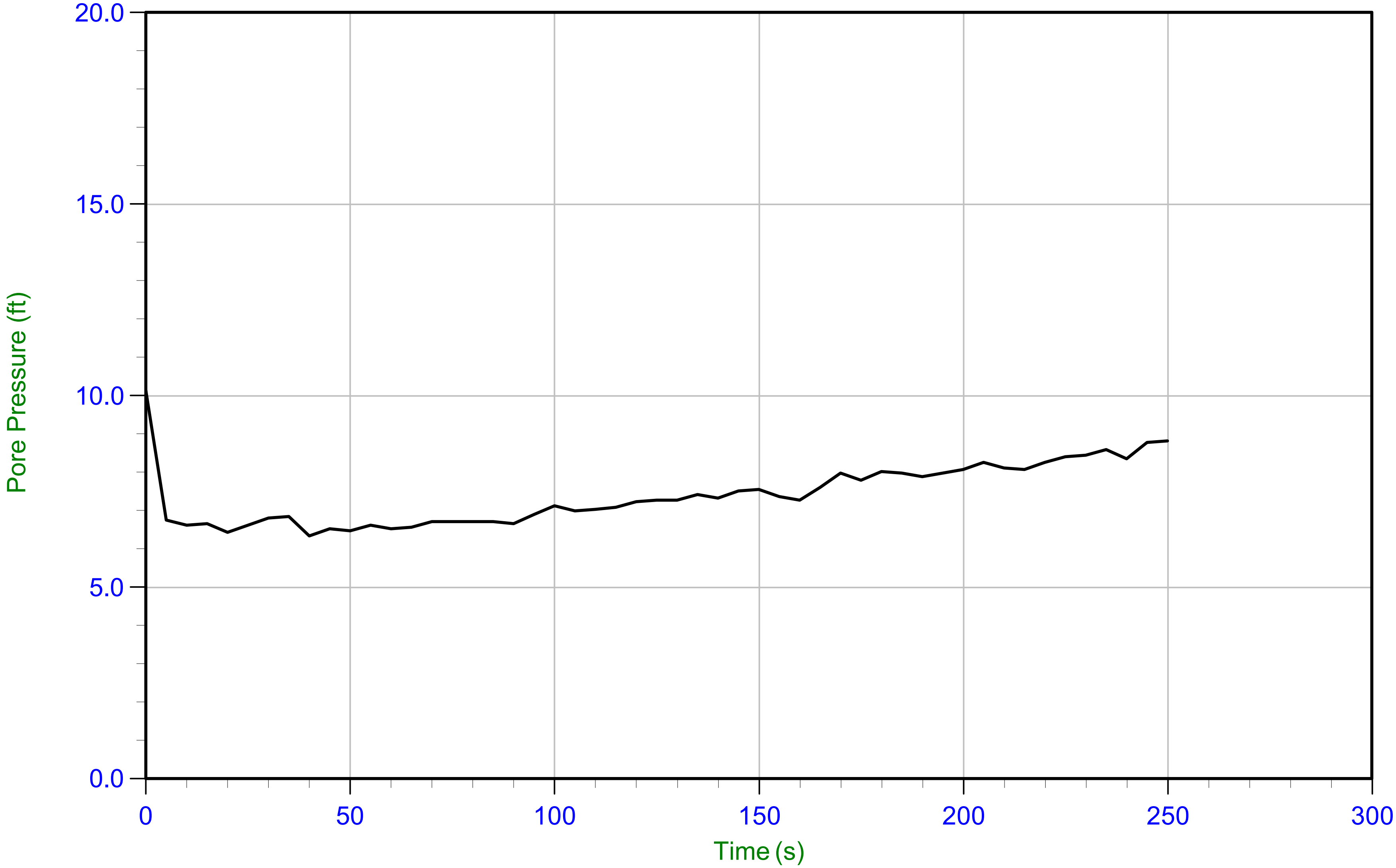
CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U_{eq} (ft)	Calculated Phreatic Surface (ft)	Estimated Phreatic Surface (ft)	t_{50} [a] (s)	Assumed Rigidity Index (I_r)	c_h [b] (cm^2/min)
COF-C049	15-53063_SP49	15	250	19.19						
COF-C049	15-53063_SP49	15	900	22.47	12.99	9.48				
COF-C049	15-53063_SP49	15	125	25.75	14.79	10.97				
COF-C050	15-53063_CP50	15	540	21.16	11.41	9.75		27	100	26.48
COF-C050	15-53063_CP50	15	260	23.95						
COF-C051	15-53063_SP51	15	1300	16.57	12.31	4.26				
COF-C051	15-53063_SP51	15	1200	20.18						
COF-C052	15-53063_SP52	15	730	23.13	13.27	9.86				
COF-C053	15-53063_SP53	15	720	25.43	12.65	12.78				
COF-C053	15-53063_SP53	15	65	25.43	12.74	12.69				
COF-C053	15-53063_SP53	15	465	53.64						
COF-C054	15-53063_CP54	15	300	17.22	14.87	2.35				
COF-C054	15-53063_CP54	15	300	65.62						
COF-C055	15-53063_SP55	15	300	15.26	12.91	2.35				

AECOM

Job No: 15-53063
Date: 07-Aug-2015 12:14:53
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP49.PPD
Depth: 5.850 m / 19.193 ft
Duration: 250.0 s

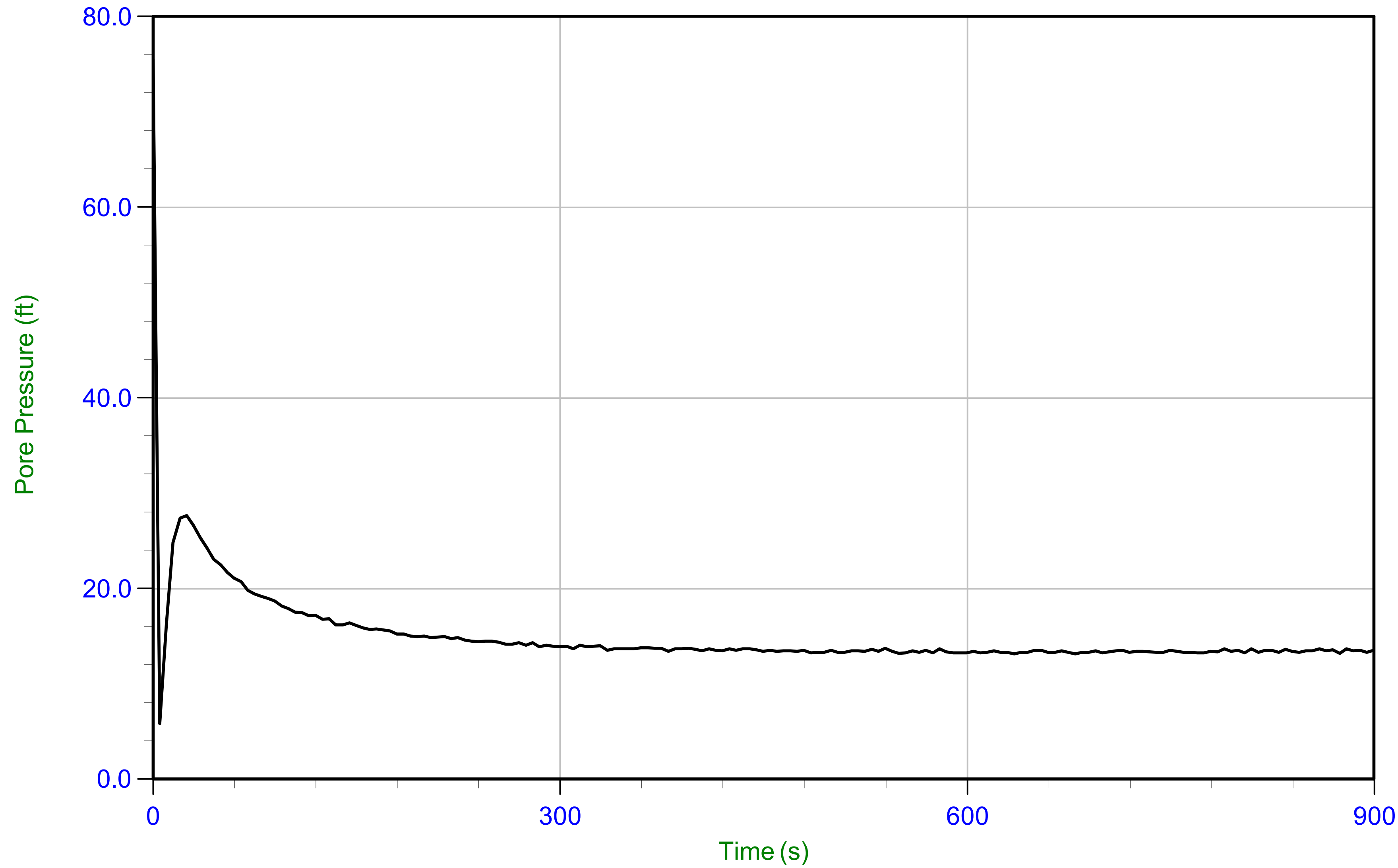
U Min: 6.3 ft
U Max: 10.1 ft

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 12:14:53
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP49.PPD
Depth: 6.850 m / 22.473 ft
Duration: 900.0 s

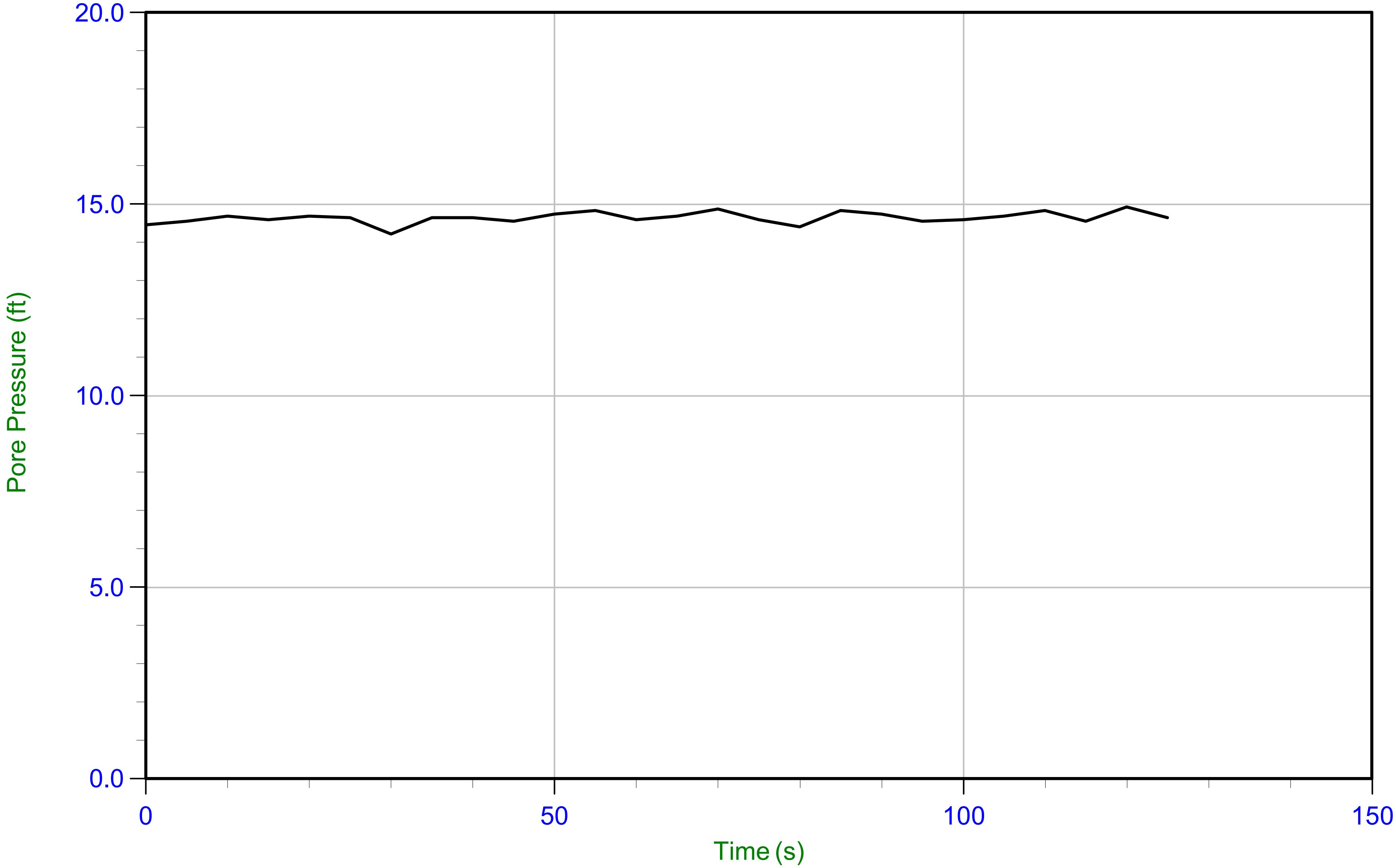
U Min: 5.9 ft
U Max: 75.6 ft

WT: 2.890 m / 9.482 ft
Ueq: 13.0 ft

AECOM

Job No: 15-53063
Date: 07-Aug-2015 12:14:53
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C049
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP49.PPD
Depth: 7.850 m / 25.754 ft
Duration: 125.0 s

U Min: 14.2 ft
U Max: 14.9 ft

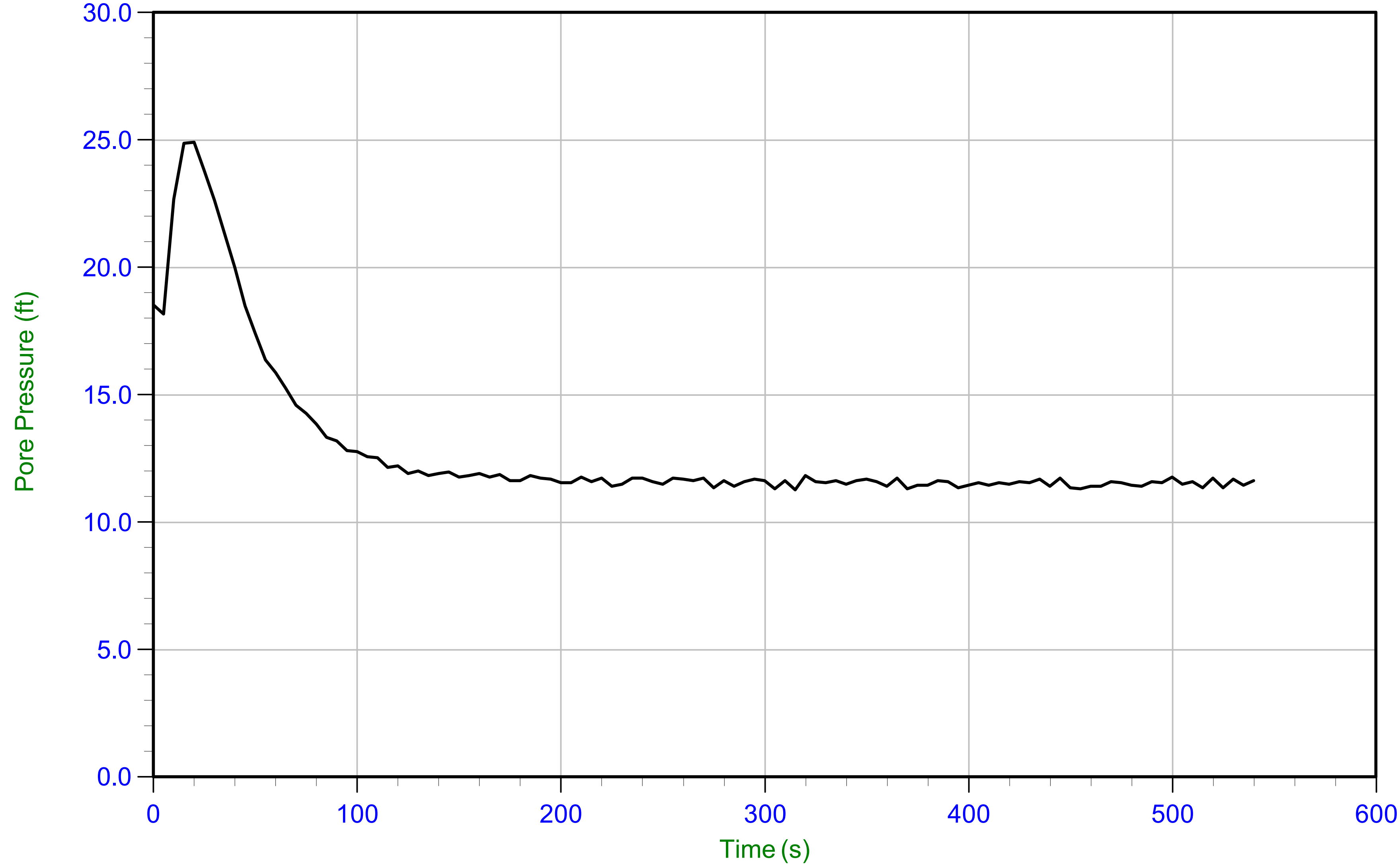
WT: 3.343 m / 10.968 ft
Ueq: 14.8 ft

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 13:50:57
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C050
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP50.PPD
Depth: 6.450 m / 21.161 ft
Duration: 540.0 s

U Min: 11.3 ft
U Max: 24.9 ft

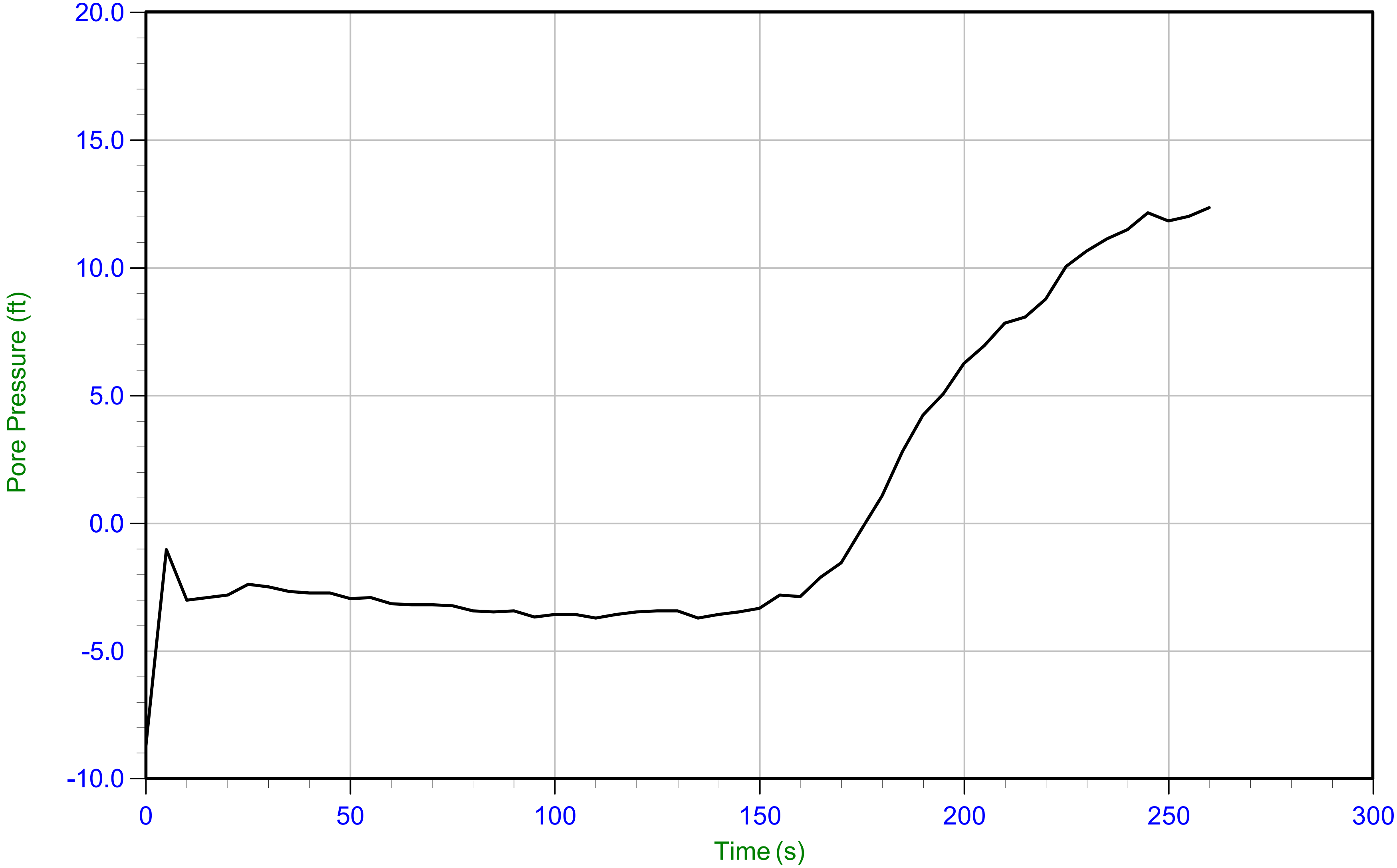
WT: 2.972 m / 9.751 ft
Ueq: 11.4 ft
U(50): 18.17 ft

T(50): 26.5 s
Ir: 100
Ch: 26.5 sq cm/min

AECOM

Job No: 15-53063
Date: 07-Aug-2015 13:50:57
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C050
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP50.PPD
Depth: 7.300 m / 23.950 ft
Duration: 260.0 s

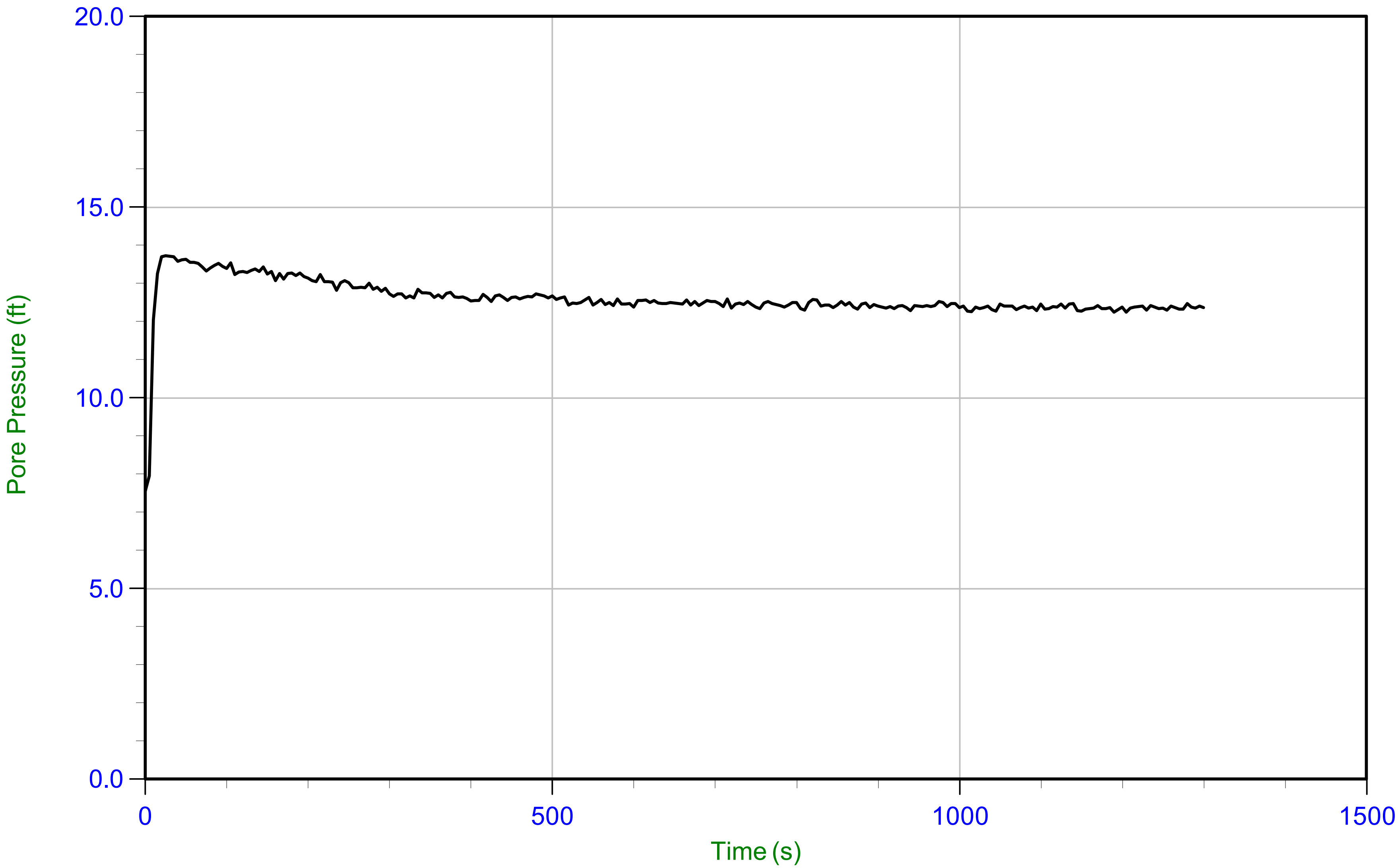
U Min: -8.7 ft
U Max: 12.3 ft

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 08:45:13
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C051
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP51.PPD
Depth: 5.050 m / 16.568 ft
Duration: 1300.0 s

U Min: 7.6 ft
U Max: 13.7 ft

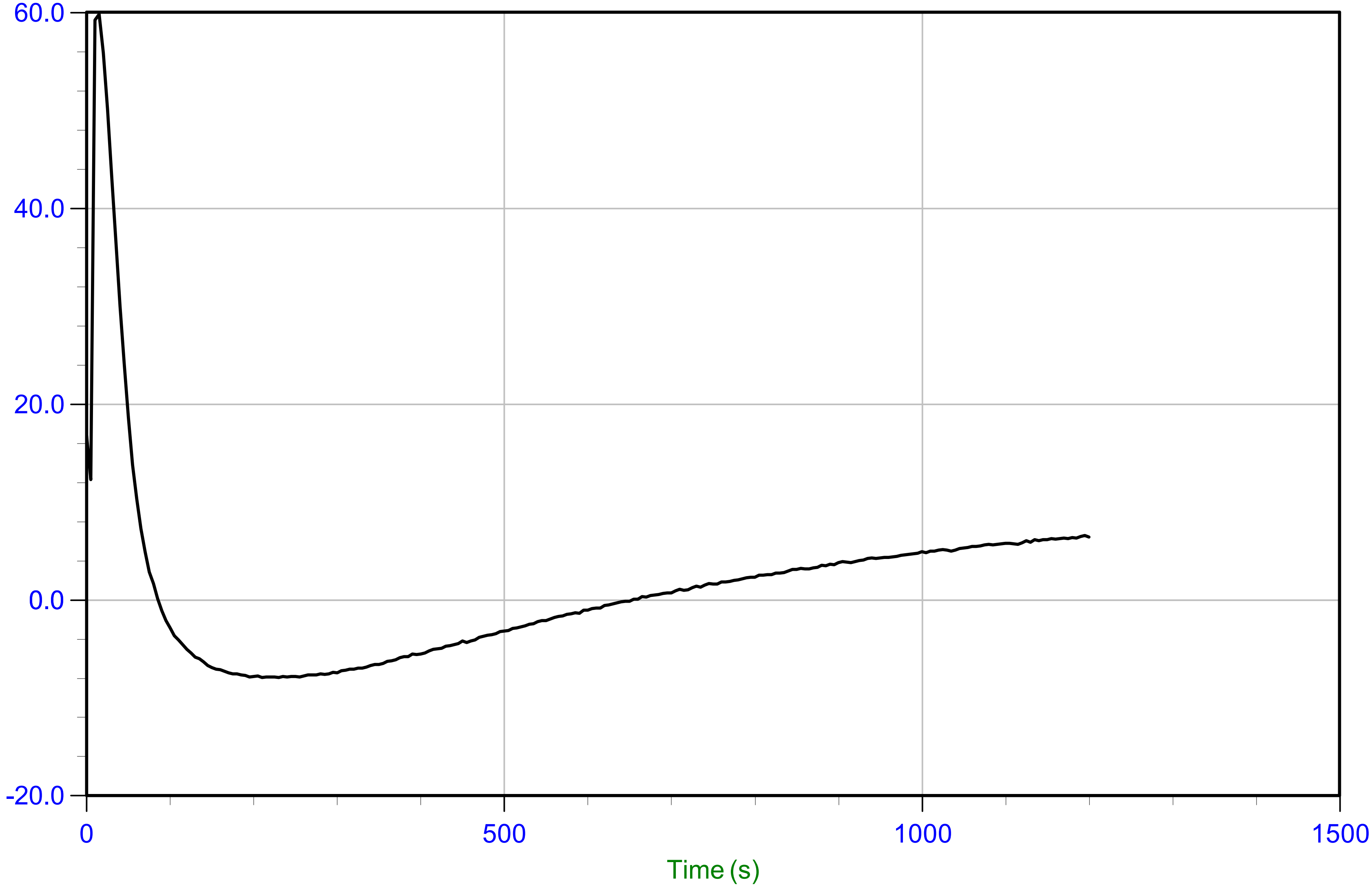
WT: 1.299 m / 4.262 ft
Ueq: 12.3 ft

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 08:45:13
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C051
Cone: 374
Cone Area: 15 sq cm



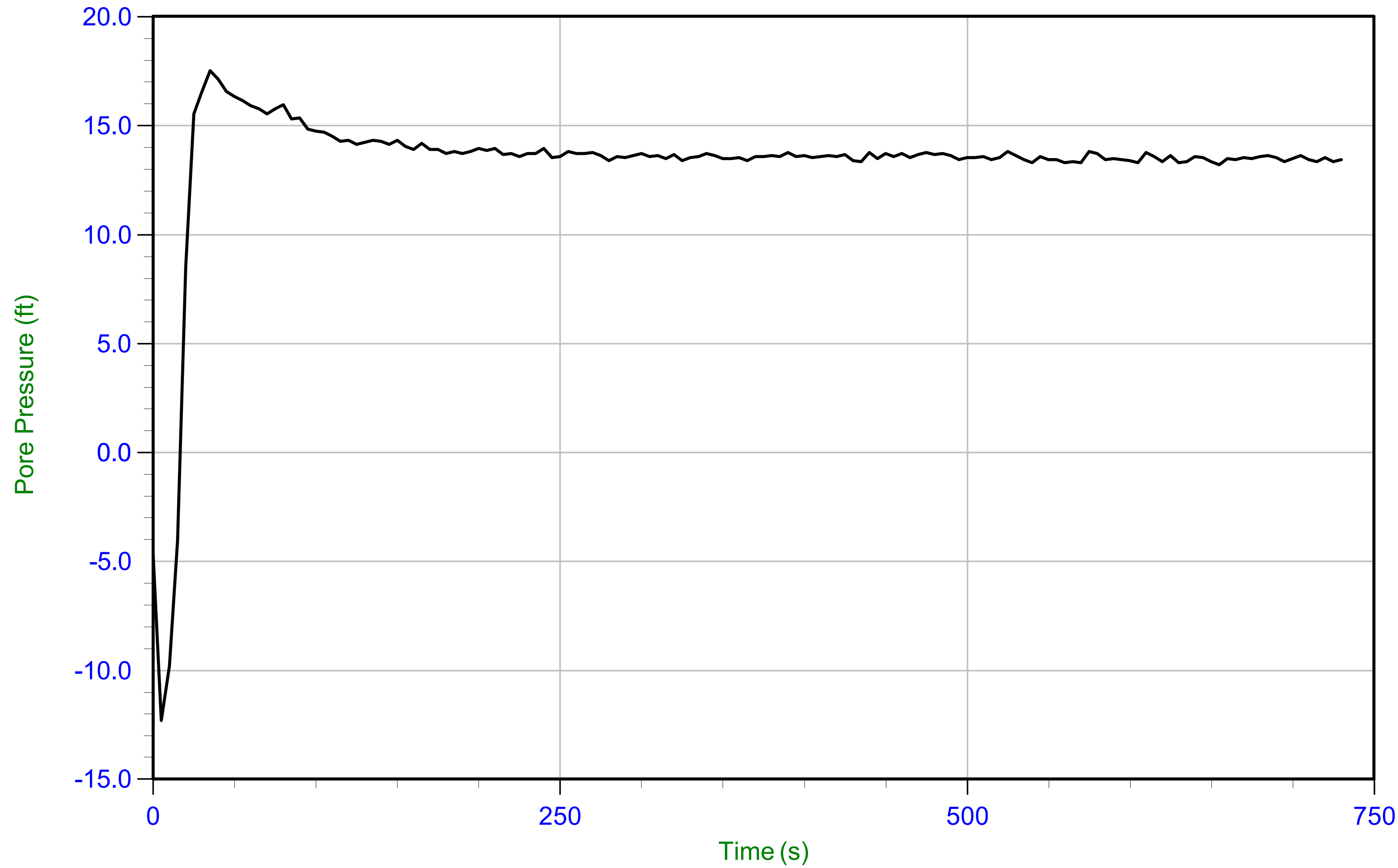
Trace Summary:

Filename: 15-53063_SP51.PPD
Depth: 6.150 m / 20.177 ft
Duration: 1200.0 s

U Min: -7.9 ft
U Max: 59.8 ft

AECOM

Job No: 15-53063
Date: 07-Aug-2015 15:53:40
Site: Coffeen Power Station, Coffeen, IL
Sounding: COF-C052
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP52.PPD
Depth: 7.050 m / 23.130 ft
Duration: 730.0 s

U Min: -12.3 ft
U Max: 17.5 ft

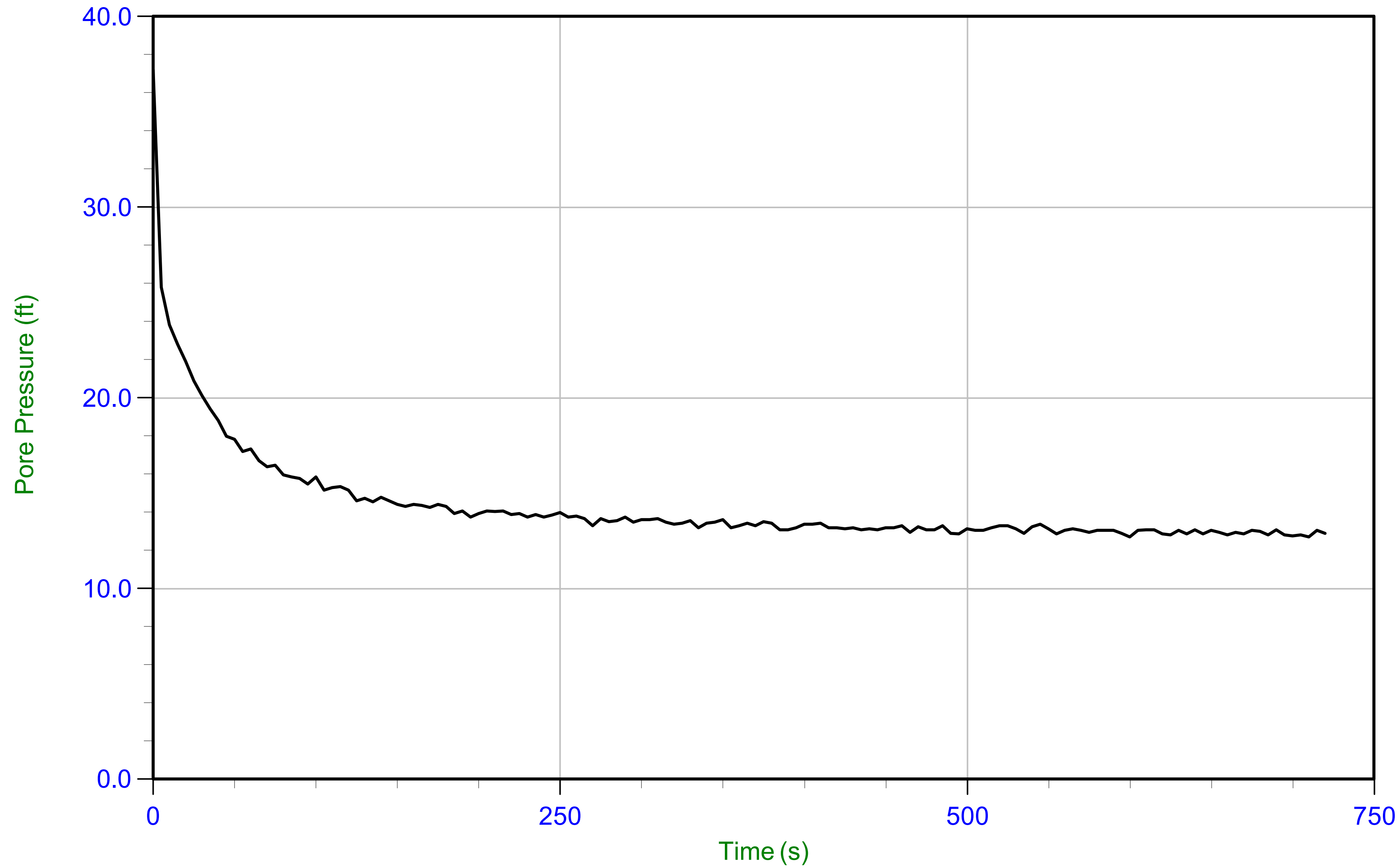
WT: 3.006 m / 9.862 ft
Ueq: 13.3 ft

CONETEC

AECOM

Job No: 15-53063
Date: 07-Aug-2015 10:02:11
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C053
Cone: 335
Cone Area: 15 sq cm



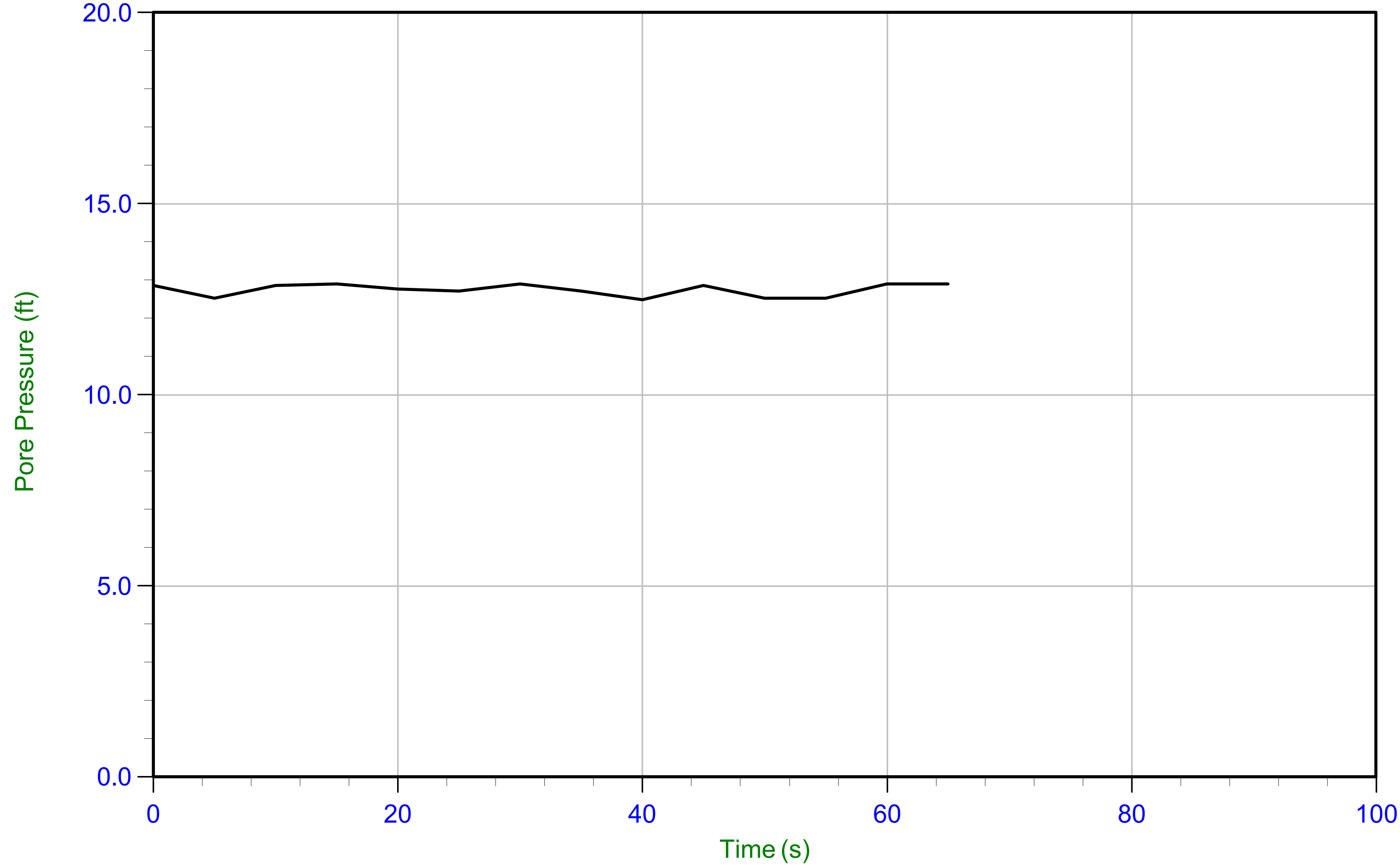
Trace Summary:

Filename: 15-53063_SP53.PPD
Depth: 7.750 m / 25.426 ft
Duration: 720.0 s

U Min: 12.7 ft
U Max: 37.2 ft

WT: 3.894 m / 12.775 ft
Ueq: 12.7 ft

AECOM	Job No: 15-53063	Sounding: COF-C053
	Date: 07-Aug-2015 10:02:11	Cone: 335
	Site: Coffeen Power Station, Coffeen, IL	Cone Area: 15 sq cm



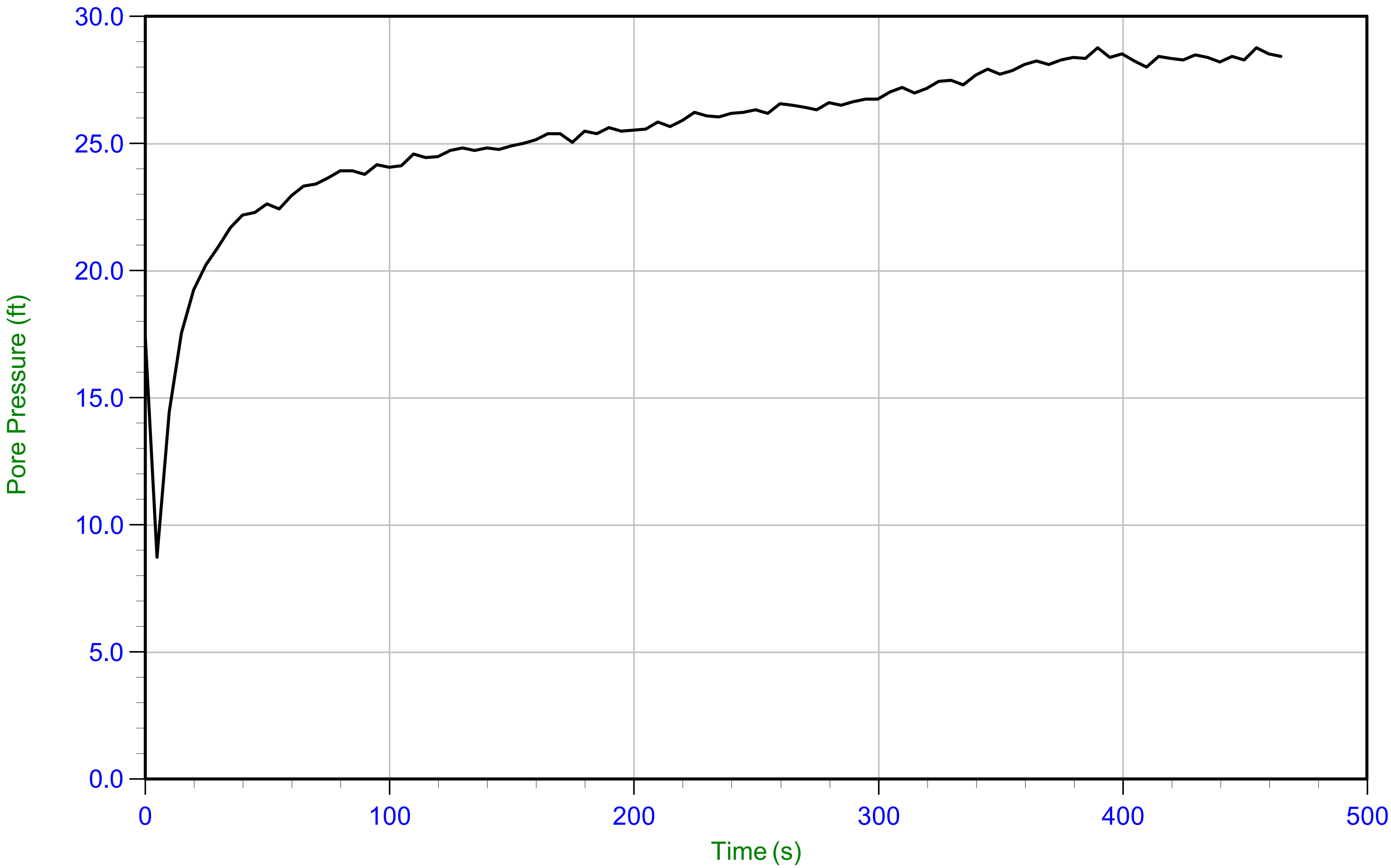
Trace Summary:

Filename: 15-53063_SP53.PPD	U Min: 12.5 ft	WT: 3.868 m / 12.690 ft
Depth: 7.750 m / 25.426 ft	U Max: 12.9 ft	Ueq: 12.7 ft
Duration: 65.0 s		

AECOM

Job No: 15-53063
Date: 07-Aug-2015 10:02:11
Site: Coffeen Power Station, Coffeen, IL

Sounding: COF-C053
Cone: 335
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP53.PPD
Depth: 16.350 m / 53.641 ft
Duration: 465.0 s

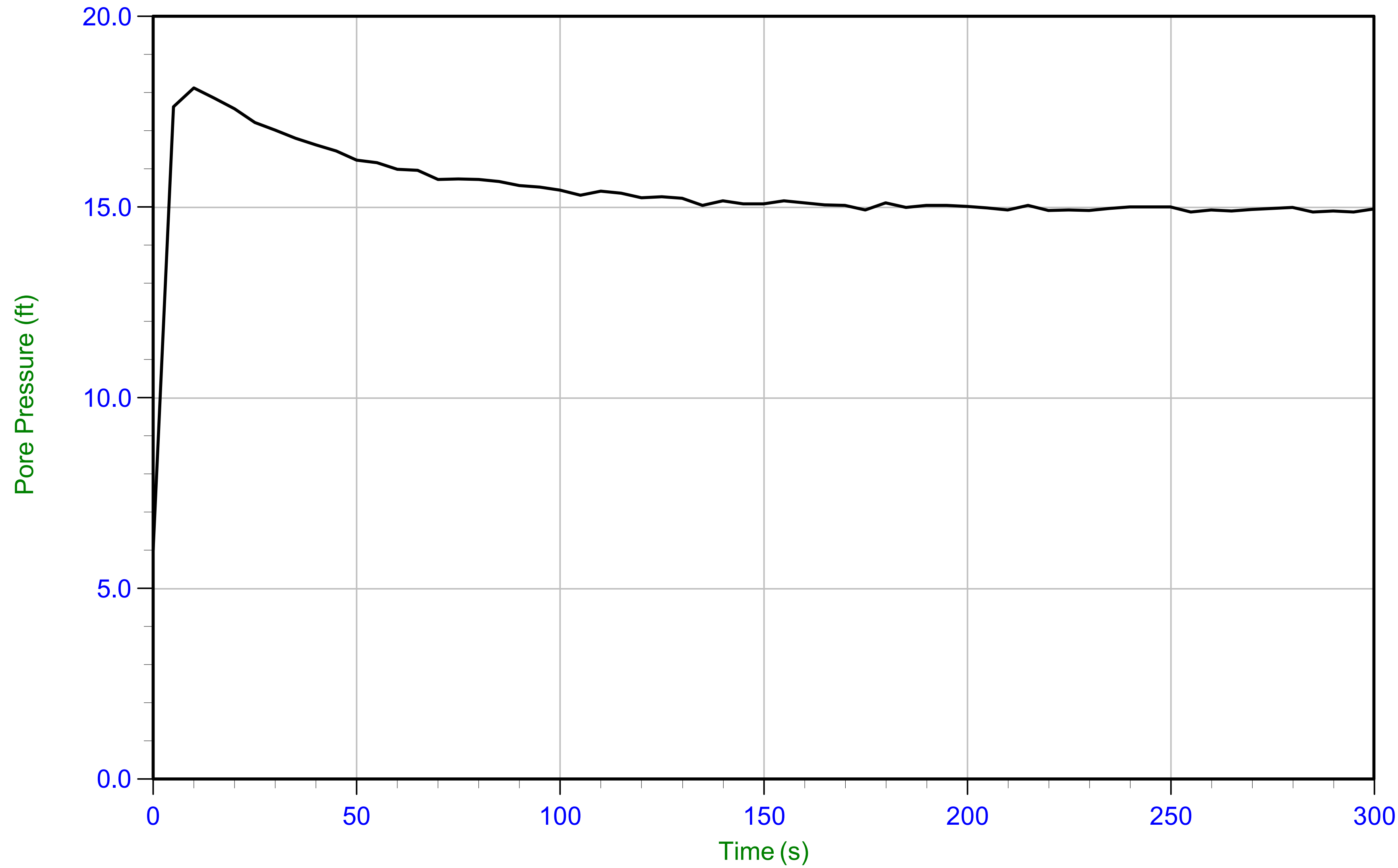
U Min: 8.7 ft
U Max: 28.8 ft

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 13:04:33
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C054
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP54.PPD
Depth: 5.250 m / 17.224 ft
Duration: 300.0 s

U Min: 6.0 ft
U Max: 18.1 ft

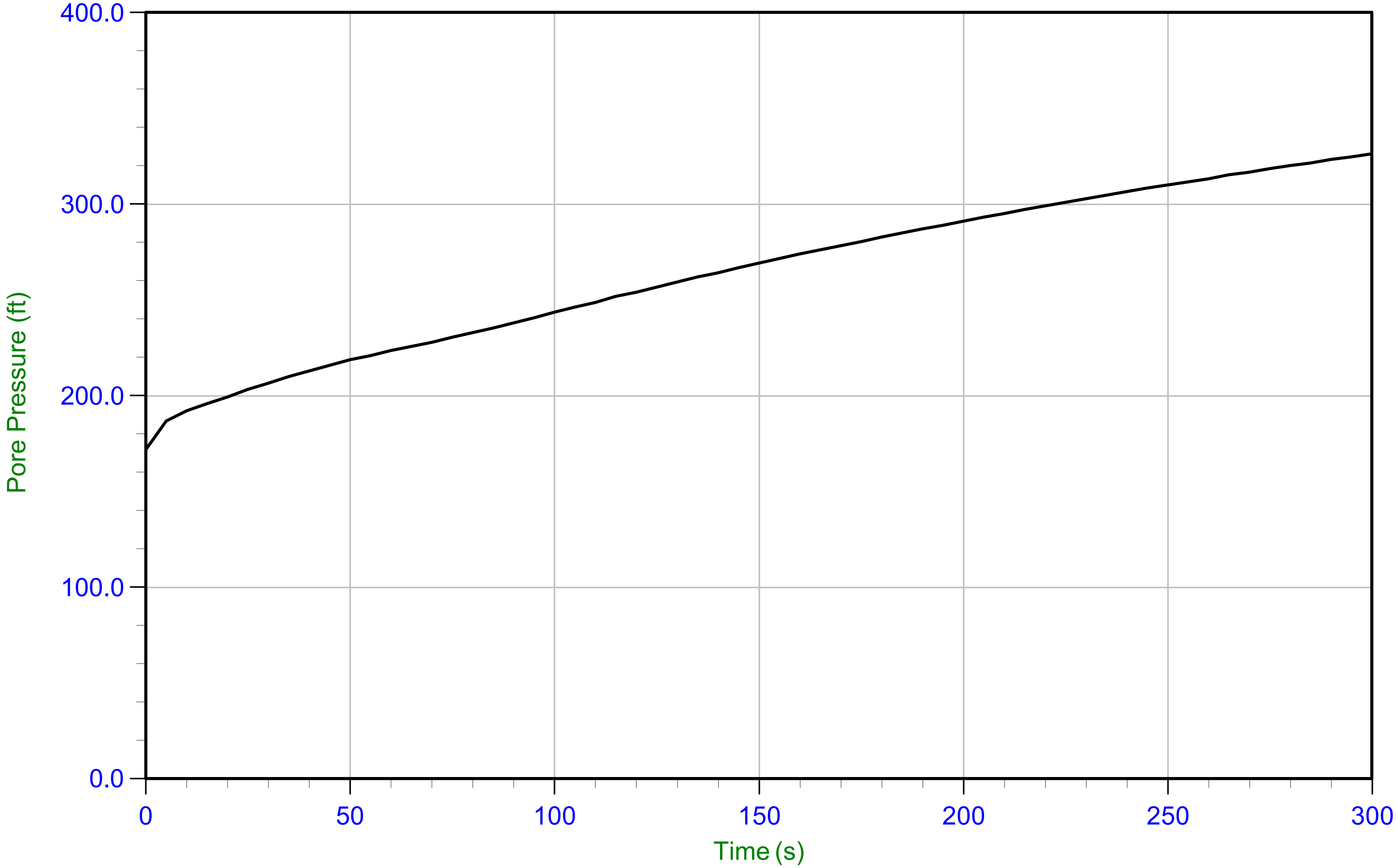
WT: 0.717 m / 2.352 ft
Ueq: 14.9 ft

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 13:04:33
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C054
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_CP54.PPD
Depth: 20.000 m / 65.616 ft
Duration: 300.0 s

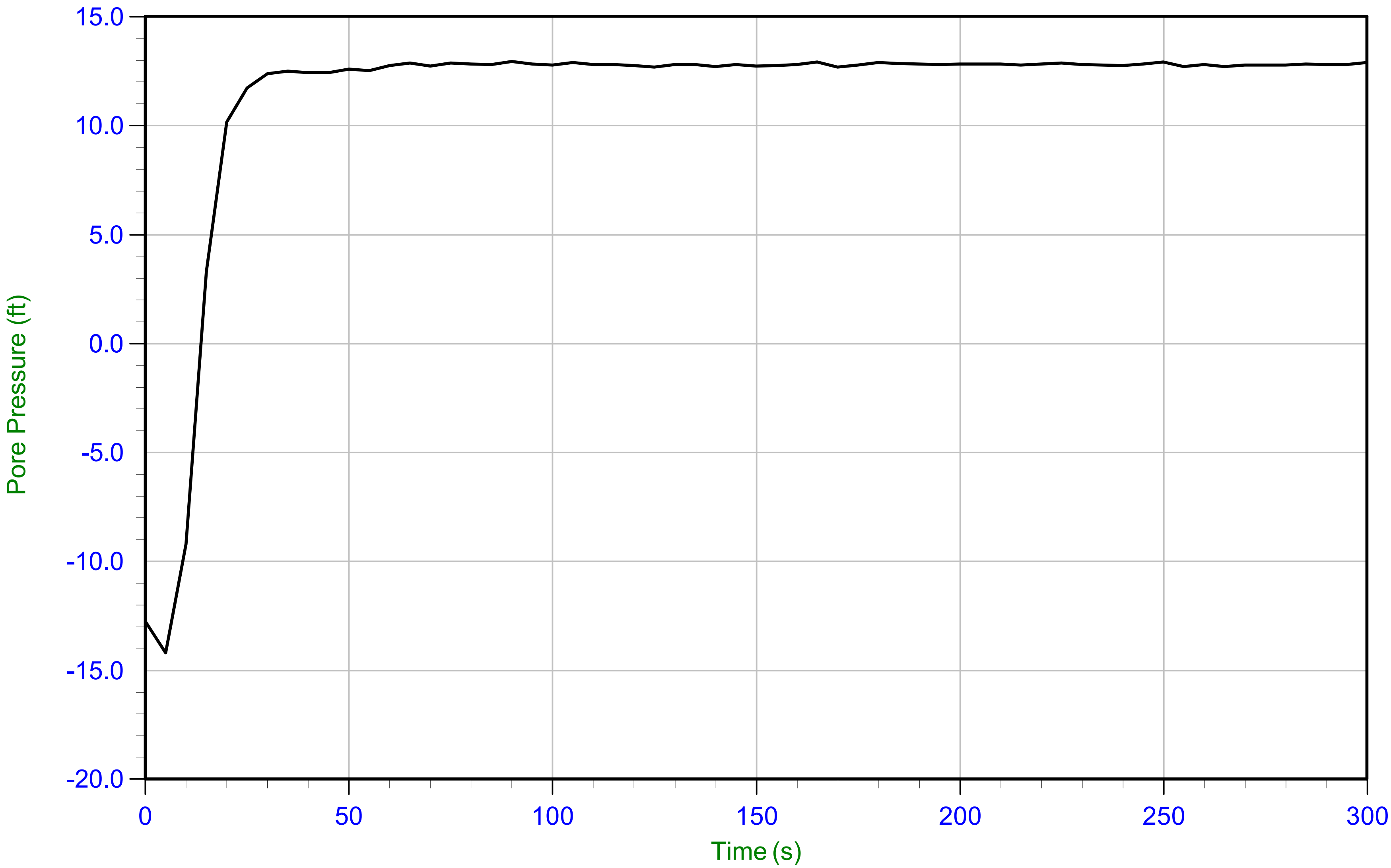
U Min: 171.9 ft
U Max: 326.2 ft

CONETEC

AECOM

Job No: 15-53063
Date: 11-Aug-2015 10:39:47
Site: Coffeen Power Plant, Coffeen, IL

Sounding: COF-C055
Cone: 374
Cone Area: 15 sq cm



Trace Summary:

Filename: 15-53063_SP55.PPD
Depth: 4.650 m / 15.256 ft
Duration: 300.0 s

U Min: -14.2 ft
U Max: 12.9 ft

WT: 0.716 m / 2.349 ft
Ueq: 12.9 ft

Attachment C. Slope Stability Analysis Calculations

Calculation Notes

Subject: Coffeen GMF Pond Slope Stability Analysis
Project Name: Dynegy CCR

By: Lucas Carr Date: 01/25/2016
Project No: 60480701

Checked By: Nick Sanna Date: 01/27/2016
Task No.: 01

Objective

A slope stability analysis was performed to calculate factors of safety (FoS) for normal operating conditions, surcharge pool, and earthquake (pseudostatic and post-earthquake) loading conditions at the Coffeen GMF Pond. The factors of safety have been compared to the USEPA CCR Rule criteria for each loading condition. The methodology used to perform the slope stability analysis is summarized in the following sections.

Development of Sections for Analysis

Slope stability analyses were performed at cross-sections stations 13+50, 22+50, 46+50, and 58+00 at the GMF Pond. The rationale behind selecting each section for analysis is described below:

- Station 13+50: Tallest embankment height along eastern dike
- Station 22+50: Tallest embankment height along northern dike
- Station 46+50: Tallest embankment height along western dike
- Station 58+00: Tallest embankment height along southern dike

Embankment geometry for each section was developed from 2015 ground surface and bathymetric survey data of the GMF Pond.

Subsurface material boundaries (stratigraphy) at each section were developed by projecting subsurface explorations conducted by AECOM in 2015 (CPTs COF-C048 though COF-C055) on to the cross-section. Explorations were projected onto the cross-section at offset distances measured in CAD. SPT borings were not advanced at the GMF Pond by AECOM. However, both CPTs and SPT borings were advanced at Ash Ponds No. 1 and 2 at Coffeen, which are located adjacent to the GMF Pond. Based on AECOM's interpretation of CPT soundings, both the embankment and foundation materials are very similar at both structures.

Material interfaces inferred from the subsurface explorations were sketched onto the cross-section and a reasonable interpretation of the subsurface stratigraphy between the subsurface exploration locations was developed. The following materials are present at the cross-sections:

- Impounded Ash
- Embankment
- Foundation Clay
- Soft Foundation Clay
- Till

Tabulated material interface depths and groundwater table depths can be found in the *Coffeen GMF Pond Liquefaction Analysis* calculation package. A description of each material can be found in the *Coffeen Ash Pond No. 1 Material Characterization* calculation package. It should be noted that CPT soundings at the GMF Pond did not identify the soft foundation clay material to be present in all CPT soundings. However, even in locations where the soft foundation clay material was not identified, the material was assumed to be present in a thickness of 2 ft over the top of the till, to account for the possible presence of the low-strength material outside of subsurface exploration locations, as it was encountered in most borings and CPTs advanced at the GMF Pond, Ash Pond No. 1, and Ash Pond No. 2 at the Coffeen Power Station, and therefore likely underlies the majority of the site.

Analysis Methodology

Loading Conditions

The slope stability analysis evaluated the following loading conditions, as required by the USEPA CCR Rule:

- Long-Term, Maximum Storage Pool Loading Condition (Static Drained), Min FoS = 1.50: This case models the static stability of the embankment under long-term conditions, using drained soil strengths. A normal operating pool elevation of 621.2 ft was assumed in Ash Pond No. 1, and pore pressures for analysis are taken from a piezometric line based on AECOM's interpretation of groundwater levels from piezometer data. Thicknesses of ash retained by the pond are based on 2015 survey data and AECOM's interpretations.
- Maximum Surcharge Pool Loading Condition (Surcharge), Min FoS = 1.40: This case models the static stability of the embankment under short-term flood loading conditions. The flood pool elevation was assumed to be El. 623.8 ft, which corresponds to the PMF flood pool for the GMF Pond. Due to the small rise in pool level above the normal pool (2.1 ft rise), the low height of the embankment, and location of the critical slip surface on the downstream slope rather than in the vicinity of the upstream pool, drained soil strengths were used for analysis. The minor additional loading from the 2.1 ft of pool is not expected to result in the development of undrained conditions in the embankment or foundation soils.
- Seismic Condition (Pseudostatic), Min FoS = 1.00: This case models the stability of the embankment under earthquake loading. Normal pool conditions (El. 621.2 ft) and groundwater conditions are assumed. Seismic loads were taken from a probabilistic seismic hazard analysis (PSHA) and dynamic response analyses performed for Coffeen Ash Pond No. 1 by AECOM, and were adjusted to account for topographic amplification of the seismic loads by the embankment. A pseudostatic seismic coefficient (k_h) of 0.13 g was selected based on these analyses. Peak undrained soil strengths were used for this analysis, due to the short duration of

the loading and the fine-grained, slow-draining nature of the embankment and foundation soils. It should be noted that Coffeen Ash Pond No. 1 is both taller and steeper than the GMF Pond embankments; therefore seismic accelerations developed from the Ash Pond No. 1 dynamic response analysis are likely to be conservative for use at the GMF Pond.

- Liquefaction Condition (Post-Earthquake), Min FoS = 1.20: This case models the stability of the embankment immediately following earthquake loading. Normal pool conditions (El. 621.2 ft) and groundwater conditions are assumed. For materials susceptible to cyclic softening and a loss of strength during earthquake loading, as determined from laboratory testing and CPT-based liquefaction analyses, reduced post-earthquake undrained shear strengths are assumed.

Stability Analysis Approach

The slope stability analysis was conducted using SLOPE/W within the GeoStudio 2012 software package (Version 8.15.1.11236). The following approach was used to conduct the analysis:

- Analysis Method: Spencer
- Slip Surface Definition: Entry and exit. Slip surfaces were allowed to enter the ground surface upstream of the middle of the embankment crest and downstream of the embankment toe.
- Minimum Slip Surface Depth: 5 ft.
- Optimization: Critical slip surfaces were optimized. This allowed the critical slip surface to pass through the soft foundation clay material in a nearly horizontal manner for many of the analysis cases.
- Tension Cracks: Added if necessary to reduce interslice tensile forces for all loading cases except pseudostatic stability. For pseudostatic stability, the short-duration nature of the loading was assumed to prevent a tension crack from opening. Where included, the tension crack was assumed to be full of water.
- Pore Pressures: From piezometric line.

Material Properties

Material properties for analysis were based on material properties listed in the *Coffeen Ash Pond No. 1 Material Characterization* calculation package. However, these material properties were based in part of laboratory testing performed on soil samples collected from Ash Pond No. 1. As soil samples were not collected at the GMF Pond by AECOM, and the GMF Pond embankments are lower, and therefore may have resulted in less consolidation and strength increases in the foundations, an analysis was performed to evaluate the suitability of the Ash Pond No. 1 strengths for use at the GMF Pond.

The analysis used CPT soundings advanced at the GMF Pond by AECOM to estimate profiles of undrained shear strength (Su) versus depth. Su was estimated following the relationship presented in Gregg Drilling (2015):

$$s_u = \frac{q_t - \sigma_v}{N_{kt}}$$

Where:

q_t = CPT tip resistance

σ_v = total vertical effective stress

N_{kt} = empirical cone factor

Based on AECOM's experience with CPT soundings in Illinois and Missouri, an N_{kt} value of 17 is general appropriate for modified loess and till soils, which comprise the foundation at the GMF Pond. This value was used, along with an estimate of total stress based on unit weights developed for Ash Pond No. 1, to develop profiles of undrained shear strength vs depth.

The profiles were then compared to the corresponding peak undrained shear strength profile using the Su/p' and minimum Su values developed for Ash Pond No. 1. Generally, the profiles compared very well, with the Su/p' profiles predicting lower strength than the CPT analysis, which indicates the Su/p' profiles are conservative for slope stability analysis. However, at CPTs COF-C049 and COF-C052 (used for cross-sections 22+50 and 58+00, respectively), slight reductions in the Su/p' ratios were required for the foundation clay and soft clay in order to provide a better match with the CPT Su profile.

For cross-sections 22+50 and 58+00, the corresponding percent reductions in peak undrained shear strength (assumed to be triaxial compression) were also applied to the free-field peak undrained strengths (direct simple shear) and post-earthquake undrained shear strengths (direct simple shear only). For the remaining cross-sections, peak (triaxial compression and direct simple shear) and post-earthquake undrained shear strengths from Coffeen Ash Pond No. 1 were used for analysis.

Drained strengths for all sections used the same peak friction angles for each material type as were used at Ash Pond No. 1. However, the Ash Pond No. 1 shear strength envelopes were nonlinear in nature, and curved upwards at low confining pressures to represent overconsolidation and higher shear strengths than could be molded using a straight-line friction angle. Due to the shorter nature of the GMF Pond dikes relative to the Ash Pond No. 1 dikes, this approach may be unconservative, and the nonlinear shear strength envelopes were not used. Straight-line drained friction angles were used for each material. Reductions in drained shear strengths, based on CPT-correlated undrained shear strengths, were not applied, as the removal of the nonlinear failure envelope was deemed to be sufficient for analysis, given the low height of the embankments and therefore low sensitivity of the slope stability results to minor changes in the drained friction angle.

Design shear strength values for cross-sections 13+50 and 46+50 are listed in Table 1. Design shear strength values for cross-section 22+50 are listed in Table 2 and design shear strengths for cross-section 58+00 are listed in Table 3.

Table 1 – Design Shear Strengths, Sta. 13+50 and 46+50

		Peak Drained Shear Strength		Peak Undrained Shear Strength	Post-Earthquake Shear Strength
Material	**Unit weight (pcf)**	**Cohesion, c' (psf)**	**Friction Angle, ϕ' (degrees)**	**Su/P'**	**Su/P'**
Ash	112	0	31	0.40	0.05
Embankment	135	0	31	Su/p' = 0.60 Minimum Su = 450 psf	Peak Undrained
Foundation Clay	125	0	Below Embankment: ϕ' = 32 Free-Field: ϕ' = 30	Below Embankment: Su/p' = 0.45 Minimum Su = 700 psf Free-Field: Su/p' = 0.28 Minimum Su = 450 psf	Peak Undrained
Soft Clay Foundation	125	0	30	Su/p' = 0.28 Minimum Su = 275 psf	Su/p' = 0.16 Minimum Su = 200 psf
Till	135	0	40	Su/p' = 0.45 Minimum Su = 700 psf	Peak Undrained

Table 2 – Design Shear Strengths, Sta. 22+50

		Peak Drained Shear Strength		Peak Undrained Shear Strength	Post-Earthquake Shear Strength
Material	**Unit weight (pcf)**	**Cohesion, c' (psf)**	**Friction Angle, ϕ' (degrees)**	**Su/P'**	**Su/P'**
Ash	112	0	31	0.40	0.05
Embankment	135	0	31	Su/p' = 0.60 Minimum Su = 450 psf	Peak Undrained
Foundation Clay	125	0	Below Embankment: ϕ' = 32 Free-Field: ϕ' = 30	Below Embankment: Su/p' = 0.39 Minimum Su = 700 psf Free-Field: Su/p' = 0.24 Minimum Su = 450 psf	Peak Undrained
Soft Clay Foundation	125	0	30	Su/p' = 0.22 Minimum Su = 275 psf	Su/p' = 0.13 Minimum Su = 200 psf
Till	135	0	40	Su/p' = 0.45 Minimum Su = 700 psf	Peak Undrained

Table 3 – Design Shear Strengths, Sta. 58+00

		Peak Drained Shear Strength		Peak Undrained Shear Strength	Post-Earthquake Shear Strength
Material	**Unit weight (pcf)**	**Cohesion, c' (psf)**	**Friction Angle, ϕ' (degrees)**	**Su/P'**	**Su/P'**
Ash	112	0	31	0.40	0.05
Embankment	135	0	31	Su/p' = 0.60 Minimum Su = 450 psf	Peak Undrained
Foundation Clay	125	0	Below Embankment: ϕ' = 32 Free-Field: ϕ' = 30	Below Embankment: Su/p' = 0.39 Minimum Su = 700 psf Free-Field: Su/p' = 0.24 Minimum Su = 450 psf	Peak Undrained
Soft Clay Foundation	125	0	30	Su/p' = 0.23 Minimum Su = 275 psf	Su/p' = 0.13 Minimum Su = 200 psf
Till	135	0	40	Su/p' = 0.45 Minimum Su = 700 psf	Peak Undrained

As discussed in the material characterization calculation package, separate shear strengths were developed for the foundation clay beneath the embankment (based on CIU' triaxial tests) and the foundation clay near and beyond the toe of the embankment (based on direct simple shear [DSS] tests). Within the foundation clay, the boundary between the two different strengths was iterated during the slope stability analysis based on the orientation of the slip surface. DSS strengths were assigned for the near-horizontal portions of the slip surface under and downstream of the embankment while CIU strengths were assigned for inclined portions of the slip surface where it is dipping into the foundation clay.

Results

The table on the following page summarizes the results of the slope stability analyses at Coffeen GMF Pond USEPA CCR Rule factor of safety criteria is met for each loading condition.

Slope stability output can be found in Appendix A, and the CPT-based analysis of undrained shear strength can be found in Appendix B.

Stability Analysis Results Table - Dynegy Coffeen GMF Pond

Cross-Section	Analysis Case	CCR Rule Minimum Factor of Safety	Calculated Factor of Safety
Sta. 13+50	Pseudostatic	1.00	1.61
	Surcharge Pool	1.40	3.45
	Static Drained	1.50	3.45
	Post-Earthquake	1.20	2.46
Sta. 22+50	Pseudostatic	1.00	1.47
	Surcharge Pool	1.40	3.48
	Static Drained	1.50	3.48
	Post-Earthquake	1.20	2.46
Sta. 46+50	Pseudostatic	1.00	1.76
	Surcharge Pool	1.40	4.19
	Static Drained	1.50	4.19
	Post-Earthquake	1.20	3.02
Sta. 58+00	Pseudostatic	1.00	1.66
	Surcharge Pool	1.40	3.57
	Static Drained	1.50	3.57
	Post-Earthquake	1.20	2.61

Calculation Notes

AECOM

Subject: Coffeen GMF Pond Slope Stability Analysis

Project Name: Dynegy CCR

By: Lucas Carr Date: 01/25/2016

Project No: 60480701

Checked By: Nick Sanna Date: 01/27/2016

Task No.: 01

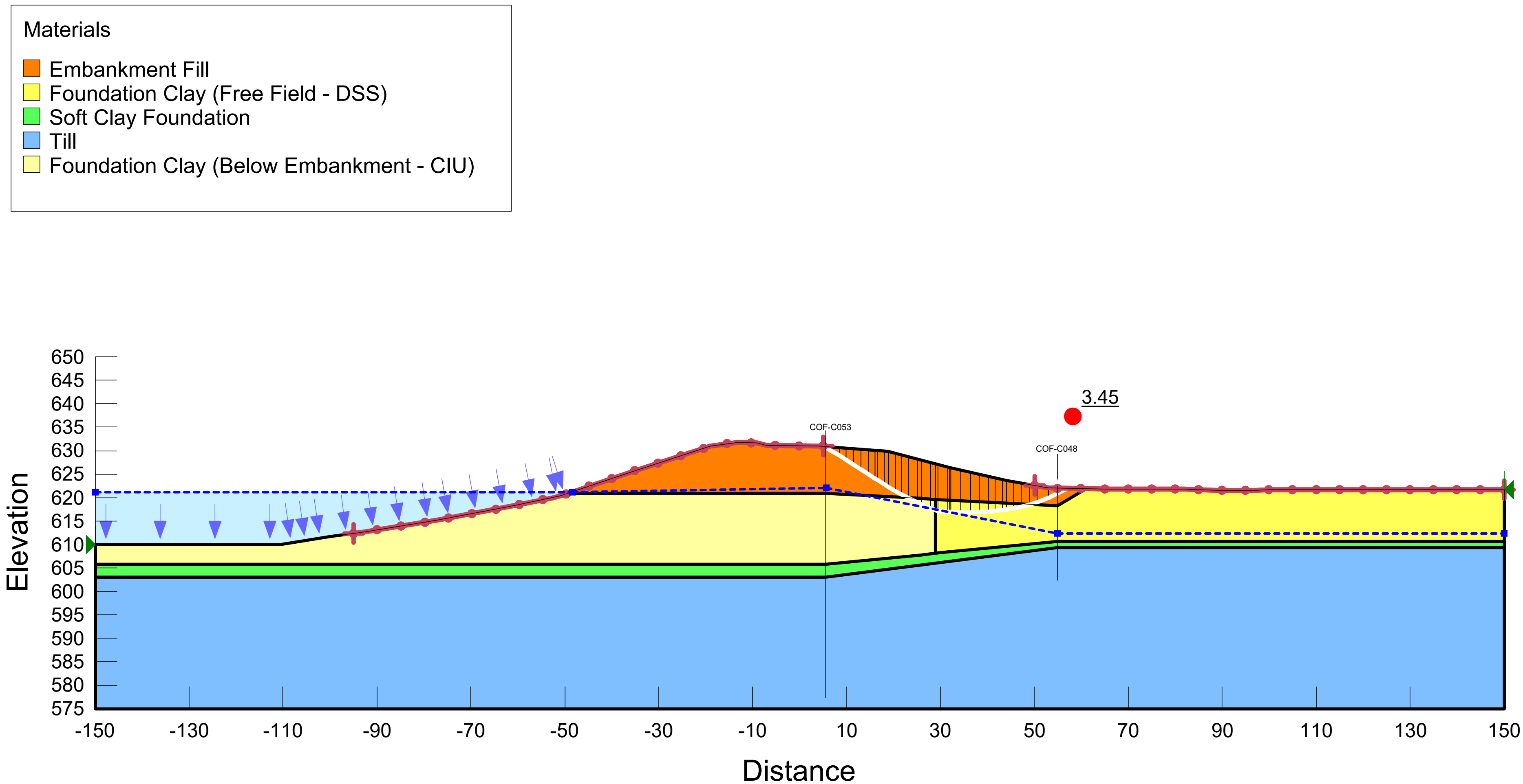
APPENDIX A

Slope Stability Output

Dynegy Coffeen
GMF Pond
Station 13+50
Slope Stability - Static Drained

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1



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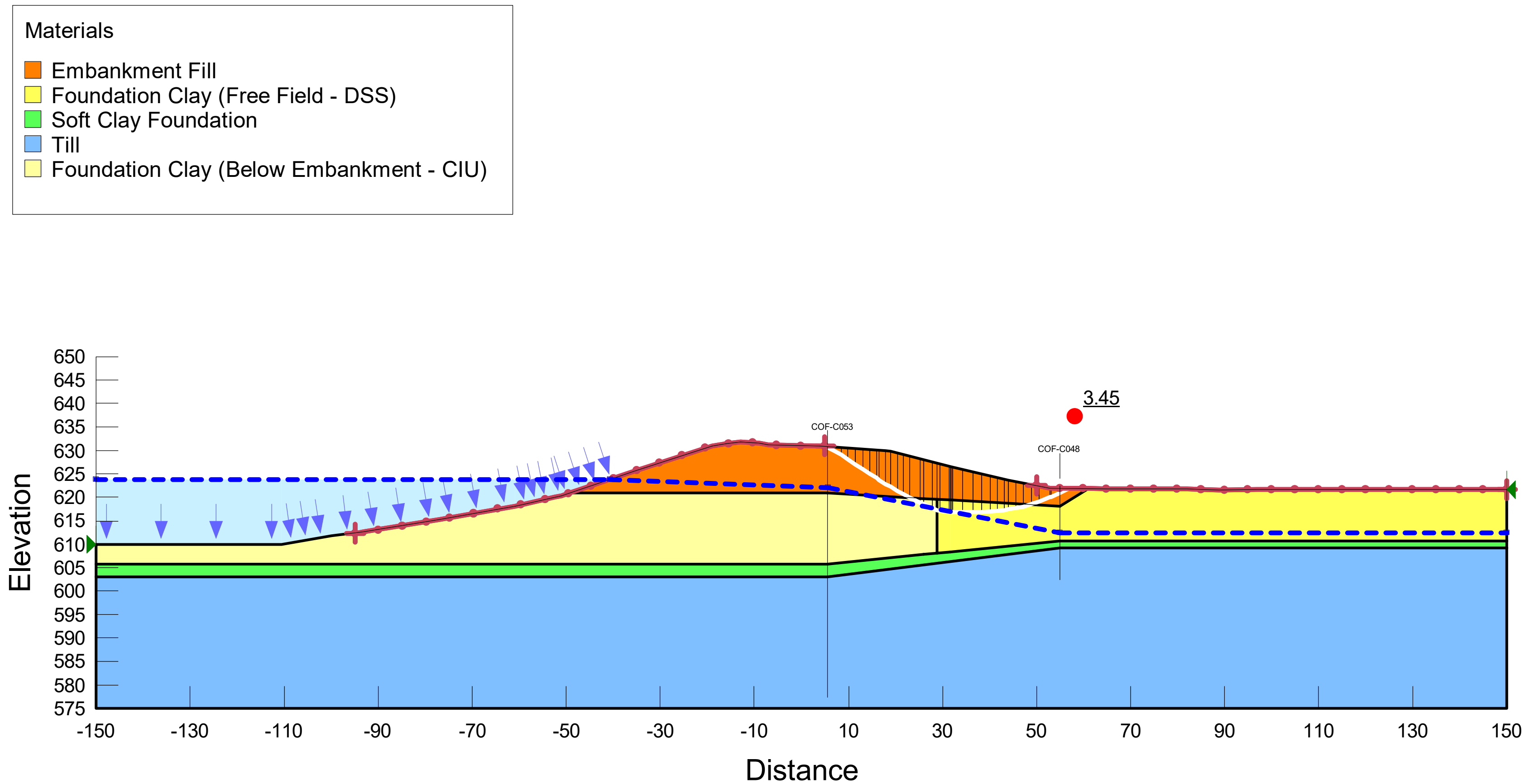
Dynegy Coffeen
GMF Pond
Station 13+50
Surcharge Pool - Static Drained - Entry Exit

Design by: Lucas Carr
Modidfied by : Betty Tesfu
Checked by: Nick Sanna
Date: 9/26/2016

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1



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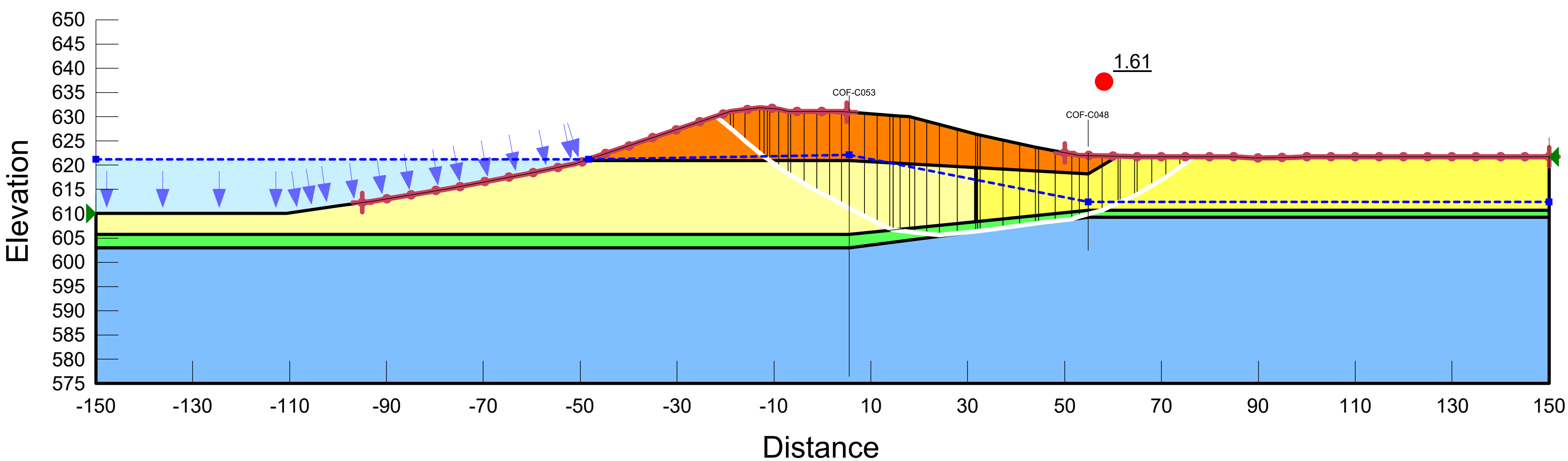
Dynegy Coffeen
GMF Pond
Station 13+50
Peak Undrained Soil Strengths
Pseudostatic - Entry-Exit

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load:
kh = 0.13 g



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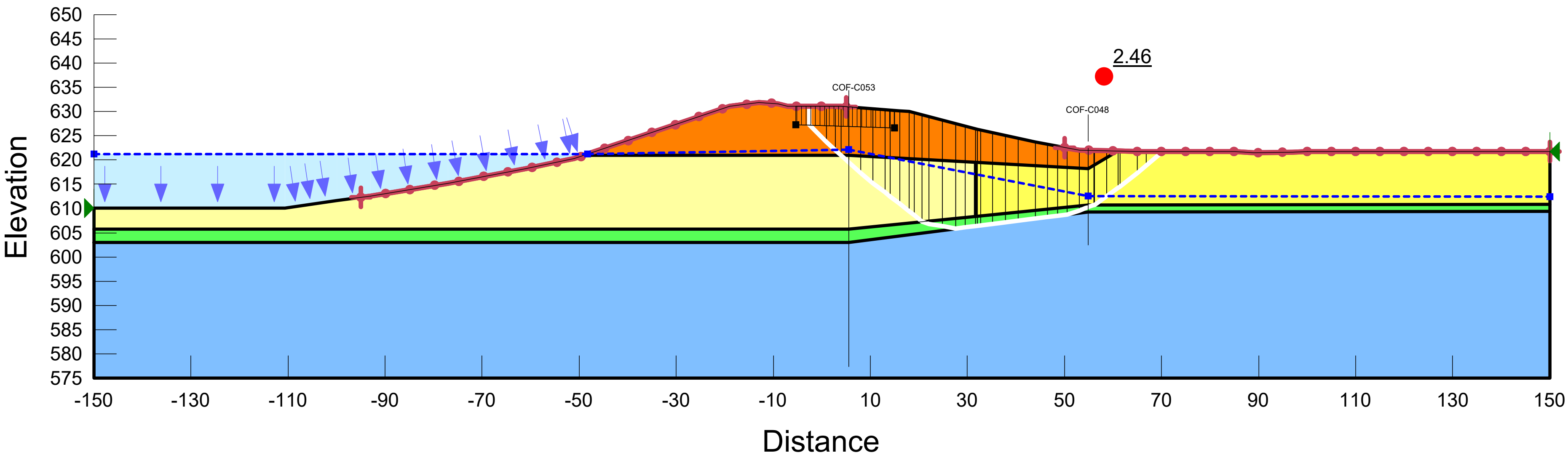
Dynegy Coffeen
GMF Pond
Station 13+50
Slope Stability - Post Earthquake

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill   Model: S=f(overburden)   Unit Weight: 135 pcf   Tau/Sigma Ratio: 0.6   Minimum Strength: 450 psf   Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS)   Model: S=f(overburden)   Unit Weight: 125 pcf   Tau/Sigma Ratio: 0.28   Minimum Strength: 450 psf   Piezometric Line: 1
Name: Soft Clay Foundation   Model: S=f(overburden)   Unit Weight: 125 pcf   Tau/Sigma Ratio: 0.16   Minimum Strength: 200 psf   Piezometric Line: 1
Name: Till   Model: S=f(overburden)   Unit Weight: 135 pcf   Tau/Sigma Ratio: 0.64   Minimum Strength: 700 psf   Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU)   Model: S=f(overburden)   Unit Weight: 125 pcf   Tau/Sigma Ratio: 0.45   Minimum Strength: 700 psf   Piezometric Line:

Materials
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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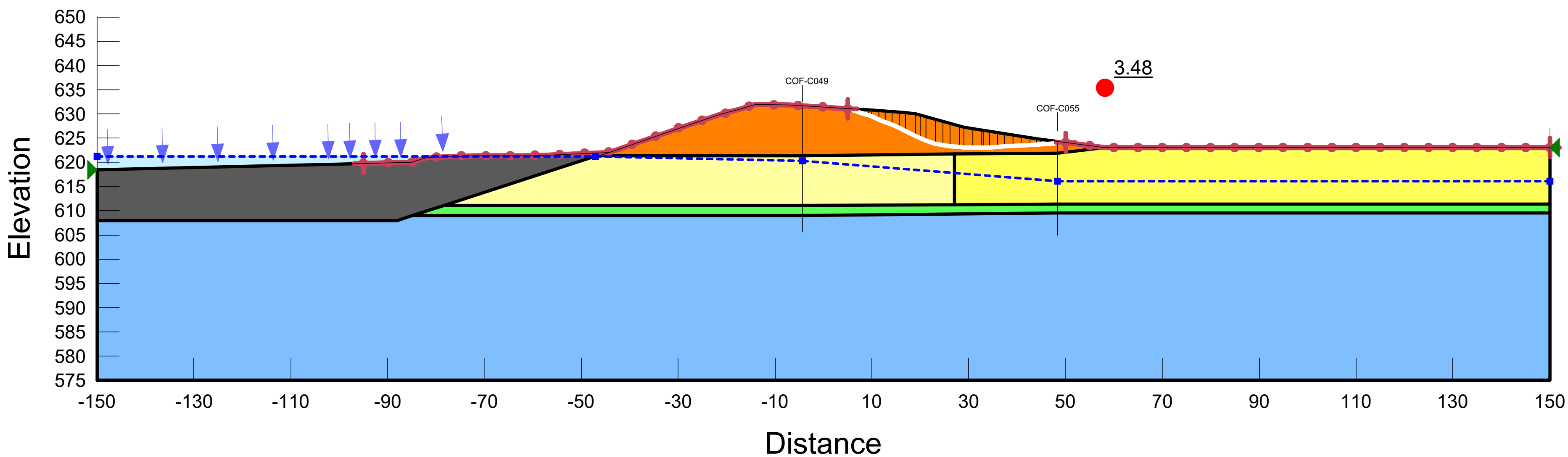
Dynegy Coffeen
GMF Pond
Station 22+50
Slope Stability - Static Drained

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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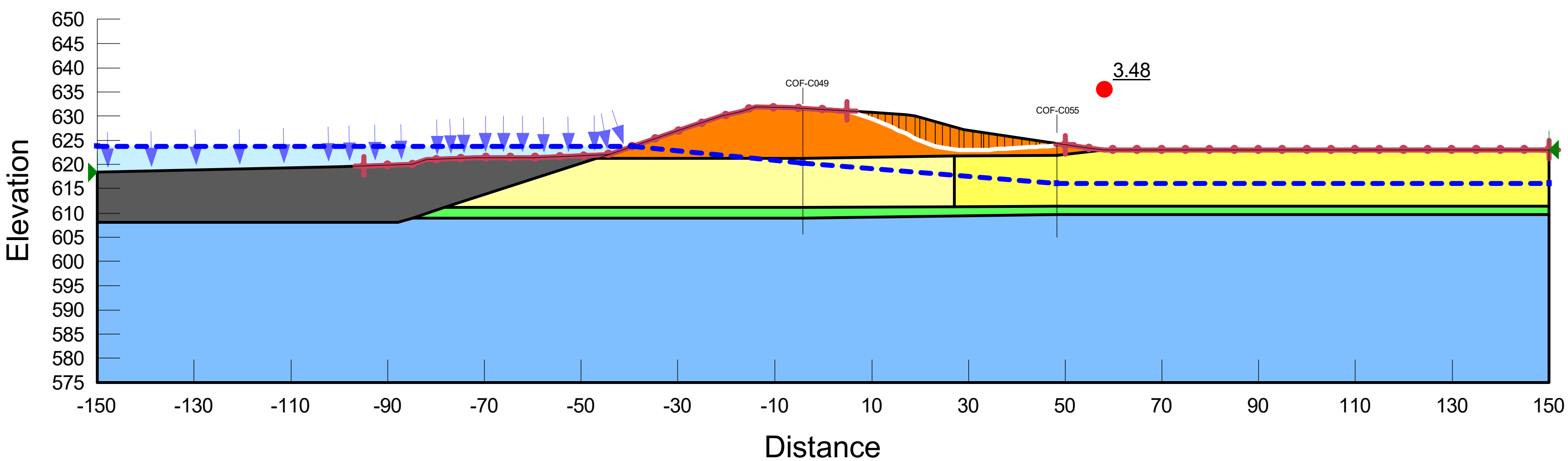
Dynegy Coffeen
GMF Pond
Station 22+50
Surcharge Pool - Static Drained - Entry - Exit

Design by: Lucas Carr
Modidfied by: Betty Tesfu
Checked by: Nick Sanna
Date: 9/26/2016

Name: Ash Model: Mohr-Coulomb Unit Weight: 112 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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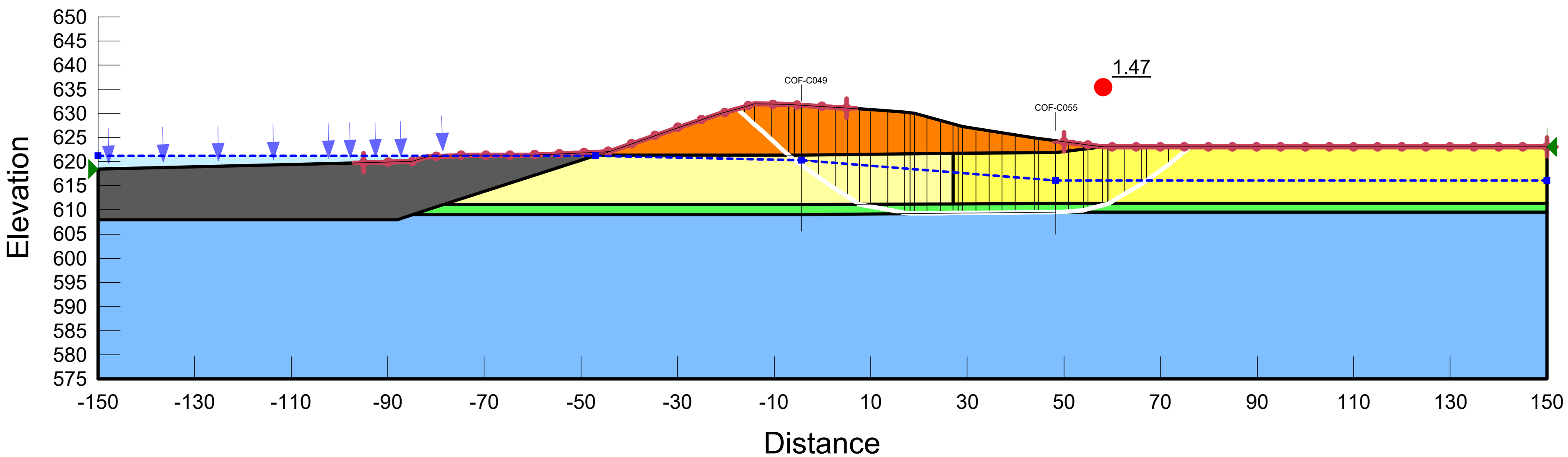
Dynegy Coffeen
GMF Pond
Station 22+50
Peak Undrained Soil Strengths
Pseudostatic - Entry & Exit

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Ash Model: S=f(overburden) Unit Weight: 112 pcf Tau/Sigma Ratio: 0.32 Minimum Strength: 0 psf Piezometric Line: 1
Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.24 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.22 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.39 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load:
kh = 0.13 g



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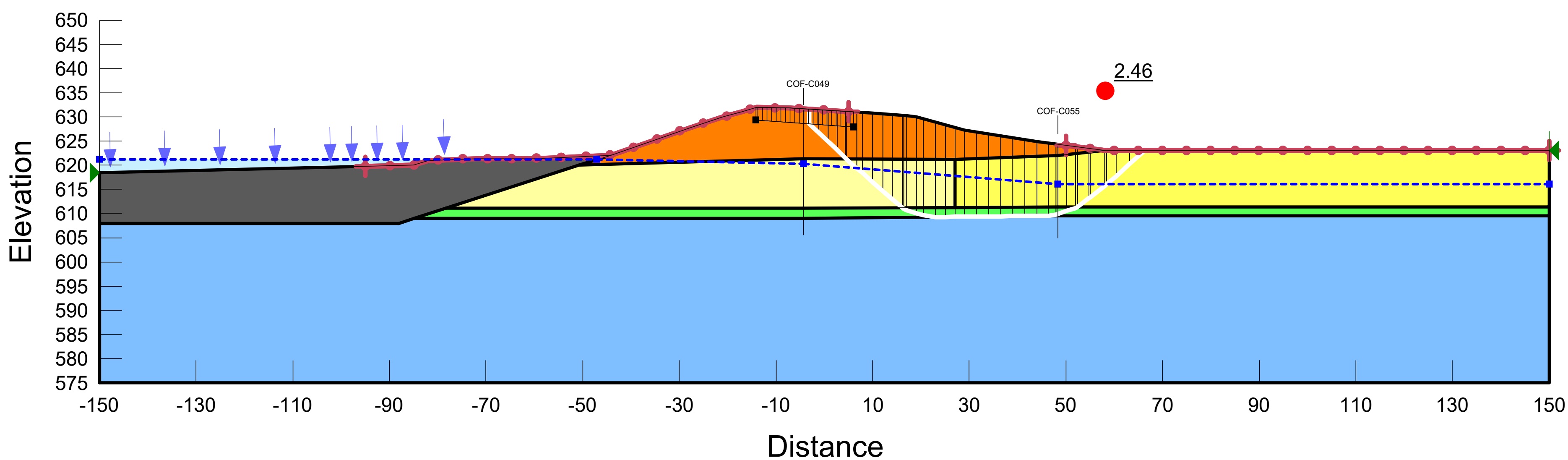
Dynegy Coffeen
GMF Pond
Station 22+50
Slope Stability - Post Earthquake

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Ash   Model: S=f(overburden)   Unit Weight: 112 pcf   Tau/Sigma Ratio: 0.05   Minimum Strength: 0 psf   Piezometric Line: 1
Name: Embankment Fill   Model: S=f(overburden)   Unit Weight: 135 pcf   Tau/Sigma Ratio: 0.6   Minimum Strength: 450 psf   Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS)   Model: S=f(overburden)   Unit Weight: 125 pcf   Tau/Sigma Ratio: 0.24   Minimum Strength: 450 psf   Piezometric Line: 1
Name: Soft Clay Foundation   Model: S=f(overburden)   Unit Weight: 125 pcf   Tau/Sigma Ratio: 0.13   Minimum Strength: 200 psf   Piezometric Line: 1
Name: Till   Model: S=f(overburden)   Unit Weight: 135 pcf   Tau/Sigma Ratio: 0.64   Minimum Strength: 700 psf   Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU)   Model: S=f(overburden)   Unit Weight: 125 pcf   Tau/Sigma Ratio: 0.39   Minimum Strength: 700 psf   Piezometric Line: 1

Materials
- Ash
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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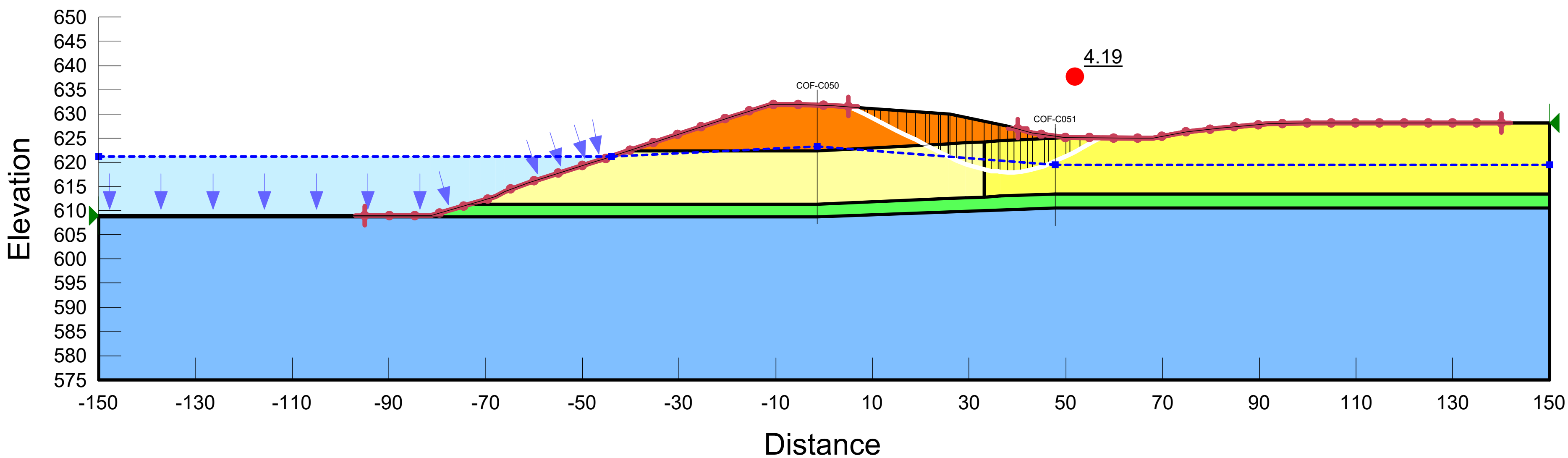
Dynegy Coffeen
GMF Pond
Station 46+50
Static Drained - Entry & Exit

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1

Materials

- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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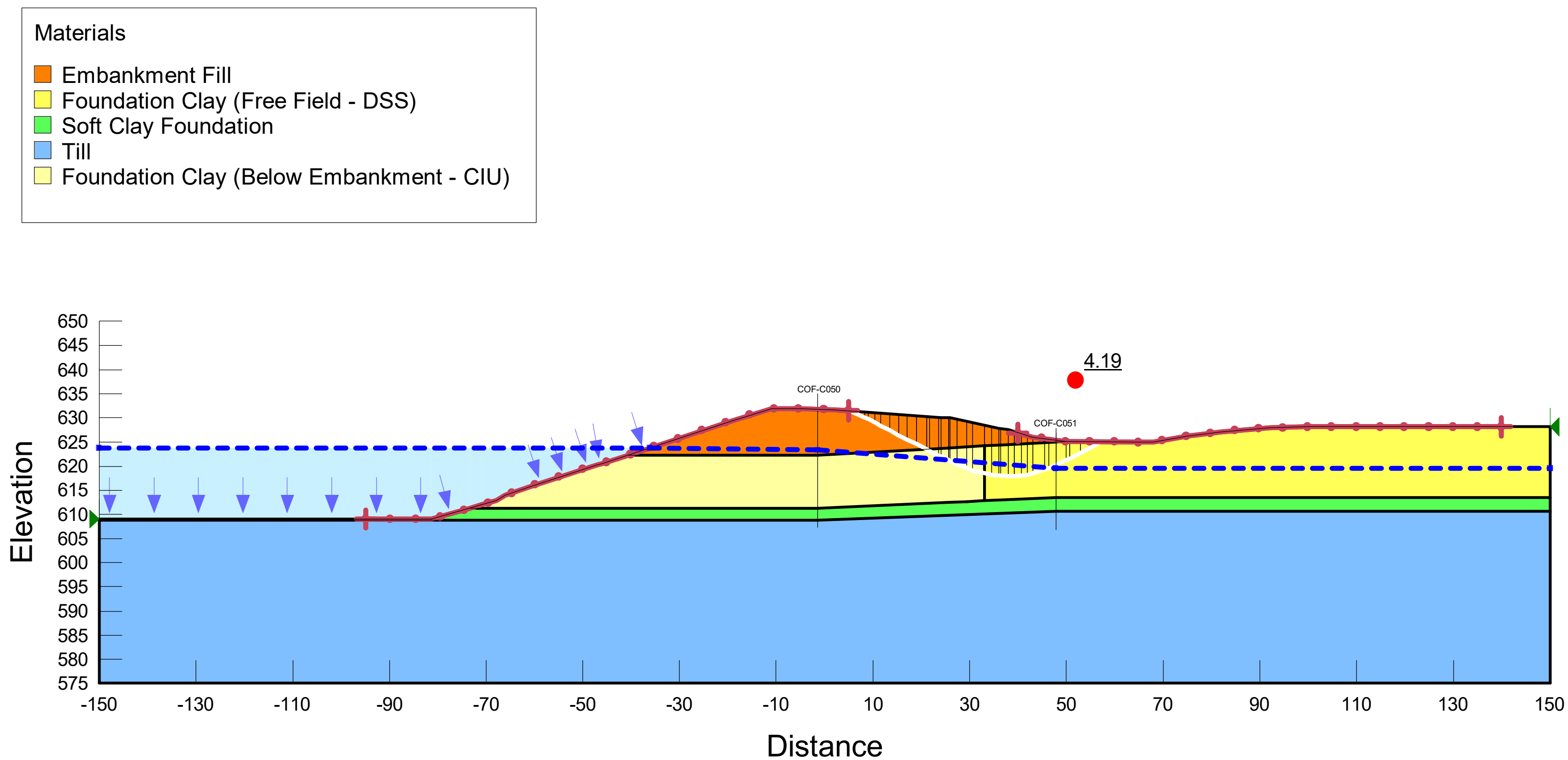
Dynegy Coffeen
GMF Pond
Station 46+50
Surcharge Pool - Static Drained - Entry & Exit

Design by: Lucas Carr
Modified by: Betty Tesfu
Checked by: Nick Sanna
Date: 9/26/2016

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1



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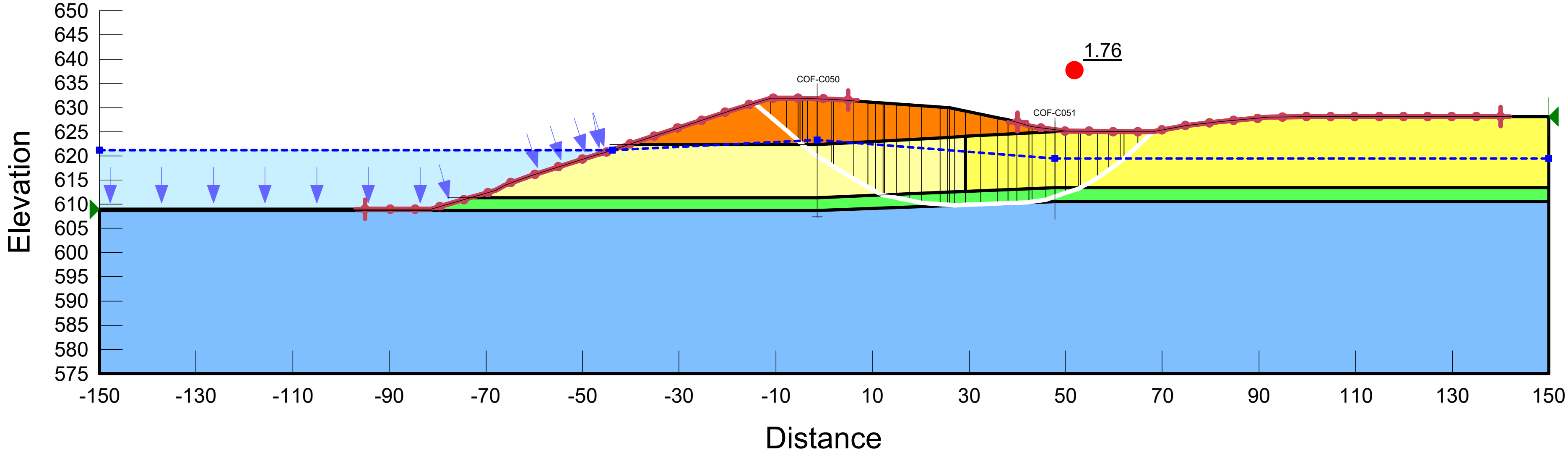
Dynegy Coffeen
GMF Pond
Station 46+50
Peak Undrained Soil Strengths
Name: Pseudostatic - Entry & Exit

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1

Materials
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)

Seismic Load
kh = 0.13 g



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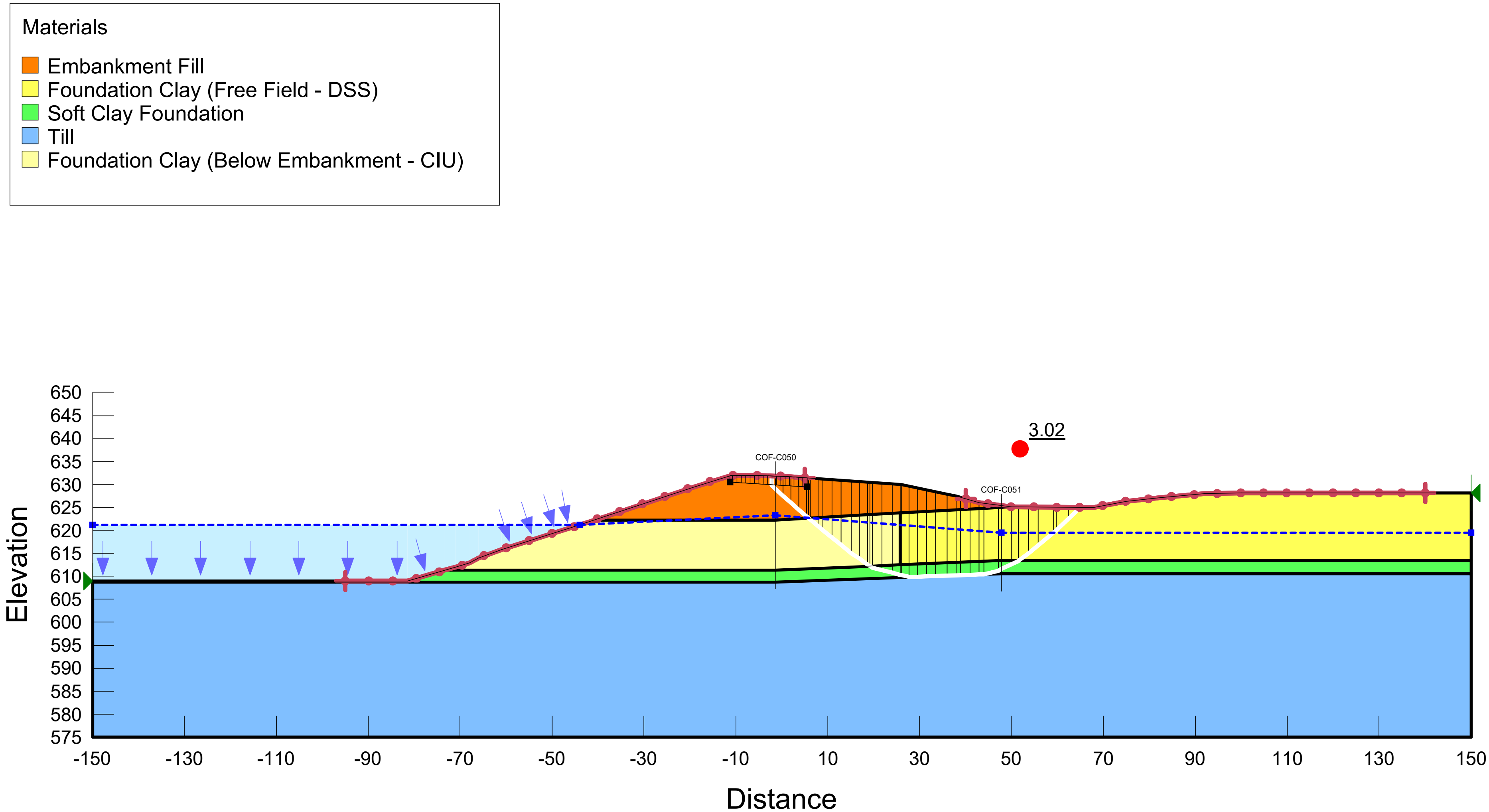
Dynegy Coffeen
GMF Pond
Station 46+50
Slope Stability - Post Earthquake

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.28 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.16 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.45 Minimum Strength: 700 psf Piezometric Line: 1



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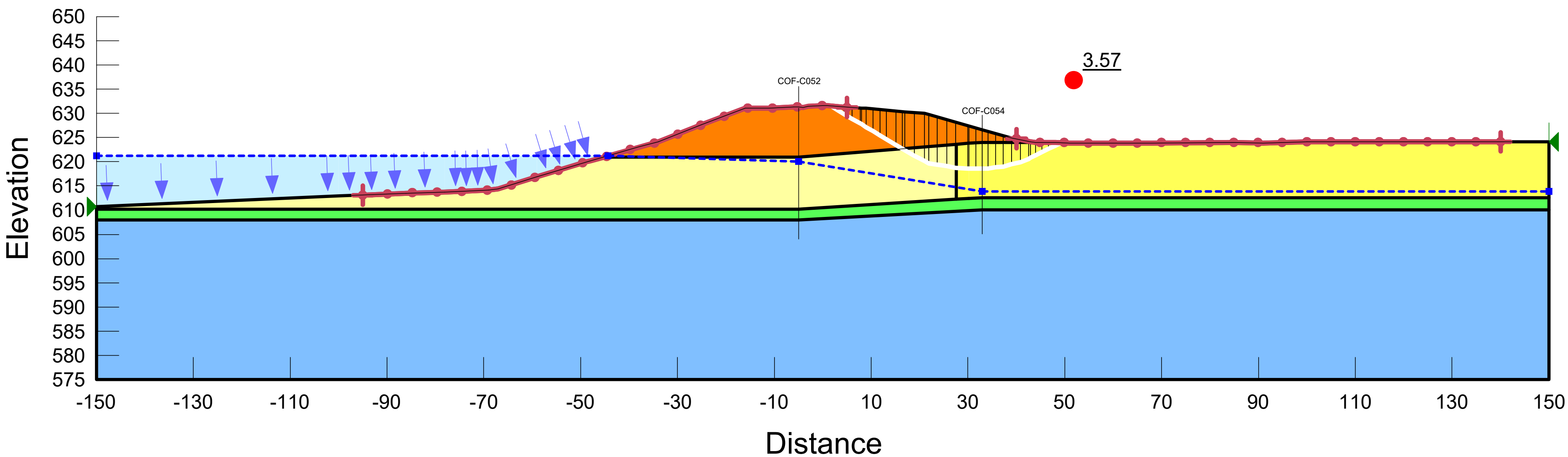
Dynegy Coffeen
GMF Pond
Station 58+00
Slope Stability - Static Drained

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1

Materials
- Embankment Fill
- Foundation Clay (Free Field - DSS)
- Soft Clay Foundation
- Till
- Foundation Clay (Below Embankment - CIU)



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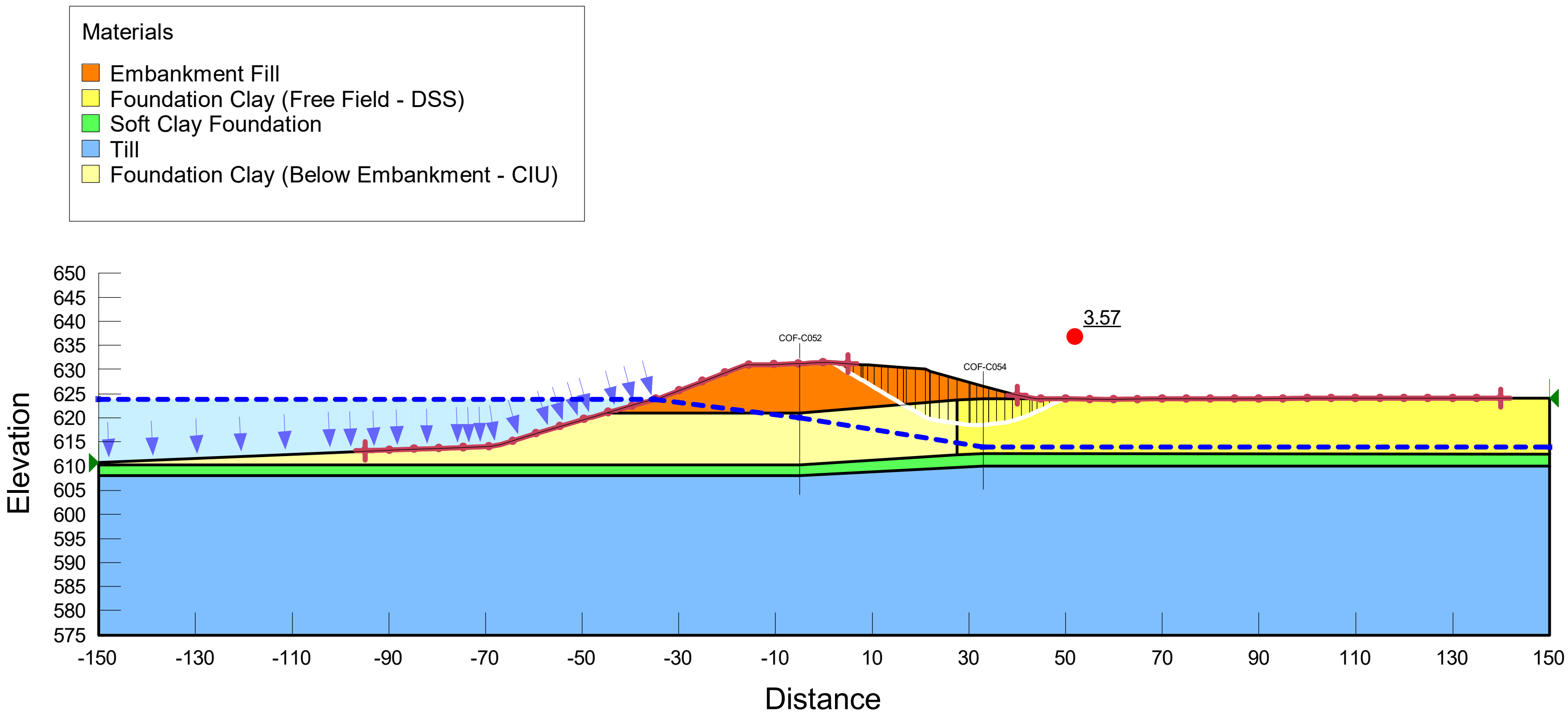
Dynegy Coffeen
GMF Pond
Station 58+00
Surcharge Pool - Static Drained - Entry Exit

Design by: Lucas Carr
Modidfied by: Betty Tesfu
Checked by: Nick Sanna
Date: 9/26/2016

Name: Embankment Fill Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 31 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Soft Clay Foundation Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Till Model: Mohr-Coulomb Unit Weight: 135 pcf Cohesion': 0 psf Phi': 40 ° Phi-B: 0 ° Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 0 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1



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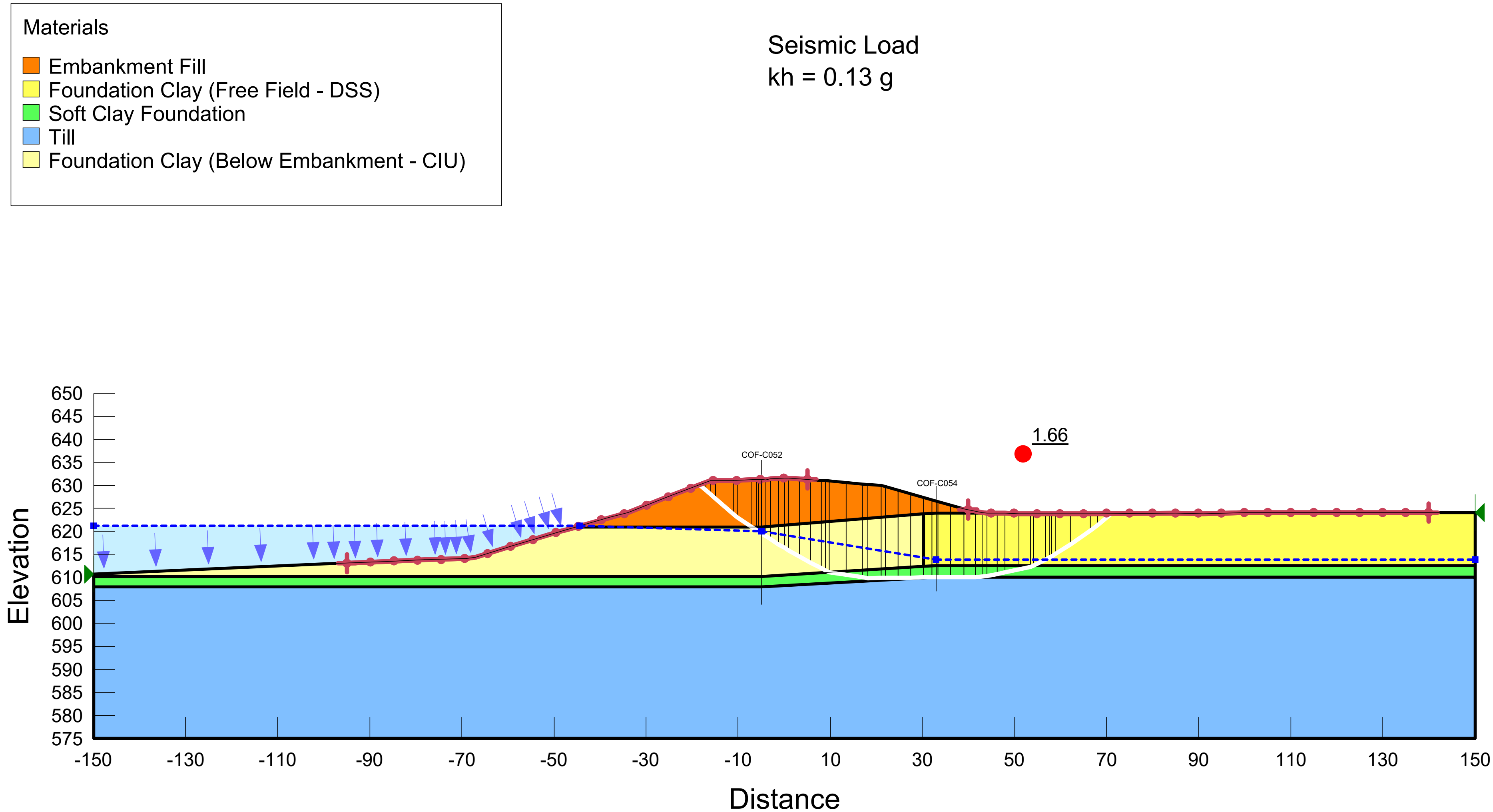
Dynegy Coffeen
GMF Pond
Station 58+00
Peak Undrained Soil Strengths
Pseudostatic - Entry-Exit

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.24 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.23 Minimum Strength: 275 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.39 Minimum Strength: 700 psf Piezometric Line:



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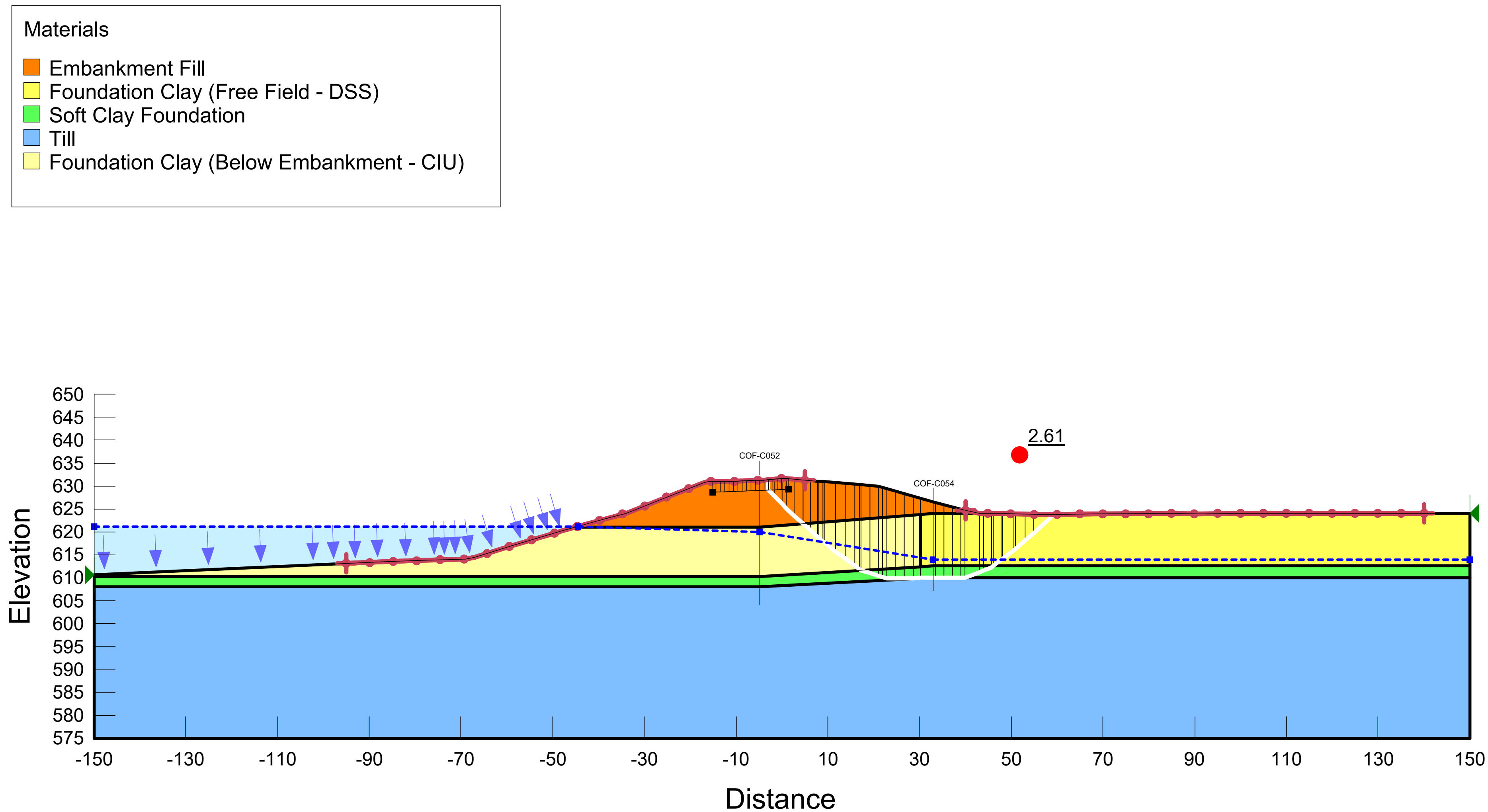
Dynegy Coffeen
GMF Pond
Station 58+00
Slope Stability - Post Earthquake

Design by: Lucas Carr
Checked by: Nick Sanna
Date: 3/7/2016

Name: Embankment Fill Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.6 Minimum Strength: 450 psf Piezometric Line: 1
Name: Foundation Clay (Free Field - DSS) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.24 Minimum Strength: 450 psf Piezometric Line: 1
Name: Soft Clay Foundation Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.13 Minimum Strength: 200 psf Piezometric Line: 1
Name: Till Model: S=f(overburden) Unit Weight: 135 pcf Tau/Sigma Ratio: 0.64 Minimum Strength: 700 psf Piezometric Line: 1
Name: Foundation Clay (Below Embankment - CIU) Model: S=f(overburden) Unit Weight: 125 pcf Tau/Sigma Ratio: 0.39 Minimum Strength: 700 psf Piezometric Line: 1



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Calculation Notes

AECOM

Subject: Coffeen GMF Pond Slope Stability Analysis

Project Name: Dynegy CCR

By: Lucas Carr Date: 01/25/2016

Project No: 60480701

Checked By: Nick Sanna Date: 01/27/2016

Task No.: 01

APPENDIX B

CPT Undrained Shear Strengths

Development of Reduced Shear Strengths for Sta. 22+50 and 58+00

	Ash Pond No. 1 Shear Strengths					
	Peak Undrained (Below Embankment - CIU)		Peak Undrained (Free-Field - DSS)		Post-Earthquake	
Material	Su/p'	Min Su (psf)	Su/p'	Min Su (psf)	Su/p'	Min Su (psf)
Foudnation Clay	0.45	700	0.28	450	Use Peak Undrained Strengths	
Soft Clay	Use DSS Strengths Only		0.28	275	0.16	200

		Reduced Peak Undrained (CIU) Strengths from CPT Analysis					
		Foundation Clay		Soft Clay		% Reduction in Su/p'	
Cross-Section	CPT Designation	Su/p'	Min Su (psf)	Su/p'	Min Su (psf)	Foundation Clay	Soft Clay
22+50	C049	0.39	700	0.22	275	13%	21%
58+00	C052	0.39	700	0.23	275	13%	18%

	GMF Pond - Sta. 22+50 Reduced Undrained Shear Strengths for Analysis					
	Peak Undrained (Below Embankment - CIU)		Peak Undrained (Free-Field - DSS)		Post-Earthquake	
Material	Su/p'	Min Su (psf)	Su/p'	Min Su (psf)	Su/p'	Min Su (psf)
Foudnation Clay	0.39	700	0.24	450	Use Peak Undrained Strengths	
Soft Clay	Use DSS Strengths Only		0.22	275	0.13	200

	GMF Pond - Sta. 58+00 Reduced Undrained Shear Strengths for Analysis					
	Peak Undrained (Below Embankment - CIU)		Peak Undrained (Free-Field - DSS)		Post-Earthquake	
Material	Su/p'	Min Su (psf)	Su/p'	Min Su (psf)	Su/p'	Min Su (psf)
Foudnation Clay	0.39	700	0.24	450	Use Peak Undrained Strengths	
Soft Clay	Use DSS Strengths Only		0.23	275	0.13	200

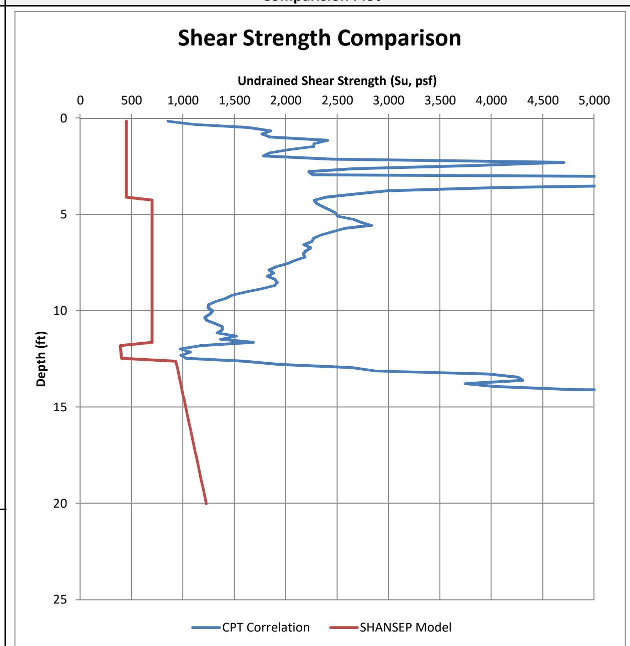
Material	Nkt	Peak Su/p'	Min Su (spf)
Fill	17.0	0.60	450.0
Fdxn Clay	17.0	0.45	700.0
Soft Clay	17.0	0.28	275.0
Till	17.0	0.64	700.0

CPT COF-C048

GWT Depth: 10.0 ft

ConeTec Data			CPT Shear Strength Correlation					SHANSEP Shear Strength Model				
Depth	qt	Material	Unit Weight (pcf)	Layer Weight	Total Vertical Stress	Nkt	CPT Su	Pore Pressure	Effective Vertical Stress	Su/p'	Min Su	SHANSEP Su
ft	tsf	Type	(pcf)	(psf)	(psf)		(psf)	(psf)	(psf)		(psf)	(psf)
0.164	7.258	Fill	135.0	22.1	22.1	17.0	853	0.0	22.1	0.6	450.0	450.0
0.328	9.412	Fill	135.0	22.1	44.3	17.0	1105	0.0	44.3	0.6	450.0	450.0
0.492	13.902	Fill	135.0	22.1	66.4	17.0	1632	0.0	66.4	0.6	450.0	450.0
0.656	15.815	Fill	135.0	22.1	88.6	17.0	1855	0.0	88.6	0.6	450.0	450.0
0.820	15.082	Fill	135.0	22.1	110.7	17.0	1768	0.0	110.7	0.6	450.0	450.0
0.984	15.819	Fill	135.0	22.1	132.9	17.0	1853	0.0	132.9	0.6	450.0	450.0
1.148	20.544	Fill	135.0	22.1	155.0	17.0	2408	0.0	155.0	0.6	450.0	450.0
1.312	19.443	Fill	135.0	22.1	177.2	17.0	2277	0.0	177.2	0.6	450.0	450.0
1.476	19.421	Fill	135.0	22.1	199.3	17.0	2273	0.0	199.3	0.6	450.0	450.0
1.640	17.345	Fill	135.0	22.1	221.5	17.0	2028	0.0	221.5	0.6	450.0	450.0
1.804	15.786	Fill	135.0	22.1	243.6	17.0	1843	0.0	243.6	0.6	450.0	450.0
1.968	15.283	Fill	135.0	22.1	265.7	17.0	1782	0.0	265.7	0.6	450.0	450.0
2.133	20.900	Fill	135.0	22.1	287.9	17.0	2442	0.0	287.9	0.6	450.0	450.0
2.297	40.164	Fill	135.0	22.1	310.0	17.0	4707	0.0	310.0	0.6	450.0	450.0
2.461	32.783	Fill	135.0	22.1	332.2	17.0	3837	0.0	332.2	0.6	450.0	450.0
2.625	22.798	Fill	135.0	22.1	354.3	17.0	2661	0.0	354.3	0.6	450.0	450.0
2.789	19.090	Fill	135.0	22.1	376.5	17.0	2224	0.0	376.5	0.6	450.0	450.0
2.953	19.484	Fill	135.0	22.1	398.6	17.0	2269	0.0	398.6	0.6	450.0	450.0
3.117	69.104	Fill	135.0	22.1	420.8	17.0	8105	0.0	420.8	0.6	450.0	450.0
3.281	72.367	Fill	135.0	22.1	442.9	17.0	8488	0.0	442.9	0.6	450.0	450.0
3.445	51.729	Fill	135.0	22.1	465.1	17.0	6058	0.0	465.1	0.6	450.0	450.0
3.609	34.776	Fill	135.0	22.1	487.2	17.0	4063	0.0	487.2	0.6	450.0	450.0
3.773	25.657	Fill	135.0	22.1	509.3	17.0	2988	0.0	509.3	0.6	450.0	450.0
3.937	23.048	Fill	135.0	22.1	531.5	17.0	2680	0.0	531.5	0.6	450.0	450.0
4.101	20.648	Fill	135.0	22.1	553.6	17.0	2397	0.0	553.6	0.6	450.0	450.0
4.265	19.632	Fdxn Clay	125.0	20.5	574.1	17.0	2276	0.0	574.1	0.5	700.0	700.0
4.429	19.862	Fdxn Clay	125.0	20.5	594.6	17.0	2302	0.0	594.6	0.5	700.0	700.0
4.593	20.347	Fdxn Clay	125.0	20.5	615.2	17.0	2358	0.0	615.2	0.5	700.0	700.0
4.757	20.936	Fdxn Clay	125.0	20.5	635.7	17.0	2426	0.0	635.7	0.5	700.0	700.0
4.921	21.457	Fdxn Clay	125.0	20.5	656.2	17.0	2486	0.0	656.2	0.5	700.0	700.0
5.085	21.618	Fdxn Clay	125.0	20.5	676.7	17.0	2504	0.0	676.7	0.5	700.0	700.0
5.249	22.965	Fdxn Clay	125.0	20.5	697.2	17.0	2661	0.0	697.2	0.5	700.0	700.0
5.413	23.655	Fdxn Clay	125.0	20.5	717.7	17.0	2741	0.0	717.7	0.5	700.0	700.0
5.577	24.461	Fdxn Clay	125.0	20.5	738.2	17.0	2834	0.0	738.2	0.5	700.0	700.0
5.741	22.170	Fdxn Clay	125.0	20.5	758.7	17.0	2564	0.0	758.7	0.5	700.0	700.0
5.905	21.225	Fdxn Clay	125.0	20.5	779.2	17.0	2451	0.0	779.2	0.5	700.0	700.0
6.069	20.312	Fdxn Clay	125.0	20.5	799.7	17.0	2343	0.0	799.7	0.5	700.0	700.0
6.234	19.713	Fdxn Clay	125.0	20.5	820.2	17.0	2271	0.0	820.2	0.5	700.0	700.0
6.398	19.574	Fdxn Clay	125.0	20.5	840.7	17.0	2253	0.0	840.7	0.5	700.0	700.0
6.562	18.940	Fdxn Clay	125.0	20.5	861.2	17.0	2178	0.0	861.2	0.5	700.0	700.0
6.726	19.523	Fdxn Clay	125.0	20.5	881.7	17.0	2245	0.0	881.7	0.5	700.0	700.0
6.890	19.082	Fdxn Clay	125.0	20.5	902.2	17.0	2192	0.0	902.2	0.5	700.0	700.0
7.054	18.918	Fdxn Clay	125.0	20.5	922.7	17.0	2171	0.0	922.7	0.5	700.0	700.0
7.218	19.050	Fdxn Clay	125.0	20.5	943.2	17.0	2186	0.0	943.2	0.5	700.0	700.0
7.382	18.258	Fdxn Clay	125.0	20.5	963.7	17.0	2091	0.0	963.7	0.5	700.0	700.0
7.546	17.649	Fdxn Clay	125.0	20.5	984.2	17.0	2018	0.0	984.2	0.5	700.0	700.0
7.710	16.691	Fdxn Clay	125.0	20.5	1004.7	17.0	1905	0.0	1004.7	0.5	700.0	700.0
7.874	16.137	Fdxn Clay	125.0	20.5	1025.3	17.0	1838	0.0	1025.3	0.5	700.0	700.0
8.038	16.499	Fdxn Clay	125.0	20.5	1045.8	17.0	1880	0.0	1045.8	0.5	700.0	700.0
8.202	16.009	Fdxn Clay	125.0	20.5	1066.3	17.0	1821	0.0	1066.3	0.5	700.0	700.0
8.366	16.631	Fdxn Clay	125.0	20.5	1086.8	17.0	1893	0.0	1086.8	0.5	700.0	700.0
8.530	16.871	Fdxn Clay	125.0	20.5	1107.3	17.0	1920	0.0	1107.3	0.5	700.0	700.0
8.694	16.641	Fdxn Clay	125.0	20.5	1127.8	17.0	1891	0.0	1127.8	0.5	700.0	700.0
8.858	15.570	Fdxn Clay	125.0	20.5	1148.3	17.0	1764	0.0	1148.3	0.5	700.0	700.0
9.022	14.256	Fdxn Clay	125.0	20.5	1168.8	17.0	1608	0.0	1168.8	0.5	700.0	700.0
9.186	13.165	Fdxn Clay	125.0	20.5	1189.3	17.0	1479	0.0	1189.3	0.5	700.0	700.0
9.350	12.655	Fdxn Clay	125.0	20.5	1209.8	17.0	1418	0.0	1209.8	0.5	700.0	700.0
9.514	11.821	Fdxn Clay	125.0	20.5	1230.3	17.0	1318	0.0	1230.3	0.5	700.0	700.0
9.678	11.244	Fdxn Clay	125.0	20.5	1250.8	17.0	1249	0.0	1250.8	0.5	700.0	700.0
9.842	11.198	Fdxn Clay	125.0	20.5	1271.3	17.0	1243	0.0	1271.3	0.5	700.0	700.0
10.006	11.579	Fdxn Clay	125.0	20.5	1291.8	17.0	1286	0.4	1291.4	0.5	700.0	700.0
10.170	11.404	Fdxn Clay	125.0	20.5	1312.3	17.0	1264	10.6	1301.7	0.5	700.0	700.0
10.335	10.965	Fdxn Clay	125.0	20.5	1332.8	17.0	1212	20.9	1312.0	0.5	700.0	700.0
10.499	11.146	Fdxn Clay	125.0	20.5	1353.3	17.0	1232	31.1	1322.2	0.5	700.0	700.0
10.663	11.886	Fdxn Clay	125.0	20.5	1373.8	17.0	1318	41.3	1332.5	0.5	700.0	700.0
10.827	12.469	Fdxn Clay	125.0	20.5	1394.3	17.0	1385	51.6	1342.8	0.5	700.0	700.0
10.991	12.461	Fdxn Clay	125.0	20.5	1414.8	17.0	1383	61.8	1353.0	0.5	700.0	700.0
11.155	12.058	Fdxn Clay	125.0	20.5	1435.4	17.0	1334	72.1	1363.3	0.5	700.0	700.0
11.319	13.639	Fdxn Clay	125.0	20.5	1455.9	17.0	1519	82.3	1373.6	0.5	700.0	700.0
11.483	12.362	Fdxn Clay	125.0	20.5	1476.4	17.0	1367	92.5	1383.8	0.5	700.0	700.0
11.647	15.069	Fdxn Clay	125.0	20.5	1496.9	17.0	1685	102.8	1394.1	0.5	700.0	700.0
11.811	10.787	Soft Clay	125.0	20.5	1517.4	17.0	1180	113.0	1404.4	0.3	275.0	393.2
11.975	9.050	Soft Clay	125.0	20.5	1537.9	17.0	974	123.2	1414.6	0.3	275.0	396.1
12.139	9.903	Soft Clay	125.0	20.5	1558.4	17.0	1073	133.5	1424.9	0.3	275.0	399.0
12.303	9.131	Soft Clay	125.0	20.5	1578.9	17.0	981	143.7	1435.2	0.3	275.0	401.8
12.467	9.593	Soft Clay	125.0	20.5	1599.4	17.0	1034	153.9	1445.4	0.3	275.0	404.7
12.631	14.390	Till	125.0	20.5	1619.9	17.0	1598	164.2	1455.7	0.6	700.0	931.7
12.795	17.252	Till	125.0	20.5	1640.4	17.0	1933	174.4	1466.0	0.6	700.0	938.2
12.959	23.309	Till	125.0	20.5	1660.9	17.0	2645	184.7	1476.3	0.6	700.0	944.8
13.123	25.255	Till	125.0	20.5	1681.4	17.0	2872	194.9	1486.5	0.6	700.0	951.4
13.287	34.582	Till	125.0	20.5	1701.9	17.0	3968	205.1	1496.8	0.6	700.0	957.9
13.451	37.080	Till	125.0	20.5	1722.4	17.0	4261	215.4	1507.1	0.6	700.0	964.5
13.615	37.466	Till	125.0	20.5	1742.9	17.0	4305	225.6	1517.3	0.6	700.0	971.1
13.779	32.726	Till	125.0	20.5	1763.4	17.0	3746	235.8	1527.6	0.6	700.0	977.7
13.943	35.148	Till	125.0	20.5	1783.9	17.0	4030	246.1	1537.9	0.6	700.0	984.2
14.107	41.811	Till	125.0	20.5	1804.4	17.0	4813	256.3	1548.1	0.6	700.0	990.8
14.271	81.704	Till	125.0	20.5	1824.9	17.0	9505	266.5	1558.4	0.6	700.0	997.4
14.436	70.433	Till	125.0	20.5	1845.5	17.0	8178	276.8	1568.7	0.6	700.0	1004.0
14.600	57.944	Till	125.0	20.5	1866.0	17.0	6707	287.0	1578.9	0.6	700.0	1010.5
14.764	74.833	Till	125.0	20.5	1886.5	17.0	8693	297.2	1589.2	0.6	700.0	1017.1
14.928	95.352	Till	125.0	20.5	1907.0	17.0	11106	307.5	1599.5	0.6	700.0	1023.7
15.092	155.689	Till	125.0	20.5	1927.5	17.0	18203	317.7	1609.7	0.6	700.0	1030.2
15.256	154.649	Till	125.0	20.5	1948.0	17.0	18079	328.0	1620.0	0.6	700.0	1036.8
15.420	175.726	Till	125.0	20.5	1968.5	17.0	20558	338.2	1630.3	0.6	700.0	1043.4
15.584	145.932	Till	125.0	20.5	1989.0	17.0	17052	348.4	1640.6	0.6	700.0	1050.0
15.748	157.272	Till	125.0	20.5	2009.5	17.0	18384	358.7	1650.8	0.6	700.0	1056.5
15.912	261.364	Till	125.0	20.5	2030.0	17.0	30629	368.9	1661.1	0.6	700.0	1063.1
16.076	330.262	Till	125.0	20.5	2050.5	17.0	38734	379.1	1671.4	0.6	700.0	1069.7
16.240	334.311	Till	125.0	20.5	2071.0	17.0	39209	389.4	1681.6	0.6	700.0	1076.2
16.404	345.933	Till	125.0	20.5	2091.5	17.0	40575	399.6	1691.9	0.6	700.0	1082.8
16.568	378.358	Till	125.0	20.5	2112.0	17.0	44388	409.8	1702.2	0.6	700.0	1089.4
16.732	380.966	Till	125.0	20.5	2132.5	17.0	44694	420.1	1712.4	0.6	700.0	1096.0
16.896	306.986	Till	125.0	20.5	2153.0	17.0	35989	430.3	1722.7	0.6	700.0	1102.5
17.060	278.135	Till	125.0	20.5	2173.5	17.0	32594	440.6	1733.0	0.6	700.0	1109.1
17.224	266.517	Till	125.0	20.5	2194.0	17.0	31226	450.8	1743.2	0.6	700.0	1115.7
17.388	255.796	Till	125.0	20.5	2214.5	17.0	29963	461.0	1753.5	0.6	700.0	1122.2
17.552	254.332	Till	125.0	20.5	2235.0	17.0	29790	471.3	1763.8	0.6	700.0	1128.8
17.716	260.747	Till	125.0	20.5	2255.6	17.0	30543	481.5	1774.1	0.6	700.0	1135.4
17.880	275.891	Till	125.0	20.5	2276.1	17.0	32324	491.7	1784.3	0.6	700.0	1142.0
18.044	321.059	Till	125.0	20.5	2296.6	17.0	37637	502.0	1794.6	0.6	700.0	1148.5
18.208	358.766	Till	125.0	20.5	2317.1	17.0	42071	512.2	1804.9	0.6	700.0	1155.1
18.372	389.120	Till	125.0	20.5	2337.6	17.0	45641	522.4	1815.1	0.6	700.0	1161.7
18.537	436.698	Till	125.0	20.5	2358.1	17.0	51238	532.7	1825.4	0.6	700.0	1168.3
18.701	441.541	Till	125.0	20.5	2378.6	17.0	51806	542.9	1835.7	0.6	700.0	1174.8
18.865	448.070	Till	125.0	20.5	2399.1	17.0	52573	553.2	1845.9	0.6	700.0	1181.4
19.029	456.839	Till	125.0	20.5	2419.6	17.0	53603	563.4	1856.2	0.6	700.0	1188.0
19.193	450.196	Till	125.0	20.5	2440.1	17.0	52821	573.6	1866.5	0.6	700.0	1194.5
19.357	468.966	Till	125.0	20.5	2460.6	17.0	55028	583.9	1876.7	0.6	700.0	1201.1
19.521	471.459	Till	125.0	20.5	2481.1	17.0	55320	594.1	1887.0	0.6	700.0	1207.7
19.685	467.077	Till	125.0	20.5	2501.6	17.0	54803	604.3	1897.3	0.6	700.0	1214.3
19.849	464.832	Till	125.0	20.5	2522.1	17.0	54538	614.6	1907.5	0.6	700.0	1220.8
20.013	498.128	Till	125.0	20.5	2542.6	17.0	58454	624.8	1917.8	0.6	700.0	1227.4

Comparision Plot



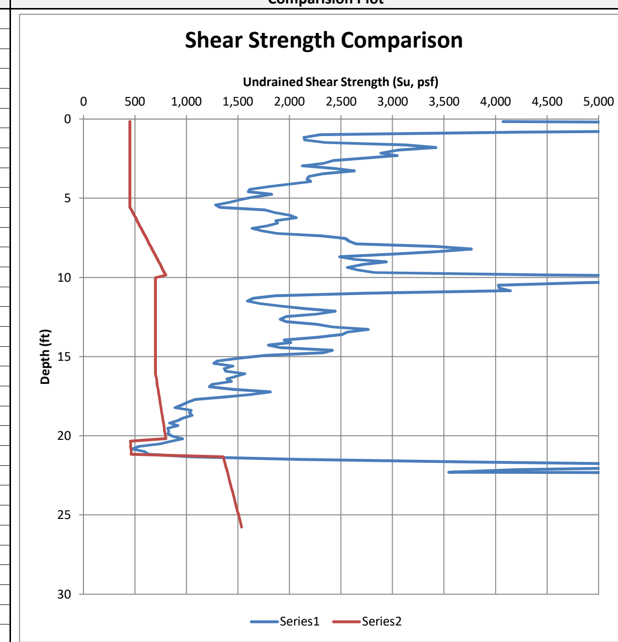
Material	Nkt	Peak Su/p'	Min Su (spf)	% Reduction	
Fill	17.0	0.60	450.0	0%	
Fdxn Clay	17.0	0.39	700.0	13%	26.6
Soft Clay	17.0	0.22	275.0	21%	24.4
Till	17.0	0.64	700.0	0%	

CPT COF-C049

GWT Depth: 11.0 ft

ConeTec Data			CPT Shear Strength Correlation					SHANSEP Shear Strength Model				
Depth	qt	Material	Unit Weight (pcf)	Layer Weight	Total Vertical Stress	Nkt	CPT Su	Pore Pressure	Effective Vertical Stress	Su/p'	Min Su	SHANSEP Su
ft	tsf	Type	(pcf)	(psf)	(psf)		(psf)	(psf)	(psf)		(psf)	(psf)
0.164	34.640	Fill	135.0	22.1	22.1	17.0	4074	0.0	22.1	0.6	450.0	450.0
0.328	77.549	Fill	135.0	22.1	44.3	17.0	9121	0.0	44.3	0.6	450.0	450.0
0.492	70.248	Fill	135.0	22.1	66.4	17.0	8261	0.0	66.4	0.6	450.0	450.0
0.656	64.119	Fill	135.0	22.1	88.6	17.0	7538	0.0	88.6	0.6	450.0	450.0
0.820	36.236	Fill	135.0	22.1	110.7	17.0	4257	0.0	110.7	0.6	450.0	450.0
0.984	19.610	Fill	135.0	22.1	132.8	17.0	2299	0.0	132.8	0.6	450.0	450.0
1.148	18.261	Fill	135.0	22.1	155.0	17.0	2139	0.0	155.0	0.6	450.0	450.0
1.312	18.310	Fill	135.0	22.1	177.1	17.0	2144	0.0	177.1	0.6	450.0	450.0
1.476	20.039	Fill	135.0	22.1	199.3	17.0	2346	0.0	199.3	0.6	450.0	450.0
1.640	26.678	Fill	135.0	22.1	221.4	17.0	3126	0.0	221.4	0.6	450.0	450.0
1.804	29.198	Fill	135.0	22.1	243.5	17.0	3421	0.0	243.5	0.6	450.0	450.0
1.968	26.090	Fill	135.0	22.1	265.7	17.0	3054	0.0	265.7	0.6	450.0	450.0
2.133	24.695	Fill	135.0	22.3	288.0	17.0	2888	0.0	288.0	0.6	450.0	450.0
2.297	26.049	Fill	135.0	22.1	310.1	17.0	3046	0.0	310.1	0.6	450.0	450.0
2.461	23.421	Fill	135.0	22.1	332.2	17.0	2736	0.0	332.2	0.6	450.0	450.0
2.625	20.716	Fill	135.0	22.1	354.4	17.0	2416	0.0	354.4	0.6	450.0	450.0
2.789	19.983	Fill	135.0	22.1	376.5	17.0	2329	0.0	376.5	0.6	450.0	450.0
2.953	18.241	Fill	135.0	22.1	398.7	17.0	2123	0.0	398.7	0.6	450.0	450.0
3.117	20.778	Fill	135.0	22.1	420.8	17.0	2420	0.0	420.8	0.6	450.0	450.0
3.281	22.578	Fill	135.0	22.1	442.9	17.0	2630	0.0	442.9	0.6	450.0	450.0
3.445	19.959	Fill	135.0	22.1	465.1	17.0	2321	0.0	465.1	0.6	450.0	450.0
3.609	18.814	Fill	135.0	22.1	487.2	17.0	2185	0.0	487.2	0.6	450.0	450.0
3.773	18.701	Fill	135.0	22.1	509.4	17.0	2170	0.0	509.4	0.6	450.0	450.0
3.937	18.996	Fill	135.0	22.1	531.5	17.0	2204	0.0	531.5	0.6	450.0	450.0
4.101	17.243	Fill	135.0	22.1	553.6	17.0	1996	0.0	553.6	0.6	450.0	450.0
4.265	15.502	Fill	135.0	22.1	575.8	17.0	1790	0.0	575.8	0.6	450.0	450.0
4.429	14.037	Fill	135.0	22.1	597.9	17.0	1616	0.0	597.9	0.6	450.0	450.0
4.593	13.901	Fill	135.0	22.1	620.1	17.0	1599	0.0	620.1	0.6	450.0	450.0
4.757	15.848	Fill	135.0	22.1	642.2	17.0	1827	0.0	642.2	0.6	450.0	450.0
4.921	14.213	Fill	135.0	22.1	664.3	17.0	1633	0.0	664.3	0.6	450.0	450.0
5.085	13.213	Fill	135.0	22.1	686.5	17.0	1514	0.0	686.5	0.6	450.0	450.0
5.249	12.374	Fill	135.0	22.1	708.6	17.0	1414	0.0	708.6	0.6	450.0	450.0
5.413	11.270	Fill	135.0	22.1	730.8	17.0	1283	0.0	730.8	0.6	450.0	450.0
5.577	11.640	Fill	135.0	22.1	752.9	17.0	1325	0.0	752.9	0.6	450.0	451.7
5.741	15.412	Fill	135.0	22.1	775.0	17.0	1768	0.0	775.0	0.6	450.0	465.0
5.905	16.207	Fill	135.0	22.1	797.2	17.0	1860	0.0	797.2	0.6	450.0	478.3
6.069	17.410	Fill	135.0	22.1	819.3	17.0	2000	0.0	819.3	0.6	450.0	491.6
6.234	17.967	Fill	135.0	22.3	841.6	17.0	2064	0.0	841.6	0.6	450.0	505.0
6.398	16.303	Fill	135.0	22.1	863.7	17.0	1867	0.0	863.7	0.6	450.0	518.2
6.562	16.446	Fill	135.0	22.1	885.9	17.0	1883	0.0	885.9	0.6	450.0	531.5
6.726	15.623	Fill	135.0	22.1	908.0	17.0	1785	0.0	908.0	0.6	450.0	544.8
6.890	14.374	Fill	135.0	22.1	930.2	17.0	1636	0.0	930.2	0.6	450.0	558.1
7.054	15.203	Fill	135.0	22.1	952.3	17.0	1733	0.0	952.3	0.6	450.0	571.4
7.218	16.483	Fill	135.0	22.1	974.4	17.0	1882	0.0	974.4	0.6	450.0	584.7
7.382	20.136	Fill	135.0	22.1	996.6	17.0	2310	0.0	996.6	0.6	450.0	597.9
7.546	22.126	Fill	135.0	22.1	1018.7	17.0	2543	0.0	1018.7	0.6	450.0	611.2
7.710	22.424	Fill	135.0	22.1	1040.9	17.0	2577	0.0	1040.9	0.6	450.0	624.5
7.874	23.040	Fill	135.0	22.1	1063.0	17.0	2648	0.0	1063.0	0.6	450.0	637.8
8.038	29.590	Fill	135.0	22.1	1085.1	17.0	3417	0.0	1085.1	0.6	450.0	651.1
8.202	32.549	Fill	135.0	22.1	1107.3	17.0	3764	0.0	1107.3	0.6	450.0	664.4
8.366	29.817	Fill	135.0	22.1	1129.4	17.0	3441	0.0	1129.4	0.6	450.0	677.6
8.530	26.028	Fill	135.0	22.1	1151.6	17.0	2994	0.0	1151.6	0.6	450.0	690.9
8.694	21.712	Fill	135.0	22.1	1173.7	17.0	2485	0.0	1173.7	0.6	450.0	704.2
8.858	22.975	Fill	135.0	22.1	1195.8	17.0	2633	0.0	1195.8	0.6	450.0	717.5
9.022	25.611	Fill	135.0	22.1	1218.0	17.0	2941	0.0	1218.0	0.6	450.0	730.8
9.186	23.744	Fill	135.0	22.1	1240.1	17.0	2720	0.0	1240.1	0.6	450.0	744.1
9.350	22.398	Fill	135.0	22.1	1262.3	17.0	2561	0.0	1262.3	0.6	450.0	757.4
9.514	23.245	Fill	135.0	22.1	1284.4	17.0	2659	0.0	1284.4	0.6	450.0	770.6
9.678	24.657	Fill	135.0	22.1	1306.5	17.0	2824	0.0	1306.5	0.6	450.0	783.9
9.842	38.723	Fill	135.0	22.1	1328.7	17.0	4477	0.0	1328.7	0.6	450.0	797.2
10.006	64.366	Fdxn Clay	125.0	20.5	1349.2	17.0	7493	0.0	1349.2	0.4	700.0	700.0
10.170	54.790	Fdxn Clay	125.0	20.5	1369.7	17.0	6365	0.0	1369.7	0.4	700.0	700.0
10.335	42.138	Fdxn Clay	125.0	20.6	1390.3	17.0	4876	0.0	1390.3	0.4	700.0	700.0
10.499	34.939	Fdxn Clay	125.0	20.5	1410.8	17.0	4027	0.0	1410.8	0.4	700.0	700.0
10.663	34.981	Fdxn Clay	125.0	20.5	1431.3	17.0	4031	0.0	1431.3	0.4	700.0	700.0
10.827	35.945	Fdxn Clay	125.0	20.5	1451.8	17.0	4143	0.0	1451.8	0.4	700.0	700.0
10.991	24.092	Fdxn Clay	125.0	20.5	1472.3	17.0	2748	0.0	1472.3	0.4	700.0	700.0
11.155	16.558	Fdxn Clay	125.0	20.5	1492.8	17.0	1860	9.7	1483.1	0.4	700.0	700.0
11.319	14.719	Fdxn Clay	125.0	20.5	1513.3	17.0	1643	19.9	1493.4	0.4	700.0	700.0
11.483	14.269	Fdxn Clay	125.0	20.5	1533.8	17.0	1588	30.1	1503.7	0.4	700.0	700.0
11.647	15.333	Fdxn Clay	125.0	20.5	1554.3	17.0	1712	40.4	1513.9	0.4	700.0	700.0
11.811	17.123	Fdxn Clay	125.0	20.5	1574.8	17.0	1922	50.6	1524.2	0.4	700.0	700.0
11.975	19.024	Fdxn Clay	125.0	20.5	1595.3	17.0	2144	60.8	1534.5	0.4	700.0	700.0
12.139	21.573	Fdxn Clay	125.0	20.5	1615.8	17.0	2443	71.1	1544.7	0.4	700.0	700.0
12.303	20.013	Fdxn Clay	125.0	20.5	1636.3	17.0	2258	81.3	1555.0	0.4	700.0	700.0
12.467	17.512	Fdxn Clay	125.0	20.5	1656.8	17.0	1963	91.5	1565.3	0.4	700.0	700.0
12.631	17.067	Fdxn Clay	125.0	20.5	1677.3	17.0	1909	101.8	1575.5	0.4	700.0	700.0
12.795	17.593	Fdxn Clay	125.0	20.5	1697.8	17.0	1970	112.0	1585.8	0.4	700.0	700.0
12.959	20.079	Fdxn Clay	125.0	20.5	1718.3	17.0	2261	122.2	1596.1	0.4	700.0	700.0
13.123	21.422	Fdxn Clay	125.0	20.5	1738.8	17.0	2418	132.5	1606.3	0.4	700.0	700.0
13.287	24.352	Fdxn Clay	125.0	20.5	1759.3	17.0	2761	142.7	1616.6	0.4	700.0	700.0
13.451	22.623	Fdxn Clay	125.0	20.5	1779.8	17.0	2557	152.9	1626.9	0.4	700.0	700.0
13.615	22.216	Fdxn Clay	125.0	20.5	1800.3	17.0	2508	163.2	1637.1	0.4	700.0	700.0
13.779	20.155	Fdxn Clay	125.0	20.5	1820.8	17.0	2264	173.4	1647.4	0.4	700.0	700.0
13.943	17.454	Fdxn Clay	125.0	20.5	1841.3	17.0	1945	183.6	1657.7	0.4	700.0	700.0
14.107	18.037	Fdxn Clay	125.0	20.5	1861.8	17.0	2012	193.9	1667.9	0.4	700.0	700.0
14.271	16.193	Fdxn Clay	125.0	20.5	1882.3	17.0	1794	204.1	1678.2	0.4	700.0	700.0
14.436	17.229	Fdxn Clay	125.0	20.6	1902.9	17.0	1915	214.4	1688.5	0.4	700.0	700.0
14.600	21.504	Fdxn Clay	125.0	20.5	1923.4	17.0	2417	224.6	1698.8	0.4	700.0	700.0
14.764	20.739	Fdxn Clay	125.0	20.5	1943.9	17.0	2326	234.9	1709.0	0.4	700.0	700.0
14.928	16.078	Fdxn Clay	125.0	20.5	1964.4	17.0	1776	245.1	1719.3	0.4	700.0	700.0
15.092	14.020	Fdxn Clay	125.0	20.5	1984.9	17.0	1533	255.3	1729.6	0.4	700.0	700.0
15.256	12.053	Fdxn Clay	125.0	20.5	2005.4	17.0	1300	265.6	1739.8	0.4	700.0	700.0
15.420	11.745	Fdxn Clay	125.0	20.5	2025.9	17.0	1263	275.8	1750.1	0.4	700.0	700.0
15.584	13.337	Fdxn Clay	125.0	20.5	2046.4	17.0	1449	286.0	1760.4	0.4	700.0	700.0
15.748	12.637	Fdxn Clay	125.0	20.5	2066.9	17.0	1365	296.3	1770.6	0.4	700.0	700.0
15.912	12.768	Fdxn Clay	125.0	20.5	2087.4	17.0	1379	306.5	1780.9	0.4	700.0	700.0
16.076	14.365	Fdxn Clay	125.0	20.5	2107.9	17.0	1566	316.7	1791.2	0.4	700.0	700.0
16.240	13.657	Fdxn Clay	125.0	20.5	2128.4	17.0	1482	327.0	1801.4	0.4	700.0	702.6
16.404	12.888	Fdxn Clay	125.0	20.5	2148.9	17.0	1390	337.2	1811.7	0.4	700.0	706.6
16.568	13.273	Fdxn Clay	125.0	20.5	2169.4	17.0	1434	347.4	1822.0	0.4	700.0	710.6
16.732	11.737	Fdxn Clay	125.0	20.5	2189.9	17.0	1252	357.7	1832.2	0.4	700.0	714.6
16.896	11.478	Fdxn Clay	125.0	20.5	2210.4	17.0	1220	367.9	1842.5	0.4	700.0	718.6
17.060	13.390	Fdxn Clay	125.0	20.5	2230.9	17.0	1444	378.1	1852.8	0.4	700.0	722.6
17.224	16.528	Fdxn Clay	125.0	20.5	2251.4	17.0	1812	388.4	1863.0	0.4	700.0	726.6
17.388	14.919	Fdxn Clay	125.0	20.5	2271.9	17.0	1622	398.6	1873.3	0.4	700.0	730.6
17.552	12.812	Fdxn Clay	125.0	20.5	2292.4	17.0	1372	408.8	1883.6	0.4	700.0	734.6
17.716	10.314	Fdxn Clay	125.0	20.5	2312.9	17.0	1077	419.1	1893.8	0.4	700.0	738.6
17.880	9.755	Fdxn Clay	125.0	20.5	2333.4	17.0	1010	429.3	1904.1	0.4	700.0	742.6
18.044	9.303	Fdxn Clay	125.0	20.5	2353.9	17.0	956	439.5	1914.4	0.4	700.0	746.6
18.208	8.742	Fdxn Clay	125.0	20.5	2374.4	17.0	889	449.8	1924.6	0.4	700.0	750.6
18.372	10.076	Fdxn Clay	125.0	20.5	2394.9	17.0	1045	460.0	1934.9	0.4	700.0	754.6
18.537	9.939	Fdxn Clay	125.0	20.6	2415.5	17.0	1027	470.3	1945.2	0.4	700.0	758.6
18.701	10.174	Fdxn Clay	125.0	20.5	2436.0	17.0	1054	480.5	1955.5	0.4	700.0	762.6
18.865	9.462	Fdxn Clay	125.0	20.5	2456.5	17.0	969	490.8	1965.8	0.4	700.0	766.6
19.029	9.018	Fdxn Clay	125.0	20.5	2477.0	17.0	915	501.0	1976.0	0.4	700.0	770.7
19.193	8.346	Fdxn Clay	125.0	20.5	2497.5	17.0	835	511.2	1986.3	0.4	700.0	774.7
19.357	9.041	Fdxn Clay	125.0	20.5	2518.0	17.0	916	521.5	1996.6	0.4	700.0	778.7
19.521	8.207	Fdxn Clay	125.0	20.5	2538.5	17.0	816	531.7	2006.8	0.4	700.0	782.7
19.685	8.298	Fdxn Clay	125.0	20.5	2559.0	17.0	826	541.9	2017.1	0.4	700.0	786.7
19.849	8.246	Fdxn Clay	125.0	20.5	2579.5	17.0	818	552.2	2027.4	0.4	700.0	790.7
20.013	8.616	Fdxn Clay	125.0	20.5	2600.0	17.0	861	562.4	2037.6	0.4	700.0	794.7
20.177	9.491	Fdxn Clay	125.0	20.5	2620.5	17.0	962	572.6	2047.9	0.4	700.0	798.7
20.341	8.538	Soft Clay	125.0	20.5	2641.0	17.0	849	582.9	2058.2	0.2	275.0	452.8
20.505	7.629	Soft Clay	125.0	20.5	2661.5	17.0	741	593.1	2068.4	0.2	275.0	455.1
20.669	5.874	Soft Clay	125.0	20.5	2682.0	17.0	533	603.3	2078.7	0.2	275.0	457.3
20.833	5.359	Soft Clay	125.0	20.5	2702.5	17.0	471	613.6	2089.0	0.2	275.0	459.6
20.997	6.374	Soft Clay	125.0	20.5	2723.0	17.0	590	623.8	2099.2	0.2	275.0	461.8
21.161	6.756	Soft Clay	125.0	20.5	2743.5	17.0	633	634.0	2109.5	0.2	275.0	464.1
21.325	10.342	Till	125.0	20.5	2764.0	17.0	1054	644.3	2119.8	0.6	700.0	1356.6
21.489	19.210	Till	125.0	20.5	2784.5	17.0	2096	654.5	2130.0	0.6	700.0	1363.2
21.653	33.178	Till	125.0	20.5	2805.0	17.0	3738	664.7	2140.3	0.6	700.0	1369.8
21.817	50.877	Till	125.0	20.5	2825.5	17.0	5819	675.0	2150.6	0.6	700.0	1376.4
21.981	50.800	Till	125.0	20.5	2846.0	17.0	5809	685.2	2160.8	0.6	700.0	1382.9
22.145	37.185	Till	125.0	20.5	2866.5	17.0	4206	695.4	2171.1	0.6	700.0	1389.5
22.309	31.582	Till	125.0	20.5	2887.0	17.0	3546	705.7	2181.4	0.6	700.0	1396.1
22.473	129.328	Till	125.0	20.5	2907.5	17.0	15044	715.9	2191.6	0.6	700.0	1402.6

Comparision Plot



22.638	256.337	Till	125.0	20.6	2928.2	17.0	29985	726.2	2202.0	0.6	700.0	1409.3
22.802	309.829	Till	125.0	20.5	2948.7	17.0	36277	736.4	2212.2	0.6	700.0	1415.8
22.966	313.348	Till	125.0	20.5	2969.2	17.0	36690	746.7	2222.5	0.6	700.0	1422.4
23.130	280.239	Till	125.0	20.5	2989.7	17.0	32793	756.9	2232.8	0.6	700.0	1429.0
23.294	279.794	Till	125.0	20.5	3010.2	17.0	32740	767.1	2243.0	0.6	700.0	1435.5
23.458	297.078	Till	125.0	20.5	3030.7	17.0	34772	777.4	2253.3	0.6	700.0	1442.1
23.622	303.197	Till	125.0	20.5	3051.2	17.0	35491	787.6	2263.6	0.6	700.0	1448.7
23.786	309.839	Till	125.0	20.5	3071.7	17.0	36271	797.8	2273.8	0.6	700.0	1455.2
23.950	305.808	Till	125.0	20.5	3092.2	17.0	35796	808.1	2284.1	0.6	700.0	1461.8
24.114	356.438	Till	125.0	20.5	3112.7	17.0	41751	818.3	2294.4	0.6	700.0	1468.4
24.278	404.706	Till	125.0	20.5	3133.2	17.0	47428	828.5	2304.6	0.6	700.0	1475.0
24.442	434.168	Till	125.0	20.5	3153.7	17.0	50893	838.8	2314.9	0.6	700.0	1481.5
24.606	440.265	Till	125.0	20.5	3174.2	17.0	51609	849.0	2325.2	0.6	700.0	1488.1
24.770	433.686	Till	125.0	20.5	3194.7	17.0	50834	859.2	2335.4	0.6	700.0	1494.7
24.934	438.242	Till	125.0	20.5	3215.2	17.0	51369	869.5	2345.7	0.6	700.0	1501.2
25.098	444.539	Till	125.0	20.5	3235.7	17.0	52108	879.7	2356.0	0.6	700.0	1507.8
25.262	473.918	Till	125.0	20.5	3256.2	17.0	55564	889.9	2366.2	0.6	700.0	1514.4
25.426	514.032	Till	125.0	20.5	3276.7	17.0	60282	900.2	2376.5	0.6	700.0	1521.0
25.590	564.215	Till	125.0	20.5	3297.2	17.0	66184	910.4	2386.8	0.6	700.0	1527.5
25.754	722.963	Till	125.0	20.5	3317.7	17.0	84859	920.6	2397.0	0.6	700.0	1534.1

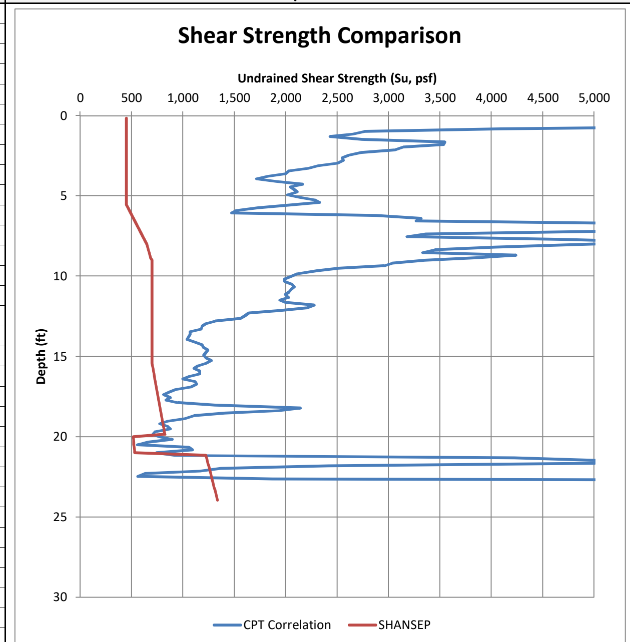
Material	Nkt	Peak Su/p'	Min Su (spf)
Fill	17.0	0.60	450.0
Fdxn Clay	17.0	0.45	700.0
Soft Clay	17.0	0.28	275.0
Till	17.0	0.64	700.0

CPT COF-C050

GWT Depth: 8.0 ft

ConeTec Data			CPT Shear Strength Correlation					SHANSEP Shear Strength Model				
Depth	qt	Material	Unit Weight (pcf)	Layer Weight	Total Vertical Stress	Nkt	CPT Su	Pore Pressure	Effective Vertical Stress	Su/p'	Min Su	SHANSEP Su
ft	tsf	Type	(pcf)	(psf)	(psf)		(psf)	(psf)	(psf)		(psf)	(psf)
0.164	56.103	Fill	135.0	22.1	22.1	17.0	6599	0.0	22.1	0.6	450.0	450.0
0.328	99.285	Fill	135.0	22.1	44.3	17.0	11678	0.0	44.3	0.6	450.0	450.0
0.492	90.586	Fill	135.0	22.1	66.4	17.0	10653	0.0	66.4	0.6	450.0	450.0
0.656	58.561	Fill	135.0	22.1	88.6	17.0	6884	0.0	88.6	0.6	450.0	450.0
0.820	34.895	Fill	135.0	22.1	110.7	17.0	4099	0.0	110.7	0.6	450.0	450.0
0.984	23.579	Fill	135.0	22.1	132.8	17.0	2766	0.0	132.8	0.6	450.0	450.0
1.148	22.636	Fill	135.0	22.1	155.0	17.0	2654	0.0	155.0	0.6	450.0	450.0
1.312	20.765	Fill	135.0	22.1	177.1	17.0	2433	0.0	177.1	0.6	450.0	450.0
1.476	23.401	Fill	135.0	22.1	199.3	17.0	2741	0.0	199.3	0.6	450.0	450.0
1.640	30.275	Fill	135.0	22.1	221.4	17.0	3549	0.0	221.4	0.6	450.0	450.0
1.804	30.180	Fill	135.0	22.1	243.5	17.0	3536	0.0	243.5	0.6	450.0	450.0
1.968	26.816	Fill	135.0	22.1	265.7	17.0	3139	0.0	265.7	0.6	450.0	450.0
2.133	26.146	Fill	135.0	22.3	288.0	17.0	3059	0.0	288.0	0.6	450.0	450.0
2.297	23.400	Fill	135.0	22.1	310.1	17.0	2735	0.0	310.1	0.6	450.0	450.0
2.461	22.383	Fill	135.0	22.1	332.2	17.0	2614	0.0	332.2	0.6	450.0	450.0
2.625	21.855	Fill	135.0	22.1	354.4	17.0	2550	0.0	354.4	0.6	450.0	450.0
2.789	21.940	Fill	135.0	22.1	376.5	17.0	2559	0.0	376.5	0.6	450.0	450.0
2.953	21.482	Fill	135.0	22.1	398.7	17.0	2504	0.0	398.7	0.6	450.0	450.0
3.117	19.880	Fill	135.0	22.1	420.8	17.0	2314	0.0	420.8	0.6	450.0	450.0
3.281	19.105	Fill	135.0	22.1	442.9	17.0	2222	0.0	442.9	0.6	450.0	450.0
3.445	17.529	Fill	135.0	22.1	465.1	17.0	2035	0.0	465.1	0.6	450.0	450.0
3.609	17.232	Fill	135.0	22.1	487.2	17.0	1999	0.0	487.2	0.6	450.0	450.0
3.773	15.779	Fill	135.0	22.1	509.4	17.0	1826	0.0	509.4	0.6	450.0	450.0
3.937	14.843	Fill	135.0	22.1	531.5	17.0	1715	0.0	531.5	0.6	450.0	450.0
4.101	16.473	Fill	135.0	22.1	553.6	17.0	1905	0.0	553.6	0.6	450.0	450.0
4.265	18.689	Fill	135.0	22.1	575.8	17.0	2165	0.0	575.8	0.6	450.0	450.0
4.429	17.687	Fill	135.0	22.1	597.9	17.0	2046	0.0	597.9	0.6	450.0	450.0
4.593	17.987	Fill	135.0	22.1	620.1	17.0	2080	0.0	620.1	0.6	450.0	450.0
4.757	18.263	Fill	135.0	22.1	642.2	17.0	2111	0.0	642.2	0.6	450.0	450.0
4.921	17.486	Fill	135.0	22.1	664.3	17.0	2018	0.0	664.3	0.6	450.0	450.0
5.085	18.508	Fill	135.0	22.1	686.5	17.0	2137	0.0	686.5	0.6	450.0	450.0
5.249	19.758	Fill	135.0	22.1	708.6	17.0	2283	0.0	708.6	0.6	450.0	450.0
5.413	20.174	Fill	135.0	22.1	730.8	17.0	2330	0.0	730.8	0.6	450.0	450.0
5.577	17.791	Fill	135.0	22.1	752.9	17.0	2049	0.0	752.9	0.6	450.0	451.7
5.741	15.091	Fill	135.0	22.1	775.0	17.0	1730	0.0	775.0	0.6	450.0	465.0
5.905	13.318	Fill	135.0	22.1	797.2	17.0	1520	0.0	797.2	0.6	450.0	478.3
6.069	12.918	Fill	135.0	22.1	819.3	17.0	1472	0.0	819.3	0.6	450.0	491.6
6.234	24.929	Fill	135.0	22.3	841.6	17.0	2883	0.0	841.6	0.6	450.0	505.0
6.398	28.625	Fill	135.0	22.1	863.7	17.0	3317	0.0	863.7	0.6	450.0	518.2
6.562	28.228	Fill	135.0	22.1	885.9	17.0	3269	0.0	885.9	0.6	450.0	531.5
6.726	46.228	Fill	135.0	22.1	908.0	17.0	5385	0.0	908.0	0.6	450.0	544.8
6.890	60.651	Fill	135.0	22.1	930.2	17.0	7081	0.0	930.2	0.6	450.0	558.1
7.054	54.828	Fill	135.0	22.1	952.3	17.0	6394	0.0	952.3	0.6	450.0	571.4
7.218	42.638	Fill	135.0	22.1	974.4	17.0	4959	0.0	974.4	0.6	450.0	584.7
7.382	29.058	Fill	135.0	22.1	996.6	17.0	3360	0.0	996.6	0.6	450.0	597.9
7.546	27.530	Fill	135.0	22.1	1018.7	17.0	3179	0.0	1018.7	0.6	450.0	611.2
7.710	40.628	Fill	135.0	22.1	1040.9	17.0	4719	0.0	1040.9	0.6	450.0	624.5
7.874	48.599	Fill	135.0	22.1	1063.0	17.0	5655	0.0	1063.0	0.6	450.0	637.8
8.038	41.534	Fill	135.0	22.1	1085.1	17.0	4823	2.4	1082.8	0.6	450.0	649.7
8.202	34.842	Fill	135.0	22.1	1107.3	17.0	4034	12.6	1094.7	0.6	450.0	656.8
8.366	29.900	Fill	135.0	22.1	1129.4	17.0	3451	22.8	1106.6	0.6	450.0	663.9
8.530	28.900	Fill	135.0	22.1	1151.6	17.0	3332	33.1	1118.5	0.6	450.0	671.1
8.694	36.623	Fill	135.0	22.1	1173.7	17.0	4240	43.3	1130.4	0.6	450.0	678.2
8.858	33.480	Fill	135.0	22.1	1195.8	17.0	3868	53.5	1142.3	0.6	450.0	685.4
9.022	29.105	Fdxn Clay	125.0	20.5	1216.3	17.0	3353	63.8	1152.6	0.5	700.0	700.0
9.186	26.429	Fdxn Clay	125.0	20.5	1236.8	17.0	3037	74.0	1162.8	0.5	700.0	700.0
9.350	25.772	Fdxn Clay	125.0	20.5	1257.3	17.0	2958	84.2	1173.1	0.5	700.0	700.0
9.514	21.998	Fdxn Clay	125.0	20.5	1277.8	17.0	2513	94.5	1183.4	0.5	700.0	700.0
9.678	20.217	Fdxn Clay	125.0	20.5	1298.3	17.0	2302	104.7	1193.6	0.5	700.0	700.0
9.842	18.614	Fdxn Clay	125.0	20.5	1318.8	17.0	2112	114.9	1203.9	0.5	700.0	700.0
10.006	18.113	Fdxn Clay	125.0	20.5	1339.3	17.0	2052	125.2	1214.2	0.5	700.0	700.0
10.170	17.607	Fdxn Clay	125.0	20.5	1359.8	17.0	1991	135.4	1224.4	0.5	700.0	700.0
10.335	17.605	Fdxn Clay	125.0	20.6	1380.5	17.0	1990	145.7	1234.8	0.5	700.0	700.0
10.499	18.234	Fdxn Clay	125.0	20.5	1401.0	17.0	2063	155.9	1245.0	0.5	700.0	700.0
10.663	18.423	Fdxn Clay	125.0	20.5	1421.5	17.0	2084	166.2	1255.3	0.5	700.0	700.0
10.827	18.173	Fdxn Clay	125.0	20.5	1442.0	17.0	2053	176.4	1265.6	0.5	700.0	700.0
10.991	17.984	Fdxn Clay	125.0	20.5	1462.5	17.0	2030	186.6	1275.8	0.5	700.0	700.0
11.155	17.716	Fdxn Clay	125.0	20.5	1483.0	17.0	1997	196.9	1286.1	0.5	700.0	700.0
11.319	17.978	Fdxn Clay	125.0	20.5	1503.5	17.0	2027	207.1	1296.3	0.5	700.0	700.0
11.483	17.279	Fdxn Clay	125.0	20.5	1524.0	17.0	1943	217.3	1306.6	0.5	700.0	700.0
11.647	17.789	Fdxn Clay	125.0	20.5	1544.5	17.0	2002	227.6	1316.9	0.5	700.0	700.0
11.811	20.144	Fdxn Clay	125.0	20.5	1565.0	17.0	2278	237.8	1327.1	0.5	700.0	700.0
11.975	19.506	Fdxn Clay	125.0	20.5	1585.5	17.0	2202	248.0	1337.4	0.5	700.0	700.0
12.139	17.395	Fdxn Clay	125.0	20.5	1606.0	17.0	1952	258.3	1347.7	0.5	700.0	700.0
12.303	14.732	Fdxn Clay	125.0	20.5	1626.5	17.0	1638	268.5	1357.9	0.5	700.0	700.0
12.467	14.444	Fdxn Clay	125.0	20.5	1647.0	17.0	1602	278.7	1368.2	0.5	700.0	700.0
12.631	14.065	Fdxn Clay	125.0	20.5	1667.5	17.0	1557	289.0	1378.5	0.5	700.0	700.0
12.795	12.021	Fdxn Clay	125.0	20.5	1688.0	17.0	1315	299.2	1388.7	0.5	700.0	700.0
12.959	11.250	Fdxn Clay	125.0	20.5	1708.5	17.0	1223	309.4	1399.0	0.5	700.0	700.0
13.123	10.937	Fdxn Clay	125.0	20.5	1729.0	17.0	1185	319.7	1409.3	0.5	700.0	700.0
13.287	10.886	Fdxn Clay	125.0	20.5	1749.5	17.0	1178	329.9	1419.5	0.5	700.0	700.0
13.451	9.995	Fdxn Clay	125.0	20.5	1770.0	17.0	1072	340.1	1429.8	0.5	700.0	700.0
13.615	9.993	Fdxn Clay	125.0	20.5	1790.5	17.0	1070	350.4	1440.1	0.5	700.0	700.0
13.779	9.869	Fdxn Clay	125.0	20.5	1811.0	17.0	1055	360.6	1450.3	0.5	700.0	700.0
13.943	9.743	Fdxn Clay	125.0	20.5	1831.5	17.0	1039	370.8	1460.6	0.5	700.0	700.0
14.107	10.440	Fdxn Clay	125.0	20.5	1852.0	17.0	1119	381.1	1470.9	0.5	700.0	700.0
14.271	11.016	Fdxn Clay	125.0	20.5	1872.5	17.0	1186	391.3	1481.1	0.5	700.0	700.0
14.436	11.136	Fdxn Clay	125.0	20.6	1893.1	17.0	1199	401.6	1491.5	0.5	700.0	700.0
14.600	11.529	Fdxn Clay	125.0	20.5	1913.6	17.0	1244	411.8	1501.7	0.5	700.0	700.0
14.764	11.333	Fdxn Clay	125.0	20.5	1934.1	17.0	1220	422.1	1512.0	0.5	700.0	700.0
14.928	11.204	Fdxn Clay	125.0	20.5	1954.6	17.0	1203	432.3	1522.3	0.5	700.0	700.0
15.092	11.397	Fdxn Clay	125.0	20.5	1975.1	17.0	1225	442.5	1532.5	0.5	700.0	700.0
15.256	11.842	Fdxn Clay	125.0	20.5	1995.6	17.0	1276	452.8	1542.8	0.5	700.0	700.0
15.420	11.404	Fdxn Clay	125.0	20.5	2016.1	17.0	1223	463.0	1553.1	0.5	700.0	700.0
15.584	10.767	Fdxn Clay	125.0	20.5	2036.6	17.0	1147	473.2	1563.3	0.5	700.0	703.5
15.748	10.444	Fdxn Clay	125.0	20.5	2057.1	17.0	1108	483.5	1573.6	0.5	700.0	708.1
15.912	10.949	Fdxn Clay	125.0	20.5	2077.6	17.0	1166	493.7	1583.9	0.5	700.0	712.7
16.076	10.954	Fdxn Clay	125.0	20.5	2098.1	17.0	1165	503.9	1594.1	0.5	700.0	717.4
16.240	10.078	Fdxn Clay	125.0	20.5	2118.6	17.0	1061	514.2	1604.4	0.5	700.0	722.0
16.404	9.561	Fdxn Clay	125.0	20.5	2139.1	17.0	999	524.4	1614.7	0.5	700.0	726.6
16.568	10.584	Fdxn Clay	125.0	20.5	2159.6	17.0	1118	534.6	1624.9	0.5	700.0	731.2
16.732	10.711	Fdxn Clay	125.0	20.5	2180.1	17.0	1132	544.9	1635.2	0.5	700.0	735.8
16.896	10.255	Fdxn Clay	125.0	20.5	2200.6	17.0	1077	555.1	1645.5	0.5	700.0	740.5
17.060	8.987	Fdxn Clay	125.0	20.5	2221.1	17.0	927	565.3	1655.7	0.5	700.0	745.1
17.224	8.476	Fdxn Clay	125.0	20.5	2241.6	17.0	865	575.6	1666.0	0.5	700.0	749.7
17.388	8.028	Fdxn Clay	125.0	20.5	2262.1	17.0	811	585.8	1676.3	0.5	700.0	754.3
17.552	8.590	Fdxn Clay	125.0	20.5	2282.6	17.0	876	596.0	1686.5	0.5	700.0	758.9
17.716	8.252	Fdxn Clay	125.0	20.5	2303.1	17.0	835	606.3	1696.8	0.5	700.0	763.6
17.880	9.199	Fdxn Clay	125.0	20.5	2323.6	17.0	946	616.5	1707.1	0.5	700.0	768.2
18.044	12.277	Fdxn Clay	125.0	20.5	2344.1	17.0	1306	626.7	1717.3	0.5	700.0	772.8
18.208	19.405	Fdxn Clay	125.0	20.5	2364.6	17.0	2144	637.0	1727.6	0.5	700.0	777.4
18.372	17.630	Fdxn Clay	125.0	20.5	2385.1	17.0	1934	647.2	1737.9	0.5	700.0	782.0
18.537	13.165	Fdxn Clay	125.0	20.6	2405.7	17.0	1407	657.5	1748.2	0.5	700.0	786.7
18.701	10.620	Fdxn Clay	125.0	20.5	2426.2	17.0	1107	667.7	1758.5	0.5	700.0	791.3
18.865	9.883	Fdxn Clay	125.0	20.5	2446.7	17.0	1019	678.0	1768.7	0.5	700.0	795.9
19.029	8.466	Fdxn Clay	125.0	20.5	2467.2	17.0	851	688.2	1779.0	0.5	700.0	800.5
19.193	7.825	Fdxn Clay	125.0	20.5	2487.7	17.0	774	698.4	1789.3	0.5	700.0	805.2
19.357	8.482	Fdxn Clay	125.0	20.5	2508.2	17.0	850	708.7	1799.5	0.5	700.0	809.8
19.521	8.728	Fdxn Clay	125.0	20.5	2528.7	17.0	878	718.9	1809.8	0.5	700.0	814.4
19.685	7.461	Fdxn Clay	125.0	20.5	2549.2	17.0	728	729.1	1820.1	0.5	700.0	819.0
19.849	7.292	Fdxn Clay	125.0	20.5	2569.7	17.0	707	739.4	1830.3	0.5	700.0	823.6
20.013	7.870	Soft Clay	125.0	20.5	2590.2	17.0	774	749.6	1840.6	0.3	275.0	515.4
20.177	8.933	Soft Clay	125.0	20.5	2610.7	17.0	897	759.8	1850.9	0.3	275.0	518.2
20.341	6.927	Soft Clay	125.0	20.5	2631.2	17.0	660	770.1	1861.1	0.3	275.0	521.1
20.505	6.051	Soft Clay	125.0	20.5	2651.7	17.0	556	780.3	1871.4	0.3	275.0	524.0
20.669	10.338	Soft Clay	125.0	20.5	2672.2	17.0	1059	790.5	1881.7	0.3	275.0	526.9
20.833	10.641	Soft Clay	125.0	20.5	2692.7	17.0	1093	800.8	1891.9	0.3	275.0	529.7
20.997	7.644	Soft Clay	125.0	20.5	2713.2	17.0	740	811.0	1902.2	0.3	275.0	532.6
21.161	9.197	Till	125.0	20.5	2733.7	17.0	921	821.2	1912.5	0.6	700.0	1224.0
21.325	37.285	Till	125.0	20.5	2754.2	17.0	4224	831.5	1922.7	0.6	700.0	1230.5
21.489	44.127	Till	125.0	20.5	2774.7	17.0	5028	841.7	1933.0	0.6	700.0	1237.1
21.653	43.917	Till	125.0	20.5	2795.2	17.0	5002	851.9	1943.3	0.6	700.0	1243.7
21.817	21.937	Till	125.0	20.5	2815.7	17.0	2415	862.2	1953.5	0.6	700.0	1250.3
21.981	13.024	Till	125.0	20.5	2836.2	17.0	1365	872.4	1963.8	0.6	700.0	1256.8
22.145	11.324	Till	125.0	20.5	2856.7	17.0	1164	882.6	1974.1	0.6	700.0	1263.4

Comparision Plot



22.309	6.783	Till	125.0	20.5	2877.2	17.0	629	892.9	1984.3	0.6	700.0	1270.0
22.473	6.208	Till	125.0	20.5	2897.7	17.0	560	903.1	1994.6	0.6	700.0	1276.5
22.638	17.336	Till	125.0	20.6	2918.3	17.0	1868	913.4	2004.9	0.6	700.0	1283.1
22.802	103.29	Till	125.0	20.5	2938.8	17.0	11979	923.6	2015.2	0.6	700.0	1289.7
22.966	201.624	Till	125.0	20.5	2959.3	17.0	23546	933.9	2025.5	0.6	700.0	1296.3
23.13	308.495	Till	125.0	20.5	2979.8	17.0	36118	944.1	2035.7	0.6	700.0	1302.9
23.294	420.008	Till	125.0	20.5	3000.3	17.0	49236	954.3	2046.0	0.6	700.0	1309.4
23.458	511.352	Till	125.0	20.5	3020.8	17.0	59981	964.6	2056.3	0.6	700.0	1316.0
23.622	549.901	Till	125.0	20.5	3041.3	17.0	64515	974.8	2066.5	0.6	700.0	1322.6
23.786	596.732	Till	125.0	20.5	3061.8	17.0	70024	985.0	2076.8	0.6	700.0	1329.1
23.95	603.924	Till	125.0	20.5	3082.3	17.0	70869	995.3	2087.0	0.6	700.0	1335.7

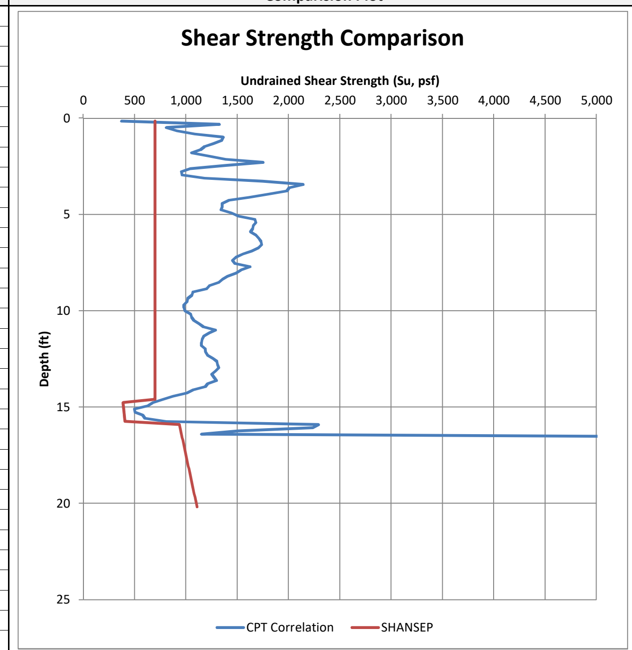
Material	Nkt	Peak Su/p'	Min Su (spf)
Fill	17.0	0.60	450.0
Fdxn Clay	17.0	0.45	700.0
Soft Clay	17.0	0.28	275.0
Till	17.0	0.64	700.0

CPT COF-C051

GWT Depth: 7.5 ft

ConeTec Data			CPT Shear Strength Correlation					SHANSEP Shear Strength Model				
Depth	qt	Material Type	Unit Weight (pcf)	Layer Weight	Total Vertical Stress	Nkt	CPT Su	Pore Pressure	Effective Vertical Stress	Su/p'	Min Su	SHANSEP Su
ft	tsf		(pcf)	(psf)	(psf)		(psf)	(psf)	(psf)		(psf)	(psf)
0.164	3.186	Fdxn Clay	125.0	20.5	20.5	17.0	374	0.0	20.5	0.5	700.0	700.0
0.328	11.306	Fdxn Clay	125.0	20.5	41.0	17.0	1328	0.0	41.0	0.5	700.0	700.0
0.492	6.911	Fdxn Clay	125.0	20.5	61.5	17.0	809	0.0	61.5	0.5	700.0	700.0
0.656	7.802	Fdxn Clay	125.0	20.5	82.0	17.0	913	0.0	82.0	0.5	700.0	700.0
0.820	9.297	Fdxn Clay	125.0	20.5	102.5	17.0	1088	0.0	102.5	0.5	700.0	700.0
0.984	11.653	Fdxn Clay	125.0	20.5	123.0	17.0	1364	0.0	123.0	0.5	700.0	700.0
1.148	11.536	Fdxn Clay	125.0	20.5	143.5	17.0	1349	0.0	143.5	0.5	700.0	700.0
1.312	10.855	Fdxn Clay	125.0	20.5	164.0	17.0	1267	0.0	164.0	0.5	700.0	700.0
1.476	10.139	Fdxn Clay	125.0	20.5	184.5	17.0	1182	0.0	184.5	0.5	700.0	700.0
1.640	9.802	Fdxn Clay	125.0	20.5	205.0	17.0	1141	0.0	205.0	0.5	700.0	700.0
1.804	9.077	Fdxn Clay	125.0	20.5	225.5	17.0	1055	0.0	225.5	0.5	700.0	700.0
1.968	10.511	Fdxn Clay	125.0	20.5	246.0	17.0	1222	0.0	246.0	0.5	700.0	700.0
2.133	11.908	Fdxn Clay	125.0	20.6	266.6	17.0	1385	0.0	266.6	0.5	700.0	700.0
2.297	15.045	Fdxn Clay	125.0	20.5	287.1	17.0	1753	0.0	287.1	0.5	700.0	700.0
2.461	11.854	Fdxn Clay	125.0	20.5	307.6	17.0	1376	0.0	307.6	0.5	700.0	700.0
2.625	8.966	Fdxn Clay	125.0	20.5	328.1	17.0	1036	0.0	328.1	0.5	700.0	700.0
2.789	8.289	Fdxn Clay	125.0	20.5	348.6	17.0	955	0.0	348.6	0.5	700.0	700.0
2.953	8.374	Fdxn Clay	125.0	20.5	369.1	17.0	963	0.0	369.1	0.5	700.0	700.0
3.117	10.221	Fdxn Clay	125.0	20.5	389.6	17.0	1180	0.0	389.6	0.5	700.0	700.0
3.281	15.051	Fdxn Clay	125.0	20.5	410.1	17.0	1747	0.0	410.1	0.5	700.0	700.0
3.445	18.435	Fdxn Clay	125.0	20.5	430.6	17.0	2143	0.0	430.6	0.5	700.0	700.0
3.609	17.261	Fdxn Clay	125.0	20.5	451.1	17.0	2004	0.0	451.1	0.5	700.0	700.0
3.773	17.101	Fdxn Clay	125.0	20.5	471.6	17.0	1984	0.0	471.6	0.5	700.0	700.0
3.937	15.579	Fdxn Clay	125.0	20.5	492.1	17.0	1804	0.0	492.1	0.5	700.0	700.0
4.101	13.992	Fdxn Clay	125.0	20.5	512.6	17.0	1616	0.0	512.6	0.5	700.0	700.0
4.265	12.336	Fdxn Clay	125.0	20.5	533.1	17.0	1420	0.0	533.1	0.5	700.0	700.0
4.429	11.785	Fdxn Clay	125.0	20.5	553.6	17.0	1354	0.0	553.6	0.5	700.0	700.0
4.593	11.792	Fdxn Clay	125.0	20.5	574.1	17.0	1354	0.0	574.1	0.5	700.0	700.0
4.757	11.716	Fdxn Clay	125.0	20.5	594.6	17.0	1343	0.0	594.6	0.5	700.0	700.0
4.921	12.590	Fdxn Clay	125.0	20.5	615.1	17.0	1445	0.0	615.1	0.5	700.0	700.0
5.085	13.183	Fdxn Clay	125.0	20.5	635.6	17.0	1514	0.0	635.6	0.5	700.0	700.0
5.249	14.551	Fdxn Clay	125.0	20.5	656.1	17.0	1673	0.0	656.1	0.5	700.0	700.0
5.413	14.625	Fdxn Clay	125.0	20.5	676.6	17.0	1681	0.0	676.6	0.5	700.0	700.0
5.577	14.438	Fdxn Clay	125.0	20.5	697.1	17.0	1658	0.0	697.1	0.5	700.0	700.0
5.741	14.376	Fdxn Clay	125.0	20.5	717.6	17.0	1649	0.0	717.6	0.5	700.0	700.0
5.905	14.203	Fdxn Clay	125.0	20.5	738.1	17.0	1628	0.0	738.1	0.5	700.0	700.0
6.069	14.671	Fdxn Clay	125.0	20.5	758.6	17.0	1681	0.0	758.6	0.5	700.0	700.0
6.234	14.933	Fdxn Clay	125.0	20.6	779.3	17.0	1711	0.0	779.3	0.5	700.0	700.0
6.398	15.122	Fdxn Clay	125.0	20.5	799.8	17.0	1732	0.0	799.8	0.5	700.0	700.0
6.562	15.178	Fdxn Clay	125.0	20.5	820.3	17.0	1737	0.0	820.3	0.5	700.0	700.0
6.726	14.922	Fdxn Clay	125.0	20.5	840.8	17.0	1706	0.0	840.8	0.5	700.0	700.0
6.890	14.392	Fdxn Clay	125.0	20.5	861.3	17.0	1643	0.0	861.3	0.5	700.0	700.0
7.054	13.666	Fdxn Clay	125.0	20.5	881.8	17.0	1556	0.0	881.8	0.5	700.0	700.0
7.218	13.094	Fdxn Clay	125.0	20.5	902.3	17.0	1487	0.0	902.3	0.5	700.0	700.0
7.382	12.835	Fdxn Clay	125.0	20.5	922.8	17.0	1456	0.0	922.8	0.5	700.0	700.0
7.546	13.055	Fdxn Clay	125.0	20.5	943.3	17.0	1480	2.9	940.4	0.5	700.0	700.0
7.710	14.303	Fdxn Clay	125.0	20.5	963.8	17.0	1626	13.1	950.6	0.5	700.0	700.0
7.874	13.579	Fdxn Clay	125.0	20.5	984.3	17.0	1540	23.3	960.9	0.5	700.0	700.0
8.038	13.163	Fdxn Clay	125.0	20.5	1004.8	17.0	1489	33.6	971.2	0.5	700.0	700.0
8.202	12.453	Fdxn Clay	125.0	20.5	1025.3	17.0	1405	43.8	981.4	0.5	700.0	700.0
8.366	12.062	Fdxn Clay	125.0	20.5	1045.8	17.0	1358	54.0	991.7	0.5	700.0	700.0
8.530	11.765	Fdxn Clay	125.0	20.5	1066.3	17.0	1321	64.3	1002.0	0.5	700.0	700.0
8.694	10.990	Fdxn Clay	125.0	20.5	1086.8	17.0	1229	74.5	1012.2	0.5	700.0	700.0
8.858	10.773	Fdxn Clay	125.0	20.5	1107.3	17.0	1202	84.7	1022.5	0.5	700.0	700.0
9.022	9.652	Fdxn Clay	125.0	20.5	1127.8	17.0	1069	95.0	1032.8	0.5	700.0	700.0
9.186	9.575	Fdxn Clay	125.0	20.5	1148.3	17.0	1059	105.2	1043.0	0.5	700.0	700.0
9.350	9.248	Fdxn Clay	125.0	20.5	1168.8	17.0	1019	115.4	1053.3	0.5	700.0	700.0
9.514	9.190	Fdxn Clay	125.0	20.5	1189.3	17.0	1011	125.7	1063.6	0.5	700.0	700.0
9.678	8.935	Fdxn Clay	125.0	20.5	1209.8	17.0	980	135.9	1073.8	0.5	700.0	700.0
9.842	8.961	Fdxn Clay	125.0	20.5	1230.3	17.0	982	146.1	1084.1	0.5	700.0	700.0
10.006	9.033	Fdxn Clay	125.0	20.5	1250.8	17.0	989	156.4	1094.4	0.5	700.0	700.0
10.170	9.519	Fdxn Clay	125.0	20.5	1271.3	17.0	1045	166.6	1104.6	0.5	700.0	700.0
10.335	9.604	Fdxn Clay	125.0	20.6	1291.9	17.0	1054	176.9	1115.0	0.5	700.0	700.0
10.499	9.813	Fdxn Clay	125.0	20.5	1312.4	17.0	1077	187.1	1125.2	0.5	700.0	700.0
10.663	10.247	Fdxn Clay	125.0	20.5	1332.9	17.0	1127	197.4	1135.5	0.5	700.0	700.0
10.827	10.623	Fdxn Clay	125.0	20.5	1353.4	17.0	1170	207.6	1145.8	0.5	700.0	700.0
10.991	11.636	Fdxn Clay	125.0	20.5	1373.9	17.0	1288	217.8	1156.0	0.5	700.0	700.0
11.155	11.137	Fdxn Clay	125.0	20.5	1394.4	17.0	1228	228.1	1166.3	0.5	700.0	700.0
11.319	10.691	Fdxn Clay	125.0	20.5	1414.9	17.0	1175	238.3	1176.6	0.5	700.0	700.0
11.483	10.565	Fdxn Clay	125.0	20.5	1435.4	17.0	1159	248.5	1186.8	0.5	700.0	700.0
11.647	10.528	Fdxn Clay	125.0	20.5	1455.9	17.0	1153	258.8	1197.1	0.5	700.0	700.0
11.811	10.538	Fdxn Clay	125.0	20.5	1476.4	17.0	1153	269.0	1207.4	0.5	700.0	700.0
11.975	10.845	Fdxn Clay	125.0	20.5	1496.9	17.0	1188	279.2	1217.6	0.5	700.0	700.0
12.139	10.888	Fdxn Clay	125.0	20.5	1517.4	17.0	1192	289.5	1227.9	0.5	700.0	700.0
12.303	11.075	Fdxn Clay	125.0	20.5	1537.9	17.0	1212	299.7	1238.2	0.5	700.0	700.0
12.467	11.516	Fdxn Clay	125.0	20.5	1558.4	17.0	1263	309.9	1248.4	0.5	700.0	700.0
12.631	11.864	Fdxn Clay	125.0	20.5	1578.9	17.0	1303	320.2	1258.7	0.5	700.0	700.0
12.795	11.912	Fdxn Clay	125.0	20.5	1599.4	17.0	1307	330.4	1269.0	0.5	700.0	700.0
12.959	12.028	Fdxn Clay	125.0	20.5	1619.9	17.0	1320	340.6	1279.2	0.5	700.0	700.0
13.123	11.777	Fdxn Clay	125.0	20.5	1640.4	17.0	1289	350.9	1289.5	0.5	700.0	700.0
13.287	11.468	Fdxn Clay	125.0	20.5	1660.9	17.0	1251	361.1	1299.8	0.5	700.0	700.0
13.451	11.674	Fdxn Clay	125.0	20.5	1681.4	17.0	1275	371.3	1310.0	0.5	700.0	700.0
13.615	11.877	Fdxn Clay	125.0	20.5	1701.9	17.0	1297	381.6	1320.3	0.5	700.0	700.0
13.779	11.157	Fdxn Clay	125.0	20.5	1722.4	17.0	1211	391.8	1330.6	0.5	700.0	700.0
13.943	10.973	Fdxn Clay	125.0	20.5	1742.9	17.0	1188	402.0	1340.8	0.5	700.0	700.0
14.107	9.976	Fdxn Clay	125.0	20.5	1763.4	17.0	1070	412.3	1351.1	0.5	700.0	700.0
14.271	9.465	Fdxn Clay	125.0	20.5	1783.9	17.0	1009	422.5	1361.4	0.5	700.0	700.0
14.436	8.342	Fdxn Clay	125.0	20.6	1804.5	17.0	875	432.8	1371.7	0.5	700.0	700.0
14.600	7.496	Fdxn Clay	125.0	20.5	1825.0	17.0	775	443.0	1382.0	0.5	700.0	700.0
14.764	6.700	Soft Clay	125.0	20.5	1845.5	17.0	680	453.3	1392.2	0.3	275.0	389.8
14.928	6.265	Soft Clay	125.0	20.5	1866.0	17.0	627	463.5	1402.5	0.3	275.0	392.7
15.092	5.171	Soft Clay	125.0	20.5	1886.5	17.0	497	473.7	1412.8	0.3	275.0	395.6
15.256	5.230	Soft Clay	125.0	20.5	1907.0	17.0	503	484.0	1423.0	0.3	275.0	398.4
15.420	5.893	Soft Clay	125.0	20.5	1927.5	17.0	580	494.2	1433.3	0.3	275.0	401.3
15.584	6.088	Soft Clay	125.0	20.5	1948.0	17.0	602	504.4	1443.6	0.3	275.0	404.2
15.748	7.841	Soft Clay	125.0	20.5	1968.5	17.0	807	514.7	1453.8	0.3	275.0	407.1
15.912	20.489	Till	125.0	20.5	1989.0	17.0	2293	524.9	1464.1	0.6	700.0	937.0
16.076	19.991	Till	125.0	20.5	2009.5	17.0	2234	535.1	1474.4	0.6	700.0	943.6
16.240	13.818	Till	125.0	20.5	2030.0	17.0	1506	545.4	1484.6	0.6	700.0	950.2
16.404	10.827	Till	125.0	20.5	2050.5	17.0	1153	555.6	1494.9	0.6	700.0	956.7
16.568	59.796	Till	125.0	20.5	2071.0	17.0	6913	565.8	1505.2	0.6	700.0	963.3
16.732	76.006	Till	125.0	20.5	2091.5	17.0	8819	576.1	1515.4	0.6	700.0	969.9
16.896	78.449	Till	125.0	20.5	2112.0	17.0	9105	586.3	1525.7	0.6	700.0	976.4
17.060	84.416	Till	125.0	20.5	2132.5	17.0	9806	596.5	1536.0	0.6	700.0	983.0
17.224	103.482	Till	125.0	20.5	2153.0	17.0	12048	606.8	1546.2	0.6	700.0	989.6
17.388	151.212	Till	125.0	20.5	2173.5	17.0	17662	617.0	1556.5	0.6	700.0	996.2
17.552	179.715	Till	125.0	20.5	2194.0	17.0	21014	627.2	1566.8	0.6	700.0	1002.7
17.716	203.231	Till	125.0	20.5	2214.5	17.0	23779	637.5	1577.0	0.6	700.0	1009.3
17.880	209.754	Till	125.0	20.5	2235.0	17.0	24545	647.7	1587.3	0.6	700.0	1015.9
18.044	206.763	Till	125.0	20.5	2255.5	17.0	24192	657.9	1597.6	0.6	700.0	1022.4
18.208	231.965	Till	125.0	20.5	2276.0	17.0	27156	668.2	1607.8	0.6	700.0	1029.0
18.372	231.224	Till	125.0	20.5	2296.5	17.0	27068	678.4	1618.1	0.6	700.0	1035.6
18.537	195.631	Till	125.0	20.6	2317.1	17.0	22879	688.7	1628.4	0.6	700.0	1042.2
18.701	204.853	Till	125.0	20.5	2337.6	17.0	23963	698.9	1638.7	0.6	700.0	1048.8
18.865	289.138	Till	125.0	20.5	2358.1	17.0	33878	709.2	1648.9	0.6	700.0	1055.3
19.029	463.781	Till	125.0	20.5	2378.6	17.0	54423	719.4	1659.2	0.6	700.0	1061.9
19.193	544.536	Till	125.0	20.5	2399.1	17.0	63922	729.6	1669.5	0.6	700.0	1068.5
19.357	601.510	Till	125.0	20.5	2419.6	17.0	70624	739.9	1679.7	0.6	700.0	1075.0
19.521	666.463	Till	125.0	20.5	2440.1	17.0	78264	750.1	1690.0	0.6	700.0	1081.6
19.685	760.163	Till	125.0	20.5	2460.6	17.0	89286	760.3	1700.3	0.6	700.0	1088.2
19.849	798.559	Till	125.0	20.5	2481.1	17.0	93802	770.6	1710.5	0.6	700.0	1094.8
20.013	872.033	Till	125.0	20.5	2501.6	17.0	102445	780.8	1720.8	0.6	700.0	1101.3
20.177	902.561	Till	125.0	20.5	2522.1	17.0	106035	791.0	1731.1	0.6	700.0	1107.9

Comparision Plot



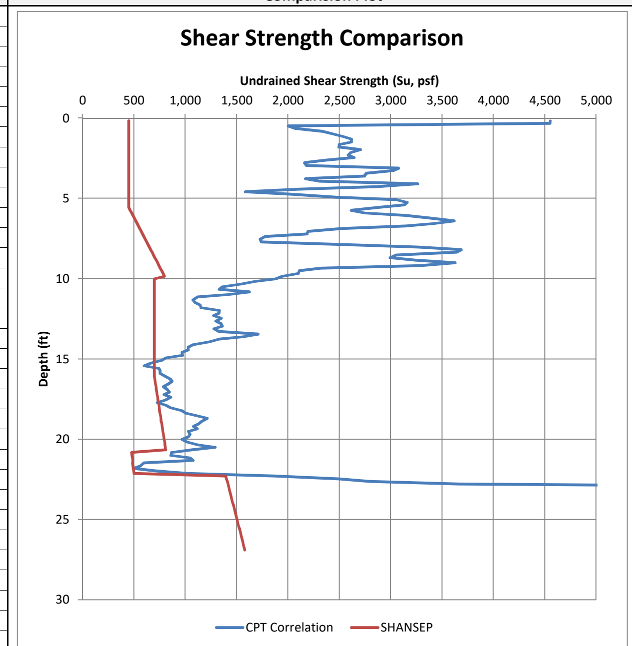
Material	Nkt	Peak Su/p'	Min Su (spf)
Fill	17.0	0.60	450.0
Fdxn Clay	17.0	0.39	700.0
Soft Clay	17.0	0.23	275.0
Till	17.0	0.64	700.0

CPT COF-C052

GWT Depth: 11.0 ft

ConeTec Data			CPT Shear Strength Correlation					SHANSEP Shear Strength Model				
Depth	qt	Material	Unit Weight (pcf)	Layer Weight	Total Vertical Stress	Nkt	CPT Su	Pore Pressure	Effective Vertical Stress	Su/p'	Min Su	SHANSEP Su
ft	tsf	Type	(pcf)	(psf)	(psf)		(psf)	(psf)	(psf)		(psf)	(psf)
0.164	38.726	Fill	135.0	22.1	22.1	17.0	4555	0.0	22.1	0.6	450.0	450.0
0.328	38.699	Fill	135.0	22.1	44.3	17.0	4550	0.0	44.3	0.6	450.0	450.0
0.492	17.045	Fill	135.0	22.1	66.4	17.0	2001	0.0	66.4	0.6	450.0	450.0
0.656	17.675	Fill	135.0	22.1	88.6	17.0	2074	0.0	88.6	0.6	450.0	450.0
0.820	19.900	Fill	135.0	22.1	110.7	17.0	2335	0.0	110.7	0.6	450.0	450.0
0.984	20.829	Fill	135.0	22.1	132.8	17.0	2443	0.0	132.8	0.6	450.0	450.0
1.148	21.655	Fill	135.0	22.1	155.0	17.0	2539	0.0	155.0	0.6	450.0	450.0
1.312	22.350	Fill	135.0	22.1	177.1	17.0	2619	0.0	177.1	0.6	450.0	450.0
1.476	22.357	Fill	135.0	22.1	199.3	17.0	2619	0.0	199.3	0.6	450.0	450.0
1.640	21.343	Fill	135.0	22.1	221.4	17.0	2498	0.0	221.4	0.6	450.0	450.0
1.804	21.330	Fill	135.0	22.1	243.5	17.0	2495	0.0	243.5	0.6	450.0	450.0
1.968	23.138	Fill	135.0	22.1	265.7	17.0	2706	0.0	265.7	0.6	450.0	450.0
2.133	22.342	Fill	135.0	22.3	288.0	17.0	2612	0.0	288.0	0.6	450.0	450.0
2.297	22.137	Fill	135.0	22.1	310.1	17.0	2586	0.0	310.1	0.6	450.0	450.0
2.461	22.634	Fill	135.0	22.1	332.2	17.0	2643	0.0	332.2	0.6	450.0	450.0
2.625	20.345	Fill	135.0	22.1	354.4	17.0	2373	0.0	354.4	0.6	450.0	450.0
2.789	18.566	Fill	135.0	22.1	376.5	17.0	2162	0.0	376.5	0.6	450.0	450.0
2.953	18.752	Fill	135.0	22.1	398.7	17.0	2183	0.0	398.7	0.6	450.0	450.0
3.117	26.369	Fill	135.0	22.1	420.8	17.0	3077	0.0	420.8	0.6	450.0	450.0
3.281	25.903	Fill	135.0	22.1	442.9	17.0	3021	0.0	442.9	0.6	450.0	450.0
3.445	23.714	Fill	135.0	22.1	465.1	17.0	2763	0.0	465.1	0.6	450.0	450.0
3.609	23.562	Fill	135.0	22.1	487.2	17.0	2743	0.0	487.2	0.6	450.0	450.0
3.773	18.700	Fill	135.0	22.1	509.4	17.0	2170	0.0	509.4	0.6	450.0	450.0
3.937	19.921	Fill	135.0	22.1	531.5	17.0	2312	0.0	531.5	0.6	450.0	450.0
4.101	28.035	Fill	135.0	22.1	553.6	17.0	3266	0.0	553.6	0.6	450.0	450.0
4.265	24.679	Fill	135.0	22.1	575.8	17.0	2870	0.0	575.8	0.6	450.0	450.0
4.429	18.158	Fill	135.0	22.1	597.9	17.0	2101	0.0	597.9	0.6	450.0	450.0
4.593	13.788	Fill	135.0	22.1	620.1	17.0	1586	0.0	620.1	0.6	450.0	450.0
4.757	17.750	Fill	135.0	22.1	642.2	17.0	2050	0.0	642.2	0.6	450.0	450.0
4.921	21.299	Fill	135.0	22.1	664.3	17.0	2467	0.0	664.3	0.6	450.0	450.0
5.085	26.377	Fill	135.0	22.1	686.5	17.0	3063	0.0	686.5	0.6	450.0	450.0
5.249	27.229	Fill	135.0	22.1	708.6	17.0	3162	0.0	708.6	0.6	450.0	450.0
5.413	26.999	Fill	135.0	22.1	730.8	17.0	3133	0.0	730.8	0.6	450.0	450.0
5.577	24.835	Fill	135.0	22.1	752.9	17.0	2877	0.0	752.9	0.6	450.0	451.7
5.741	22.632	Fill	135.0	22.1	775.0	17.0	2617	0.0	775.0	0.6	450.0	465.0
5.905	23.745	Fill	135.0	22.1	797.2	17.0	2747	0.0	797.2	0.6	450.0	478.3
6.069	27.158	Fill	135.0	22.1	819.3	17.0	3147	0.0	819.3	0.6	450.0	491.6
6.234	29.123	Fill	135.0	22.3	841.6	17.0	3377	0.0	841.6	0.6	450.0	505.0
6.398	31.192	Fill	135.0	22.1	863.7	17.0	3619	0.0	863.7	0.6	450.0	518.2
6.562	29.509	Fill	135.0	22.1	885.9	17.0	3420	0.0	885.9	0.6	450.0	531.5
6.726	27.214	Fill	135.0	22.1	908.0	17.0	3148	0.0	908.0	0.6	450.0	544.8
6.890	21.920	Fill	135.0	22.1	930.2	17.0	2524	0.0	930.2	0.6	450.0	558.1
7.054	19.100	Fill	135.0	22.1	952.3	17.0	2191	0.0	952.3	0.6	450.0	571.4
7.218	19.076	Fill	135.0	22.1	974.4	17.0	2187	0.0	974.4	0.6	450.0	584.7
7.382	15.578	Fill	135.0	22.1	996.6	17.0	1774	0.0	996.6	0.6	450.0	597.9
7.546	15.191	Fill	135.0	22.1	1018.7	17.0	1727	0.0	1018.7	0.6	450.0	611.2
7.710	15.329	Fill	135.0	22.1	1040.9	17.0	1742	0.0	1040.9	0.6	450.0	624.5
7.874	22.008	Fill	135.0	22.1	1063.0	17.0	2527	0.0	1063.0	0.6	450.0	637.8
8.038	28.324	Fill	135.0	22.1	1085.1	17.0	3268	0.0	1085.1	0.6	450.0	651.1
8.202	31.902	Fill	135.0	22.1	1107.3	17.0	3688	0.0	1107.3	0.6	450.0	664.4
8.366	31.482	Fill	135.0	22.1	1129.4	17.0	3637	0.0	1129.4	0.6	450.0	677.6
8.530	26.503	Fill	135.0	22.1	1151.6	17.0	3050	0.0	1151.6	0.6	450.0	690.9
8.694	26.033	Fill	135.0	22.1	1173.7	17.0	2994	0.0	1173.7	0.6	450.0	704.2
8.858	28.171	Fill	135.0	22.1	1195.8	17.0	3244	0.0	1195.8	0.6	450.0	717.5
9.022	31.460	Fill	135.0	22.1	1218.0	17.0	3630	0.0	1218.0	0.6	450.0	730.8
9.186	28.566	Fill	135.0	22.1	1240.1	17.0	3288	0.0	1240.1	0.6	450.0	744.1
9.350	20.342	Fill	135.0	22.1	1262.3	17.0	2319	0.0	1262.3	0.6	450.0	757.4
9.514	18.565	Fill	135.0	22.1	1284.4	17.0	2109	0.0	1284.4	0.6	450.0	770.6
9.678	18.510	Fill	135.0	22.1	1306.5	17.0	2101	0.0	1306.5	0.6	450.0	783.9
9.842	17.173	Fill	135.0	22.1	1328.7	17.0	1942	0.0	1328.7	0.6	450.0	797.2
10.006	16.675	Fdxn Clay	125.0	20.5	1349.2	17.0	1882	0.0	1349.2	0.4	700.0	700.0
10.170	14.939	Fdxn Clay	125.0	20.5	1369.7	17.0	1677	0.0	1369.7	0.4	700.0	700.0
10.335	13.841	Fdxn Clay	125.0	20.6	1390.3	17.0	1547	0.0	1390.3	0.4	700.0	700.0
10.499	12.233	Fdxn Clay	125.0	20.5	1410.8	17.0	1356	0.0	1410.8	0.4	700.0	700.0
10.663	12.025	Fdxn Clay	125.0	20.5	1431.3	17.0	1331	0.0	1431.3	0.4	700.0	700.0
10.827	14.530	Fdxn Clay	125.0	20.5	1451.8	17.0	1624	0.0	1451.8	0.4	700.0	700.0
10.991	12.808	Fdxn Clay	125.0	20.5	1472.3	17.0	1420	0.0	1472.3	0.4	700.0	700.0
11.155	10.243	Fdxn Clay	125.0	20.5	1492.8	17.0	1117	9.7	1483.1	0.4	700.0	700.0
11.319	9.883	Fdxn Clay	125.0	20.5	1513.3	17.0	1074	19.9	1493.4	0.4	700.0	700.0
11.483	10.079	Fdxn Clay	125.0	20.5	1533.8	17.0	1096	30.1	1503.7	0.4	700.0	700.0
11.647	10.529	Fdxn Clay	125.0	20.5	1554.3	17.0	1147	40.4	1513.9	0.4	700.0	700.0
11.811	10.589	Fdxn Clay	125.0	20.5	1574.8	17.0	1153	50.6	1524.2	0.4	700.0	700.0
11.975	12.118	Fdxn Clay	125.0	20.5	1595.3	17.0	1332	60.8	1534.5	0.4	700.0	700.0
12.139	12.116	Fdxn Clay	125.0	20.5	1615.8	17.0	1330	71.1	1544.7	0.4	700.0	700.0
12.303	11.669	Fdxn Clay	125.0	20.5	1636.3	17.0	1277	81.3	1555.0	0.4	700.0	700.0
12.467	12.306	Fdxn Clay	125.0	20.5	1656.8	17.0	1350	91.5	1565.3	0.4	700.0	700.0
12.631	11.863	Fdxn Clay	125.0	20.5	1677.3	17.0	1297	101.8	1575.5	0.4	700.0	700.0
12.795	12.300	Fdxn Clay	125.0	20.5	1697.8	17.0	1347	112.0	1585.8	0.4	700.0	700.0
12.959	12.433	Fdxn Clay	125.0	20.5	1718.3	17.0	1362	122.2	1596.1	0.4	700.0	700.0
13.123	11.737	Fdxn Clay	125.0	20.5	1738.8	17.0	1279	132.5	1606.3	0.4	700.0	700.0
13.287	12.173	Fdxn Clay	125.0	20.5	1759.3	17.0	1329	142.7	1616.6	0.4	700.0	700.0
13.451	15.428	Fdxn Clay	125.0	20.5	1779.8	17.0	1710	152.9	1626.9	0.4	700.0	700.0
13.615	14.214	Fdxn Clay	125.0	20.5	1800.3	17.0	1566	163.2	1637.1	0.4	700.0	700.0
13.779	12.169	Fdxn Clay	125.0	20.5	1820.8	17.0	1325	173.4	1647.4	0.4	700.0	700.0
13.943	11.401	Fdxn Clay	125.0	20.5	1841.3	17.0	1233	183.6	1657.7	0.4	700.0	700.0
14.107	10.058	Fdxn Clay	125.0	20.5	1861.8	17.0	1074	193.9	1667.9	0.4	700.0	700.0
14.271	9.681	Fdxn Clay	125.0	20.5	1882.3	17.0	1028	204.1	1678.2	0.4	700.0	700.0
14.436	9.701	Fdxn Clay	125.0	20.6	1902.9	17.0	1029	214.4	1688.5	0.4	700.0	700.0
14.600	9.188	Fdxn Clay	125.0	20.5	1923.4	17.0	968	224.6	1698.8	0.4	700.0	700.0
14.764	9.246	Fdxn Clay	125.0	20.5	1943.9	17.0	973	234.9	1709.0	0.4	700.0	700.0
14.928	7.894	Fdxn Clay	125.0	20.5	1964.4	17.0	813	245.1	1719.3	0.4	700.0	700.0
15.092	7.514	Fdxn Clay	125.0	20.5	1984.9	17.0	767	255.3	1729.6	0.4	700.0	700.0
15.256	6.685	Fdxn Clay	125.0	20.5	2005.4	17.0	669	265.6	1739.8	0.4	700.0	700.0
15.420	6.110	Fdxn Clay	125.0	20.5	2025.9	17.0	600	275.8	1750.1	0.4	700.0	700.0
15.584	7.340	Fdxn Clay	125.0	20.5	2046.4	17.0	743	286.0	1760.4	0.4	700.0	700.0
15.748	7.468	Fdxn Clay	125.0	20.5	2066.9	17.0	757	296.3	1770.6	0.4	700.0	700.0
15.912	7.478	Fdxn Clay	125.0	20.5	2087.4	17.0	757	306.5	1780.9	0.4	700.0	700.0
16.076	7.916	Fdxn Clay	125.0	20.5	2107.9	17.0	807	316.7	1791.2	0.4	700.0	700.0
16.240	8.302	Fdxn Clay	125.0	20.5	2128.4	17.0	852	327.0	1801.4	0.4	700.0	702.6
16.404	8.493	Fdxn Clay	125.0	20.5	2148.9	17.0	873	337.2	1811.7	0.4	700.0	706.6
16.568	8.171	Fdxn Clay	125.0	20.5	2169.4	17.0	834	347.4	1822.0	0.4	700.0	710.6
16.732	7.799	Fdxn Clay	125.0	20.5	2189.9	17.0	789	357.7	1832.2	0.4	700.0	714.6
16.896	8.109	Fdxn Clay	125.0	20.5	2210.4	17.0	824	367.9	1842.5	0.4	700.0	718.6
17.060	8.309	Fdxn Clay	125.0	20.5	2230.9	17.0	846	378.1	1852.8	0.4	700.0	722.6
17.224	7.861	Fdxn Clay	125.0	20.5	2251.4	17.0	792	388.4	1863.0	0.4	700.0	726.6
17.388	8.436	Fdxn Clay	125.0	20.5	2271.9	17.0	859	398.6	1873.3	0.4	700.0	730.6
17.552	7.998	Fdxn Clay	125.0	20.5	2292.4	17.0	806	408.8	1883.6	0.4	700.0	734.6
17.716	7.358	Fdxn Clay	125.0	20.5	2312.9	17.0	730	419.1	1893.8	0.4	700.0	738.6
17.880	8.057	Fdxn Clay	125.0	20.5	2333.4	17.0	811	429.3	1904.1	0.4	700.0	742.6
18.044	8.441	Fdxn Clay	125.0	20.5	2353.9	17.0	855	439.5	1914.4	0.4	700.0	746.6
18.208	9.390	Fdxn Clay	125.0	20.5	2374.4	17.0	965	449.8	1924.6	0.4	700.0	750.6
18.372	9.755	Fdxn Clay	125.0	20.5	2394.9	17.0	1007	460.0	1934.9	0.4	700.0	754.6
18.537	10.651	Fdxn Clay	125.0	20.6	2415.5	17.0	1111	470.3	1945.2	0.4	700.0	758.6
18.701	11.541	Fdxn Clay	125.0	20.5	2436.0	17.0	1214	480.5	1955.5	0.4	700.0	762.6
18.865	11.133	Fdxn Clay	125.0	20.5	2456.5	17.0	1165	490.8	1965.8	0.4	700.0	766.6
19.029	10.882	Fdxn Clay	125.0	20.5	2477.0	17.0	1135	501.0	1976.0	0.4	700.0	770.7
19.193	10.442	Fdxn Clay	125.0	20.5	2497.5	17.0	1082	511.2	1986.3	0.4	700.0	774.7
19.357	10.762	Fdxn Clay	125.0	20.5	2518.0	17.0	1118	521.5	1996.6	0.4	700.0	778.7
19.521	10.030	Fdxn Clay	125.0	20.5	2538.5	17.0	1031	531.7	2006.8	0.4	700.0	782.7
19.685	10.158	Fdxn Clay	125.0	20.5	2559.0	17.0	1045	541.9	2017.1	0.4	700.0	786.7
19.849	10.045	Fdxn Clay	125.0	20.5	2579.5	17.0	1030	552.2	2027.4	0.4	700.0	790.7
20.013	9.536	Fdxn Clay	125.0	20.5	2600.0	17.0	969	562.4	2037.6	0.4	700.0	794.7
20.177	9.926	Fdxn Clay	125.0	20.5	2620.5	17.0	1014	572.6	2047.9	0.4	700.0	798.7
20.341	10.837	Fdxn Clay	125.0	20.5	2641.0	17.0	1120	582.9	2058.2	0.4	700.0	802.7
20.505	12.304	Fdxn Clay	125.0	20.5	2661.5	17.0	1291	593.1	2068.4	0.4	700.0	806.7
20.669	10.428	Fdxn Clay	125.0	20.5	2682.0	17.0	1069	603.3	2078.7	0.4	700.0	810.7
20.833	8.703	Soft Clay	125.0	20.5	2702.5	17.0	865	613.6	2089.0	0.2	275.0	480.5
20.997	8.664	Soft Clay	125.0	20.5	2723.0	17.0	859	623.8	2099.2	0.2	275.0	482.8
21.161	10.281	Soft Clay	125.0	20.5	2743.5	17.0	1048	634.0	2109.5	0.2	275.0	485.2
21.325	10.532	Soft Clay	125.0	20.5	2764.0	17.0	1076	644.3	2119.8	0.2	275.0	487.5
21.489	6.434	Soft Clay	125.0	20.5	2784.5	17.0	593	654.5	2130.0	0.2	275.0	489.9
21.653	6.188	Soft Clay	125.0	20.5	2805.0	17.0	563	664.7	2140.3	0.2	275.0	492.3
21.817	5.617	Soft Clay	125.0	20.5	2825.5	17.0	495	675.0	2150.6	0.2	275.0	494.6
21.981	7.476	Soft Clay	125.0	20.5	2846.0	17.0	712	685.2	2160.8	0.2	275.0	497.0
22.145	10.105	Soft Clay	125.0	20.5	2866.5	17.0	1020	695.4	2171.1	0.2	275.0	499.4

Comparision Plot



22.309	17.322	Till	125.0	20.5	2887.0	17.0	1868	705.7	2181.4	0.6	700.0	1396.1
22.473	22.672	Till	125.0	20.5	2907.5	17.0	2496	715.9	2191.6	0.6	700.0	1402.6
22.638	25.229	Till	125.0	20.6	2928.2	17.0	2796	726.2	2202.0	0.6	700.0	1409.3
22.802	32.585	Till	125.0	20.5	2948.7	17.0	3660	736.4	2212.2	0.6	700.0	1415.8
22.966	61.959	Till	125.0	20.5	2969.2	17.0	7115	746.7	2222.5	0.6	700.0	1422.4
23.13	108.555	Till	125.0	20.5	2989.7	17.0	12595	756.9	2232.8	0.6	700.0	1429.0
23.294	227.053	Till	125.0	20.5	3010.2	17.0	26535	767.1	2243.0	0.6	700.0	1435.5
23.458	322.583	Till	125.0	20.5	3030.7	17.0	37773	777.4	2253.3	0.6	700.0	1442.1
23.622	319.513	Till	125.0	20.5	3051.2	17.0	37410	787.6	2263.6	0.6	700.0	1448.7
23.786	327.236	Till	125.0	20.5	3071.7	17.0	38318	797.8	2273.8	0.6	700.0	1455.2
23.95	358.493	Till	125.0	20.5	3092.2	17.0	41994	808.1	2284.1	0.6	700.0	1461.8
24.114	330.722	Till	125.0	20.5	3112.7	17.0	38725	818.3	2294.4	0.6	700.0	1468.4
24.278	277.409	Till	125.0	20.5	3133.2	17.0	32452	828.5	2304.6	0.6	700.0	1475.0
24.442	201.237	Till	125.0	20.5	3153.7	17.0	23489	838.8	2314.9	0.6	700.0	1481.5
24.606	201.444	Till	125.0	20.5	3174.2	17.0	23513	849.0	2325.2	0.6	700.0	1488.1
24.77	184.264	Till	125.0	20.5	3194.7	17.0	21490	859.2	2335.4	0.6	700.0	1494.7
24.934	189.772	Till	125.0	20.5	3215.2	17.0	22137	869.5	2345.7	0.6	700.0	1501.2
25.098	208.515	Till	125.0	20.5	3235.7	17.0	24341	879.7	2356.0	0.6	700.0	1507.8
25.262	193.326	Till	125.0	20.5	3256.2	17.0	22553	889.9	2366.2	0.6	700.0	1514.4
25.426	184.098	Till	125.0	20.5	3276.7	17.0	21466	900.2	2376.5	0.6	700.0	1521.0
25.59	192.819	Till	125.0	20.5	3297.2	17.0	22491	910.4	2386.8	0.6	700.0	1527.5
25.754	212.811	Till	125.0	20.5	3317.7	17.0	24841	920.6	2397.0	0.6	700.0	1534.1
25.918	228.161	Till	125.0	20.5	3338.2	17.0	26646	930.9	2407.3	0.6	700.0	1540.7
26.082	230.855	Till	125.0	20.5	3358.7	17.0	26962	941.1	2417.6	0.6	700.0	1547.2
26.246	230.408	Till	125.0	20.5	3379.2	17.0	26908	951.4	2427.8	0.6	700.0	1553.8
26.41	239.644	Till	125.0	20.5	3399.7	17.0	27993	961.6	2438.1	0.6	700.0	1560.4
26.574	242.098	Till	125.0	20.5	3420.2	17.0	28281	971.8	2448.4	0.6	700.0	1566.9
26.739	248.864	Till	125.0	20.6	3440.8	17.0	29076	982.1	2458.7	0.6	700.0	1573.6
26.903	274.731	Till	125.0	20.5	3461.3	17.0	32118	992.3	2468.9	0.6	700.0	1580.1

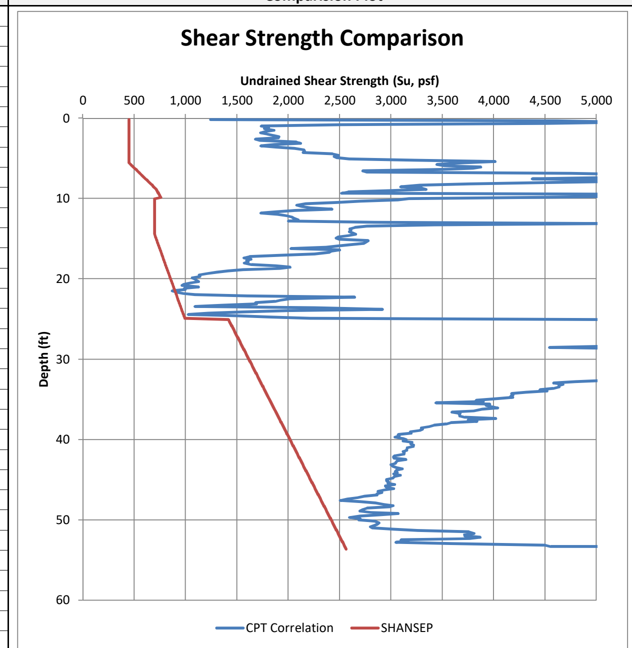
Material	Nkt	Peak Su/p'	Min Su (spf)
Fill	17.0	0.60	450.0
Fdxn Clay	17.0	0.45	700.0
Soft Clay	17.0	0.28	275.0
Till	17.0	0.64	700.0

CPT COF-C053

GWT Depth: 8.8 ft

ConeTec Data			CPT Shear Strength Correlation					SHANSEP Shear Strength Model				
Depth	qt	Material	Unit Weight (pcf)	Layer Weight	Total Vertical Stress	Nkt	CPT Su	Pore Pressure	Effective Vertical Stress	Su/p'	Min Su	SHANSEP Su
ft	tsf	Type	(pcf)	(psf)	(psf)		(psf)	(psf)	(psf)		(psf)	(psf)
0.164	10.593	Fill	135.0	22.1	22.1	17.0	1245	0.0	22.1	0.6	450.0	450.0
0.328	39.278	Fill	135.0	22.1	44.3	17.0	4618	0.0	44.3	0.6	450.0	450.0
0.492	45.205	Fill	135.0	22.1	66.4	17.0	5314	0.0	66.4	0.6	450.0	450.0
0.656	38.378	Fill	135.0	22.1	88.6	17.0	4510	0.0	88.6	0.6	450.0	450.0
0.820	21.417	Fill	135.0	22.1	110.7	17.0	2513	0.0	110.7	0.6	450.0	450.0
0.984	14.843	Fill	135.0	22.1	132.8	17.0	1738	0.0	132.8	0.6	450.0	450.0
1.148	15.447	Fill	135.0	22.1	155.0	17.0	1808	0.0	155.0	0.6	450.0	450.0
1.312	15.112	Fill	135.0	22.1	177.1	17.0	1767	0.0	177.1	0.6	450.0	450.0
1.476	15.923	Fill	135.0	22.1	199.3	17.0	1862	0.0	199.3	0.6	450.0	450.0
1.640	15.186	Fill	135.0	22.1	221.4	17.0	1774	0.0	221.4	0.6	450.0	450.0
1.804	14.843	Fill	135.0	22.1	243.5	17.0	1732	0.0	243.5	0.6	450.0	450.0
1.968	15.399	Fill	135.0	22.1	265.7	17.0	1796	0.0	265.7	0.6	450.0	450.0
2.133	15.901	Fill	135.0	22.3	288.0	17.0	1854	0.0	288.0	0.6	450.0	450.0
2.297	16.374	Fill	135.0	22.1	310.1	17.0	1908	0.0	310.1	0.6	450.0	450.0
2.461	16.353	Fill	135.0	22.1	332.2	17.0	1904	0.0	332.2	0.6	450.0	450.0
2.625	14.484	Fill	135.0	22.1	354.4	17.0	1683	0.0	354.4	0.6	450.0	450.0
2.789	14.865	Fill	135.0	22.1	376.5	17.0	1727	0.0	376.5	0.6	450.0	450.0
2.953	17.877	Fill	135.0	22.1	398.7	17.0	2080	0.0	398.7	0.6	450.0	450.0
3.117	18.231	Fill	135.0	22.1	420.8	17.0	2120	0.0	420.8	0.6	450.0	450.0
3.281	16.043	Fill	135.0	22.1	442.9	17.0	1861	0.0	442.9	0.6	450.0	450.0
3.445	14.965	Fill	135.0	22.1	465.1	17.0	1733	0.0	465.1	0.6	450.0	450.0
3.609	16.226	Fill	135.0	22.1	487.2	17.0	1880	0.0	487.2	0.6	450.0	450.0
3.773	17.768	Fill	135.0	22.1	509.4	17.0	2060	0.0	509.4	0.6	450.0	450.0
3.937	18.556	Fill	135.0	22.1	531.5	17.0	2152	0.0	531.5	0.6	450.0	450.0
4.101	18.626	Fill	135.0	22.1	553.6	17.0	2159	0.0	553.6	0.6	450.0	450.0
4.265	18.520	Fill	135.0	22.1	575.8	17.0	2145	0.0	575.8	0.6	450.0	450.0
4.429	20.981	Fill	135.0	22.1	597.9	17.0	2433	0.0	597.9	0.6	450.0	450.0
4.593	21.460	Fill	135.0	22.1	620.1	17.0	2488	0.0	620.1	0.6	450.0	450.0
4.757	21.125	Fill	135.0	22.1	642.2	17.0	2448	0.0	642.2	0.6	450.0	450.0
4.921	21.386	Fill	135.0	22.1	664.3	17.0	2477	0.0	664.3	0.6	450.0	450.0
5.085	22.403	Fill	135.0	22.1	686.5	17.0	2595	0.0	686.5	0.6	450.0	450.0
5.249	27.846	Fill	135.0	22.1	708.6	17.0	3234	0.0	708.6	0.6	450.0	450.0
5.413	34.502	Fill	135.0	22.1	730.8	17.0	4016	0.0	730.8	0.6	450.0	450.0
5.577	31.948	Fill	135.0	22.1	752.9	17.0	3714	0.0	752.9	0.6	450.0	451.7
5.741	29.695	Fill	135.0	22.1	775.0	17.0	3448	0.0	775.0	0.6	450.0	465.0
5.905	30.305	Fill	135.0	22.1	797.2	17.0	3518	0.0	797.2	0.6	450.0	478.3
6.069	33.344	Fill	135.0	22.1	819.3	17.0	3875	0.0	819.3	0.6	450.0	491.6
6.234	32.703	Fill	135.0	22.3	841.6	17.0	3798	0.0	841.6	0.6	450.0	505.0
6.398	29.848	Fill	135.0	22.1	863.7	17.0	3461	0.0	863.7	0.6	450.0	518.2
6.562	23.606	Fill	135.0	22.1	885.9	17.0	2725	0.0	885.9	0.6	450.0	531.5
6.726	23.964	Fill	135.0	22.1	908.0	17.0	2766	0.0	908.0	0.6	450.0	544.8
6.890	40.875	Fill	135.0	22.1	930.2	17.0	4754	0.0	930.2	0.6	450.0	558.1
7.054	47.942	Fill	135.0	22.1	952.3	17.0	5584	0.0	952.3	0.6	450.0	571.4
7.218	55.202	Fill	135.0	22.1	974.4	17.0	6437	0.0	974.4	0.6	450.0	584.7
7.382	44.210	Fill	135.0	22.1	996.6	17.0	5143	0.0	996.6	0.6	450.0	597.9
7.546	37.699	Fill	135.0	22.1	1018.7	17.0	4375	0.0	1018.7	0.6	450.0	611.2
7.710	43.531	Fill	135.0	22.1	1040.9	17.0	5060	0.0	1040.9	0.6	450.0	624.5
7.874	45.215	Fill	135.0	22.1	1063.0	17.0	5257	0.0	1063.0	0.6	450.0	637.8
8.038	38.530	Fill	135.0	22.1	1085.1	17.0	4469	0.0	1085.1	0.6	450.0	651.1
8.202	32.529	Fill	135.0	22.1	1107.3	17.0	3762	0.0	1107.3	0.6	450.0	664.4
8.366	28.455	Fill	135.0	22.1	1129.4	17.0	3281	0.0	1129.4	0.6	450.0	677.6
8.530	26.897	Fill	135.0	22.1	1151.6	17.0	3097	0.0	1151.6	0.6	450.0	690.9
8.694	28.674	Fill	135.0	22.1	1173.7	17.0	3304	0.0	1173.7	0.6	450.0	704.2
8.858	29.015	Fill	135.0	22.1	1195.8	17.0	3343	3.6	1192.2	0.6	450.0	715.3
9.022	26.047	Fill	135.0	22.1	1218.0	17.0	2993	13.9	1204.1	0.6	450.0	722.5
9.186	22.557	Fill	135.0	22.1	1240.1	17.0	2581	24.1	1216.0	0.6	450.0	729.6
9.350	22.056	Fill	135.0	22.1	1262.3	17.0	2521	34.3	1227.9	0.6	450.0	736.8
9.514	50.967	Fill	135.0	22.1	1284.4	17.0	5921	44.6	1239.8	0.6	450.0	743.9
9.678	48.490	Fill	135.0	22.1	1306.5	17.0	5628	54.8	1251.7	0.6	450.0	751.0
9.842	38.662	Fill	135.0	22.1	1328.7	17.0	4470	65.0	1263.6	0.6	450.0	758.2
10.006	27.656	Fdxn Clay	125.0	20.5	1349.2	17.0	3174	75.3	1273.9	0.5	700.0	700.0
10.170	26.758	Fdxn Clay	125.0	20.5	1369.7	17.0	3067	85.5	1284.2	0.5	700.0	700.0
10.335	23.655	Fdxn Clay	125.0	20.6	1390.3	17.0	2701	95.8	1294.5	0.5	700.0	700.0
10.499	21.728	Fdxn Clay	125.0	20.5	1410.8	17.0	2473	106.0	1304.8	0.5	700.0	700.0
10.663	19.142	Fdxn Clay	125.0	20.5	1431.3	17.0	2168	116.3	1315.0	0.5	700.0	700.0
10.827	18.430	Fdxn Clay	125.0	20.5	1451.8	17.0	2083	126.5	1325.3	0.5	700.0	700.0
10.991	18.815	Fdxn Clay	125.0	20.5	1472.3	17.0	2127	136.7	1335.6	0.5	700.0	700.0
11.155	19.560	Fdxn Clay	125.0	20.5	1492.8	17.0	2213	147.0	1345.8	0.5	700.0	700.0
11.319	21.374	Fdxn Clay	125.0	20.5	1513.3	17.0	2426	157.2	1356.1	0.5	700.0	700.0
11.483	18.308	Fdxn Clay	125.0	20.5	1533.8	17.0	2064	167.4	1366.4	0.5	700.0	700.0
11.647	16.841	Fdxn Clay	125.0	20.5	1554.3	17.0	1890	177.7	1376.6	0.5	700.0	700.0
11.811	15.531	Fdxn Clay	125.0	20.5	1574.8	17.0	1735	187.9	1386.9	0.5	700.0	700.0
11.975	16.891	Fdxn Clay	125.0	20.5	1595.3	17.0	1893	198.1	1397.2	0.5	700.0	700.0
12.139	17.658	Fdxn Clay	125.0	20.5	1615.8	17.0	1982	208.4	1407.4	0.5	700.0	700.0
12.303	18.099	Fdxn Clay	125.0	20.5	1636.3	17.0	2033	218.6	1417.7	0.5	700.0	700.0
12.467	18.307	Fdxn Clay	125.0	20.5	1656.8	17.0	2056	228.8	1428.0	0.5	700.0	700.0
12.631	18.655	Fdxn Clay	125.0	20.5	1677.3	17.0	2096	239.1	1438.2	0.5	700.0	700.0
12.795	17.862	Fdxn Clay	125.0	20.5	1697.8	17.0	2002	249.3	1448.5	0.5	700.0	700.0
12.959	25.040	Fdxn Clay	125.0	20.5	1718.3	17.0	2845	259.5	1458.8	0.5	700.0	700.0
13.123	44.536	Fdxn Clay	125.0	20.5	1738.8	17.0	5137	269.8	1469.0	0.5	700.0	700.0
13.287	30.003	Fdxn Clay	125.0	20.5	1759.3	17.0	3426	280.0	1479.3	0.5	700.0	700.0
13.451	24.392	Fdxn Clay	125.0	20.5	1779.8	17.0	2765	290.2	1489.6	0.5	700.0	700.0
13.615	23.396	Fdxn Clay	125.0	20.5	1800.3	17.0	2647	300.5	1499.8	0.5	700.0	700.0
13.779	23.007	Fdxn Clay	125.0	20.5	1820.8	17.0	2600	310.7	1510.1	0.5	700.0	700.0
13.943	23.103	Fdxn Clay	125.0	20.5	1841.3	17.0	2610	320.9	1520.4	0.5	700.0	700.0
14.107	22.980	Fdxn Clay	125.0	20.5	1861.8	17.0	2594	331.2	1530.6	0.5	700.0	700.0
14.271	23.280	Fdxn Clay	125.0	20.5	1882.3	17.0	2628	341.4	1540.9	0.5	700.0	700.0
14.436	23.528	Fdxn Clay	125.0	20.6	1902.9	17.0	2656	351.7	1551.2	0.5	700.0	700.0
14.600	22.955	Fdxn Clay	125.0	20.5	1923.4	17.0	2587	361.9	1561.5	0.5	700.0	702.7
14.764	22.123	Fdxn Clay	125.0	20.5	1943.9	17.0	2488	372.2	1571.8	0.5	700.0	707.3
14.928	21.937	Fdxn Clay	125.0	20.5	1964.4	17.0	2465	382.4	1582.0	0.5	700.0	711.9
15.092	22.253	Fdxn Clay	125.0	20.5	1984.9	17.0	2501	392.6	1592.3	0.5	700.0	716.5
15.256	24.624	Fdxn Clay	125.0	20.5	2005.4	17.0	2779	402.9	1602.6	0.5	700.0	721.2
15.420	24.417	Fdxn Clay	125.0	20.5	2025.9	17.0	2753	413.1	1612.8	0.5	700.0	725.8
15.584	24.234	Fdxn Clay	125.0	20.5	2046.4	17.0	2731	423.3	1623.1	0.5	700.0	730.4
15.748	23.167	Fdxn Clay	125.0	20.5	2066.9	17.0	2604	433.6	1633.4	0.5	700.0	735.0
15.912	22.153	Fdxn Clay	125.0	20.5	2087.4	17.0	2483	443.8	1643.6	0.5	700.0	739.6
16.076	21.202	Fdxn Clay	125.0	20.5	2107.9	17.0	2370	454.0	1653.9	0.5	700.0	744.3
16.240	18.300	Fdxn Clay	125.0	20.5	2128.4	17.0	2028	464.3	1664.2	0.5	700.0	748.9
16.404	22.323	Fdxn Clay	125.0	20.5	2148.9	17.0	2500	474.5	1674.4	0.5	700.0	753.5
16.568	21.625	Fdxn Clay	125.0	20.5	2169.4	17.0	2417	484.7	1684.7	0.5	700.0	758.1
16.732	21.453	Fdxn Clay	125.0	20.5	2189.9	17.0	2395	495.0	1695.0	0.5	700.0	762.7
16.896	20.293	Fdxn Clay	125.0	20.5	2210.4	17.0	2257	505.2	1705.2	0.5	700.0	767.4
17.060	17.493	Fdxn Clay	125.0	20.5	2230.9	17.0	1927	515.4	1715.5	0.5	700.0	772.0
17.224	14.912	Fdxn Clay	125.0	20.5	2251.4	17.0	1622	525.7	1725.8	0.5	700.0	776.6
17.388	14.481	Fdxn Clay	125.0	20.5	2271.9	17.0	1570	535.9	1736.0	0.5	700.0	781.2
17.552	15.072	Fdxn Clay	125.0	20.5	2292.4	17.0	1638	546.1	1746.3	0.5	700.0	785.8
17.716	14.714	Fdxn Clay	125.0	20.5	2312.9	17.0	1595	556.4	1756.6	0.5	700.0	790.5
17.880	14.855	Fdxn Clay	125.0	20.5	2333.4	17.0	1610	566.6	1766.8	0.5	700.0	795.1
18.044	14.542	Fdxn Clay	125.0	20.5	2353.9	17.0	1572	576.8	1777.1	0.5	700.0	799.7
18.208	15.129	Fdxn Clay	125.0	20.5	2374.4	17.0	1640	587.1	1787.4	0.5	700.0	804.3
18.372	17.183	Fdxn Clay	125.0	20.5	2394.9	17.0	1881	597.3	1797.6	0.5	700.0	808.9
18.537	18.359	Fdxn Clay	125.0	20.6	2415.5	17.0	2018	607.6	1808.0	0.5	700.0	813.6
18.701	17.508	Fdxn Clay	125.0	20.5	2436.0	17.0	1916	617.8	1818.2	0.5	700.0	818.2
18.865	14.500	Fdxn Clay	125.0	20.5	2456.5	17.0	1561	628.1	1828.5	0.5	700.0	822.8
19.029	13.231	Fdxn Clay	125.0	20.5	2477.0	17.0	1411	638.3	1838.8	0.5	700.0	827.4
19.193	12.328	Fdxn Clay	125.0	20.5	2497.5	17.0	1303	648.5	1849.0	0.5	700.0	832.1
19.357	11.511	Fdxn Clay	125.0	20.5	2518.0	17.0	1206	658.8	1859.3	0.5	700.0	836.7
19.521	10.900	Fdxn Clay	125.0	20.5	2538.5	17.0	1133	669.0	1869.6	0.5	700.0	841.3
19.685	10.968	Fdxn Clay	125.0	20.5	2559.0	17.0	1140	679.2	1879.8	0.5	700.0	845.9
19.849	10.338	Fdxn Clay	125.0	20.5	2579.5	17.0	1064	689.5	1890.1	0.5	700.0	850.5
20.013	10.591	Fdxn Clay	125.0	20.5	2600.0	17.0	1093	699.7	1900.4	0.5	700.0	855.2
20.177	10.718	Fdxn Clay	125.0	20.5	2620.5	17.0	1107	709.9	1910.6	0.5	700.0	859.8
20.341	10.903	Fdxn Clay	125.0	20.5	2641.0	17.0	1127	720.2	1920.9	0.5	700.0	864.4
20.505	10.223	Fdxn Clay	125.0	20.5	2661.5	17.0	1046	730.4	1931.2	0.5	700.0	869.0
20.669	9.736	Fdxn Clay	125.0	20.5	2682.0	17.0	988	740.6	1941.4	0.5	700.0	873.6
20.833	9.564	Fdxn Clay	125.0	20.5	2702.5	17.0	966	750.9	1951.7	0.5	700.0	878.3
20.997	10.937	Fdxn Clay	125.0	20.5	2723.0	17.0	1127	761.1	1962.0	0.5	700.0	882.9
21.161	9.793	Fdxn Clay	125.0	20.5	2743.5	17.0	991	771.3	1972.2	0.5	700.0	887.5
21.325	9.848	Fdxn Clay	125.0	20.5	2764.0	17.0	996	781.6	1982.5	0.5	700.0	892.1
21.489	8.793	Fdxn Clay	125.0	20.5	2784.5	17.0	871	791.8	1992.8	0.5	700.0	896.7
21.653	9.157	Fdxn Clay	125.0	20.5	2805.0	17.0	912	802.0	2003.0	0.5	700.0	901.4
21.817	9.726	Fdxn Clay	125.0	20.5	2825.5	17.0	978	812.3	2013.3	0.5	700.0	906.0
21.981	10.722	Fdxn Clay	125.0	20.5	2846.0	17.0	1094	822.5	2023.6	0.5	700.0	910.6
22.145	15.045	Fdxn Clay	125.0	20.5	2866.5	17.0	1601	832.7	2033.8	0.5	700.0	915.2

Comparision Plot



22.309	23.947	Fdxn Clay	125.0	20.5	2887.0	17.0	2647	843.0	2044.1	0.5	700.0	919.8
22.473	18.574	Fdxn Clay	125.0	20.5	2907.5	17.0	2014	853.2	2054.3	0.5	700.0	924.5
22.638	17.834	Fdxn Clay	125.0	20.6	2928.2	17.0	1926	863.5	2064.7	0.5	700.0	929.1
22.802	17.383	Fdxn Clay	125.0	20.5	2948.7	17.0	1872	873.7	2074.9	0.5	700.0	933.7
22.966	15.782	Fdxn Clay	125.0	20.5	2969.2	17.0	1682	884.0	2085.2	0.5	700.0	938.3
23.130	15.865	Fdxn Clay	125.0	20.5	2989.7	17.0	1691	894.2	2095.5	0.5	700.0	943.0
23.294	13.151	Fdxn Clay	125.0	20.5	3010.2	17.0	1370	904.4	2105.7	0.5	700.0	947.6
23.458	10.815	Fdxn Clay	125.0	20.5	3030.7	17.0	1094	914.7	2116.0	0.5	700.0	952.2
23.622	20.735	Fdxn Clay	125.0	20.5	3051.2	17.0	2260	924.9	2126.3	0.5	700.0	956.8
23.786	26.347	Fdxn Clay	125.0	20.5	3071.7	17.0	2919	935.1	2136.5	0.5	700.0	961.4
23.950	18.528	Fdxn Clay	125.0	20.5	3092.2	17.0	1998	945.4	2146.8	0.5	700.0	966.1
24.114	14.867	Fdxn Clay	125.0	20.5	3112.7	17.0	1566	955.6	2157.1	0.5	700.0	970.7
24.278	11.935	Fdxn Clay	125.0	20.5	3133.2	17.0	1220	965.8	2167.3	0.5	700.0	975.3
24.442	10.305	Fdxn Clay	125.0	20.5	3153.7	17.0	1027	976.1	2177.6	0.5	700.0	979.9
24.606	14.253	Fdxn Clay	125.0	20.5	3174.2	17.0	1490	986.3	2187.9	0.5	700.0	984.5
24.770	17.055	Fdxn Clay	125.0	20.5	3194.7	17.0	1819	996.5	2198.1	0.5	700.0	989.2
24.934	20.405	Fdxn Clay	125.0	20.5	3215.2	17.0	2211	1006.8	2208.4	0.5	700.0	993.8
25.098	44.778	Till	125.0	20.5	3235.7	17.0	5078	1017.0	2218.7	0.6	700.0	1420.0
25.262	73.140	Till	125.0	20.5	3256.2	17.0	8413	1027.2	2228.9	0.6	700.0	1426.5
25.426	118.000	Till	125.0	20.5	3276.7	17.0	13690	1037.5	2239.2	0.6	700.0	1433.1
25.590	168.671	Till	125.0	20.5	3297.2	17.0	19650	1047.7	2249.5	0.6	700.0	1439.7
25.754	189.848	Till	125.0	20.5	3317.7	17.0	22140	1057.9	2259.7	0.6	700.0	1446.2
25.918	179.889	Till	125.0	20.5	3338.2	17.0	20967	1068.2	2270.0	0.6	700.0	1452.8
26.082	144.664	Till	125.0	20.5	3358.7	17.0	16822	1078.4	2280.3	0.6	700.0	1459.4
26.246	100.529	Till	125.0	20.5	3379.2	17.0	11628	1088.6	2290.5	0.6	700.0	1465.9
26.410	57.762	Till	125.0	20.5	3399.7	17.0	6596	1098.9	2300.8	0.6	700.0	1472.5
26.574	137.815	Till	125.0	20.5	3420.2	17.0	16012	1109.1	2311.1	0.6	700.0	1479.1
26.739	182.001	Till	125.0	20.6	3440.8	17.0	21209	1119.4	2321.4	0.6	700.0	1485.7
26.903	166.813	Till	125.0	20.5	3461.3	17.0	19421	1129.6	2331.7	0.6	700.0	1492.3
27.067	158.391	Till	125.0	20.5	3481.8	17.0	18429	1139.9	2341.9	0.6	700.0	1498.8
27.231	163.799	Till	125.0	20.5	3502.3	17.0	19064	1150.1	2352.2	0.6	700.0	1505.4
27.395	154.141	Till	125.0	20.5	3522.8	17.0	17927	1160.3	2362.5	0.6	700.0	1512.0
27.559	82.960	Till	125.0	20.5	3543.3	17.0	9552	1170.6	2372.7	0.6	700.0	1518.5
27.723	58.866	Till	125.0	20.5	3563.8	17.0	6716	1180.8	2383.0	0.6	700.0	1525.1
27.887	54.004	Till	125.0	20.5	3584.3	17.0	6143	1191.0	2393.3	0.6	700.0	1531.7
28.051	55.452	Till	125.0	20.5	3604.8	17.0	6312	1201.3	2403.5	0.6	700.0	1538.3
28.215	50.652	Till	125.0	20.5	3625.3	17.0	5746	1211.5	2413.8	0.6	700.0	1544.8
28.379	45.640	Till	125.0	20.5	3645.8	17.0	5155	1221.7	2424.1	0.6	700.0	1551.4
28.543	40.472	Till	125.0	20.5	3666.3	17.0	4546	1232.0	2434.3	0.6	700.0	1558.0
28.707	47.806	Till	125.0	20.5	3686.8	17.0	5407	1242.2	2444.6	0.6	700.0	1564.5
28.871	51.274	Till	125.0	20.5	3707.3	17.0	5814	1252.4	2454.9	0.6	700.0	1571.1
29.035	51.820	Till	125.0	20.5	3727.8	17.0	5877	1262.7	2465.1	0.6	700.0	1577.7
29.199	50.316	Till	125.0	20.5	3748.3	17.0	5699	1272.9	2475.4	0.6	700.0	1584.3
29.363	55.701	Till	125.0	20.5	3768.8	17.0	6331	1283.1	2485.7	0.6	700.0	1590.8
29.527	58.066	Till	125.0	20.5	3789.3	17.0	6608	1293.4	2495.9	0.6	700.0	1597.4
29.691	61.992	Till	125.0	20.5	3809.8	17.0	7069	1303.6	2506.2	0.6	700.0	1604.0
29.855	62.534	Till	125.0	20.5	3830.3	17.0	7132	1313.8	2516.5	0.6	700.0	1610.5
30.019	62.805	Till	125.0	20.5	3850.8	17.0	7162	1324.1	2526.7	0.6	700.0	1617.1
30.183	62.634	Till	125.0	20.5	3871.3	17.0	7141	1334.3	2537.0	0.6	700.0	1623.7
30.347	63.201	Till	125.0	20.5	3891.8	17.0	7206	1344.5	2547.3	0.6	700.0	1630.2
30.511	62.341	Till	125.0	20.5	3912.3	17.0	7104	1354.8	2557.5	0.6	700.0	1636.8
30.675	66.113	Till	125.0	20.5	3932.8	17.0	7547	1365.0	2567.8	0.6	700.0	1643.4
30.840	65.456	Till	125.0	20.6	3953.4	17.0	7468	1375.3	2578.1	0.6	700.0	1650.0
31.004	59.190	Till	125.0	20.5	3973.9	17.0	6730	1385.5	2588.4	0.6	700.0	1656.6
31.168	59.121	Till	125.0	20.5	3994.4	17.0	6720	1395.8	2598.7	0.6	700.0	1663.1
31.332	54.971	Till	125.0	20.5	4014.9	17.0	6231	1406.0	2608.9	0.6	700.0	1669.7
31.496	54.223	Till	125.0	20.5	4035.4	17.0	6142	1416.2	2619.2	0.6	700.0	1676.3
31.660	52.539	Till	125.0	20.5	4055.9	17.0	5942	1426.5	2629.5	0.6	700.0	1682.9
31.824	53.725	Till	125.0	20.5	4076.4	17.0	6081	1436.7	2639.7	0.6	700.0	1689.4
31.988	51.726	Till	125.0	20.5	4096.9	17.0	5844	1446.9	2650.0	0.6	700.0	1696.0
32.152	69.897	Till	125.0	20.5	4117.4	17.0	7981	1457.2	2660.3	0.6	700.0	1702.6
32.316	48.002	Till	125.0	20.5	4137.9	17.0	5404	1467.4	2670.5	0.6	700.0	1709.1
32.480	46.432	Till	125.0	20.5	4158.4	17.0	5218	1477.6	2680.8	0.6	700.0	1715.7
32.644	45.441	Till	125.0	20.5	4178.9	17.0	5100	1487.9	2691.1	0.6	700.0	1722.3
32.808	42.837	Till	125.0	20.5	4199.4	17.0	4793	1498.1	2701.3	0.6	700.0	1728.8
32.972	41.091	Till	125.0	20.5	4219.9	17.0	4586	1508.3	2711.6	0.6	700.0	1735.4
33.136	41.869	Till	125.0	20.5	4240.4	17.0	4676	1518.6	2721.9	0.6	700.0	1742.0
33.300	41.520	Till	125.0	20.5	4260.9	17.0	4634	1528.8	2732.1	0.6	700.0	1748.6
33.464	41.560	Till	125.0	20.5	4281.4	17.0	4638	1539.0	2742.4	0.6	700.0	1755.1
33.628	41.060	Till	125.0	20.5	4301.9	17.0	4578	1549.3	2752.7	0.6	700.0	1761.7
33.792	40.009	Till	125.0	20.5	4322.4	17.0	4453	1559.5	2762.9	0.6	700.0	1768.3
33.956	40.599	Till	125.0	20.5	4342.9	17.0	4521	1569.7	2773.2	0.6	700.0	1774.8
34.120	38.882	Till	125.0	20.5	4363.4	17.0	4318	1580.0	2783.5	0.6	700.0	1781.4
34.284	37.677	Till	125.0	20.5	4383.9	17.0	4175	1590.2	2793.7	0.6	700.0	1788.0
34.448	37.818	Till	125.0	20.5	4404.4	17.0	4190	1600.4	2804.0	0.6	700.0	1794.6
34.612	37.629	Till	125.0	20.5	4424.9	17.0	4167	1610.7	2814.3	0.6	700.0	1801.1
34.776	37.811	Till	125.0	20.5	4445.4	17.0	4187	1620.9	2824.5	0.6	700.0	1807.7
34.941	36.204	Till	125.0	20.6	4466.0	17.0	3997	1631.2	2834.8	0.6	700.0	1814.3
35.105	34.806	Till	125.0	20.5	4486.5	17.0	3831	1641.4	2845.1	0.6	700.0	1820.9
35.269	35.398	Till	125.0	20.5	4507.0	17.0	3899	1651.7	2855.4	0.6	700.0	1827.4
35.433	31.486	Till	125.0	20.5	4527.5	17.0	3438	1661.9	2865.6	0.6	700.0	1834.0
35.597	35.961	Till	125.0	20.5	4548.0	17.0	3963	1672.1	2875.9	0.6	700.0	1840.6
35.761	35.663	Till	125.0	20.5	4568.5	17.0	3927	1682.4	2886.2	0.6	700.0	1847.2
35.925	36.146	Till	125.0	20.5	4589.0	17.0	3983	1692.6	2896.4	0.6	700.0	1853.7
36.089	36.647	Till	125.0	20.5	4609.5	17.0	4040	1702.8	2906.7	0.6	700.0	1860.3
36.253	35.369	Till	125.0	20.5	4630.0	17.0	3889	1713.1	2917.0	0.6	700.0	1866.9
36.417	34.674	Till	125.0	20.5	4650.5	17.0	3806	1723.3	2927.2	0.6	700.0	1873.4
36.581	32.896	Till	125.0	20.5	4671.0	17.0	3595	1733.5	2937.5	0.6	700.0	1880.0
36.745	33.559	Till	125.0	20.5	4691.5	17.0	3672	1743.8	2947.8	0.6	700.0	1886.6
36.909	33.514	Till	125.0	20.5	4712.0	17.0	3666	1754.0	2958.0	0.6	700.0	1893.1
37.073	33.546	Till	125.0	20.5	4732.5	17.0	3668	1764.2	2968.3	0.6	700.0	1899.7
37.237	33.992	Till	125.0	20.5	4753.0	17.0	3719	1774.5	2978.6	0.6	700.0	1906.3
37.401	36.561	Till	125.0	20.5	4773.5	17.0	4020	1784.7	2988.8	0.6	700.0	1912.9
37.565	34.298	Till	125.0	20.5	4794.0	17.0	3753	1794.9	2999.1	0.6	700.0	1919.4
37.729	35.036	Till	125.0	20.5	4814.5	17.0	3839	1805.2	3009.4	0.6	700.0	1926.0
37.893	32.854	Till	125.0	20.5	4835.0	17.0	3581	1815.4	3019.6	0.6	700.0	1932.6
38.057	32.514	Till	125.0	20.5	4855.5	17.0	3540	1825.6	3029.9	0.6	700.0	1939.1
38.221	31.469	Till	125.0	20.5	4876.0	17.0	3415	1835.9	3040.2	0.6	700.0	1945.7
38.385	31.119	Till	125.0	20.5	4896.5	17.0	3373	1846.1	3050.4	0.6	700.0	1952.3
38.549	30.482	Till	125.0	20.5	4917.0	17.0	3297	1856.3	3060.7	0.6	700.0	1958.9
38.713	30.580	Till	125.0	20.5	4937.5	17.0	3307	1866.6	3071.0	0.6	700.0	1965.4
38.877	30.360	Till	125.0	20.5	4958.0	17.0	3280	1876.8	3081.2	0.6	700.0	1972.0
39.042	29.599	Till	125.0	20.6	4978.7	17.0	3189	1887.1	3091.6	0.6	700.0	1978.6
39.206	29.675	Till	125.0	20.5	4999.2	17.0	3197	1897.3	3101.8	0.6	700.0	1985.2
39.370	28.604	Till	125.0	20.5	5019.7	17.0	3070	1907.6	3112.1	0.6	700.0	1991.7
39.534	28.709	Till	125.0	20.5	5040.2	17.0	3081	1917.8	3122.4	0.6	700.0	1998.3
39.698	28.358	Till	125.0	20.5	5060.7	17.0	3039	1928.0	3132.6	0.6	700.0	2004.9
39.862	29.026	Till	125.0	20.5	5081.2	17.0	3116	1938.3	3142.9	0.6	700.0	2011.5
40.026	29.311	Till	125.0	20.5	5101.7	17.0	3148	1948.5	3153.2	0.6	700.0	2018.0
40.190	29.066	Till	125.0	20.5	5122.2	17.0	3118	1958.7	3163.4	0.6	700.0	2024.6
40.354	29.821	Till	125.0	20.5	5142.7	17.0	3206	1969.0	3173.7	0.6	700.0	2031.2
40.518	29.706	Till	125.0	20.5	5163.2	17.0	3191	1979.2	3184.0	0.6	700.0	2037.7
40.682	29.960	Till	125.0	20.5	5183.7	17.0	3220	1989.4	3194.2	0.6	700.0	2044.3
40.846	29.945	Till	125.0	20.5	5204.2	17.0	3217	1999.7	3204.5	0.6	700.0	2050.9
41.010	29.464	Till	125.0	20.5	5224.7	17.0	3159	2009.9	3214.8	0.6	700.0	2057.5
41.174	29.430	Till	125.0	20.5	5245.2	17.0	3154	2020.1	3225.0	0.6	700.0	2064.0
41.338	29.456	Till	125.0	20.5	5265.7	17.0	3156	2030.4	3235.3	0.6	700.0	2070.6
41.502	29.136	Till	125.0	20.5	5286.2	17.0	3117	2040.6	3245.6	0.6	700.0	2077.2
41.666	29.271	Till	125.0	20.5	5306.7	17.0	3131	2050.8	3255.8	0.6	700.0	2083.7
41.830	29.244	Till	125.0	20.5	5327.2	17.0	3127	2061.1	3266.1	0.6	700.0	2090.3
41.994	28.502	Till	125.0	20.5	5347.7	17.0	3039	2071.3	3276.4	0.6	700.0	2096.9
42.158	28.404	Till	125.0	20.5	5368.2	17.0	3026	2081.5	3286.6	0.6	700.0	2103.4
42.322	28.452	Till	125.0	20.5	5388.7	17.0	3030	2091.8	3296.9	0.6	700.0	2110.0
42.486	29.434	Till	125.0	20.5	5409.2	17.0	3145	2102.0	3307.2	0.6	700.0	2116.6
42.650	28.735	Till	125.0	20.5	5429.7	17.0	3061	2112.2	3317.4	0.6	700.0	2123.2
42.814	28.651	Till	125.0	20.5	5450.2	17.0	3050	2122.5	3327.7	0.6	700.0	2129.7
42.978	28.601	Till	125.0	20.5	5470.7	17.0	3043	2132.7	3338.0	0.6	700.0	2136.3
43.143	28.251	Till	125.0	20.6	5491.3	17.0	3001	2143.0	3348.3	0.6	700.0	2142.9
43.307	28.409	Till	125.0	20.5	5511.8	17.0	3018	2153.2	3358.6	0.6	700.0	2149.5
43.471	28.709	Till	125.0	20.5	5532.3	17.0	3052	2163.5	3368.8	0.6	700.0	2156.0
43.635	29.213	Till	125.0	20.5	5552.8	17.0	3110	2173.7	3379.1	0.6	700.0	2162.6
43.799	28.766	Till	125.0	20.5	5573.3	17.0	3056	2183.9	3389.4	0.6	700.0	2169.2
43.963	28.675	Till	125.0	20.5	5593.8	17.0	3044	2194.2	3399.6	0.6	700.0	2175.8
44.127	28.838	Till	125.0	20.5	5614.3	17.0	3062	2204.4	3409.9	0.6	700.0	2182.3
44.291	28.539	Till	125.0	20.5	5634.8	17.0	3026	2214.6	3420.2	0.6	700.0	2188.9
44.455	29.122	Till	125.0	20.5	5655.3	17.0	3093	2224.9	3430.4	0.6	700.0	2195.5
44.619	28.632	Till	125.0	20.5	5675.8	17.0	3035	2235.1	3440.7	0.6	700.0	2202.0
44.783	28.500	Till	125.0	20.5	5696.3	17.0	3018	2245.3	3451.0	0.6	700.0	2208.6
44.947	28.014	Till	125.0	20.5	5716.8	17.0	2959	2255.6	3461.2	0.6	700.0	2215.2
45.111	28.018	Till	125.0	20.5	5737.3	17.0	2959	2265.8	3471.5	0.6	700.0	2221.8
45.275	28.184	Till	125.0	20.5	5757.8	17.0	2977	2276.0	3481.8	0.6	700.0	2228.3
45.439	28.156	Till	125.0	20.5	5778.3	17.0	2973	2286.3	3492.0	0.6	700.0	2234.9
45.603	28.713	Till	125.0	20.5	5798.8	17.0	3037	2296.5	3502.3	0.6	700.0	2241.5
45.767	27.942	Till	125.0	20.5	5819.3	17.0	2945	2306.7	3512.6	0.6	700.0	2248.0
45.931	28.033	Till	125.0	20.5	5839.8	17.0	2954	2317.0	3522.8	0.6	700.0	2254.6
46.095	28.677	Till	125.0	20.5	5860.3	17.0	3029	2327.2	3533.1	0.6	700.0	2261.2
46.259	27.884	Till	125.0	20.5	5880.8	17.0	2935	2337.4	3543.4	0.6	700.0	2267.7

46.423	27.392	Till	125.0	20.5	5901.3	17.0	2875	2347.7	3553.6	0.6	700.0	2274.3
46.587	27.727	Till	125.0	20.5	5921.8	17.0	2914	2357.9	3563.9	0.6	700.0	2280.9
46.751	27.323	Till	125.0	20.5	5942.3	17.0	2865	2368.1	3574.2	0.6	700.0	2287.5
46.915	27.328	Till	125.0	20.5	5962.8	17.0	2864	2378.4	3584.4	0.6	700.0	2294.0
47.079	26.295	Till	125.0	20.5	5983.3	17.0	2742	2388.6	3594.7	0.6	700.0	2300.6
47.244	25.732	Till	125.0	20.6	6003.9	17.0	2674	2398.9	3605.0	0.6	700.0	2307.2
47.408	24.899	Till	125.0	20.5	6024.4	17.0	2575	2409.1	3615.3	0.6	700.0	2313.8
47.572	24.337	Till	125.0	20.5	6044.9	17.0	2508	2419.4	3625.5	0.6	700.0	2320.4
47.736	26.008	Till	125.0	20.5	6065.4	17.0	2703	2429.6	3635.8	0.6	700.0	2326.9
47.900	27.260	Till	125.0	20.5	6085.9	17.0	2849	2439.8	3646.1	0.6	700.0	2333.5
48.064	27.946	Till	125.0	20.5	6106.4	17.0	2929	2450.1	3656.3	0.6	700.0	2340.1
48.228	28.745	Till	125.0	20.5	6126.9	17.0	3021	2460.3	3666.6	0.6	700.0	2346.6
48.392	28.440	Till	125.0	20.5	6147.4	17.0	2984	2470.5	3676.9	0.6	700.0	2353.2
48.556	26.593	Till	125.0	20.5	6167.9	17.0	2766	2480.8	3687.1	0.6	700.0	2359.8
48.720	26.287	Till	125.0	20.5	6188.4	17.0	2729	2491.0	3697.4	0.6	700.0	2366.3
48.884	26.018	Till	125.0	20.5	6208.9	17.0	2696	2501.2	3707.7	0.6	700.0	2372.9
49.048	26.927	Till	125.0	20.5	6229.4	17.0	2801	2511.5	3717.9	0.6	700.0	2379.5
49.212	29.228	Till	125.0	20.5	6249.9	17.0	3071	2521.7	3728.2	0.6	700.0	2386.1
49.376	27.767	Till	125.0	20.5	6270.4	17.0	2898	2531.9	3738.5	0.6	700.0	2392.6
49.540	26.062	Till	125.0	20.5	6290.9	17.0	2696	2542.2	3748.7	0.6	700.0	2399.2
49.704	25.237	Till	125.0	20.5	6311.4	17.0	2598	2552.4	3759.0	0.6	700.0	2405.8
49.868	26.113	Till	125.0	20.5	6331.9	17.0	2700	2562.6	3769.3	0.6	700.0	2412.3
50.032	26.018	Till	125.0	20.5	6352.4	17.0	2687	2572.9	3779.5	0.6	700.0	2418.9
50.196	27.378	Till	125.0	20.5	6372.9	17.0	2846	2583.1	3789.8	0.6	700.0	2425.5
50.360	27.700	Till	125.0	20.5	6393.4	17.0	2883	2593.3	3800.1	0.6	700.0	2432.0
50.524	27.581	Till	125.0	20.5	6413.9	17.0	2868	2603.6	3810.3	0.6	700.0	2438.6
50.688	27.328	Till	125.0	20.5	6434.4	17.0	2837	2613.8	3820.6	0.6	700.0	2445.2
50.852	27.030	Till	125.0	20.5	6454.9	17.0	2800	2624.0	3830.9	0.6	700.0	2451.8
51.016	27.223	Till	125.0	20.5	6475.4	17.0	2822	2634.3	3841.1	0.6	700.0	2458.3
51.180	28.921	Till	125.0	20.5	6495.9	17.0	3020	2644.5	3851.4	0.6	700.0	2464.9
51.345	30.959	Till	125.0	20.6	6516.5	17.0	3259	2654.8	3861.7	0.6	700.0	2471.5
51.509	35.230	Till	125.0	20.5	6537.0	17.0	3760	2665.0	3872.0	0.6	700.0	2478.1
51.673	35.659	Till	125.0	20.5	6557.5	17.0	3809	2675.3	3882.3	0.6	700.0	2484.7
51.837	34.878	Till	125.0	20.5	6578.0	17.0	3716	2685.5	3892.5	0.6	700.0	2491.2
52.001	34.910	Till	125.0	20.5	6598.5	17.0	3719	2695.7	3902.8	0.6	700.0	2497.8
52.165	36.187	Till	125.0	20.5	6619.0	17.0	3868	2706.0	3913.1	0.6	700.0	2504.4
52.329	35.324	Till	125.0	20.5	6639.5	17.0	3765	2716.2	3923.3	0.6	700.0	2510.9
52.493	29.675	Till	125.0	20.5	6660.0	17.0	3099	2726.4	3933.6	0.6	700.0	2517.5
52.657	30.237	Till	125.0	20.5	6680.5	17.0	3164	2736.7	3943.9	0.6	700.0	2524.1
52.821	29.260	Till	125.0	20.5	6701.0	17.0	3048	2746.9	3954.1	0.6	700.0	2530.6
52.985	33.853	Till	125.0	20.5	6721.5	17.0	3587	2757.1	3964.4	0.6	700.0	2537.2
53.149	41.658	Till	125.0	20.5	6742.0	17.0	4504	2767.4	3974.7	0.6	700.0	2543.8
53.313	42.086	Till	125.0	20.5	6762.5	17.0	4553	2777.6	3984.9	0.6	700.0	2550.4
53.477	231.490	Till	125.0	20.5	6783.0	17.0	26835	2787.8	3995.2	0.6	700.0	2556.9
53.641	359.244	Till	125.0	20.5	6803.5	17.0	41864	2798.1	4005.5	0.6	700.0	2563.5

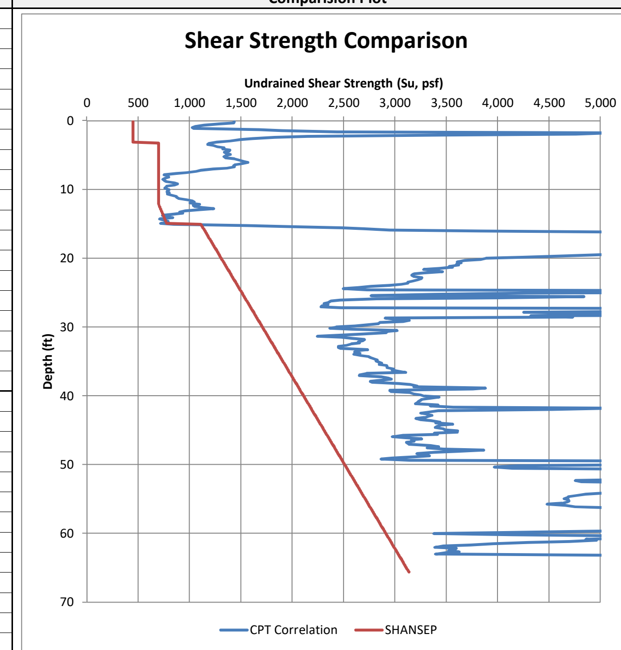
Material	Nkt	Peak Su/p'	Min Su (spf)
Fill	17.0	0.60	450.0
Fdxn Clay	17.0	0.45	700.0
Soft Clay	17.0	0.28	275.0
Till	17.0	0.64	700.0

CPT COF-C054

GWT Depth: 12.2 ft

ConeTec Data			CPT Shear Strength Correlation					SHANSEP Shear Strength Model				
Depth	qt	Material	Unit Weight (pcf)	Layer Weight	Total Vertical Stress	Nkt	CPT Su	Pore Pressure	Effective Vertical Stress	Su/p'	Min Su	SHANSEP Su
ft	tsf	Type	(pcf)	(psf)	(psf)		(psf)	(psf)	(psf)		(psf)	(psf)
0.164	12.202	Fill	135.0	22.1	22.1	17.0	1434	0.0	22.1	0.6	450.0	450.0
0.328	12.170	Fill	135.0	22.1	44.3	17.0	1429	0.0	44.3	0.6	450.0	450.0
0.492	10.999	Fill	135.0	22.1	66.4	17.0	1290	0.0	66.4	0.6	450.0	450.0
0.656	9.720	Fill	135.0	22.1	88.6	17.0	1138	0.0	88.6	0.6	450.0	450.0
0.820	9.089	Fill	135.0	22.1	110.7	17.0	1063	0.0	110.7	0.6	450.0	450.0
0.984	8.809	Fill	135.0	22.1	132.9	17.0	1029	0.0	132.9	0.6	450.0	450.0
1.148	8.944	Fill	135.0	22.1	155.0	17.0	1043	0.0	155.0	0.6	450.0	450.0
1.312	14.369	Fill	135.0	22.1	177.2	17.0	1680	0.0	177.2	0.6	450.0	450.0
1.476	16.210	Fill	135.0	22.1	199.3	17.0	1895	0.0	199.3	0.6	450.0	450.0
1.640	20.811	Fill	135.0	22.1	221.5	17.0	2435	0.0	221.5	0.6	450.0	450.0
1.804	43.463	Fill	135.0	22.1	243.6	17.0	5099	0.0	243.6	0.6	450.0	450.0
1.968	40.606	Fill	135.0	22.1	265.7	17.0	4762	0.0	265.7	0.6	450.0	450.0
2.133	29.596	Fill	135.0	22.1	287.9	17.0	3465	0.0	287.9	0.6	450.0	450.0
2.297	18.433	Fill	135.0	22.1	310.0	17.0	2150	0.0	310.0	0.6	450.0	450.0
2.461	15.715	Fill	135.0	22.1	332.2	17.0	1829	0.0	332.2	0.6	450.0	450.0
2.625	13.901	Fill	135.0	22.1	354.3	17.0	1615	0.0	354.3	0.6	450.0	450.0
2.789	12.890	Fill	135.0	22.1	376.5	17.0	1494	0.0	376.5	0.6	450.0	450.0
2.953	12.044	Fill	135.0	22.1	398.6	17.0	1394	0.0	398.6	0.6	450.0	450.0
3.117	10.951	Fill	135.0	22.1	420.8	17.0	1264	0.0	420.8	0.6	450.0	450.0
3.281	10.384	Fdxn Clay	125.0	20.5	441.3	17.0	1196	0.0	441.3	0.5	700.0	700.0
3.445	10.236	Fdxn Clay	125.0	20.5	461.8	17.0	1177	0.0	461.8	0.5	700.0	700.0
3.609	10.730	Fdxn Clay	125.0	20.5	482.3	17.0	1234	0.0	482.3	0.5	700.0	700.0
3.773	11.059	Fdxn Clay	125.0	20.5	502.8	17.0	1272	0.0	502.8	0.5	700.0	700.0
3.937	11.627	Fdxn Clay	125.0	20.5	523.3	17.0	1337	0.0	523.3	0.5	700.0	700.0
4.101	11.531	Fdxn Clay	125.0	20.5	543.8	17.0	1325	0.0	543.8	0.5	700.0	700.0
4.265	12.126	Fdxn Clay	125.0	20.5	564.3	17.0	1393	0.0	564.3	0.5	700.0	700.0
4.429	12.054	Fdxn Clay	125.0	20.5	584.8	17.0	1384	0.0	584.8	0.5	700.0	700.0
4.593	11.674	Fdxn Clay	125.0	20.5	605.3	17.0	1338	0.0	605.3	0.5	700.0	700.0
4.757	11.890	Fdxn Clay	125.0	20.5	625.8	17.0	1362	0.0	625.8	0.5	700.0	700.0
4.921	12.207	Fdxn Clay	125.0	20.5	646.3	17.0	1398	0.0	646.3	0.5	700.0	700.0
5.085	11.851	Fdxn Clay	125.0	20.5	666.8	17.0	1355	0.0	666.8	0.5	700.0	700.0
5.249	11.689	Fdxn Clay	125.0	20.5	687.3	17.0	1335	0.0	687.3	0.5	700.0	700.0
5.413	11.829	Fdxn Clay	125.0	20.5	707.8	17.0	1350	0.0	707.8	0.5	700.0	700.0
5.577	12.595	Fdxn Clay	125.0	20.5	728.3	17.0	1439	0.0	728.3	0.5	700.0	700.0
5.741	13.009	Fdxn Clay	125.0	20.5	748.8	17.0	1486	0.0	748.8	0.5	700.0	700.0
5.905	13.378	Fdxn Clay	125.0	20.5	769.3	17.0	1529	0.0	769.3	0.5	700.0	700.0
6.069	13.746	Fdxn Clay	125.0	20.5	789.9	17.0	1571	0.0	789.9	0.5	700.0	700.0
6.234	13.253	Fdxn Clay	125.0	20.5	810.4	17.0	1511	0.0	810.4	0.5	700.0	700.0
6.398	12.715	Fdxn Clay	125.0	20.5	830.9	17.0	1447	0.0	830.9	0.5	700.0	700.0
6.562	12.581	Fdxn Clay	125.0	20.5	851.4	17.0	1430	0.0	851.4	0.5	700.0	700.0
6.726	12.649	Fdxn Clay	125.0	20.5	871.9	17.0	1437	0.0	871.9	0.5	700.0	700.0
6.890	12.046	Fdxn Clay	125.0	20.5	892.4	17.0	1365	0.0	892.4	0.5	700.0	700.0
7.054	10.910	Fdxn Clay	125.0	20.5	912.9	17.0	1230	0.0	912.9	0.5	700.0	700.0
7.218	9.916	Fdxn Clay	125.0	20.5	933.4	17.0	1112	0.0	933.4	0.5	700.0	700.0
7.382	9.523	Fdxn Clay	125.0	20.5	953.9	17.0	1064	0.0	953.9	0.5	700.0	700.0
7.546	8.712	Fdxn Clay	125.0	20.5	974.4	17.0	968	0.0	974.4	0.5	700.0	700.0
7.710	7.893	Fdxn Clay	125.0	20.5	994.9	17.0	870	0.0	994.9	0.5	700.0	700.0
7.874	6.913	Fdxn Clay	125.0	20.5	1015.4	17.0	754	0.0	1015.4	0.5	700.0	700.0
8.038	7.246	Fdxn Clay	125.0	20.5	1035.9	17.0	792	0.0	1035.9	0.5	700.0	700.0
8.202	7.307	Fdxn Clay	125.0	20.5	1056.4	17.0	798	0.0	1056.4	0.5	700.0	700.0
8.366	7.059	Fdxn Clay	125.0	20.5	1076.9	17.0	767	0.0	1076.9	0.5	700.0	700.0
8.530	6.840	Fdxn Clay	125.0	20.5	1097.4	17.0	740	0.0	1097.4	0.5	700.0	700.0
8.694	6.997	Fdxn Clay	125.0	20.5	1117.9	17.0	757	0.0	1117.9	0.5	700.0	700.0
8.858	7.167	Fdxn Clay	125.0	20.5	1138.4	17.0	776	0.0	1138.4	0.5	700.0	700.0
9.022	7.868	Fdxn Clay	125.0	20.5	1158.9	17.0	857	0.0	1158.9	0.5	700.0	700.0
9.186	8.100	Fdxn Clay	125.0	20.5	1179.4	17.0	884	0.0	1179.4	0.5	700.0	700.0
9.350	7.830	Fdxn Clay	125.0	20.5	1200.0	17.0	851	0.0	1200.0	0.5	700.0	700.0
9.514	7.212	Fdxn Clay	125.0	20.5	1220.5	17.0	777	0.0	1220.5	0.5	700.0	700.0
9.678	7.192	Fdxn Clay	125.0	20.5	1241.0	17.0	773	0.0	1241.0	0.5	700.0	700.0
9.842	7.074	Fdxn Clay	125.0	20.5	1261.5	17.0	758	0.0	1261.5	0.5	700.0	700.0
10.006	7.435	Fdxn Clay	125.0	20.5	1282.0	17.0	799	0.0	1282.0	0.5	700.0	700.0
10.170	7.357	Fdxn Clay	125.0	20.5	1302.5	17.0	789	0.0	1302.5	0.5	700.0	700.0
10.335	7.312	Fdxn Clay	125.0	20.5	1323.0	17.0	782	0.0	1323.0	0.5	700.0	700.0
10.499	7.494	Fdxn Clay	125.0	20.5	1343.5	17.0	803	0.0	1343.5	0.5	700.0	700.0
10.663	7.346	Fdxn Clay	125.0	20.5	1364.0	17.0	784	0.0	1364.0	0.5	700.0	700.0
10.827	7.651	Fdxn Clay	125.0	20.5	1384.5	17.0	819	0.0	1384.5	0.5	700.0	700.0
10.991	8.081	Fdxn Clay	125.0	20.5	1405.0	17.0	868	0.0	1405.0	0.5	700.0	700.0
11.155	8.143	Fdxn Clay	125.0	20.5	1425.5	17.0	874	0.0	1425.5	0.5	700.0	700.0
11.319	8.356	Fdxn Clay	125.0	20.5	1446.0	17.0	898	0.0	1446.0	0.5	700.0	700.0
11.483	9.048	Fdxn Clay	125.0	20.5	1466.5	17.0	978	0.0	1466.5	0.5	700.0	700.0
11.647	9.441	Fdxn Clay	125.0	20.5	1487.0	17.0	1023	0.0	1487.0	0.5	700.0	700.0
11.811	9.646	Fdxn Clay	125.0	20.5	1507.5	17.0	1046	0.0	1507.5	0.5	700.0	700.0
11.975	9.312	Fdxn Clay	125.0	20.5	1528.0	17.0	1006	0.0	1528.0	0.5	700.0	700.0
12.139	10.109	Fdxn Clay	125.0	20.5	1548.5	17.0	1098	0.0	1548.5	0.5	700.0	700.0
12.303	9.583	Fdxn Clay	125.0	20.5	1569.0	17.0	1035	6.4	1562.6	0.5	700.0	703.2
12.467	9.778	Fdxn Clay	125.0	20.5	1589.5	17.0	1057	16.7	1572.9	0.5	700.0	707.8
12.631	10.424	Fdxn Clay	125.0	20.5	1610.1	17.0	1132	26.9	1583.2	0.5	700.0	712.4
12.795	11.310	Fdxn Clay	125.0	20.5	1630.6	17.0	1235	37.1	1593.4	0.5	700.0	717.0
12.959	10.234	Fdxn Clay	125.0	20.5	1651.1	17.0	1107	47.4	1603.7	0.5	700.0	721.7
13.123	8.954	Fdxn Clay	125.0	20.5	1671.6	17.0	955	57.6	1614.0	0.5	700.0	726.3
13.287	8.537	Fdxn Clay	125.0	20.5	1692.1	17.0	905	67.8	1624.2	0.5	700.0	730.9
13.451	8.782	Fdxn Clay	125.0	20.5	1712.6	17.0	932	78.1	1634.5	0.5	700.0	735.5
13.615	8.128	Fdxn Clay	125.0	20.5	1733.1	17.0	854	88.3	1644.8	0.5	700.0	740.1
13.779	7.141	Fdxn Clay	125.0	20.5	1753.6	17.0	737	98.6	1655.0	0.5	700.0	744.8
13.943	7.484	Fdxn Clay	125.0	20.5	1774.1	17.0	776	108.8	1665.3	0.5	700.0	749.4
14.107	8.027	Fdxn Clay	125.0	20.5	1794.6	17.0	839	119.0	1675.6	0.5	700.0	754.0
14.271	6.936	Fdxn Clay	125.0	20.5	1815.1	17.0	709	129.3	1685.8	0.5	700.0	758.6
14.436	7.218	Fdxn Clay	125.0	20.5	1835.6	17.0	741	139.5	1696.1	0.5	700.0	763.3
14.600	7.635	Fdxn Clay	125.0	20.5	1856.1	17.0	789	149.7	1706.4	0.5	700.0	767.9
14.764	7.687	Fdxn Clay	125.0	20.5	1876.6	17.0	794	160.0	1716.6	0.5	700.0	772.5
14.928	7.064	Fdxn Clay	125.0	20.5	1897.1	17.0	719	170.2	1726.9	0.5	700.0	777.1
15.092	8.123	Till	125.0	20.5	1917.6	17.0	843	180.4	1737.2	0.6	700.0	1111.8
15.256	14.276	Till	125.0	20.5	1938.1	17.0	1566	190.7	1747.5	0.6	700.0	1118.4
15.420	17.473	Till	125.0	20.5	1958.6	17.0	1940	200.9	1757.7	0.6	700.0	1124.9
15.584	22.123	Till	125.0	20.5	1979.1	17.0	2486	211.1	1768.0	0.6	700.0	1131.5
15.748	23.981	Till	125.0	20.5	1999.6	17.0	2704	221.4	1778.3	0.6	700.0	1138.1
15.912	26.061	Till	125.0	20.5	2020.2	17.0	2947	231.6	1788.5	0.6	700.0	1144.7
16.076	33.665	Till	125.0	20.5	2040.7	17.0	3841	241.9	1798.8	0.6	700.0	1151.2
16.240	47.568	Till	125.0	20.5	2061.2	17.0	5475	252.1	1809.1	0.6	700.0	1157.8
16.404	66.483	Till	125.0	20.5	2081.7	17.0	7699	262.3	1819.3	0.6	700.0	1164.4
16.568	95.069	Till	125.0	20.5	2102.2	17.0	11061	272.6	1829.6	0.6	700.0	1170.9
16.732	108.785	Till	125.0	20.5	2122.7	17.0	12673	282.8	1839.9	0.6	700.0	1177.5
16.896	116.969	Till	125.0	20.5	2143.2	17.0	13635	293.0	1850.1	0.6	700.0	1184.1
17.060	127.105	Till	125.0	20.5	2163.7	17.0	14826	303.3	1860.4	0.6	700.0	1190.7
17.224	153.187	Till	125.0	20.5	2184.2	17.0	17894	313.5	1870.7	0.6	700.0	1197.2
17.388	180.349	Till	125.0	20.5	2204.7	17.0	21088	323.7	1881.0	0.6	700.0	1203.8
17.552	202.893	Till	125.0	20.5	2225.2	17.0	23739	334.0	1891.2	0.6	700.0	1210.4
17.716	240.421	Till	125.0	20.5	2245.7	17.0	28153	344.2	1901.5	0.6	700.0	1217.0
17.880	268.272	Till	125.0	20.5	2266.2	17.0	31428	354.5	1911.8	0.6	700.0	1223.5
18.044	283.749	Till	125.0	20.5	2286.7	17.0	33248	364.7	1922.0	0.6	700.0	1230.1
18.208	274.044	Till	125.0	20.5	2307.2	17.0	32105	374.9	1932.3	0.6	700.0	1236.7
18.372	209.178	Till	125.0	20.5	2327.7	17.0	24472	385.2	1942.6	0.6	700.0	1243.2
18.537	149.354	Till	125.0	20.5	2348.2	17.0	17433	395.4	1952.8	0.6	700.0	1249.8
18.701	84.181	Till	125.0	20.5	2368.7	17.0	9764	405.6	1963.1	0.6	700.0	1256.4
18.865	66.980	Till	125.0	20.5	2389.2	17.0	7739	415.9	1973.4	0.6	700.0	1263.0
19.029	56.656	Till	125.0	20.5	2409.7	17.0	6524	426.1	1983.6	0.6	700.0	1269.5
19.193	51.661	Till	125.0	20.5	2430.3	17.0	5935	436.3	1993.9	0.6	700.0	1276.1
19.357	46.806	Till	125.0	20.5	2450.8	17.0	5362	446.6	2004.2	0.6	700.0	1282.7
19.521	43.820	Till	125.0	20.5	2471.3	17.0	5010	456.8	2014.4	0.6	700.0	1289.2
19.685	40.641	Till	125.0	20.5	2491.8	17.0	4635	467.1	2024.7	0.6	700.0	1295.8
19.849	37.309	Till	125.0	20.5	2512.3	17.0	4242	477.3	2035.0	0.6	700.0	1302.4
20.013	34.292	Till	125.0	20.5	2532.8	17.0	3885	487.5	2045.3	0.6	700.0	1309.0
20.177	33.839	Till	125.0	20.5	2553.3	17.0	3831	497.8	2055.5	0.6	700.0	1315.5
20.341	32.558	Till	125.0	20.5	2573.8	17.0	3679	508.0	2065.8	0.6	700.0	1322.1
20.505	31.950	Till	125.0	20.5	2594.3	17.0	3606	518.2	2076.1	0.6	700.0	1328.7
20.669	32.272	Till	125.0	20.5	2614.8	17.0	3643	528.5	2086.3	0.6	700.0	1335.3
20.833	31.913	Till	125.0	20.5	2635.3	17.0	3599	538.7	2096.6	0.6	700.0	1341.8
20.997	32.083	Till	125.0	20.5	2655.8	17.0	3618	548.9	2106.9	0.6	700.0	1348.4
21.161	31.338	Till	125.0	20.5	2676.3	17.0	3529	559.2	2117.1	0.6	700.0	1355.0
21.325	31.619	Till	125.0	20.5	2696.8	17.0	3561	569.4	2127.4	0.6	700.0	1361.5
21.489	30.516	Till	125.0	20.5	2717.3	17.0	3430	579.6	2137.7	0.6	700.0	1368.1
21.653	29.239	Till	125.0	20.5	2737.8	17.0	3279	589.9	2147.9	0.6	700.0	1374.7
21.817	30.306	Till	125.0	20.5	2758.3	17.0	3403	600.1	2158.2	0.6	700.0	1381.3
21.981	30.838	Till	125.0	20.5	2778.8	17.0	3465	610.4	2168.5	0.6	700.0	1387.8
22.145	29.282	Till	125.0	20.5	2799.3	17.0	3280	620.6	2178.7	0.6	700.0	1394.4

Comparision Plot



22.309	28.481	Till	125.0	20.5	2819.8	17.0	3185	630.8	2189.0	0.6	700.0	1401.0
22.473	28.315	Till	125.0	20.5	2840.4	17.0	3164	641.1	2199.3	0.6	700.0	1407.5
22.638	28.515	Till	125.0	20.5	2860.9	17.0	3186	651.3	2209.6	0.6	700.0	1414.1
22.802	29.154	Till	125.0	20.5	2881.4	17.0	3260	661.5	2219.8	0.6	700.0	1420.7
22.966	29.099	Till	125.0	20.5	2901.9	17.0	3253	671.8	2230.1	0.6	700.0	1427.3
23.130	28.850	Till	125.0	20.5	2922.4	17.0	3222	682.0	2240.4	0.6	700.0	1433.8
23.294	28.445	Till	125.0	20.5	2942.9	17.0	3173	692.2	2250.6	0.6	700.0	1440.4
23.458	28.089	Till	125.0	20.5	2963.4	17.0	3130	702.5	2260.9	0.6	700.0	1447.0
23.622	28.008	Till	125.0	20.5	2983.9	17.0	3120	712.7	2271.2	0.6	700.0	1453.5
23.786	27.563	Till	125.0	20.5	3004.4	17.0	3066	723.0	2281.4	0.6	700.0	1460.1
23.950	26.566	Till	125.0	20.5	3024.9	17.0	2948	733.2	2291.7	0.6	700.0	1466.7
24.114	25.032	Till	125.0	20.5	3045.4	17.0	2766	743.4	2302.0	0.6	700.0	1473.3
24.278	23.957	Till	125.0	20.5	3065.9	17.0	2638	753.7	2312.2	0.6	700.0	1479.8
24.442	22.787	Till	125.0	20.5	3086.4	17.0	2499	763.9	2322.5	0.6	700.0	1486.4
24.606	24.753	Till	125.0	20.5	3106.9	17.0	2729	774.1	2332.8	0.6	700.0	1493.0
24.770	57.963	Till	125.0	20.5	3127.4	17.0	6635	784.4	2343.1	0.6	700.0	1499.6
24.934	60.476	Till	125.0	20.5	3147.9	17.0	6930	794.6	2353.3	0.6	700.0	1506.1
25.098	38.022	Till	125.0	20.5	3168.4	17.0	4287	804.8	2363.6	0.6	700.0	1512.7
25.262	30.347	Till	125.0	20.5	3188.9	17.0	3383	815.1	2373.9	0.6	700.0	1519.3
25.426	25.147	Till	125.0	20.5	3209.4	17.0	2770	825.3	2384.1	0.6	700.0	1525.8
25.590	42.751	Till	125.0	20.5	3229.9	17.0	4840	835.6	2394.4	0.6	700.0	1532.4
25.754	35.708	Till	125.0	20.5	3250.5	17.0	4010	845.8	2404.7	0.6	700.0	1539.0
25.918	25.641	Till	125.0	20.5	3271.0	17.0	2824	856.0	2414.9	0.6	700.0	1545.6
26.082	22.609	Till	125.0	20.5	3291.5	17.0	2466	866.3	2425.2	0.6	700.0	1552.1
26.246	21.834	Till	125.0	20.5	3312.0	17.0	2374	876.5	2435.5	0.6	700.0	1558.7
26.410	21.643	Till	125.0	20.5	3332.5	17.0	2350	886.7	2445.7	0.6	700.0	1565.3
26.574	21.328	Till	125.0	20.5	3353.0	17.0	2312	897.0	2456.0	0.6	700.0	1571.8
26.739	21.645	Till	125.0	20.5	3373.5	17.0	2348	907.2	2466.3	0.6	700.0	1578.4
26.903	21.218	Till	125.0	20.5	3394.0	17.0	2297	917.4	2476.5	0.6	700.0	1585.0
27.067	21.085	Till	125.0	20.5	3414.5	17.0	2280	927.7	2486.8	0.6	700.0	1591.6
27.231	22.760	Till	125.0	20.5	3435.0	17.0	2476	937.9	2497.1	0.6	700.0	1598.1
27.395	72.130	Till	125.0	20.5	3455.5	17.0	8283	948.1	2507.4	0.6	700.0	1604.7
27.559	51.774	Till	125.0	20.5	3476.0	17.0	5887	958.4	2517.6	0.6	700.0	1611.3
27.723	49.112	Till	125.0	20.5	3496.5	17.0	5572	968.6	2527.9	0.6	700.0	1617.9
27.887	37.929	Till	125.0	20.5	3517.0	17.0	4255	978.9	2538.2	0.6	700.0	1624.4
28.051	42.422	Till	125.0	20.5	3537.5	17.0	4783	989.1	2548.4	0.6	700.0	1631.0
28.215	63.667	Till	125.0	20.5	3558.0	17.0	7281	999.3	2558.7	0.6	700.0	1637.6
28.379	38.544	Till	125.0	20.5	3578.5	17.0	4324	1009.6	2569.0	0.6	700.0	1644.1
28.543	42.020	Till	125.0	20.5	3599.0	17.0	4732	1019.8	2579.2	0.6	700.0	1650.7
28.707	26.523	Till	125.0	20.5	3619.5	17.0	2907	1030.0	2589.5	0.6	700.0	1657.3
28.871	27.286	Till	125.0	20.5	3640.0	17.0	2996	1040.3	2599.8	0.6	700.0	1663.9
29.035	28.507	Till	125.0	20.5	3660.6	17.0	3138	1050.5	2610.0	0.6	700.0	1670.4
29.199	28.000	Till	125.0	20.5	3681.1	17.0	3078	1060.7	2620.3	0.6	700.0	1677.0
29.363	26.083	Till	125.0	20.5	3701.6	17.0	2851	1071.0	2630.6	0.6	700.0	1683.6
29.527	25.974	Till	125.0	20.5	3722.1	17.0	2837	1081.2	2640.9	0.6	700.0	1690.1
29.691	25.158	Till	125.0	20.5	3742.6	17.0	2740	1091.5	2651.1	0.6	700.0	1696.7
29.855	24.056	Till	125.0	20.5	3763.1	17.0	2609	1101.7	2661.4	0.6	700.0	1703.3
30.019	22.511	Till	125.0	20.5	3783.6	17.0	2426	1111.9	2671.7	0.6	700.0	1709.9
30.183	22.016	Till	125.0	20.5	3804.1	17.0	2366	1122.2	2681.9	0.6	700.0	1716.4
30.347	23.794	Till	125.0	20.5	3824.6	17.0	2574	1132.4	2692.2	0.6	700.0	1723.0
30.511	27.614	Till	125.0	20.5	3845.1	17.0	3022	1142.6	2702.5	0.6	700.0	1729.6
30.675	26.783	Till	125.0	20.5	3865.6	17.0	2924	1152.9	2712.7	0.6	700.0	1736.1
30.840	26.690	Till	125.0	20.5	3886.1	17.0	2911	1163.1	2723.0	0.6	700.0	1742.7
31.004	24.836	Till	125.0	20.5	3906.6	17.0	2692	1173.3	2733.3	0.6	700.0	1749.3
31.168	23.308	Till	125.0	20.5	3927.1	17.0	2511	1183.6	2743.5	0.6	700.0	1755.9
31.332	21.066	Till	125.0	20.5	3947.6	17.0	2246	1193.8	2753.8	0.6	700.0	1762.4
31.496	23.038	Till	125.0	20.5	3968.1	17.0	2477	1204.1	2764.1	0.6	700.0	1769.0
31.660	24.058	Till	125.0	20.5	3988.6	17.0	2596	1214.3	2774.3	0.6	700.0	1775.6
31.824	24.996	Till	125.0	20.5	4009.1	17.0	2705	1224.5	2784.6	0.6	700.0	1782.2
31.988	24.835	Till	125.0	20.5	4029.6	17.0	2685	1234.8	2794.9	0.6	700.0	1788.7
32.152	24.496	Till	125.0	20.5	4050.1	17.0	2644	1245.0	2805.2	0.6	700.0	1795.3
32.316	24.581	Till	125.0	20.5	4070.7	17.0	2652	1255.2	2815.4	0.6	700.0	1801.9
32.480	23.916	Till	125.0	20.5	4091.2	17.0	2573	1265.5	2825.7	0.6	700.0	1808.4
32.644	23.564	Till	125.0	20.5	4111.7	17.0	2530	1275.7	2836.0	0.6	700.0	1815.0
32.808	22.900	Till	125.0	20.5	4132.2	17.0	2451	1285.9	2846.2	0.6	700.0	1821.6
32.972	22.907	Till	125.0	20.5	4152.7	17.0	2451	1296.2	2856.5	0.6	700.0	1828.2
33.136	23.112	Till	125.0	20.5	4173.2	17.0	2474	1306.4	2866.8	0.6	700.0	1834.7
33.300	25.341	Till	125.0	20.5	4193.7	17.0	2735	1316.6	2877.0	0.6	700.0	1841.3
33.464	24.456	Till	125.0	20.5	4214.2	17.0	2629	1326.9	2887.3	0.6	700.0	1847.9
33.628	24.279	Till	125.0	20.5	4234.7	17.0	2607	1337.1	2897.6	0.6	700.0	1854.4
33.792	24.747	Till	125.0	20.5	4255.2	17.0	2661	1347.4	2907.8	0.6	700.0	1861.0
33.956	24.255	Till	125.0	20.5	4275.7	17.0	2602	1357.6	2918.1	0.6	700.0	1867.6
34.120	24.847	Till	125.0	20.5	4296.2	17.0	2670	1367.8	2928.4	0.6	700.0	1874.2
34.284	25.461	Till	125.0	20.5	4316.7	17.0	2741	1378.1	2938.6	0.6	700.0	1880.7
34.448	25.689	Till	125.0	20.5	4337.2	17.0	2767	1388.3	2948.9	0.6	700.0	1887.3
34.612	25.922	Till	125.0	20.5	4357.7	17.0	2793	1398.5	2959.2	0.6	700.0	1893.9
34.776	26.232	Till	125.0	20.5	4378.2	17.0	2829	1408.8	2969.5	0.6	700.0	1900.5
34.941	26.122	Till	125.0	20.5	4398.7	17.0	2814	1419.0	2979.7	0.6	700.0	1907.0
35.105	26.406	Till	125.0	20.5	4419.2	17.0	2847	1429.2	2990.0	0.6	700.0	1913.6
35.269	26.622	Till	125.0	20.5	4439.7	17.0	2871	1439.5	3000.3	0.6	700.0	1920.2
35.433	26.429	Till	125.0	20.5	4460.2	17.0	2847	1449.7	3010.5	0.6	700.0	1926.7
35.597	27.049	Till	125.0	20.5	4480.8	17.0	2919	1460.0	3020.8	0.6	700.0	1933.3
35.761	27.115	Till	125.0	20.5	4501.3	17.0	2925	1470.2	3031.1	0.6	700.0	1939.9
35.925	27.126	Till	125.0	20.5	4521.8	17.0	2925	1480.4	3041.3	0.6	700.0	1946.5
36.089	27.656	Till	125.0	20.5	4542.3	17.0	2986	1490.7	3051.6	0.6	700.0	1953.0
36.253	27.528	Till	125.0	20.5	4562.8	17.0	2970	1500.9	3061.9	0.6	700.0	1959.6
36.417	28.115	Till	125.0	20.5	4583.3	17.0	3038	1511.1	3072.1	0.6	700.0	1966.2
36.581	28.688	Till	125.0	20.5	4603.8	17.0	3104	1521.4	3082.4	0.6	700.0	1972.7
36.745	25.451	Till	125.0	20.5	4624.3	17.0	2722	1531.6	3092.7	0.6	700.0	1979.3
36.909	24.922	Till	125.0	20.5	4644.8	17.0	2659	1541.8	3103.0	0.6	700.0	1985.9
37.073	24.879	Till	125.0	20.5	4665.3	17.0	2653	1552.1	3113.2	0.6	700.0	1992.5
37.237	26.721	Till	125.0	20.5	4685.8	17.0	2868	1562.3	3123.5	0.6	700.0	1999.0
37.401	27.271	Till	125.0	20.5	4706.3	17.0	2932	1572.5	3133.8	0.6	700.0	2005.6
37.565	27.566	Till	125.0	20.5	4726.8	17.0	2965	1582.8	3144.0	0.6	700.0	2012.2
37.729	26.888	Till	125.0	20.5	4747.3	17.0	2884	1593.0	3154.3	0.6	700.0	2018.7
37.893	25.848	Till	125.0	20.5	4767.8	17.0	2761	1603.3	3164.6	0.6	700.0	2025.3
38.057	26.041	Till	125.0	20.5	4788.3	17.0	2782	1613.5	3174.8	0.6	700.0	2031.9
38.221	28.227	Till	125.0	20.5	4808.8	17.0	3038	1623.7	3185.1	0.6	700.0	2038.5
38.385	29.192	Till	125.0	20.5	4829.3	17.0	3150	1634.0	3195.4	0.6	700.0	2045.0
38.549	29.752	Till	125.0	20.5	4849.8	17.0	3215	1644.2	3205.6	0.6	700.0	2051.6
38.713	29.486	Till	125.0	20.5	4870.3	17.0	3182	1654.4	3215.9	0.6	700.0	2058.2
38.877	35.437	Till	125.0	20.5	4890.9	17.0	3881	1664.7	3226.2	0.6	700.0	2064.8
39.042	34.408	Till	125.0	20.5	4911.4	17.0	3759	1674.9	3236.4	0.6	700.0	2071.3
39.206	27.528	Till	125.0	20.5	4931.9	17.0	2948	1685.1	3246.7	0.6	700.0	2077.9
39.370	27.715	Till	125.0	20.5	4952.4	17.0	2969	1695.4	3257.0	0.6	700.0	2084.5
39.534	29.227	Till	125.0	20.5	4972.9	17.0	3146	1705.6	3267.3	0.6	700.0	2091.0
39.698	29.553	Till	125.0	20.5	4993.4	17.0	3183	1715.9	3277.5	0.6	700.0	2097.6
39.862	30.121	Till	125.0	20.5	5013.9	17.0	3249	1726.1	3287.8	0.6	700.0	2104.2
40.026	30.453	Till	125.0	20.5	5034.4	17.0	3287	1736.3	3298.1	0.6	700.0	2110.8
40.190	31.665	Till	125.0	20.5	5054.9	17.0	3428	1746.6	3308.3	0.6	700.0	2117.3
40.354	30.907	Till	125.0	20.5	5075.4	17.0	3338	1756.8	3318.6	0.6	700.0	2123.9
40.518	30.291	Till	125.0	20.5	5095.9	17.0	3264	1767.0	3328.9	0.6	700.0	2130.5
40.682	30.147	Till	125.0	20.5	5116.4	17.0	3246	1777.3	3339.1	0.6	700.0	2137.0
40.846	30.003	Till	125.0	20.5	5136.9	17.0	3228	1787.5	3349.4	0.6	700.0	2143.6
41.010	29.903	Till	125.0	20.5	5157.4	17.0	3215	1797.7	3359.7	0.6	700.0	2150.2
41.174	29.773	Till	125.0	20.5	5177.9	17.0	3198	1808.0	3369.9	0.6	700.0	2156.8
41.338	31.657	Till	125.0	20.5	5198.4	17.0	3419	1818.2	3380.2	0.6	700.0	2163.3
41.502	31.046	Till	125.0	20.5	5218.9	17.0	3345	1828.5	3390.5	0.6	700.0	2169.9
41.666	32.926	Till	125.0	20.5	5239.4	17.0	3565	1838.7	3400.7	0.6	700.0	2176.5
41.830	46.185	Till	125.0	20.5	5259.9	17.0	5124	1848.9	3411.0	0.6	700.0	2183.1
41.994	41.151	Till	125.0	20.5	5280.4	17.0	4531	1859.2	3421.3	0.6	700.0	2189.6
42.158	31.729	Till	125.0	20.5	5301.0	17.0	3421	1869.4	3431.6	0.6	700.0	2196.2
42.322	31.071	Till	125.0	20.5	5321.5	17.0	3342	1879.6	3441.8	0.6	700.0	2202.8
42.486	30.319	Till	125.0	20.5	5342.0	17.0	3253	1889.9	3452.1	0.6	700.0	2209.3
42.650	30.798	Till	125.0	20.5	5362.5	17.0	3308	1900.1	3462.4	0.6	700.0	2215.9
42.814	31.266	Till	125.0	20.5	5383.0	17.0	3362	1910.3	3472.6	0.6	700.0	2222.5
42.978	30.978	Till	125.0	20.5	5403.5	17.0	3327	1920.6	3482.9	0.6	700.0	2229.1
43.143	30.687	Till	125.0	20.5	5424.0	17.0	3291	1930.8	3493.2	0.6	700.0	2235.6
43.307	29.974	Till	125.0	20.5	5444.5	17.0	3206	1941.0	3503.4	0.6	700.0	2242.2
43.471	30.361	Till	125.0	20.5	5465.0	17.0	3250	1951.3	3513.7	0.6	700.0	2248.8
43.635	31.236	Till	125.0	20.5	5485.5	17.0	3352	1961.5	3524.0	0.6	700.0	2255.3
43.799	31.974	Till	125.0	20.5	5506.0	17.0	3438	1971.8	3534.2	0.6	700.0	2261.9
43.963	31.654	Till	125.0	20.5	5526.5	17.0	3399	1982.0	3544.5	0.6	700.0	2268.5
44.127	33.072	Till	125.0	20.5	5547.0	17.0	3564	1992.2	3554.8	0.6	700.0	2275.1
44.291	32.049	Till	125.0	20.5	5567.5	17.0	3443	2002.5	3565.1	0.6	700.0	2281.6
44.455	31.761	Till	125.0	20.5	5588.0	17.0	3408	2012.7	3575.3	0.6	700.0	2288.2
44.619	31.648	Till	125.0	20.5	5608.5	17.0	3393	2022.9	3585.6	0.6	700.0	2294.8
44.783	32.312	Till	125.0	20.5	5629.0	17.0	3470	2033.2	3595.9	0.6	700.0	2301.3
44.947	32.514	Till	125.0	20.5	5649.5	17.0	3493	2043.4	3606.1	0.6	700.0	2307.9
45.111	33.531	Till	125.0	20.5	5670.0	17.0	3611	2053.6	3616.4	0.6	700.0	2314.5
45.275	33.510	Till	125.0	20.5	5690.5	17.0	3608	2063.9	3626.7	0.6	700.0	2321.1
45.439	31.621	Till	125.0	20.5	5711.1	17.0	3384	2074.1	3636.9	0.6	700.0	2327.6
45.603	31.881	Till	125.0	20.5	5731.6	17.0	3414	2084.4	3647.2	0.6	700.0	2334.2
45.767	29.036	Till	125.0	20.5	5752.1	17.0	3078	2094.6	3657.5	0.6	700.0	2340.8
45.931	28.176	Till	125.0	20.5	5772.6	17.0	2975	2104.8	3667.7	0.6	700.0	2347.4
46.095	29.120	Till	125.0	20.5	5793.1	17.0	3085	2115.1	3678.0	0.6	700.0	2353.9
46.259	30.627	Till	125.0	20.5	5813.6	17.0	3261	2125.3	3688.3	0.6	700.0	2360.5

46.423	29.791	Till	125.0	20.5	5834.1	17.0	3162	2135.5	3698.5	0.6	700.0	2367.1
46.587	30.015	Till	125.0	20.5	5854.6	17.0	3187	2145.8	3708.8	0.6	700.0	2373.6
46.751	29.393	Till	125.0	20.5	5875.1	17.0	3112	2156.0	3719.1	0.6	700.0	2380.2
46.915	29.561	Till	125.0	20.5	5895.6	17.0	3131	2166.2	3729.4	0.6	700.0	2386.8
47.079	29.676	Till	125.0	20.5	5916.1	17.0	3143	2176.5	3739.6	0.6	700.0	2393.4
47.244	31.431	Till	125.0	20.5	5936.6	17.0	3349	2186.7	3749.9	0.6	700.0	2399.9
47.408	32.108	Till	125.0	20.5	5957.1	17.0	3427	2197.0	3760.2	0.6	700.0	2406.5
47.572	31.165	Till	125.0	20.5	5977.6	17.0	3315	2207.2	3770.4	0.6	700.0	2413.1
47.736	32.525	Till	125.0	20.5	5998.1	17.0	3474	2217.4	3780.7	0.6	700.0	2419.6
47.900	35.879	Till	125.0	20.5	6018.6	17.0	3867	2227.7	3791.0	0.6	700.0	2426.2
48.064	33.695	Till	125.0	20.5	6039.1	17.0	3609	2237.9	3801.2	0.6	700.0	2432.8
48.228	31.787	Till	125.0	20.5	6059.6	17.0	3383	2248.1	3811.5	0.6	700.0	2439.4
48.392	30.363	Till	125.0	20.5	6080.1	17.0	3214	2258.4	3821.8	0.6	700.0	2445.9
48.556	31.217	Till	125.0	20.5	6100.6	17.0	3314	2268.6	3832.0	0.6	700.0	2452.5
48.720	31.414	Till	125.0	20.5	6121.2	17.0	3336	2278.8	3842.3	0.6	700.0	2459.1
48.884	30.261	Till	125.0	20.5	6141.7	17.0	3199	2289.1	3852.6	0.6	700.0	2465.7
49.048	28.343	Till	125.0	20.5	6162.2	17.0	2972	2299.3	3862.8	0.6	700.0	2472.2
49.212	27.455	Till	125.0	20.5	6182.7	17.0	2866	2309.5	3873.1	0.6	700.0	2478.8
49.376	29.841	Till	125.0	20.5	6203.2	17.0	3146	2319.8	3883.4	0.6	700.0	2485.4
49.540	56.408	Till	125.0	20.5	6223.7	17.0	6270	2330.0	3893.7	0.6	700.0	2491.9
49.704	69.555	Till	125.0	20.5	6244.2	17.0	7816	2340.3	3903.9	0.6	700.0	2498.5
49.868	51.589	Till	125.0	20.5	6264.7	17.0	5701	2350.5	3914.2	0.6	700.0	2505.1
50.032	48.318	Till	125.0	20.5	6285.2	17.0	5315	2360.7	3924.5	0.6	700.0	2511.7
50.196	38.736	Till	125.0	20.5	6305.7	17.0	4186	2371.0	3934.7	0.6	700.0	2518.2
50.360	36.885	Till	125.0	20.5	6326.2	17.0	3967	2381.2	3945.0	0.6	700.0	2524.8
50.524	38.381	Till	125.0	20.5	6346.7	17.0	4142	2391.4	3955.3	0.6	700.0	2531.4
50.688	49.286	Till	125.0	20.5	6367.2	17.0	5424	2401.7	3965.5	0.6	700.0	2537.9
50.852	358.260	Till	125.0	20.5	6387.7	17.0	41773	2411.9	3975.8	0.6	700.0	2544.5
51.016	231.907	Till	125.0	20.5	6408.2	17.0	26906	2422.1	3986.1	0.6	700.0	2551.1
51.180	115.023	Till	125.0	20.5	6428.7	17.0	13154	2432.4	3996.3	0.6	700.0	2557.7
51.345	78.815	Till	125.0	20.5	6449.2	17.0	8893	2442.6	4006.6	0.6	700.0	2564.2
51.509	61.276	Till	125.0	20.5	6469.7	17.0	6828	2452.9	4016.9	0.6	700.0	2570.8
51.673	54.006	Till	125.0	20.5	6490.2	17.0	5972	2463.1	4027.2	0.6	700.0	2577.4
51.837	53.246	Till	125.0	20.5	6510.7	17.0	5881	2473.3	4037.4	0.6	700.0	2583.9
52.001	50.037	Till	125.0	20.5	6531.3	17.0	5502	2483.6	4047.7	0.6	700.0	2590.5
52.165	48.410	Till	125.0	20.5	6551.8	17.0	5310	2493.8	4058.0	0.6	700.0	2597.1
52.329	43.711	Till	125.0	20.5	6572.3	17.0	4756	2504.0	4068.2	0.6	700.0	2603.7
52.493	44.235	Till	125.0	20.5	6592.8	17.0	4816	2514.3	4078.5	0.6	700.0	2610.2
52.657	49.382	Till	125.0	20.5	6613.3	17.0	5421	2524.5	4088.8	0.6	700.0	2616.8
52.821	54.233	Till	125.0	20.5	6633.8	17.0	5990	2534.7	4099.0	0.6	700.0	2623.4
52.985	54.164	Till	125.0	20.5	6654.3	17.0	5981	2545.0	4109.3	0.6	700.0	2630.0
53.149	50.338	Till	125.0	20.5	6674.8	17.0	5529	2555.2	4119.6	0.6	700.0	2636.5
53.313	47.161	Till	125.0	20.5	6695.3	17.0	5155	2565.5	4129.8	0.6	700.0	2643.1
53.477	47.430	Till	125.0	20.5	6715.8	17.0	5185	2575.7	4140.1	0.6	700.0	2649.7
53.641	47.960	Till	125.0	20.5	6736.3	17.0	5246	2585.9	4150.4	0.6	700.0	2656.2
53.805	48.358	Till	125.0	20.5	6756.8	17.0	5292	2596.2	4160.6	0.6	700.0	2662.8
53.969	48.059	Till	125.0	20.5	6777.3	17.0	5255	2606.4	4170.9	0.6	700.0	2669.4
54.133	46.389	Till	125.0	20.5	6797.8	17.0	5058	2616.6	4181.2	0.6	700.0	2676.0
54.297	44.684	Till	125.0	20.5	6818.3	17.0	4856	2626.9	4191.5	0.6	700.0	2682.5
54.461	44.071	Till	125.0	20.5	6838.8	17.0	4783	2637.1	4201.7	0.6	700.0	2689.1
54.625	43.337	Till	125.0	20.5	6859.3	17.0	4695	2647.3	4212.0	0.6	700.0	2695.7
54.789	43.225	Till	125.0	20.5	6879.8	17.0	4681	2657.6	4222.3	0.6	700.0	2702.2
54.953	42.943	Till	125.0	20.5	6900.3	17.0	4646	2667.8	4232.5	0.6	700.0	2708.8
55.117	43.312	Till	125.0	20.5	6920.8	17.0	4688	2678.0	4242.8	0.6	700.0	2715.4
55.281	43.362	Till	125.0	20.5	6941.4	17.0	4693	2688.3	4253.1	0.6	700.0	2722.0
55.446	43.235	Till	125.0	20.5	6961.9	17.0	4677	2698.5	4263.3	0.6	700.0	2728.5
55.610	42.825	Till	125.0	20.5	6982.4	17.0	4627	2708.8	4273.6	0.6	700.0	2735.1
55.774	41.597	Till	125.0	20.5	7002.9	17.0	4482	2719.0	4283.9	0.6	700.0	2741.7
55.938	43.110	Till	125.0	20.5	7023.4	17.0	4659	2729.2	4294.1	0.6	700.0	2748.3
56.102	43.920	Till	125.0	20.5	7043.9	17.0	4753	2739.5	4304.4	0.6	700.0	2754.8
56.266	46.281	Till	125.0	20.5	7064.4	17.0	5029	2749.7	4314.7	0.6	700.0	2761.4
56.430	50.792	Till	125.0	20.5	7084.9	17.0	5559	2759.9	4325.0	0.6	700.0	2768.0
56.594	55.055	Till	125.0	20.5	7105.4	17.0	6059	2770.2	4335.2	0.6	700.0	2774.5
56.758	55.295	Till	125.0	20.5	7125.9	17.0	6086	2780.4	4345.5	0.6	700.0	2781.1
56.922	59.423	Till	125.0	20.5	7146.4	17.0	6571	2790.6	4355.8	0.6	700.0	2787.7
57.086	63.905	Till	125.0	20.5	7166.9	17.0	7097	2800.9	4366.0	0.6	700.0	2794.3
57.250	67.235	Till	125.0	20.5	7187.4	17.0	7487	2811.1	4376.3	0.6	700.0	2800.8
57.414	63.030	Till	125.0	20.5	7207.9	17.0	6991	2821.4	4386.6	0.6	700.0	2807.4
57.578	60.747	Till	125.0	20.5	7228.4	17.0	6722	2831.6	4396.8	0.6	700.0	2814.0
57.742	60.583	Till	125.0	20.5	7248.9	17.0	6701	2841.8	4407.1	0.6	700.0	2820.5
57.906	61.420	Till	125.0	20.5	7269.4	17.0	6798	2852.1	4417.4	0.6	700.0	2827.1
58.070	63.651	Till	125.0	20.5	7289.9	17.0	7060	2862.3	4427.6	0.6	700.0	2833.7
58.234	65.498	Till	125.0	20.5	7310.4	17.0	7276	2872.5	4437.9	0.6	700.0	2840.3
58.398	67.315	Till	125.0	20.5	7330.9	17.0	7488	2882.8	4448.2	0.6	700.0	2846.8
58.562	68.367	Till	125.0	20.5	7351.5	17.0	7611	2893.0	4458.4	0.6	700.0	2853.4
58.726	70.381	Till	125.0	20.5	7372.0	17.0	7847	2903.2	4468.7	0.6	700.0	2860.0
58.890	66.878	Till	125.0	20.5	7392.5	17.0	7433	2913.5	4479.0	0.6	700.0	2866.5
59.054	65.032	Till	125.0	20.5	7413.0	17.0	7215	2923.7	4489.3	0.6	700.0	2873.1
59.218	65.496	Till	125.0	20.5	7433.5	17.0	7268	2934.0	4499.5	0.6	700.0	2879.7
59.382	60.016	Till	125.0	20.5	7454.0	17.0	6622	2944.2	4509.8	0.6	700.0	2886.3
59.547	51.252	Till	125.0	20.5	7474.5	17.0	5590	2954.4	4520.1	0.6	700.0	2892.8
59.711	45.114	Till	125.0	20.5	7495.0	17.0	4867	2964.7	4530.3	0.6	700.0	2899.4
59.875	38.166	Till	125.0	20.5	7515.5	17.0	4048	2974.9	4540.6	0.6	700.0	2906.0
60.039	32.483	Till	125.0	20.5	7536.0	17.0	3378	2985.1	4550.9	0.6	700.0	2912.6
60.203	38.986	Till	125.0	20.5	7556.5	17.0	4142	2995.4	4561.1	0.6	700.0	2919.1
60.367	47.048	Till	125.0	20.5	7577.0	17.0	5089	3005.6	4571.4	0.6	700.0	2925.7
60.531	49.745	Till	125.0	20.5	7597.5	17.0	5405	3015.8	4581.7	0.6	700.0	2932.3
60.695	48.677	Till	125.0	20.5	7618.0	17.0	5279	3026.1	4591.9	0.6	700.0	2938.8
60.859	45.128	Till	125.0	20.5	7638.5	17.0	4860	3036.3	4602.2	0.6	700.0	2945.4
61.023	45.997	Till	125.0	20.5	7659.0	17.0	4961	3046.5	4612.5	0.6	700.0	2952.0
61.187	43.798	Till	125.0	20.5	7679.5	17.0	4701	3056.8	4622.7	0.6	700.0	2958.6
61.351	40.355	Till	125.0	20.5	7700.0	17.0	4295	3067.0	4633.0	0.6	700.0	2965.1
61.515	37.462	Till	125.0	20.5	7720.5	17.0	3953	3077.3	4643.3	0.6	700.0	2971.7
61.679	35.609	Till	125.0	20.5	7741.0	17.0	3734	3087.5	4653.6	0.6	700.0	2978.3
61.843	33.384	Till	125.0	20.5	7761.6	17.0	3471	3097.7	4663.8	0.6	700.0	2984.8
62.007	32.693	Till	125.0	20.5	7782.1	17.0	3389	3108.0	4674.1	0.6	700.0	2991.4
62.171	34.484	Till	125.0	20.5	7802.6	17.0	3598	3118.2	4684.4	0.6	700.0	2998.0
62.335	34.369	Till	125.0	20.5	7823.1	17.0	3583	3128.4	4694.6	0.6	700.0	3004.6
62.499	33.876	Till	125.0	20.5	7843.6	17.0	3524	3138.7	4704.9	0.6	700.0	3011.1
62.663	34.743	Till	125.0	20.5	7864.1	17.0	3625	3148.9	4715.2	0.6	700.0	3017.7
62.827	33.638	Till	125.0	20.5	7884.6	17.0	3494	3159.1	4725.4	0.6	700.0	3024.3
62.991	32.813	Till	125.0	20.5	7905.1	17.0	3395	3169.4	4735.7	0.6	700.0	3030.9
63.155	43.367	Till	125.0	20.5	7925.6	17.0	4636	3179.6	4746.0	0.6	700.0	3037.4
63.319	58.884	Till	125.0	20.5	7946.1	17.0	6460	3189.9	4756.2	0.6	700.0	3044.0
63.483	56.414	Till	125.0	20.5	7966.6	17.0	6168	3200.1	4766.5	0.6	700.0	3050.6
63.648	55.944	Till	125.0	20.5	7987.1	17.0	6112	3210.3	4776.8	0.6	700.0	3057.1
63.812	59.037	Till	125.0	20.5	8007.6	17.0	6475	3220.6	4787.1	0.6	700.0	3063.7
63.976	57.444	Till	125.0	20.5	8028.1	17.0	6286	3230.8	4797.3	0.6	700.0	3070.3
64.140	54.702	Till	125.0	20.5	8048.6	17.0	5962	3241.0	4807.6	0.6	700.0	3076.9
64.304	56.348	Till	125.0	20.5	8069.1	17.0	6155	3251.3	4817.9	0.6	700.0	3083.4
64.468	64.961	Till	125.0	20.5	8089.6	17.0	7167	3261.5	4828.1	0.6	700.0	3090.0
64.632	107.467	Till	125.0	20.5	8110.1	17.0	12166	3271.7	4838.4	0.6	700.0	3096.6
64.796	157.533	Till	125.0	20.5	8130.6	17.0	18055	3282.0	4848.7	0.6	700.0	3103.1
64.960	155.787	Till	125.0	20.5	8151.1	17.0	17848	3292.2	4858.9	0.6	700.0	3109.7
65.124	145.461	Till	125.0	20.5	8171.7	17.0	16632	3302.5	4869.2	0.6	700.0	3116.3
65.288	132.102	Till	125.0	20.5	8192.2	17.0	15060	3312.7	4879.5	0.6	700.0	3122.9
65.452	126.596	Till	125.0	20.5	8212.7	17.0	14410	3322.9	4889.7	0.6	700.0	3129.4
65.616	121.527	Till	125.0	20.5	8233.2	17.0	13813	3333.2	4900.0	0.6	700.0	3136.0

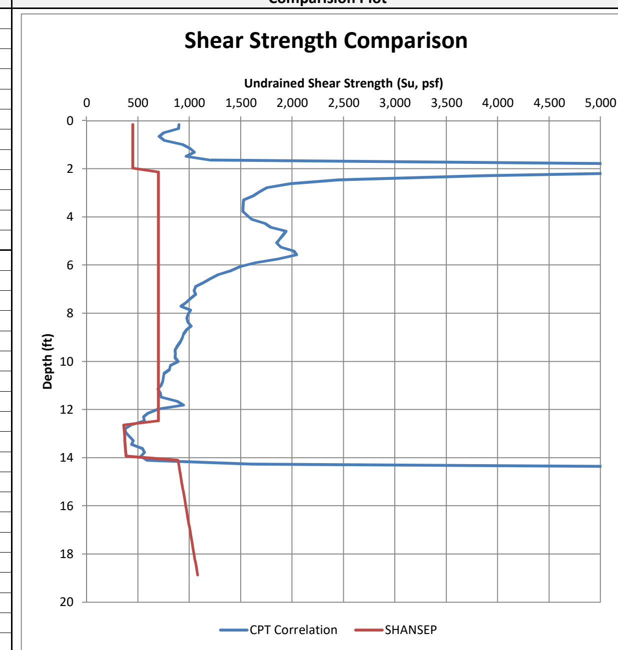
Material	Nkt	Peak Su/p'	Min Su (spf)
Fill	17.0	0.60	450.0
Fdxn Clay	17.0	0.45	700.0
Soft Clay	17.0	0.28	275.0
Till	17.0	0.64	700.0

CPT COF-C055

GWT Depth: 7.8 ft

ConeTec Data			CPT Shear Strength Correlation					SHANSEP Shear Strength Model				
Depth	qt	Material	Unit Weight (pcf)	Layer Weight	Total Vertical Stress	Nkt	CPT Su	Pore Pressure	Effective Vertical Stress	Su/p'	Min Su	SHANSEP Su
ft	tsf	Type	(pcf)	(psf)	(psf)		(psf)	(psf)	(psf)		(psf)	(psf)
0.164	7.661	Fill	135.0	22.1	22.1	17.0	900	0.0	22.1	0.6	450.0	450.0
0.328	7.639	Fill	135.0	22.1	44.3	17.0	896	0.0	44.3	0.6	450.0	450.0
0.492	6.434	Fill	135.0	22.1	66.4	17.0	753	0.0	66.4	0.6	450.0	450.0
0.656	6.037	Fill	135.0	22.1	88.6	17.0	705	0.0	88.6	0.6	450.0	450.0
0.820	6.455	Fill	135.0	22.1	110.7	17.0	753	0.0	110.7	0.6	450.0	450.0
0.984	7.996	Fill	135.0	22.1	132.8	17.0	933	0.0	132.8	0.6	450.0	450.0
1.148	8.623	Fill	135.0	22.1	155.0	17.0	1005	0.0	155.0	0.6	450.0	450.0
1.312	8.995	Fill	135.0	22.1	177.1	17.0	1048	0.0	177.1	0.6	450.0	450.0
1.476	8.319	Fill	135.0	22.1	199.3	17.0	967	0.0	199.3	0.6	450.0	450.0
1.640	10.367	Fill	135.0	22.1	221.4	17.0	1207	0.0	221.4	0.6	450.0	450.0
1.804	45.797	Fill	135.0	22.1	243.5	17.0	5374	0.0	243.5	0.6	450.0	450.0
1.968	78.069	Fill	135.0	22.1	265.7	17.0	9169	0.0	265.7	0.6	450.0	450.0
2.133	50.199	Fdxn Clay	125.0	20.6	286.3	17.0	5889	0.0	286.3	0.5	700.0	700.0
2.297	32.983	Fdxn Clay	125.0	20.5	306.8	17.0	3862	0.0	306.8	0.5	700.0	700.0
2.461	21.013	Fdxn Clay	125.0	20.5	327.3	17.0	2453	0.0	327.3	0.5	700.0	700.0
2.625	17.000	Fdxn Clay	125.0	20.5	347.8	17.0	1980	0.0	347.8	0.5	700.0	700.0
2.789	15.074	Fdxn Clay	125.0	20.5	368.3	17.0	1752	0.0	368.3	0.5	700.0	700.0
2.953	14.494	Fdxn Clay	125.0	20.5	388.8	17.0	1682	0.0	388.8	0.5	700.0	700.0
3.117	14.021	Fdxn Clay	125.0	20.5	409.3	17.0	1625	0.0	409.3	0.5	700.0	700.0
3.281	13.208	Fdxn Clay	125.0	20.5	429.8	17.0	1529	0.0	429.8	0.5	700.0	700.0
3.445	13.187	Fdxn Clay	125.0	20.5	450.3	17.0	1525	0.0	450.3	0.5	700.0	700.0
3.609	13.190	Fdxn Clay	125.0	20.5	470.8	17.0	1524	0.0	470.8	0.5	700.0	700.0
3.773	13.193	Fdxn Clay	125.0	20.5	491.3	17.0	1523	0.0	491.3	0.5	700.0	700.0
3.937	13.532	Fdxn Clay	125.0	20.5	511.8	17.0	1562	0.0	511.8	0.5	700.0	700.0
4.101	13.926	Fdxn Clay	125.0	20.5	532.3	17.0	1607	0.0	532.3	0.5	700.0	700.0
4.265	15.054	Fdxn Clay	125.0	20.5	552.8	17.0	1739	0.0	552.8	0.5	700.0	700.0
4.429	15.545	Fdxn Clay	125.0	20.5	573.3	17.0	1795	0.0	573.3	0.5	700.0	700.0
4.593	16.786	Fdxn Clay	125.0	20.5	593.8	17.0	1940	0.0	593.8	0.5	700.0	700.0
4.757	16.533	Fdxn Clay	125.0	20.5	614.3	17.0	1909	0.0	614.3	0.5	700.0	700.0
4.921	16.272	Fdxn Clay	125.0	20.5	634.8	17.0	1877	0.0	634.8	0.5	700.0	700.0
5.085	16.046	Fdxn Clay	125.0	20.5	655.3	17.0	1849	0.0	655.3	0.5	700.0	700.0
5.249	16.416	Fdxn Clay	125.0	20.5	675.8	17.0	1892	0.0	675.8	0.5	700.0	700.0
5.413	17.482	Fdxn Clay	125.0	20.5	696.3	17.0	2016	0.0	696.3	0.5	700.0	700.0
5.577	17.733	Fdxn Clay	125.0	20.5	716.8	17.0	2044	0.0	716.8	0.5	700.0	700.0
5.741	16.204	Fdxn Clay	125.0	20.5	737.3	17.0	1863	0.0	737.3	0.5	700.0	700.0
5.905	14.310	Fdxn Clay	125.0	20.5	757.8	17.0	1639	0.0	757.8	0.5	700.0	700.0
6.069	13.070	Fdxn Clay	125.0	20.5	778.3	17.0	1492	0.0	778.3	0.5	700.0	700.0
6.234	12.309	Fdxn Clay	125.0	20.6	798.9	17.0	1401	0.0	798.9	0.5	700.0	700.0
6.398	11.278	Fdxn Clay	125.0	20.5	819.4	17.0	1279	0.0	819.4	0.5	700.0	700.0
6.562	10.637	Fdxn Clay	125.0	20.5	839.9	17.0	1202	0.0	839.9	0.5	700.0	700.0
6.726	10.087	Fdxn Clay	125.0	20.5	860.4	17.0	1136	0.0	860.4	0.5	700.0	700.0
6.890	9.458	Fdxn Clay	125.0	20.5	880.9	17.0	1061	0.0	880.9	0.5	700.0	700.0
7.054	9.336	Fdxn Clay	125.0	20.5	901.4	17.0	1045	0.0	901.4	0.5	700.0	700.0
7.218	9.474	Fdxn Clay	125.0	20.5	921.9	17.0	1060	0.0	921.9	0.5	700.0	700.0
7.382	9.111	Fdxn Clay	125.0	20.5	942.4	17.0	1016	0.0	942.4	0.5	700.0	700.0
7.546	8.723	Fdxn Clay	125.0	20.5	962.9	17.0	970	0.0	962.9	0.5	700.0	700.0
7.710	8.285	Fdxn Clay	125.0	20.5	983.4	17.0	917	0.0	983.4	0.5	700.0	700.0
7.874	9.094	Fdxn Clay	125.0	20.5	1003.9	17.0	1011	4.6	999.3	0.5	700.0	700.0
8.038	8.911	Fdxn Clay	125.0	20.5	1024.4	17.0	988	14.9	1009.6	0.5	700.0	700.0
8.202	8.805	Fdxn Clay	125.0	20.5	1044.9	17.0	974	25.1	1019.8	0.5	700.0	700.0
8.366	8.899	Fdxn Clay	125.0	20.5	1065.4	17.0	984	35.3	1030.1	0.5	700.0	700.0
8.530	9.188	Fdxn Clay	125.0	20.5	1085.9	17.0	1017	45.6	1040.4	0.5	700.0	700.0
8.694	8.814	Fdxn Clay	125.0	20.5	1106.4	17.0	972	55.8	1050.6	0.5	700.0	700.0
8.858	8.585	Fdxn Clay	125.0	20.5	1126.9	17.0	944	66.0	1060.9	0.5	700.0	700.0
9.022	8.487	Fdxn Clay	125.0	20.5	1147.4	17.0	931	76.3	1071.2	0.5	700.0	700.0
9.186	8.344	Fdxn Clay	125.0	20.5	1167.9	17.0	913	86.5	1081.4	0.5	700.0	700.0
9.350	8.105	Fdxn Clay	125.0	20.5	1188.4	17.0	884	96.7	1091.7	0.5	700.0	700.0
9.514	7.939	Fdxn Clay	125.0	20.5	1208.9	17.0	863	107.0	1102.0	0.5	700.0	700.0
9.678	7.973	Fdxn Clay	125.0	20.5	1229.4	17.0	866	117.2	1112.2	0.5	700.0	700.0
9.842	7.946	Fdxn Clay	125.0	20.5	1249.9	17.0	861	127.4	1122.5	0.5	700.0	700.0
10.006	8.205	Fdxn Clay	125.0	20.5	1270.4	17.0	891	137.7	1132.8	0.5	700.0	700.0
10.170	7.568	Fdxn Clay	125.0	20.5	1290.9	17.0	814	147.9	1143.0	0.5	700.0	700.0
10.335	7.507	Fdxn Clay	125.0	20.6	1311.6	17.0	806	158.2	1153.4	0.5	700.0	700.0
10.499	7.072	Fdxn Clay	125.0	20.5	1332.1	17.0	754	168.4	1163.6	0.5	700.0	700.0
10.663	7.026	Fdxn Clay	125.0	20.5	1352.6	17.0	747	178.7	1173.9	0.5	700.0	700.0
10.827	6.972	Fdxn Clay	125.0	20.5	1373.1	17.0	739	188.9	1184.2	0.5	700.0	700.0
10.991	6.855	Fdxn Clay	125.0	20.5	1393.6	17.0	724	199.1	1194.4	0.5	700.0	700.0
11.155	6.596	Fdxn Clay	125.0	20.5	1414.1	17.0	693	209.4	1204.7	0.5	700.0	700.0
11.319	6.840	Fdxn Clay	125.0	20.5	1434.6	17.0	720	219.6	1215.0	0.5	700.0	700.0
11.483	6.880	Fdxn Clay	125.0	20.5	1455.1	17.0	724	229.8	1225.2	0.5	700.0	700.0
11.647	8.229	Fdxn Clay	125.0	20.5	1475.6	17.0	881	240.1	1235.5	0.5	700.0	700.0
11.811	8.757	Fdxn Clay	125.0	20.5	1496.1	17.0	942	250.3	1245.8	0.5	700.0	700.0
11.975	6.705	Fdxn Clay	125.0	20.5	1516.6	17.0	700	260.5	1256.0	0.5	700.0	700.0
12.139	5.868	Fdxn Clay	125.0	20.5	1537.1	17.0	600	270.8	1266.3	0.5	700.0	700.0
12.303	5.475	Fdxn Clay	125.0	20.5	1557.6	17.0	552	281.0	1276.6	0.5	700.0	700.0
12.467	5.589	Fdxn Clay	125.0	20.5	1578.1	17.0	565	291.2	1286.8	0.5	700.0	700.0
12.631	4.467	Soft Clay	125.0	20.5	1598.6	17.0	431	301.5	1297.1	0.3	275.0	363.2
12.795	3.974	Soft Clay	125.0	20.5	1619.1	17.0	372	311.7	1307.4	0.3	275.0	366.1
12.959	4.063	Soft Clay	125.0	20.5	1639.6	17.0	382	321.9	1317.6	0.3	275.0	368.9
13.123	4.403	Soft Clay	125.0	20.5	1660.1	17.0	420	332.2	1327.9	0.3	275.0	371.8
13.287	4.699	Soft Clay	125.0	20.5	1680.6	17.0	454	342.4	1338.2	0.3	275.0	374.7
13.451	4.565	Soft Clay	125.0	20.5	1701.1	17.0	437	352.6	1348.4	0.3	275.0	377.6
13.615	5.490	Soft Clay	125.0	20.5	1721.6	17.0	545	362.9	1358.7	0.3	275.0	380.4
13.779	5.646	Soft Clay	125.0	20.5	1742.1	17.0	562	373.1	1369.0	0.3	275.0	383.3
13.943	5.381	Soft Clay	125.0	20.5	1762.6	17.0	529	383.3	1379.2	0.3	275.0	386.2
14.107	5.923	Till	125.0	20.5	1783.1	17.0	592	393.6	1389.5	0.6	700.0	889.3
14.271	14.572	Till	125.0	20.5	1803.6	17.0	1608	403.8	1399.8	0.6	700.0	895.8
14.436	68.181	Till	125.0	20.6	1824.2	17.0	7914	414.1	1410.1	0.6	700.0	902.5
14.600	67.004	Till	125.0	20.5	1844.7	17.0	7774	424.3	1420.4	0.6	700.0	909.0
14.764	75.244	Till	125.0	20.5	1865.2	17.0	8743	434.6	1430.6	0.6	700.0	915.6
14.928	67.580	Till	125.0	20.5	1885.7	17.0	7840	444.8	1440.9	0.6	700.0	922.2
15.092	154.531	Till	125.0	20.5	1906.2	17.0	18068	455.0	1451.2	0.6	700.0	928.7
15.256	199.644	Till	125.0	20.5	1926.7	17.0	23374	465.3	1461.4	0.6	700.0	935.3
15.420	195.931	Till	125.0	20.5	1947.2	17.0	22936	475.5	1471.7	0.6	700.0	941.9
15.584	191.900	Till	125.0	20.5	1967.7	17.0	22461	485.7	1482.0	0.6	700.0	948.5
15.748	199.571	Till	125.0	20.5	1988.2	17.0	23362	496.0	1492.2	0.6	700.0	955.0
15.912	223.297	Till	125.0	20.5	2008.7	17.0	26152	506.2	1502.5	0.6	700.0	961.6
16.076	284.446	Till	125.0	20.5	2029.2	17.0	33345	516.4	1512.8	0.6	700.0	968.2
16.240	345.331	Till	125.0	20.5	2049.7	17.0	40507	526.7	1523.0	0.6	700.0	974.7
16.404	430.782	Till	125.0	20.5	2070.2	17.0	50558	536.9	1533.3	0.6	700.0	981.3
16.568	496.521	Till	125.0	20.5	2090.7	17.0	58291	547.1	1543.6	0.6	700.0	987.9
16.732	477.627	Till	125.0	20.5	2111.2	17.0	56067	557.4	1553.8	0.6	700.0	994.4
16.896	572.859	Till	125.0	20.5	2131.7	17.0	67270	567.6	1564.1	0.6	700.0	1001.0
17.060	584.682	Till	125.0	20.5	2152.2	17.0	68660	577.8	1574.4	0.6	700.0	1007.6
17.224	593.935	Till	125.0	20.5	2172.7	17.0	69747	588.1	1584.6	0.6	700.0	1014.2
17.388	609.865	Till	125.0	20.5	2193.2	17.0	71620	598.3	1594.9	0.6	700.0	1020.7
17.552	584.407	Till	125.0	20.5	2213.7	17.0	68624	608.5	1605.2	0.6	700.0	1027.3
17.716	572.385	Till	125.0	20.5	2234.2	17.0	67208	618.8	1615.4	0.6	700.0	1033.9
17.880	595.417	Till	125.0	20.5	2254.7	17.0	69916	629.0	1625.7	0.6	700.0	1040.4
18.044	632.719	Till	125.0	20.5	2275.2	17.0	74304	639.2	1636.0	0.6	700.0	1047.0
18.208	659.571	Till	125.0	20.5	2295.7	17.0	77462	649.5	1646.2	0.6	700.0	1053.6
18.372	670.980	Till	125.0	20.5	2316.2	17.0	78803	659.7	1656.5	0.6	700.0	1060.2
18.537	680.148	Till	125.0	20.6	2336.8	17.0	79880	670.0	1666.8	0.6	700.0	1066.8
18.701	689.357	Till	125.0	20.5	2357.3	17.0	80962	680.2	1677.1	0.6	700.0	1073.3
18.865	664.617	Till	125.0	20.5	2377.8	17.0	78050	690.5	1687.3	0.6	700.0	1079.9

Comparision Plot



Attachment D. Liquefaction Analysis Calculations

Calculation Notes AECOM

Subject: Coffeen GMF Gypsum Stack Pond Liquefaction Analysis   Project Name: Dynegy CCR

By: Lucas Carr   Date: 01/25/2016   Project No: 60480701

Checked By: Vonmarie Martinez   Date: 01/26/2016   Task No.: 01

Objective

A liquefaction analysis was performed to calculate factors of safety against liquefaction (FS_{liq}) for the embankment and foundation soils at the Coffeen GMF Gypsum Stack Pond. The factors of safety have been compared to Dynegy Programmatic guidance to evaluate potential zones of soils susceptible to liquefaction during the design seismic event (2% probability of exceedance in 50 years of 2,475-yr return period earthquake). The methodology used to perform the liquefaction analysis is summarized in the following sections.

Analysis Methodology

Subsurface Explorations and Material Characterization

Subsurface explorations, in the form of cone penetration tests (CPTs) were advanced at the Stack Pond by AECOM in 2015. The CPTs were intended to be used for correlation purposes with other CPTs and geotechnical borings advanced by AECOM in 2015 at the adjacent Ash Ponds No. 1 and No. 2. CPTs advanced at the Stack Pond by AECOM are listed in Table 1.

Table 1 – 2015 AECOM CPTs at the Coffeen GMF Gypsum Stack Pond

CPT Designation	Ground Surface Elevation (ft)	Location
COF-C048	620	East Dike Toe
COF-C049	630	North Dike Crest
COF-C050	630	West Dike Crest
COF-C051	625	West Dike Toe
COF-C052	630	South Dike Crest
COF-C053	630	East Dike Crest
COF-C054	624	South Dike Toe
COF-C055	624	North Dike Toe

A review of the CPT explorations shows that the subsurface materials are very similar to the subsurface materials at Coffeen Ash Pond No. 1, where AECOM has also collected geotechnical borings. Material present in the subsurface can be characterized as Fill, Foundation Clay, Soft Clay, and Till.

AECOM's interpreted the subsurface conditions from the CPTs to define the interfaces between each material type, based on tip resistance, side friction, and friction ratio. Raw data files provided by ConeTec, the CPT subcontractor, were imported into RapidCPT for analysis. Soil behavior type, following Robertson (1990) was also plotted for each CPT log, and AECOM added manual annotations for the logs to denote changes in material type. This interpretation is included as **Appendix B**.

AECOM also evaluated the location of the groundwater table, based on pore pressure readings during CPT advancement. The groundwater table was generally assumed to be encountered where pore pressures exceeded 0 tsf and generally began increasing at a consistent rate. Tabulated subsurface material boundaries and groundwater table elevations are listed in Table 2.

Table 2 – Subsurface Material Boundaries and Groundwater Table Depths

CPT Designation	Groundwater Depth (ft)	Top of Fill Depth (ft)	Top of Foundation Clay Depth (ft)	Top of Soft Clay Depth (ft)	Top of Till Depth (ft)	Total Depth (ft)
COF-C048	10.0	0.0	4.2	11.7	12.6	20.0
COF-C049	11.0	0.4	10.0	20.2	21.3	25.8
COF-C050	8.0	0.0	9.0	20.0	21.1	24.0
COF-C051	7.5	NP	0.0	14.6	15.9	20.2
COF-C052	11.0	0.0	10.0	20.8	22.2	26.9
COF-C053	8.8	0.0	10.0	NP	25.0	53.6
COF-C054	12.2	0.0	3.00	NP	15.0	65.6
COF-C055	7.8	NP	0.0	12.5	14.0	18.9

Based on AECOM's review of the CPTs, in terms of tip resistance, side friction, pore pressures, soil behavior types, and information obtained at Ash Ponds No. 1 and No. 2 from CPTs and borings, each material type can be described as follows:

- **Embankment Fill:** Compacted clay and silty clay fill used to construct the embankments. May contained isolated lenses of sandy soil. Due to the presence of a liner in the pond, and AECOM's interpretation of pore pressures from the CPT sounding, this material is not saturated. Due to the clayey nature of the embankment fill, and the fact that it is above the groundwater table, the material is not susceptible to liquefaction, and liquefaction calculations were not performed for this material.
- **Foundation Clay:** Clayey and silty clay foundation soils beneath the embankments, likely consisting of weathered loess soils. Based on the CPT soil behavior type and information collected at the Ash Ponds No. 1 and 2, this material is predominantly clay and is not susceptible to liquefaction, and liquefaction calculations were not performed for this material.
- **Soft clay:** Thin (1-2 ft) clayey, sandy, or silty zone between the foundation clay and the underlying till, located below the groundwater table. This material is likely to be susceptible to post-earthquake strength losses in the form of either liquefaction or cyclic softening, depending on the relative fines content, which varies across the site. AECOM performed cyclic direct simple shear laboratory tests on this material at Ash Ponds No. 1 and 2 to evaluate the post-earthquake

shear strength of this material, and these shear strengths will be used for stability analysis. Where present, this material was assumed to be susceptible to post-earthquake strength losses based on the low observed strength and the results of AECOM's tests at Ash Ponds No. 1 and 2.

- **Till:** Clayey, sandy, and silty material underlying the soft clay, located below the groundwater table. Due to the variable nature of this material, liquefaction calculations were performed for the till to evaluate if liquefaction is likely to occur during the design seismic event. In the event that the analysis predicted liquefaction in the till, but the CPT soil behavior type of the corresponding depth interval was fine-grained in nature (e.g. Clays or Silt Mixtures), it was assumed that the corresponding depth interval was not susceptible to liquefaction.

Fines content data is required for liquefaction analysis. For the Till material, fines content data was taken from laboratory sieve analyses performed by AECOM for Coffeen Ash Ponds No. 1 and 2. Tabulated data from fines content tests within the till are listed in Table 3.

Table 3 – Tabulated Fines Content Data for Till

Laboratory Testing of Till Fines Content from Coffeen Ash Pond Nos. 1 and 2 Subsruface Explorations

(Taken from *30% Design Data Report for Dynegy Coffeen Power Station; Ash Ponds Nos. 1 and 2 CCR Units,* dated 1/14/2016

Boring	Sample Number	Depth Interval (ft)	Fines Content* (%)
COF-B001	S11	33.5-35	NM
COF-B002	S10	33.5-35	NM
COF-B003	S10	33.5-35	2.7
	S11	38.5-40	48.2
	S12	43.5-45	NM
COF-B004	S9	33.5-35	NM
	S10	38.5-40	NM
	S11	43.5-45	61
COF-B005	S10	38.5-10	26
	S11	43.5-45	69.7
	S12	48.5-50	NM
	S13	53.5-55	NM
	S14	58.5-60	82
COF-B006	S8	28.5-30	NM
	S9	32-33.5	NM
COF-B007	S10	34-35.5	NM
	S11	36-37.5	70.9
COF-B008	S11	33-34.5	NM
COF-B009	S11	38.5-40	96.2
COF-B010	S10	38.5-40	61.6
	S11	42.5-44	NM
COF-B011	S13	33.5-35	41.8
	S14	38.5-40	NM

*NM = Not Measured

Analysis of Fines Content Data	
Minimum Till Fines Content (%):	3
Maximum Till Fines Content (%):	96
Average Till Fines Content (%):	56

For the till, the mean fines content value of 56% was used for analysis, as most values were in the range of 40% to 90%. One test (COF-B003, S-10) did return a fines content value of 2.7%, but this value was assumed to be an outlier and was not used for analysis.

Unit weights for each analysis were taken from the *Coffeen Ash Pond No. 1 Material Characterization* calculation package, and are summarized in Table 4. Unit weights were assumed to be constant above and below the groundwater table.

Table 4 – Unit Weights for Liquefaction Analysis

Material	Total Unit Weight (pcf)
Fill	135
Foundation Clay	125
Soft Clay	125
Till	135

Seismic Accelerations

Seismic accelerations for analysis were taken from a dynamic response analysis for Coffeen Ash Pond No. 1. The analysis, which used QUAD4 software and input motions developed from a Probabilistic Seismic Hazard Analysis (PSHA) for the Coffeen Station, was performed for an embankment with a different orientation than the Coffeen Stack Pond. The Coffeen Ash Pond No. 1 embankment is considerably higher than the Stack Pond embankment (up to 40 ft vs. 10 ft in total height) and has steeper exterior slopes (approximately 2H:1V vs. 3H:1V). As the foundation conditions and embankment materials at each pond are similar, the steeper slopes and higher embankment at Ash Pond No. 1 are likely to amplify seismic accelerations more than the shorter, flatter slopes at the Stack Pond. Therefore, accelerations developed for Coffeen Ash Pond No. 1, when used for the Stack Pond, are likely to be higher for CPTs advanced from the crest of the embankment are similar for CPTs advanced at the toe.

Per the QUAD4 analysis and PSHA for the Coffeen Ash Pond No. 1, the following ground surface elevations and earthquake magnitudes were used for analysis:

- Embankment Crest PGA: 0.39 g
- Embankment Downstream Toe PGA: 0.20 g
- Earthquake Magnitude: 6.5

Analysis Method

Liquefaction was evaluated using a spreadsheet developed by AECOM that utilizes the Idriss & Boulanger (2014) method for CPT soundings. The method relies on inputs including:

- Depth
- CPT Tip Resistance
- CPT Side Friction
- Unit Weight
- Groundwater Table Depth
- Fines Content
- Earthquake Magnitude
- Earthquake PGA
- Ground Surface Elevation

CPT tip resistance, side friction, and depth were taken from raw data files provided by ConeTec for each CPT sounding. Groundwater table depths during the earthquake were assumed to be the same as the depths estimated in Table 2, and ground surface elevations were taken from Table 1. Fines contents and earthquake parameters used for analysis are discussed in the preceding section.

Soils are assumed to be liquefaction-susceptible during the design seismic event FS_{liq} is below 1.2.

Results

The liquefaction analysis found that liquefaction may occur in within the soft clay and in the transition zone between the soft clay and till within the foundation soils, during the design 2,475-yr return period seismic event. FS_{liq} is below 1.2 in this zone. This zone is typically less than a foot thick, and corresponds to an area where CPT tip resistances are steadily increasing between the low-strength Soft Clay and Till. Tabulated results of zones with the potential for liquefaction are listed in Table 5. Liquefaction analysis output is included in **Appendix A**.

Table 5 – Results of Liquefaction Analysis

CPT Designation	Liquefaction-Susceptible Zone Depth Range (ft)
COF-C048	12.63 - 13.12
COF-C049	21.33 – 22.31
COF-C050	21.16 – 22.64
COF-C051	16.08 – 16.40
COF-C052	22.31 – 22.97
COF-C053	25.10 – 25.26, 26.41 – 26.41, 27.56 – 27.89
COF-C054	15.09 – 16.08
COF-C055	14.11 – 14.27

APPENDIX A

LIQUEFACTION ANALYSIS SPREADSHEETS

CPT Liquefaction Analysis

Method: Idriss and Boulanger (2014), CPT and SPT Based Liquefaction Triggering Procedures

Title: Liquefaction Analysis
Project: Dynegy - Coffeen
Project No.: 60480701

Date: 1/15/2016
Boring No. COF-C048

Unit wt AGWT: 135 pcf
Unit wt BGWT: 135 pcf

Input Parameters:
Peak ground acceleration, pga (g): 0.2
Earthquake Magnitude (M): 6.5
Water Table Depth at the time of drilling 10 ft
Water Table Depth at the time of earthquake 10 ft
Ground Surface Elevation 620 ft

Notes:
1. Sand-like behavior = "Yes", Clay-like behavior = "No" (See Idriss and Boulanger, 2014).
2. Make sure to turn on iterative calculations.
3. User to confirm highlighted values are reasonable.

Depth	Qt	Fs	Unit Weight	Liquefiable?[1]	FC	α (From static stress analysis)	Fs/Qt	Below Water Table?	Liquefaction Calculation Needed?	Sample Elev.	Total stress	At the time of earthquake: Pore Pressure	At the time of earthquake: Effective stress	At the time of earthquake: Stress reduction coeff, r_d	At the time of earthquake: CSR	At the time of drilling: Pore Pressure	At the time of drilling: Effective stress
(ft)	(TSF)	(TSF)	(pcf)	(Yes/No)			(%)			(ft)	(psf)	(psf)	(psf)			(psf)	(psf)
0.16	7.26	0.116	135	No	90	0	1.598236	No	No	619.84	22.14		22.14				22.14
0.33	9.41	0.234	135	No	90	0	2.486188	No	No	619.67	44.28		44.28				44.28
0.49	13.90	0.33	135	No	90	0	2.373759	No	No	619.51	66.42		66.42				66.42
0.66	15.82	0.408	135	No	90	0	2.579829	No	No	619.34	88.56		88.56				88.56
0.82	15.08	0.403	135	No	90	0	2.672059	No	No	619.18	110.70		110.70				110.70
0.98	15.82	0.404	135	No	90	0	2.553891	No	No	619.02	132.84		132.84				132.84
1.15	20.54	0.439	135	No	90	0	2.136877	No	No	618.85	154.98		154.98				154.98
1.31	19.44	0.5	135	No	90	0	2.57162	No	No	618.69	177.12		177.12				177.12
1.48	19.42	0.505	135	No	90	0	2.600278	No	No	618.52	199.26		199.26				199.26
1.64	17.35	0.517	135	No	90	0	2.980686	No	No	618.36	221.40		221.40				221.40
1.80	15.79	0.548	135	No	90	0	3.47143	No	No	618.20	243.54		243.54				243.54
1.97	15.28	0.554	135	No	90	0	3.624943	No	No	618.03	265.68		265.68				265.68
2.13	20.90	0.615	135	No	90	0	2.942584	No	No	617.87	287.96		287.96				287.96
2.30	40.16	0.768	135	No	90	0	1.91216	No	No	617.70	310.10		310.10				310.10
2.46	32.78	0.939	135	No	90	0	2.864289	No	No	617.54	332.24		332.24				332.24
2.63	22.80	0.927	135	No	90	0	4.066146	No	No	617.38	354.38		354.38				354.38
2.79	19.09	0.912	135	No	90	0	4.77737	No	No	617.21	376.52		376.52				376.52
2.95	19.48	0.937	135	No	90	0	4.809074	No	No	617.05	398.66		398.66				398.66
3.12	69.10	1.51	135	No	90	0	2.185112	No	No	616.88	420.80		420.80				420.80
3.28	72.37	1.911	135	No	90	0	2.640706	No	No	616.72	442.94		442.94				442.94
3.45	51.73	1.716	135	No	90	0	3.317288	No	No	616.56	465.08		465.08				465.08
3.61	34.78	1.442	135	No	90	0	4.146538	No	No	616.39	487.22		487.22				487.22
3.77	25.66	0.989	135	No	90	0	3.854699	No	No	616.23	509.36		509.36				509.36
3.94	23.05	0.786	135	No	90	0	3.410274	No	No	616.06	531.50		531.50				531.50
4.10	20.65	0.659	135	No	90	0	3.191592	No	No	615.90	553.64		553.64				553.64
4.27	19.63	0.57	135	No	90	0	2.903423	No	No	615.74	575.78		575.78				575.78
4.43	19.86	0.549	135	No	90	0	2.764072	No	No	615.57	597.92		597.92				597.92
4.59	20.35	0.552	135	No	90	0	2.712931	No	No	615.41	620.06		620.06				620.06
4.76	20.94	0.579	135	No	90	0	2.765571	No	No	615.24	642.20		642.20				642.20
4.92	21.46	0.572	135	No	90	0	2.665797	No	No	615.08	664.34		664.34				664.34
5.09	21.62	0.565	135	No	90	0	2.613563	No	No	614.92	686.48		686.48				686.48
5.25	22.97	0.57	135	No	90	0	2.482038	No	No	614.75	708.62		708.62				708.62
5.41	23.66	0.658	135	No	90	0	2.781653	No	No	614.59	730.76		730.76				730.76
5.58	24.46	0.707	135	No	90	0	2.890315	No	No	614.42	752.90		752.90				752.90
5.74	22.17	0.655	135	No	90	0	2.954443	No	No	614.26	775.04		775.04				775.04
5.91	21.23	0.575	135	No	90	0	2.709069	No	No	614.10	797.18		797.18				797.18
6.07	20.31	0.512	135	No	90	0	2.520677	No	No	613.93	819.32		819.32				819.32
6.23	19.71	0.491	135	No	90	0	2.490742	No	No	613.77	841.59		841.59				841.59
6.40	19.57	0.5	135	No	90	0	2.554409	No	No	613.60	863.73		863.73				863.73
6.56	18.94	0.527	135	No	90	0	2.782471	No	No	613.44	885.87		885.87				885.87
6.73	19.52	0.566	135	No	90	0	2.899145	No	No	613.27	908.01		908.01				908.01
6.89	19.08	0.586	135	No	90	0	3.070957	No	No	613.11	930.15		930.15				930.15
7.05	18.92	0.509	135	No	90	0	2.690559	No	No	612.95	952.29		952.29				952.29
7.22	19.05	0.495	135	No	90	0	2.598425	No	No	612.78	974.43		974.43				974.43
7.38	18.26	0.436	135	No	90	0	2.387994	No	No	612.62	996.57		996.57				996.57
7.55	17.65	0.35	135	No	90	0	1.983115	No	No	612.45	1018.71		1018.71				1018.71
7.71	16.69	0.29	135	No	90	0	1.737463	No	No	612.29	1040.85		1040.85				1040.85
7.87	16.14	0.275	135	No	90	0	1.704158	No	No	612.13	1062.99		1062.99				1062.99
8.04	16.50	0.3	135	No	90	0	1.818292	No	No	611.96	1085.13		1085.13				1085.13
8.20	16.01	0.359	135	No	90	0	2.242489	No	No	611.80	1107.27		1107.27				1107.27
8.37	16.63	0.391	135	No	90	0	2.351031	No	No	611.63	1129.41		1129.41				1129.41
8.53	16.87	0.412	135	No	90	0	2.44206	No	No	611.47	1151.55		1151.55				1151.55
8.69	16.64	0.408	135	No	90	0	2.451776	No	No	611.31	1173.69		1173.69				1173.69
8.86	15.57	0.422	135	No	90	0	2.71034	No	No	611.14	1195.83		1195.83				1195.83
9.02	14.26	0.382	135	No	90	0	2.679574	No	No	610.98	1217.97		1217.97				1217.97
9.19	13.17	0.348	135	No	90	0	2.643373	No	No	610.81	1240.11		1240.11				1240.11
9.35	12.66	0.248	135	No	90	0	1.9597	No	No	610.65	1262.25		1262.25				1262.25
9.51	11.82	0.227	135	No	90	0	1.920311	No	No	610.49	1284.39		1284.39				1284.39
9.68	11.24	0.214	135	No	90	0	1.903237	No	No	610.32	1306.53		1306.53				1306.53
9.84	11.20	0.202	135	No	90	0	1.803894	No	No	610.16	1328.67		1328.67				1328.67
10.01	11.58	0.212	135	No	90	0	1.830901	Yes	No	609.99	1350.81	0.37	1350.44			0.37	1350.44
10.17	11.40	0.249	135	No	90	0	2.183444	Yes	No	609.83	1372.95	10.61	1362.34			10.61	1362.34
10.34	10.97	0.241	135	No	90	0	2.197902	Yes	No	609.67	1395.23	20.90	1374.32			20.90	1374.32
10.50	11.15	0.249	135	No	90	0	2.233985	Yes	No	609.50	1417.37	31.14	1386.23			31.14	1386.23
10.66	11.89	0.246	135	No	90	0	2.069662	Yes	No	609.34	1439.51	41.37	1398.13			41.37	1398.13
10.83	12.47	0.226	135	No	90	0	1.812495	Yes	No	609.17	1461.65	51.60	1410.04			51.60	1410.04
10.99	12.46	0.277	135	No	90	0	2.222936	Yes	No	609.01	1483.79	61.84	1421.95			61.84	1421.95
11.16	12.06	0.298	135	No	90	0	2.471388	Yes	No	608.85	1505.93	72.07	1433.85			72.07	1433.85
11.32	13.64	0.301	135	No	90	0	2.206907	Yes	No	608.68	1528.07	82.31	1445.76			82.31	1445.76
11.48	12.36	0.341	135	No	90	0	2.758453	Yes	No	608.52	1550.21	92.54	1457.67			92.54	1457.67
11.65	15.07	0.306	135	No	90	0	2.030659	Yes	No	608.35	1572.35	102.77	1469.57			102.77	1469.57
11.81	10.79	0.328	125	No	90	0	3.040697	Yes	No	608.19	1592.85	113.01	1479.84			113.01	1479.84
11.98	9.05	0.195	125	No	90	0	2.154696	Yes	No	608.03	1613.35	123.24	1490.11			123.24	1490.11
12.14	9.90	0.197	125	No	90	0	1.989296	Yes	No	607.86	1633.85	133.47	1500.37			133.47	1500.37
12.30	9.13	0.199	125	No	90	0	2.179389	Yes	No	607.70	1654.35	143.71	1510.64			143.71	1510.64
12.47	9.59	0.221	125	No	90	0	2.303763	Yes	No	607.53	1674.85	153.94	1520.90			153.94	1520.90
12.63	14.39	0.281	135	Yes	56	0	1.952745	Yes	Yes	607.37	1696.99	164.17	1532.81	0.95	0.137	164.17	1532.81
12.80	17.25	0.225	135	Yes	56	0	1.304197	Yes	Yes	607.21	1719.13	174.41	1544.72	0.95	0.138	174.41	1544.72
12.96	23.31	0.277	135	Yes	56	0	1.188382	Yes	Yes	607.04	1741.27	184.64	1556.62	0.95	0.138	184.64	1556.62
13.12	25.26	0.257	135	Yes	56	0	1.01762	Yes	Yes	606.88	1763.41	194.88	1568.53	0.95	0.139	194.88	1568.53
13.29	34.58	0.192	135	Yes	56	0	0.555202	Yes	Yes	606.71	1785.55	205.11	1580.44	0.95	0.139	205.11	1580.44
13.45	37.08	0.151	135	Yes	56	0	0.407228	Yes	Yes	606.55	1807.69	215.34	1592.34	0.95	0.140	215.34	1592.34
13.62	37.47	0.186	135	Yes	56	0	0.49645	Yes	Yes	606.39	1829.83	225.58	1604.25	0.95	0.141	225.58	1604.25
13.78	32.73	0.522	135	Yes	56	0	1.595062	Yes	Yes	606.22	1851.97	235.81	1616.16	0.95	0.141	235.81	1616.16
13.94	35.15	0.6	135	Yes	56	0	1.707067	Yes	Yes	606.06	1874.11	246.04	1628.06	0.95	0.142	246.04	1628.06
14.11	41.81	0.808	135	Yes	56	0	1.932506	Yes	Yes	605.89	1896.25	256.28	1639.97	0.94	0.142	256.28	1639.97
14.27	81.70	1.069	135	Yes	56	0	1.308381	Yes	Yes	605.73	1918.39	266.51	1651.87	0.94	0.143	266.51	1651.87
14.44	70.43	1.342	135	Yes	56	0	1.905357	Yes	Yes	605.56	1940.66	276.81	1663.85	0.94	0.143	276.81	1663.85
14.60	57.94	1.368	135	Yes	56	0	2.3609	Yes	Yes	605.40	1962.80	287.04	1675.76	0.94	0.143	287.04	1675.76
14.76	74.83	1.612	135	Yes	56	0	2.15413	Yes	Yes	605.24	1984.94	297.27	1687.67	0.94	0.144	297.27	1687.67
14.93	95.35	2.783	135	Yes	56	0	2.918659	Yes	Yes	605.07	2007.08	307.51	1699.57	0.94	0.144	307.51	1699.57
15.09	155.69	4.092	135	Yes	56	0	2.628317	Yes	Yes	604.91	2029.22	317.74	1711.48	0.94	0.145	317.74	1711.48
15.26	154.65	5.329	135	Yes	56	0	3.445868	Yes	Yes	604.74	2051.36	327.97	1723.39	0.94	0.145	327.97	1723.39

Depth	qc1n	m	Cn	qc1	Delta qc1ncs	qc1ncs	CRR_{cpt}[3]	C_s	K_s	Assg. a	State Para	Para a	Para b	Para c	Ka	MSF_{max}	MSF	IB FSL
(ft)				(TSF)														
12.63	17.64	0.807	1.30	18.67	52.6	71.3	0.108	0.05	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.152	1.057	0.85
12.80	20.86	0.783	1.28	22.07	53.5	75.6	0.112	0.05	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.164	1.062	0.88
12.96	27.65	0.740	1.26	29.25	55.4	84.6	0.120	0.06	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.194	1.073	0.95
13.12	29.69	0.729	1.24	31.41	55.9	87.3	0.123	0.06	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.204	1.077	0.97
13.29	39.85	0.679	1.22	42.16	58.7	100.9	0.138	0.06	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.266	1.100	1.11
13.45	42.38	0.668	1.21	44.84	59.4	104.2	0.143	0.07	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.284	1.107	1.15
13.62	42.60	0.668	1.20	45.07	59.5	104.5	0.144	0.07	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.286	1.108	1.15
13.78	37.26	0.691	1.20	39.42	58.0	97.4	0.134	0.06	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.249	1.094	1.06
13.94	39.70	0.680	1.20	42.01	58.7	100.7	0.138	0.06	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.265	1.100	1.09
14.11	46.65	0.651	1.18	49.36	60.6	109.9	0.152	0.07	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.318	1.120	1.22
14.27	87.97	0.526	1.14	93.07	71.9	165.0	0.429	0.10	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.860	1.324	4.08
14.44	76.10	0.557	1.14	80.52	68.7	149.2	0.283	0.09	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.659	1.248	2.52
14.60	62.92	0.595	1.15	66.57	65.0	131.6	0.202	0.08	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.481	1.181	1.70
14.76	80.03	0.546	1.13	84.67	69.7	154.4	0.321	0.09	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.721	1.271	2.89
14.93	100.50	0.497	1.12	106.33	75.4	181.7	0.77795	0.11	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.119	1.421	7.84
15.09	159.77	0.388	1.09	169.03	91.7	260.7	3.724576	0.17	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.71
15.26	158.35	0.390	1.08	167.53	91.3	258.8	3.724576	0.17	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.54

CPT Liquefaction Analysis

15.42	175.73	6.549	135	Yes	56	0	3.726825	Yes	Yes	604.58	2073.50	338.21	1735.29	0.94	0.146	338.21	1735.29	178.37	0.360	1.07	188.72	96.8	285.5	3.724576	0.21	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.65
15.58	145.93	6.429	135	Yes	56	0	4.405477	Yes	Yes	604.42	2095.64	348.44	1747.20	0.94	0.146	348.44	1747.20	149.05	0.405	1.08	157.70	88.7	246.4	3.724576	0.16	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.13
15.75	157.27	6.165	135	Yes	56	0	3.91996	Yes	Yes	604.25	2117.78	358.68	1759.10	0.94	0.146	358.68	1759.10	159.69	0.388	1.07	168.95	91.6	260.6	3.724576	0.17	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.10
15.91	261.36	6.367	135	Yes	56	0	2.436066	Yes	Yes	604.09	2139.92	368.91	1771.01	0.94	0.147	368.91	1771.01	258.67	0.259	1.05	273.68	118.8	392.5	3.724576	0.30	1.05	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.78
16.08	330.26	6.647	135	Yes	56	0	2.012645	Yes	Yes	603.92	2162.06	379.14	1782.92	0.93	0.147	379.14	1782.92	322.69	0.194	1.03	341.41	136.4	477.8	3.724576	0.30	1.05	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.60
16.24	334.31	6.985	135	Yes	56	0	2.089372	Yes	Yes	603.76	2184.20	389.38	1794.82	0.93	0.148	389.38	1794.82	326.06	0.191	1.03	344.97	137.4	482.3	3.724576	0.30	1.05	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.43
16.40	345.93	7.393	135	Yes	56	0	2.137119	Yes	Yes	603.60	2206.34	399.61	1806.73	0.93	0.148	399.61	1806.73	336.46	0.181	1.03	355.97	140.2	496.2	3.724576	0.30	1.05	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.26
16.57	378.36	7.023	135	Yes	56	0	1.856179	Yes	Yes	603.43	2228.48	409.84	1818.64	0.93	0.148	409.84	1818.64	366.11	0.155	1.02	387.34	148.4	535.7	3.724576	0.30	1.05	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.10
16.73	380.97	7.147	135	Yes	56	0	1.87602	Yes	Yes	603.27	2250.62	420.08	1830.54	0.93	0.149	420.08	1830.54	368.17	0.153	1.02	389.52	148.9	538.5	3.724576	0.30	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	37.94
16.90	306.99	7.198	135	Yes	56	0	2.344732	Yes	Yes	603.10	2272.76	430.31	1842.45	0.93	0.149	430.31	1842.45	298.99	0.217	1.03	316.33	129.9	446.3	3.724576	0.30	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	37.78
17.06	278.14	7.242	135	Yes	56	0	2.603772	Yes	Yes	602.94	2294.90	440.54	1854.36	0.93	0.149	440.54	1854.36	271.52	0.245	1.03	287.27	122.4	409.6	3.724576	0.30	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	37.62
17.22	266.52	8.493	135	Yes	56	0	3.186664	Yes	Yes	602.78	2317.04	450.78	1866.26	0.93	0.150	450.78	1866.26	260.17	0.257	1.03	275.26	119.3	394.5	3.724576	0.30	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	37.47
17.39	255.80	9.53	135	Yes	56	0	3.725625	Yes	Yes	602.61	2339.18	461.01	1878.17	0.93	0.150	461.01	1878.17	249.64	0.269	1.03	264.12	116.4	380.5	3.724576	0.30	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	37.32
17.55	254.33	10.362	135	Yes	56	0	4.074202	Yes	Yes	602.45	2361.32	471.24	1890.08	0.93	0.150	471.24	1890.08	247.85	0.271	1.03	262.23	115.9	378.1	3.724576	0.30	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	37.18
17.72	260.75	10.961	135	Yes	56	0	4.203692	Yes	Yes	602.28	2383.46	481.48	1901.98	0.92	0.151	481.48	1901.98	253.50	0.264	1.03	268.20	117.4	385.6	3.724576	0.30	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	37.03
17.88	275.89	12.379	135	Yes	56	0	4.486917	Yes	Yes	602.12	2405.60	491.71	1913.89	0.92	0.151	491.71	1913.89	267.37	0.249	1.03	282.88	121.2	404.1	3.724576	0.30	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.89
18.04	321.06	12.956	135	Yes	56	0	4.035395	Yes	Yes	601.96	2427.74	501.95	1925.79	0.92	0.151	501.95	1925.79	309.41	0.206	1.02	327.36	132.8	460.2	3.724576	0.30	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.76
18.21	358.77	12.421	135	Yes	56	0	3.462145	Yes	Yes	601.79	2449.88	512.18	1937.70	0.92	0.152	512.18	1937.70	344.33	0.174	1.02	364.30	142.4	506.7	3.724576	0.30	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.62
18.37	389.12	12.52	135	Yes	56	0	3.217516	Yes	Yes	601.63	2472.02	522.41	1949.61	0.92	0.152	522.41	1949.61	372.33	0.150	1.01	393.92	150.1	544.0	3.724576	0.30	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.49
18.54	436.70	12.552	135	Yes	56	0	2.874298	Yes	Yes	601.46	2494.30	532.71	1961.59	0.92	0.152	532.71	1961.59	416.34	0.114	1.01	440.49	162.2	602.7	3.724576	0.30	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.36
18.70	441.54	12.416	135	Yes	56	0	2.81197	Yes	Yes	601.30	2516.44	542.94	1973.49	0.92	0.152	542.94	1973.49	420.57	0.111	1.01	444.97	163.3	608.3	3.724576	0.30	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.23
18.87	448.07	12.407	135	Yes	56	0	2.768987	Yes	Yes	601.14	2538.58	553.18	1985.40	0.92	0.153	553.18	1985.40	426.39	0.106	1.01	451.12	164.9	616.1	3.724576	0.30	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.10
19.03	456.84	12.409	135	Yes	56	0	2.716274	Yes	Yes	600.97	2560.72	563.41	1997.31	0.92	0.153	563.41	1997.31	434.31	0.100	1.01	459.49	167.1	626.6	3.724576	0.30	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.98
19.19	450.20	9.919	135	Yes	56	0	2.203263	Yes	Yes	600.81	2582.86	573.64	2009.21	0.92	0.153	573.64	2009.21	427.84	0.105	1.01	452.66	165.3	618.0	3.724576	0.30	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.86
19.36	468.97	9.498	135	Yes	56	0	2.025307	Yes	Yes	600.64	2605.00	583.88	2021.12	0.92	0.153	583.88	2021.12	445.14	0.092	1.00	470.96	170.1	641.1	3.724576	0.30	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.74
19.52	471.46	10.826	135	Yes	56	0	2.296276	Yes	Yes	600.48	2627.14	594.11	2033.02	0.91	0.154	594.11	2033.02	447.23	0.091	1.00	473.17	170.7	643.8	3.724576	0.30	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.62
19.69	467.08	11.207	135	Yes	56	0	2.39939	Yes	Yes	600.32	2649.28	604.34	2044.93	0.91	0.154	604.34	2044.93	442.89	0.094	1.00	468.58	169.5	638.1	3.724576	0.30	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.51
19.85	464.83	0	135	Yes	56	0	0	Yes	Yes	600.15	2671.42	614.58	2056.84	0.91	0.154	614.58	2056.84	440.54	0.096	1.00	466.10	168.8	634.9	3.724576	0.30	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.40
20.01	498.13	0	135	Yes	56	0	0	Yes	Yes	599.99	2693.56	624.81	2068.74	0.91	0.154	624.81	2068.74	471.60	0.073	1.00	498.95	177.4	676.3	3.724576	0.30	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.29

CPT Liquefaction Analysis

Method: Idriss and Boulanger (2014), CPT and SPT Based Liquefaction Triggering Procedures

Title: Liquefaction Analysis
Project: Dynegy - Coffeen
Project No.: 60480701

Date: 1/15/2016
Boring No. COF-C049

Unit wt AGWT: 135 pcf
Unit wt BGWT: 135 pcf

Input Parameters:
Peak ground acceleration, pga (g): 0.39
Earthquake Magnitude (M): 6.5
Water Table Depth at the time of drilling 11 ft
Water Table Depth at the time of earthquake 11 ft
Ground Surface Elevation 630 ft

Notes:
1. Sand-like behavior = "Yes", Clay-like behavior = "No" (See Idriss and Boulanger, 2014).
2. Make sure to turn on iterative calculations.
3. User to confirm highlighted values are reasonable.

												At the time of earthquake				At the time of drilling																			
Depth	Qt	Fs	Unit Weight	Liquefiable?[1]	FC	α (From static stress analysis)	Fs/Qt	Below Water Table?	Liquefaction Calculation Needed?	Sample Elev.	Total stress	Pore Pressure	Effective stress	Stress reduction coeff, r_d	CSR	Pore Pressure	Effective stress	qc1n	m	Cn	qc1	Delta qc1ncs	qc1ncs	CRR_{cpt}[3]	C_σ	K_σ	Assg. α	State Para	Para a	Para b	Para c	Kα	MSF_{max}	MSF	IB FSL
(ft)	(TSF)	(TSF)	(pcf)	(Yes/No)			(%)			(ft)	(psf)	(psf)	(psf)			(psf)	(psf)				(TSF)														
0.16	34.64	0.046	135	No	90	0	0.132794	No	No	629.84	22.14		22.14				22.14																		
0.33	77.55	0.083	135	No	90	0	0.107029	No	No	629.67	44.28		44.28				44.28																		
0.49	70.25	0.136	135	No	90	0	0.1936	No	No	629.51	66.42		66.42				66.42																		
0.66	64.12	0.217	135	No	90	0	0.338433	No	No	629.34	88.56		88.56				88.56																		
0.82	36.24	0.449	135	No	90	0	1.239099	No	No	629.18	110.70		110.70				110.70																		
0.98	19.61	0.673	135	No	90	0	3.431922	No	No	629.02	132.84		132.84				132.84																		
1.15	18.26	0.772	135	No	90	0	4.227589	No	No	628.85	154.98		154.98				154.98																		
1.31	18.31	0.813	135	No	90	0	4.440197	No	No	628.69	177.12		177.12				177.12																		
1.48	20.04	0.83	135	No	90	0	4.141923	No	No	628.52	199.26		199.26				199.26																		
1.64	26.68	0.758	135	No	90	0	2.841292	No	No	628.36	221.40		221.40				221.40																		
1.80	29.20	0.848	135	No	90	0	2.904309	No	No	628.20	243.54		243.54				243.54																		
1.97	26.09	0.943	135	No	90	0	3.614412	No	No	628.03	265.68		265.68				265.68																		
2.13	24.70	1.005	135	No	90	0	4.06965	No	No	627.87	287.96		287.96				287.96																		
2.30	26.05	1.031	135	No	90	0	3.957925	No	No	627.70	310.10		310.10				310.10																		
2.46	23.42	1.033	135	No	90	0	4.410572	No	No	627.54	332.24		332.24				332.24																		
2.63	20.72	0.947	135	No	90	0	4.571346	No	No	627.38	354.38		354.38				354.38																		
2.79	19.98	0.941	135	No	90	0	4.709003	No	No	627.21	376.52		376.52				376.52																		
2.95	18.24	0.836	135	No	90	0	4.583082	No	No	627.05	398.66		398.66				398.66																		
3.12	20.78	0.794	135	No	90	0	3.82135	No	No	626.88	420.80		420.80				420.80																		
3.28	22.58	0.774	135	No	90	0	3.428116	No	No	626.72	442.94		442.94				442.94																		
3.45	19.96	0.797	135	No	90	0	3.993186	No	No	626.56	465.08		465.08				465.08																		
3.61	18.81	0.783	135	No	90	0	4.161794	No	No	626.39	487.22		487.22				487.22																		
3.77	18.70	0.711	135	No	90	0	3.801936	No	No	626.23	509.36		509.36				509.36																		
3.94	19.00	0.631	135	No	90	0	3.321752	No	No	626.06	531.50		531.50				531.50																		
4.10	17.24	0.633	135	No	90	0	3.671055	No	No	625.90	553.64		553.64				553.64																		
4.27	15.50	0.57	135	No	90	0	3.676945	No	No	625.74	575.78		575.78				575.78																		
4.43	14.04	0.551	135	No	90	0	3.92534	No	No	625.57	597.92		597.92				597.92																		
4.59	13.90	0.544	135	No	90	0	3.913388	No	No	625.41	620.06		620.06				620.06																		
4.76	15.85	0.466	135	No	90	0	2.940434	No	No	625.24	642.20		642.20				642.20																		
4.92	14.21	0.433	135	No	90	0	3.046507	No	No	625.08	664.34		664.34				664.34																		
5.09	13.21	0.382	135	No	90	0	2.891092	No	No	624.92	686.48		686.48				686.48																		
5.25	12.37	0.345	135	No	90	0	2.788104	No	No	624.75	708.62		708.62				708.62																		
5.41	11.27	0.317	135	No	90	0	2.812777	No	No	624.59	730.76		730.76				730.76																		
5.58	11.64	0.331	135	No	90	0	2.843643	No	No	624.42	752.90		752.90				752.90																		
5.74	15.41	0.35	135	No	90	0	2.270958	No	No	624.26	775.04		775.04				775.04																		
5.91	16.21	0.452	135	No	90	0	2.788918	No	No	624.10	797.18		797.18				797.18																		
6.07	17.41	0.676	135	No	90	0	3.882826	No	No	623.93	819.32		819.32				819.32																		
6.23	17.97	0.748	135	No	90	0	4.163188	No	No	623.77	841.59		841.59				841.59																		
6.40	16.30	0.746	135	No	90	0	4.575845	No	No	623.60	863.73		863.73				863.73																		
6.56	16.45	0.636	135	No	90	0	3.867202	No	No	623.44	885.87		885.87				885.87																		
6.73	15.62	0.574	135	No	90	0	3.67407	No	No	623.27	908.01		908.01				908.01																		
6.89	14.37	0.549	135	No	90	0	3.819396	No	No	623.11	930.15		930.15				930.15																		
7.05	15.20	0.547	135	No	90	0	3.597974	No	No	622.95	952.29		952.29				952.29																		
7.22	16.48	0.617	135	No	90	0	3.743251	No	No	622.78	974.43		974.43				974.43																		
7.38	20.14	0.622	135	No	90	0	3.088995	No	No	622.62	996.57		996.57				996.57																		
7.55	22.13	0.697	135	No	90	0	3.15014	No	No	622.45	1018.71		1018.71				1018.71																		
7.71	22.42	0.873	135	No	90	0	3.89315	No	No	622.29	1040.85		1040.85				1040.85																		
7.87	23.04	1.024	135	No	90	0	4.444444	No	No	622.13	1062.99		1062.99				1062.99																		
8.04	29.59	1.19	135	No	90	0	4.021629	No	No	621.96	1085.13		1085.13				1085.13																		
8.20	32.55	1.432	135	No	90	0	4.399521	No	No	621.80	1107.27		1107.27				1107.27																		
8.37	29.82	1.611	135	No	90	0	5.402958	No	No	621.63	1129.41		1129.41				1129.41																		
8.53	26.03	1.542	135	No	90	0	5.924389	No	No	621.47	1151.55		1151.55				1151.55																		
8.69	21.71	1.294	135	No	90	0	5.959838	No	No	621.31	1173.69		1173.69				1173.69																		
8.86	22.98	1	135	No	90	0	4.352557	No	No	621.14	1195.83		1195.83				1195.83																		
9.02	25.61	0.855	135	No	90	0	3.338409	No	No	620.98	1217.97		1217.97				1217.97																		
9.19	23.74	0.815	135	No	90	0	3.432446	No	No	620.81	1240.11		1240.11				1240.11																		
9.35	22.40	0.813	135	No	90	0	3.629788	No	No	620.65	1262.25		1262.25				1262.25																		
9.51	23.25	0.817	135	No	90	0	3.514734	No	No	620.49	1284.39		1284.39				1284.39																		
9.68	24.66	0.949	135	No	90	0	3.848806	No	No	620.32	1306.53		1306.53				1306.53																		
9.84	38.72	1.145	135	No	90	0	2.956899	No	No	620.16	1328.67		1328.67				1328.67																		
10.01	64.37	1.592	125	No	90	0	2.473355	No	No	619.99	1349.17		1349.17				1349.17																		
10.17	54.79	1.922	125	No	90	0	3.507939	No	No	619.83	1369.67		1369.67				1369.67																		
10.34	42.14	1.878	125	No	90	0	4.456785	No	No	619.67	1390.30		1390.30				1390.30																		
10.50	34.94	1.505	125	No	90	0	4.307507	No	No	619.50	1410.80		1410.80				1410.80																		
10.66	34.98	1.36	125	No	90	0	3.887825	No	No	619.34	1431.30		1431.30				1431.30																		
10.83	35.95	1.248	125	No	90	0	3.471971	No	No	619.17	1451.80		1451.80				1451.80																		
10.99	24.09	1.083	125	No	90	0	4.495268	No	No	619.01	1472.30		1472.30				1472.30																		
11.16	16.56	0.86	125	No	90	0	5.193864	Yes	No	618.85	1492.80	9.67	1483.12			9.67	1483.12																		
11.32	14.72	0.621	125	No	90	0	4.219037	Yes	No	618.68	1513.30	19.91	1493.39			19.91	1493.39																		
11.48	14.27	0.525	125	No	90	0	3.679305	Yes	No	618.52	1533.80	30.14	1503.66			30.14	1503.66																		
11.65	15.33	0.489	125	No	90	0	3.1892	Yes	No	618.35	1554.30	40.37	1513.92			40.37	1513.92																		
11.81	17.12	0.479	125	No	90	0	2.797407	Yes	No	618.19	1574.80	50.61	1524.19			50.61	1524.19																		
11.98	19.02	0.516	125	No	90	0	2.712363	Yes	No	618.03	1595.30	60.84	1534.46			60.84	1534.46																		
12.14	21.57	0.557	125	No	90	0	2.581931	Yes	No	617.86	1615.80	71.07	1544.72			71.07	1544.72																		
12.30	20.01	0.578	125	No	90	0	2.888123	Yes	No	617.70	1636.30	81.31	1554.99			81.31	1554.99																		
12.47	17.51	0.635	125	No	90	0	3.626085	Yes	No	617.53	1656.80	91.54	1565.25			91.54	1565.25																		
12.63	17.07	0.699	125	No	90	0	4.095623	Yes	No	617.37	1677.30	101.77	1575.52			101.77	1575.52																		
12.80	17.59	0.701	125	No	90	0	3.984539	Yes	No	617.21	1697.80	112.01	1585.79			112.01	1585.79																		
12.96	20.08	0.671	125	No	90	0	3.3418	Yes	No	617.04	1718.30	122.24	1596.05			122.24	1596.05																		
13.12	21.42	0.685	125	No	90	0	3.197647	Yes	No	616.88	1738.80	132.48	1606.32			132.48	1606.32																		
13.29	24.35	0.7	125	No	90	0	2.874507	Yes	No	616.71	1759.30	142.71	1616.59			142.71	1616.59																		
13.45	22.62	0.676	125	No	90	0	2.988109	Yes	No	616.55	1779.80	152.94	1626.85			152.94	1626.85																		
13.62	22.22	0.675	125	No	90	0	3.038351	Yes	No	616.39	1800.30	163.18	1637.12			163.18	1637.12																		
13.78	20.16	0.667	125	No	90	0	3.309353	Yes	No	616.22	1820.80	173.41	1647.39			173.41	1647.39																		
13.94	17.45	0.668	125	No	90	0	3.827203	Yes	No	616.06	1841.30	183.64	1657.65			183.64	1657.65																		
14.11	18.04	0.621	125	No	90	0	3.442923	Yes	No	615.89	1861.80	193.88	1667.92			193.88	1667.92																		
14.27	16.19	0.606	125	No	90	0	3.742358	Yes	No	615.73	1882.30	204.11	1678.18			204.11	1678.18																		
14.44	17.23	0.533	125	No	90	0	3.093621	Yes	No	615.56	1902.92	214.41	1688.51			214.41	1688.51																		
14.60	21.50	0.54	125	No	90	0	2.511161	Yes	No	615.40	1923.42	224.64	1698.78			224.64	1698.78																		
14.76	20.74	0.541	125	No	90	0	2.608612	Yes	No	615.24	1943.92	234.87	1709.05			234.87	1709.05																		
14.93	16.08	0.644	125	No	90	0	4.005473	Yes	No	615.07	1964.42	245.11	1719.31			245.11	1719.31																		
15.09	14.02	0.616	125	No	90	0	4.393723	Yes	No	614.91	1984.92	255.34	1729.58			255.34	1729.58																		
15.26	12.05	0.563	125	No	90	0	4.671036	Yes	No	614.74	2005.42	265.57	1739.85			265.57	1739.85																		

CPT Liquefaction Analysis

15.42	11.75	0.484	125	No	90	0	4.120903	Yes	No	614.58	2025.92	275.81	1750.11			275.81	1750.11																		
15.58	13.34	0.435	125	No	90	0	3.261603	Yes	No	614.42	2046.42	286.04	1760.38			286.04	1760.38																		
15.75	12.64	0.383	125	No	90	0	3.030783	Yes	No	614.25	2066.92	296.28	1770.64			296.28	1770.64																		
15.91	12.77	0.423	125	No	90	0	3.31297	Yes	No	614.09	2087.42	306.51	1780.91			306.51	1780.91																		
16.08	14.37	0.432	125	No	90	0	3.007309	Yes	No	613.92	2107.92	316.74	1791.18			316.74	1791.18																		
16.24	13.66	0.442	125	No	90	0	3.236436	Yes	No	613.76	2128.42	326.98	1801.44			326.98	1801.44																		
16.40	12.89	0.481	125	No	90	0	3.732154	Yes	No	613.60	2148.92	337.21	1811.71			337.21	1811.71																		
16.57	13.27	0.504	125	No	90	0	3.797182	Yes	No	613.43	2169.42	347.44	1821.98			347.44	1821.98																		
16.73	11.74	0.47	125	No	90	0	4.00443	Yes	No	613.27	2189.92	357.68	1832.24			357.68	1832.24																		
16.90	11.48	0.444	125	No	90	0	3.86827	Yes	No	613.10	2210.42	367.91	1842.51			367.91	1842.51																		
17.06	13.39	0.495	125	No	90	0	3.696789	Yes	No	612.94	2230.92	378.14	1852.78			378.14	1852.78																		
17.22	16.53	0.496	125	No	90	0	3.000968	Yes	No	612.78	2251.42	388.38	1863.04			388.38	1863.04																		
17.39	14.92	0.464	125	No	90	0	3.110128	Yes	No	612.61	2271.92	398.61	1873.31			398.61	1873.31																		
17.55	12.81	0.418	125	No	90	0	3.262566	Yes	No	612.45	2292.42	408.84	1883.58			408.84	1883.58																		
17.72	10.31	0.366	125	No	90	0	3.548575	Yes	No	612.28	2312.92	419.08	1893.84			419.08	1893.84																		
17.88	9.76	0.333	125	No	90	0	3.413634	Yes	No	612.12	2333.42	429.31	1904.11			429.31	1904.11																		
18.04	9.30	0.293	125	No	90	0	3.149522	Yes	No	611.96	2353.92	439.55	1914.37			439.55	1914.37																		
18.21	8.74	0.27	125	No	90	0	3.088538	Yes	No	611.79	2374.42	449.78	1924.64			449.78	1924.64																		
18.37	10.08	0.259	125	No	90	0	2.570464	Yes	No	611.63	2394.92	460.01	1934.91			460.01	1934.91																		
18.54	9.94	0.279	125	No	90	0	2.807123	Yes	No	611.46	2415.55	470.31	1945.24			470.31	1945.24																		
18.70	10.17	0.294	125	No	90	0	2.889719	Yes	No	611.30	2436.05	480.54	1955.50			480.54	1955.50																		
18.87	9.46	0.287	125	No	90	0	3.033185	Yes	No	611.14	2456.55	490.78	1965.77			490.78	1965.77																		
19.03	9.02	0.198	125	No	90	0	2.195609	Yes	No	610.97	2477.05	501.01	1976.04			501.01	1976.04																		
19.19	8.35	0.2	125	No	90	0	2.396358	Yes	No	610.81	2497.55	511.24	1986.30			511.24	1986.30																		
19.36	9.04	0.222	125	No	90	0	2.455481	Yes	No	610.64	2518.05	521.48	1996.57			521.48	1996.57																		
19.52	8.21	0.21	125	No	90	0	2.558791	Yes	No	610.48	2538.55	531.71	2006.83			531.71	2006.83																		
19.69	8.30	0.18	125	No	90	0	2.169197	Yes	No	610.32	2559.05	541.94	2017.10			541.94	2017.10																		
19.85	8.25	0.184	125	No	90	0	2.231385	Yes	No	610.15	2579.55	552.18	2027.37			552.18	2027.37																		
20.01	8.62	0.152	125	No	90	0	1.76416	Yes	No	609.99	2600.05	562.41	2037.63			562.41	2037.63																		
20.18	9.49	0.101	125	No	90	0	1.064166	Yes	No	609.82	2620.55	572.64	2047.90			572.64	2047.90																		
20.34	8.54	0.06	125	No	90	0	0.702741	Yes	No	609.66	2641.05	582.88	2058.17			582.88	2058.17																		
20.51	7.63	0.04	125	No	90	0	0.524315	Yes	No	609.50	2661.55	593.11	2068.43			593.11	2068.43																		
20.67	5.87	0.043	125	No	90	0	0.732039	Yes	No	609.33	2682.05	603.35	2078.70			603.35	2078.70																		
20.83	5.36	0.03	125	No	90	0	0.559806	Yes	No	609.17	2702.55	613.58	2088.97			613.58	2088.97																		
21.00	6.37	0.027	125	No	90	0	0.423596	Yes	No	609.00	2723.05	623.81	2099.23			623.81	2099.23																		
21.16	6.76	0.048	125	No	90	0	0.71048	Yes	No	608.84	2743.55	634.05	2109.50			634.05	2109.50																		
21.33	10.34	0.084	135	Yes	56	0	0.812222	Yes	Yes	608.68	2765.68	644.28	2121.41	0.90	0.299	644.28	2121.41	9.75	0.884	1.00	10.32	50.4	60.8	0.100	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.128	1.048	0.35
21.49	19.21	0.446	135	Yes	56	0	2.321707	Yes	Yes	608.51	2787.83	654.51	2133.31	0.90	0.299	654.51	2133.31	18.04	0.804	0.99	19.08	52.7	71.8	0.109	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.153	1.058	0.38
21.65	33.18	0.978	135	Yes	56	0	2.947736	Yes	Yes	608.35	2809.97	664.75	2145.22	0.90	0.299	664.75	2145.22	31.05	0.721	0.99	32.85	56.3	89.1	0.125	0.06	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.211	1.080	0.45
21.82	50.88	1.377	135	Yes	56	0	2.706528	Yes	Yes	608.18	2832.11	674.98	2157.12	0.90	0.300	674.98	2157.12	47.49	0.648	0.99	50.25	60.8	111.1	0.154	0.07	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.325	1.122	0.58
21.98	50.80	1.683	135	Yes	56	0	3.312992	Yes	Yes	608.02	2854.25	685.21	2169.03	0.90	0.300	685.21	2169.03	47.25	0.649	0.98	49.99	60.7	110.7	0.153	0.07	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.323	1.121	0.57
22.15	37.19	1.839	135	Yes	56	0	4.945543	Yes	Yes	607.86	2876.39	695.45	2180.94	0.90	0.300	695.45	2180.94	34.41	0.704	0.98	36.40	57.2	93.6	0.130	0.06	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.231	1.087	0.47
22.31	31.58	1.739	135	Yes	56	0	5.506301	Yes	Yes	607.69	2898.53	705.68	2192.84	0.90	0.301	705.68	2192.84	29.08	0.732	0.97	30.77	55.7	86.5	0.122	0.06	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.201	1.076	0.44
22.47	129.33	1.412	135	Yes	56	0	1.091798	Yes	Yes	607.53	2920.67	715.92	2204.75	0.90	0.301	715.92	2204.75	119.97	0.457	0.98	126.92	80.7	207.6	2.990184	0.12	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	14.34
22.64	256.34	1.773	135	Yes	56	0	0.691668	Yes	Yes	607.36	2942.81	726.15	2216.66	0.90	0.301	726.15	2216.66	239.14	0.281	0.99	253.01	113.5	366.5	3.724576	0.30	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.69
22.80	309.83	2.535	135	Yes	56	0	0.818193	Yes	Yes	607.20	2964.95	736.38	2228.56	0.89	0.302	736.38	2228.56	289.43	0.226	0.99	306.22	127.3	433.5	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.64
22.97	313.35	3.207	135	Yes	56	0	1.023463	Yes	Yes	607.04	2987.09	746.62	2240.47	0.89	0.302	746.62	2240.47	292.42	0.223	0.99	309.38	128.1	437.5	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.60
23.13	280.24	2.804	135	Yes	56	0	1.000575	Yes	Yes	606.87	3009.23	756.85	2252.38	0.89	0.302	756.85	2252.38	260.67	0.256	0.98	275.79	119.4	395.2	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.55
23.29	279.79	2.312	135	Yes	56	0	0.826322	Yes	Yes	606.71	3031.37	767.08	2264.28	0.89	0.303	767.08	2264.28	259.89	0.257	0.98	274.96	119.2	394.1	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.51
23.46	297.08	2.176	135	Yes	56	0	0.732468	Yes	Yes	606.54	3053.51	777.32	2276.19	0.89	0.303	777.32	2276.19	275.92	0.240	0.98	291.92	123.6	415.5	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.46
23.62	303.20	2.584	135	Yes	56	0	0.852251	Yes	Yes	606.38	3075.65	787.55	2288.09	0.89	0.303	787.55	2288.09	281.37	0.234	0.98	297.69	125.1	422.8	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.42
23.79	309.84	2.46	135	Yes	56	0	0.793961	Yes	Yes	606.22	3097.79	797.78	2300.00	0.89	0.303	797.78	2300.00	287.33	0.228	0.98	304.00	126.7	430.7	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.38
23.95	305.81	1.826	135	Yes	56	0	0.597107	Yes	Yes	606.05	3119.93	808.02	2311.91	0.89	0.304	808.02	2311.91	283.15	0.233	0.98	299.57	125.6	425.2	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.34
24.11	356.44	1.758	135	Yes	56	0	0.493213	Yes	Yes	605.89	3142.07	818.25	2323.81	0.89	0.304	818.25	2323.81	331.08	0.186	0.98	350.28	138.7	489.0	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.30
24.28	404.71	1.918	135	Yes	56	0	0.473924	Yes	Yes	605.72	3164.21	828.48	2335.72	0.89	0.304	828.48	2335.72	377.05	0.146	0.99	398.92	151.4	550.3	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.26
24.44	434.17	2.462	135	Yes	56	0	0.567062	Yes	Yes	605.56	3186.35	838.72	2347.63	0.88	0.304	838.72	2347.63	405.16	0.123	0.99	428.66	159.1	587.8	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.22
24.61	440.27	3.151	135	Yes	56	0	0.715705	Yes	Yes	605.40	3208.49	848.95	2359.53	0.88	0.304	848.95	2359.53	410.79	0.118	0.99	434.62	160.7	595.3	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.18
24.77	433.69	4.078	135	Yes	56	0	0.940312	Yes	Yes	605.23	3230.63	859.19	2371.44	0.88	0.305	859.19	2371.44	404.17	0.124	0.99	427.62	158.8	586.5	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.14
24.93	438.24	4.664	135	Yes	56	0	1.064252	Yes	Yes	605.07	3252.77	869.42	2383.35	0.88	0.305	869.42	2383.35	408.33	0.120	0.99	432.01	160.0	592.0	3.724576	0.30	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.10
25.10	444.54	5.336	135	Yes	56	0	1.200345	Yes	Yes	604.90	3274.91	879.65	2395.25	0.88	0.305	879.65	2395.25	414.18	0.116	0.99	438.20	161.6	599.8	3.724576	0.30	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.06
25.26	473.92	5.313	135	Yes	56	0	1.12108	Yes	Yes	604.74	3297.05	889.89	2407.16	0.88	0.305	889.89	2407.16	442.53	0.094	0.99	468.19	169.4	637.6	3.724576	0.30	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.03
25.43	514.03	7.764	135	Yes	56	0	1.510412	Yes	Yes	604.58	3319.19	900.12	2419.07	0.88	0.305	900.12	2419.07	481.57	0.066	0.99	509.50	180.1	689.6	3.724576	0.30	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.99
25.59	564.22	0	135	Yes	56	0	0	Yes	Yes	604.41	3341.33	910.35	2430.97	0.88	0.306	910.35	2430.97	530.84	0.033	1.00	561.63	193.7	755.3	3.724576	0.30	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.96
25.75	722.96	0	135	Yes	56	0	0	Yes	Yes	604.25	3363.47	920.59	2442.88	0.88	0.306	920.59	2442.88	689.25	-0.060	1.01	729.23	237.2	966.4	3.724576	0.30	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.92

CPT Liquefaction Analysis

Method: Idriss and Boulanger (2014), CPT and SPT Based Liquefaction Triggering Procedures

Title: Liquefaction Analysis
Project: Dynegy - Coffeen
Project No.: 60480701

Date: 1/15/2016
Boring No. COF-C050

Unit wt AGWT: 135 pcf
Unit wt BGWT: 135 pcf

Input Parameters:
Peak ground acceleration, pga (g): 0.39
Earthquake Magnitude (M): 6.5
Water Table Depth at the time of drilling 8 ft
Water Table Depth at the time of earthquake 8 ft
Ground Surface Elevation 630 ft

Notes:
1. Sand-like behavior = "Yes", Clay-like behavior = "No" (See Idriss and Boulanger, 2014).
2. Make sure to turn on iterative calculations.
3. User to confirm highlighted values are reasonable.

												At the time of earthquake				At the time of drilling																			
Depth	Qt	Fs	Unit Weight	Liquefiable?[1]	FC	α (From static stress analysis)	Fs/Qt	Below Water Table?	Liquefaction Calculation Needed?	Sample Elev.	Total stress	Pore Pressure	Effective stress	Stress reduction coeff, r_d	CSR	Pore Pressure	Effective stress	qc1n	m	Cn	qc1	Delta qc1ncs	qc1ncs	CRR_{cpt}[3]	C_σ	K_σ	Assg. α	State Para	Para a	Para b	Para c	Kα	MSF_{max}	MSF	IB FSL
(ft)	(TSF)	(TSF)	(pcf)	(Yes/No)			(%)			(ft)	(psf)	(psf)	(psf)			(psf)	(psf)				(TSF)													
0.16	56.10	0.031	135	No	90	0	0.055256	No	No	629.84	22.14		22.14				22.14																	
0.33	99.29	0.056	135	No	90	0	0.056403	No	No	629.67	44.28		44.28				44.28																	
0.49	90.59	0.072	135	No	90	0	0.079482	No	No	629.51	66.42		66.42				66.42																	
0.66	58.56	0.236	135	No	90	0	0.402999	No	No	629.34	88.56		88.56				88.56																	
0.82	34.90	0.546	135	No	90	0	1.564694	No	No	629.18	110.70		110.70				110.70																	
0.98	23.58	0.658	135	No	90	0	2.790619	No	No	629.02	132.84		132.84				132.84																	
1.15	22.64	0.754	135	No	90	0	3.330977	No	No	628.85	154.98		154.98				154.98																	
1.31	20.77	0.732	135	No	90	0	3.525163	No	No	628.69	177.12		177.12				177.12																	
1.48	23.40	0.767	135	No	90	0	3.277638	No	No	628.52	199.26		199.26				199.26																	
1.64	30.28	0.839	135	No	90	0	2.771263	No	No	628.36	221.40		221.40				221.40																	
1.80	30.18	1.033	135	No	90	0	3.422797	No	No	628.20	243.54		243.54				243.54																	
1.97	26.82	1.105	135	No	90	0	4.120674	No	No	628.03	265.68		265.68				265.68																	
2.13	26.15	1.073	135	No	90	0	4.103878	No	No	627.87	287.96		287.96				287.96																	
2.30	23.40	1.007	135	No	90	0	4.303419	No	No	627.70	310.10		310.10				310.10																	
2.46	22.38	0.935	135	No	90	0	4.177277	No	No	627.54	332.24		332.24				332.24																	
2.63	21.86	0.813	135	No	90	0	3.719973	No	No	627.38	354.38		354.38				354.38																	
2.79	21.94	0.82	135	No	90	0	3.737466	No	No	627.21	376.52		376.52				376.52																	
2.95	21.48	0.834	135	No	90	0	3.88232	No	No	627.05	398.66		398.66				398.66																	
3.12	19.88	0.82	135	No	90	0	4.124748	No	No	626.88	420.80		420.80				420.80																	
3.28	19.11	0.744	135	No	90	0	3.894269	No	No	626.72	442.94		442.94				442.94																	
3.45	17.53	0.634	135	No	90	0	3.616863	No	No	626.56	465.08		465.08				465.08																	
3.61	17.23	0.606	135	No	90	0	3.516713	No	No	626.39	487.22		487.22				487.22																	
3.77	15.78	0.595	135	No	90	0	3.770835	No	No	626.23	509.36		509.36				509.36																	
3.94	14.84	0.625	135	No	90	0	4.210739	No	No	626.06	531.50		531.50				531.50																	
4.10	16.47	0.636	135	No	90	0	3.860863	No	No	625.90	553.64		553.64				553.64																	
4.27	18.69	0.581	135	No	90	0	3.108781	No	No	625.74	575.78		575.78				575.78																	
4.43	17.69	0.641	135	No	90	0	3.624131	No	No	625.57	597.92		597.92				597.92																	
4.59	17.99	0.642	135	No	90	0	3.569244	No	No	625.41	620.06		620.06				620.06																	
4.76	18.26	0.616	135	No	90	0	3.37294	No	No	625.24	642.20		642.20				642.20																	
4.92	17.49	0.593	135	No	90	0	3.391284	No	No	625.08	664.34		664.34				664.34																	
5.09	18.51	0.605	135	No	90	0	3.268857	No	No	624.92	686.48		686.48				686.48																	
5.25	19.76	0.632	135	No	90	0	3.198704	No	No	624.75	708.62		708.62				708.62																	
5.41	20.17	0.653	135	No	90	0	3.236839	No	No	624.59	730.76		730.76				730.76																	
5.58	17.79	0.632	135	No	90	0	3.552358	No	No	624.42	752.90		752.90				752.90																	
5.74	15.09	0.602	135	No	90	0	3.989133	No	No	624.26	775.04		775.04				775.04																	
5.91	13.32	0.621	135	No	90	0	4.662862	No	No	624.10	797.18		797.18				797.18																	
6.07	12.92	0.584	135	No	90	0	4.520824	No	No	623.93	819.32		819.32				819.32																	
6.23	24.93	0.637	135	No	90	0	2.555257	No	No	623.77	841.59		841.59				841.59																	
6.40	28.63	1.001	135	No	90	0	3.496943	No	No	623.60	863.73		863.73				863.73																	
6.56	28.23	1.249	135	No	90	0	4.424685	No	No	623.44	885.87		885.87				885.87																	
6.73	46.23	1.573	135	No	90	0	3.4027	No	No	623.27	908.01		908.01				908.01																	
6.89	60.65	1.727	135	No	90	0	2.847439	No	No	623.11	930.15		930.15				930.15																	
7.05	54.83	1.809	135	No	90	0	3.299409	No	No	622.95	952.29		952.29				952.29																	
7.22	42.64	1.809	135	No	90	0	4.242694	No	No	622.78	974.43		974.43				974.43																	
7.38	29.06	1.745	135	No	90	0	6.005231	No	No	622.62	996.57		996.57				996.57																	
7.55	27.53	1.635	135	No	90	0	5.938976	No	No	622.45	1018.71		1018.71				1018.71																	
7.71	40.63	1.729	135	No	90	0	4.255686	No	No	622.29	1040.85		1040.85				1040.85																	
7.87	48.60	1.938	135	No	90	0	3.987736	No	No	622.13	1062.99		1062.99				1062.99																	
8.04	41.53	2.159	135	No	90	0	5.198151	Yes	No	621.96	1085.13	2.37	1082.76			2.37	1082.76																	
8.20	34.84	1.826	135	No	90	0	5.240801	Yes	No	621.80	1107.27	12.60	1094.67			12.60	1094.67																	
8.37	29.90	1.491	135	No	90	0	4.986622	Yes	No	621.63	1129.41	22.84	1106.57			22.84	1106.57																	
8.53	28.90	1.223	135	No	90	0	4.231834	Yes	No	621.47	1151.55	33.07	1118.48			33.07	1118.48																	
8.69	36.62	1.231	135	No	90	0	3.361276	Yes	No	621.31	1173.69	43.31	1130.38			43.31	1130.38																	
8.86	33.48	1.31	135	No	90	0	3.912784	Yes	No	621.14	1195.83	53.54	1142.29			53.54	1142.29																	
9.02	29.11	1.305	125	No	90	0	4.483766	Yes	No	620.98	1216.33	63.77	1152.56			63.77	1152.56																	
9.19	26.43	1.052	125	No	90	0	3.980476	Yes	No	620.81	1236.83	74.01	1162.82			74.01	1162.82																	
9.35	25.77	0.939	125	No	90	0	3.643489	Yes	No	620.65	1257.33	84.24	1173.09			84.24	1173.09																	
9.51	22.00	0.873	125	No	90	0	3.968543	Yes	No	620.49	1277.83	94.47	1183.36			94.47	1183.36																	
9.68	20.22	0.883	125	No	90	0	4.367611	Yes	No	620.32	1298.33	104.71	1193.62			104.71	1193.62																	
9.84	18.61	0.885	125	No	90	0	4.754486	Yes	No	620.16	1318.83	114.94	1203.89			114.94	1203.89																	
10.01	18.11	0.817	125	No	90	0	4.510573	Yes	No	619.99	1339.33	125.17	1214.16			125.17	1214.16																	
10.17	17.61	0.734	125	No	90	0	4.168797	Yes	No	619.83	1359.83	135.41	1224.42			135.41	1224.42																	
10.34	17.61	0.7	125	No	90	0	3.976143	Yes	No	619.67	1380.46	145.70	1234.75			145.70	1234.75																	
10.50	18.23	0.695	125	No	90	0	3.811561	Yes	No	619.50	1400.96	155.94	1245.02			155.94	1245.02																	
10.66	18.42	0.696	125	No	90	0	3.777886	Yes	No	619.34	1421.46	166.17	1255.28			166.17	1255.28																	
10.83	18.17	0.687	125	No	90	0	3.780333	Yes	No	619.17	1441.96	176.40	1265.55			176.40	1265.55																	
10.99	17.98	0.667	125	No	90	0	3.708852	Yes	No	619.01	1462.46	186.64	1275.82			186.64	1275.82																	
11.16	17.72	0.642	125	No	90	0	3.623843	Yes	No	618.85	1482.96	196.87	1286.08			196.87	1286.08																	
11.32	17.98	0.622	125	No	90	0	3.459784	Yes	No	618.68	1503.46	207.11	1296.35			207.11	1296.35																	
11.48	17.28	0.577	125	No	90	0	3.339314	Yes	No	618.52	1523.96	217.34	1306.62			217.34	1306.62																	
11.65	17.79	0.558	125	No	90	0	3.13677	Yes	No	618.35	1544.46	227.57	1316.88			227.57	1316.88																	
11.81	20.14	0.589	125	No	90	0	2.923948	Yes	No	618.19	1564.96	237.81	1327.15			237.81	1327.15																	
11.98	19.51	0.577	125	No	90	0	2.958064	Yes	No	618.03	1585.46	248.04	1337.42			248.04	1337.42																	
12.14	17.40	0.53	125	No	90	0	3.046853	Yes	No	617.86	1605.96	258.27	1347.68			258.27	1347.68																	
12.30	14.73	0.444	125	No	90	0	3.013847	Yes	No	617.70	1626.46	268.51	1357.95			268.51	1357.95																	
12.47	14.44	0.369	125	No	90	0	2.554694	Yes	No	617.53	1646.96	278.74	1368.21			278.74	1368.21																	
12.63	14.07	0.35	125	No	90	0	2.488446	Yes	No	617.37	1667.46	288.97	1378.48			288.97	1378.48																	
12.80	12.02	0.344	125	No	90	0	2.861659	Yes	No	617.21	1687.96	299.21	1388.75			299.21	1388.75																	
12.96	11.25	0.341	125	No	90	0	3.031111	Yes	No	617.04	1708.46	309.44	1399.01			309.44	1399.01																	
13.12	10.94	0.295	125	No	90	0	2.697266	Yes	No	616.88	1728.96	319.68	1409.28			319.68	1409.28																	
13.29	10.89	0.265	125	No	90	0	2.434319	Yes	No	616.71	1749.46	329.91	1419.55			329.91	1419.55																	
13.45	10.00	0.271	125	No	90	0	2.711356	Yes	No	616.55	1769.96	340.14	1429.81			340.14	1429.81																	
13.62	9.99	0.268	125	No	90	0	2.681877	Yes	No	616.39	1790.46	350.38	1440.08			350.38	1440.08																	
13.78	9.87	0.247	125	No	90	0	2.502787	Yes	No	616.22	1810.96	360.61	1450.35			360.61	1450.35																	
13.94	9.74	0.235	125	No	90	0	2.411988	Yes	No	616.06	1831.46	370.84	1460.61			370.84	1460.61																	
14.11	10.44	0.239	125	No	90	0	2.289272	Yes	No	615.89	1851.96	381.08	1470.88			381.08	1470.88																	
14.27	11.02	0.252	125	No	90	0	2.287582	Yes	No	615.73	1872.46	391.31	1481.14			391.31	1481.14																	
14.44	11.14	0.284	125	No	90	0	2.550287	Yes	No	615.56	1893.08	401.61	1491.47			401.61	1491.47																	
14.60	11.53	0.311	125	No	90	0	2.697545	Yes	No	615.40	1913.58	411.84	1501.74			411.84	1501.74																	
14.76	11.33	0.321	125	No	90	0	2.832436	Yes	No	615.24	1934.08	422.07	1512.01			422.07	1512.01																	
14.93	11.20	0.313	125	No	90	0	2.793645	Yes	No	615.07	1954.58	432.31	1522.27			432.31	1522.27																	
15.09	11.40	0.316	125	No	90	0	2.772659	Yes	No	614.91	1975.08	442.54	1532.54			442.54	1532.54																	
15.26	11.84	0.327	125	No	90	0	2.761358	Yes	No	614.74	1995.58	452.77	1542.81			452.77	1542.81																	

CPT Liquefaction Analysis

15.42	11.40	0.351	125	No	90	0	3.077867	Yes	No	614.58	2016.08	463.01	1553.07			463.01	1553.07																		
15.58	10.77	0.323	125	No	90	0	2.999907	Yes	No	614.42	2036.58	473.24	1563.34			473.24	1563.34																		
15.75	10.44	0.306	125	No	90	0	2.929912	Yes	No	614.25	2057.08	483.48	1573.60			483.48	1573.60																		
15.91	10.95	0.319	125	No	90	0	2.913508	Yes	No	614.09	2077.58	493.71	1583.87			493.71	1583.87																		
16.08	10.95	0.328	125	No	90	0	2.99434	Yes	No	613.92	2098.08	503.94	1594.14			503.94	1594.14																		
16.24	10.08	0.319	125	No	90	0	3.165311	Yes	No	613.76	2118.58	514.18	1604.40			514.18	1604.40																		
16.40	9.56	0.319	125	No	90	0	3.336471	Yes	No	613.60	2139.08	524.41	1614.67			524.41	1614.67																		
16.57	10.58	0.324	125	No	90	0	3.061224	Yes	No	613.43	2159.58	534.64	1624.94			534.64	1624.94																		
16.73	10.71	0.332	125	No	90	0	3.099617	Yes	No	613.27	2180.08	544.88	1635.20			544.88	1635.20																		
16.90	10.26	0.333	125	No	90	0	3.247196	Yes	No	613.10	2200.58	555.11	1645.47			555.11	1645.47																		
17.06	8.99	0.321	125	No	90	0	3.571826	Yes	No	612.94	2221.08	565.34	1655.74			565.34	1655.74																		
17.22	8.48	0.294	125	No	90	0	3.468617	Yes	No	612.78	2241.58	575.58	1666.00			575.58	1666.00																		
17.39	8.03	0.264	125	No	90	0	3.28849	Yes	No	612.61	2262.08	585.81	1676.27			585.81	1676.27																		
17.55	8.59	0.238	125	No	90	0	2.770664	Yes	No	612.45	2282.58	596.04	1686.54			596.04	1686.54																		
17.72	8.25	0.248	125	No	90	0	3.005332	Yes	No	612.28	2303.08	606.28	1696.80			606.28	1696.80																		
17.88	9.20	0.274	125	No	90	0	2.978585	Yes	No	612.12	2323.58	616.51	1707.07			616.51	1707.07																		
18.04	12.28	0.283	125	No	90	0	2.305123	Yes	No	611.96	2344.08	626.75	1717.33			626.75	1717.33																		
18.21	19.41	0.549	125	No	90	0	2.829168	Yes	No	611.79	2364.58	636.98	1727.60			636.98	1727.60																		
18.37	17.63	0.616	125	No	90	0	3.494044	Yes	No	611.63	2385.08	647.21	1737.87			647.21	1737.87																		
18.54	13.17	0.552	125	No	90	0	4.192936	Yes	No	611.46	2405.71	657.51	1748.20			657.51	1748.20																		
18.70	10.62	0.498	125	No	90	0	4.689266	Yes	No	611.30	2426.21	667.74	1758.46			667.74	1758.46																		
18.87	9.88	0.373	125	No	90	0	3.774158	Yes	No	611.14	2446.71	677.98	1768.73			677.98	1768.73																		
19.03	8.47	0.266	125	No	90	0	3.14198	Yes	No	610.97	2467.21	688.21	1779.00			688.21	1779.00																		
19.19	7.83	0.237	125	No	90	0	3.028754	Yes	No	610.81	2487.71	698.44	1789.26			698.44	1789.26																		
19.36	8.48	0.247	125	No	90	0	2.912049	Yes	No	610.64	2508.21	708.68	1799.53			708.68	1799.53																		
19.52	8.73	0.228	125	No	90	0	2.612282	Yes	No	610.48	2528.71	718.91	1809.79			718.91	1809.79																		
19.69	7.46	0.229	125	No	90	0	3.069294	Yes	No	610.32	2549.21	729.14	1820.06			729.14	1820.06																		
19.85	7.29	0.207	125	No	90	0	2.838727	Yes	No	610.15	2569.71	739.38	1830.33			739.38	1830.33																		
20.01	7.87	0.178	125	No	90	0	2.261753	Yes	No	609.99	2590.21	749.61	1840.59			749.61	1840.59																		
20.18	8.93	0.156	125	No	90	0	1.746334	Yes	No	609.82	2610.71	759.84	1850.86			759.84	1850.86																		
20.34	6.93	0.119	125	No	90	0	1.717915	Yes	No	609.66	2631.21	770.08	1861.13			770.08	1861.13																		
20.51	6.05	0.082	125	No	90	0	1.355148	Yes	No	609.50	2651.71	780.31	1871.39			780.31	1871.39																		
20.67	10.34	0.075	125	No	90	0	0.725479	Yes	No	609.33	2672.21	790.55	1881.66			790.55	1881.66																		
20.83	10.64	0.077	125	No	90	0	0.723616	Yes	No	609.17	2692.71	800.78	1891.93			800.78	1891.93																		
21.00	7.64	0.121	125	No	90	0	1.582941	Yes	No	609.00	2713.21	811.01	1902.19			811.01	1902.19																		
21.16	9.20	0.138	135	Yes	56	0	1.500489	Yes	Yes	608.84	2735.35	821.25	1914.10	0.90	0.328	821.25	1914.10	9.50	0.887	1.09	10.05	50.4	60.4	0.100	0.04	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.128	1.048	0.32
21.33	37.29	0.169	135	Yes	56	0	0.453265	Yes	Yes	608.68	2757.49	831.48	1926.01	0.90	0.328	831.48	1926.01	37.60	0.689	1.07	39.78	58.1	97.9	0.135	0.06	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.251	1.094	0.45
21.49	44.13	0.207	135	Yes	56	0	0.469101	Yes	Yes	608.51	2779.63	841.71	1937.91	0.90	0.328	841.71	1937.91	44.20	0.661	1.06	46.77	59.9	106.7	0.147	0.07	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.298	1.112	0.50
21.65	43.92	0.207	135	Yes	56	0	0.471344	Yes	Yes	608.35	2801.77	851.95	1949.82	0.90	0.328	851.95	1949.82	43.82	0.663	1.06	46.36	59.8	106.2	0.146	0.07	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.295	1.111	0.50
21.82	21.94	0.196	135	Yes	56	0	0.893468	Yes	Yes	608.18	2823.91	862.18	1961.72	0.90	0.329	862.18	1961.72	21.99	0.775	1.06	23.26	53.8	77.1	0.113	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.168	1.063	0.37
21.98	13.02	0.173	135	Yes	56	0	1.328317	Yes	Yes	608.02	2846.05	872.41	1973.63	0.90	0.329	872.41	1973.63	13.06	0.847	1.06	13.82	51.3	65.2	0.103	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.137	1.052	0.33
22.15	11.32	0.143	135	Yes	56	0	1.262805	Yes	Yes	607.86	2868.19	882.65	1985.54	0.90	0.329	882.65	1985.54	11.31	0.866	1.06	11.97	50.9	62.8	0.102	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.133	1.050	0.33
22.31	6.78	0.212	135	Yes	56	0	3.125461	Yes	Yes	607.69	2890.33	892.88	1997.44	0.90	0.329	892.88	1997.44	6.76	0.926	1.05	7.15	49.6	56.8	0.097	0.04	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.121	1.046	0.31
22.47	6.21	0.532	135	Yes	56	0	8.569588	Yes	Yes	607.53	2912.47	903.12	2009.35	0.90	0.329	903.12	2009.35	6.16	0.936	1.05	6.52	49.4	56.0	0.097	0.04	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.120	1.045	0.31
22.64	17.34	0.48	135	Yes	56	0	2.768805	Yes	Yes	607.36	2934.61	913.35	2021.26	0.90	0.330	913.35	2021.26	17.01	0.812	1.04	17.99	52.4	70.4	0.108	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.150	1.056	0.35
22.80	103.29	1.252	135	Yes	56	0	1.212121	Yes	Yes	607.20	2956.75	923.58	2033.16	0.89	0.330	923.58	2033.16	99.59	0.499	1.02	105.37	75.1	180.5	0.74064	0.11	1.00	0.00	0.100	1.000	0.000	0.138	1.000	2.098	1.413	3.19
22.97	201.62	2.467	135	Yes	56	0	1.223565	Yes	Yes	607.04	2978.89	933.82	2045.07	0.89	0.330	933.82	2045.07	192.79	0.339	1.01	203.97	100.7	304.7	3.724576	0.24	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.52
23.13	308.50	3.725	135	Yes	56	0	1.207475	Yes	Yes	606.87	3001.03	944.05	2056.98	0.89	0.330	944.05	2056.98	293.42	0.222	1.01	310.44	128.4	438.8	3.724576	0.30	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.52
23.29	420.01	4.249	135	Yes	56	0	1.011647	Yes	Yes	606.71	3023.17	954.28	2068.88	0.89	0.330	954.28	2068.88	398.13	0.128	1.00	421.23	157.2	578.4	3.724576	0.30	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.48
23.46	511.35	4.987	135	Yes	56	0	0.975258	Yes	Yes	606.54	3045.31	964.52	2080.79	0.89	0.330	964.52	2080.79	483.84	0.065	1.00	511.91	180.7	692.6	3.724576	0.30	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.45
23.62	549.90	5.026	135	Yes	56	0	0.913983	Yes	Yes	606.38	3067.45	974.75	2092.69	0.89	0.330	974.75	2092.69	519.99	0.040	1.00	550.15	190.7	740.8	3.724576	0.30	1.00	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.41
23.79	596.73	0	135	Yes	56	0	0	Yes	Yes	606.22	3089.59	984.98	2104.60	0.89	0.331	984.98	2104.60	564.06	0.012	1.00	596.77	202.8	799.6	3.724576	0.30	1.00	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.38
23.95	603.92	0	135	Yes	56	0	0	Yes	Yes	606.05	3111.73	995.22	2116.51	0.89	0.331	995.22	2116.51	570.82	0.008	1.00	603.92	204.6	808.6	3.724576	0.30	1.00	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.35

CPT Liquefaction Analysis

Method: Idriss and Boulanger (2014), CPT and SPT Based Liquefaction Triggering Procedures

Title: Liquefaction Analysis
Project: Dynegy - Coffeen
Project No.: 60480701

Date: 1/15/2016
Boring No. COF-C051

Unit wt AGWT: 135 pcf
Unit wt BGWT: 135 pcf

Input Parameters:
Peak ground acceleration, pga (g): 0.2
Earthquake Magnitude (M): 6.5
Water Table Depth at the time of drilling 7.5 ft
Water Table Depth at the time of earthquake 7.5 ft
Ground Surface Elevation 625 ft

Notes:
1. Sand-like behavior = "Yes", Clay-like behavior = "No" (See Idriss and Boulanger, 2014).
2. Make sure to turn on iterative calculations.
3. User to confirm highlighted values are reasonable.

												At the time of earthquake				At the time of drilling																			
Depth	Qt	Fs	Unit Weight	Liquefiable?[1]	FC	α (From static stress analysis)	Fs/Qt	Below Water Table?	Liquefaction Calculation Needed?	Sample Elev.	Total stress	Pore Pressure	Effective stress	Stress reduction coeff, r_d	CSR	Pore Pressure	Effective stress	qc1n	m	Cn	qc1	Delta qc1ncs	qc1ncs	CRR_{cpt}[3]	C_σ	K_σ	Assg. α	State Para	Para a	Para b	Para c	Kα	MSF_{max}	MSF	IB FSL
(ft)	(TSF)	(TSF)	(pcf)	(Yes/No)			(%)			(ft)	(psf)	(psf)	(psf)			(psf)	(psf)				(TSF)														
0.16	3.19	0.083	125	No	90	0	2.605148	No	No	624.84	22.14		22.14				22.14																		
0.33	11.31	0.173	125	No	90	0	1.530161	No	No	624.67	42.64		42.64				42.64																		
0.49	6.91	0.265	125	No	90	0	3.834467	No	No	624.51	63.14		63.14				63.14																		
0.66	7.80	0.34	125	No	90	0	4.357857	No	No	624.34	83.64		83.64				83.64																		
0.82	9.30	0.368	125	No	90	0	3.958266	No	No	624.18	104.14		104.14				104.14																		
0.98	11.65	0.395	125	No	90	0	3.389685	No	No	624.02	124.64		124.64				124.64																		
1.15	11.54	0.386	125	No	90	0	3.346047	No	No	623.85	145.14		145.14				145.14																		
1.31	10.86	0.366	125	No	90	0	3.371718	No	No	623.69	165.64		165.64				165.64																		
1.48	10.14	0.363	125	No	90	0	3.580235	No	No	623.52	186.14		186.14				186.14																		
1.64	9.80	0.343	125	No	90	0	3.499286	No	No	623.36	206.64		206.64				206.64																		
1.80	9.08	0.371	125	No	90	0	4.087253	No	No	623.20	227.14		227.14				227.14																		
1.97	10.51	0.453	125	No	90	0	4.309771	No	No	623.03	247.64		247.64				247.64																		
2.13	11.91	0.532	125	No	90	0	4.467585	No	No	622.87	268.27		268.27				268.27																		
2.30	15.05	0.575	125	No	90	0	3.821868	No	No	622.70	288.77		288.77				288.77																		
2.46	11.85	0.642	125	No	90	0	5.415893	No	No	622.54	309.27		309.27				309.27																		
2.63	8.97	0.559	125	No	90	0	6.234664	No	No	622.38	329.77		329.77				329.77																		
2.79	8.29	0.419	125	No	90	0	5.054892	No	No	622.21	350.27		350.27				350.27																		
2.95	8.37	0.378	125	No	90	0	4.513972	No	No	622.05	370.77		370.77				370.77																		
3.12	10.22	0.47	125	No	90	0	4.598376	No	No	621.88	391.27		391.27				391.27																		
3.28	15.05	0.575	125	No	90	0	3.820344	No	No	621.72	411.77		411.77				411.77																		
3.45	18.44	0.651	125	No	12	0	3.531326	No	No	621.56	432.27		432.27				432.27																		
3.61	17.26	0.725	125	No	90	0	4.20022	No	No	621.39	452.77		452.77				452.77																		
3.77	17.10	0.704	125	No	90	0	4.116718	No	No	621.23	473.27		473.27				473.27																		
3.94	15.58	0.715	125	No	90	0	4.589512	No	No	621.06	493.77		493.77				493.77																		
4.10	13.99	0.586	125	No	90	0	4.188107	No	No	620.90	514.27		514.27				514.27																		
4.27	12.34	0.578	125	No	90	0	4.685473	No	No	620.74	534.77		534.77				534.77																		
4.43	11.79	0.545	125	No	90	0	4.624523	No	No	620.57	555.27		555.27				555.27																		
4.59	11.79	0.524	125	No	90	0	4.443691	No	No	620.41	575.77		575.77				575.77																		
4.76	11.72	0.492	125	No	90	0	4.199385	No	No	620.24	596.27		596.27				596.27																		
4.92	12.59	0.51	125	No	90	0	4.050834	No	No	620.08	616.77		616.77				616.77																		
5.09	13.18	0.617	125	No	90	0	4.68027	No	No	619.92	637.27		637.27				637.27																		
5.25	14.55	0.757	125	No	90	0	5.202392	No	No	619.75	657.77		657.77				657.77																		
5.41	14.63	0.875	125	No	90	0	5.982906	No	No	619.59	678.27		678.27				678.27																		
5.58	14.44	0.946	125	No	90	0	6.552154	No	No	619.42	698.77		698.77				698.77																		
5.74	14.38	0.942	125	No	90	0	6.552588	No	No	619.26	719.27		719.27				719.27																		
5.91	14.20	0.939	125	No	90	0	6.611279	No	No	619.10	739.77		739.77				739.77																		
6.07	14.67	0.906	125	No	90	0	6.175448	No	No	618.93	760.27		760.27				760.27																		
6.23	14.93	0.896	125	No	90	0	6.000134	No	No	618.77	780.89		780.89				780.89																		
6.40	15.12	0.839	125	No	90	0	5.548208	No	No	618.60	801.39		801.39				801.39																		
6.56	15.18	0.778	125	No	90	0	5.12584	No	No	618.44	821.89		821.89				821.89																		
6.73	14.92	0.755	125	No	90	0	5.059643	No	No	618.27	842.39		842.39				842.39																		
6.89	14.39	0.74	125	No	90	0	5.141745	No	No	618.11	862.89		862.89				862.89																		
7.05	13.67	0.739	125	No	90	0	5.407581	No	No	617.95	883.39		883.39				883.39																		
7.22	13.09	0.678	125	No	90	0	5.177944	No	No	617.78	903.89		903.89				903.89																		
7.38	12.84	0.532	125	No	90	0	4.144916	No	No	617.62	924.39		924.39				924.39																		
7.55	13.06	0.524	125	No	90	0	4.013788	Yes	No	617.45	944.89	2.87	942.02			2.87	942.02																		
7.71	14.30	0.469	125	No	90	0	3.279032	Yes	No	617.29	965.39	13.10	952.29			13.10	952.29																		
7.87	13.58	0.425	125	No	90	0	3.129833	Yes	No	617.13	985.89	23.34	962.55			23.34	962.55																		
8.04	13.16	0.418	125	No	90	0	3.175568	Yes	No	616.96	1006.39	33.57	972.82			33.57	972.82																		
8.20	12.45	0.414	125	No	90	0	3.3245	Yes	No	616.80	1026.89	43.80	983.09			43.80	983.09																		
8.37	12.06	0.365	125	No	90	0	3.026032	Yes	No	616.63	1047.39	54.04	993.35			54.04	993.35																		
8.53	11.77	0.335	125	No	90	0	2.847429	Yes	No	616.47	1067.89	64.27	1003.62			64.27	1003.62																		
8.69	10.99	0.299	125	No	90	0	2.720655	Yes	No	616.31	1088.39	74.51	1013.88			74.51	1013.88																		
8.86	10.77	0.265	125	No	90	0	2.459853	Yes	No	616.14	1108.89	84.74	1024.15			84.74	1024.15																		
9.02	9.65	0.221	125	No	90	0	2.289681	Yes	No	615.98	1129.39	94.97	1034.42			94.97	1034.42																		
9.19	9.58	0.208	125	No	90	0	2.172324	Yes	No	615.81	1149.89	105.21	1044.68			105.21	1044.68																		
9.35	9.25	0.209	125	No	90	0	2.259948	Yes	No	615.65	1170.39	115.44	1054.95			115.44	1054.95																		
9.51	9.19	0.219	125	No	90	0	2.383025	Yes	No	615.49	1190.89	125.67	1065.22			125.67	1065.22																		
9.68	8.94	0.235	125	No	90	0	2.630106	Yes	No	615.32	1211.39	135.91	1075.48			135.91	1075.48																		
9.84	8.96	0.241	125	No	90	0	2.689432	Yes	No	615.16	1231.89	146.14	1085.75			146.14	1085.75																		
10.01	9.03	0.267	125	No	90	0	2.955829	Yes	No	614.99	1252.39	156.37	1096.02			156.37	1096.02																		
10.17	9.52	0.333	125	No	90	0	3.498267	Yes	No	614.83	1272.89	166.61	1106.28			166.61	1106.28																		
10.34	9.60	0.339	125	No	90	0	3.529779	Yes	No	614.67	1293.52	176.90	1116.61			176.90	1116.61																		
10.50	9.81	0.359	125	No	90	0	3.658412	Yes	No	614.50	1314.02	187.14	1126.88			187.14	1126.88																		
10.66	10.25	0.385	125	No	90	0	3.757197	Yes	No	614.34	1334.52	197.37	1137.14			197.37	1137.14																		
10.83	10.62	0.387	125	No	90	0	3.643039	Yes	No	614.17	1355.02	207.60	1147.41			207.60	1147.41																		
10.99	11.64	0.324	125	No	90	0	2.784462	Yes	No	614.01	1375.52	217.84	1157.68			217.84	1157.68																		
11.16	11.14	0.299	125	No	90	0	2.684745	Yes	No	613.85	1396.02	228.07	1167.94			228.07	1167.94																		
11.32	10.69	0.238	125	No	90	0	2.226172	Yes	No	613.68	1416.52	238.31	1178.21			238.31	1178.21																		
11.48	10.57	0.227	125	No	90	0	2.148604	Yes	No	613.52	1437.02	248.54	1188.48			248.54	1188.48																		
11.65	10.53	0.239	125	No	90	0	2.270137	Yes	No	613.35	1457.52	258.77	1198.74			258.77	1198.74																		
11.81	10.54	0.295	125	No	90	0	2.799393	Yes	No	613.19	1478.02	269.01	1209.01			269.01	1209.01																		
11.98	10.85	0.324	125	No	90	0	2.987552	Yes	No	613.03	1498.52	279.24	1219.28			279.24	1219.28																		
12.14	10.89	0.344	125	No	90	0	3.159442	Yes	No	612.86	1519.02	289.47	1229.54			289.47	1229.54																		
12.30	11.08	0.387	125	No	90	0	3.494357	Yes	No	612.70	1539.52	299.71	1239.81			299.71	1239.81																		
12.47	11.52	0.415	125	No	90	0	3.603682	Yes	No	612.53	1560.02	309.94	1250.07			309.94	1250.07																		
12.63	11.86	0.423	125	No	90	0	3.565408	Yes	No	612.37	1580.52	320.17	1260.34			320.17	1260.34																		
12.80	11.91	0.44	125	No	90	0	3.693754	Yes	No	612.21	1601.02	330.41	1270.61			330.41	1270.61																		
12.96	12.03	0.425	125	No	90	0	3.533422	Yes	No	612.04	1621.52	340.64	1280.87			340.64	1280.87																		
13.12	11.78	0.37	125	No	90	0	3.141717	Yes	No	611.88	1642.02	350.88	1291.14			350.88	1291.14																		
13.29	11.47	0.326	125	No	90	0	2.842693	Yes	No	611.71	1662.52	361.11	1301.41			361.11	1301.41																		
13.45	11.67	0.302	125	No	90	0	2.586945	Yes	No	611.55	1683.02	371.34	1311.67			371.34	1311.67																		
13.62	11.88	0.309	125	No	90	0	2.601667	Yes	No	611.39	1703.52	381.58	1321.94			381.58	1321.94																		
13.78	11.16	0.337	125	No	90	0	3.020525	Yes	No	611.22	1724.02	391.81	1332.21			391.81	1332.21																		
13.94	10.97	0.356	125	No	90	0	3.244327	Yes	No	611.06	1744.52	402.04	1342.47			402.04	1342.47																		
14.11	9.98	0.311	125	No	90	0	3.117482	Yes	No	610.89	1765.02	412.28	1352.74			412.28	1352.74																		
14.27	9.47	0.27	125	No	90	0	2.852615	Yes	No	610.73	1785.52	422.51	1363.00			422.51	1363.00																		
14.44	8.34	0.239	125	No	90	0	2.86502	Yes	No	610.56	1806.14	432.81	1373.33			432.81	1373.33																		
14.60	7.50	0.235	125	No	90	0	3.135005	Yes	No	610.40	1826.64	443.04	1383.60			443.04	1383.60																		
14.76	6.70	0.179	125	No	90	0	2.671642	Yes	No	610.24	1847.14	453.27	1393.87			453.27	1393.87																		
14.93	6.27	0.155	125	No	90	0	2.474062	Yes	No	610.07	1867.64	463.51	1404.13			463.51	1404.13																		
15.09	5.17	0.133	125	No	90	0	2.572036	Yes	No	609.91	1888.14	473.74	1414.40			473.74	1414.40																		
15.26	5.23	0.152	125	No	90	0	2.90631	Yes	No	609.74	1908.64	483.97	1424.67			483.97	1424.67																		

CPT Liquefaction Analysis

15.42	5.89	0.143	125	No	90	0	2.426608	Yes	No	609.58	1929.14	494.21	1434.93			494.21	1434.93																		
15.58	6.09	0.135	125	No	90	0	2.217477	Yes	No	609.42	1949.64	504.44	1445.20			504.44	1445.20																		
15.75	7.84	0.126	125	No	90	0	1.606938	Yes	No	609.25	1970.14	514.68	1455.46			514.68	1455.46																		
15.91	20.49	0.094	125	No	90	0	0.458783	Yes	No	609.09	1990.64	524.91	1465.73			524.91	1465.73																		
16.08	19.99	0.071	135	Yes	56	0	0.35516	Yes	Yes	608.92	2012.78	535.14	1477.64	0.93	0.165	535.14	1477.64	24.80	0.757	1.31	26.23	54.6	80.8	0.117	0.06	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.180	1.068	0.77
16.24	13.82	0.119	135	Yes	56	0	0.861196	Yes	Yes	608.76	2034.92	545.38	1489.54	0.93	0.166	545.38	1489.54	17.35	0.809	1.33	18.36	52.5	70.9	0.108	0.05	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.151	1.057	0.70
16.40	10.83	0.108	135	Yes	56	0	0.997506	Yes	Yes	608.60	2057.06	555.61	1501.45	0.93	0.166	555.61	1501.45	13.66	0.841	1.33	14.45	51.5	66.0	0.104	0.05	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.139	1.052	0.67
16.57	59.80	0.106	135	Yes	56	0	0.177269	Yes	Yes	608.43	2079.20	565.84	1513.36	0.93	0.166	565.84	1513.36	68.59	0.578	1.21	72.57	66.6	139.2	0.231	0.08	1.03	0.00	0.100	1.000	0.000	0.138	1.000	1.552	1.208	1.72
16.73	76.01	0.271	135	Yes	56	0	0.356551	Yes	Yes	608.27	2101.34	576.08	1525.26	0.93	0.167	576.08	1525.26	85.51	0.532	1.19	90.47	71.3	161.7	0.390	0.09	1.03	0.00	0.100	1.000	0.000	0.138	1.000	1.815	1.307	3.15
16.90	78.45	0.671	135	Yes	56	0	0.855333	Yes	Yes	608.10	2123.48	586.31	1537.17	0.93	0.167	586.31	1537.17	87.74	0.527	1.18	92.83	71.9	164.7	0.425	0.10	1.03	0.00	0.100	1.000	0.000	0.138	1.000	1.856	1.322	3.47
17.06	84.42	0.934	135	Yes	56	0	1.106425	Yes	Yes	607.94	2145.62	596.54	1549.08	0.93	0.167	596.54	1549.08	93.62	0.513	1.17	99.05	73.5	172.5	0.549	0.10	1.03	0.00	0.100	1.000	0.000	0.138	1.000	1.971	1.365	4.62
17.22	103.48	0.93	135	Yes	56	0	0.898707	Yes	Yes	607.78	2167.76	606.78	1560.98	0.93	0.167	606.78	1560.98	112.87	0.471	1.15	119.42	78.8	198.2	1.709357	0.12	1.04	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	15.35
17.39	151.21	1.026	135	Yes	56	0	0.678518	Yes	Yes	607.61	2189.90	617.01	1572.89	0.93	0.168	617.01	1572.89	160.29	0.387	1.12	169.59	91.8	261.4	3.724576	0.18	1.05	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.91
17.55	179.72	1.015	135	Yes	56	0	0.564783	Yes	Yes	607.45	2212.04	627.24	1584.80	0.93	0.168	627.24	1584.80	187.74	0.346	1.11	198.63	99.4	298.0	3.724576	0.23	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.32
17.72	203.23	1.097	135	Yes	56	0	0.53978	Yes	Yes	607.28	2234.18	637.48	1596.70	0.92	0.168	637.48	1596.70	209.99	0.316	1.09	222.17	105.5	327.6	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.82
17.88	209.75	0.956	135	Yes	56	0	0.455772	Yes	Yes	607.12	2256.32	647.71	1608.61	0.92	0.168	647.71	1608.61	215.79	0.309	1.09	228.30	107.1	335.4	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.73
18.04	206.76	1.453	135	Yes	56	0	0.702737	Yes	Yes	606.96	2278.46	657.95	1620.51	0.92	0.169	657.95	1620.51	212.46	0.313	1.09	224.79	106.1	330.9	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.61
18.21	231.97	2.678	135	Yes	56	0	1.154485	Yes	Yes	606.79	2300.60	668.18	1632.42	0.92	0.169	668.18	1632.42	236.04	0.284	1.08	249.73	112.6	362.4	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.50
18.37	231.22	3.715	135	Yes	56	0	1.606667	Yes	Yes	606.63	2322.74	678.41	1644.33	0.92	0.169	678.41	1644.33	234.88	0.286	1.07	248.50	112.3	360.8	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.38
18.54	195.63	5.236	135	Yes	56	0	2.676467	Yes	Yes	606.46	2345.02	688.71	1656.31	0.92	0.169	688.71	1656.31	200.42	0.329	1.08	212.05	102.8	314.9	3.724576	0.26	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.99
18.70	204.85	5.733	135	Yes	56	0	2.798592	Yes	Yes	606.30	2367.16	698.94	1668.21	0.92	0.170	698.94	1668.21	208.83	0.318	1.08	220.94	105.1	326.1	3.724576	0.29	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.10
18.87	289.14	5.371	135	Yes	56	0	1.85759	Yes	Yes	606.14	2389.30	709.18	1680.12	0.92	0.170	709.18	1680.12	288.02	0.228	1.05	304.72	126.9	431.6	3.724576	0.30	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.06
19.03	463.78	5.375	135	Yes	56	0	1.158952	Yes	Yes	605.97	2411.44	719.41	1692.03	0.92	0.170	719.41	1692.03	447.34	0.091	1.02	473.28	170.7	644.0	3.724576	0.30	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.95
19.19	544.54	5.94	135	Yes	56	0	1.090837	Yes	Yes	605.81	2433.58	729.64	1703.93	0.92	0.170	729.64	1703.93	519.24	0.041	1.01	549.35	190.5	739.8	3.724576	0.30	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.85
19.36	601.51	7.226	135	Yes	56	0	1.20131	Yes	Yes	605.64	2455.72	739.88	1715.84	0.92	0.170	739.88	1715.84	569.56	0.009	1.00	602.59	204.3	806.9	3.724576	0.30	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.75
19.52	666.46	6.571	135	Yes	56	0	0.985951	Yes	Yes	605.48	2477.86	750.11	1727.74	0.91	0.170	750.11	1727.74	626.69	-0.025	0.99	663.04	220.0	883.0	3.724576	0.30	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.65
19.69	760.16	6.182	135	Yes	56	0	0.813247	Yes	Yes	605.32	2500.00	760.34	1739.65	0.91	0.171	760.34	1739.65	708.66	-0.070	0.99	749.76	242.5	992.3	3.724576	0.30	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.55
19.85	798.56	5.688	135	Yes	56	0	0.712283	Yes	Yes	605.15	2522.14	770.58	1751.56	0.91	0.171	770.58	1751.56	742.37	-0.088	0.98	785.42	251.8	1037.2	3.724576	0.30	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.45
20.01	872.03	0	135	Yes	56	0	0	Yes	Yes	604.99	2544.28	780.81	1763.46	0.91	0.171	780.81	1763.46	806.50	-0.119	0.98	853.28	269.4	1122.7	3.724576	0.30	1.05	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.36
20.18	902.56	0	135	Yes	56	0	0	Yes	Yes	604.82	2566.42	791.04	1775.37	0.91	0.171	791.04	1775.37	833.54	-0.132	0.98	881.89	276.8	1158.7	3.724576	0.30	1.05	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	33.27

CPT Liquefaction Analysis

Method: Idriss and Boulanger (2014), CPT and SPT Based Liquefaction Triggering Procedures

Title: Liquefaction Analysis
Project: Dynegy - Coffeen
Project No.: 60480701

Date: 1/15/2016
Boring No. COF-C052

Unit wt AGWT: 135 pcf
Unit wt BGWT: 135 pcf

Input Parameters:
Peak ground acceleration, pga (g): 0.39
Earthquake Magnitude (M): 6.5
Water Table Depth at the time of drilling 11 ft
Water Table Depth at the time of earthquake 11 ft
Ground Surface Elevation 630 ft

Notes:
1. Sand-like behavior = "Yes", Clay-like behavior = "No" (See Idriss and Boulanger, 2014).
2. Make sure to turn on iterative calculations.
3. User to confirm highlighted values are reasonable.

												At the time of earthquake				At the time of drilling																			
Depth	Qt	Fs	Unit Weight	Liquefiable?[1]	FC	α (From static stress analysis)	Fs/Qt	Below Water Table?	Liquefaction Calculation Needed?	Sample Elev.	Total stress	Pore Pressure	Effective stress	Stress reduction coeff, r_d	CSR	Pore Pressure	Effective stress	qc1n	m	Cn	qc1	Delta qc1ncs	qc1ncs	CRR_{cpt}[3]	C_σ	K_σ	Assg. α	State Para	Para a	Para b	Para c	Kα	MSF_{max}	MSF	IB FSL
(ft)	(TSF)	(TSF)	(pcf)	(Yes/No)			(%)			(ft)	(psf)	(psf)	(psf)			(psf)	(psf)				(TSF)														
0.16	38.73	0.115	135	No	90	0	0.296958	No	No	629.84	22.14		22.14				22.14																		
0.33	38.70	0.275	135	No	90	0	0.710613	No	No	629.67	44.28		44.28				44.28																		
0.49	17.05	0.451	135	No	90	0	2.645937	No	No	629.51	66.42		66.42				66.42																		
0.66	17.68	0.56	135	No	90	0	3.168317	No	No	629.34	88.56		88.56				88.56																		
0.82	19.90	0.616	135	No	90	0	3.095477	No	No	629.18	110.70		110.70				110.70																		
0.98	20.83	0.651	135	No	90	0	3.12545	No	No	629.02	132.84		132.84				132.84																		
1.15	21.66	0.677	135	No	90	0	3.126299	No	No	628.85	154.98		154.98				154.98																		
1.31	22.35	0.714	135	No	90	0	3.194631	No	No	628.69	177.12		177.12				177.12																		
1.48	22.36	0.765	135	No	90	0	3.421747	No	No	628.52	199.26		199.26				199.26																		
1.64	21.34	0.759	135	No	90	0	3.556201	No	No	628.36	221.40		221.40				221.40																		
1.80	21.33	0.737	135	No	90	0	3.455227	No	No	628.20	243.54		243.54				243.54																		
1.97	23.14	0.723	135	No	90	0	3.12473	No	No	628.03	265.68		265.68				265.68																		
2.13	22.34	0.78	135	No	90	0	3.491183	No	No	627.87	287.96		287.96				287.96																		
2.30	22.14	0.854	135	No	90	0	3.857795	No	No	627.70	310.10		310.10				310.10																		
2.46	22.63	0.846	135	No	90	0	3.73774	No	No	627.54	332.24		332.24				332.24																		
2.63	20.35	0.821	135	No	90	0	4.03539	No	No	627.38	354.38		354.38				354.38																		
2.79	18.57	0.768	135	No	90	0	4.136594	No	No	627.21	376.52		376.52				376.52																		
2.95	18.75	0.832	135	No	90	0	4.43686	No	No	627.05	398.66		398.66				398.66																		
3.12	26.37	0.847	135	No	90	0	3.212105	No	No	626.88	420.80		420.80				420.80																		
3.28	25.90	0.978	135	No	90	0	3.775624	No	No	626.72	442.94		442.94				442.94																		
3.45	23.71	1.061	135	No	90	0	4.47415	No	No	626.56	465.08		465.08				465.08																		
3.61	23.56	1.002	135	No	90	0	4.25261	No	No	626.39	487.22		487.22				487.22																		
3.77	18.70	0.993	135	No	90	0	5.31016	No	No	626.23	509.36		509.36				509.36																		
3.94	19.92	0.929	135	No	90	0	4.663421	No	No	626.06	531.50		531.50				531.50																		
4.10	28.04	0.92	135	No	90	0	3.281612	No	No	625.90	553.64		553.64				553.64																		
4.27	24.68	0.964	135	No	90	0	3.906155	No	No	625.74	575.78		575.78				575.78																		
4.43	18.16	0.961	135	No	90	0	5.292433	No	No	625.57	597.92		597.92				597.92																		
4.59	13.79	0.939	135	No	90	0	6.81027	No	No	625.41	620.06		620.06				620.06																		
4.76	17.75	0.759	135	No	90	0	4.276056	No	No	625.24	642.20		642.20				642.20																		
4.92	21.30	0.763	135	No	90	0	3.582328	No	No	625.08	664.34		664.34				664.34																		
5.09	26.38	0.831	135	No	90	0	3.150472	No	No	624.92	686.48		686.48				686.48																		
5.25	27.23	0.946	135	No	90	0	3.474237	No	No	624.75	708.62		708.62				708.62																		
5.41	27.00	1.071	135	No	90	0	3.966814	No	No	624.59	730.76		730.76				730.76																		
5.58	24.84	1.253	135	No	90	0	5.045299	No	No	624.42	752.90		752.90				752.90																		
5.74	22.63	1.193	135	No	90	0	5.271297	No	No	624.26	775.04		775.04				775.04																		
5.91	23.75	1.11	135	No	90	0	4.674668	No	No	624.10	797.18		797.18				797.18																		
6.07	27.16	0.975	135	No	90	0	3.590102	No	No	623.93	819.32		819.32				819.32																		
6.23	29.12	1.096	135	No	90	0	3.763349	No	No	623.77	841.59		841.59				841.59																		
6.40	31.19	1.404	135	No	90	0	4.501154	No	No	623.60	863.73		863.73				863.73																		
6.56	29.51	1.626	135	No	90	0	5.510183	No	No	623.44	885.87		885.87				885.87																		
6.73	27.21	1.6	135	No	90	0	5.879327	No	No	623.27	908.01		908.01				908.01																		
6.89	21.92	1.387	135	No	90	0	6.327555	No	No	623.11	930.15		930.15				930.15																		
7.05	19.10	1.156	135	No	90	0	6.052356	No	No	622.95	952.29		952.29				952.29																		
7.22	19.08	0.925	135	No	90	0	4.849025	No	No	622.78	974.43		974.43				974.43																		
7.38	15.58	0.889	135	No	90	0	5.706766	No	No	622.62	996.57		996.57				996.57																		
7.55	15.19	0.906	135	No	90	0	5.964058	No	No	622.45	1018.71		1018.71				1018.71																		
7.71	15.33	0.996	135	No	90	0	6.497488	No	No	622.29	1040.85		1040.85				1040.85																		
7.87	22.01	0.999	135	No	90	0	4.539258	No	No	622.13	1062.99		1062.99				1062.99																		
8.04	28.32	1.103	135	No	90	0	3.894224	No	No	621.96	1085.13		1085.13				1085.13																		
8.20	31.90	1.27	135	No	90	0	3.980942	No	No	621.80	1107.27		1107.27				1107.27																		
8.37	31.48	1.518	135	No	90	0	4.821803	No	No	621.63	1129.41		1129.41				1129.41																		
8.53	26.50	1.617	135	No	90	0	6.101196	No	No	621.47	1151.55		1151.55				1151.55																		
8.69	26.03	1.616	135	No	90	0	6.207506	No	No	621.31	1173.69		1173.69				1173.69																		
8.86	28.17	1.482	135	No	90	0	5.260729	No	No	621.14	1195.83		1195.83				1195.83																		
9.02	31.46	1.328	135	No	90	0	4.221233	No	No	620.98	1217.97		1217.97				1217.97																		
9.19	28.57	1.356	135	No	90	0	4.746902	No	No	620.81	1240.11		1240.11				1240.11																		
9.35	20.34	1.196	135	No	90	0	5.879461	No	No	620.65	1262.25		1262.25				1262.25																		
9.51	18.57	1.027	135	No	90	0	5.531915	No	No	620.49	1284.39		1284.39				1284.39																		
9.68	18.51	0.802	135	No	90	0	4.332793	No	No	620.32	1306.53		1306.53				1306.53																		
9.84	17.17	0.745	135	No	90	0	4.338205	No	No	620.16	1328.67		1328.67				1328.67																		
10.01	16.68	0.649	125	No	90	0	3.892054	No	No	619.99	1349.17		1349.17				1349.17																		
10.17	14.94	0.6	125	No	90	0	4.016333	No	No	619.83	1369.67		1369.67				1369.67																		
10.34	13.84	0.572	125	No	90	0	4.132649	No	No	619.67	1390.30		1390.30				1390.30																		
10.50	12.23	0.54	125	No	90	0	4.414289	No	No	619.50	1410.80		1410.80				1410.80																		
10.66	12.03	0.56	125	No	90	0	4.656965	No	No	619.34	1431.30		1431.30				1431.30																		
10.83	14.53	0.615	125	No	90	0	4.232622	No	No	619.17	1451.80		1451.80				1451.80																		
10.99	12.81	0.685	125	No	90	0	5.34822	No	No	619.01	1472.30		1472.30				1472.30																		
11.16	10.24	0.695	125	No	90	0	6.785122	Yes	No	618.85	1492.80	9.67	1483.12			9.67	1483.12																		
11.32	9.88	0.565	125	No	90	0	5.716888	Yes	No	618.68	1513.30	19.91	1493.39			19.91	1493.39																		
11.48	10.08	0.475	125	No	90	0	4.712769	Yes	No	618.52	1533.80	30.14	1503.66			30.14	1503.66																		
11.65	10.53	0.452	125	No	90	0	4.292905	Yes	No	618.35	1554.30	40.37	1513.92			40.37	1513.92																		
11.81	10.59	0.493	125	No	90	0	4.655775	Yes	No	618.19	1574.80	50.61	1524.19			50.61	1524.19																		
11.98	12.12	0.532	125	No	90	0	4.390163	Yes	No	618.03	1595.30	60.84	1534.46			60.84	1534.46																		
12.14	12.12	0.563	125	No	90	0	4.646748	Yes	No	617.86	1615.80	71.07	1544.72			71.07	1544.72																		
12.30	11.67	0.614	125	No	90	0	5.261805	Yes	No	617.70	1636.30	81.31	1554.99			81.31	1554.99																		
12.47	12.31	0.607	125	No	90	0	4.932553	Yes	No	617.53	1656.80	91.54	1565.25			91.54	1565.25																		
12.63	11.86	0.588	125	No	90	0	4.956588	Yes	No	617.37	1677.30	101.77	1575.52			101.77	1575.52																		
12.80	12.30	0.544	125	No	90	0	4.422764	Yes	No	617.21	1697.80	112.01	1585.79			112.01	1585.79																		
12.96	12.43	0.504	125	No	90	0	4.053728	Yes	No	617.04	1718.30	122.24	1596.05			122.24	1596.05																		
13.12	11.74	0.473	125	No	90	0	4.029991	Yes	No	616.88	1738.80	132.48	1606.32			132.48	1606.32																		
13.29	12.17	0.529	125	No	90	0	4.345683	Yes	No	616.71	1759.30	142.71	1616.59			142.71	1616.59																		
13.45	15.43	0.62	125	No	90	0	4.018667	Yes	No	616.55	1779.80	152.94	1626.85			152.94	1626.85																		
13.62	14.21	0.595	125	No	90	0	4.186014	Yes	No	616.39	1800.30	163.18	1637.12			163.18	1637.12																		
13.78	12.17	0.561	125	No	90	0	4.610075	Yes	No	616.22	1820.80	173.41	1647.39			173.41	1647.39																		
13.94	11.40	0.486	125	No	90	0	4.262784	Yes	No	616.06	1841.30	183.64	1657.65			183.64	1657.65																		
14.11	10.06	0.463	125	No	90	0	4.603301	Yes	No	615.89	1861.80	193.88	1667.92			193.88	1667.92																		
14.27	9.68	0.444	125	No	90	0	4.586303	Yes	No	615.73	1882.30	204.11	1678.18			204.11	1678.18																		
14.44	9.70	0.393	125	No	90	0	4.051129	Yes	No	615.56	1902.92	214.41	1688.51			214.41	1688.51																		
14.60	9.19	0.396	125	No	90	0	4.30997	Yes	No	615.40	1923.42	224.64	1698.78			224.64	1698.78																		
14.76	9.25	0.425	125	No	90	0	4.596582	Yes	No	615.24	1943.92	234.87	1709.05			234.87	1709.05																		
14.93	7.89	0.509	125	No	90	0	6.447935	Yes	No	615.07	1964.42	245.11	1719.31			245.11	1719.31																		
15.09	7.51	0.531	125	No	90	0	7.066809	Yes	No	614.91	1984.92	255.34	1729.58			255.34	1729.58																		
15.26	6.69	0.511	125	No	90	0	7.643979	Yes	No	614.74	2005.42	265.57	1739.85			265.57	1739.85																		

CPT Liquefaction Analysis

15.42	6.11	0.465	125	No	90	0	7.610475	Yes	No	614.58	2025.92	275.81	1750.11			275.81	1750.11																		
15.58	7.34	0.432	125	No	90	0	5.885559	Yes	No	614.42	2046.42	286.04	1760.38			286.04	1760.38																		
15.75	7.47	0.414	125	No	90	0	5.543653	Yes	No	614.25	2066.92	296.28	1770.64			296.28	1770.64																		
15.91	7.48	0.396	125	No	90	0	5.295534	Yes	No	614.09	2087.42	306.51	1780.91			306.51	1780.91																		
16.08	7.92	0.399	125	No	90	0	5.040424	Yes	No	613.92	2107.92	316.74	1791.18			316.74	1791.18																		
16.24	8.30	0.403	125	No	90	0	4.854252	Yes	No	613.76	2128.42	326.98	1801.44			326.98	1801.44																		
16.40	8.49	0.461	125	No	90	0	5.428	Yes	No	613.60	2148.92	337.21	1811.71			337.21	1811.71																		
16.57	8.17	0.46	125	No	90	0	5.629666	Yes	No	613.43	2169.42	347.44	1821.98			347.44	1821.98																		
16.73	7.80	0.463	125	No	90	0	5.936659	Yes	No	613.27	2189.92	357.68	1832.24			357.68	1832.24																		
16.90	8.11	0.444	125	No	90	0	5.475398	Yes	No	613.10	2210.42	367.91	1842.51			367.91	1842.51																		
17.06	8.31	0.396	125	No	90	0	4.765916	Yes	No	612.94	2230.92	378.14	1852.78			378.14	1852.78																		
17.22	7.86	0.401	125	No	90	0	5.101132	Yes	No	612.78	2251.42	388.38	1863.04			388.38	1863.04																		
17.39	8.44	0.379	125	No	90	0	4.492651	Yes	No	612.61	2271.92	398.61	1873.31			398.61	1873.31																		
17.55	8.00	0.377	125	No	90	0	4.713678	Yes	No	612.45	2292.42	408.84	1883.58			408.84	1883.58																		
17.72	7.36	0.348	125	No	90	0	4.729546	Yes	No	612.28	2312.92	419.08	1893.84			419.08	1893.84																		
17.88	8.06	0.35	125	No	90	0	4.344049	Yes	No	612.12	2333.42	429.31	1904.11			429.31	1904.11																		
18.04	8.44	0.368	125	No	90	0	4.359673	Yes	No	611.96	2353.92	439.55	1914.37			439.55	1914.37																		
18.21	9.39	0.395	125	No	90	0	4.206603	Yes	No	611.79	2374.42	449.78	1924.64			449.78	1924.64																		
18.37	9.76	0.418	125	No	90	0	4.284982	Yes	No	611.63	2394.92	460.01	1934.91			460.01	1934.91																		
18.54	10.65	0.421	125	No	90	0	3.95268	Yes	No	611.46	2415.55	470.31	1945.24			470.31	1945.24																		
18.70	11.54	0.44	125	No	90	0	3.812495	Yes	No	611.30	2436.05	480.54	1955.50			480.54	1955.50																		
18.87	11.13	0.525	125	No	90	0	4.71571	Yes	No	611.14	2456.55	490.78	1965.77			490.78	1965.77																		
19.03	10.88	0.537	125	No	90	0	4.934755	Yes	No	610.97	2477.05	501.01	1976.04			501.01	1976.04																		
19.19	10.44	0.53	125	No	90	0	5.075656	Yes	No	610.81	2497.55	511.24	1986.30			511.24	1986.30																		
19.36	10.76	0.49	125	No	90	0	4.553057	Yes	No	610.64	2518.05	521.48	1996.57			521.48	1996.57																		
19.52	10.03	0.444	125	No	90	0	4.42672	Yes	No	610.48	2538.55	531.71	2006.83			531.71	2006.83																		
19.69	10.16	0.405	125	No	90	0	3.987005	Yes	No	610.32	2559.05	541.94	2017.10			541.94	2017.10																		
19.85	10.05	0.403	125	No	90	0	4.011946	Yes	No	610.15	2579.55	552.18	2027.37			552.18	2027.37																		
20.01	9.54	0.416	125	No	90	0	4.362416	Yes	No	609.99	2600.05	562.41	2037.63			562.41	2037.63																		
20.18	9.93	0.381	125	No	90	0	3.838404	Yes	No	609.82	2620.55	572.64	2047.90			572.64	2047.90																		
20.34	10.84	0.385	125	No	90	0	3.552644	Yes	No	609.66	2641.05	582.88	2058.17			582.88	2058.17																		
20.51	12.30	0.453	125	No	90	0	3.68173	Yes	No	609.50	2661.55	593.11	2068.43			593.11	2068.43																		
20.67	10.43	0.521	125	No	90	0	4.996164	Yes	No	609.33	2682.05	603.35	2078.70			603.35	2078.70																		
20.83	8.70	0.481	125	No	90	0	5.52683	Yes	No	609.17	2702.55	613.58	2088.97			613.58	2088.97																		
21.00	8.66	0.428	125	No	90	0	4.939982	Yes	No	609.00	2723.05	623.81	2099.23			623.81	2099.23																		
21.16	10.28	0.39	125	No	90	0	3.793405	Yes	No	608.84	2743.55	634.05	2109.50			634.05	2109.50																		
21.33	10.53	0.39	125	No	90	0	3.703	Yes	No	608.68	2764.04	644.28	2119.76			644.28	2119.76																		
21.49	6.43	0.315	125	No	90	0	4.895866	Yes	No	608.51	2784.54	654.51	2130.03			654.51	2130.03																		
21.65	6.19	0.224	125	No	90	0	3.61991	Yes	No	608.35	2805.04	664.75	2140.30			664.75	2140.30																		
21.82	5.62	0.207	125	No	90	0	3.685241	Yes	No	608.18	2825.54	674.98	2150.56			674.98	2150.56																		
21.98	7.48	0.254	125	No	90	0	3.397539	Yes	No	608.02	2846.04	685.21	2160.83			685.21	2160.83																		
22.15	10.11	0.247	125	No	90	0	2.444334	Yes	No	607.86	2866.54	695.45	2171.10			695.45	2171.10																		
22.31	17.32	0.471	135	Yes	56	0	2.719086	Yes	Yes	607.69	2888.68	705.68	2183.00	0.90	0.301	705.68	2183.00	15.96	0.821	0.97	16.88	52.1	69.0	0.106	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.146	1.055	0.37
22.47	22.67	0.507	135	Yes	56	0	2.236239	Yes	Yes	607.53	2910.82	715.92	2194.91	0.90	0.301	715.92	2194.91	20.82	0.783	0.97	22.03	53.5	75.5	0.112	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.164	1.062	0.39
22.64	25.23	0.546	135	Yes	56	0	2.164176	Yes	Yes	607.36	2932.96	726.15	2206.82	0.90	0.302	726.15	2206.82	23.09	0.768	0.97	24.43	54.1	78.5	0.114	0.05	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.173	1.065	0.40
22.80	32.59	0.697	135	Yes	56	0	2.139021	Yes	Yes	607.20	2955.10	736.38	2218.72	0.89	0.302	736.38	2218.72	29.75	0.728	0.97	31.48	55.9	87.4	0.123	0.06	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.205	1.077	0.44
22.97	61.96	0.656	135	Yes	56	0	1.058765	Yes	Yes	607.04	2977.24	746.62	2230.63	0.89	0.302	746.62	2230.63	56.69	0.615	0.97	59.98	63.3	123.3	0.179	0.08	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.412	1.155	0.68
23.13	108.56	1.69	135	Yes	56	0	1.556815	Yes	Yes	606.87	2999.38	756.85	2242.54	0.89	0.303	756.85	2242.54	99.67	0.499	0.97	105.45	75.1	180.6	0.743873	0.11	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.100	1.414	3.45
23.29	227.05	3.58	135	Yes	56	0	1.576724	Yes	Yes	606.71	3021.52	767.08	2254.44	0.89	0.303	767.08	2254.44	210.35	0.316	0.98	222.55	105.6	328.1	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.51
23.46	322.58	5.619	135	Yes	56	0	1.741877	Yes	Yes	606.54	3043.66	777.32	2266.35	0.89	0.303	777.32	2266.35	300.43	0.215	0.99	317.85	130.3	448.2	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.47
23.62	319.51	8.306	135	Yes	56	0	2.599581	Yes	Yes	606.38	3065.80	787.55	2278.25	0.89	0.303	787.55	2278.25	297.16	0.218	0.98	314.40	129.4	443.8	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.43
23.79	327.24	10.127	135	Yes	56	0	3.094708	Yes	Yes	606.22	3087.95	797.78	2290.16	0.89	0.304	797.78	2290.16	304.17	0.211	0.98	321.81	131.4	453.2	3.724576	0.30	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.38
23.95	358.49	10.715	135	Yes	56	0	2.988901	Yes	Yes	606.05	3110.09	808.02	2302.07	0.89	0.304	808.02	2302.07	333.64	0.184	0.98	352.99	139.5	492.4	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.34
24.11	330.72	9.66	135	Yes	56	0	2.920882	Yes	Yes	605.89	3132.23	818.25	2313.97	0.89	0.304	818.25	2313.97	306.81	0.209	0.98	324.60	132.1	456.7	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.30
24.28	277.41	8.479	135	Yes	56	0	3.056498	Yes	Yes	605.72	3154.37	828.48	2325.88	0.89	0.304	828.48	2325.88	255.79	0.262	0.98	270.62	118.1	388.7	3.724576	0.30	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.26
24.44	201.24	8	135	Yes	56	0	3.975412	Yes	Yes	605.56	3176.51	838.72	2337.79	0.88	0.305	838.72	2337.79	183.65	0.352	0.97	194.30	98.2	292.5	3.724576	0.22	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.36
24.61	201.44	8.116	135	Yes	56	0	4.028911	Yes	Yes	605.40	3198.65	848.95	2349.69	0.88	0.305	848.95	2349.69	183.50	0.352	0.96	194.15	98.2	292.3	3.724576	0.22	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.33
24.77	184.26	8.598	135	Yes	56	0	4.666131	Yes	Yes	605.23	3220.79	859.19	2361.60	0.88	0.305	859.19	2361.60	167.11	0.376	0.96	176.81	93.7	270.5	3.724576	0.19	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.36
24.93	189.77	8.679	135	Yes	56	0	4.573383	Yes	Yes	605.07	3242.93	869.42	2373.51	0.88	0.305	869.42	2373.51	171.93	0.369	0.96	181.90	95.0	276.9	3.724576	0.20	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.32
25.10	208.52	8.731	135	Yes	56	0	4.187229	Yes	Yes	604.90	3265.07	879.65	2385.41	0.88	0.305	879.65	2385.41	189.12	0.344	0.96	200.09	99.7	299.8	3.724576	0.23	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.21
25.26	193.33	9.052	135	Yes	56	0	4.682247	Yes	Yes	604.74	3287.21	889.89	2397.32	0.88	0.306	889.89	2397.32	174.59	0.365	0.96	184.71	95.7	280.5	3.724576	0.20	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.25
25.43	184.10	8.955	135	Yes	56	0	4.864257	Yes	Yes	604.58	3309.35	900.12	2409.23	0.88	0.306	900.12	2409.23	165.67	0.378	0.95	175.28	93.3	268.6	3.724576	0.18	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.26
25.59	192.82	9.043	135	Yes	56	0	4.689891	Yes	Yes	604.41	3331.49	910.35	2421.13	0.88	0.306	910.35	2421.13	173.46	0.367	0.95	183.53	95.4	279.0	3.724576	0.20	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.20
25.75	212.81	9.3	135	Yes	56	0	4.370075	Yes	Yes	604.25	3353.63	920.59	2433.04	0.88	0.306	920.59	2433.04	191.80	0.341	0.95	202.93	100.5	303.4	3.724576	0.24	0.97	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	17.07
25.92	228.16	9.744	135	Yes	56	0	4.270669	Yes	Yes	604.08	3375.77	930.82	2444.94	0.87	0.306	930.82	2444.94	205.86	0.322	0.95	217.79	104.3	322.1	3.724576	0.28	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.94
26.08	230.86	10.282	135	Yes	56	0	4.453878	Yes	Yes	603.92	3397.91	941.05	2456.85	0.87	0.306	941.05	2456.85	208.05	0.319	0.95	220.12	104.9	325.0	3.724576	0.29	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.88
26.25	230.41	10.983	135	Yes	56	0	4.766762	Yes	Yes	603.76	3420.05	951.29	2468.76	0.87	0.307	951.29	2468.76	207.29	0.320	0.95	219.32	104.7	324.0	3.724576	0.29	0.96	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.86
26.41	239.64	11.285	135	Yes	56	0	4.709068	Yes	Yes	603.59	3442.19	961.52	2480.66	0.87	0.307	961.52	2480.66	215.64	0.309	0.95	228.15	107.0	335.2	3.724576	0.30	0.95	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.79
26.57	242.10	11.409	135	Yes	56	0	4.712554	Yes	Yes	603.43	3464.33	971.76	2492.57	0.87	0.307	971.76	2492.57	217.61	0.307	0.95	230.23	107.6	337.8	3.724576	0.30	0.95	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.76
26.74	248.86	0	135	Yes	56	0	0	Yes	Yes	603.26	3486.47	981.99	2504.48	0.87	0.307	981.99	2504.48	223.65	0.299	0.95	236.62	109.2	345.8	3.724576	0.30	0.95	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.72
26.90	274.73	0	135	Yes	56	0	0	Yes	Yes	603.10	3508.61	992.22	2516.38	0.87	0.307	992.22	2516.38	247.76	0.271	0.95	262.13	115.8	378.0	3.724576	0.30	0.95	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.69

CPT Liquefaction Analysis

Method: Idriss and Boulanger (2014), CPT and SPT Based Liquefaction Triggering Procedures

Title: Liquefaction Analysis
Project: Dynegy - Coffeen
Project No.: 60480701

Date: 1/15/2016
Boring No. COF-C053

Unit wt AGWT: 135 pcf
Unit wt BGWT: 135 pcf

Input Parameters:
Peak ground acceleration, pga (g): 0.39
Earthquake Magnitude (M): 6.5
Water Table Depth at the time of drilling 8.8 ft
Water Table Depth at the time of earthquake 8.8 ft
Ground Surface Elevation 630 ft

Notes:
1. Sand-like behavior = "Yes", Clay-like behavior = "No" (See Idriss and Boulanger, 2014).
2. Make sure to turn on iterative calculations.
3. User to confirm highlighted values are reasonable.

												At the time of earthquake				At the time of drilling																			
Depth	Qt	Fs	Unit Weight	Liquefiable?[1]	FC	α (From static stress analysis)	Fs/Qt	Below Water Table?	Liquefaction Calculation Needed?	Sample Elev.	Total stress	Pore Pressure	Effective stress	Stress reduction coeff, r_d	CSR	Pore Pressure	Effective stress	qc1n	m	Cn	qc1	Delta qc1ncs	qc1ncs	CRR_{cpt}[3]	C_σ	K_σ	Assg. α	State Para	Para a	Para b	Para c	K_α	MSF_{max}	MSF	IB FSL
(ft)	(TSF)	(TSF)	(pcf)	(Yes/No)			(%)			(ft)	(psf)	(psf)	(psf)			(psf)	(psf)				(TSF)														
0.16	10.59	0.054	135	No	90	0	0.509771	No	No	629.84	22.14		22.14				22.14																		
0.33	39.28	0.061	135	No	90	0	0.155303	No	No	629.67	44.28		44.28				44.28																		
0.49	45.21	0.073	135	No	90	0	0.161487	No	No	629.51	66.42		66.42				66.42																		
0.66	38.38	0.199	135	No	90	0	0.518526	No	No	629.34	88.56		88.56				88.56																		
0.82	21.42	0.314	135	No	90	0	1.466125	No	No	629.18	110.70		110.70				110.70																		
0.98	14.84	0.43	135	No	90	0	2.896988	No	No	629.02	132.84		132.84				132.84																		
1.15	15.45	0.444	135	No	90	0	2.874345	No	No	628.85	154.98		154.98				154.98																		
1.31	15.11	0.444	135	No	90	0	2.938062	No	No	628.69	177.12		177.12				177.12																		
1.48	15.92	0.456	135	No	90	0	2.863782	No	No	628.52	199.26		199.26				199.26																		
1.64	15.19	0.457	135	No	90	0	3.009351	No	No	628.36	221.40		221.40				221.40																		
1.80	14.84	0.488	135	No	90	0	3.287745	No	No	628.20	243.54		243.54				243.54																		
1.97	15.40	0.528	135	No	90	0	3.428794	No	No	628.03	265.68		265.68				265.68																		
2.13	15.90	0.505	135	No	90	0	3.175901	No	No	627.87	287.96		287.96				287.96																		
2.30	16.37	0.562	135	No	90	0	3.432271	No	No	627.70	310.10		310.10				310.10																		
2.46	16.35	0.62	135	No	90	0	3.791353	No	No	627.54	332.24		332.24				332.24																		
2.63	14.48	0.74	135	No	90	0	5.109086	No	No	627.38	354.38		354.38				354.38																		
2.79	14.87	0.753	135	No	90	0	5.06559	No	No	627.21	376.52		376.52				376.52																		
2.95	17.88	0.702	135	No	90	0	3.926833	No	No	627.05	398.66		398.66				398.66																		
3.12	18.23	0.665	135	No	90	0	3.647633	No	No	626.88	420.80		420.80				420.80																		
3.28	16.04	0.668	135	No	90	0	4.16381	No	No	626.72	442.94		442.94				442.94																		
3.45	14.97	0.72	135	No	90	0	4.811226	No	No	626.56	465.08		465.08				465.08																		
3.61	16.23	0.706	135	No	90	0	4.351042	No	No	626.39	487.22		487.22				487.22																		
3.77	17.77	0.73	135	No	90	0	4.10851	No	No	626.23	509.36		509.36				509.36																		
3.94	18.56	0.742	135	No	90	0	3.998707	No	No	626.06	531.50		531.50				531.50																		
4.10	18.63	0.749	135	No	90	0	4.021261	No	No	625.90	553.64		553.64				553.64																		
4.27	18.52	0.72	135	No	90	0	3.887689	No	No	625.74	575.78		575.78				575.78																		
4.43	20.98	0.704	135	No	90	0	3.355417	No	No	625.57	597.92		597.92				597.92																		
4.59	21.46	0.786	135	No	90	0	3.662628	No	No	625.41	620.06		620.06				620.06																		
4.76	21.13	0.954	135	No	90	0	4.515976	No	No	625.24	642.20		642.20				642.20																		
4.92	21.39	1.003	135	No	90	0	4.689984	No	No	625.08	664.34		664.34				664.34																		
5.09	22.40	0.996	135	No	90	0	4.445833	No	No	624.92	686.48		686.48				686.48																		
5.25	27.85	1.027	135	No	90	0	3.688142	No	No	624.75	708.62		708.62				708.62																		
5.41	34.50	1.16	135	No	90	0	3.362124	No	No	624.59	730.76		730.76				730.76																		
5.58	31.95	1.314	135	No	90	0	4.112934	No	No	624.42	752.90		752.90				752.90																		
5.74	29.70	1.379	135	No	90	0	4.643879	No	No	624.26	775.04		775.04				775.04																		
5.91	30.31	1.213	135	No	90	0	4.00264	No	No	624.10	797.18		797.18				797.18																		
6.07	33.34	1.149	135	No	90	0	3.445897	No	No	623.93	819.32		819.32				819.32																		
6.23	32.70	1.277	135	No	90	0	3.904841	No	No	623.77	841.59		841.59				841.59																		
6.40	29.85	1.367	135	No	90	0	4.579871	No	No	623.60	863.73		863.73				863.73																		
6.56	23.61	1.315	135	No	90	0	5.570618	No	No	623.44	885.87		885.87				885.87																		
6.73	23.96	1.359	135	No	90	0	5.671007	No	No	623.27	908.01		908.01				908.01																		
6.89	40.88	1.722	135	No	90	0	4.212844	No	No	623.11	930.15		930.15				930.15																		
7.05	47.94	2.413	135	No	90	0	5.033165	No	No	622.95	952.29		952.29				952.29																		
7.22	55.20	2.673	135	No	90	0	4.842216	No	No	622.78	974.43		974.43				974.43																		
7.38	44.21	2.704	135	No	90	0	6.116263	No	No	622.62	996.57		996.57				996.57																		
7.55	37.70	2.256	135	No	90	0	5.984244	No	No	622.45	1018.71		1018.71				1018.71																		
7.71	43.53	2.07	135	No	90	0	4.755232	No	No	622.29	1040.85		1040.85				1040.85																		
7.87	45.22	2.245	135	No	90	0	4.965166	No	No	622.13	1062.99		1062.99				1062.99																		
8.04	38.53	2.348	135	No	90	0	6.093953	No	No	621.96	1085.13		1085.13				1085.13																		
8.20	32.53	2.2	135	No	90	0	6.763196	No	No	621.80	1107.27		1107.27				1107.27																		
8.37	28.46	1.809	135	No	90	0	6.357406	No	No	621.63	1129.41		1129.41				1129.41																		
8.53	26.90	1.572	135	No	90	0	5.844518	No	No	621.47	1151.55		1151.55				1151.55																		
8.69	28.67	1.38	135	No	90	0	4.812722	No	No	621.31	1173.69		1173.69				1173.69																		
8.86	29.02	1.419	135	No	90	0	4.890574	Yes	No	621.14	1195.83	3.62	1192.21			3.62	1192.21																		
9.02	26.05	1.295	135	No	90	0	4.971782	Yes	No	620.98	1217.97	13.85	1204.12			13.85	1204.12																		
9.19	22.56	1.106	135	No	90	0	4.903134	Yes	No	620.81	1240.11	24.09	1216.02			24.09	1216.02																		
9.35	22.06	0.91	135	No	90	0	4.125861	Yes	No	620.65	1262.25	34.32	1227.93			34.32	1227.93																		
9.51	50.97	1.05	135	No	90	0	2.060157	Yes	No	620.49	1284.39	44.55	1239.84			44.55	1239.84																		
9.68	48.49	1.578	135	No	90	0	3.254279	Yes	No	620.32	1306.53	54.79	1251.74			54.79	1251.74																		
9.84	38.66	1.82	135	No	90	0	4.707465	Yes	No	620.16	1328.67	65.02	1263.65			65.02	1263.65																		
10.01	27.66	1.83	125	No	90	0	6.617009	Yes	No	619.99	1349.17	75.25	1273.92			75.25	1273.92																		
10.17	26.76	1.412	125	No	90	0	5.276927	Yes	No	619.83	1369.67	85.49	1284.18			85.49	1284.18																		
10.34	23.66	1.192	125	No	90	0	5.039104	Yes	No	619.67	1390.30	95.78	1294.51			95.78	1294.51																		
10.50	21.73	1.123	125	No	90	0	5.168446	Yes	No	619.50	1410.80	106.02	1304.78			106.02	1304.78																		
10.66	19.14	0.971	125	No	90	0	5.072615	Yes	No	619.34	1431.30	116.25	1315.04			116.25	1315.04																		
10.83	18.43	0.861	125	No	90	0	4.671731	Yes	No	619.17	1451.80	126.48	1325.31			126.48	1325.31																		
10.99	18.82	0.786	125	No	90	0	4.177518	Yes	No	619.01	1472.30	136.72	1335.58			136.72	1335.58																		
11.16	19.56	0.742	125	No	90	0	3.793456	Yes	No	618.85	1492.80	146.95	1345.84			146.95	1345.84																		
11.32	21.37	0.734	125	No	90	0	3.434079	Yes	No	618.68	1513.30	157.19	1356.11			157.19	1356.11																		
11.48	18.31	0.777	125	No	90	0	4.244046	Yes	No	618.52	1533.80	167.42	1366.38			167.42	1366.38																		
11.65	16.84	0.695	125	No	90	0	4.126833	Yes	No	618.35	1554.30	177.65	1376.64			177.65	1376.64																		
11.81	15.53	0.628	125	No	90	0	4.043526	Yes	No	618.19	1574.80	187.89	1386.91			187.89	1386.91																		
11.98	16.89	0.536	125	No	90	0	3.173288	Yes	No	618.03	1595.30	198.12	1397.18			198.12	1397.18																		
12.14	17.66	0.548	125	No	90	0	3.103409	Yes	No	617.86	1615.80	208.35	1407.44			208.35	1407.44																		
12.30	18.10	0.553	125	No	90	0	3.055417	Yes	No	617.70	1636.30	218.59	1417.71			218.59	1417.71																		
12.47	18.31	0.586	125	No	90	0	3.200961	Yes	No	617.53	1656.80	228.82	1427.97			228.82	1427.97																		
12.63	18.66	0.608	125	No	90	0	3.25918	Yes	No	617.37	1677.30	239.05	1438.24			239.05	1438.24																		
12.80	17.86	0.883	125	No	90	0	4.943455	Yes	No	617.21	1697.80	249.29	1448.51			249.29	1448.51																		
12.96	25.04	1.01	125	No	90	0	4.033546	Yes	No	617.04	1718.30	259.52	1458.77			259.52	1458.77																		
13.12	44.54	1.291	125	No	90	0	2.898779	Yes	No	616.88	1738.80	269.76	1469.04			269.76	1469.04																		
13.29	30.00	1.402	125	No	90	0	4.672866	Yes	No	616.71	1759.30	279.99	1479.31			279.99	1479.31																		
13.45	24.39	1.204	125	No	90	0	4.936045	Yes	No	616.55	1779.80	290.22	1489.57			290.22	1489.57																		
13.62	23.40	0.971	125	No	90	0	4.150282	Yes	No	616.39	1800.30	300.46	1499.84			300.46	1499.84																		
13.78	23.01	0.908	125	No	90	0	3.946625	Yes	No	616.22	1820.80	310.69	1510.11			310.69	1510.11																		
13.94	23.10	0.97	125	No	90	0	4.198589	Yes	No	616.06	1841.30	320.92	1520.37			320.92	1520.37																		
14.11	22.98	1.004	125	No	90	0	4.369017	Yes	No	615.89	1861.80	331.16	1530.64			331.16	1530.64																		
14.27	23.28	0.986	125	No	90	0	4.235395	Yes	No	615.73	1882.30	341.39	1540.90			341.39	1540.90																		
14.44	23.53	0.949	125	No	90	0	4.033492	Yes	No	615.56	1902.92	351.69	1551.23			351.69	1551.23																		
14.60	22.96	0.939	125	No	90	0	4.090612	Yes	No	615.40	1923.42	361.92	1561.50			361.92	1561.50																		
14.76	22.12	0.912	125	No	90	0	4.122407	Yes	No	615.24	1943.92	372.15	1571.77			372.15	1571.77																		
14.93	21.94	0.869	125	No	90	0	3.961344	Yes	No	615.07	1964.42	382.39	1582.03			382.39	1582.03																		
15.09	22.25	0.848	125	No	90	0	3.810722	Yes	No	614.91	1984.92	392.62	1592.30			392.62	1592.30																		
15.26	24.62	0.813	125	No	90	0	3.301657	Yes	No	614.74	2005.42	402.85	1602.57			402.85	1602.57																		

CPT Liquefaction Analysis

15.42	24.42	0.808	125	No	90	0	3.30917	Yes	No	614.58	2025.92	413.09	1612.83			413.09	1612.83																		
15.58	24.23	0.783	125	No	90	0	3.230998	Yes	No	614.42	2046.42	423.32	1623.10			423.32	1623.10																		
15.75	23.17	0.72	125	No	90	0	3.107869	Yes	No	614.25	2066.92	433.56	1633.36			433.56	1633.36																		
15.91	22.15	0.635	125	No	90	0	2.866429	Yes	No	614.09	2087.42	443.79	1643.63			443.79	1643.63																		
16.08	21.20	0.526	125	No	90	0	2.480898	Yes	No	613.92	2107.92	454.02	1653.90			454.02	1653.90																		
16.24	18.30	0.532	125	No	90	0	2.907104	Yes	No	613.76	2128.42	464.26	1664.16			464.26	1664.16																		
16.40	22.32	0.534	125	No	90	0	2.392152	Yes	No	613.60	2148.92	474.49	1674.43			474.49	1674.43																		
16.57	21.63	0.536	125	No	90	0	2.478613	Yes	No	613.43	2169.42	484.72	1684.70			484.72	1684.70																		
16.73	21.45	0.507	125	No	90	0	2.363306	Yes	No	613.27	2189.92	494.96	1694.96			494.96	1694.96																		
16.90	20.29	0.447	125	No	90	0	2.20273	Yes	No	613.10	2210.42	505.19	1705.23			505.19	1705.23																		
17.06	17.49	0.383	125	No	90	0	2.189447	Yes	No	612.94	2230.92	515.42	1715.50			515.42	1715.50																		
17.22	14.91	0.287	125	No	90	0	1.924624	Yes	No	612.78	2251.42	525.66	1725.76			525.66	1725.76																		
17.39	14.48	0.235	125	No	90	0	1.622816	Yes	No	612.61	2271.92	535.89	1736.03			535.89	1736.03																		
17.55	15.07	0.224	125	No	90	0	1.4862	Yes	No	612.45	2292.42	546.12	1746.30			546.12	1746.30																		
17.72	14.71	0.225	125	No	90	0	1.529156	Yes	No	612.28	2312.92	556.36	1756.56			556.36	1756.56																		
17.88	14.86	0.217	125	No	90	0	1.460788	Yes	No	612.12	2333.42	566.59	1766.83			566.59	1766.83																		
18.04	14.54	0.225	125	No	90	0	1.547242	Yes	No	611.96	2353.92	576.83	1777.09			576.83	1777.09																		
18.21	15.13	0.256	125	No	90	0	1.692114	Yes	No	611.79	2374.42	587.06	1787.36			587.06	1787.36																		
18.37	17.18	0.315	125	No	90	0	1.833207	Yes	No	611.63	2394.92	597.29	1797.63			597.29	1797.63																		
18.54	18.36	0.393	125	No	90	0	2.140639	Yes	No	611.46	2415.55	607.59	1807.96			607.59	1807.96																		
18.70	17.51	0.407	125	No	90	0	2.324652	Yes	No	611.30	2436.05	617.82	1818.22			617.82	1818.22																		
18.87	14.50	0.406	125	No	90	0	2.8	Yes	No	611.14	2456.55	628.06	1828.49			628.06	1828.49																		
19.03	13.23	0.356	125	No	90	0	2.690651	Yes	No	610.97	2477.05	638.29	1838.76			638.29	1838.76																		
19.19	12.33	0.325	125	No	90	0	2.636275	Yes	No	610.81	2497.55	648.52	1849.02			648.52	1849.02																		
19.36	11.51	0.322	125	No	90	0	2.797324	Yes	No	610.64	2518.05	658.76	1859.29			658.76	1859.29																		
19.52	10.90	0.322	125	No	90	0	2.954128	Yes	No	610.48	2538.55	668.99	1869.55			668.99	1869.55																		
19.69	10.97	0.277	125	No	90	0	2.525529	Yes	No	610.32	2559.05	679.22	1879.82			679.22	1879.82																		
19.85	10.34	0.247	125	No	90	0	2.389244	Yes	No	610.15	2579.55	689.46	1890.09			689.46	1890.09																		
20.01	10.59	0.242	125	No	90	0	2.284959	Yes	No	609.99	2600.05	699.69	1900.35			699.69	1900.35																		
20.18	10.72	0.294	125	No	90	0	2.743049	Yes	No	609.82	2620.55	709.92	1910.62			709.92	1910.62																		
20.34	10.90	0.319	125	No	90	0	2.9258	Yes	No	609.66	2641.05	720.16	1920.89			720.16	1920.89																		
20.51	10.22	0.342	125	No	90	0	3.345398	Yes	No	609.50	2661.55	730.39	1931.15			730.39	1931.15																		
20.67	9.74	0.323	125	No	90	0	3.317584	Yes	No	609.33	2682.05	740.63	1941.42			740.63	1941.42																		
20.83	9.56	0.307	125	No	90	0	3.209954	Yes	No	609.17	2702.55	750.86	1951.69			750.86	1951.69																		
21.00	10.94	0.306	125	No	90	0	2.797842	Yes	No	609.00	2723.05	761.09	1961.95			761.09	1961.95																		
21.16	9.79	0.29	125	No	90	0	2.961299	Yes	No	608.84	2743.55	771.33	1972.22			771.33	1972.22																		
21.33	9.85	0.26	125	No	90	0	2.64013	Yes	No	608.68	2764.04	781.56	1982.48			781.56	1982.48																		
21.49	8.79	0.228	125	No	90	0	2.592972	Yes	No	608.51	2784.54	791.79	1992.75			791.79	1992.75																		
21.65	9.16	0.215	125	No	90	0	2.347931	Yes	No	608.35	2805.04	802.03	2003.02			802.03	2003.02																		
21.82	9.73	0.207	125	No	90	0	2.128316	Yes	No	608.18	2825.54	812.26	2013.28			812.26	2013.28																		
21.98	10.72	0.287	125	No	90	0	2.676739	Yes	No	608.02	2846.04	822.49	2023.55			822.49	2023.55																		
22.15	15.05	0.347	125	No	90	0	2.306414	Yes	No	607.86	2866.54	832.73	2033.82			832.73	2033.82																		
22.31	23.95	0.379	125	No	90	0	1.582662	Yes	No	607.69	2887.04	842.96	2044.08			842.96	2044.08																		
22.47	18.57	0.359	125	No	90	0	1.932809	Yes	No	607.53	2907.54	853.20	2054.35			853.20	2054.35																		
22.64	17.83	0.429	125	No	90	0	2.405518	Yes	No	607.36	2928.04	863.43	2064.62			863.43	2064.62																		
22.80	17.38	0.362	125	No	90	0	2.082494	Yes	No	607.20	2948.54	873.66	2074.88			873.66	2074.88																		
22.97	15.78	0.359	125	No	90	0	2.274743	Yes	No	607.04	2969.04	883.90	2085.15			883.90	2085.15																		
23.13	15.87	0.324	125	No	90	0	2.042231	Yes	No	606.87	2989.54	894.13	2095.42			894.13	2095.42																		
23.29	13.15	0.315	125	No	90	0	2.395255	Yes	No	606.71	3010.04	904.36	2105.68			904.36	2105.68																		
23.46	10.82	0.28	125	No	90	0	2.588997	Yes	No	606.54	3030.54	914.60	2115.95			914.60	2115.95																		
23.62	20.74	0.518	125	No	90	0	2.498191	Yes	No	606.38	3051.04	924.83	2126.21			924.83	2126.21																		
23.79	26.35	0.564	125	No	90	0	2.140661	Yes	No	606.22	3071.54	935.06	2136.48			935.06	2136.48																		
23.95	18.53	0.533	125	No	90	0	2.876727	Yes	No	606.05	3092.04	945.30	2146.75			945.30	2146.75																		
24.11	14.87	0.281	125	No	90	0	1.890092	Yes	No	605.89	3112.54	955.53	2157.01			955.53	2157.01																		
24.28	11.94	0.198	125	No	90	0	1.658986	Yes	No	605.72	3133.04	965.76	2167.28			965.76	2167.28																		
24.44	10.31	0.224	125	No	90	0	2.173702	Yes	No	605.56	3153.54	976.00	2177.55			976.00	2177.55																		
24.61	14.25	0.236	125	No	90	0	1.655792	Yes	No	605.40	3174.04	986.23	2187.81			986.23	2187.81																		
24.77	17.06	0.393	125	No	90	0	2.30431	Yes	No	605.23	3194.54	996.47	2198.08			996.47	2198.08																		
24.93	20.41	0.491	125	No	90	0	2.406273	Yes	No	605.07	3215.04	1006.70	2208.35			1006.70	2208.35																		
25.10	44.78	0.548	135	Yes	56	0	1.223815	Yes	Yes	604.90	3237.18	1016.93	2220.25	0.88	0.325	1016.93	2220.25	40.97	0.674	0.97	43.35	59.0	102.4	0.140	0.07	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.274	1.103	0.47
25.26	73.14	0.45	135	Yes	56	0	0.615258	Yes	Yes	604.74	3259.32	1027.17	2232.16	0.88	0.325	1027.17	2232.16	67.01	0.582	0.97	70.90	66.2	137.1	0.222	0.08	1.00	0.00	0.100	1.000	0.000	0.138	1.000	1.532	1.200	0.82
25.43	118.00	0.423	135	Yes	56	0	0.358475	Yes	Yes	604.58	3281.46	1037.40	2244.06	0.88	0.325	1037.40	2244.06	108.43	0.480	0.97	114.72	77.6	192.3	1.255653	0.11	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	5.56
25.59	168.67	0.408	135	Yes	56	0	0.241891	Yes	Yes	604.41	3303.60	1047.63	2255.97	0.88	0.326	1047.63	2255.97	155.45	0.394	0.98	164.46	90.5	254.9	3.724576	0.17	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.43
25.75	189.85	0.487	135	Yes	56	0	0.256521	Yes	Yes	604.25	3325.74	1057.87	2267.88	0.88	0.326	1057.87	2267.88	174.96	0.364	0.98	185.11	95.8	281.0	3.724576	0.20	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.37
25.92	179.89	0.552	135	Yes	56	0	0.306856	Yes	Yes	604.08	3347.89	1068.10	2279.78	0.87	0.326	1068.10	2279.78	165.29	0.379	0.97	174.88	93.2	268.1	3.724576	0.18	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.37
26.08	144.66	0.913	135	Yes	56	0	0.631118	Yes	Yes	603.92	3370.03	1078.33	2291.69	0.87	0.326	1078.33	2291.69	132.08	0.434	0.97	139.74	84.1	223.8	3.724576	0.14	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.41
26.25	100.53	1.313	135	Yes	56	0	1.306091	Yes	Yes	603.76	3392.17	1088.57	2303.60	0.87	0.326	1088.57	2303.60	90.92	0.519	0.96	96.19	72.7	168.9	0.486	0.10	0.99	0.00	0.100	1.000	0.000	0.138	1.000	1.917	1.345	1.99
26.41	57.76	1.378	135	Yes	56	0	2.385651	Yes	Yes	603.59	3414.31	1098.80	2315.50	0.87	0.326	1098.80	2315.50	51.57	0.633	0.94	54.56	61.9	116.5	0.164	0.07	0.99	0.00	0.100	1.000	0.000	0.138	1.000	1.361	1.136	0.57
26.57	137.82	1.272	135	Yes	56	0	0.922976	Yes	Yes	603.43	3436.45	1109.04	2327.41	0.87	0.326	1109.04	2327.41	124.83	0.448	0.96	132.07	82.1	214.1	3.724576	0.13	0.99	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.38
26.74	182.00	1.286	135	Yes	56	0	0.70659	Yes	Yes	603.26	3458.59	1119.27	2339.32	0.87	0.326	1119.27	2339.32	165.61	0.379	0.96	175.22	93.3	268.5	3.724576	0.18	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.28
26.90	166.81	0.96	135	Yes	56	0	0.575495	Yes	Yes	603.10	3480.73	1129.50	2351.22	0.87	0.326	1129.50	2351.22	151.14	0.401	0.96	159.90	89.3	249.2	3.724576	0.16	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.30
27.07	158.39	1.328	135	Yes	56	0	0.838431	Yes	Yes	602.94	3502.86	1139.74	2363.13	0.87	0.326	1139.74	2363.13	143.00	0.415	0.96	151.29	87.1	238.3	3.724576	0.15	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.31
27.23	163.80	1.739	135	Yes	56	0	1.061667	Yes	Yes	602.77	3525.00	1149.97	2375.04	0.87	0.326	1149.97	2375.04	147.71	0.407	0.95	156.28	88.4	244.6	3.724576	0.16	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.28
27.39	154.14	1.625	135	Yes	56	0	1.05423	Yes	Yes	602.61	3547.14	1160.20	2386.94	0.87	0.326	1160.20	2386.94	138.45	0.423	0.95	146.49	85.8	232.3	3.724576	0.14	0.98	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	16.29
27.56	82.96	2.269	135	Yes	56	0	2.735053	Yes	Yes	602.44	3569.28	1170.44	2398.85	0.86	0.326	1170.44	2398.85	73.05	0.565	0.93	77.28	67.8	145.1	0.259	0.09	0.99	0.00	0.100	1.000	0.000	0.138	1.000	1.614	1.231	0.97
27.72	58.87	1.934	135	Yes	56	0	3.285428	Yes	Yes	602.28	3591.42	1180.67	2410.75	0.86	0.326	1180.67	2410.75	51.22	0.634	0.92	54.19	61.8	116.0	0.163	0.07	0.99	0.00	0.100	1.000	0.000	0.138	1.000	1.358	1.135	0.56
27.89	54.00	1.588	135	Yes	56	0	2.940523	Yes	Yes	602.12	3613.56	1190.90	2422.66	0.86	0.326	1190.90	2422.66	46.74	0.651	0.92	49.45	60.6	110.0	0.152	0.07	0.99	0.00	0.100	1.000	0.000	0.138	1.000	1.319	1.120	0.52
28.05	55.45	0.831	135	No	56	0	1.498593	Yes	No	601.95	3635.70	1201.14	2434.57			1201.14	2434.57																		
28.21	50.65	0.617	135	No	56	0	1.218116	Yes	No	601.79	3657.84	1211.37	2446.47			1211.37	2446.47																		
28.38	45.64	0.693	135	No	56	0	1.518405	Yes	No	601.62	3679.98	1221.60	2458.38			1221.60	2458.38																		
28.54	40.47	0.695	135	No	56	0	1.717237	Yes	No	601.46	3702.12	1231.84	2470.29			1231.84	2470.29																		
28.71	47.81	0.642	135	No	56	0	1.342928	Yes	No	601.30	3724.26	1242.07	2482.19			1242.07	2482.19																		
28.87	51.27	0.712	135	No	56	0	1.388618	Yes	No	601.13	3746.40	1252.31	2494.10			1252.31	2494.10																		
29.03	51.82	1.163	135	No	56	0	2.244307	Yes	No	600.97	3768.54	1262.54	2506.01			1262.54	2506.01																		
29.20	50.32	1.192	135	No	56	0	2.369028	Yes	No	600.80	3790.68	1272.77	2517.91			1272.77	2517.91																		
29.36	55.70	1.244	135	No	56	0	2.233353	Yes	No	600.64	3812.82	1283.01	2529.82			1283.01	2529.82																		
29.52	58.07	1.284	135	No	56	0	2.211277	Yes	No	600.48	3834.96	1293.24	2541.72			1293.24	2541.72																		
29.69	61.99	1.253	135	No	56	0	2.021229	Yes	No	600.31	3857.10	1303.47	2553.63			1303.47	2553.63																		
29.85	62.53	1.385	135	No	56	0	2.214795	Yes	No	600.15	3879.24	1313.71	2565.54			1313.71	2565.54																		
30.02	62.81	1.546	135	No	56	0	2.461587	Yes	No	599.98	3901.38	1323.94	2577.44			1323.94	2577.44																		
30.18	62.63	1.593	135	No	56	0	2.543347	Yes	No	599.82	3923.52	1334.17	2589.35			1334.17	2589.35																		
30.34	63.20	1.659	135	No	56	0	2.624958	Yes	No	599.66	3945.66	1344.41	2601.26			1344.41	2601.26																		
30.51	62.34	1.618	135	No	56	0	2.595403	Yes	No	599.49	3967.80	1354.64	2613.16			1354.64	2613.16																		
30.67	66.11	1.664	135	No	56	0	2.516903	Yes	No	599.33	3989.94	1364.88	2625.07			1364.88	2625.07																		
30.84	65.46	1.832	135	No	56	0	2.798827	Yes	No	599.16	4012.08	1375.11	2636.98			1375.11	2636.98																		
31.00	59.19	1.841	135	No	56	0	3.110323	Yes	No	599.00	4034.22	1385.34	2648.88			1385.34	2648.88																		
31.16	59.12	1.775	135	No	56	0	3.002317	Yes	No	598.84	4056.36	1395.58	2660.79			1395.58	2660.79																		
31.33	54.97	1.66	135	No	56	0	3.019774	Yes	No	598.67	4078.50	1405.81	2672.70			1405.81	2672.70																		
31.49	54.22	1.586	135	No	56	0	2.924958	Yes	No	598.51	4100.64	1416.04	2684.60			1416.04	2684.60																		
31.66	52.54	1.57	135	No	56	0	2.988256	Yes	No	598.34	4122.78	1426.28	2696.51			1426.28	2696.51																		
31.82	53.73	1.762	135	No	56	0	3.279665	Yes	No	598.18	4144.92	1436.51	2708.41			1436.51	2708.41																		
31.98	51.73	2.309	135	No	56	0	4.463906	Yes	No	598.02	4167.06	1446.74	2720.32			1446.74	2720.32																		
32.15	69.90	2.208	135	No	56	0	3.158934	Yes	No	597.85	4189.20	1456.98	2732.23			1456.98	2732.23																		
32.31	48.00	2.103	135	No	56	0	4.381067	Yes	No	597.69	4211.34	1467.21	2744.13			1467.21	2744.13																		
32.48	46.43	1.571	135	No	56	0	3.383442	Yes	No	597.52	4233.48	1477.44	2756.04			1477.44	2756.04																		
32.64	45.44	1.455	135	No	56	0	3.201954	Yes	No	597.36	4255.62	1487.68	2767.95			1487.68	2767.95																		
32.80	42.84	1.301	135	No	56	0	3.037094	Yes	No	597.20	4277.76	1497.91	2779.85			1497.91	2779.85																		

32.97	41.09	1.232	135	No	56	0	2.998223	Yes	No	597.03	4299.90	1508.15	2791.76			1508.15	2791.76																		
33.13	41.87	1.147	135	No	56	0	2.739497	Yes	No	596.87	4322.04	1518.38	2803.67			1518.38	2803.67																		
33.30	41.52	1.122	135	No	56	0	2.702312	Yes	No	596.70	4344.18	1528.61	2815.57			1528.61	2815.57																		
33.46	41.56	1.141	135	No	56	0	2.745428	Yes	No	596.54	4366.32	1538.85	2827.48			1538.85	2827.48																		
33.62	41.06	1.156	135	No	56	0	2.815392	Yes	No	596.38	4388.46	1549.08	2839.38			1549.08	2839.38																		
33.79	40.01	1.149	135	No	56	0	2.871854	Yes	No	596.21	4410.60	1559.31	2851.29			1559.31	2851.29																		
33.95	40.60	1.126	135	No	56	0	2.773467	Yes	No	596.05	4432.74	1569.55	2863.20			1569.55	2863.20																		
34.12	38.88	1.085	135	No	56	0	2.790494	Yes	No	595.88	4454.88	1579.78	2875.10			1579.78	2875.10																		
34.28	37.68	1.045	135	No	56	0	2.773575	Yes	No	595.72	4477.02	1590.01	2887.01			1590.01	2887.01																		
34.44	37.82	1.046	135	No	56	0	2.765879	Yes	No	595.56	4499.16	1600.25	2898.92			1600.25	2898.92																		
34.61	37.63	0.992	135	No	56	0	2.636265	Yes	No	595.39	4521.30	1610.48	2910.82			1610.48	2910.82																		
34.77	37.81	0.995	135	No	56	0	2.631509	Yes	No	595.23	4543.44	1620.72	2922.73			1620.72	2922.73																		
34.94	36.20	0.952	135	No	56	0	2.629544	Yes	No	595.06	4565.58	1630.95	2934.64			1630.95	2934.64																		
35.10	34.81	0.767	135	No	56	0	2.203643	Yes	No	594.90	4587.72	1641.18	2946.54			1641.18	2946.54																		
35.26	35.40	0.882	135	No	56	0	2.491666	Yes	No	594.74	4609.86	1651.42	2958.45			1651.42	2958.45																		
35.43	31.49	0.86	135	No	56	0	2.731373	Yes	No	594.57	4632.00	1661.65	2970.36			1661.65	2970.36																		
35.59	35.96	0.867	135	No	56	0	2.410945	Yes	No	594.41	4654.14	1671.88	2982.26			1671.88	2982.26																		
35.76	35.66	0.894	135	No	56	0	2.5068	Yes	No	594.24	4676.28	1682.12	2994.17			1682.12	2994.17																		
35.92	36.15	0.955	135	No	56	0	2.642063	Yes	No	594.08	4698.42	1692.35	3006.07			1692.35	3006.07																		
36.08	36.65	0.949	135	No	56	0	2.589571	Yes	No	593.92	4720.56	1702.58	3017.98			1702.58	3017.98																		
36.25	35.37	0.905	135	No	56	0	2.558738	Yes	No	593.75	4742.70	1712.82	3029.89			1712.82	3029.89																		
36.41	34.67	0.899	135	No	56	0	2.592721	Yes	No	593.59	4764.84	1723.05	3041.79			1723.05	3041.79																		
36.58	32.90	0.873	135	No	56	0	2.653818	Yes	No	593.42	4786.98	1733.28	3053.70			1733.28	3053.70																		
36.74	33.56	0.846	135	No	56	0	2.520933	Yes	No	593.26	4809.12	1743.52	3065.61			1743.52	3065.61																		
36.90	33.51	0.846	135	No	56	0	2.524318	Yes	No	593.10	4831.26	1753.75	3077.51			1753.75	3077.51																		
37.07	33.55	0.783	135	No	56	0	2.334108	Yes	No	592.93	4853.40	1763.99	3089.42			1763.99	3089.42																		
37.23	33.99	0.904	135	No	56	0	2.659449	Yes	No	592.77	4875.54	1774.22	3101.33			1774.22	3101.33																		
37.40	36.56	0.898	135	No	56	0	2.456169	Yes	No	592.60	4897.68	1784.45	3113.23			1784.45	3113.23																		
37.56	34.30	0.871	135	No	56	0	2.539507	Yes	No	592.44	4919.82	1794.69	3125.14			1794.69	3125.14																		
37.72	35.04	0.854	135	No	56	0	2.437493	Yes	No	592.28	4941.96	1804.92	3137.04			1804.92	3137.04																		
37.89	32.85	0.875	135	No	56	0	2.663298	Yes	No	592.11	4964.10	1815.15	3148.95			1815.15	3148.95																		
38.05	32.51	0.858	135	No	56	0	2.638863	Yes	No	591.95	4986.24	1825.39	3160.86			1825.39	3160.86																		
38.22	31.47	0.867	135	No	56	0	2.755092	Yes	No	591.78	5008.38	1835.62	3172.76			1835.62	3172.76																		
38.38	31.12	0.815	135	No	56	0	2.618979	Yes	No	591.62	5030.52	1845.85	3184.67			1845.85	3184.67																		
38.54	30.48	0.808	135	No	56	0	2.650745	Yes	No	591.46	5052.66	1856.09	3196.58			1856.09	3196.58																		
38.71	30.58	0.792	135	No	56	0	2.589928	Yes	No	591.29	5074.80	1866.32	3208.48			1866.32	3208.48																		
38.87	30.36	0.794	135	No	56	0	2.615283	Yes	No	591.13	5096.94	1876.56	3220.39			1876.56	3220.39																		
39.04	29.60	0.767	135	No	56	0	2.591304	Yes	No	590.96	5119.08	1886.79	3232.30			1886.79	3232.30																		
39.20	29.68	0.766	135	No	56	0	2.581297	Yes	No	590.80	5141.22	1897.02	3244.20			1897.02	3244.20																		
39.36	28.60	0.756	135	No	56	0	2.642987	Yes	No	590.64	5163.36	1907.26	3256.11			1907.26	3256.11																		
39.53	28.71	0.741	135	No	56	0	2.581072	Yes	No	590.47	5185.50	1917.49	3268.02			1917.49	3268.02																		
39.69	28.36	0.731	135	No	56	0	2.577756	Yes	No	590.31	5207.64	1927.72	3279.92			1927.72	3279.92																		
39.86	29.03	0.693	135	No	56	0	2.387515	Yes	No	590.14	5229.78	1937.96	3291.83			1937.96	3291.83																		
40.02	29.31	0.72	135	No	56	0	2.456416	Yes	No	589.98	5251.92	1948.19	3303.73			1948.19	3303.73																		
40.18	29.07	0.711	135	No	56	0	2.446157	Yes	No	589.82	5274.06	1958.42	3315.64			1958.42	3315.64																		
40.35	29.82	0.752	135	No	56	0	2.521713	Yes	No	589.65	5296.20	1968.66	3327.55			1968.66	3327.55																		
40.51	29.71	0.757	135	No	56	0	2.548307	Yes	No	589.49	5318.34	1978.89	3339.45			1978.89	3339.45																		
40.68	29.96	0.759	135	No	56	0	2.533378	Yes	No	589.32	5340.48	1989.12	3351.36			1989.12	3351.36																		
40.84	29.95	0.758	135	No	56	0	2.531307	Yes	No	589.16	5362.62	1999.36	3363.27			1999.36	3363.27																		
41.00	29.46	0.771	135	No	56	0	2.616753	Yes	No	589.00	5384.76	2009.59	3375.17			2009.59	3375.17																		
41.17	29.43	0.75	135	No	56	0	2.54842	Yes	No	588.83	5406.90	2019.83	3387.08			2019.83	3387.08																		
41.33	29.46	0.738	135	No	56	0	2.505432	Yes	No	588.67	5429.04	2030.06	3398.99			2030.06	3398.99																		
41.50	29.14	0.741	135	No	56	0	2.543245	Yes	No	588.50	5451.18	2040.29	3410.89			2040.29	3410.89																		
41.66	29.27	0.662	135	No	56	0	2.261624	Yes	No	588.34	5473.32	2050.53	3422.80			2050.53	3422.80																		
41.82	29.24	0.707	135	No	56	0	2.41759	Yes	No	588.18	5495.46	2060.76	3434.70			2060.76	3434.70																		
41.99	28.50	0.716	135	No	56	0	2.512104	Yes	No	588.01	5517.60	2070.99	3446.61			2070.99	3446.61																		
42.15	28.40	0.714	135	No	56	0	2.51373	Yes	No	587.85	5539.74	2081.23	3458.52			2081.23	3458.52																		
42.32	28.45	0.702	135	No	56	0	2.467313	Yes	No	587.68	5561.88	2091.46	3470.42			2091.46	3470.42																		
42.48	29.43	0.692	135	No	56	0	2.351023	Yes	No	587.52	5584.02	2101.69	3482.33			2101.69	3482.33																		
42.64	28.74	0.695	135	No	56	0	2.418653	Yes	No	587.36	5606.16	2111.93	3494.24			2111.93	3494.24																		
42.81	28.65	0.695	135	No	56	0	2.425744	Yes	No	587.19	5628.30	2122.16	3506.14			2122.16	3506.14																		
42.97	28.60	0.694	135	No	56	0	2.426489	Yes	No	587.03	5650.44	2132.40	3518.05			2132.40	3518.05																		
43.14	28.25	0.704	135	No	56	0	2.491947	Yes	No	586.86	5672.58	2142.63	3529.96			2142.63	3529.96																		
43.30	28.41	0.702	135	No	56	0	2.471048	Yes	No	586.70	5694.72	2152.86	3541.86			2152.86	3541.86																		
43.46	28.71	0.697	135	No	56	0	2.42781	Yes	No	586.54	5716.86	2163.10	3553.77			2163.10	3553.77																		
43.63	29.21	0.72	135	No	56	0	2.464656	Yes	No	586.37	5739.00	2173.33	3565.68			2173.33	3565.68																		
43.79	28.77	0.722	135	No	56	0	2.509908	Yes	No	586.21	5761.14	2183.56	3577.58			2183.56	3577.58																		
43.96	28.68	0.716	135	No	56	0	2.496949	Yes	No	586.04	5783.28	2193.80	3589.49			2193.80	3589.49																		
44.12	28.84	0.714	135	No	56	0	2.4759	Yes	No	585.88	5805.42	2204.03	3601.39			2204.03	3601.39																		
44.28	28.54	0.71	135	No	56	0	2.487824	Yes	No	585.72	5827.56	2214.26	3613.30			2214.26	3613.30																		
44.45	29.12	0.712	135	No	56	0	2.444887	Yes	No	585.55	5849.70	2224.50	3625.21			2224.50	3625.21																		
44.61	28.63	0.718	135	No	56	0	2.507684	Yes	No	585.39	5871.84	2234.73	3637.11			2234.73	3637.11																		
44.78	28.50	0.686	135	No	56	0	2.407018	Yes	No	585.22	5893.98	2244.96	3649.02			2244.96	3649.02																		
44.94	28.01	0.613	135	No	56	0	2.188192	Yes	No	585.06	5916.12	2255.20	3660.93			2255.20	3660.93																		
45.10	28.02	0.623	135	No	56	0	2.223571	Yes	No	584.90	5938.26	2265.43	3672.83			2265.43	3672.83																		
45.27	28.18	0.639	135	No	56	0	2.267244	Yes	No	584.73	5960.40	2275.67	3684.74			2275.67	3684.74																		
45.43	28.16	0.674	135	No	56	0	2.393806	Yes	No	584.57	5982.54	2285.90	3696.65			2285.90	3696.65																		
45.60	28.71	0.671	135	No	56	0	2.336921	Yes	No	584.40	6004.68	2296.13	3708.55			2296.13	3708.55																		
45.76	27.94	0.678	135	No	56	0	2.426455	Yes	No	584.24	6026.82	2306.37	3720.46			2306.37	3720.46																		
45.92	28.03	0.669	135	No	56	0	2.386473	Yes	No	584.08	6048.96	2316.60	3732.36			2316.60	3732.36																		
46.09	28.68	0.675	135	No	56	0	2.353803	Yes	No	583.91	6071.10	2326.83	3744.27			2326.83	3744.27																		
46.25	27.88	0.679	135	No	56	0	2.435088	Yes	No	583.75	6093.24	2337.07	3756.18			2337.07	3756.18																		
46.42	27.39	0.668	135	No	56	0	2.438668	Yes	No	583.58	6115.38	2347.30	3768.08			2347.30	3768.08																		
46.58	27.73	0.672	135	No	56	0	2.42363	Yes	No	583.42	6137.52	2357.53	3779.99			2357.53	3779.99																		
46.74	27.32	0.671	135	No	56	0	2.455806	Yes	No	583.26	6159.66	2367.77	3791.90			2367.77	3791.90																		
46.91	27.33	0.664	135	No	56	0	2.429742	Yes	No	583.09	6181.80	2378.00	3803.80			2378.00	3803.80																		
47.07	26.30	0.658	135	No	56	0	2.502377	Yes	No	582.93	6203.94	2388.24	3815.71			2388.24	3815.71																		
47.24	25.73	0.657	135	No	56	0	2.553241	Yes	No	582.76	6226.08	2398.47	3827.62			2398.47	3827.62																		
47.40	24.90	0.621	135	No	56	0	2.494076	Yes	No	582.60	6248.22	2408.70	3839.52			2408.70	3839.52																		
47.56	24.34	0.603	135	No	56	0	2.477709	Yes	No	582.44	6270.36	2418.94	3851.43			2418.94	3851.43																		
47.73	26.01	0.617	135	No	56	0	2.372347	Yes	No	582.27	6292.50	2429.17	3863.34			2429.17	3863.34																		
47.89	27.26	0.619	135	No	56	0	2.270726	Yes	No	582.11	6314.64	2439.40	3875.24			2439.40	3875.24																		
48.06	27.95	0.672	135	No	56	0	2.404638	Yes	No	581.94	6336.78	2449.64	3887.15			2449.64	3887.15																		
48.22	28.75	0.669	135	No	56	0	2.327361	Yes	No	581.78	6358.92	2459.87	3899.05			2459.87	3899.05																		
48.38	28.44	0.685	135	No	56	0	2.408579	Yes	No	581.62	6381.06	2470.10	3910.96			2470.10	3910.96																		
48.55	26.59	0.685	135	No	56	0	2.575866	Yes	No	581.45	6403.20	2480.34	3922.87			2480.34	3922.87																		
48.71	26.29	0.611	135	No	56	0	2.324343	Yes	No	581.29	6425.34	2490.57	3934.77			2490.57	3934.77																		
48.88	26.02	0.616	135	No	56	0	2.367592	Yes	No	581.12	6447.48	2500.80	3946.68			2500.80	3946.68																		
49.04	26.93	0.607	135	No	56	0	2.254243	Yes	No	580.96	6469.62	2511.04	3958.59			2511.04	3958.59																		
49.20	29.23	0.713	135	No	56	0	2.439442	Yes	No	580.80	6491.76	2521.27	3970.49			2521.27	3970.49																		
49.37	27.77	0.674	135	No	56	0	2.427342	Yes	No	580.63	6513.90	2531.51	3982.40			2531.51	3982.40																		
49.53	26.06	0.664	135	No	56	0	2.547771	Yes	No	580.47	6536.04	2541.74	3994.31			2541.74	3994.31																		
49.70	25.24	0.635	135	No	56	0	2.516147	Yes	No	580.30	6558.18	2551.97	4006.21			2551.97	4006.21																		
49.86	26.11	0.569	135	No	56	0	2.178991	Yes	No	580.14	6580.32	2562.21	4018.12			2562.21	4018.12																		
50.02	26.02	0.594	135	No	56	0	2.283035	Yes	No	579.98	6602.46	2572.44	4030.02			2572.44	4030.02																		
50.19	27.38	0.635	135	No	56	0	2.319381	Yes	No	579.81	6624.60	2582.67	4041.93			2582.67	4041.93																		
50.35	27.70	0.635	135	No	56	0	2.292419	Yes	No	579.65	6646.74	2592.91	4053.84			2592.91	4053.84																		

CPT Liquefaction Analysis

50.52	27.58	0.647	135	No	56	0	2.345818	Yes	No	579.48	6668.88	2603.14	4065.74			2603.14	4065.74
50.68	27.33	0.574	135	No	56	0	2.10041	Yes	No	579.32	6691.02	2613.37	4077.65			2613.37	4077.65
50.84	27.03	0.567	135	No	56	0	2.097669	Yes	No	579.16	6713.16	2623.61	4089.56			2623.61	4089.56
51.01	27.22	0.572	135	No	56	0	2.101164	Yes	No	578.99	6735.30	2633.84	4101.46			2633.84	4101.46
51.17	28.92	0.628	135	No	56	0	2.171433	Yes	No	578.83	6757.44	2644.08	4113.37			2644.08	4113.37
51.34	30.96	0.697	135	No	56	0	2.251365	Yes	No	578.66	6779.58	2654.31	4125.28			2654.31	4125.28
51.50	35.23	0.787	135	No	56	0	2.233892	Yes	No	578.50	6801.72	2664.54	4137.18			2664.54	4137.18
51.66	35.66	0.834	135	No	56	0	2.33882	Yes	No	578.34	6823.86	2674.78	4149.09			2674.78	4149.09
51.83	34.88	0.909	135	No	56	0	2.606227	Yes	No	578.17	6846.00	2685.01	4161.00			2685.01	4161.00
51.99	34.91	0.895	135	No	56	0	2.563735	Yes	No	578.01	6868.14	2695.24	4172.90			2695.24	4172.90
52.16	36.19	0.869	135	No	56	0	2.401415	Yes	No	577.84	6890.28	2705.48	4184.81			2705.48	4184.81
52.32	35.32	0.961	135	No	56	0	2.72053	Yes	No	577.68	6912.42	2715.71	4196.71			2715.71	4196.71
52.48	29.68	0.865	135	No	56	0	2.914912	Yes	No	577.52	6934.56	2725.94	4208.62			2725.94	4208.62
52.65	30.24	0.898	135	No	56	0	2.969871	Yes	No	577.35	6956.70	2736.18	4220.53			2736.18	4220.53
52.81	29.26	0.734	135	No	56	0	2.508544	Yes	No	577.19	6978.84	2746.41	4232.43			2746.41	4232.43
52.98	33.85	0.705	135	No	56	0	2.082533	Yes	No	577.02	7000.98	2756.64	4244.34			2756.64	4244.34
53.14	41.66	1.199	135	No	56	0	2.878199	Yes	No	576.86	7023.12	2766.88	4256.25			2766.88	4256.25
53.30	42.09	1.523	135	No	56	0	3.618781	Yes	No	576.70	7045.26	2777.11	4268.15			2777.11	4268.15
53.47	231.49	0	135	No	56	0	0	Yes	No	576.53	7067.40	2787.35	4280.06			2787.35	4280.06
53.63	359.24	0	135	No	56	0	0	Yes	No	576.37	7089.54	2797.58	4291.97			2797.58	4291.97

CPT Liquefaction Analysis

Method: Idriss and Boulanger (2014), CPT and SPT Based Liquefaction Triggering Procedures

Title: Liquefaction Analysis
Project: Dynegy - Coffeen
Project No.: 60480701

Date: 1/15/2016
Boring No. COF-C054

Unit wt AGWT: 135 pcf
Unit wt BGWT: 135 pcf

Input Parameters:
Peak ground acceleration, pga (g): 0.2
Earthquake Magnitude (M): 6.5
Water Table Depth at the time of drilling 12.2 ft
Water Table Depth at the time of earthquake 12.2 ft
Ground Surface Elevation 624 ft

Notes:
1. Sand-like behavior = "Yes", Clay-like behavior = "No" (See Idriss and Boulanger, 2014).
2. Make sure to turn on iterative calculations.
3. User to confirm highlighted values are reasonable.

												At the time of earthquake				At the time of drilling																			
Depth	Qt	Fs	Unit Weight	Liquefiable?[1]	FC	α (From static stress analysis)	Fs/Qt	Below Water Table?	Liquefaction Calculation Needed?	Sample Elev.	Total stress	Pore Pressure	Effective stress	Stress reduction coeff, r_d	CSR	Pore Pressure	Effective stress	qc1n	m	Cn	qc1	Delta qc1ncs	qc1ncs	CRR_{cpt}[3]	C_σ	K_σ	Assg. α	State Para	Para a	Para b	Para c	Kα	MSF_{max}	MSF	IB FSL
(ft)	(TSF)	(TSF)	(pcf)	(Yes/No)			(%)			(ft)	(psf)	(psf)	(psf)			(psf)	(psf)				(TSF)														
0.16	12.20	0.152	135	No	90	0	1.245697	No	No	623.84	22.14		22.14				22.14																		
0.33	12.17	0.322	135	No	90	0	2.64585	No	No	623.67	44.28		44.28				44.28																		
0.49	11.00	0.436	135	No	90	0	3.963997	No	No	623.51	66.42		66.42				66.42																		
0.66	9.72	0.446	135	No	90	0	4.588477	No	No	623.34	88.56		88.56				88.56																		
0.82	9.09	0.444	135	No	90	0	4.885026	No	No	623.18	110.70		110.70				110.70																		
0.98	8.81	0.478	135	No	90	0	5.426269	No	No	623.02	132.84		132.84				132.84																		
1.15	8.94	0.437	135	No	90	0	4.885957	No	No	622.85	154.98		154.98				154.98																		
1.31	14.37	0.505	135	No	90	0	3.51451	No	No	622.69	177.12		177.12				177.12																		
1.48	16.21	0.584	135	No	90	0	3.602714	No	No	622.52	199.26		199.26				199.26																		
1.64	20.81	0.629	135	No	90	0	3.02244	No	No	622.36	221.40		221.40				221.40																		
1.80	43.46	0.62	135	No	90	0	1.426501	No	No	622.20	243.54		243.54				243.54																		
1.97	40.61	0.737	135	No	90	0	1.815003	No	No	622.03	265.68		265.68				265.68																		
2.13	29.60	0.769	135	No	90	0	2.598324	No	No	621.87	287.96		287.96				287.96																		
2.30	18.43	0.775	135	No	90	0	4.204416	No	No	621.70	310.10		310.10				310.10																		
2.46	15.72	0.68	135	No	90	0	4.327076	No	No	621.54	332.24		332.24				332.24																		
2.63	13.90	0.666	135	No	90	0	4.791022	No	No	621.38	354.38		354.38				354.38																		
2.79	12.89	0.675	135	No	90	0	5.236618	No	No	621.21	376.52		376.52				376.52																		
2.95	12.04	0.637	135	No	90	0	5.288941	No	No	621.05	398.66		398.66				398.66																		
3.12	10.95	0.577	135	No	90	0	5.268925	No	No	620.88	420.80		420.80				420.80																		
3.28	10.38	0.519	125	No	90	0	4.998074	No	No	620.72	441.30		441.30				441.30																		
3.45	10.24	0.467	125	No	90	0	4.562329	No	No	620.56	461.80		461.80				461.80																		
3.61	10.73	0.449	125	No	90	0	4.184529	No	No	620.39	482.30		482.30				482.30																		
3.77	11.06	0.446	125	No	90	0	4.032914	No	No	620.23	502.80		502.80				502.80																		
3.94	11.63	0.444	125	No	90	0	3.818698	No	No	620.06	523.30		523.30				523.30																		
4.10	11.53	0.467	125	No	90	0	4.049952	No	No	619.90	543.80		543.80				543.80																		
4.27	12.13	0.491	125	No	90	0	4.049151	No	No	619.74	564.30		564.30				564.30																		
4.43	12.05	0.51	125	No	90	0	4.230961	No	No	619.57	584.80		584.80				584.80																		
4.59	11.67	0.503	125	No	90	0	4.30872	No	No	619.41	605.30		605.30				605.30																		
4.76	11.89	0.497	125	No	90	0	4.179983	No	No	619.24	625.80		625.80				625.80																		
4.92	12.21	0.469	125	No	90	0	3.842058	No	No	619.08	646.30		646.30				646.30																		
5.09	11.85	0.469	125	No	90	0	3.957472	No	No	618.92	666.80		666.80				666.80																		
5.25	11.69	0.425	125	No	90	0	3.635897	No	No	618.75	687.30		687.30				687.30																		
5.41	11.83	0.41	125	No	90	0	3.466058	No	No	618.59	707.80		707.80				707.80																		
5.58	12.60	0.417	125	No	90	0	3.310838	No	No	618.42	728.30		728.30				728.30																		
5.74	13.01	0.424	125	No	90	0	3.259282	No	No	618.26	748.80		748.80				748.80																		
5.91	13.38	0.449	125	No	90	0	3.356257	No	No	618.10	769.30		769.30				769.30																		
6.07	13.75	0.458	125	No	90	0	3.331878	No	No	617.93	789.80		789.80				789.80																		
6.23	13.25	0.454	125	No	90	0	3.425639	No	No	617.77	810.42		810.42				810.42																		
6.40	12.72	0.417	125	No	90	0	3.279591	No	No	617.60	830.92		830.92				830.92																		
6.56	12.58	0.433	125	No	90	0	3.441698	No	No	617.44	851.42		851.42				851.42																		
6.73	12.65	0.451	125	No	90	0	3.565499	No	No	617.27	871.92		871.92				871.92																		
6.89	12.05	0.465	125	No	90	0	3.860203	No	No	617.11	892.42		892.42				892.42																		
7.05	10.91	0.474	125	No	90	0	4.344638	No	No	616.95	912.92		912.92				912.92																		
7.22	9.92	0.436	125	No	90	0	4.396934	No	No	616.78	933.42		933.42				933.42																		
7.38	9.52	0.416	125	No	90	0	4.368371	No	No	616.62	953.92		953.92				953.92																		
7.55	8.71	0.389	125	No	90	0	4.465106	No	No	616.45	974.42		974.42				974.42																		
7.71	7.89	0.366	125	No	90	0	4.63702	No	No	616.29	994.92		994.92				994.92																		
7.87	6.91	0.321	125	No	90	0	4.643425	No	No	616.13	1015.42		1015.42				1015.42																		
8.04	7.25	0.297	125	No	90	0	4.098813	No	No	615.96	1035.92		1035.92				1035.92																		
8.20	7.31	0.298	125	No	90	0	4.078281	No	No	615.80	1056.42		1056.42				1056.42																		
8.37	7.06	0.344	125	No	90	0	4.873212	No	No	615.63	1076.92		1076.92				1076.92																		
8.53	6.84	0.311	125	No	90	0	4.546784	No	No	615.47	1097.42		1097.42				1097.42																		
8.69	7.00	0.3	125	No	90	0	4.287552	No	No	615.31	1117.92		1117.92				1117.92																		
8.86	7.17	0.3	125	No	90	0	4.185852	No	No	615.14	1138.42		1138.42				1138.42																		
9.02	7.87	0.337	125	No	90	0	4.283172	No	No	614.98	1158.92		1158.92				1158.92																		
9.19	8.10	0.348	125	No	90	0	4.296296	No	No	614.81	1179.42		1179.42				1179.42																		
9.35	7.83	0.358	125	No	90	0	4.572158	No	No	614.65	1199.92		1199.92				1199.92																		
9.51	7.21	0.367	125	No	90	0	5.088741	No	No	614.49	1220.42		1220.42				1220.42																		
9.68	7.19	0.342	125	No	90	0	4.755284	No	No	614.32	1240.92		1240.92				1240.92																		
9.84	7.07	0.317	125	No	90	0	4.481199	No	No	614.16	1261.42		1261.42				1261.42																		
10.01	7.44	0.276	125	No	90	0	3.712172	No	No	613.99	1281.92		1281.92				1281.92																		
10.17	7.36	0.281	125	No	90	0	3.819492	No	No	613.83	1302.42		1302.42				1302.42																		
10.34	7.31	0.303	125	No	90	0	4.143873	No	No	613.67	1323.05		1323.05				1323.05																		
10.50	7.49	0.325	125	No	90	0	4.336803	No	No	613.50	1343.55		1343.55				1343.55																		
10.66	7.35	0.331	125	No	90	0	4.505854	No	No	613.34	1364.05		1364.05				1364.05																		
10.83	7.65	0.352	125	No	90	0	4.600706	No	No	613.17	1384.55		1384.55				1384.55																		
10.99	8.08	0.344	125	No	90	0	4.256899	No	No	613.01	1405.05		1405.05				1405.05																		
11.16	8.14	0.351	125	No	90	0	4.310451	No	No	612.85	1425.55		1425.55				1425.55																		
11.32	8.36	0.38	125	No	90	0	4.54763	No	No	612.68	1446.05		1446.05				1446.05																		
11.48	9.05	0.401	125	No	90	0	4.431919	No	No	612.52	1466.55		1466.55				1466.55																		
11.65	9.44	0.383	125	No	90	0	4.056774	No	No	612.35	1487.05		1487.05				1487.05																		
11.81	9.65	0.336	125	No	90	0	3.483309	No	No	612.19	1507.55		1507.55				1507.55																		
11.98	9.31	0.345	125	No	90	0	3.704897	No	No	612.03	1528.05		1528.05				1528.05																		
12.14	10.11	0.35	125	No	90	0	3.462261	No	No	611.86	1548.55		1548.55				1548.55																		
12.30	9.58	0.389	125	No	90	0	4.059272	Yes	No	611.70	1569.05	6.43	1562.62			6.43	1562.62																		
12.47	9.78	0.429	125	No	90	0	4.3874	Yes	No	611.53	1589.55	16.66	1572.88			16.66	1572.88																		
12.63	10.42	0.431	125	No	90	0	4.134689	Yes	No	611.37	1610.05	26.89	1583.15			26.89	1583.15																		
12.80	11.31	0.423	125	No	90	0	3.740053	Yes	No	611.21	1630.55	37.13	1593.42			37.13	1593.42																		
12.96	10.23	0.396	125	No	90	0	3.869455	Yes	No	611.04	1651.05	47.36	1603.68			47.36	1603.68																		
13.12	8.95	0.333	125	No	90	0	3.719008	Yes	No	610.88	1671.55	57.60	1613.95			57.60	1613.95																		
13.29	8.54	0.262	125	No	90	0	3.068994	Yes	No	610.71	1692.05	67.83	1624.22			67.83	1624.22																		
13.45	8.78	0.176	125	No	90	0	2.004099	Yes	No	610.55	1712.55	78.06	1634.48			78.06	1634.48																		
13.62	8.13	0.127	125	No	90	0	1.5625	Yes	No	610.39	1733.05	88.30	1644.75			88.30	1644.75																		
13.78	7.14	0.101	125	No	90	0	1.414368	Yes	No	610.22	1753.55	98.53	1655.02			98.53	1655.02																		
13.94	7.48	0.111	125	No	90	0	1.483164	Yes	No	610.06	1774.05	108.76	1665.28			108.76	1665.28																		
14.11	8.03	0.103	125	No	90	0	1.283169	Yes	No	609.89	1794.55	119.00	1675.55			119.00	1675.55																		
14.27	6.94	0.108	125	No	90	0	1.557093	Yes	No	609.73	1815.05	129.23	1685.81			129.23	1685.81																		
14.44	7.22	0.117	125	No	90	0	1.620948	Yes	No	609.56	1835.67	139.53	1696.14			139.53	1696.14																		
14.60	7.64	0.106	125	No	90	0	1.388343	Yes	No	609.40	1856.17	149.76	1706.41			149.76	1706.41																		
14.76	7.69	0.104	125	No	90	0	1.352934	Yes	No	609.24	1876.67	159.99	1716.68			159.99	1716.68																		
14.93	7.06	0.167	125	No	90	0	2.3641	Yes	No	609.07	1897.17	170.23	1726.94			170.23	1726.94																		
15.09	8.12	0.196	135	Yes	56	0	2.412902	Yes	Yes	608.91	1919.31	180.46	1738.85	0.94	0.135	180.46	1738.85	9.15	0.891	1.19	9.68	50.3	59.9	0.099	0.04	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.127	1.048	0.78
15.26	14.28	0.184	135	Yes	56	0	1.288876	Yes	Yes	608.74	1941.45	190.69	1750.76	0.94	0.135	190.69	1750.76	15.77	0.822	1.17	16.68	52.1	68.8	0.106	0.05	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.146	1.055	0.84

CPT Liquefaction Analysis

15.42	17.47	0.101	135	Yes	56	0	0.578035	Yes	Yes	608.58	1963.59	200.93	1762.66	0.94	0.136	200.93	1762.66	19.10	0.796	1.16	20.21	53.0	73.2	0.110	0.05	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.157	1.059	0.87
15.58	22.12	0.071	135	Yes	56	0	0.320933	Yes	Yes	608.42	1985.73	211.16	1774.57	0.94	0.136	211.16	1774.57	23.91	0.762	1.14	25.30	54.3	79.6	0.115	0.06	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.177	1.066	0.91
15.75	23.98	0.076	135	Yes	56	0	0.316918	Yes	Yes	608.25	2007.87	221.40	1786.47	0.94	0.137	221.40	1786.47	25.74	0.751	1.14	27.23	54.8	82.1	0.118	0.06	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.185	1.070	0.93
15.91	26.06	0.16	135	Yes	56	0	0.613944	Yes	Yes	608.09	2030.01	231.63	1798.38	0.94	0.137	231.63	1798.38	27.78	0.739	1.13	29.39	55.4	84.8	0.120	0.06	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.194	1.073	0.95
16.08	33.67	0.299	135	Yes	56	0	0.888163	Yes	Yes	607.92	2052.15	241.86	1810.29	0.93	0.138	241.86	1810.29	35.49	0.699	1.12	37.55	57.5	95.1	0.131	0.06	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.237	1.089	1.05
16.24	47.57	0.442	135	Yes	56	0	0.929196	Yes	Yes	607.76	2074.29	252.10	1822.19	0.93	0.138	252.10	1822.19	49.48	0.641	1.10	52.35	61.4	113.7	0.158	0.07	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.342	1.129	1.31
16.40	66.48	0.544	135	Yes	56	0	0.818254	Yes	Yes	607.60	2096.43	262.33	1834.10	0.93	0.139	262.33	1834.10	68.26	0.579	1.09	72.22	66.5	138.7	0.229	0.08	1.01	0.00	0.100	1.000	0.000	0.138	1.000	1.548	1.206	2.02
16.57	95.07	0.526	135	Yes	56	0	0.553282	Yes	Yes	607.43	2118.57	272.56	1846.01	0.93	0.139	272.56	1846.01	96.29	0.506	1.07	101.87	74.2	176.1	0.624297	0.10	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.026	1.386	6.32
16.73	108.79	0.531	135	Yes	56	0	0.488119	Yes	Yes	607.27	2140.71	282.80	1857.91	0.93	0.139	282.80	1857.91	109.42	0.478	1.06	115.76	77.8	193.6	1.341209	0.11	1.01	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	14.18
16.90	116.97	0.434	135	Yes	56	0	0.371038	Yes	Yes	607.10	2162.85	293.03	1869.82	0.93	0.140	293.03	1869.82	117.07	0.462	1.06	123.85	79.9	203.8	2.354324	0.12	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	24.82
17.06	127.11	0.677	135	Yes	56	0	0.532631	Yes	Yes	606.94	2184.99	303.26	1881.73	0.93	0.140	303.26	1881.73	126.57	0.444	1.05	133.91	82.5	216.4	3.724576	0.13	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	39.17
17.22	153.19	1.381	135	Yes	56	0	0.901513	Yes	Yes	606.78	2207.13	313.50	1893.63	0.93	0.141	313.50	1893.63	151.38	0.401	1.05	160.16	89.4	249.5	3.724576	0.16	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	39.16
17.39	180.35	2.149	135	Yes	56	0	1.191579	Yes	Yes	606.61	2229.27	323.73	1905.54	0.93	0.141	323.73	1905.54	177.04	0.361	1.04	187.31	96.4	283.7	3.724576	0.21	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	39.19
17.55	202.89	2.406	135	Yes	56	0	1.185847	Yes	Yes	606.45	2251.41	333.96	1917.45	0.93	0.141	333.96	1917.45	198.15	0.332	1.03	209.64	102.2	311.9	3.724576	0.26	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	39.23
17.72	240.42	3.316	135	Yes	56	0	1.379247	Yes	Yes	606.28	2273.55	344.20	1929.35	0.92	0.142	344.20	1929.35	233.36	0.288	1.03	246.89	111.9	358.8	3.724576	0.30	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	39.22
17.88	268.27	3.632	135	Yes	56	0	1.35385	Yes	Yes	606.12	2295.69	354.43	1941.26	0.92	0.142	354.43	1941.26	259.27	0.258	1.02	274.30	119.0	393.3	3.724576	0.30	1.03	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	39.05
18.04	283.75	3.646	135	Yes	56	0	1.284938	Yes	Yes	605.96	2317.83	364.67	1953.16	0.92	0.142	364.67	1953.16	273.46	0.243	1.02	289.32	122.9	412.2	3.724576	0.30	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.88
18.21	274.04	3.826	135	Yes	56	0	1.396126	Yes	Yes	605.79	2339.97	374.90	1965.07	0.92	0.143	374.90	1965.07	263.91	0.253	1.02	279.22	120.3	399.5	3.724576	0.30	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.72
18.37	209.18	5.014	135	Yes	56	0	2.397002	Yes	Yes	605.63	2362.11	385.13	1976.98	0.92	0.143	385.13	1976.98	202.15	0.327	1.02	213.87	103.3	317.2	3.724576	0.27	1.02	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	38.48
18.54	149.35	5.147	135	No	56	0	3.446175	Yes	No	605.46	2384.39	395.43	1988.96			395.43	1988.96																		
18.70	84.18	3.948	135	No	56	0	4.689894	Yes	No	605.30	2406.53	405.66	2000.86			405.66	2000.86																		
18.87	66.98	2.648	135	No	56	0	3.953419	Yes	No	605.14	2428.67	415.90	2012.77			415.90	2012.77																		
19.03	56.66	1.878	135	No	56	0	3.314742	Yes	No	604.97	2450.81	426.13	2024.68			426.13	2024.68																		
19.19	51.66	1.684	135	No	56	0	3.259712	Yes	No	604.81	2472.95	436.36	2036.58			436.36	2036.58																		
19.36	46.81	1.618	135	No	56	0	3.456822	Yes	No	604.64	2495.09	446.60	2048.49			446.60	2048.49																		
19.52	43.82	1.557	135	No	56	0	3.553172	Yes	No	604.48	2517.23	456.83	2060.39			456.83	2060.39																		
19.69	40.64	1.462	135	No	56	0	3.597352	Yes	No	604.32	2539.37	467.06	2072.30			467.06	2072.30																		
19.85	37.31	1.383	135	No	56	0	3.70688	Yes	No	604.15	2561.51	477.30	2084.21			477.30	2084.21																		
20.01	34.29	1.312	135	No	56	0	3.825965	Yes	No	603.99	2583.65	487.53	2096.11			487.53	2096.11																		
20.18	33.84	1.239	135	No	56	0	3.661456	Yes	No	603.82	2605.79	497.76	2108.02			497.76	2108.02																		
20.34	32.56	0.959	135	No	56	0	2.945513	Yes	No	603.66	2627.93	508.00	2119.93			508.00	2119.93																		
20.51	31.95	0.946	135	No	56	0	2.960876	Yes	No	603.50	2650.07	518.23	2131.83			518.23	2131.83																		
20.67	32.27	0.939	135	No	56	0	2.909643	Yes	No	603.33	2672.21	528.47	2143.74			528.47	2143.74																		
20.83	31.91	0.893	135	No	56	0	2.798233	Yes	No	603.17	2694.35	538.70	2155.65			538.70	2155.65																		
21.00	32.08	0.836	135	No	56	0	2.605741	Yes	No	603.00	2716.49	548.93	2167.55			548.93	2167.55																		
21.16	31.34	0.85	135	No	56	0	2.712362	Yes	No	602.84	2738.63	559.17	2179.46			559.17	2179.46																		
21.33	31.62	0.849	135	No	56	0	2.685094	Yes	No	602.68	2760.77	569.40	2191.37			569.40	2191.37																		
21.49	30.52	0.819	135	No	56	0	2.683838	Yes	No	602.51	2782.91	579.63	2203.27			579.63	2203.27																		
21.65	29.24	0.886	135	No	56	0	3.030199	Yes	No	602.35	2805.05	589.87	2215.18			589.87	2215.18																		
21.82	30.31	0.89	135	No	56	0	2.936712	Yes	No	602.18	2827.19	600.10	2227.08			600.10	2227.08																		
21.98	30.84	0.841	135	No	56	0	2.727155	Yes	No	602.02	2849.33	610.33	2238.99			610.33	2238.99																		
22.15	29.28	0.81	135	No	56	0	2.766204	Yes	No	601.86	2871.47	620.57	2250.90			620.57	2250.90																		
22.31	28.48	0.805	135	No	56	0	2.826446	Yes	No	601.69	2893.61	630.80	2262.80			630.80	2262.80																		
22.47	28.32	0.796	135	No	56	0	2.811231	Yes	No	601.53	2915.75	641.04	2274.71			641.04	2274.71																		
22.64	28.52	0.796	135	No	56	0	2.791513	Yes	No	601.36	2937.89	651.27	2286.62			651.27	2286.62																		
22.80	29.15	0.773	135	No	56	0	2.651437	Yes	No	601.20	2960.03	661.50	2298.52			661.50	2298.52																		
22.97	29.10	0.814	135	No	56	0	2.797347	Yes	No	601.04	2982.17	671.74	2310.43			671.74	2310.43																		
23.13	28.85	0.843	135	No	56	0	2.92201	Yes	No	600.87	3004.31	681.97	2322.34			681.97	2322.34																		
23.29	28.45	0.813	135	No	56	0	2.858147	Yes	No	600.71	3026.45	692.20	2334.24			692.20	2334.24																		
23.46	28.09	0.792	135	No	56	0	2.819609	Yes	No	600.54	3048.59	702.44	2346.15			702.44	2346.15																		
23.62	28.01	0.785	135	No	56	0	2.802771	Yes	No	600.38	3070.73	712.67	2358.05			712.67	2358.05																		
23.79	27.56	0.793	135	No	56	0	2.877045	Yes	No	600.22	3092.87	722.90	2369.96			722.90	2369.96																		
23.95	26.57	0.778	135	No	56	0	2.928555	Yes	No	600.05	3115.01	733.14	2381.87			733.14	2381.87																		
24.11	25.03	0.766	135	No	56	0	3.060083	Yes	No	599.89	3137.15	743.37	2393.77			743.37	2393.77																		
24.28	23.96	0.644	135	No	56	0	2.68815	Yes	No	599.72	3159.29	753.60	2405.68			753.60	2405.68																		
24.44	22.79	0.719	135	No	56	0	3.155308	Yes	No	599.56	3181.43	763.84	2417.59			763.84	2417.59																		
24.61	24.75	1.097	135	No	56	0	4.431786	Yes	No	599.40	3203.57	774.07	2429.49			774.07	2429.49																		
24.77	57.96	1.646	135	No	56	0	2.839743	Yes	No	599.23	3225.71	784.31	2441.40			784.31	2441.40																		
24.93	60.48	1.689	135	No	56	0	2.792843	Yes	No	599.07	3247.85	794.54	2453.31			794.54	2453.31																		
25.10	38.02	1.833	135	No	56	0	4.820893	Yes	No	598.90	3269.99	804.77	2465.21			804.77	2465.21																		
25.26	30.35	1.149	135	No	56	0	3.786206	Yes	No	598.74	3292.13	815.01	2477.12			815.01	2477.12																		
25.43	25.15	0.946	135	No	56	0	3.76188	Yes	No	598.58	3314.27	825.24	2489.03			825.24	2489.03																		
25.59	42.75	0.875	135	No	56	0	2.046736	Yes	No	598.41	3336.41	835.47	2500.93			835.47	2500.93																		
25.75	35.71	0.919	135	No	56	0	2.573653	Yes	No	598.25	3358.55	845.71	2512.84			845.71	2512.84																		
25.92	25.64	0.964	135	No	56	0	3.759604	Yes	No	598.08	3380.69	855.94	2524.74			855.94	2524.74																		
26.08	22.61	0.766	135	No	56	0	3.388031	Yes	No	597.92	3402.83	866.17	2536.65			866.17	2536.65																		
26.25	21.83	0.569	135	No	56	0	2.606027	Yes	No	597.76	3424.97	876.41	2548.56			876.41	2548.56																		
26.41	21.64	0.544	135	No	56	0	2.513515	Yes	No	597.59	3447.11	886.64	2560.46			886.64	2560.46																		
26.57	21.33	0.524	135	No	56	0	2.456864	Yes	No	597.43	3469.25	896.88	2572.37			896.88	2572.37																		
26.74	21.65	0.509	135	No	56	0	2.351582	Yes	No	597.26	3491.39	907.11	2584.28			907.11	2584.28																		
26.90	21.22	0.474	135	No	56	0	2.233952	Yes	No	597.10	3513.53	917.34	2596.18			917.34	2596.18																		
27.07	21.09	0.573	135	No	56	0	2.717572	Yes	No	596.94	3535.67	927.58	2608.09			927.58	2608.09																		
27.23	22.76	1.373	135	No	56	0	6.032513	Yes	No	596.77	3557.81	937.81	2620.00			937.81	2620.00																		
27.39	72.13	1.499	135	No	56	0	2.078192	Yes	No	596.61	3579.95	948.04	2631.90			948.04	2631.90																		
27.56	51.77	1.694	135	No	56	0	3.271913	Yes	No	596.44	3602.09	958.28	2643.81			958.28	2643.81																		
27.72	49.11	1.783	135	No	56	0	3.630477	Yes	No	596.28	3624.23	968.51	2655.71			968.51	2655.71																		
27.89	37.93	1.348	135	No	56	0	3.554009	Yes	No	596.12	3646.37	978.74	2667.62			978.74	2667.62																		
28.05	42.42	1.341	135	No	56	0	3.161096	Yes	No	595.95	3668.51	988.98	2679.53			988.98	2679.53																		
28.21	63.67	1.374	135	No	56	0	2.158104	Yes	No	595.79	3690.65	999.21	2691.43			999.21	2691.43																		
28.38	38.54	1.776	135	No	56	0	4.607721	Yes	No	595.62	3712.79	1009.44	2703.34			1009.44	2703.34																		
28.54	42.02	1.632	135	No	56	0	3.883865	Yes	No	595.46	3734.93	1019.68	2715.25			1019.68	2715.25																		
28.71	26.52	1.058	135	No	56	0	3.988991	Yes	No	595.30	3757.07	1029.91	2727.15			1029.91	2727.15																		
28.87	27.29	0.776	135	No	56	0	2.843949	Yes	No	595.13	3779.21	1040.15	2739.06			1040.15	2739.06																		
29.03	28.51	0.617	135	No	56	0	2.164381	Yes	No	594.97	3801.35	1050.38	2750.97			1050.38	2750.97																		
29.20	28.00	0.644	135	No	56	0	2.3	Yes	No	594.80	3823.49	1060.61	2762.87			1060.61	2762.87																		
29.36	26.08	0.589	135	No	56	0	2.258176	Yes	No	594.64	3845.63	1070.85	2774.78			1070.85	2774.78																		
29.52	25.97	0.551	135	No	56	0	2.121352	Yes	No	594.48	3867.77	1081.08	2786.69			1081.08	2786.69																		
29.69	25.16	0.527	135	No	56	0	2.094761	Yes	No	594.31	3889.91	1091.31	2798.59			1091.31	2798.59																		
29.85	24.06	0.565	135	No	56	0	2.348686	Yes	No	594.15	3912.05	1101.55	2810.50			1101.55	2810.50																		
30.02	22.51	0.53	135	No	56	0	2.354405	Yes	No	593.98	3934.19	1111.78	2822.40			1111.78	2822.40																		
30.18	22.02	0.404	135	No	56	0	1.835029	Yes	No	593.82	3956.33	1122.01	2834.31			1122.01	2834.31																		
30.34	23.79	0.413	135	No	56	0	1.735732	Yes	No	593.66	3978.47	1132.25	2846.22			1132.25	2846.22																		
30.51	27.61	0.442	135	No	56	0	1.600637	Yes	No	593.49	4000.61	1142.48	2858.12			1142.48	2858.12																		
30.67	26.78	0.49	135	No	56	0	1.829519	Yes	No	593.33	4022.75	1152.72	2870.03			1152.72	2870.03																		
30.84	26.69	0.526	135	No	56	0	1.970776	Yes	No	593.16	4044.89	1162.95	2881.94			1162.95	2881.94																		
31.00	24.84	0.549	135	No	56	0	2.210501	Yes	No	593.00	4067.03	1173.18	2893.84			1173.18	2893.84																		
31.16	23.31	0.491	135	No	56	0	2.106573	Yes	No	592.84	4089.17	1183.42	2905.75			1183.42	2905.75																		
31.33	21.07	0.434	135	No	56	0	2.060192	Yes	No	592.67	4111.31	1193.65	2917.66			1193.65	2917.66																		
31.49	23.04	0.4	135	No	56	0	1.736262	Yes	No	592.51	4133.45	1203.88	2929.56			1203.88	2929.56																		
31.66	24.06	0.434	135	No	56	0	1.803974	Yes	No	592.34	4155.59	1214.12	2941.47			1214.12	2941.47																		
31.82	25.00	0.475	135	No	56	0	1.900304	Yes	No	592.18	4177.73	1224.35	2953.37			1224.35	2953.37																		
31.98	24.84	0.492	135	No	56	0	1.981075	Yes	No	592.02	4199.87	1234.58	2965.28			1234.58	2965.28																		
32.15	24.50	0.47	135	No	56	0	1.918681	Yes	No	591.85	4222.01	1244.82	2977.19			1244.82	2977.19																		
32.31	24.58	0.427	135	No	56	0	1.737114	Yes	No	591.69	4244.15	1255.05	2989.09			1255.05	2989.09																		
32.48	23.92	0.395	135	No	56	0	1.651614	Yes	No	591.52	4266.29	1265.28	3001.00			1265.28	3001.00																		
32.64	23.56	0.394	135	No	56	0	1.672042	Yes	No	591.36	4288.43	1275.52	3012.91			1275.52	3012.91																		
32.80	22.90	0.406	135	No	56	0	1.772926	Yes	No	591.20	4310.57	1285.75	3024.81			1285.75	3024.81																		

32.97	22.91	0.409	135	No	56	0	1.78548	Yes	No	591.03	4332.71	1295.99	3036.72			1295.99	3036.72																		
33.13	23.11	0.415	135	No	56	0	1.795604	Yes	No	590.87	4354.85	1306.22	3048.63			1306.22	3048.63																		
33.30	25.34	0.438	135	No	56	0	1.728424	Yes	No	590.70	4376.99	1316.45	3060.53			1316.45	3060.53																		
33.46	24.46	0.47	135	No	56	0	1.921819	Yes	No	590.54	4399.13	1326.69	3072.44			1326.69	3072.44																		
33.62	24.28	0.486	135	No	56	0	2.00173	Yes	No	590.38	4421.27	1336.92	3084.35			1336.92	3084.35																		
33.79	24.75	0.45	135	No	56	0	1.818402	Yes	No	590.21	4443.41	1347.15	3096.25			1347.15	3096.25																		
33.95	24.26	0.451	135	No	56	0	1.85941	Yes	No	590.05	4465.55	1357.39	3108.16			1357.39	3108.16																		
34.12	24.85	0.437	135	No	56	0	1.758764	Yes	No	589.88	4487.69	1367.62	3120.06			1367.62	3120.06																		
34.28	25.46	0.469	135	No	56	0	1.842033	Yes	No	589.72	4509.83	1377.85	3131.97			1377.85	3131.97																		
34.44	25.69	0.506	135	No	56	0	1.969715	Yes	No	589.56	4531.97	1388.09	3143.88			1388.09	3143.88																		
34.61	25.92	0.513	135	No	56	0	1.979014	Yes	No	589.39	4554.11	1398.32	3155.78			1398.32	3155.78																		
34.77	26.23	0.531	135	No	56	0	2.024245	Yes	No	589.23	4576.25	1408.56	3167.69			1408.56	3167.69																		
34.94	26.12	0.518	135	No	56	0	1.983003	Yes	No	589.06	4598.39	1418.79	3179.60			1418.79	3179.60																		
35.10	26.41	0.484	135	No	56	0	1.832917	Yes	No	588.90	4620.53	1429.02	3191.50			1429.02	3191.50																		
35.26	26.62	0.482	135	No	56	0	1.810533	Yes	No	588.74	4642.67	1439.26	3203.41			1439.26	3203.41																		
35.43	26.43	0.475	135	No	56	0	1.797268	Yes	No	588.57	4664.81	1449.49	3215.32			1449.49	3215.32																		
35.59	27.05	0.458	135	No	56	0	1.693223	Yes	No	588.41	4686.95	1459.72	3227.22			1459.72	3227.22																		
35.76	27.12	0.462	135	No	56	0	1.703854	Yes	No	588.24	4709.09	1469.96	3239.13			1469.96	3239.13																		
35.92	27.13	0.469	135	No	56	0	1.728969	Yes	No	588.08	4731.23	1480.19	3251.03			1480.19	3251.03																		
36.08	27.66	0.48	135	No	56	0	1.735609	Yes	No	587.92	4753.37	1490.42	3262.94			1490.42	3262.94																		
36.25	27.53	0.503	135	No	56	0	1.82723	Yes	No	587.75	4775.51	1500.66	3274.85			1500.66	3274.85																		
36.41	28.12	0.485	135	No	56	0	1.725058	Yes	No	587.59	4797.65	1510.89	3286.75			1510.89	3286.75																		
36.58	28.69	0.486	135	No	56	0	1.694088	Yes	No	587.42	4819.79	1521.12	3298.66			1521.12	3298.66																		
36.74	25.45	0.486	135	No	56	0	1.909552	Yes	No	587.26	4841.93	1531.36	3310.57			1531.36	3310.57																		
36.90	24.92	0.459	135	No	56	0	1.841746	Yes	No	587.10	4864.07	1541.59	3322.47			1541.59	3322.47																		
37.07	24.88	0.451	135	No	56	0	1.812774	Yes	No	586.93	4886.21	1551.83	3334.38			1551.83	3334.38																		
37.23	26.72	0.483	135	No	56	0	1.807567	Yes	No	586.77	4908.35	1562.06	3346.29			1562.06	3346.29																		
37.40	27.27	0.516	135	No	56	0	1.89212	Yes	No	586.60	4930.48	1572.29	3358.19			1572.29	3358.19																		
37.56	27.57	0.533	135	No	56	0	1.933541	Yes	No	586.44	4952.62	1582.53	3370.10			1582.53	3370.10																		
37.72	26.89	0.552	135	No	56	0	2.05296	Yes	No	586.28	4974.76	1592.76	3382.01			1592.76	3382.01																		
37.89	25.85	0.534	135	No	56	0	2.065924	Yes	No	586.11	4996.90	1602.99	3393.91			1602.99	3393.91																		
38.05	26.04	0.528	135	No	56	0	2.027572	Yes	No	585.95	5019.04	1613.23	3405.82			1613.23	3405.82																		
38.22	28.23	0.542	135	No	56	0	1.920147	Yes	No	585.78	5041.18	1623.46	3417.72			1623.46	3417.72																		
38.38	29.19	0.581	135	No	56	0	1.990271	Yes	No	585.62	5063.32	1633.69	3429.63			1633.69	3429.63																		
38.54	29.75	0.643	135	No	56	0	2.161199	Yes	No	585.46	5085.46	1643.93	3441.54			1643.93	3441.54																		
38.71	29.49	0.641	135	No	56	0	2.173913	Yes	No	585.29	5107.60	1654.16	3453.44			1654.16	3453.44																		
38.87	35.44	0.617	135	No	56	0	1.741118	Yes	No	585.13	5129.74	1664.40	3465.35			1664.40	3465.35																		
39.04	34.41	0.601	135	No	56	0	1.746687	Yes	No	584.96	5151.88	1674.63	3477.26			1674.63	3477.26																		
39.20	27.53	0.555	135	No	56	0	2.016129	Yes	No	584.80	5174.02	1684.86	3489.16			1684.86	3489.16																		
39.36	27.72	0.586	135	No	56	0	2.114378	Yes	No	584.64	5196.16	1695.10	3501.07			1695.10	3501.07																		
39.53	29.23	0.548	135	No	56	0	1.874979	Yes	No	584.47	5218.30	1705.33	3512.98			1705.33	3512.98																		
39.69	29.55	0.565	135	No	56	0	1.911819	Yes	No	584.31	5240.44	1715.56	3524.88			1715.56	3524.88																		
39.86	30.12	0.577	135	No	56	0	1.915607	Yes	No	584.14	5262.58	1725.80	3536.79			1725.80	3536.79																		
40.02	30.45	0.607	135	No	56	0	1.993235	Yes	No	583.98	5284.72	1736.03	3548.69			1736.03	3548.69																		
40.18	31.67	0.62	135	No	56	0	1.957998	Yes	No	583.82	5306.86	1746.26	3560.60			1746.26	3560.60																		
40.35	30.91	0.646	135	No	56	0	2.090141	Yes	No	583.65	5329.00	1756.50	3572.51			1756.50	3572.51																		
40.51	30.29	0.63	135	No	56	0	2.079826	Yes	No	583.49	5351.14	1766.73	3584.41			1766.73	3584.41																		
40.68	30.15	0.631	135	No	56	0	2.093077	Yes	No	583.32	5373.28	1776.96	3596.32			1776.96	3596.32																		
40.84	30.00	0.626	135	No	56	0	2.086458	Yes	No	583.16	5395.42	1787.20	3608.23			1787.20	3608.23																		
41.00	29.90	0.653	135	No	56	0	2.183727	Yes	No	583.00	5417.56	1797.43	3620.13			1797.43	3620.13																		
41.17	29.77	0.598	135	No	56	0	2.008531	Yes	No	582.83	5439.70	1807.67	3632.04			1807.67	3632.04																		
41.33	31.66	0.653	135	No	56	0	2.062735	Yes	No	582.67	5461.84	1817.90	3643.95			1817.90	3643.95																		
41.50	31.05	0.603	135	No	56	0	1.942279	Yes	No	582.50	5483.98	1828.13	3655.85			1828.13	3655.85																		
41.66	32.93	0.792	135	No	56	0	2.405394	Yes	No	582.34	5506.12	1838.37	3667.76			1838.37	3667.76																		
41.82	46.19	1.164	135	No	56	0	2.520299	Yes	No	582.18	5528.26	1848.60	3679.67			1848.60	3679.67																		
41.99	41.15	1.171	135	No	56	0	2.845617	Yes	No	582.01	5550.40	1858.83	3691.57			1858.83	3691.57																		
42.15	31.73	1.056	135	No	56	0	3.328186	Yes	No	581.85	5572.54	1869.07	3703.48			1869.07	3703.48																		
42.32	31.07	0.723	135	No	56	0	2.326929	Yes	No	581.68	5594.68	1879.30	3715.38			1879.30	3715.38																		
42.48	30.32	0.654	135	No	56	0	2.157063	Yes	No	581.52	5616.82	1889.53	3727.29			1889.53	3727.29																		
42.64	30.80	0.682	135	No	56	0	2.21443	Yes	No	581.36	5638.96	1899.77	3739.20			1899.77	3739.20																		
42.81	31.27	0.691	135	No	56	0	2.210068	Yes	No	581.19	5661.10	1910.00	3751.10			1910.00	3751.10																		
42.97	30.98	0.711	135	No	56	0	2.295177	Yes	No	581.03	5683.24	1920.24	3763.01			1920.24	3763.01																		
43.14	30.69	0.68	135	No	56	0	2.215922	Yes	No	580.86	5705.38	1930.47	3774.92			1930.47	3774.92																		
43.30	29.97	0.638	135	No	56	0	2.128511	Yes	No	580.70	5727.53	1940.70	3786.82			1940.70	3786.82																		
43.46	30.36	0.667	135	No	56	0	2.196897	Yes	No	580.54	5749.66	1950.94	3798.73			1950.94	3798.73																		
43.63	31.24	0.65	135	No	56	0	2.080932	Yes	No	580.37	5771.80	1961.17	3810.64			1961.17	3810.64																		
43.79	31.97	0.645	135	No	56	0	2.017264	Yes	No	580.21	5793.95	1971.40	3822.54			1971.40	3822.54																		
43.96	31.65	0.644	135	No	56	0	2.034498	Yes	No	580.04	5816.09	1981.64	3834.45			1981.64	3834.45																		
44.12	33.07	0.614	135	No	56	0	1.856555	Yes	No	579.88	5838.23	1991.87	3846.35			1991.87	3846.35																		
44.28	32.05	0.604	135	No	56	0	1.884614	Yes	No	579.72	5860.37	2002.10	3858.26			2002.10	3858.26																		
44.45	31.76	0.584	135	No	56	0	1.838733	Yes	No	579.55	5882.51	2012.34	3870.17			2012.34	3870.17																		
44.61	31.65	0.599	135	No	56	0	1.892695	Yes	No	579.39	5904.65	2022.57	3882.07			2022.57	3882.07																		
44.78	32.31	0.604	135	No	56	0	1.869275	Yes	No	579.22	5926.79	2032.80	3893.98			2032.80	3893.98																		
44.94	32.51	0.613	135	No	56	0	1.885342	Yes	No	579.06	5948.93	2043.04	3905.89			2043.04	3905.89																		
45.10	33.53	0.71	135	No	56	0	2.117444	Yes	No	578.90	5971.07	2053.27	3917.79			2053.27	3917.79																		
45.27	33.51	0.677	135	No	56	0	2.020292	Yes	No	578.73	5993.20	2063.51	3929.70			2063.51	3929.70																		
45.43	31.62	0.693	135	No	56	0	2.191582	Yes	No	578.57	6015.34	2073.74	3941.61			2073.74	3941.61																		
45.60	31.88	0.694	135	No	56	0	2.176845	Yes	No	578.40	6037.48	2083.97	3953.51			2083.97	3953.51																		
45.76	29.04	0.595	135	No	56	0	2.04918	Yes	No	578.24	6059.62	2094.21	3965.42			2094.21	3965.42																		
45.92	28.18	0.604	135	No	56	0	2.143668	Yes	No	578.08	6081.76	2104.44	3977.33			2104.44	3977.33																		
46.09	29.12	0.592	135	No	56	0	2.032967	Yes	No	577.91	6103.90	2114.67	3989.23			2114.67	3989.23																		
46.25	30.63	0.679	135	No	56	0	2.216998	Yes	No	577.75	6126.04	2124.91	4001.14			2124.91	4001.14																		
46.42	29.79	0.69	135	No	56	0	2.316136	Yes	No	577.58	6148.18	2135.14	4013.04			2135.14	4013.04																		
46.58	30.02	0.664	135	No	56	0	2.212227	Yes	No	577.42	6170.32	2145.37	4024.95			2145.37	4024.95																		
46.74	29.39	0.65	135	No	56	0	2.211411	Yes	No	577.26	6192.46	2155.61	4036.86			2155.61	4036.86																		
46.91	29.56	0.633	135	No	56	0	2.141335	Yes	No	577.09	6214.60	2165.84	4048.76			2165.84	4048.76																		
47.07	29.68	0.615	135	No	56	0	2.072382	Yes	No	576.93	6236.74	2176.08	4060.67			2176.08	4060.67																		
47.24	31.43	0.653	135	No	56	0	2.077567	Yes	No	576.76	6258.88	2186.31	4072.58			2186.31	4072.58																		
47.40	32.11	0.667	135	No	56	0	2.077364	Yes	No	576.60	6281.02	2196.54	4084.48			2196.54	4084.48																		
47.56	31.17	0.621	135	No	56	0	1.99262	Yes	No	576.44	6303.16	2206.78	4096.39			2206.78	4096.39																		
47.73	32.53	0.649	135	No	56	0	1.995388	Yes	No	576.27	6325.30	2217.01	4108.30			2217.01	4108.30																		
47.89	35.88	0.612	135	No	56	0	1.705733	Yes	No	576.11	6347.44	2227.24	4120.20			2227.24	4120.20																		
48.06	33.70	0.692	135	No	56	0	2.053717	Yes	No	575.94	6369.58	2237.48	4132.11			2237.48	4132.11																		
48.22	31.79	0.639	135	No	56	0	2.010256	Yes	No	575.78	6391.72	2247.71	4144.01			2247.71	4144.01																		
48.38	30.36	0.597	135	No	56	0	1.966209	Yes	No	575.62	6413.86	2257.94	4155.92			2257.94	4155.92																		
48.55	31.22	0.594	135	No	56	0	1.902809	Yes	No	575.45	6436.00	2268.18	4167.83			2268.18	4167.83																		
48.71	31.41	0.673	135	No	56	0	2.142357	Yes	No	575.29	6458.14	2278.41	4179.73			2278.41	4179.73																		
48.88	30.26	0.737	135	No	56	0	2.435478	Yes	No	575.12	6480.28	2288.64	4191.64			2288.64	4191.64																		
49.04	28.34	0.834	135	No	56	0	2.942525	Yes	No	574.96	6502.42	2298.88	4203.55			2298.88	4203.55																		
49.20	27.46	0.894	135	No	56	0	3.256237	Yes	No	574.80	6524.56	2309.11	4215.45			2309.11	4215.45																		
49.37	29.84	0.918	135	No	56	0	3.076304	Yes	No	574.63	6546.70	2319.35	4227.36			2319.35	4227.36																		
49.53	56.41	1.679	135	No	56	0	2.976528	Yes	No	574.47	6568.84	2329.58	4239.27			2329.58	4239.27																		
49.70	69.56	2.018	135	No	56	0	2.901301	Yes	No	574.30	6590.98	2339.81	4251.17			2339.81	4251.17																		
49.86	51.59	2.249	135	No	56	0	4.359456	Yes	No	574.14	6613.12	2350.05	4263.08			2350.05	4263.08																		
50.02	48.32	1.707	135	No	56	0	3.532845	Yes	No	573.98	6635.26	2360.28	4274.99			2360.28	4274.99																		
50.19	38.74	1.156	135	No	56	0	2.984304	Yes	No	573.81	6657.40	2370.51	4286.89			2370.51	4286.89																		
50.35	36.89	0.96	135	No	56	0	2.602684	Yes	No	573.65	6679.54	2380.75	4298.80			2380.75	4298.80																		

CPT Liquefaction Analysis

50.52	38.38	1.114	135	No	56	0	2.902478	Yes	No	573.48	6701.68	2390.98	4310.70			2390.98	4310.70																		
50.68	49.29	2.049	135	No	56	0	4.157367	Yes	No	573.32	6723.82	2401.21	4322.61			2401.21	4322.61																		
50.84	358.26	3.133	135	No	56	0	0.874505	Yes	No	573.16	6745.96	2411.45	4334.52			2411.45	4334.52																		
51.01	231.91	3.859	135	No	56	0	1.664029	Yes	No	572.99	6768.10	2421.68	4346.42			2421.68	4346.42																		
51.17	115.02	4.07	135	No	56	0	3.538423	Yes	No	572.83	6790.24	2431.92	4358.33			2431.92	4358.33																		
51.34	78.82	3.393	135	No	56	0	4.305018	Yes	No	572.66	6812.38	2442.15	4370.24			2442.15	4370.24																		
51.50	61.28	2.307	135	No	56	0	3.764932	Yes	No	572.50	6834.52	2452.38	4382.14			2452.38	4382.14																		
51.66	54.01	1.276	135	No	56	0	2.3627	Yes	No	572.34	6856.66	2462.62	4394.05			2462.62	4394.05																		
51.83	53.25	0.826	135	No	56	0	1.55129	Yes	No	572.17	6878.80	2472.85	4405.96			2472.85	4405.96																		
51.99	50.04	0.81	135	No	56	0	1.618802	Yes	No	572.01	6900.94	2483.08	4417.86			2483.08	4417.86																		
52.16	48.41	0.759	135	No	56	0	1.567858	Yes	No	571.84	6923.08	2493.32	4429.77			2493.32	4429.77																		
52.32	43.71	0.694	135	No	56	0	1.587701	Yes	No	571.68	6945.22	2503.55	4441.67			2503.55	4441.67																		
52.48	44.24	0.547	135	No	56	0	1.236577	Yes	No	571.52	6967.36	2513.78	4453.58			2513.78	4453.58																		
52.65	49.38	0.558	135	No	56	0	1.129966	Yes	No	571.35	6989.50	2524.02	4465.49			2524.02	4465.49																		
52.81	54.23	0.646	135	No	56	0	1.191157	Yes	No	571.19	7011.64	2534.25	4477.39			2534.25	4477.39																		
52.98	54.16	0.81	135	No	56	0	1.495458	Yes	No	571.02	7033.78	2544.48	4489.30			2544.48	4489.30																		
53.14	50.34	0.838	135	No	56	0	1.664746	Yes	No	570.86	7055.92	2554.72	4501.21			2554.72	4501.21																		
53.30	47.16	0.814	135	No	56	0	1.726002	Yes	No	570.70	7078.06	2564.95	4513.11			2564.95	4513.11																		
53.47	47.43	0.694	135	No	56	0	1.463209	Yes	No	570.53	7100.20	2575.19	4525.02			2575.19	4525.02																		
53.63	47.96	0.58	135	No	56	0	1.209341	Yes	No	570.37	7122.34	2585.42	4536.93			2585.42	4536.93																		
53.80	48.36	0.58	135	No	56	0	1.199388	Yes	No	570.20	7144.48	2595.65	4548.83			2595.65	4548.83																		
53.96	48.06	0.598	135	No	56	0	1.244304	Yes	No	570.04	7166.62	2605.89	4560.74			2605.89	4560.74																		
54.12	46.39	0.622	135	No	56	0	1.340835	Yes	No	569.88	7188.76	2616.12	4572.65			2616.12	4572.65																		
54.29	44.68	0.637	135	No	56	0	1.425566	Yes	No	569.71	7210.90	2626.35	4584.55			2626.35	4584.55																		
54.45	44.07	0.627	135	No	56	0	1.422704	Yes	No	569.55	7233.04	2636.59	4596.46			2636.59	4596.46																		
54.62	43.34	0.551	135	No	56	0	1.271431	Yes	No	569.38	7255.18	2646.82	4608.36			2646.82	4608.36																		
54.78	43.23	0.588	135	No	56	0	1.360324	Yes	No	569.22	7277.32	2657.05	4620.27			2657.05	4620.27																		
54.94	42.94	0.624	135	No	56	0	1.453089	Yes	No	569.06	7299.46	2667.29	4632.18			2667.29	4632.18																		
55.11	43.31	0.669	135	No	56	0	1.544607	Yes	No	568.89	7321.60	2677.52	4644.08			2677.52	4644.08																		
55.27	43.36	0.587	135	No	56	0	1.35372	Yes	No	568.73	7343.74	2687.76	4655.99			2687.76	4655.99																		
55.44	43.24	0.549	135	No	56	0	1.269805	Yes	No	568.56	7365.88	2697.99	4667.90			2697.99	4667.90																		
55.60	42.83	0.59	135	No	56	0	1.3777	Yes	No	568.40	7388.02	2708.22	4679.80			2708.22	4679.80																		
55.76	41.60	0.682	135	No	56	0	1.639541	Yes	No	568.24	7410.16	2718.46	4691.71			2718.46	4691.71																		
55.93	43.11	0.695	135	No	56	0	1.612155	Yes	No	568.07	7432.30	2728.69	4703.62			2728.69	4703.62																		
56.09	43.92	0.741	135	No	56	0	1.687158	Yes	No	567.91	7454.44	2738.92	4715.52			2738.92	4715.52																		
56.26	46.28	0.762	135	No	56	0	1.646464	Yes	No	567.74	7476.58	2749.16	4727.43			2749.16	4727.43																		
56.42	50.79	0.852	135	No	56	0	1.67743	Yes	No	567.58	7498.72	2759.39	4739.33			2759.39	4739.33																		
56.58	55.06	0.891	135	No	56	0	1.618382	Yes	No	567.42	7520.86	2769.62	4751.24			2769.62	4751.24																		
56.75	55.30	0.98	135	No	56	0	1.772312	Yes	No	567.25	7543.00	2779.86	4763.15			2779.86	4763.15																		
56.91	59.42	1.152	135	No	56	0	1.938643	Yes	No	567.09	7565.14	2790.09	4775.05			2790.09	4775.05																		
57.08	63.91	1.576	135	No	56	0	2.466161	Yes	No	566.92	7587.28	2800.32	4786.96			2800.32	4786.96																		
57.24	67.24	1.593	135	No	56	0	2.369302	Yes	No	566.76	7609.42	2810.56	4798.87			2810.56	4798.87																		
57.40	63.03	1.608	135	No	56	0	2.551166	Yes	No	566.60	7631.56	2820.79	4810.77			2820.79	4810.77																		
57.57	60.75	1.32	135	No	56	0	2.172947	Yes	No	566.43	7653.70	2831.03	4822.68			2831.03	4822.68																		
57.73	60.58	1.39	135	No	56	0	2.294373	Yes	No	566.27	7675.84	2841.26	4834.59			2841.26	4834.59																		
57.90	61.42	1.508	135	No	56	0	2.455226	Yes	No	566.10	7697.98	2851.49	4846.49			2851.49	4846.49																		
58.06	63.65	1.631	135	No	56	0	2.562411	Yes	No	565.94	7720.12	2861.73	4858.40			2861.73	4858.40																		
58.22	65.50	1.483	135	No	56	0	2.264191	Yes	No	565.78	7742.26	2871.96	4870.31			2871.96	4870.31																		
58.39	67.32	1.584	135	No	56	0	2.353116	Yes	No	565.61	7764.40	2882.19	4882.21			2882.19	4882.21																		
58.55	68.37	1.456	135	No	56	0	2.129682	Yes	No	565.45	7786.54	2892.43	4894.12			2892.43	4894.12																		
58.72	70.38	1.588	135	No	56	0	2.256291	Yes	No	565.28	7808.68	2902.66	4906.02			2902.66	4906.02																		
58.88	66.88	1.867	135	No	56	0	2.79165	Yes	No	565.12	7830.82	2912.89	4917.93			2912.89	4917.93																		
59.04	65.03	2.165	135	No	56	0	3.32913	Yes	No	564.96	7852.96	2923.13	4929.84			2923.13	4929.84																		
59.21	65.50	2.263	135	No	56	0	3.455173	Yes	No	564.79	7875.10	2933.36	4941.74			2933.36	4941.74																		
59.37	60.02	2.194	135	No	56	0	3.655692	Yes	No	564.63	7897.24	2943.60	4953.65			2943.60	4953.65																		
59.54	51.25	1.94	135	No	56	0	3.785218	Yes	No	564.46	7919.38	2953.83	4965.56			2953.83	4965.56																		
59.70	45.11	1.142	135	No	56	0	2.531365	Yes	No	564.30	7941.52	2964.06	4977.46			2964.06	4977.46																		
59.86	38.17	0.835	135	No	56	0	2.187811	Yes	No	564.14	7963.66	2974.30	4989.37			2974.30	4989.37																		
60.03	32.48	0.715	135	No	56	0	2.201151	Yes	No	563.97	7985.80	2984.53	5001.28			2984.53	5001.28																		
60.19	38.99	0.524	135	No	56	0	1.344072	Yes	No	563.81	8007.94	2994.76	5013.18			2994.76	5013.18																		
60.36	47.05	0.641	135	No	56	0	1.362438	Yes	No	563.64	8030.08	3005.00	5025.09			3005.00	5025.09																		
60.52	49.75	0.92	135	No	56	0	1.849432	Yes	No	563.48	8052.22	3015.23	5036.99			3015.23	5036.99																		
60.68	48.68	1.004	135	No	56	0	2.062576	Yes	No	563.32	8074.36	3025.46	5048.90			3025.46	5048.90																		
60.85	45.13	1.078	135	No	56	0	2.388761	Yes	No	563.15	8096.50	3035.70	5060.81			3035.70	5060.81																		
61.01	46.00	1.102	135	No	56	0	2.395808	Yes	No	562.99	8118.64	3045.93	5072.71			3045.93	5072.71																		
61.18	43.80	1.278	135	No	56	0	2.917941	Yes	No	562.82	8140.78	3056.16	5084.62			3056.16	5084.62																		
61.34	40.36	1.206	135	No	56	0	2.988477	Yes	No	562.66	8162.92	3066.40	5096.53			3066.40	5096.53																		
61.50	37.46	1.15	135	No	56	0	3.069777	Yes	No	562.50	8185.06	3076.63	5108.43			3076.63	5108.43																		
61.67	35.61	1.046	135	No	56	0	2.93746	Yes	No	562.33	8207.20	3086.87	5120.34			3086.87	5120.34																		
61.83	33.38	1.089	135	No	56	0	3.262042	Yes	No	562.17	8229.34	3097.10	5132.25			3097.10	5132.25																		
62.00	32.69	1.169	135	No	56	0	3.575689	Yes	No	562.00	8251.48	3107.33	5144.15			3107.33	5144.15																		
62.16	34.48	1.138	135	No	56	0	3.300081	Yes	No	561.84	8273.62	3117.57	5156.06			3117.57	5156.06																		
62.32	34.37	1.064	135	No	56	0	3.095813	Yes	No	561.68	8295.76	3127.80	5167.96			3127.80	5167.96																		
62.49	33.88	1.141	135	No	56	0	3.368166	Yes	No	561.51	8317.90	3138.03	5179.87			3138.03	5179.87																		
62.65	34.74	1.385	135	No	56	0	3.986415	Yes	No	561.35	8340.04	3148.27	5191.78			3148.27	5191.78																		
62.82	33.64	1.362	135	No	56	0	4.048992	Yes	No	561.18	8362.18	3158.50	5203.68			3158.50	5203.68																		
62.98	32.81	1.313	135	No	56	0	4.001463	Yes	No	561.02	8384.32	3168.73	5215.59			3168.73	5215.59																		
63.14	43.37	1.248	135	No	56	0	2.877764	Yes	No	560.86	8406.46	3178.97	5227.50			3178.97	5227.50																		
63.31	58.88	1.206	135	No	56	0	2.048095	Yes	No	560.69	8428.60	3189.20	5239.40			3189.20	5239.40																		
63.47	56.41	1.027	135	No	56	0	1.82047	Yes	No	560.53	8450.74	3199.44	5251.31			3199.44	5251.31																		
63.64	55.94	1.024	135	No	56	0	1.830402	Yes	No	560.36	8472.88	3209.67	5263.22			3209.67	5263.22																		
63.80	59.04	1.09	135	No	56	0	1.8463	Yes	No	560.20	8495.02	3219.90	5275.12			3219.90	5275.12																		
63.96	57.44	1.156	135	No	56	0	2.012395	Yes	No	560.04	8517.16	3230.14	5287.03			3230.14	5287.03																		
64.13	54.70	1.289	135	No	56	0	2.356404	Yes	No	559.87	8539.30	3240.37	5298.94			3240.37	5298.94																		
64.29	56.35	1.44	135	No	56	0	2.555548	Yes	No	559.71	8561.44	3250.60	5310.84			3250.60	5310.84																		
64.46	64.96	1.494	135	No	56	0	2.299841	Yes	No	559.54	8583.58	3260.84	5322.75			3260.84	5322.75																		
64.62	107.47	2.269	135	No	56	0	2.111346	Yes	No	559.38	8605.72	3271.07	5334.65			3271.07	5334.65																		
64.78	157.53	3.542	135	No	56	0	2.248418	Yes	No	559.22	8627.86	3281.30	5346.56			3281.30	5346.56																		
64.95	155.79	4.984	135	No	56	0	3.19924	Yes	No	559.05	8650.00	3291.54	5358.47			3291.54	5358.47																		
65.11	145.46	5.397	135	No	56	0	3.710273	Yes	No	558.89	8672.14	3301.77	5370.37			3301.77	5370.37																		
65.28	132.10	4.97	135	No	56	0	3.762244	Yes	No	558.72	8694.28	3312.00	5382.28			3312.00	5382.28																		
65.44	126.60	0	135	No	56	0	0	Yes	No	558.56	8716.42	3322.24	5394.19			3322.24	5394.19																		
65.60	121.53	0	135	No	56	0	0	Yes	No	558.40	8738.56	3332.47	5406.09			3332.47	5406.09																		

CPT Liquefaction Analysis

Method: Idriss and Boulanger (2014), CPT and SPT Based Liquefaction Triggering Procedures

Title: Liquefaction Analysis
Project: Dynegy - Coffeen
Project No.: 60480701

Date: 1/15/2016
Boring No. COF-C055

Unit wt AGWT: 135 pcf
Unit wt BGWT: 135 pcf

Input Parameters:
Peak ground acceleration, pga (g): 0.2
Earthquake Magnitude (M): 6.5
Water Table Depth at the time of drilling 7.8 ft
Water Table Depth at the time of earthquake 7.8 ft
Ground Surface Elevation 624 ft

Notes:
1. Sand-like behavior = "Yes", Clay-like behavior = "No" (See Idriss and Boulanger, 2014).
2. Make sure to turn on iterative calculations.
3. User to confirm highlighted values are reasonable.

												At the time of earthquake				At the time of drilling	
Depth	Qt	Fs	Unit Weight	Liquefiable?[1]	FC	α (From static stress analysis)	Fs/Qt	Below Water Table?	Liquefaction Calculation Needed?	Sample Elev.	Total stress	Pore Pressure	Effective stress	Stress reduction coeff, r_d	CSR	Pore Pressure	Effective stress
(ft)	(TSF)	(TSF)	(pcf)	(Yes/No)			(%)			(ft)	(psf)	(psf)	(psf)			(psf)	(psf)
0.16	7.66	0.129	135	No	90	0	1.683853	No	No	623.84	22.14		22.14				22.14
0.33	7.64	0.231	135	No	90	0	3.023956	No	No	623.67	44.28		44.28				44.28
0.49	6.43	0.285	135	No	90	0	4.429593	No	No	623.51	66.42		66.42				66.42
0.66	6.04	0.249	135	No	90	0	4.124565	No	No	623.34	88.56		88.56				88.56
0.82	6.46	0.201	135	No	90	0	3.113865	No	No	623.18	110.70		110.70				110.70
0.98	8.00	0.207	135	No	90	0	2.588794	No	No	623.02	132.84		132.84				132.84
1.15	8.62	0.236	135	No	90	0	2.736867	No	No	622.85	154.98		154.98				154.98
1.31	9.00	0.278	135	No	90	0	3.090606	No	No	622.69	177.12		177.12				177.12
1.48	8.32	0.396	135	No	90	0	4.760188	No	No	622.52	199.26		199.26				199.26
1.64	10.37	0.348	135	No	90	0	3.356805	No	No	622.36	221.40		221.40				221.40
1.80	45.80	0.532	135	No	90	0	1.161648	No	No	622.20	243.54		243.54				243.54
1.97	78.07	0.777	135	No	90	0	0.995273	No	No	622.03	265.68		265.68				265.68
2.13	50.20	0.832	125	No	90	0	1.657404	No	No	621.87	286.31		286.31				286.31
2.30	32.98	1.146	125	No	90	0	3.474517	No	No	621.70	306.81		306.81				306.81
2.46	21.01	1.21	125	No	90	0	5.75834	No	No	621.54	327.31		327.31				327.31
2.63	17.00	1.117	125	No	90	0	6.570588	No	No	621.38	347.81		347.81				347.81
2.79	15.07	1.036	125	No	90	0	6.872761	No	No	621.21	368.31		368.31				368.31
2.95	14.49	0.988	125	No	90	0	6.816614	No	No	621.05	388.81		388.81				388.81
3.12	14.02	1.001	125	No	90	0	7.139291	No	No	620.88	409.31		409.31				409.31
3.28	13.21	0.978	125	No	90	0	7.404603	No	No	620.72	429.81		429.81				429.81
3.45	13.19	0.924	125	No	90	0	7.006901	No	No	620.56	450.31		450.31				450.31
3.61	13.19	0.892	125	No	90	0	6.762699	No	No	620.39	470.81		470.81				470.81
3.77	13.19	0.836	125	No	90	0	6.336694	No	No	620.23	491.31		491.31				491.31
3.94	13.53	0.778	125	No	90	0	5.749335	No	No	620.06	511.81		511.81				511.81
4.10	13.93	0.749	125	No	90	0	5.378429	No	No	619.90	532.31		532.31				532.31
4.27	15.05	0.741	125	No	90	0	4.92228	No	No	619.74	552.81		552.81				552.81
4.43	15.55	0.748	125	No	90	0	4.811837	No	No	619.57	573.31		573.31				573.31
4.59	16.79	0.768	125	No	90	0	4.575241	No	No	619.41	593.81		593.81				593.81
4.76	16.53	0.754	125	No	90	0	4.560576	No	No	619.24	614.31		614.31				614.31
4.92	16.27	0.719	125	No	90	0	4.418633	No	No	619.08	634.81		634.81				634.81
5.09	16.05	0.693	125	No	90	0	4.318833	No	No	618.92	655.31		655.31				655.31
5.25	16.42	0.655	125	No	90	0	3.99001	No	No	618.75	675.81		675.81				675.81
5.41	17.48	0.602	125	No	90	0	3.443542	No	No	618.59	696.31		696.31				696.31
5.58	17.73	0.586	125	No	90	0	3.304573	No	No	618.42	716.81		716.81				716.81
5.74	16.20	0.556	125	No	90	0	3.431252	No	No	618.26	737.31		737.31				737.31
5.91	14.31	0.536	125	No	90	0	3.745632	No	No	618.10	757.81		757.81				757.81
6.07	13.07	0.529	125	No	90	0	4.047437	No	No	617.93	778.31		778.31				778.31
6.23	12.31	0.501	125	No	90	0	4.070193	No	No	617.77	798.93		798.93				798.93
6.40	11.28	0.442	125	No	90	0	3.919135	No	No	617.60	819.43		819.43				819.43
6.56	10.64	0.386	125	No	90	0	3.628843	No	No	617.44	839.93		839.93				839.93
6.73	10.09	0.353	125	No	90	0	3.499554	No	No	617.27	860.43		860.43				860.43
6.89	9.46	0.337	125	No	90	0	3.563121	No	No	617.11	880.93		880.93				880.93
7.05	9.34	0.326	125	No	90	0	3.491859	No	No	616.95	901.43		901.43				901.43
7.22	9.47	0.33	125	No	90	0	3.483217	No	No	616.78	921.93		921.93				921.93
7.38	9.11	0.343	125	No	90	0	3.76468	No	No	616.62	942.43		942.43				942.43
7.55	8.72	0.344	125	No	90	0	3.943597	No	No	616.45	962.93		962.93				962.93
7.71	8.29	0.333	125	No	90	0	4.019312	No	No	616.29	983.43		983.43				983.43
7.87	9.09	0.318	125	No	90	0	3.496811	Yes	No	616.13	1003.93	4.62	999.31			4.62	999.31
8.04	8.91	0.31	125	No	90	0	3.478846	Yes	No	615.96	1024.43	14.85	1009.58			14.85	1009.58
8.20	8.81	0.283	125	No	90	0	3.214083	Yes	No	615.80	1044.93	25.08	1019.85			25.08	1019.85
8.37	8.90	0.274	125	No	90	0	3.078998	Yes	No	615.63	1065.43	35.32	1030.11			35.32	1030.11
8.53	9.19	0.28	125	No	90	0	3.047453	Yes	No	615.47	1085.93	45.55	1040.38			45.55	1040.38
8.69	8.81	0.303	125	No	90	0	3.437713	Yes	No	615.31	1106.43	55.79	1050.64			55.79	1050.64
8.86	8.59	0.329	125	No	90	0	3.832266	Yes	No	615.14	1126.93	66.02	1060.91			66.02	1060.91
9.02	8.49	0.331	125	No	90	0	3.900082	Yes	No	614.98	1147.43	76.25	1071.18			76.25	1071.18
9.19	8.34	0.341	125	No	90	0	4.086769	Yes	No	614.81	1167.93	86.49	1081.44			86.49	1081.44
9.35	8.11	0.329	125	No	90	0	4.059223	Yes	No	614.65	1188.43	96.72	1091.71			96.72	1091.71
9.51	7.94	0.317	125	No	90	0	3.992946	Yes	No	614.49	1208.93	106.95	1101.98			106.95	1101.98
9.68	7.97	0.316	125	No	90	0	3.963376	Yes	No	614.32	1229.43	117.19	1112.24			117.19	1112.24
9.84	7.95	0.314	125	No	90	0	3.951674	Yes	No	614.16	1249.93	127.42	1122.51			127.42	1122.51
10.01	8.21	0.322	125	No	90	0	3.924436	Yes	No	613.99	1270.43	137.65	1132.78			137.65	1132.78
10.17	7.57	0.31	125	No	90	0	4.096195	Yes	No	613.83	1290.93	147.89	1143.04			147.89	1143.04
10.34	7.51	0.317	125	No	90	0	4.222725	Yes	No	613.67	1311.56	158.18	1153.37			158.18	1153.37
10.50	7.07	0.32	125	No	90	0	4.524887	Yes	No	613.50	1332.06	168.42	1163.64			168.42	1163.64
10.66	7.03	0.312	125	No	90	0	4.440649	Yes	No	613.34	1352.56	178.65	1173.90			178.65	1173.90
10.83	6.97	0.3	125	No	90	0	4.302926	Yes	No	613.17	1373.06	188.88	1184.17			188.88	1184.17
10.99	6.86	0.279	125	No	90	0	4.070022	Yes	No	613.01	1393.56	199.12	1194.44			199.12	1194.44
11.16	6.60	0.259	125	No	90	0	3.926622	Yes	No	612.85	1414.06	209.35	1204.70			209.35	1204.70
11.32	6.84	0.25	125	No	90	0	3.654971	Yes	No	612.68	1434.56	219.59	1214.97			219.59	1214.97
11.48	6.88	0.237	125	No	90	0	3.444767	Yes	No	612.52	1455.06	229.82	1225.24			229.82	1225.24
11.65	8.23	0.241	125	No	90	0	2.928667	Yes	No	612.35	1475.56	240.05	1235.50			240.05	1235.50
11.81	8.76	0.27	125	No	90	0	3.083248	Yes	No	612.19	1496.06	250.29	1245.77			250.29	1245.77
11.98	6.71	0.299	125	No	90	0	4.459359	Yes	No	612.03	1516.56	260.52	1256.04			260.52	1256.04
12.14	5.87	0.214	125	No	90	0	3.646898	Yes	No	611.86	1537.06	270.75	1266.30			270.75	1266.30
12.30	5.48	0.185	125	No	90	0	3.378995	Yes	No	611.70	1557.56	280.99	1276.57			280.99	1276.57
12.47	5.59	0.172	125	No	90	0	3.077474	Yes	No	611.53	1578.06	291.22	1286.83			291.22	1286.83
12.63	4.47	0.148	125	No	90	0	3.313186	Yes	No	611.37	1598.56	301.45	1297.10			301.45	1297.10
12.80	3.97	0.097	125	No	90	0	2.440866	Yes	No	611.21	1619.06	311.69	1307.37			311.69	1307.37
12.96	4.06	0.089	125	No	90	0	2.1905	Yes	No	611.04	1639.56	321.92	1317.63			321.92	1317.63
13.12	4.40	0.111	125	No	90	0	2.521008	Yes	No	610.88	1660.06	332.16	1327.90			332.16	1327.90
13.29	4.70	0.115	125	No	90	0	2.447329	Yes	No	610.71	1680.56	342.39	1338.17			342.39	1338.17
13.45	4.57	0.119	125	No	90	0	2.606791	Yes	No	610.55	1701.06	352.62	1348.43			352.62	1348.43
13.62	5.49	0.134	125	No	90	0	2.440801	Yes	No	610.39	1721.56	362.86	1358.70			362.86	1358.70
13.78	5.65	0.11	125	No	90	0	1.948282	Yes	No	610.22	1742.06	373.09	1368.97			373.09	1368.97
13.94	5.38	0.155	125	No	90	0	2.880505	Yes	No	610.06	1762.56	383.32	1379.23			383.32	1379.23
14.11	5.92	0.302	135	Yes	56	0	5.098768	Yes	Yes	609.89	1784.70	393.56	1391.14	0.94	0.158	393.56	1391.14
14.27	14.57	0.978	135	Yes	56	0	6.711502	Yes	Yes	609.73	1806.84	403.79	1403.04	0.94	0.158	403.79	1403.04
14.44	68.18	1.083	135	Yes	56	0	1.588419	Yes	Yes	609.56	1829.11	414.09	1415.02	0.94	0.158	414.09	1415.02
14.60	67.00	1.876	135	Yes	56	0	2.799833	Yes	Yes	609.40	1851.25	424.32	1426.93	0.94	0.159	424.32	1426.93
14.76	75.24	2.056	135	Yes	56	0	2.732444	Yes	Yes	609.24	1873.39	434.55	1438.84	0.94	0.159	434.55	1438.84
14.93	67.58	2.06	135	Yes	56	0	3.048239	Yes	Yes	609.07	1895.53	444.79	1450.74	0.94	0.160	444.79	1450.74
15.09	154.53	1.854	135	Yes	56	0	1.199759	Yes	Yes	608.91	1917.67	455.02	1462.65	0.94	0.160	455.02	1462.65
15.26	199.64	1.398	135	Yes	56	0	0.700246	Yes	Yes	608.74	1939.81	465.25	1474.56	0.94	0.161	465.25	1474.56

Depth	qc1n	m	Cn	qc1	Delta qc1ncs	qc1ncs	CRR_{cpt}[3]	C_σ	K_σ	Assg. α	State Para	Para a	Para b	Para c	Kα	MSF_{max}	MSF	IB FSL
(ft)				(TSF)														
14.11	8.18	0.904	1.46	8.65	50.0	58.7	0.099	0.04	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.125	1.047	0.67
14.27	19.10	0.796	1.39	20.21	53.0	73.2	0.110	0.05	1.02	0.00	0.100	1.000	0.000	0.138	1.000	1.157	1.059	0.75
14.44	80.26	0.546	1.25	84.92	69.8	154.7	0.323	0.09	1.04	0.00	0.100	1.000	0.000	0.138	1.000	1.725	1.273	2.69
14.60	78.65	0.550	1.24	83.21	69.4	152.6	0.307	0.09	1.04	0.00	0.100	1.000	0.000	0.138	1.000	1.699	1.263	2.52
14.76	87.18	0.528	1.23	92.24	71.7	164.0	0.416	0.10	1.04	0.00	0.100	1.000	0.000	0.138	1.000	1.846	1.318	3.57
14.93	78.61	0.550	1.23	83.17	69.4	152.5	0.306	0.09	1.03	0.00	0.100	1.000	0.000	0.138	1.000	1.698	1.263	2.50
15.09	167.77	0.375	1.15	177.50	93.9	271.4	3.724576	0.19	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.10
15.26	211.41	0.315	1.12	223.67	105.9	329.5	3.724576	0.30	1.10	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	37.05

CPT Liquefaction Analysis

15.42	195.93	1.124	135	Yes	56	0	0.573671	Yes	Yes	608.58	1961.95	475.49	1486.46	0.94	0.161	475.49	1486.46	207.34	0.320	1.12	219.36	104.7	324.1	3.724576	0.29	1.10	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.96
15.58	191.90	1.412	135	Yes	56	0	0.7358	Yes	Yes	608.42	1984.09	485.72	1498.37	0.94	0.161	485.72	1498.37	202.95	0.326	1.12	214.72	103.5	318.3	3.724576	0.27	1.09	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.67
15.75	199.57	1.628	135	Yes	56	0	0.81575	Yes	Yes	608.25	2006.23	495.96	1510.27	0.94	0.162	495.96	1510.27	209.88	0.317	1.11	222.06	105.4	327.5	3.724576	0.30	1.10	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.79
15.91	223.30	1.556	135	Yes	56	0	0.69683	Yes	Yes	608.09	2028.37	506.19	1522.18	0.94	0.162	506.19	1522.18	232.14	0.289	1.10	245.60	111.6	357.2	3.724576	0.30	1.10	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.68
16.08	284.45	1.572	135	Yes	56	0	0.552653	Yes	Yes	607.92	2050.51	516.42	1534.09	0.93	0.162	516.42	1534.09	289.16	0.226	1.08	305.93	127.2	433.2	3.724576	0.30	1.10	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.52
16.24	345.33	2.615	135	Yes	56	0	0.757244	Yes	Yes	607.76	2072.65	526.66	1545.99	0.93	0.163	526.66	1545.99	344.68	0.174	1.06	364.68	142.5	507.2	3.724576	0.30	1.09	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.37
16.40	430.78	3.855	135	Yes	56	0	0.894884	Yes	Yes	607.60	2094.79	536.89	1557.90	0.93	0.163	536.89	1557.90	421.17	0.110	1.03	445.59	163.5	609.1	3.724576	0.30	1.09	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.22
16.57	496.52	5.729	135	Yes	56	0	1.153828	Yes	Yes	607.43	2116.93	547.12	1569.81	0.93	0.163	547.12	1569.81	478.93	0.068	1.02	506.71	179.4	686.1	3.724576	0.30	1.09	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	36.08
16.73	477.63	4.857	135	Yes	56	0	1.016902	Yes	Yes	607.27	2139.07	557.36	1581.71	0.93	0.164	557.36	1581.71	462.08	0.080	1.02	488.88	174.8	663.6	3.724576	0.30	1.09	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.94
16.90	572.86	4.239	135	Yes	56	0	0.739973	Yes	Yes	607.10	2161.21	567.59	1593.62	0.93	0.164	567.59	1593.62	545.13	0.024	1.01	576.75	197.6	774.3	3.724576	0.30	1.09	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.80
17.06	584.68	4.441	135	Yes	56	0	0.759558	Yes	Yes	606.94	2183.35	577.82	1605.53	0.93	0.164	577.82	1605.53	555.30	0.017	1.00	587.51	200.4	787.9	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.66
17.22	593.94	4.698	135	Yes	56	0	0.790996	Yes	Yes	606.78	2205.49	588.06	1617.43	0.93	0.164	588.06	1617.43	563.26	0.012	1.00	595.93	202.6	798.5	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.53
17.39	609.87	4.863	135	Yes	56	0	0.79739	Yes	Yes	606.61	2227.63	598.29	1629.34	0.93	0.165	598.29	1629.34	577.03	0.004	1.00	610.50	206.3	816.9	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.40
17.55	584.41	7.239	135	Yes	56	0	1.238692	Yes	Yes	606.45	2249.77	608.52	1641.25	0.93	0.165	608.52	1641.25	554.86	0.018	1.00	587.04	200.3	787.3	3.724576	0.30	1.08	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.27
17.72	572.39	8.313	135	Yes	56	0	1.452344	Yes	Yes	606.28	2271.91	618.76	1653.15	0.92	0.165	618.76	1653.15	544.28	0.024	1.01	575.85	197.3	773.2	3.724576	0.30	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.15
17.88	595.42	9.381	135	Yes	56	0	1.575534	Yes	Yes	606.12	2294.05	628.99	1665.06	0.92	0.165	628.99	1665.06	564.37	0.012	1.00	597.10	202.9	800.0	3.724576	0.30	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	35.02
18.04	632.72	8.823	135	Yes	56	0	1.394458	Yes	Yes	605.96	2316.19	639.23	1676.96	0.92	0.166	639.23	1676.96	596.92	-0.008	1.00	631.54	211.8	843.4	3.724576	0.30	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.90
18.21	659.57	8.368	135	Yes	56	0	1.268703	Yes	Yes	605.79	2338.33	649.46	1688.87	0.92	0.166	649.46	1688.87	620.36	-0.022	1.00	656.34	218.3	874.6	3.724576	0.30	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.78
18.37	670.98	8.197	135	Yes	56	0	1.221646	Yes	Yes	605.63	2360.47	659.69	1700.78	0.92	0.166	659.69	1700.78	630.40	-0.028	0.99	666.96	221.0	888.0	3.724576	0.30	1.07	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.67
18.54	680.15	7.837	135	Yes	56	0	1.152249	Yes	Yes	605.46	2382.75	669.99	1712.76	0.92	0.166	669.99	1712.76	638.51	-0.032	0.99	675.54	223.2	898.8	3.724576	0.30	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.55
18.70	689.36	0	135	Yes	56	0	0	Yes	Yes	605.30	2404.89	680.22	1724.66	0.92	0.167	680.22	1724.66	646.69	-0.037	0.99	684.20	225.5	909.7	3.724576	0.30	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.44
18.87	664.62	0	135	Yes	56	0	0	Yes	Yes	605.14	2427.03	690.46	1736.57	0.92	0.167	690.46	1736.57	625.15	-0.025	1.00	661.41	219.6	881.0	3.724576	0.30	1.06	0.00	0.100	1.000	0.000	0.138	1.000	2.200	1.452	34.33

Calculation Notes

AECOM

Subject: Coffeen GMF Gypsum Stack Pond Liquefaction Analysis

Project Name: Dynegy CCR

By: Lucas Carr Date: 01/25/2016

Project No: 60480701

Checked By: Vonmarie Martinez Date: 01/26/2016

Task No.: 01

APPENDIX B

ANNOTATED CPT LOGS

ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

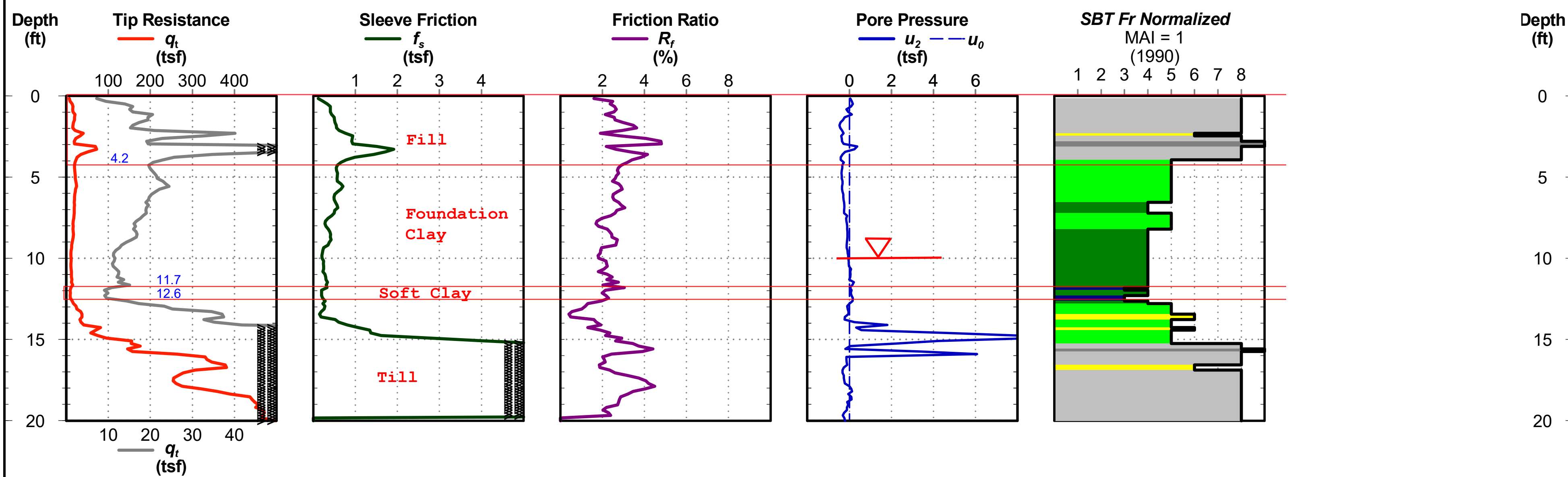
AECOM

Dynegy - Coffeen

Cone Penetration Test

COF-C048

Total Depth: 20.0 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



- 1 - Sensitive, Fine Grained Soils
- 2 - Organic Soils, Peats
- 3 - Clays-Clay to Silty Clay
- 4 - Silt Mixtures-Clayey Silt to Silty Clay
- 5 - Sand Mixtures-Silty Sand to Sandy Silt
- 6 - Sands-Clean Sand to Silty Sand
- 7 - Gravelly Sand to Sand
- 8 - Very Stiff Clay to Clayey Sand
- 9 - Very Stiff Fine Grained Soils

CPT REPORT - DYNAMIC COFFEEN CPT.GPJ CPT V3.0.GDT 1/13/16
P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\04TASKS\01 COFFEEN TASKS\8.0 CPT\RAPID CPT\COFFEEN CPT.GPJ

$S_u=(q_t-\sigma_{vo})/N_{kt}$ $N_{kt}=17$

Electronic File Name: 15-53063_CP48.COR

ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

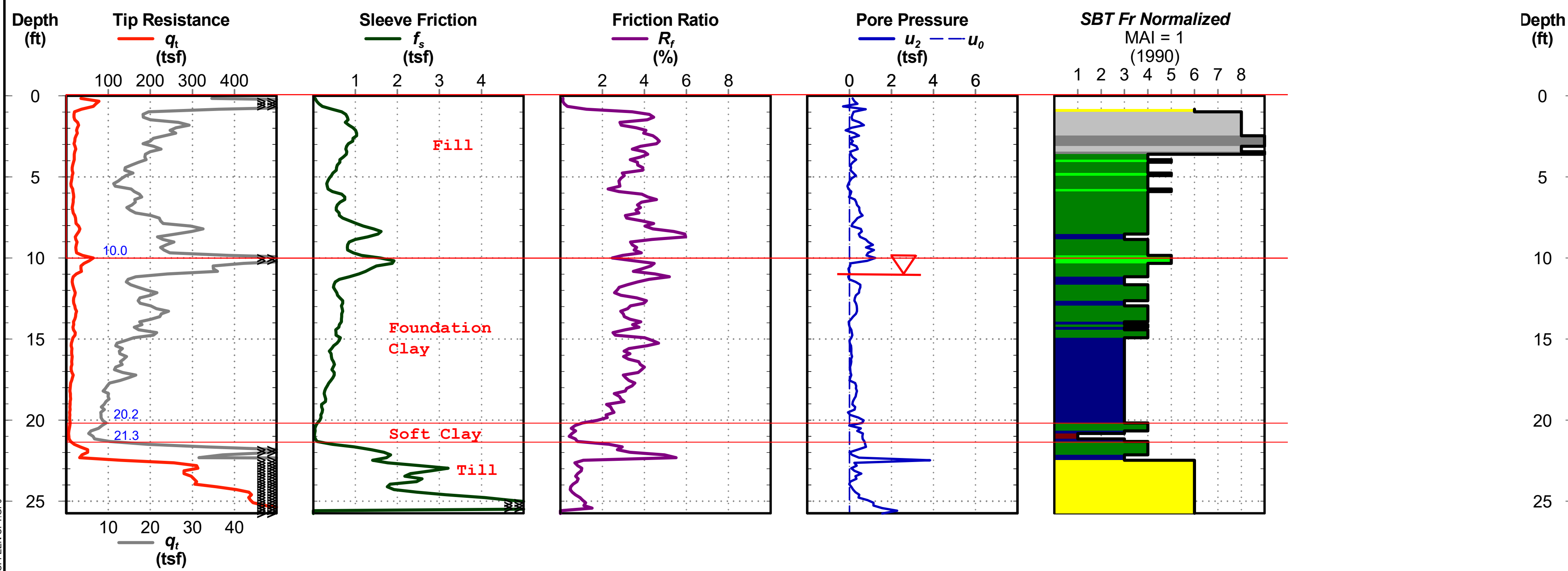
AECOM

Dynegy - Coffeen

Cone Penetration Test

COF-C049

Total Depth: 25.8 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



1 - Sensitive, Fine Grained Soils
2 - Organic Soils, Peats
3 - Clays-Clay to Silty Clay
4 - Silt Mixtures-Clayey Silt to Silty Clay
5 - Sand Mixtures-Silty Sand to Sandy Silt
6 - Sands-Clean Sand to Silty Sand
7 - Gravelly Sand to Sand
8 - Very Stiff Clay to Clayey Sand
9 - Very Stiff Fine Grained Soils

$S_u=(q_t-\sigma_{vo})/N_{kt}$ $N_{kt}=17$

Electronic File Name: 15-53063_SP49.COR

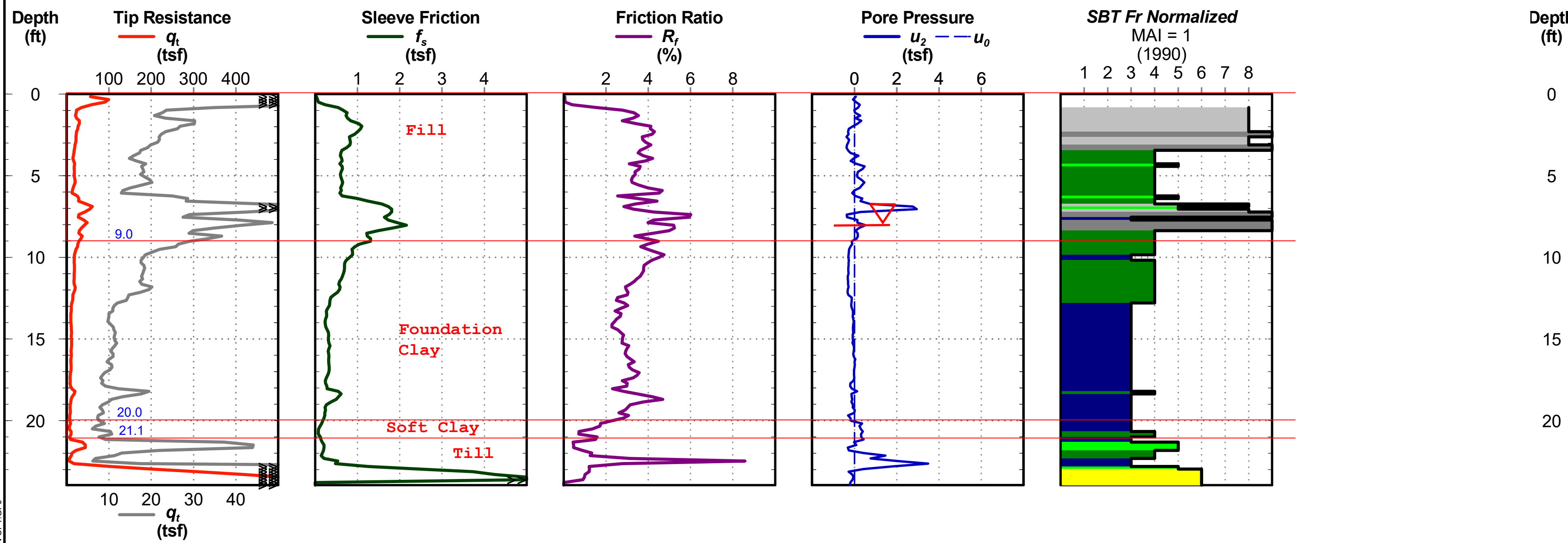
ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

Dynegy - Coffeen

Cone Penetration Test

COF-C050

Total Depth: 24.0 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



1 - Sensitive, Fine Grained Soils	4 - Silt Mixtures-Clayey Silt to Silty Clay
2 - Organic Soils, Peats	5 - Sand Mixtures-Silty Sand to Sandy Silt
3 - Clays-Clay to Silty Clay	6 - Sands-Clean Sand to Silty Sand
7 - Gravelly Sand to Sand	8 - Very Stiff Clay to Clayey Sand
9 - Very Stiff Fine Grained Soils	

$S_u=(q_t-\sigma_{vo})/N_{kt}$ $N_{kt}=17$

Electronic File Name: 15-53063_CP50.COR

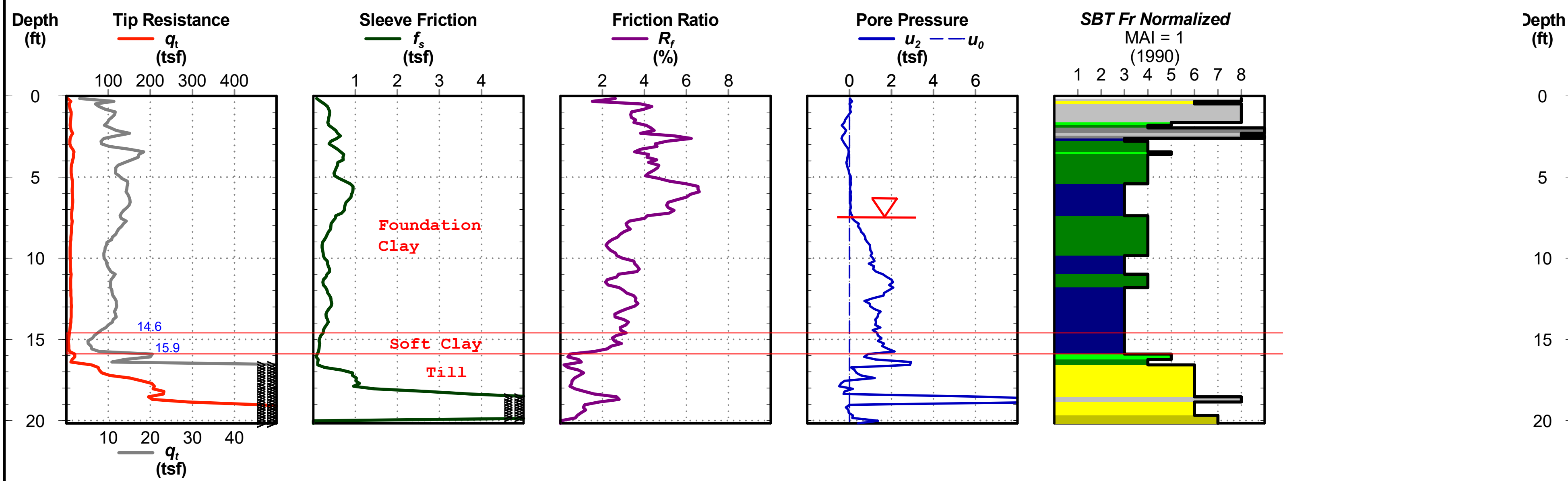
AECOM

Dynegy - Coffeen

Cone Penetration Test

COF-C051

Total Depth: 20.2 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



1 - Sensitive, Fine Grained Soils
2 - Organic Soils, Peats
3 - Clays-Clay to Silty Clay
4 - Silt Mixtures-Clayey Silt to Silty Clay
5 - Sand Mixtures-Silty Sand to Sandy Silt
6 - Sands-Clean Sand to Silty Sand
7 - Gravelly Sand to Sand
8 - Very Stiff Clay to Clayey Sand
9 - Very Stiff Fine Grained Soils

CPT REPORT - DYNAMIC COFFEEN CPT.GPJ CPT V3.0.GDT 1/13/16
P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\04TASKS\01 COFFEEN TASKS\8.0 CPT\RAPID CPT\COFFEEN CPT.GPJ

$S_u=(q_t-\sigma_{vo})/N_{kt}$ N_{kt}=17

Electronic File Name: 15-53063_SP51.COR

ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

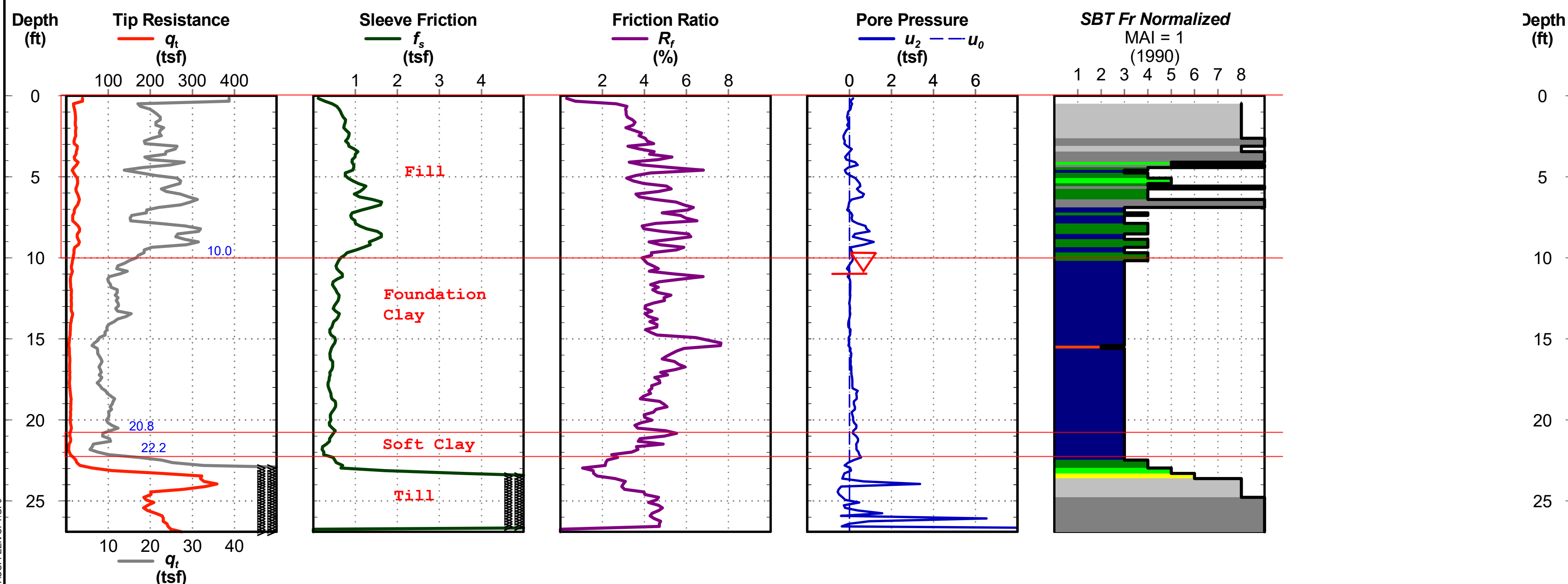
AECOM

Dynegy - Coffeen

Cone Penetration Test

COF-C052

Total Depth: 26.9 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



1 - Sensitive, Fine Grained Soils	4 - Silt Mixtures-Clayey Silt to Silty Clay	7 - Gravelly Sand to Sand
2 - Organic Soils, Peats	5 - Sand Mixtures-Silty Sand to Sandy Silt	8 - Very Stiff Clay to Clayey Sand
3 - Clays-Clay to Silty Clay	6 - Sands-Clean Sand to Silty Sand	9 - Very Stiff Fine Grained Soils

$S_u=(q_t-\sigma_{vo})/N_{kt}$ $N_{kt}=17$

Electronic File Name: 15-53063_SP52.COR

ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

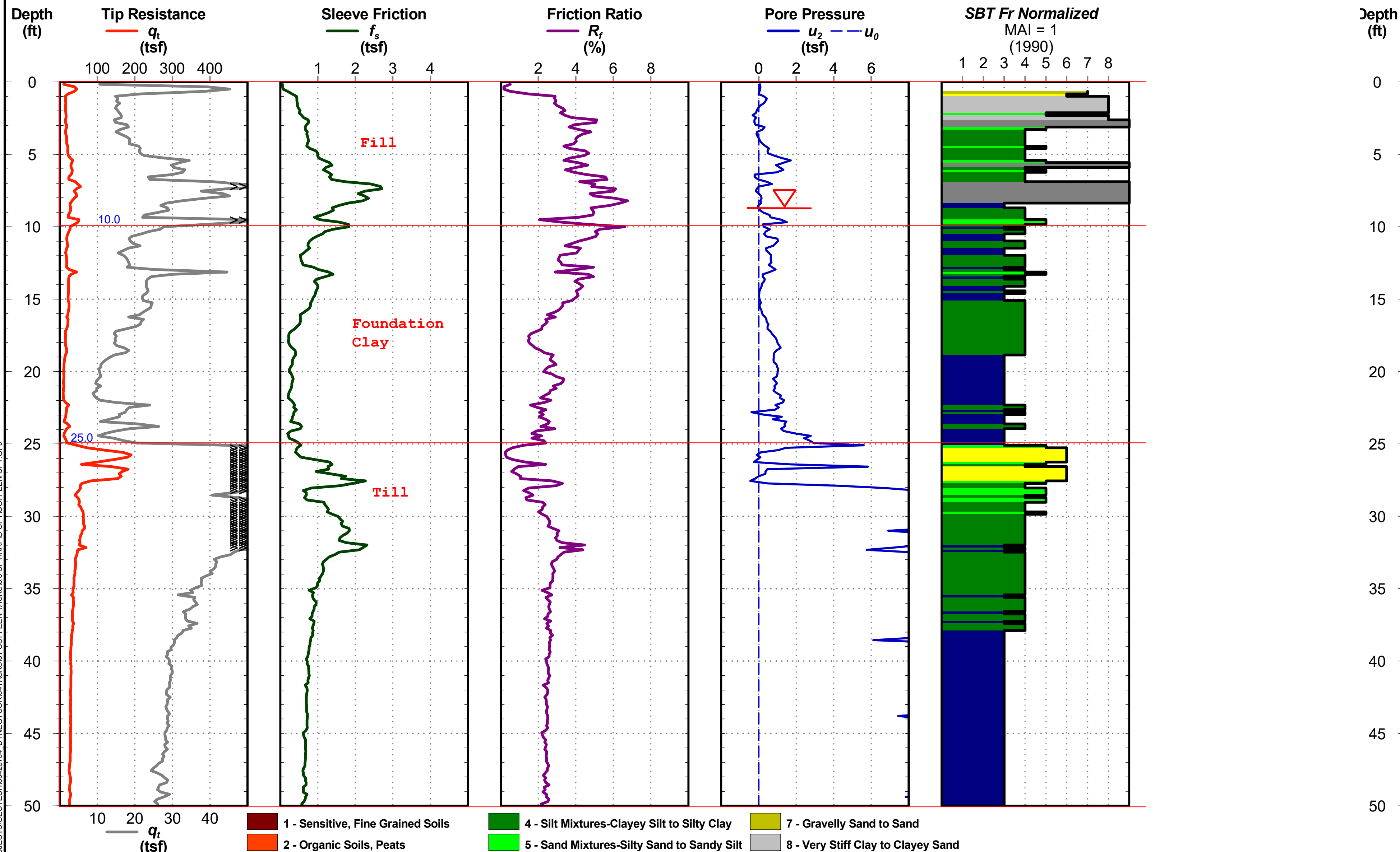
AECOM

Dynegy - Coffeen

Cone Penetration Test

COF-C053

Total Depth: 53.6 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



1 - Sensitive, Fine Grained Soils
2 - Organic Soils, Peats
3 - Clays-Clay to Silty Clay
4 - Silt Mixtures-Clayey Silt to Silty Clay
5 - Sand Mixtures-Silty Sand to Sandy Silt
6 - Sands-Clean Sand to Silty Sand
7 - Gravelly Sand to Sand
8 - Very Stiff Clay to Clayey Sand
9 - Very Stiff Fine Grained Soils

CPT REPORT - DYNAMIC COFFEEN CPT.GPJ CPT V3.0.GDT 1/13/16
P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\04TASKS\01 COFFEEN TASKS\8.0 CPT\RAPID CPT\COFFEEN CPT.GPJ

$S_u=(q_t-\sigma_{vo})/N_{kt}$ N_{kt}=17

Electronic File Name: 15-53063_SP53.COR

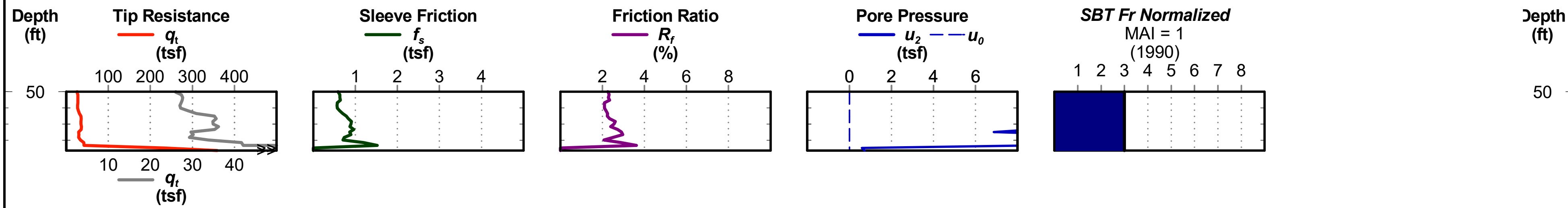
ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

Dynegy - Coffeen

Cone Penetration Test

COF-C053

Total Depth: 53.6 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



1 - Sensitive, Fine Grained Soils
2 - Organic Soils, Peats
3 - Clays-Clay to Silty Clay
4 - Silt Mixtures-Clayey Silt to Silty Clay
5 - Sand Mixtures-Silty Sand to Sandy Silt
6 - Sands-Clean Sand to Silty Sand
7 - Gravelly Sand to Sand
8 - Very Stiff Clay to Clayey Sand
9 - Very Stiff Fine Grained Soils

CPT REPORT - DYNAMIC COFFEEN CPT.GPJ CPT V3.0.GDT 1/13/16
P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\04TASKS\01 COFFEEN TASKS\8.0 CPT\RAPID CPT\COFFEEN CPT.GPJ

$S_u=(q_t-\sigma_{vo})/N_{kt}$ $N_{kt}=17$

Electronic File Name: 15-53063_SP53.COR

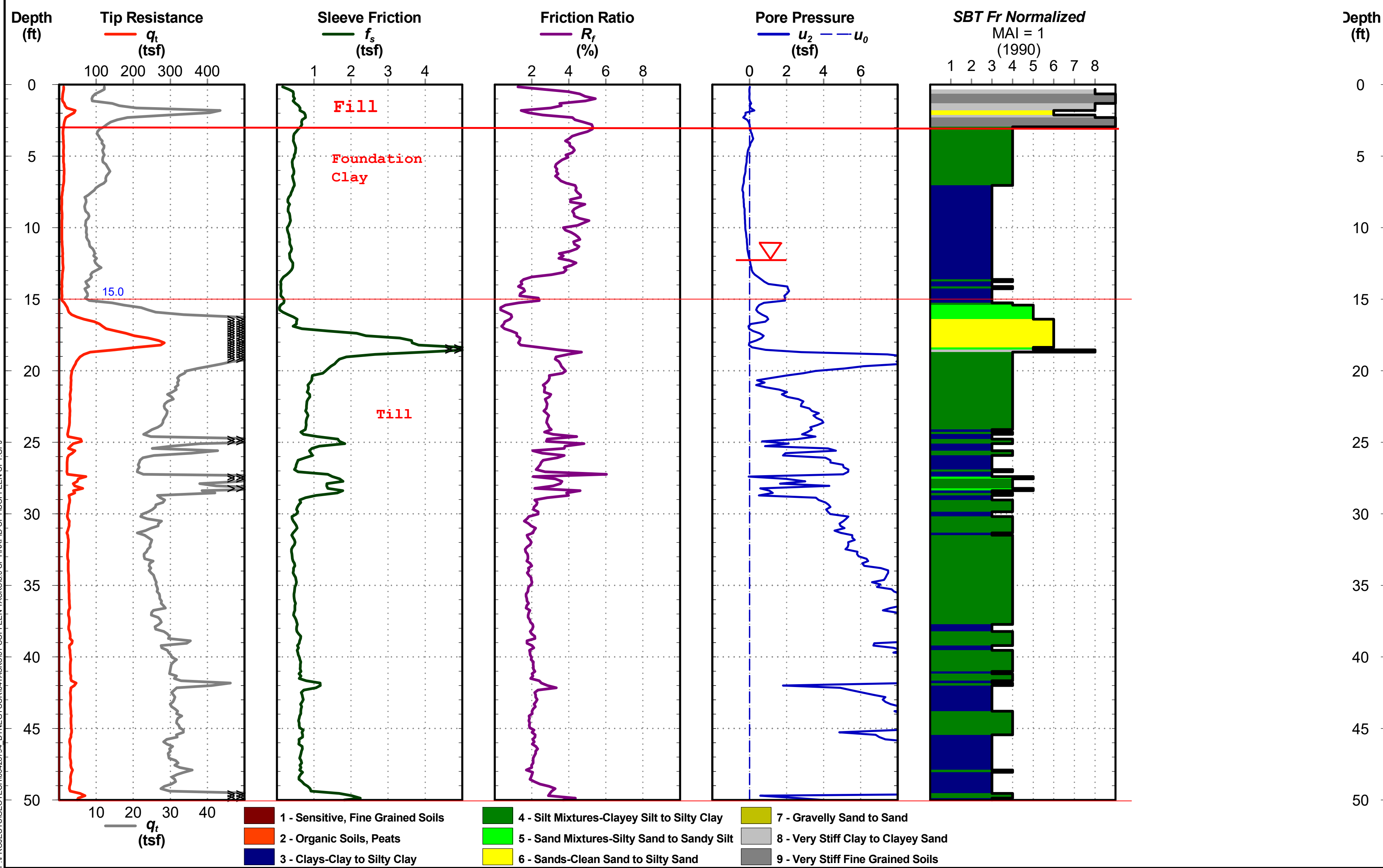
ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

Dynegy - Coffeen

Cone Penetration Test

COF-C054

Total Depth: 65.6 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



$S_u=(q_t-\sigma_{vo})/N_{kt}$ $N_{kt}=17$

Electronic File Name: 15-53063_CP54.COR

CPT REPORT - DYNAMIC COFFEEN CPT.GPJ CPT V3.0.GDT 1/13/16

ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

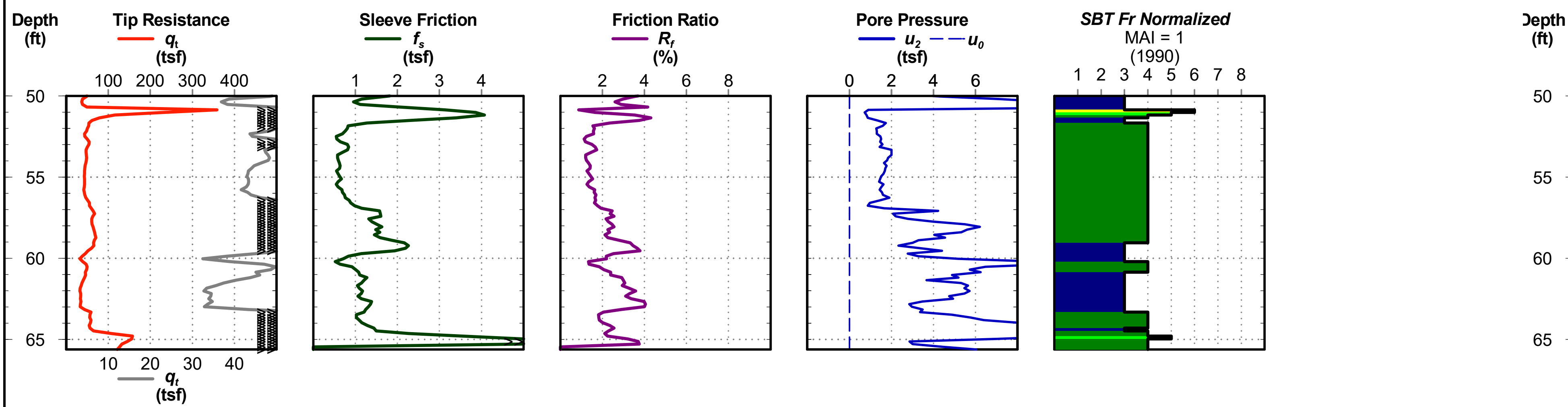
AECOM

Dynegy - Coffeen

Cone Penetration Test

COF-C054

Total Depth: 65.6 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



1 - Sensitive, Fine Grained Soils
2 - Organic Soils, Peats
3 - Clays-Clay to Silty Clay
4 - Silt Mixtures-Clayey Silt to Silty Clay
5 - Sand Mixtures-Silty Sand to Sandy Silt
6 - Sands-Clean Sand to Silty Sand
7 - Gravelly Sand to Sand
8 - Very Stiff Clay to Clayey Sand
9 - Very Stiff Fine Grained Soils

$S_u=(q_t-\sigma_{vo})/N_{kt}$ $N_{kt}=17$

Electronic File Name: 15-53063_CP54.COR

CPT REPORT - DYNAMIC COFFEEN CPT.GPJ CPT V3.0.GDT 1/13/16
P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\04TASKS\01 COFFEEN TASKS\8.0 CPT\RAPID CPT\COFFEEN CPT.GPJ

ANNOTATED CPT LOG - FOR CALCULATION PURPOSES ONLY

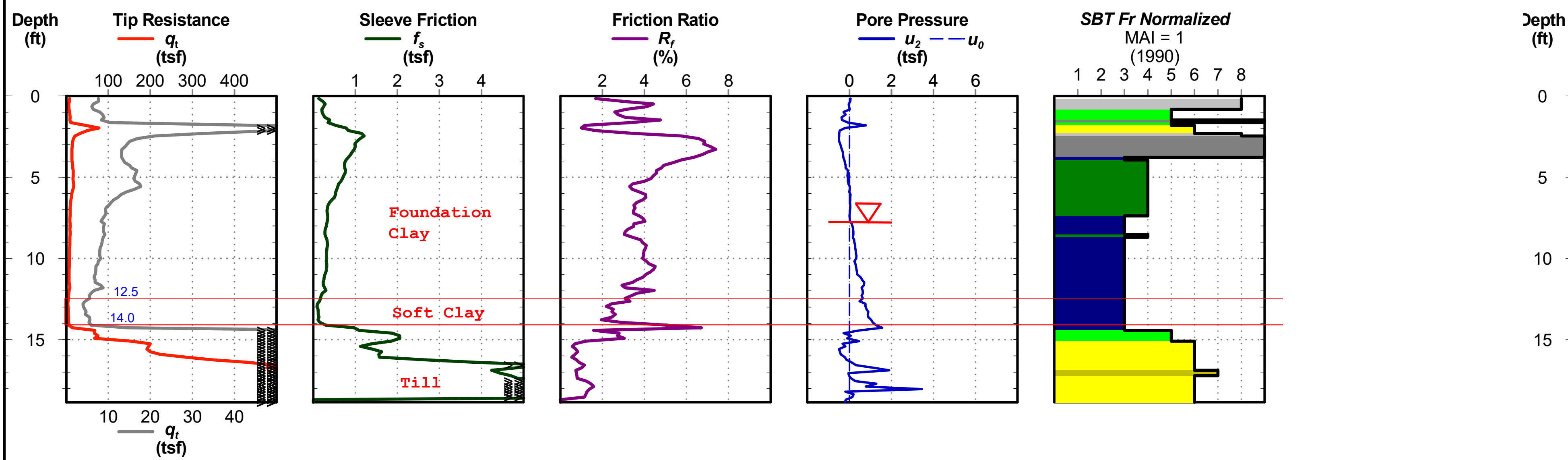
AECOM

Dynegy - Coffeen

Cone Penetration Test

COF-C055

Total Depth: 18.9 ft
Termination Criteria:
Cone Size: 15 cm^2 Tip Area



1 - Sensitive, Fine Grained Soils
2 - Organic Soils, Peats
3 - Clays-Clay to Silty Clay
4 - Silt Mixtures-Clayey Silt to Silty Clay
5 - Sand Mixtures-Silty Sand to Sandy Silt
6 - Sands-Clean Sand to Silty Sand
7 - Gravelly Sand to Sand
8 - Very Stiff Clay to Clayey Sand
9 - Very Stiff Fine Grained Soils

$S_u=(q_t-\sigma_{vo})/N_{kt}$ $N_{kt}=17$

Electronic File Name: 15-53063_SP55.COR

CPT REPORT - DYNAMIC COFFEEN CPT.GPJ CPT V3.0.GDT 1/13/16
P:\PROJECTS\GEOTECH\60428794 DYNEGYCCR\04TASKS\01 COFFEEN TASKS\8.0 CPT\RAPID CPT\COFFEEN CPT.GPJ

Appendix B. Hydrologic and Hydraulic Report

AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110-1337
www.aecom.com

314.429.0100 tel
314.429.0462 fax

October 7, 2016

Mr. Matt Ballance, PE
Senior Project Engineer
Dynegy Inc.
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

RE: Hydrologic and Hydraulic Summary Report
Coffeen Power Station
GMF Pond

Dear Mr. Ballance:

AECOM is pleased to provide this Summary Report of Hydrologic and Hydraulic Modeling for the Illinois Power Generating Company (IPGC) Coffeen GMF Pond Coal Combustion Residual (CCR) Unit. This analysis was performed to document that the facility meets the requirements of 40 CFR §257.82(a) with regard to the Inflow Design Flood Control Plan. Based on AECOM's analysis, the GMF Pond meet all hydraulic requirements for certification per 40 CFR §257.82(a).

AECOM looks forward to providing continued support to IPGC and working together on this important program. Please do not hesitate to call Ron Hager at 314-429-0100 (office) / 440-591-7868 (mobile), if you have any questions.

Sincerely,

AECOM

Victor Modeer, PE, D.GE
Site Manager
victor.modeer@aecom.com

Ronald Hager
Program Manager
Ronald.hager@aecom.com

cc: Mark Rokoff, PE – AECOM

Attachments:

A. Location Map
B. Support Documentation and Hydrologic and Hydraulic Analysis Summary

1. INTRODUCTION

1.1. *Purpose Of This Memorandum*

This report presents the results of the hydrologic and hydraulic analysis prepared by AECOM for the Illinois Power Generating Company (IPGC)[1] GMF Pond Coal Combustion Residual (CCR) Unit at the Coffeen Power Station, located approximately 2.4 miles south-southwest of Coffeen, Illinois in Montgomery County (See **Attachment A** for Location Map). This analysis was completed in accordance with the Environmental Protection Agency (EPA) 40 CFR Part §257, Subpart D, regulations for the disposal of CCR. As required by §257.82(a), by October 17, 2016, owners and operators of existing CCR surface impoundments must develop an Inflow Design Flood Control Plan that documents how the inflow design flood control system has been designed and constructed to meet the following requirements:

- *(40 CFR 257.82, (a)(1)* - The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood.

- *(40 CFR 257.82, (a)(2) -* The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood.

The GMF Pond has a high hazard potential, based on the initial hazard potential classification performed by Stantec in 2016 in accordance with §257.73(a)(2). The high hazard category indicates that the inflow design flood is the probable maximum flood (PMF) storm event. Since the GMF Pond does not have an inflow watershed outside of precipitation that falls directly into the CCR Unit, the PMF corresponds to the probable maximum precipitation (PMP) rainfall event. This event is the basis for AECOM certification.

1.2. *Brief Description of Impoundments*

The Coffeen GMF Pond receives and impounds gypsum from the plant's scrubber operations. The total surface area of the impoundment is approximately 36.2 acres. The embankment forms a ring dike that is approximately 5,000 feet in length and forms a complete perimeter around the impoundment. The elevation of the embankment crest ranges from El. 631.0 to approximately 632 ft. Unless otherwise noted, all elevations in this report are referenced to the North American Vertical Datum of 1988 (NAV88).

There is a lined overflow channel located along the south berm of the GMF Pond unit. The channel serves as the primary overflow for the pond and is 32 feet wide at its base, 9 feet deep, and has 3H:1V (horizontal to vertical) side slopes, and in invert elevation of 624.0 feet. A 14-inch high-density polyethylene (HDPE) low-flow pipe, with an invert elevation of 619.0 feet, is buried beneath the transfer channel and transmits flows under normal conditions. The GMF Pond and corresponding downstream GMF Recycle Pond

---

[1] Although the Coffeen Power Station and the GMF Pond are owned and operated by IPGC, Dynegy Administrative Services Company (*Dynegy*) contracted AECOM to develop this Hydrologic and Hydraulic Summary Report on behalf of IPRG. Therefore, "Dynegy" is referenced in materials attached to this hydrologic and hydraulic report.

are together operated as zero-discharge facilities during normal operations, as sluice water pumped into the GMF Pond is transmitted to the GMF Recycle Pond via the low-flow pipe, and outflow from the GMF Recycle Pond is then pumped back to the Coffeen Power Station for use as sluice water and returned to the GMF Pond.

2. POND CAPACITY / IMPOUNDMENT COMPUTATIONS

The elevation/areas for the GMF Pond was determined using design drawings prepared by Hanson Professional Services, Inc. in 2007 and 2015 survey data provided by the Weaver Consultant Group. Record drawings from Ameren Energy (2008) were also used. The starting water surface elevation for the analysis was assumed to be EL. 621.2 feet, based on the 2015 Weaver Consultants survey. This elevation was assumed to be representative of normal operational conditions at the GMF Pond as it is 2.2 feet higher than the invert elevation of the low-flow spillway pipe, and therefore corresponds to process flow conditions. Since the GMF Pond is a zero-discharge facility, process water inflow and outflow volumes were assumed to be equal. Please refer to Attachment B for further details.

3. HYDROLOGIC AND HYDRAULIC ANALYSIS OF GMF POND

3.1. ***Rainfall Data***

The high hazard rainfall depths were selected using National Weather Service – Hydrometeorological Report No. 51 (HMR 51) for the 10-square mile all-season Probable Maximum Precipitation (PMP). The 24-hour PMP rainfall total is 34.25 inches. The HMR 51 figure is included in Attachment B. The 24-hour PMP was distributed according to the Soil Conservation Service (SCS) Type B distribution.

3.2. ***Runoff Computations***

To assess the capacity of the ponds to store and convey the storm flows, a hydraulic model was created in HydroCAD 10.00-12. HydroCAD has the capability to evaluate each pond within the network, to respond to variable tailwater, pumping rates, permit flow loops, and reversing flows. HydroCAD routing calculations reevaluate the pond systems' discharge capability at each time increment, making the program an efficient and dynamic tool for this evaluation. Runoff was calculated using the SCS Curve Number Method, where curve numbers were assigned to each subcatchment based on the type of land cover and soil type present.

Tailwater conditions in the downstream GMF Recycle Pond were not considered in this analysis due to the fact that both the transfer channel and 14-inch low-flow pipe discharge several feet above the normal pool in the GMF Recycle Pond, as observed by AECOM during 2015 site visits. Therefore, tailwater conditions are expected to be free-discharge during the inflow design flood event.

Please refer to Attachment B for further details and modeling results.

4. CONCLUSIONS

- The H&H evaluation under the described scenario indicates that the GMF Pond will not overtop during the PMF event corresponding to the 24-hour PMP rainfall event. Results of the model are summarized below in Table 4.1.

Table 4.1
Summary of Hydrologic and Hydraulic Analysis

CCR Unit	Beginning WSE[1] (ft)	Peak WSE (ft)	Minimum Crest Elevation (ft)
GMF Pond	621.2	623.8	631.0

Notes:
1 WSE = Water Surface Elevation

- The GMF Pond is certified to be able to pass the Inflow Design Flood (IDF) per the §257.82(a) CCR Rule.

5. LIMITATIONS

Background information, design basis, and other data, which AECOM has used in preparing this report have been furnished to AECOM by IPGC. AECOM has relied on this information as furnished, and is not responsible for the accuracy of this information. Our recommendations are based on available information from previous and current investigations. These recommendations may be updated as future investigations are performed.

The conclusions presented in this report are intended only for the purpose, site location, and project indicated. The recommendations presented in this report should not be used for other projects or purposes. Conclusions or recommendations made from these data by others are their responsibility. The conclusions and recommendations are based on AECOM's understanding of current plant operations, maintenance, stormwater handling, and ash handling procedures at the station, as provided by IPG. Changes in any of these operations or procedures may invalidate the findings in this report until AECOM has had the opportunity to review the findings, and revise the report if necessary.

This hydrologic and hydraulic analysis was performed in accordance with the standard of care commonly used as state-of-practice in our profession. Specifically, our services have been performed in accordance with accepted principles and practices of the engineering profession. The conclusions presented in this report are professional opinions based on the indicated project criteria and data available at the time this report was prepared. Our services were provided in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation is intended.

6. REFERENCES

1. Ameren Energy, 2011. Recycle Pond Plan and Control Data, CCB Management Facility.
2. Hanson Professional Services, 2007. Design Drawings for Coffeen Gypsum Stack and Recycle Ponds
3. Weaver Consultants, 2015. Coffeen Site Aerial Mapping.
4. National Weather Service, 1982. Hydrometeorological Report No. 51

Attachment A

Location Map

LOCATION MAP

NOT TO SCALE

VICINITY MAP

NOT TO SCALE

AECOM

1001 Highlands Plaza Drive, Suite 300
St. Louis, Mo. 63110
314 429-0100 (phone)
314-429-0462 (fax)

DYNEGY

Dynegy Inc.
1500 East Port Plaza Drive
Collinsville, IL 62234

CCR RULE ASSESSMENT OF PLANTS

COFFEEN STATION
MONTGOMERY COUNTY, ILLINOIS

GMF GYPSUM STACK POND

ISSUED FOR BIDDING — DATE BY

ISSUED FOR CONSTRUCTION — DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	
DRAWN BY:	GJH
DESIGNED BY:	EJV
CHECKED BY:	MCR
DATE CREATED:	12/23/2015
PLOT DATE:	2/9/2016
SCALE:	AS SHOWN
ACAD VER:	2014

SHEET TITLE

LOCATION MAP &
SITE VICINITY MAP

Figure 1-1

SHEET OF

SMITH, CURT 2/9/2016 11:40 AM

Attachment B

Support Documentation and Hydrologic and Hydraulic Analysis Summary

Objective: **This analysis describes the independent investigation and design calculations and considerations of the on-site hydrology and hydraulics for certification of the GMF Pond Coal Combustion Residuals (CCR) Unit at the Dynegy Coffeen Energy Complex as required by the Environmental Protection Agency's (EPA's) Final CCR Rule. In particular, the analysis investigates the performance of the existing impoundment, spillways, and outlet structures for the pond during the Inflow Design Flood; the 24-hour Probable Maximum Flood (PMF) storm event as required by the aforementioned CCR rule for a High Hazard facility. Since the GMF Pond does not have an inflow watershed outside of precipitation that falls directly into the CCR Unit, the PMP corresponds to the Probable Maximum Precipitation (PMP) rainfall event.**

I. Overview

AECOM has reviewed historical design documents for the GMF Pond at the Dynegy Coffeen Energy Complex. The impoundment has been modeled using the design precipitation event as required by 40 CFR § 257.82 for a High Hazard unit. The 24-hour PMP storm event for the site is 34.25 inches. A Soil Conservation Service (SCS) Type B, 24-hour storm distribution was selected for this site. A HydroCAD model was used to simulate the pond system. Field surveys, previous design calculations, system descriptions, design drawings, as-built drawings, reports, letters, and system descriptions were used to verify input for the model.

It should be noted that record drawings from Ameren Energy (Sheet C-10206, January 2011) were used for the geometry of the transfer channel, rather than survey data from the 2015 Weaver Consultants survey of the site. The Weaver survey indicated an irregular profile within the transfer channel, which does not correspond to conditions observed by AECOM during site visits in 2015. Since this area is near the edge of the survey limits, it may be inaccurate. Therefore, the 2011 Ameren record drawings were used for the geometry, as they are more representative of the conditions observed in the field by AECOM in 2015.

II. Selected Methods

- HydroCAD 10.0 was used to model the routing, storage, and conveyance of stormwater and plant flow through the pond, discharge structures, and outfall pipes.
- Within the HydroCAD program, runoff was calculated using the Soil Conservation Service Technical Release 20 (SCS TR-20) method.
- Rainfall depths for the 24-hour PMP were taken from the National Weather Service – Hydrometeorological Report No. 51 (HMR 51) for the specific site location.

III. Design Criteria

- The GMF Pond was analyzed as a high hazard impoundment, as found in a hazard potential classification performed by Stantec in 2016. As a result, the Inflow Design Flood (IDF) for this impoundment is the PMP, 24-hour flood.
- Certification criteria are based on whether the GMF Pond can pass the 24-hour PMP without overtopping any of the pond's embankments.

- The elevation/areas for the GMF Pond were determined using design drawing prepared by Hanson Professional Services, Inc. in 2007, Ameren in 2011 and 2015 survey data from Weaver (except for the transfer channel, as described above).

IV. Data & Assumptions

The following is a list of assumptions and determining factors used for the HydroCAD modeling effort:

- The starting water surface elevation was assumed to be El. 621.2 feet, as shown in the 2015 Weaver Consultants Group survey of the site. This elevation is 2.2 feet above the invert elevation of the low-flow spillway and therefore includes plant process flows.
- The on-site berm elevations, control structure inverts, hazard classification and other relevant hydraulic controls are taken from field surveys, and historic documents. The elevation/areas for the GMF Pond were determined using design drawing prepared by Hanson Professional Services, Inc. in 2007 and 2015 survey data.
- There are no off-site drainage areas flowing into the impoundments.
- Runoff Curve Numbers (CN) were assigned based on ground cover. As the only area that drains to the pond is the rain that falls directly into the pond or onto the surrounding berm which is largely protected by an impervious liner, the highest impervious category was selected.
- Elevations are in feet and referenced with respect to North American Vertical Datum 1988 (NAVD 88).

V. Hydrology

The following chart shows the rainfall depths and duration for the storm modeled, in addition to the distribution applied to the rainfall depth. Refer to Attachment 1 for copies of the rainfall source data.

Storm Event	Rainfall Depth (Inches)	Duration (Hours)	Rainfall Distribution
24-hour PMP	34.25	24	SCS Type B/ 24-hr

VI. Hydraulic Calculations

All hydraulic modeling was done on HydroCAD using the available information provided by Dynegy. Storage areas, inverts, and other details for outlet structures were taken from field surveys, design drawings, and as-built drawings.

The HydroCAD calculations were based on the following information, developed for each element:

GMF Pond

The Coffeen GMF Pond receives and impounds gypsum from the plant's scrubbing operations. The total surface area of the impoundment is approximately 36.2 acres, including the embankments.

There is a lined transfer channel located along the south berm if the GMF Pond unit. The channel serves as the primary overflow for the pond and is 32 feet wide at its base, 9 feet deep, and has 3:1 side slopes. A 14-inch high density polyethylene (HDPE) pipe at an approximate elevation of 619.0 passes through the embankment to handle very low flows.

VII. Results

HydroCAD H&H Model Output

Table 2 below summarizes the results of AECOM HydroCAD model for the GMF Pond CCR Unit. The associated detailed HydroCAD output report follows.

Table 2 – PMP, 24-hour Flood Pond Responses – Existing Conditions Model

Storage Area	Qpeak In (cfs)	Qpeak Out (cfs)	Storage[1] (ac-ft)	Max WSE[2] (ft)	Primary Spillway Elevation (ft)	Secondary Spillway Elevation (ft)	Minimum Crest Elevation (ft)
GMF Pond	226.7	4.6	88.3	623.8	Variable (Decanting Structure Only)	624.0 (619.0 Low Flow)	631.0

[1]The storage is the volume of water stored in the area upstream of the outlet structure above normal pool.
[2]WSE is water surface elevation.

VIII. Conclusions

The following conclusions are based on the HydroCAD model of the GMF Pond CCR Unit:

- There is no anticipated overtopping during the PMP, 24-hour flood for the impoundment.
- The site meets the hydraulic requirements for certification under 40 CFR § 257.82(a).

ATTACHMENT 1

SUPPORTING DATA

INCLUDING:

RAINFALL DATA

DRAINAGE SCHEMATIC

AND

HYDROCAD INPUT AND OUTPUT REPORTS

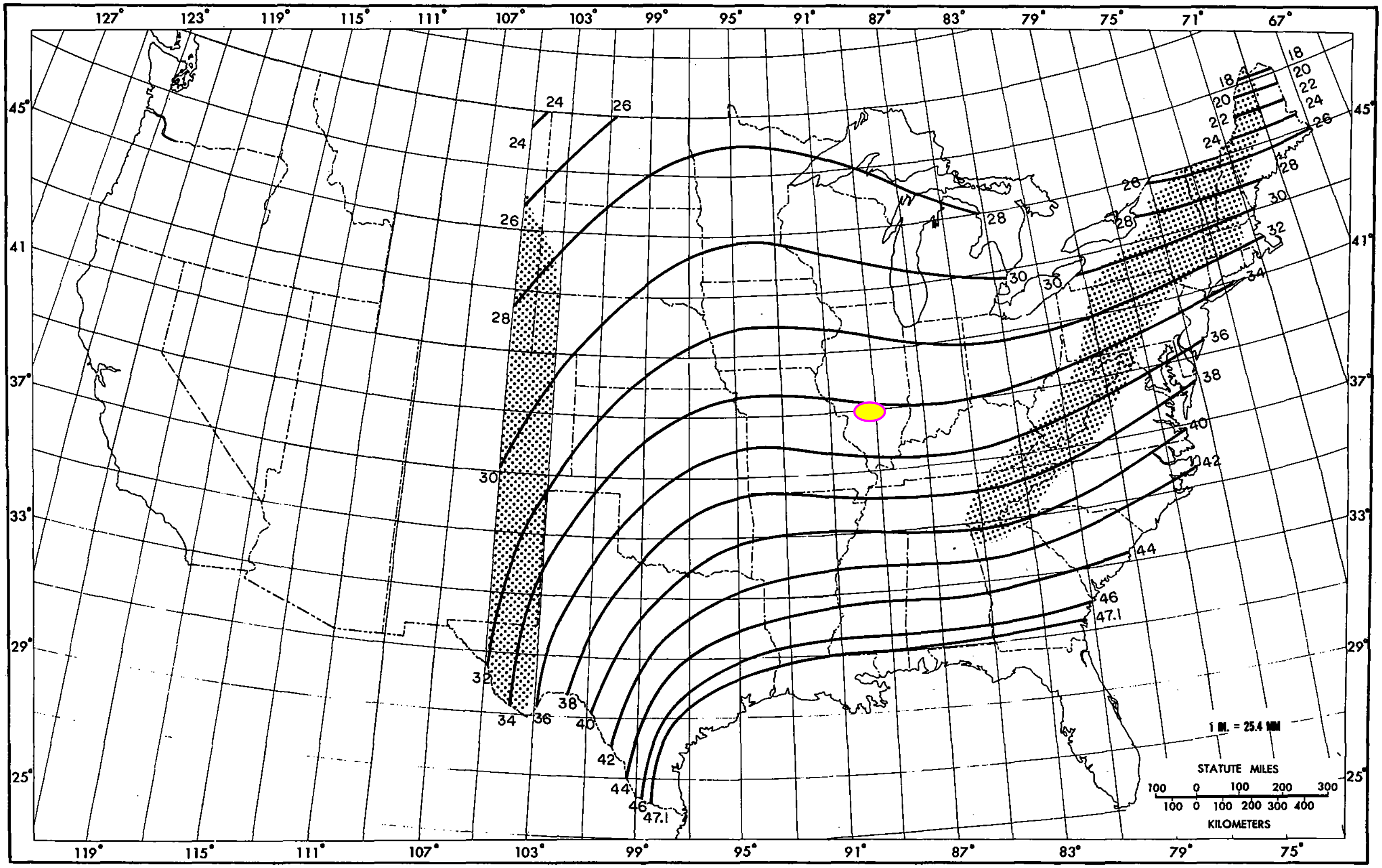
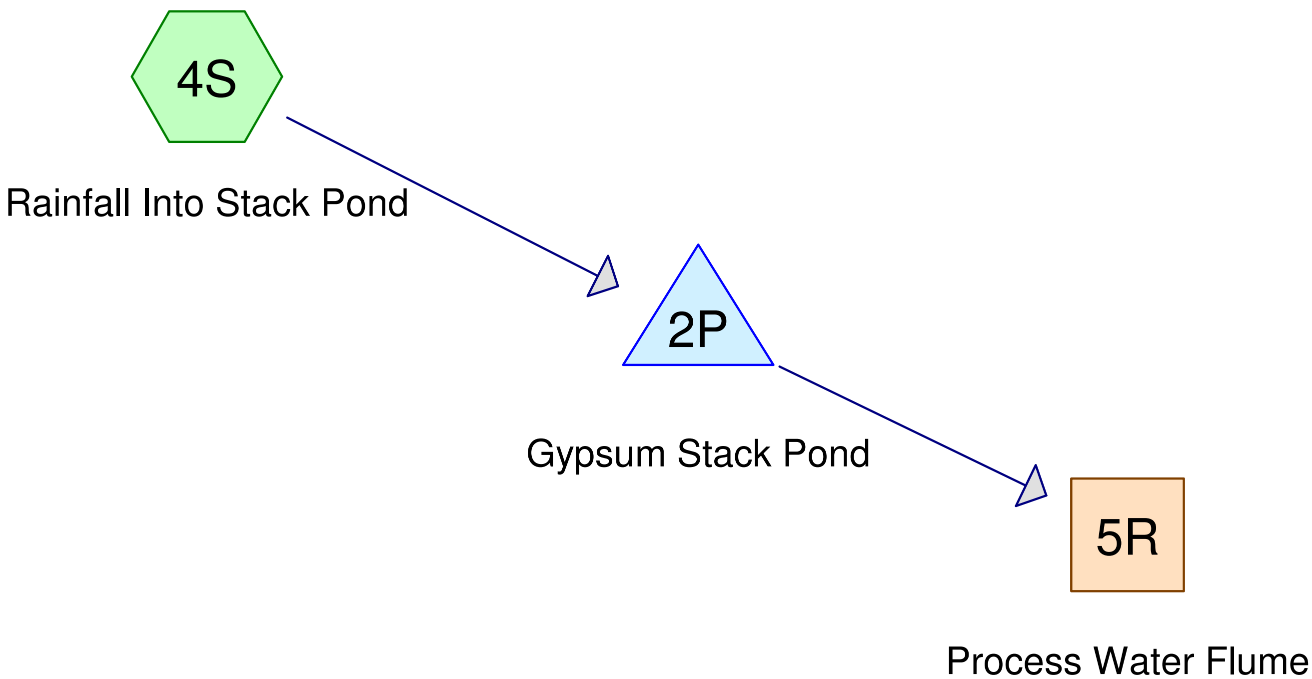
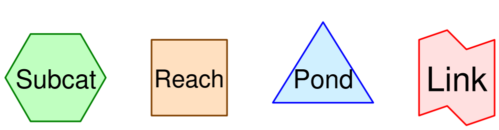


Figure 20.--All-season PMP (in.) for 24 hr 10 mi² (26 km²).





Routing Diagram for 2016-09-01-Revised-ExistingStack
Prepared by URS Corp., Printed 9/23/2016
HydroCAD® 10.00-12 s/n 05502 © 2014 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
33.800	98	Water Surface, HSG C (4S)
33.800	**98**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
33.800	HSG C	4S
0.000	HSG D	
0.000	Other	
33.800		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	33.800	0.000	0.000	33.800	Water Surface	4S
0.000	**0.000**	**33.800**	**0.000**	**0.000**	**33.800**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	2P	619.00	617.60	600.0	0.0023	0.013	14.0	0.0	0.0

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 4S: Rainfall Into Stack Runoff Area=33.800 ac 100.00% Impervious Runoff Depth=34.01"
Tc=5.0 min CN=98 Runoff=226.68 cfs 95.784 af

Reach 5R: Process Water Flume Avg. Flow Depth=0.09' Max Vel=1.52 fps Inflow=4.63 cfs 25.276 af
n=0.012 L=580.0' S=0.0034 '/' Capacity=12,709.44 cfs Outflow=4.63 cfs 25.198 af

Pond 2P: Gypsum Stack Pond Peak Elev=623.78' Storage=3,846,901 cf Inflow=226.68 cfs 95.784 af
Outflow=4.63 cfs 25.276 af

Total Runoff Area = 33.800 ac Runoff Volume = 95.784 af Average Runoff Depth = 34.01"
0.00% Pervious = 0.000 ac 100.00% Impervious = 33.800 ac

Summary for Subcatchment 4S: Rainfall Into Stack Pond

[49] Hint: Tc<2dt may require smaller dt

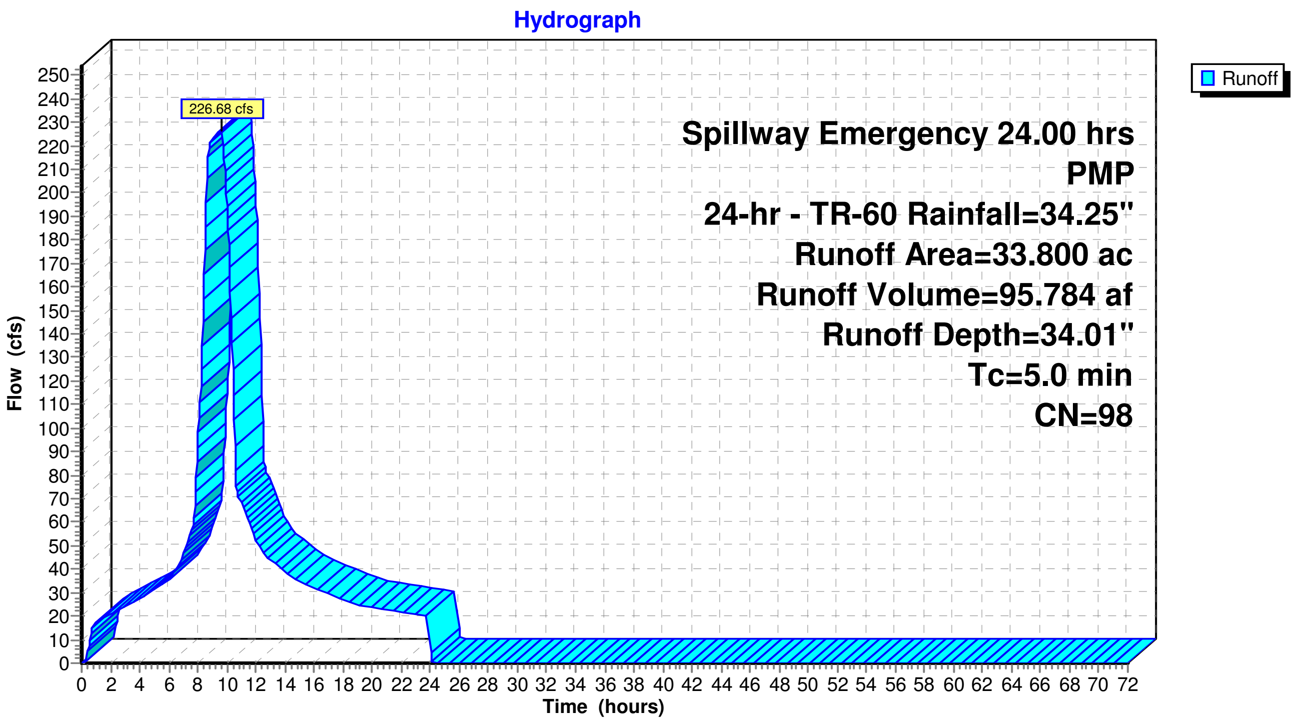
Runoff = 226.68 cfs @ 9.60 hrs, Volume= 95.784 af, Depth=34.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Spillway Emergency 24.00 hrs PMP, 24-hr - TR-60 Rainfall=34.25"

Area (ac)	CN	Description
33.800	98	Water Surface, HSG C
33.800		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct Fall**

Subcatchment 4S: Rainfall Into Stack Pond



Summary for Reach 5R: Process Water Flume

[81] Warning: Exceeded Pond 2P by 2.90' @ 0.00 hrs

Inflow Area = 33.800 ac,100.00% Impervious, Inflow Depth > 8.97" for PMP, 24-hr - TR-60 event
Inflow = 4.63 cfs @ 24.11 hrs, Volume= 25.276 af
Outflow = 4.63 cfs @ 24.28 hrs, Volume= 25.198 af, Atten= 0%, Lag= 10.3 min

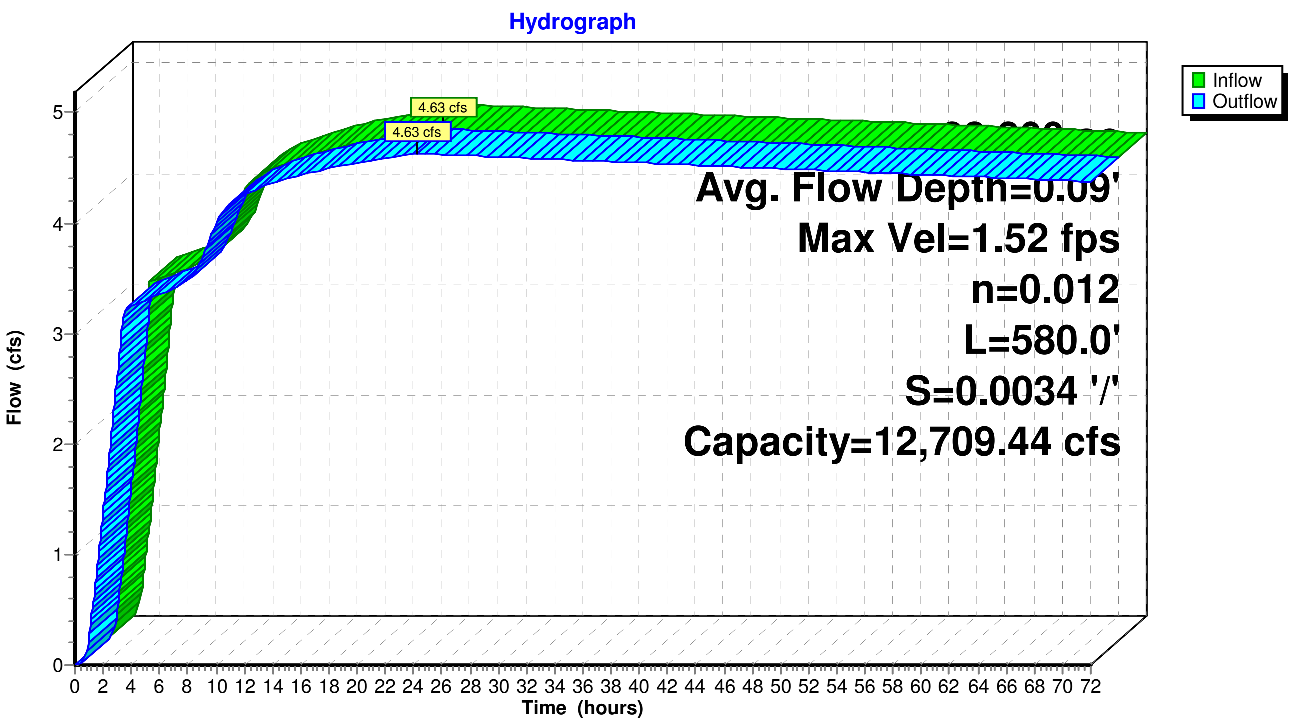
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.52 fps, Min. Travel Time= 6.3 min
Avg. Velocity = 1.49 fps, Avg. Travel Time= 6.5 min

Peak Storage= 1,761 cf @ 24.17 hrs
Average Depth at Peak Storage= 0.09'
Bank-Full Depth= 9.00' Flow Area= 531.0 sf, Capacity= 12,709.44 cfs

32.00' x 9.00' deep channel, n= 0.012 HDPE Liner
Side Slope Z-value= 3.0 '/' Top Width= 86.00'
Length= 580.0' Slope= 0.0034 '/'
Inlet Invert= 624.00', Outlet Invert= 622.00'

‡

Reach 5R: Process Water Flume



Summary for Pond 2P: Gypsum Stack Pond

Inflow Area = 33.800 ac,100.00% Impervious, Inflow Depth = 34.01" for PMP, 24-hr - TR-60 event
Inflow = 226.68 cfs @ 9.60 hrs, Volume= 95.784 af
Outflow = 4.63 cfs @ 24.11 hrs, Volume= 25.276 af, Atten= 98%, Lag= 870.5 min
Primary = 4.63 cfs @ 24.11 hrs, Volume= 25.276 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 623.78' @ 24.11 hrs Surf.Area= 1,453,751 sf Storage= 3,846,901 cf

Plug-Flow detention time= 1,918.4 min calculated for 25.276 af (26% of inflow)
Center-of-Mass det. time= 1,607.4 min (2,267.3 - 659.9)

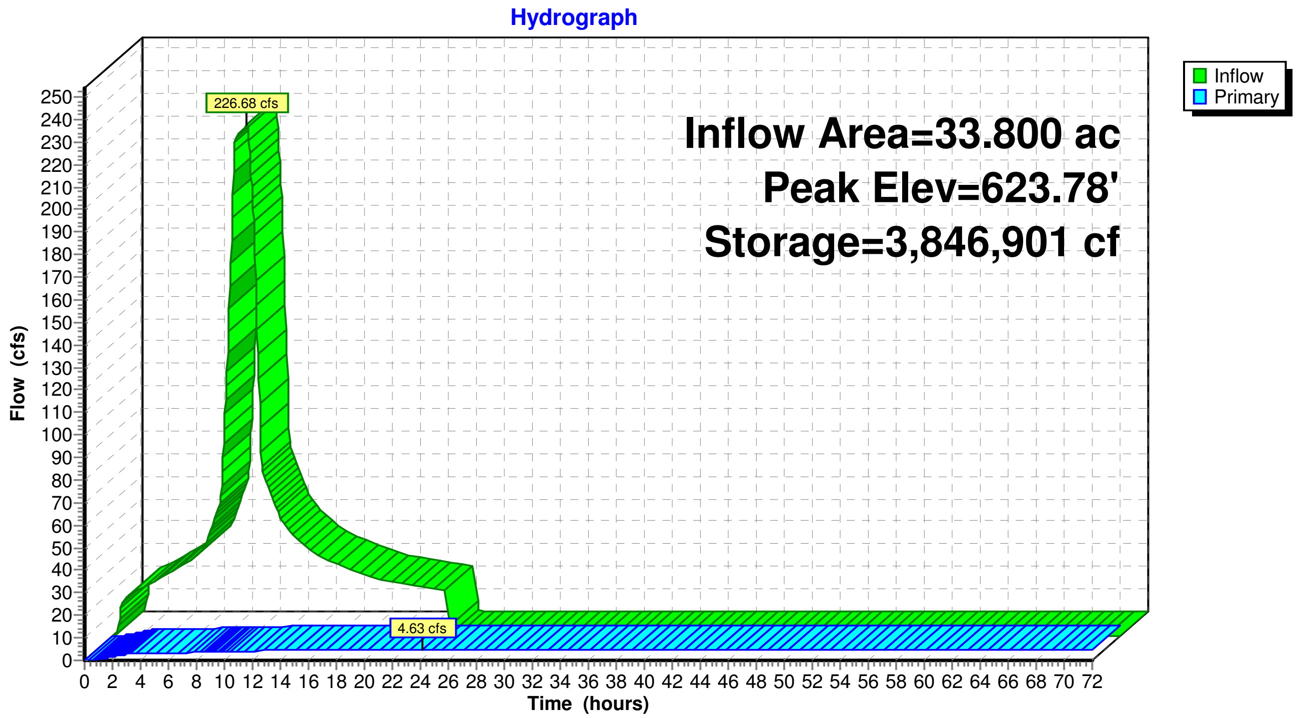
Volume	Invert	Avail.Storage	Storage Description
#1	621.10'	16,293,078 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
621.10	1,420,000	0	0
623.00	1,442,491	2,719,366	2,719,366
624.00	1,456,952	1,449,722	4,169,088
625.00	1,471,498	1,464,225	5,633,313
626.00	1,486,043	1,478,771	7,112,083
627.00	1,500,674	1,493,359	8,605,442
628.00	1,515,361	1,508,018	10,113,459
629.00	1,530,105	1,522,733	11,636,192
630.00	1,544,863	1,537,484	13,173,676
631.00	1,559,621	1,552,242	14,725,918
632.00	1,574,698	1,567,160	16,293,078

Device	Routing	Invert	Outlet Devices
#1	Primary	619.00'	**14.0" Round Culvert** L= 600.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 619.00' / 617.60' S= 0.0023 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.07 sf
#2	Primary	625.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 9.00 Width (feet) 32.00 86.00

Primary OutFlow Max=4.63 cfs @ 24.11 hrs HW=623.78' (Free Discharge)
1=Culvert (Barrel Controls 4.63 cfs @ 4.33 fps)
2=Custom Weir/Orifice (Controls 0.00 cfs)

Pond 2P: Gypsum Stack Pond



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1001 Highlands Plaza Drive West, Suite 300
St. Louis, MO 63110
1-314-429-0100

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AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With nearly 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $19 billion.

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CCR Documentation Report:

Initial Structural Stability Assessment, Initial Safety Factor Assessment, and Initial Inflow Design Flood Control System Plan

GMF Recycle Pond
Coffeen Power Station
Montgomery County, Illinois

Submitted to Illinois Power Generating Company
October 2016

HANSON
Engineering | Planning | Allied Services

1. Introduction

The initial structural stability assessment, initial safety factor assessment, and initial inflow design flood control system plan for the GMF Recycle Pond at the Coffeen Power Station have been prepared in accordance with the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule 40 Code of Federal Regulations (CFR) §257.73(d), §257.73(e), and §257.82, respectively. The supporting documentation for the GMF Recycle Pond is summarized in Section 2 below.

2. Supporting Document Matrix

Report Section	CCR Rule Reference	Requirement Summary	Requirement Met?	Supporting Documentation
Attachment A - Initial Structural Stability Assessment				
2.1	40 CFR 257.73(d)(1)(i)	Stable foundations and abutments	Yes	See Appendix 2 for Foundation Soil Information See Appendix 5 for Structural Fill Specifications See Appendix 6 for Slope Stability Calculations
2.2	40 CFR 257.73(d)(1)(ii)	Adequate slope protection	Yes	See Appendix 5 for Vegetation Specifications and Maintanence Plan See Appendix 5 for HDPE Geomembrane Specifications See Appendix 4B for Wave Runup Calculations
2.3	40 CFR 257.73(d)(1)(iii)	Sufficiency of dike compaction	Yes	See Appendix 2 for Structural Fill Information & Compaction Records See Appendix 5 for Structural Fill Specifications
2.4	40 CFR 257.73(d)(1)(iv)	Presence and condition of slope vegetation	Yes	See Appendix 5 for Vegetation Specifications and Maintanence Plan
2.5	40 CFR 257.73(d)(1)(v)(A) and (B)	Adequacy of spillway design and management	Yes	See Appendix 1 for Emergency Spillway Record Drawings See Appendix 3 for Emergency Spillway-Stage Storage Information See Appendix 4 for Emergency Spillway Hydraulic Design Calculations
2.6	40 CFR 257.73(d)(1)(vi)	Structural integrity of hydraulic structures	Yes	See Appendix 1 for Emergency Spillway Record Drawings See Appendix 2 for Structural Backfill Information & Compaction Records See Appendix 5 for Emergency Spillway material specifications
2.7	40 CFR 257.73(d)(1)(vii)	Stability of downstream slopes inundated by water body	Not Applicable	
Attachment B - Initial Safety Factor Assessment				
2	40 CFR 257.73(e)(1)(i)	Maximum storage pool safety factor must be at least 1.50	Yes	See Appendix 6 for Geotechnical Calculations
2	40 CFR 257.73(e)(1)(ii)	Maximum surcharge pool safety factor must be at least 1.40	Yes	See Appendix 6 for Geotechnical Calculations
2	40 CFR 257.73(e)(1)(iii)	Seismic safety factor must be at least 1.00	Yes	See Appendix 6 for Geotechnical Calculations
2	40 CFR 257.73(e)(1)(iv)	Liquefaction safety factor must be at least 1.20	Not Applicable	See Appendix 6 for Geotechnical Calculations
Attachment C - Initial Inflow Design Flood Control System Plan				
2.1	40 CFR 257.82(a)(1), (2),(3)	Adequacy of inflow design flood control system	Yes	See Appendix 4 for GMF Recycle Pond Hydraulic Design Calculations
2.2	40 CFR 257.82(b)	Discharge from the CCR Unit	Yes	See Appendix 4C for GMF Water Balance Assessment

3. List of Appendices:

Appendix 1 – Drawings
Appendix 2 – Soil Data
Appendix 3 – Stage Storage Information
Appendix 4 – Hydraulic Design Calculations
    Appendix 4A – Hydrologic and Hydraulic Design Calculations
    Appendix 4B – Wave Runup/Freeboard Calculations
    Appendix 4C – GMF Water Balance Assessment
Appendix 5 – Specifications / Operation & Maintenance Plan
Appendix 6 – Recycle Pond Geotechnical Design

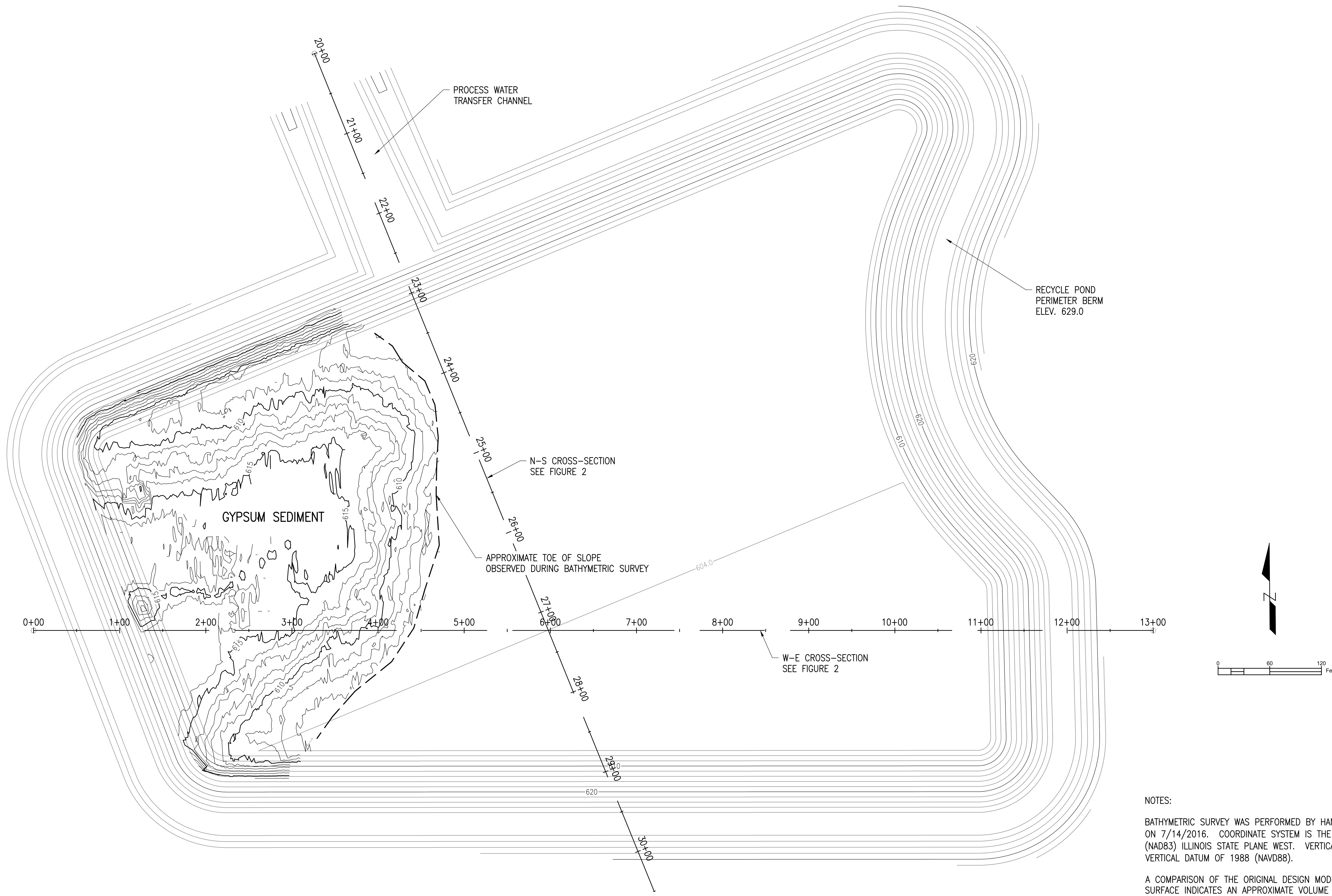
Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

Appendix 1

Drawings



NOTES:

BATHYMETRIC SURVEY WAS PERFORMED BY HANSON PROFESSIONAL SERVICES INC. ON 7/14/2016. COORDINATE SYSTEM IS THE NORTH AMERICAN DATUM OF 1983 (NAD83) ILLINOIS STATE PLANE WEST. VERTICAL DATUM IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

A COMPARISON OF THE ORIGINAL DESIGN MODEL VS THE BATHYMETRIC SURVEY SURFACE INDICATES AN APPROXIMATE VOLUME OF 42,800 CUBIC YARDS OF GYPSUM AS OF 7/14/2016.

DATE	REVISION

Hanson No. 16E0098
Filename MODEL.DWG
Scale SEE SCALE BAR
Date 8/18/16

LAYOUT	DBH	8/18/16
DRAWN	DBH	8/18/16
REVIEWED	TBD	8/18/16

HANSON

Hanson Professional Services Inc.
1525 South Sixth Street
Springfield, Illinois 62703-2886

Phone: (217) 788-2450
Fax: (217) 788-2503
www.hanson-inc.com
Offices Nationwide

GYPSUM BATHYMETRIC SURVEY
GYPSUM MANAGEMENT FACILITY RECYCLE POND

COFFEEN POWER STATION
ILLINOIS POWER HOLDINGS, LLC.
MONTGOMERY COUNTY, ILLINOIS

FIG. 1

1 of 2 sheets

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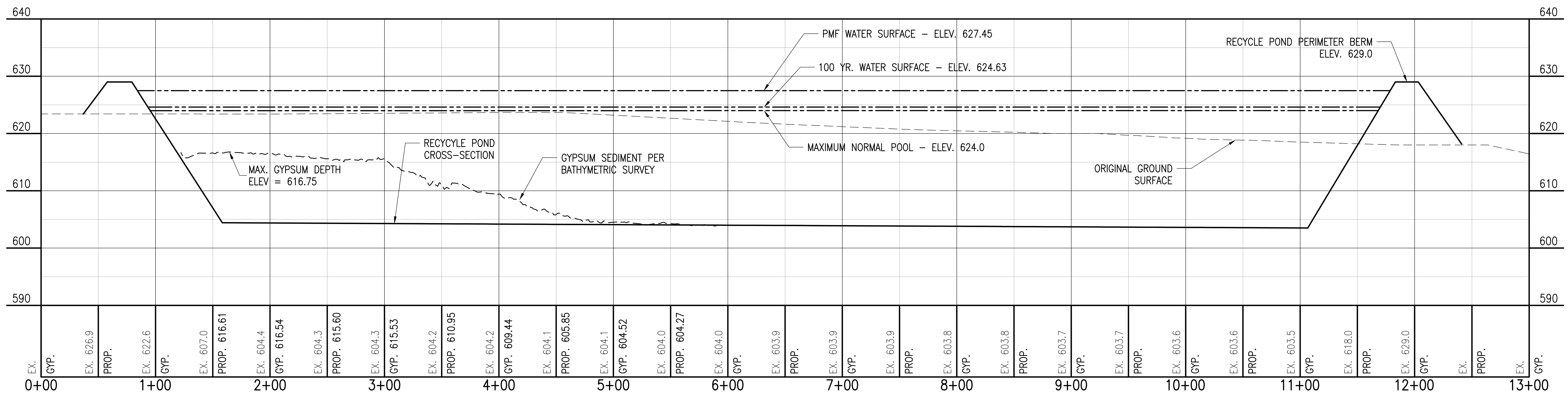

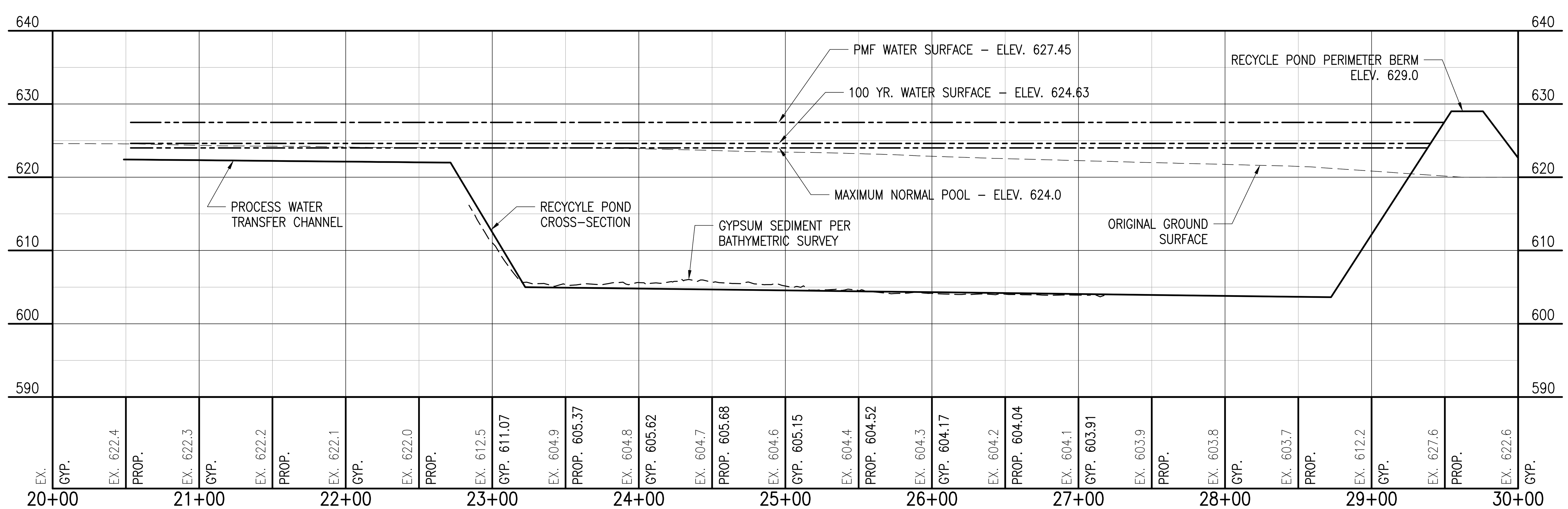

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DATE	REVISION

Hanson No. 16E0098
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Scale SEE SCALE BAR
Date 8/18/16

LAYOUT	DBH	8/18/16
DRAWN	DBH	8/18/16
REVIEWED	SMB	8/18/16

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Offices Nationwide

RECYCLE POND CROSS SECTONS
GYPSUM MANAGEMENT FACILITY RECYCLE POND

COFFEEN POWER STATION
ILLINOIS POWER HOLDINGS, LLC.
MONTGOMERY COUNTY, ILLINOIS

FIG. 2

1 of 2 sheets

C-10206 SHEET NO. 1

CONSTRUCTION DOCUMENTS

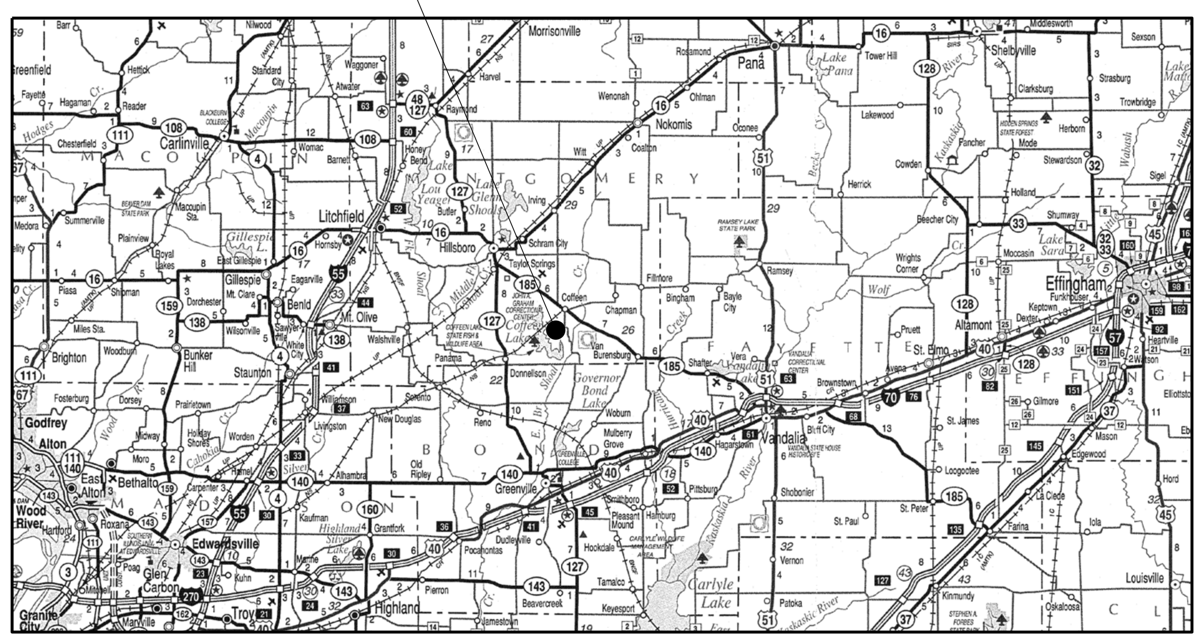
GYPSUM STACK – CELL G1

COAL COMBUSTION BY-PRODUCT MANAGEMENT FACILITY

AMEREN COFFEEN POWER STATION
MONTGOMERY COUNTY, ILLINOIS

JULY 2008

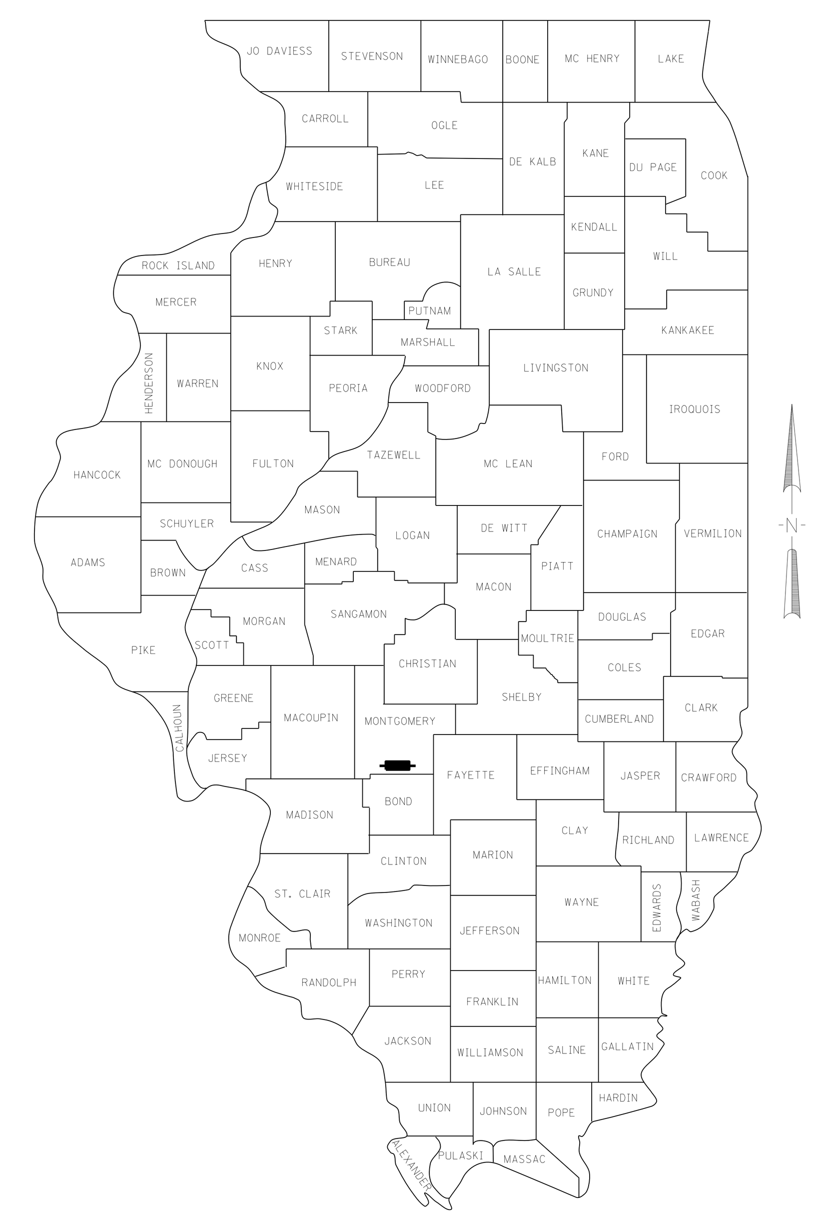
PROJECT LOCATION



AREA LOCATION PLAN

C-10206 SHEET INDEX

* LD/LCRS = LEAK DETECTION /LEACHATE COLLECTION RECOVERY SYSTEM
PWRS = PROCESS WATER RECOVERY SYSTEM



STATE LOCATION PLAN

UTILITY NOTE

THE LOCATIONS OF THOSE BURIED AND ABOVEGROUND UTILITIES SHOWN ARE APPROXIMATE, ARE SHOWN FOR CONTRACTOR INFORMATIONAL USE ONLY, AND ARE NOT TO BE REFERENCED FOR CONSTRUCTION PURPOSES. THE IMPLIED PRESENCE OR ABSENCE OF UTILITIES IS NOT TO BE CONSTRUED BY THE OWNER, ENGINEER, CONTRACTOR, OR SUBCONTRACTORS TO BE AN ACCURATE AND COMPLETE REPRESENTATION OF UTILITIES THAT MAY OR MAY NOT EXIST ON THE CONSTRUCTION SITE. BURIED AND ABOVEGROUND UTILITY LOCATION, IDENTIFICATION, AND MARKING ARE THE SOLE RESPONSIBILITY OF THE CONTRACTOR. REROUTING, DISCONNECTION, PROTECTION, ETC. OF ANY UTILITIES MUST BE COORDINATED BETWEEN THE CONTRACTOR, UTILITY COMPANY, AND OWNER. SITE SAFETY, INCLUDING THE AVOIDANCE OF HAZARDS ASSOCIATED WITH BURIED AND ABOVEGROUND UTILITIES, REMAIN THE SOLE RESPONSIBILITY OF THE CONTRACTOR.

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Illinois Licensed Professional Service Corporation #184-001084

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REFERENCE DRAWINGS

C-10207 LANDFILL PLANS
C-10211 LANDFILL ACCEPTANCE PLANS
C-10212 GYPSUM STACK ACCEPTANCE PLANS
E-10850 SUBDRAINAGE POWER PLANS
E-10855 LEACHATE COLLECTION POWER PLANS

DRAWING RECORD

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
5	12-21-10	–	–	TCJ			–		RECORD DRAWINGS

SCALE: –
LOC. NO.
CLASS

TITLE & INDEX
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY
SITE: COFFEEN

AmerenEnergy Generating

DRAWING NO. C-10206 REV. 5
SHEET NO. 01

LAYOUT	SKB	07-11-08
DRAWN	SKB	08-19-10
REVIEWED	JDH	08-19-10

30x42

SHEET NO. 2
C-10206

PROJECT DESCRIPTION

THIS PROJECT AT THE GYPSUM STACK WILL CONSIST OF THE WORK AS DESCRIBED IN SECTINO L-01010 OF THE PROJECT SPECIFICATIONS

COORDINATION WITH OTHER WORK

THIS CONTRACTOR WILL WORK IN CLOSE HARMONY WITH OTHER CONTRACTORS OR AMEREN PERSONNEL WHO MAY BE EMPLOYED AT THIS SITE. IN THE EVENT OF DIFFERENCES OF OPINION REGARDING SCHEDULING OF WORK, THE DECISION OF THE OWNER WILL BE FINAL.

SITE ACCESS

ACCESS TO THE SITE SHALL BE FROM CIPS LANE OR AS DETERMINED BY OWNER.

CLOSURE OR BLOCKING OF THE RAILROAD ALONG THE WEST SIDE OF THE PROJECT WILL NOT BE PERMITTED.

RESPONSIBILITIES FOR EXISTING UTILITIES

THE LOCATION, SIZE AND/OR TYPE OF MATERIAL OF EXISTING UNDERGROUND OR OVERHEAD UTILITIES AS MAY BE INDICATED ON THESE CONSTRUCTION PLANS ARE NOT REPRESENTED AS BEING ACCURATE, SUFFICIENT OR COMPLETE. THE OWNER AND THE PROJECT ENGINEER HAVE NOT INDEPENDENTLY VERIFIED THIS INFORMATION AND DO NOT ASSUME ANY RESPONSIBILITY WHATSOEVER WITH RESPECT TO THE ACCURACY, SUFFICIENCY OR COMPLETENESS OF THE INFORMATION AND GIVE NO EXPRESSED OR IMPLIED GUARANTEE THAT ANY CONDITIONS INDICATED ARE REPRESENTATIVE OF ACTUAL CONDITIONS TO BE ENCOUNTERED.

IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO DETERMINE THE ACTUAL LOCATION OF ALL SUCH FACILITIES, INCLUDING SERVICE CONNECTIONS TO UNDERGROUND UTILITIES. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL NOTIFY ALL UTILITY COMPANIES AND AGENCIES OF HIS CONSTRUCTION PLANS AND SHALL OBTAIN FROM EACH PARTY DETAILED INFORMATION AND ASSISTANCE RELATIVE TO THE LOCATION OF ALL UTILITIES AND THE SCHEDULE OF ANY REMOVALS AND ADJUSTMENTS REQUIRED OF THE UTILITY. THE CONTRACTOR SHALL CONTACT J.U.L.I.E. (PHONE 800-892-0123) TO ASSIST IN COMPLETING THIS RESPONSIBILITY.

THE CONTRACTOR SHALL PROTECT ANY FACILITIES TO THE SATISFACTION OF THE UTILITY OR OWNING-AGENCY WITH THE COST OF ANY REQUIRED PROTECTION TO BE INCIDENTAL TO THE CONTRACT. IN THE EVENT A UTILITY LINE OR SERVICE IS UNEXPECTEDLY ENCOUNTERED DURING CONSTRUCTION, THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE OWNER AND THE UTILITY COMPANY OR AGENCY OF JURISDICTION. ANY SUCH UTILITIES DISTURBED BY THE CONTRACTOR'S OPERATIONS SHALL BE RESTORED TO SERVICE AT ONCE.

PROTECTIVE FENCES, BERMS, AND BOLLARDS AT POWER POLES, TRANSMISSION TOWERS AND MONITORING WELLS SHALL BE CONSTRUCTED BY OTHERS BEFORE CONSTRUCTION IN THIS CONTRACT COMMENCES.

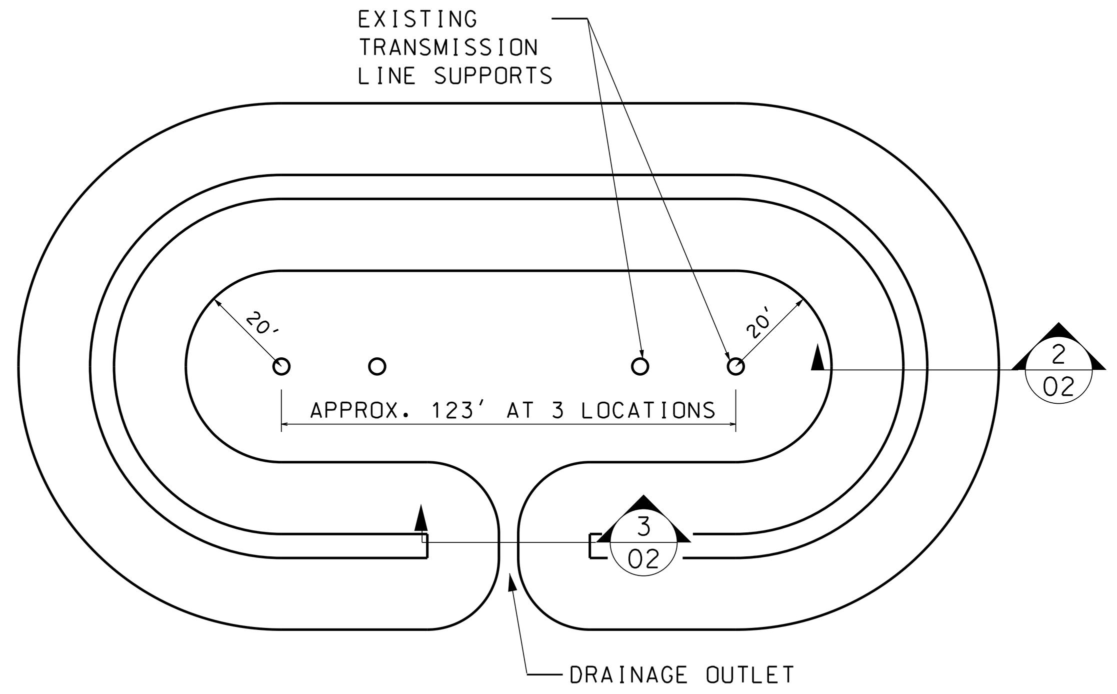
PROTECTION OF TRANSMISSION TOWERS, MONITORING WELLS & POWER POLES IS OF PARAMOUNT IMPORTANCE.
ANY DAMAGE TO TRANSMISSION TOWERS, WELLS OR POWER POLES SHALL BE REPAIRED AT CONTRACTOR'S EXPENSE.

AVAILABLE SOIL DATA

SOIL TEST DATA ARE INCLUDED IN THE PLANS AND IN THE GEOTECHNICAL APPENDIX OF THE SPECIFICATIONS. INFORMATION ON SOIL TESTS IS MADE AVAILABLE SOLELY FOR THE CONVENIENCE OF THE BIDDER AND/OR CONTRACTOR. NEITHER THE OWNER NOR THE PROJECT ENGINEER ASSUMES ANY RESPONSIBILITY WHATSOEVER IN RESPECT TO THE ACCURACY OR SUFFICIENCY OF THE AVAILABLE INFORMATION, AND THERE IS NO EXPRESSED OR IMPLIED GUARANTEE THAT THE CONDITIONS DESCRIBED IN THE SOIL TEST DATA ARE REPRESENTATIVE OF ALL CONDITIONS THAT MAY BE ENCOUNTERED.

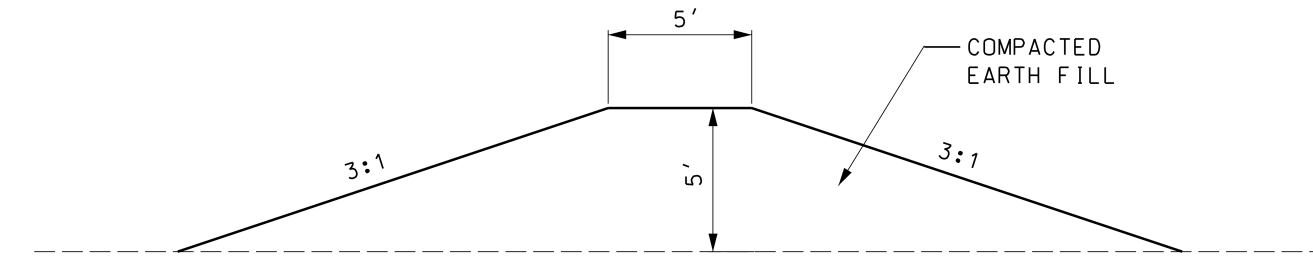
SITE WORK

THE CONTRACTOR SHALL CONSTRUCT NEW EROSION CONTROL MEASURES NECESSARY TO CONTROL EROSION AND PREVENT SEDIMENT MIGRATION FROM THE PROJECT SITE IN ACCORDANCE WITH THE PLANS AND SECTION 01356 OF THE SPECIFICATIONS.

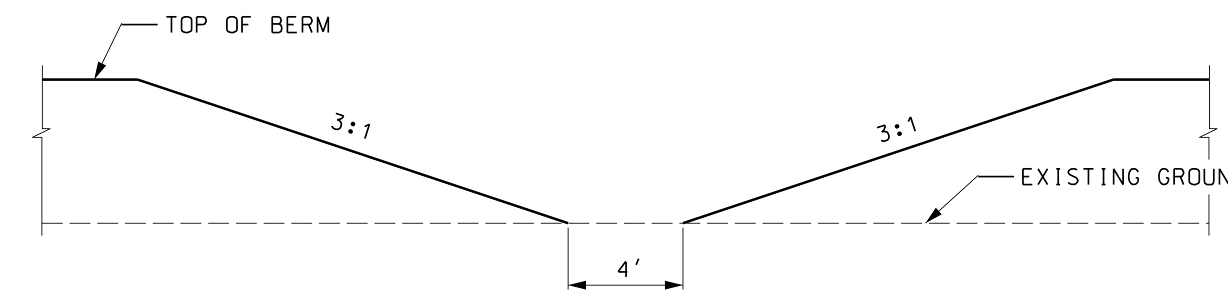


1/02 PROTECTIVE BERM AT DOUBLE TRANSMISSION TOWERS
NTS

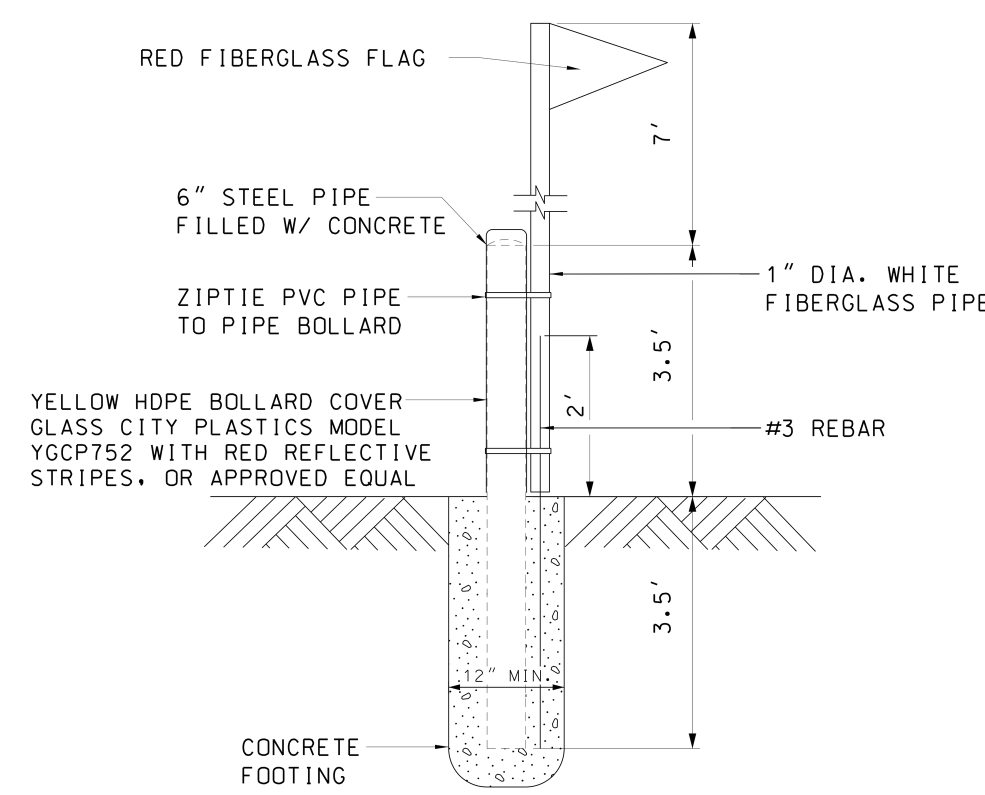
NOTE:
PROTECTIVE BERMS FOR IN THIS CONTRACT INCLUDE THE BERM BETWEEN GYPSUM STACK CELL G1 AND RECYCLE POND AND THE TWO EASTERN MOST BERMS ONLY.



2/02 TYPICAL BERM SECTION
NTS

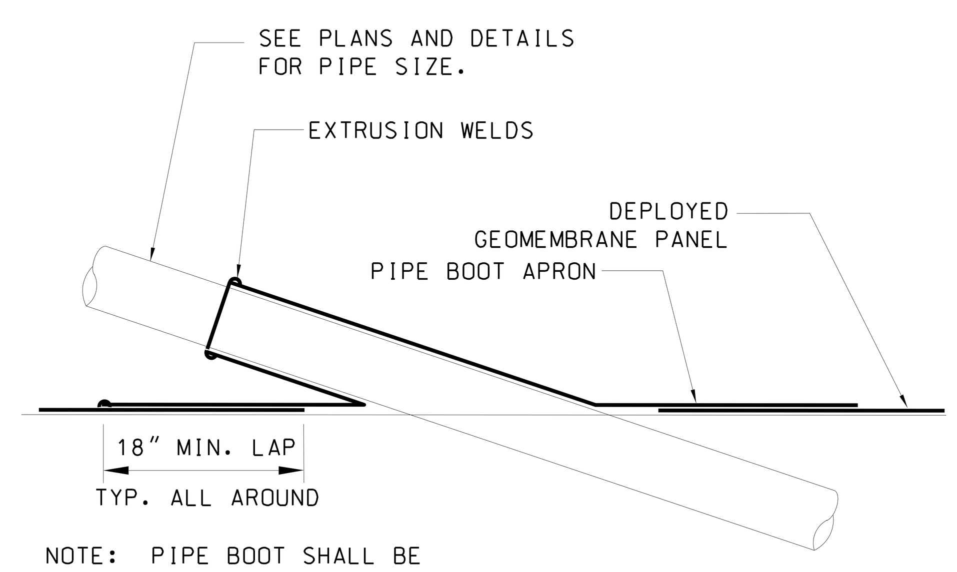


3/02 DRAINAGE OUTLET
NTS



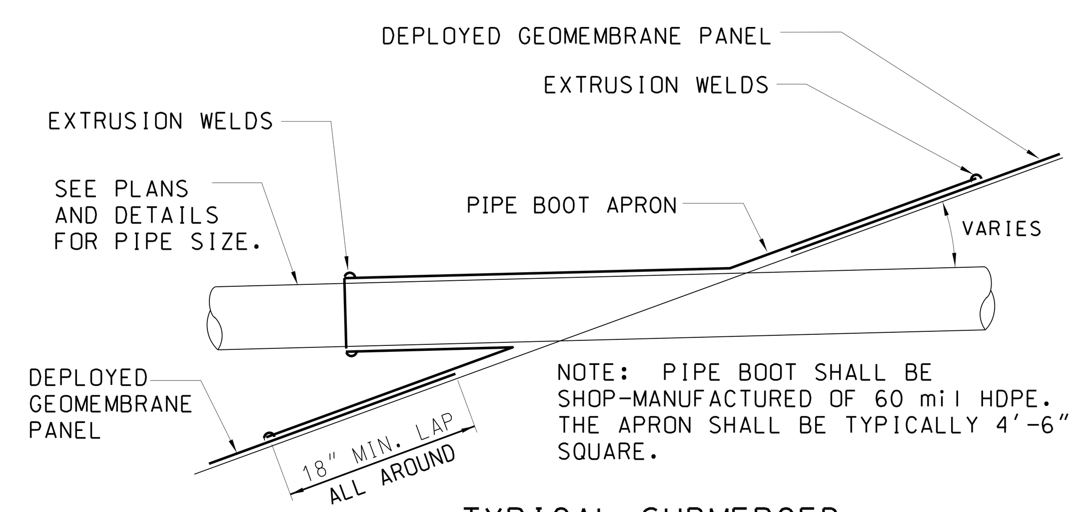
4/02 PIPE BOLLARD DETAIL
NTS

NOTE: ALL BOLLARDS SHALL BE LOCATED OUTSIDE ANCHOR TRENCHES AT ALL LOCATIONS.



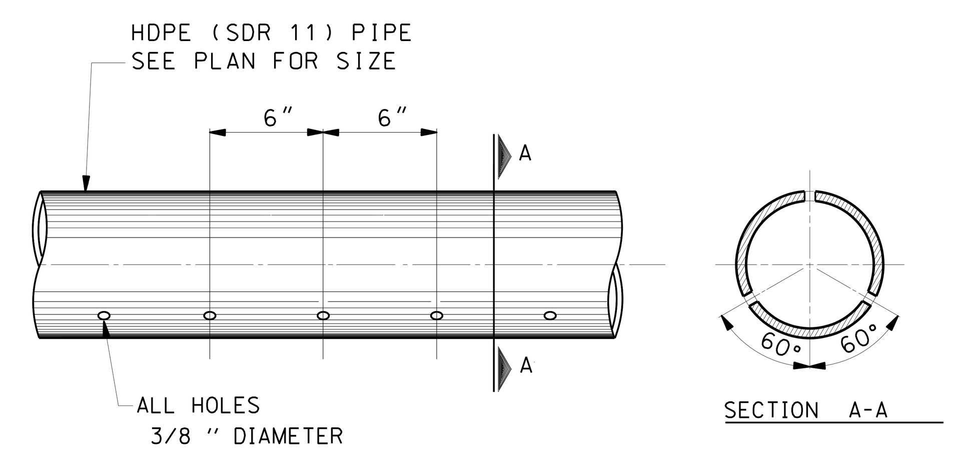
NOTE: PIPE BOOT SHALL BE SHOP-MANUFACTURED OF 60 mil HDPE. THE APRON SHALL BE TYPICALLY 4'-6" SQUARE.

5/02 TYPICAL LINER PENETRATION DETAIL
NTS



NOTE: PIPE BOOT SHALL BE SHOP-MANUFACTURED OF 60 mil HDPE. THE APRON SHALL BE TYPICALLY 4'-6" SQUARE.

6/02 TYPICAL SUBMERGED LINER PENETRATION DETAIL
NTS



7/02 PERFORATED COLLECTION PIPE
NTS

Hanson Professional Services Inc.
1525 South Sixth Street
Springfield, Illinois 62703-2886
Phone: (217)788-2450 Fax: (217) 788-2503
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C-10212 GYPSUM STACK ACCEPTANCE PLANS
E-10850 SUBDRAINAGE POWER PLANS
E-10855 LEACHATE COLLECTION POWER PLANS

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
3	12-21-10	-	-	TCJ					RECORD DRAWINGS

SCALE –
LOC. NO. –
CLASS –

GENERAL NOTES & TYPICAL DETAILS
GYPSUM CELL G1
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY

SITE: COFFEEN

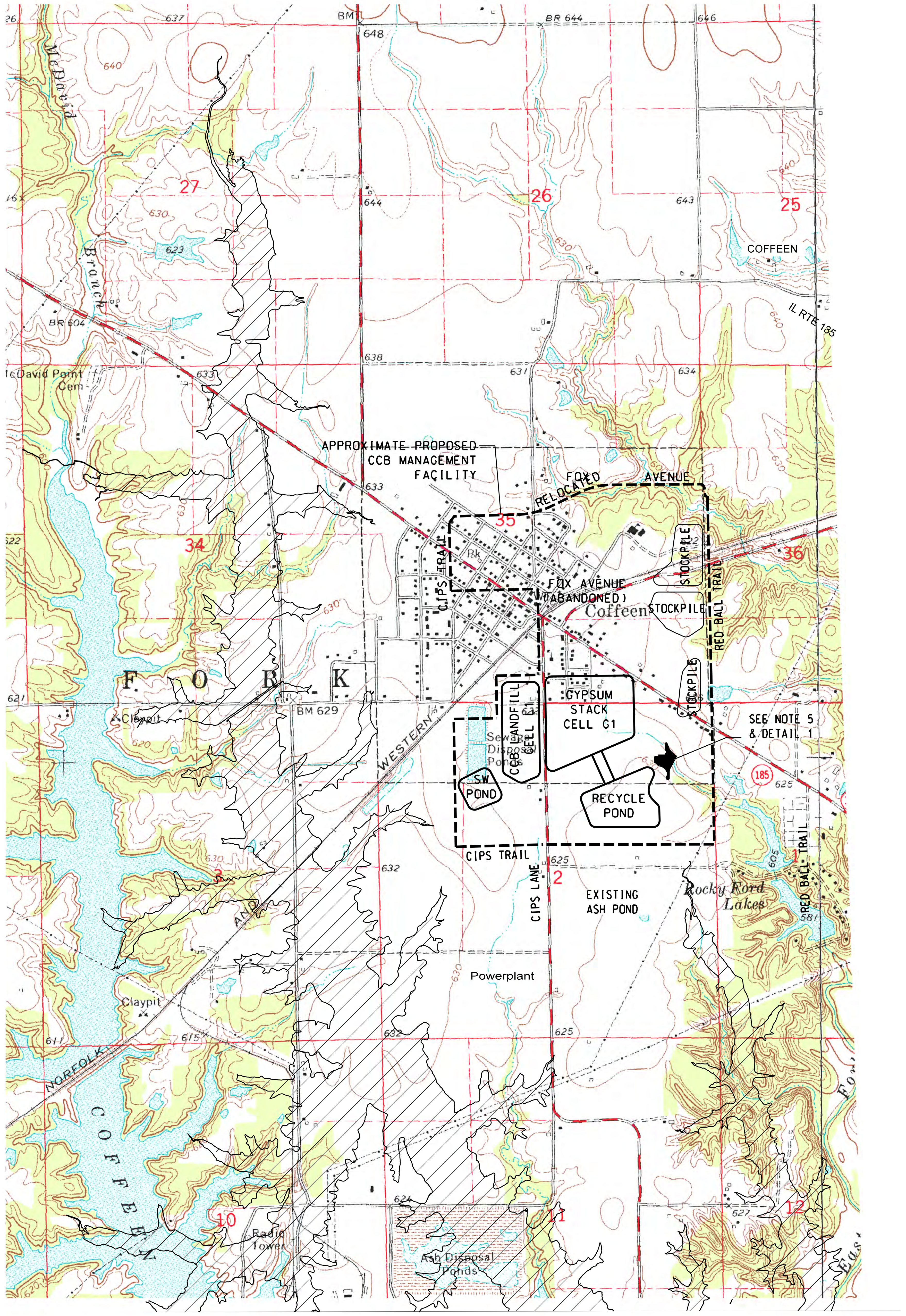
Ameren Energy Generating

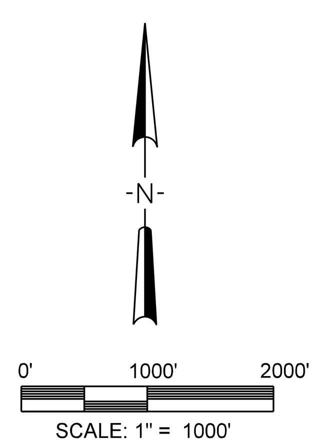
DRAWING NO. C-10206 | REV. 3
SHEET NO. 02

LAYOUT	SKB	02-27-08
DRAWN	SKB	02-27-08
REVIEWED	SMB	04-30-08

30x42

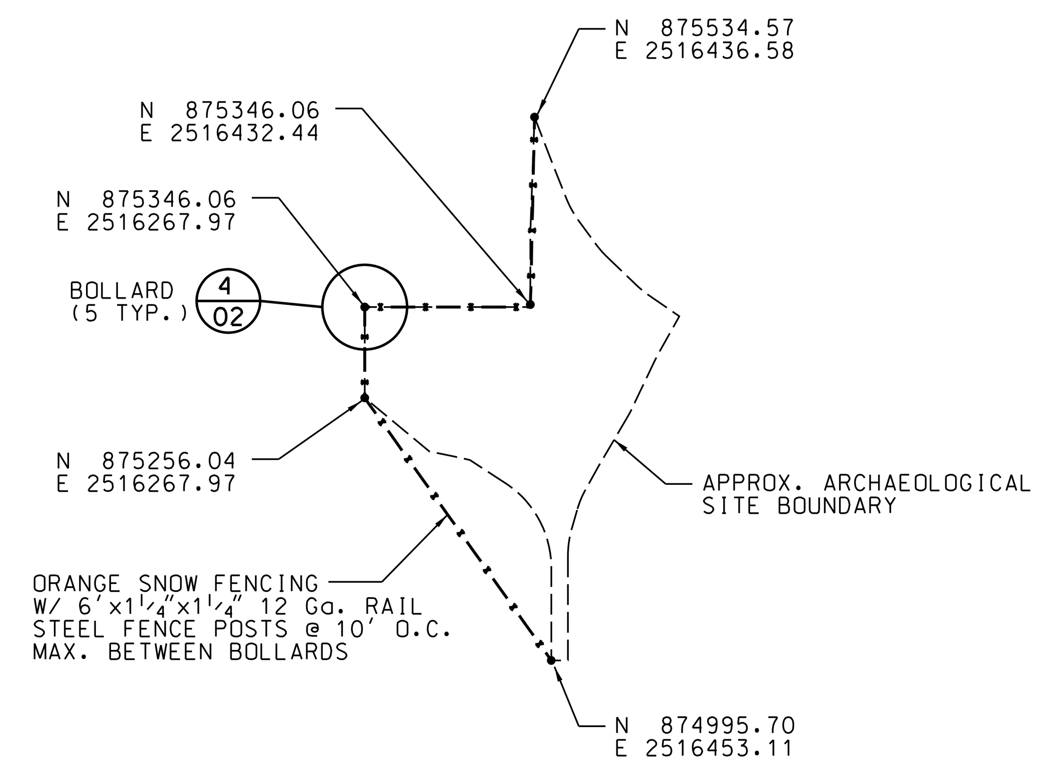
C-10206
SHEET NO. 03





NOTES:

1. ALL AREAS WITHIN THE FACILITY BOUNDARY WILL POTENTIALLY BE DISTURBED DURING THE LIFE OF THIS PROJECT.
2. BASE MAP IS A THE 1974 COFFEEN, IL USGS 7.5 MINUTE SERIES QUADRANGLE TOPOGRAPHIC MAP.
3. THE PROPOSED CCB MANAGEMENT FACILITY CONSISTS OF APPROXIMATELY 429 ACRES.
4. THE LOCATION OF THE 100-YEAR FLOODPLAIN WAS OBTAINED FROM THE FEMA FLOOD HAZARD BOUNDARY MAP FOR MONTGOMERY COUNTY, ILLINOIS, COMMUNITY PANEL NUMBER 1709920009A, DATED JANUARY 09, 1981.
5. IHPA APPROVED THE REMOVAL OF THE POTENTIALLY SIGNIFICANT ARCHAEOLOGICAL LOCATION FROM THE PROJECT BOUNDARIES FOR PROTECTION FROM DISTURBANCE. CONTRACTOR SHALL INSTALL BOLLARDS AT LOCATIONS INDICATED IN DETAIL 1 AND INSTALL SNOW FENCING AS SHOWN.



1/03 ARCHAEOLOGICAL SITE PROTECTION
NTS

LEGEND

(dashed box)	APPROXIMATE FACILITY BOUNDARY
(hatched box)	APPROXIMATE 100-YEAR FLOODPLAIN LIMITS

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DRAWING RECORD

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
2	12-21-10	–	–	TCJ			–		RECORD DRAWINGS

SCALE –
LOC. NO. –
CLASS –

SITE LOCATION MAP

CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY

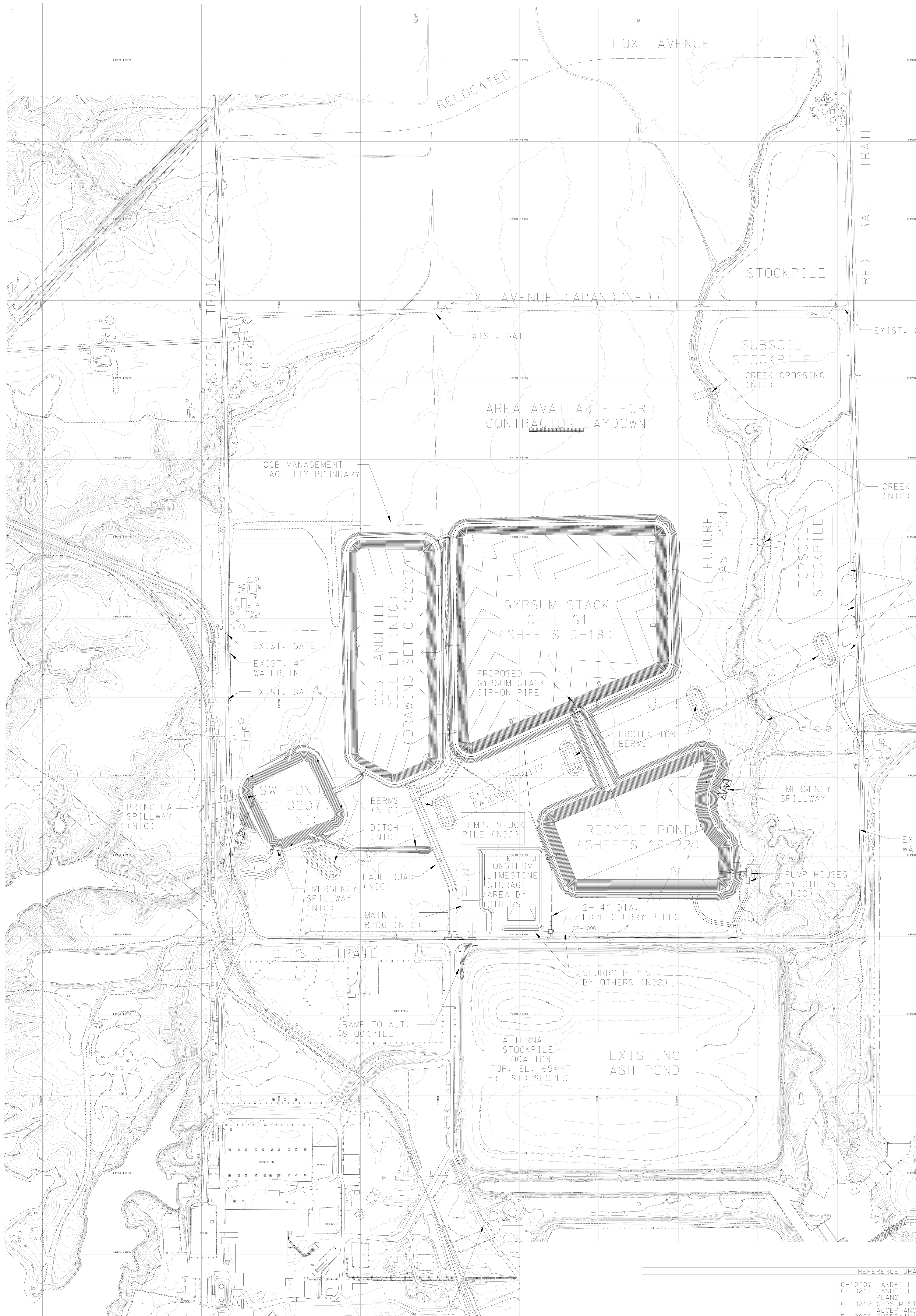
SITE: COFFEEN

Ameren Energy Generating

DRAWING NO.	REV.
C-10206	2

SHEET NO. 03

30x42



STANDARD LEGEND

(ALL SYMBOLS MAY NOT BE USED ON EACH PLAN)

- ORIGINAL CONTOURS
- FENCELINE
- TRANSMISSION TOWERS
- OVERHEAD ELECTRIC
- WATER MAIN
- TELEPHONE LINE
- LIMITS OF VEGETATION
- GRAVEL ROAD
- RAILROAD
- CP-1000 CONTROL POINT - HORIZ. & VERT.
- A ___ A' GEOLOGICAL CROSS SECTION LINE
- LANDFILL CONTOURS
- SB-55 BORING
- GXXX PREVIOUSLY INSTALLED GROUNDWATER MONITORING WELL
- GXXX GROUNDWATER MONITORING WELL
- MW13S WELLS - NOT PART OF MONITORING PLAN

NOTES:

1. SEE NOTES ON SHEET 2 REGARDING THE RESPONSIBILITY FOR EXISTING UTILITIES.
2. (NIC) INDICATES SITE FEATURES WHICH ARE NOT PART OF THIS CONTRACT. THEY ARE SHOWN FOR INFORMATIONAL PURPOSES ONLY.
3. HORIZONTAL AND VERTICAL CONTROL ARE BASED ON NAD 83, ILLINOIS STATE PLANE COORDINATE SYSTEM WEST ZONE, NAVD 88, US SURVEY FEET AND THE FOLLOWING PROJECT CONTROL POINTS WERE ESTABLISHED BY HANSON PROFESSIONAL SERVICES:

HORIZONTAL CONTROL

POINT	NORTHING	EASTING	ELEV.	DESCRIPTION
CP-1000	873998.37	2515334.17	620.81	#8 REBAR IN 6" DIA. CONCRETE MONUMENT
CP-1001	873985.17	2513180.64	621.96	#8 REBAR IN 6" DIA. CONCRETE MONUMENT
CP-1002	877937.14	2514533.34	623.15	#8 REBAR IN 6" DIA. CONCRETE MONUMENT
CP-1003	877949.62	2516989.49	622.10	#8 REBAR IN 6" DIA. CONCRETE MONUMENT

-N-

0' 300' 600'
SCALE: 1" = 300'

HANSON
Hanson Professional Services Inc.
1525 South Sixth Street
Springfield, Illinois 62703-2886
Phone: (217)788-2450 Fax: (217) 788-2503
Illinois Licensed Professional Service Corporation #184-001084

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C-10212 GYPSUM STACK ACCEPTANCE PLANS
E-10850 SUBDRAINAGE POWER PLANS
E-10855 LEACHATE COLLECTION POWER PLANS

DRAWING RECORD

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
3	12-21-10	-	-	TCJ			-		RECORD DRAWING

SCALE -
LOC. NO. -
CLASS -

PROPOSED SITE PLAN
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY
SITE: COFFEEN

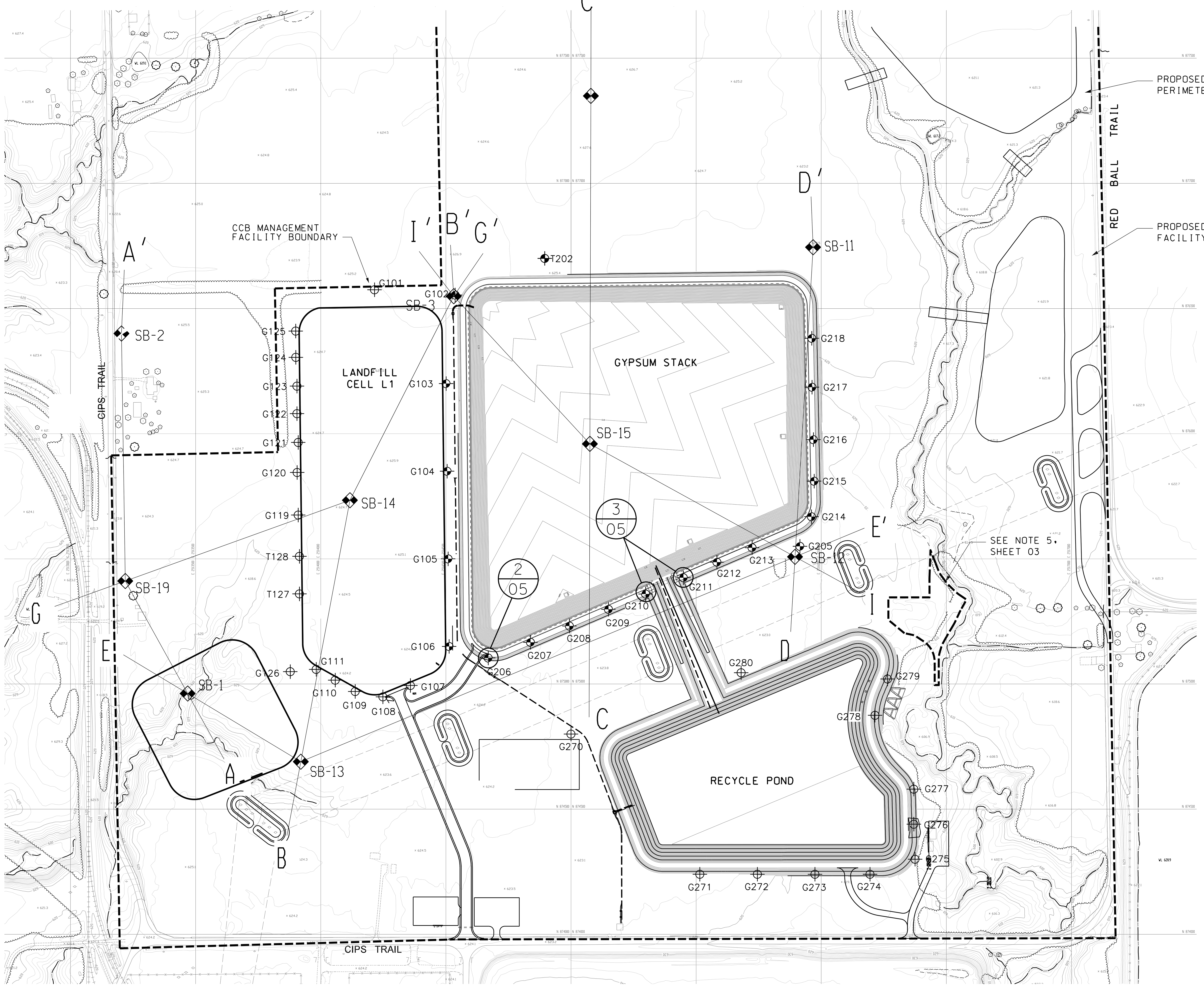
Ameren Energy Generating

DRAWING NO. C-10206 | REV. 3
SHEET NO. 04

C-10206 SHEET NO. 4

LAYOUT SKB 07-11-08
DRAWN SKB 02-28-08
REVIEWED SMB 04-30-09

30x42



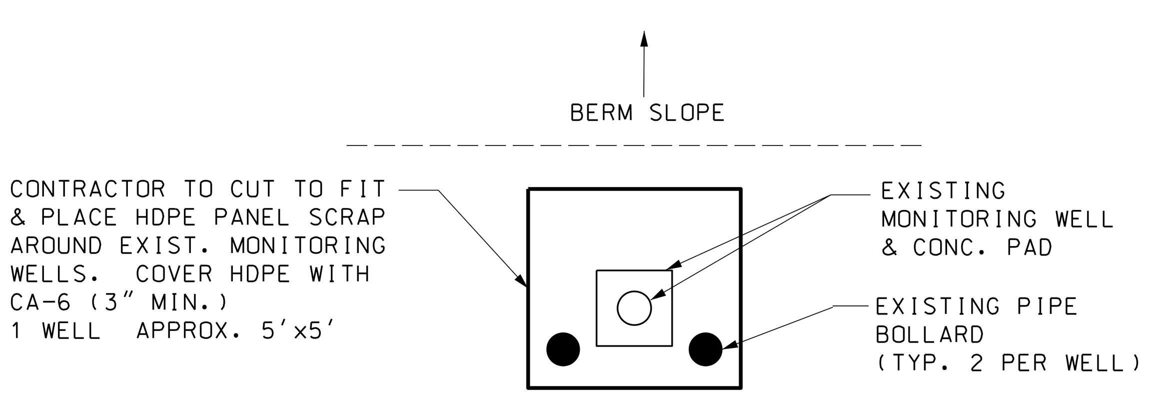
STANDARD LEGEND

(ALL SYMBOLS MAY NOT BE USED ON EACH PLAN)

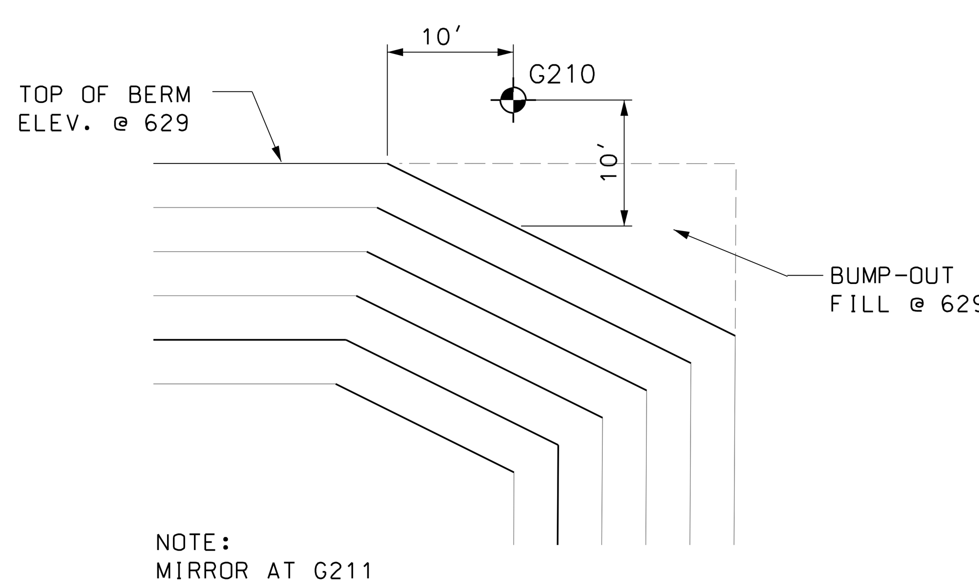
- 650 — ORIGINAL CONTOURS
- FENCELINE
- TRANSMISSION TOWERS
- OVERHEAD ELECTRIC
- WATER MAIN
- TELEPHONE LINE
- LIMITS OF VEGETATION
- GRAVEL ROAD
- RAILROAD
- CP-1000 — CONTROL POINT - HORIZ. & VERT.
- A — A' — GEOLOGICAL CROSS SECTION LINE
- 650 — LANDFILL CONTOURS
- SB-55 — BORING
- GXXX — GYPSUM STACK GROUNDWATER MONITORING WELL
- GXXX — OTHER MONITORING WELL

NOTES:

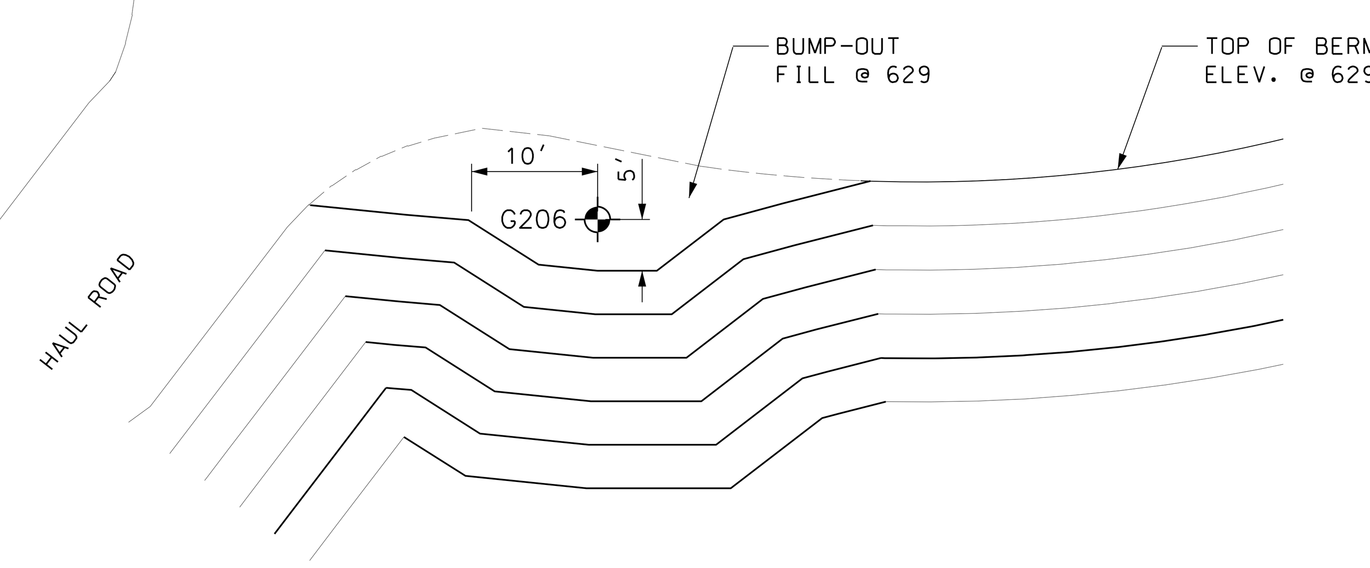
1. CONTOURS SHOWN IN GYPSUM STACK ARE TOP OF CLAY LINER. (NOTE: THE UPPER PORTION OF THE PROCESS WATER RECOVERY SYSTEM LINER WAS ELIMINATED AS PART OF THE CLEAN CLOSURE REVISION) 7
2. THE PROPERTY IS LOCATED IN SECTIONS 10 & 11, TOWNSHIP 7 NORTH, RANGE 3 WEST, 3RD P.M., MONTGOMERY COUNTY, ILLINOIS
3. THE DESIGN ELEMENTS INCLUDED IN THESE DRAWINGS WERE BASED UPON EXISTING AERIAL MAPPING AS OBTAINED FROM AMEREN.
4. ALL DISTURBED AREAS, INCLUDING THE CREST AND EXTERIOR FACE OF BOTH DAMS WILL BE SEEDED AND MULCHED WITH IDOT CLASS 1A SEED MIXTURE.
5. FILL MATERIAL FOR DAM EMBANKMENT WILL BE PLACED IN MAXIMUM UNCOMPACTED LIFTS OF 9-INCHES AND COMPACTED TO 95% OF THE STANDARD PROCTOR DENSITY.
6. SURFICIAL CONTOURS WERE DEVELOPED USING AERIAL PHOTOGRAMMETRIC METHODS WITH PHOTOGRAPHS TAKEN BY SURDEX.
7. CURRENT SURFACE TOPOGRAPHY MAY DIFFER FROM THAT SHOWN DUE TO ON GOING OPERATIONS AT THE SITE.
8. FOR CLARITY, NOT ALL EXISTING SITE FEATURES ARE SHOWN ON THIS DRAWING.



1/05 WEED CONTROL AT EXIST. SINGLE MONITORING WELLS



3/05 MONITORING WELL BUMP-OUT NEAR TRANSFER CHANNEL



2/05 MONITORING WELL BUMP-OUT AT HAUL ROAD

-N-

0' 200' 400'

SCALE: 1" = 200'

HANSON

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REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
7	12-22-10	-	-	TCJ			-		RECORD DRAWINGS

SCALE: —
LOC. NO.: —
CLASS: —

GROUNDWATER MONITORING & BORING PLAN
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY

SITE: COFFEEN

Ameren Energy Generating

DRAWING NO. C-10206 — REV. 7

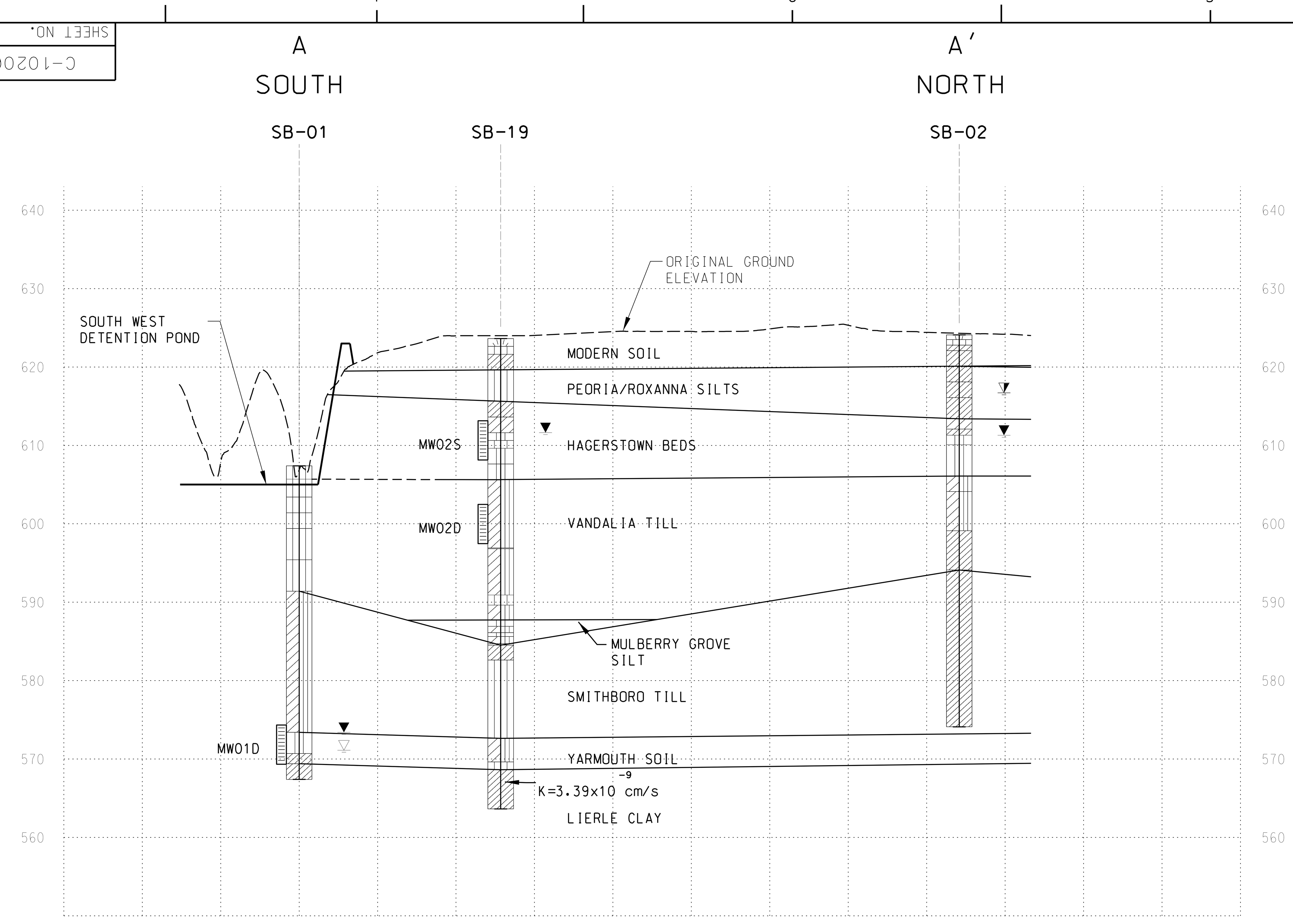
SHEET NO. 05

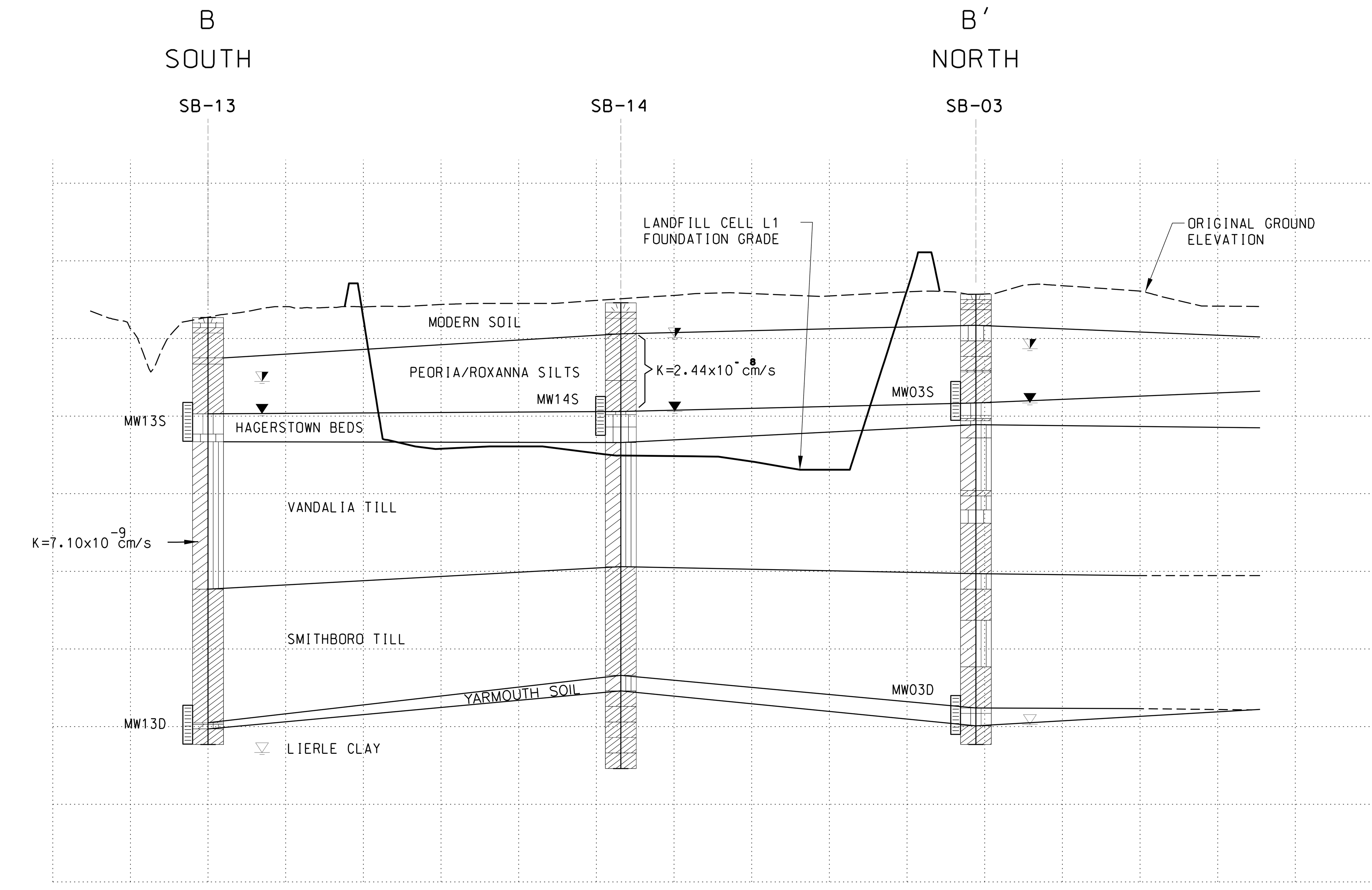
C-10206 SHEET NO. 5

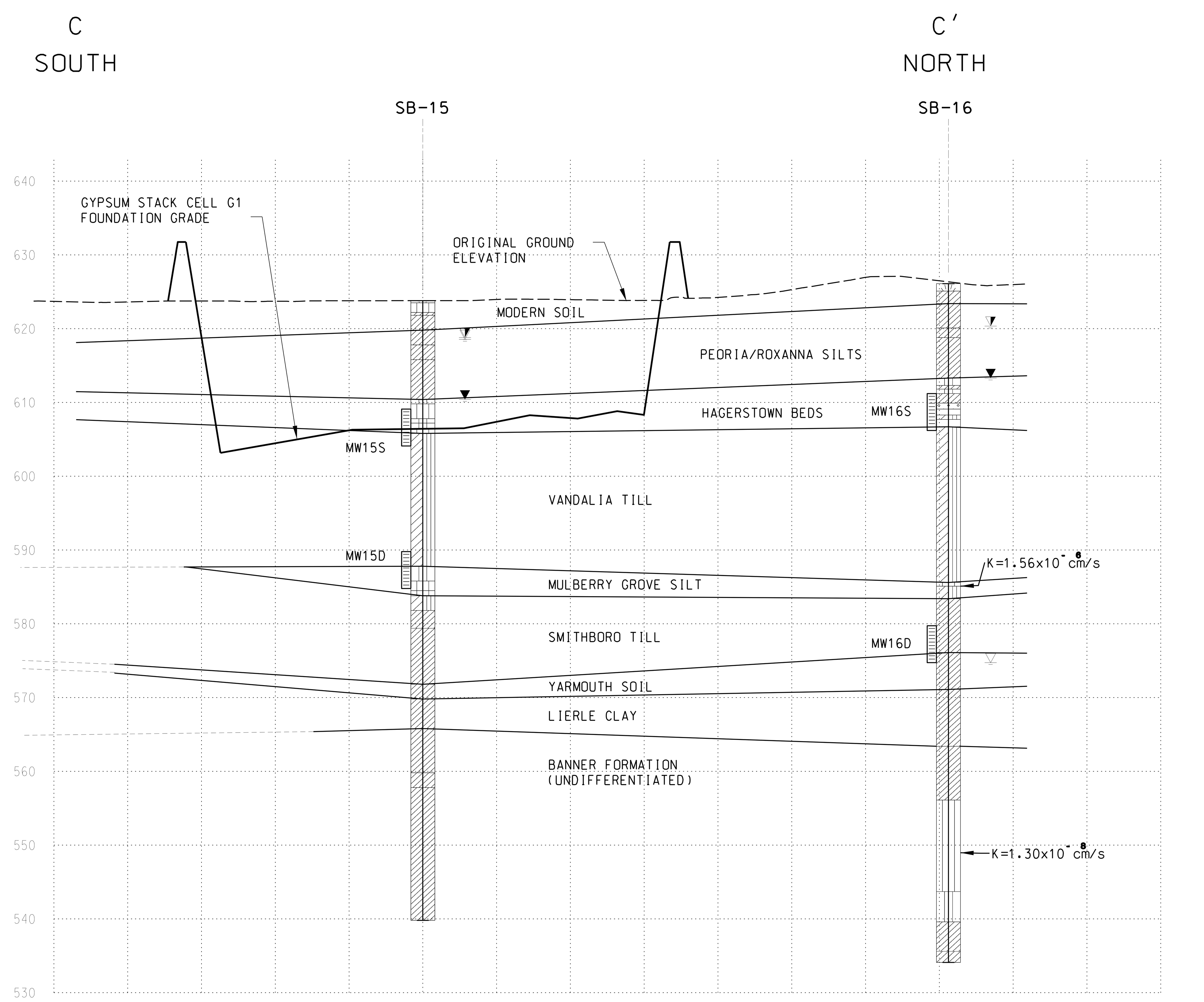
LAYOUT	SKB	02-28-08
DRAWN	SKB	12-09-10
REVIEWED	RMW	12-09-10

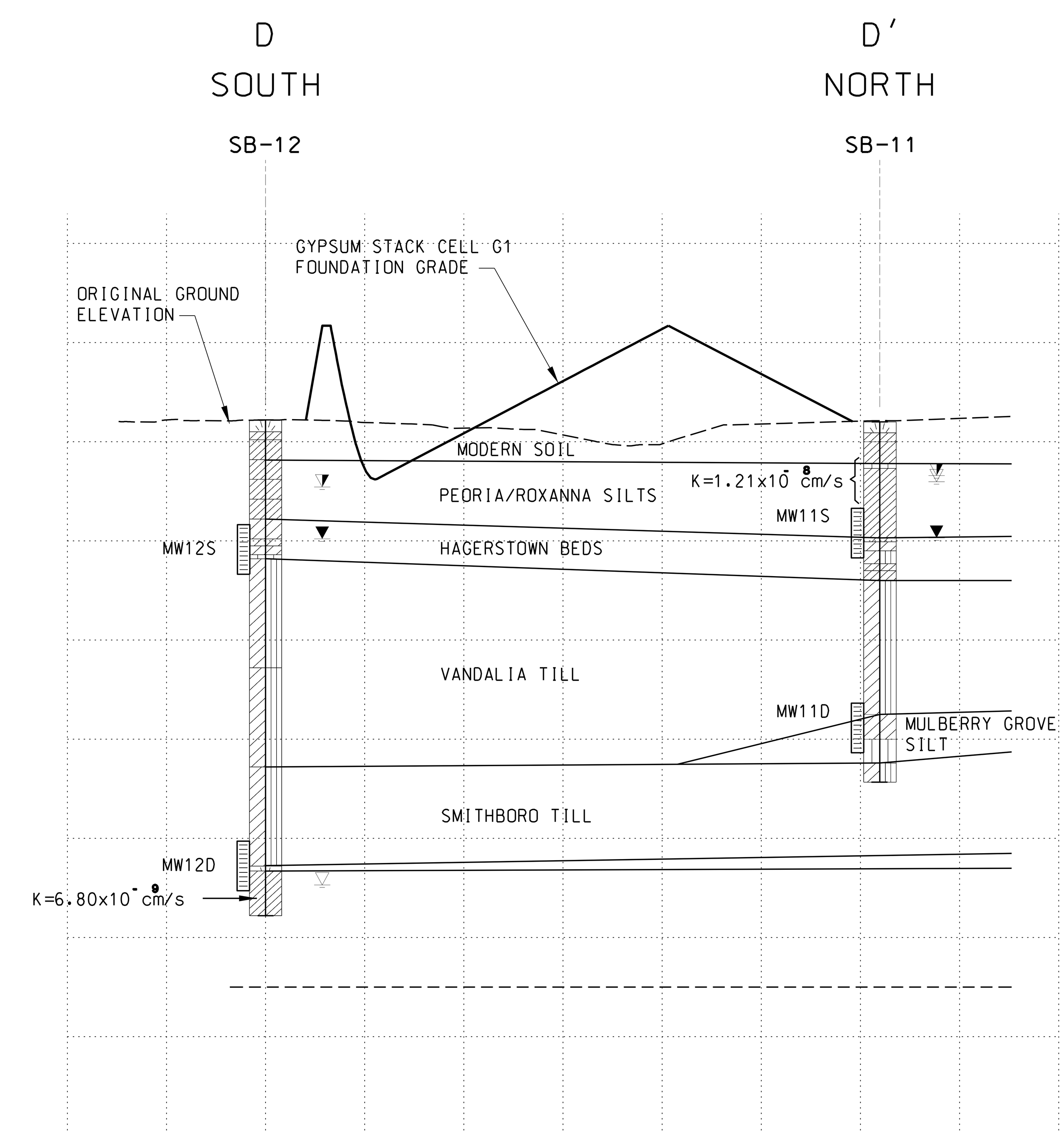
30x42

SHEET NO. 6
C-10206









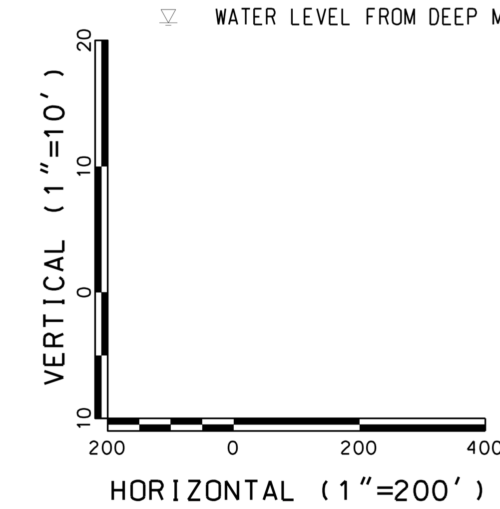
GENERAL NOTES

1. GROUNDWATER ELEVATIONS WERE MEASURED JUNE 1, 2006.
2. ALL NESTED GROUNDWATER MONITORING WELLS AND PIEZOMETERS ARE CONSTRUCTED IN SEPARATE BORINGS. NESTS DEPICTED AT A SINGLE LOCATION FOR CONVENIENCE AND CLARITY.
3. GEOLOGIC FORMATIONS ARE INTERPOLATED BETWEEN BORING LOCATIONS.
4. LITHOLOGIC INTERPRETATIONS ARE GENERALIZED. DETAILED DESCRIPTIONS ARE INCLUDED ON THE FIELD BORING LOGS.

EXPLANATION

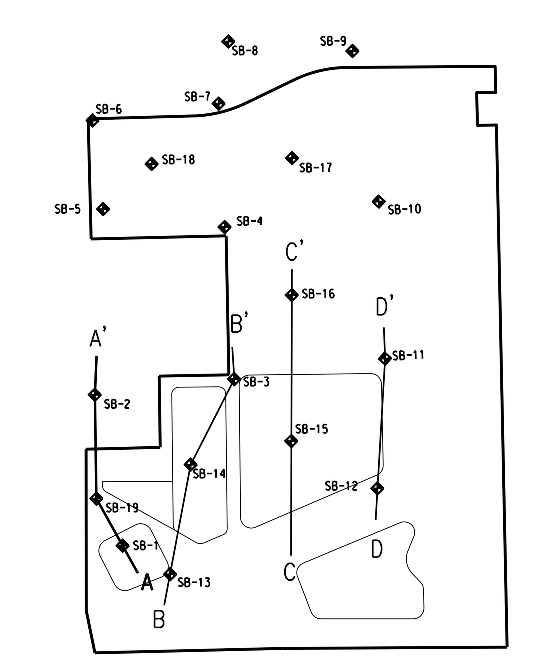
- USCS LOW PLASTICITY ORGANIC SILT OR CLAY
- USCS LOW PLASTICITY CLAY
- USCS SILT
- USCS POORLY-GRADED SAND
- USCS SILTY SAND
- USCS WELL-GRADED SAND
- USCS LOW PLASTICITY SANDY CLAY
- USCS LOW PLASTICITY SILTY CLAY
- USCS SANDY SILT
- SANDSTONE
- SHALE

- ▼ WATER LEVEL ENCOUNTERED DURING DRILLING
- WATER LEVEL FROM SHALLOW MONITORING WELL
- WATER LEVEL FROM DEEP MONITORING WELL



VERTICAL ENHANCEMENT =20x

SCALES



CROSS SECTION LOCATION MAP

NOTE:
FOR THIS PROJECT - ONLY THE GEOLOGICAL CROSS SECTIONS ASSOCIATED WITH THE SOUTH PORTION OF THE FACILITY ARE SHOWN.

HANSON

NOTICE OF LIMITED RESPONSIBILITY

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REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRFTR	CHK'D	SUPV	ENGR APPROVAL AMEREN	OTHER	DESCRIPTION
2	12-22-10	-	-	TCJ			-		RECORD DRAWINGS

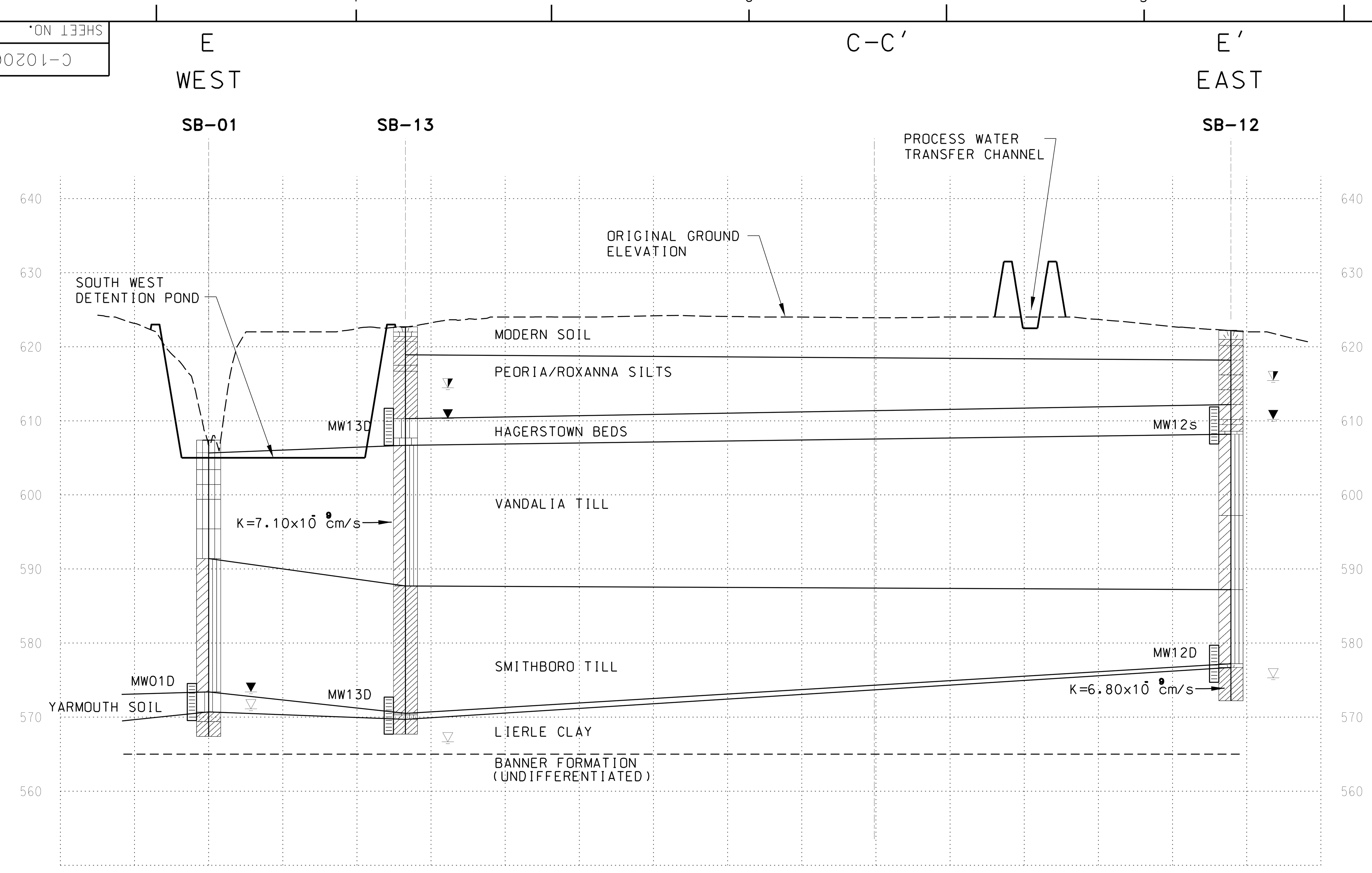
GEOLOGICAL CROSS SECTIONS
A, B, C & D
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY
SITE: COFFEEN

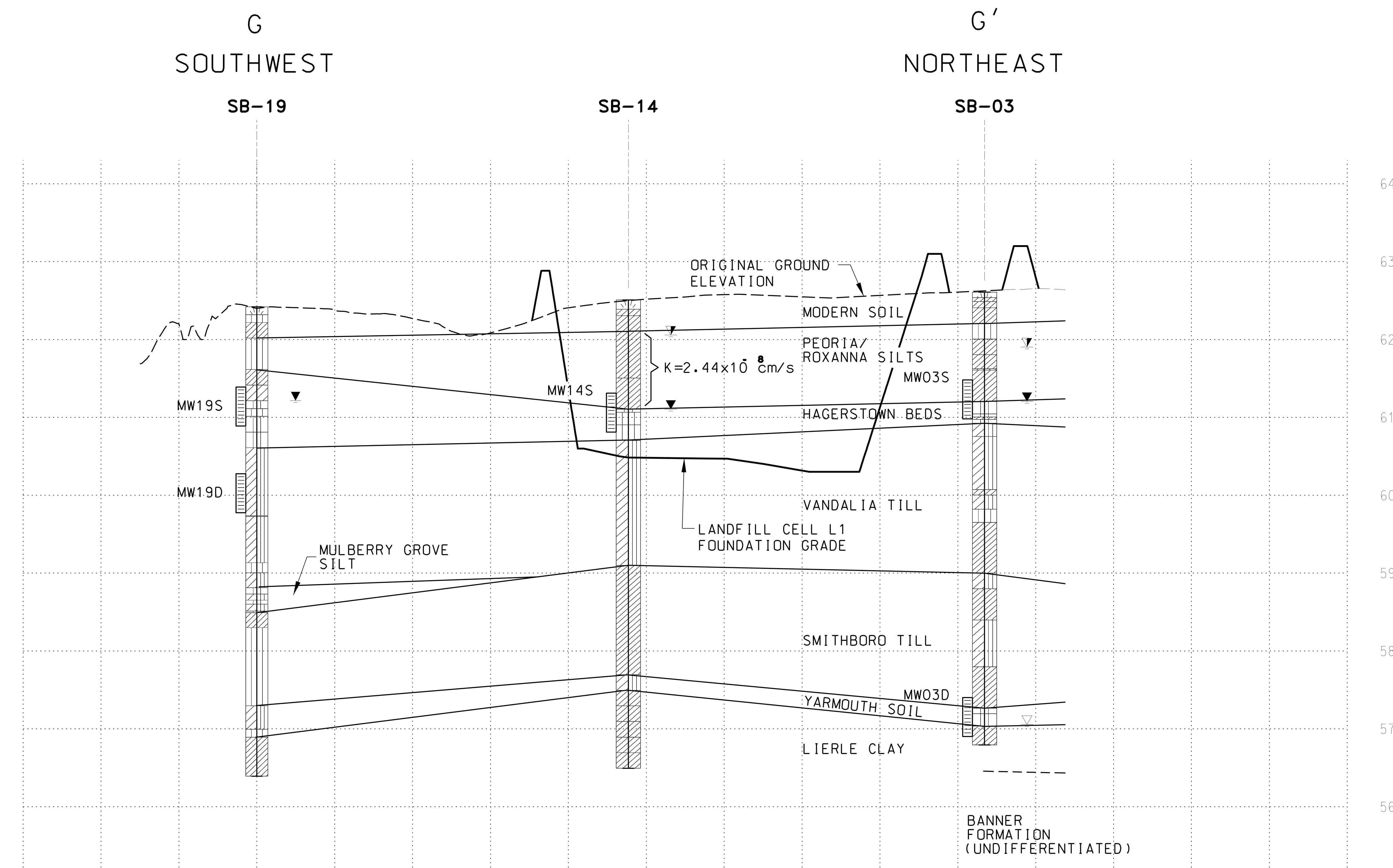
Ameren Energy Generating

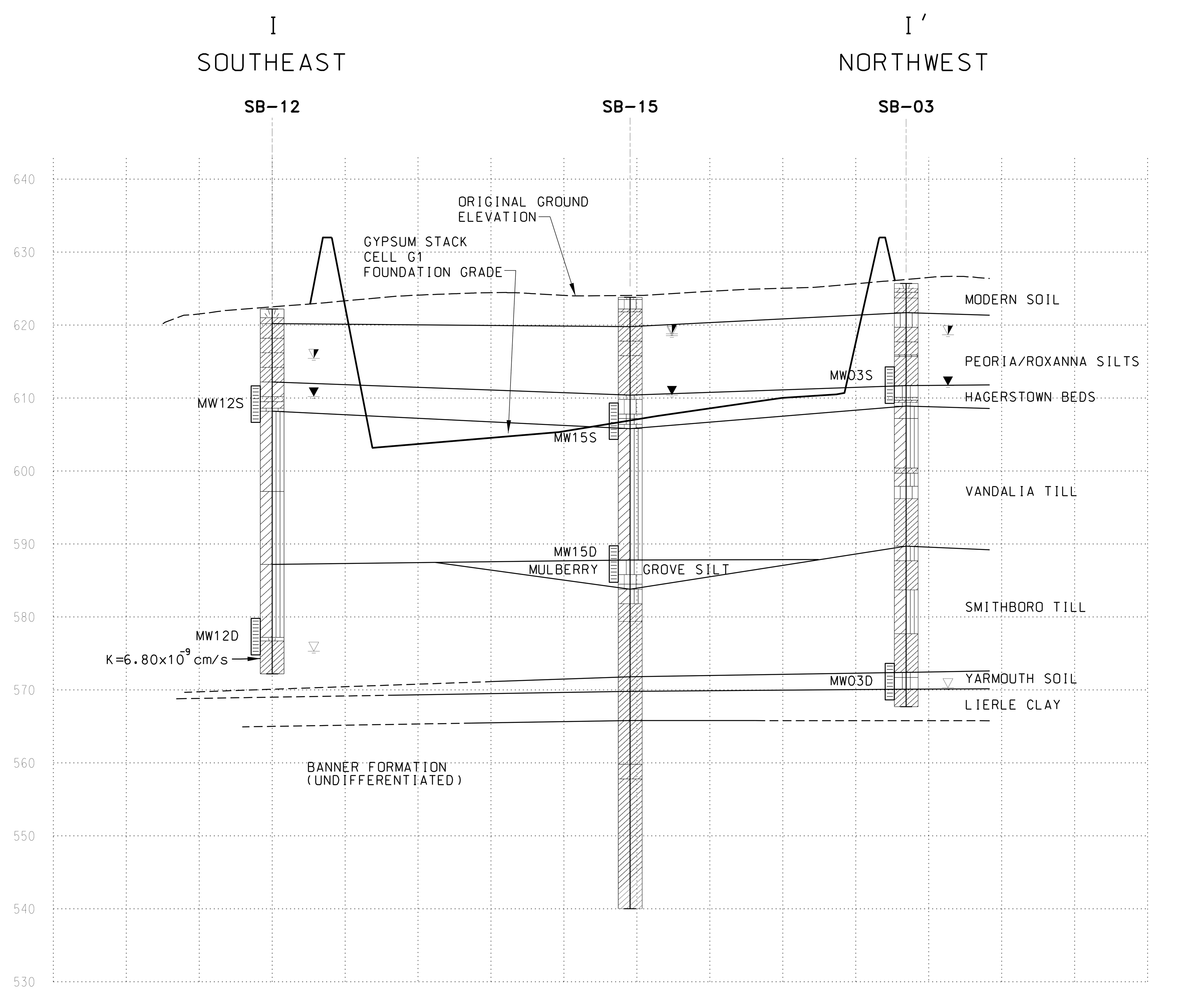
DRAWING NO. C-10206 REV. 2
SHEET NO. 06

LAYOUT SKB 02-28-08
DRAWN SKB 02-28-08
REVIEWED

30x42







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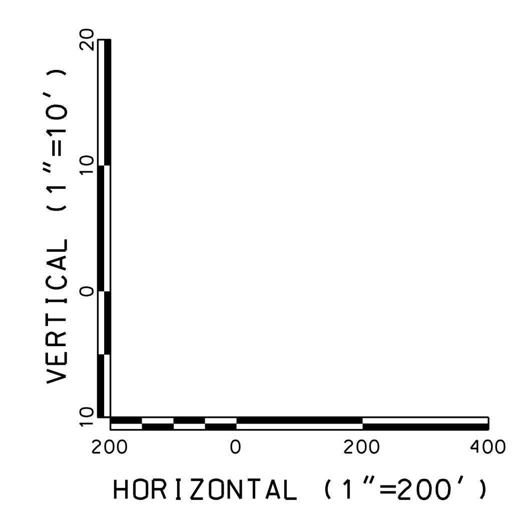
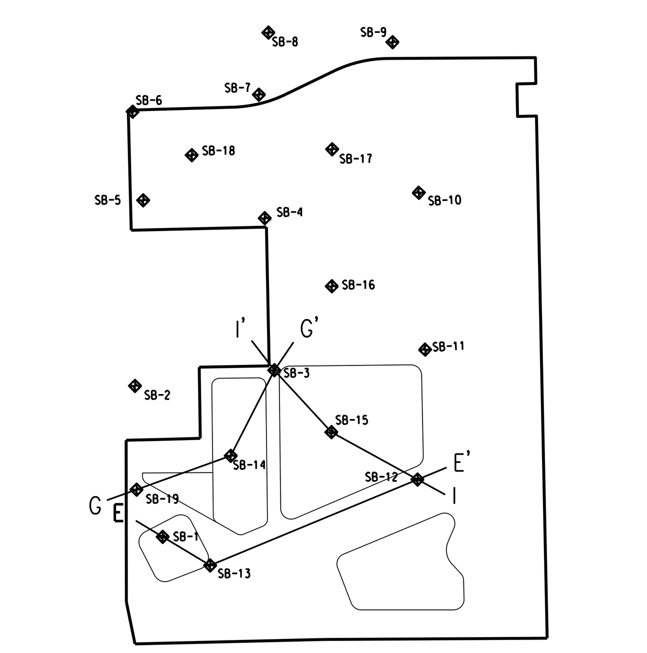
▼ WATER LEVEL ENCOUNTERED DURING DRILLING
WATER LEVEL FROM SHALLOW MONITORING WELL
▽ WATER LEVEL FROM DEEP MONITORING WELL



VERTICAL ENHANCEMENT =20x

SCALES



CROSS SECTION LOCATION MAP

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DRAWING RECORD

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
2	12-22-10			TCJ					RECORD DRAWINGS

SCALE: –
LOC. NO.: –
CLASS: –

GEOLOGICAL CROSS SECTIONS
E, G & I
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY

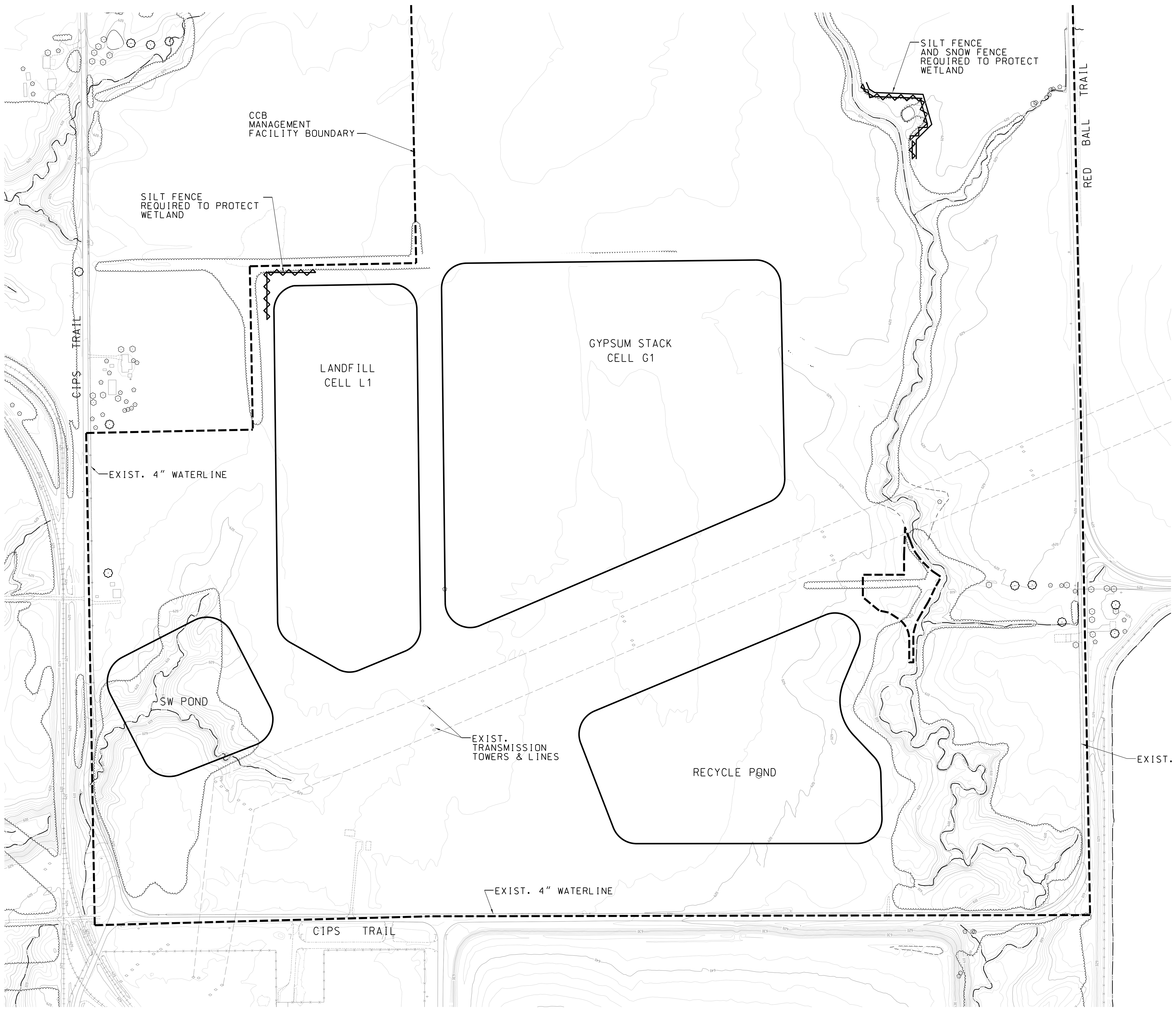
SITE: COFFEEN

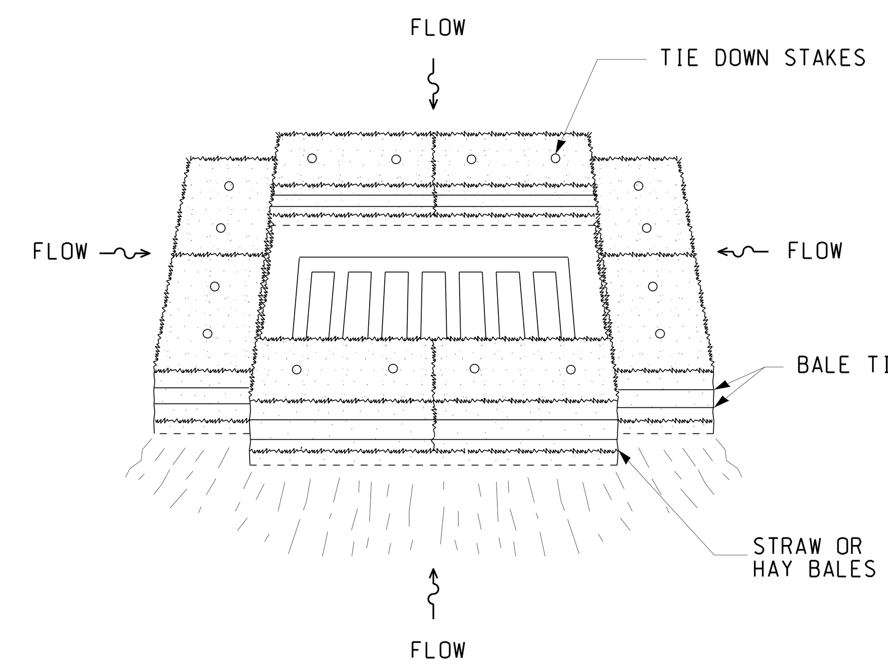
Ameren Energy Generating

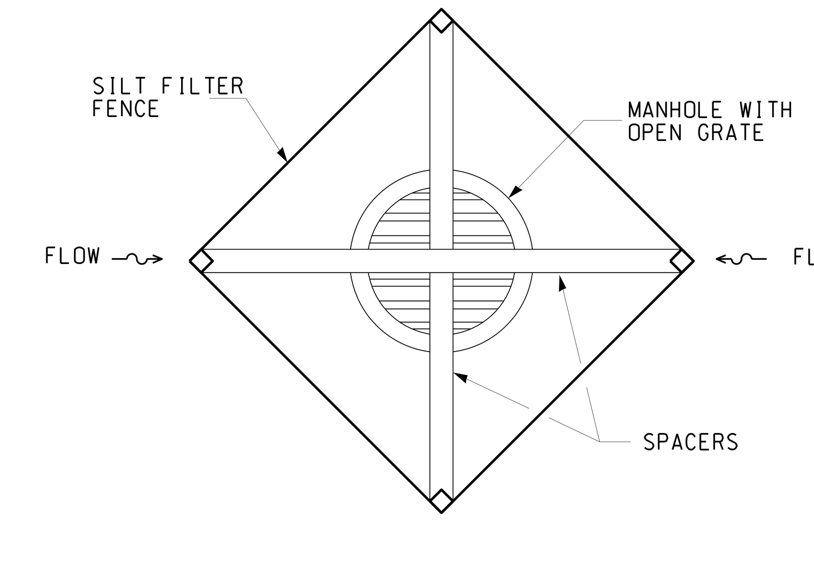
DRAWING NO.: C-10206
REV.: 2
SHEET NO. 07

LAYOUT	SKB	02-28-08
DRAWN	SKB	02-28-08
REVIEWED		

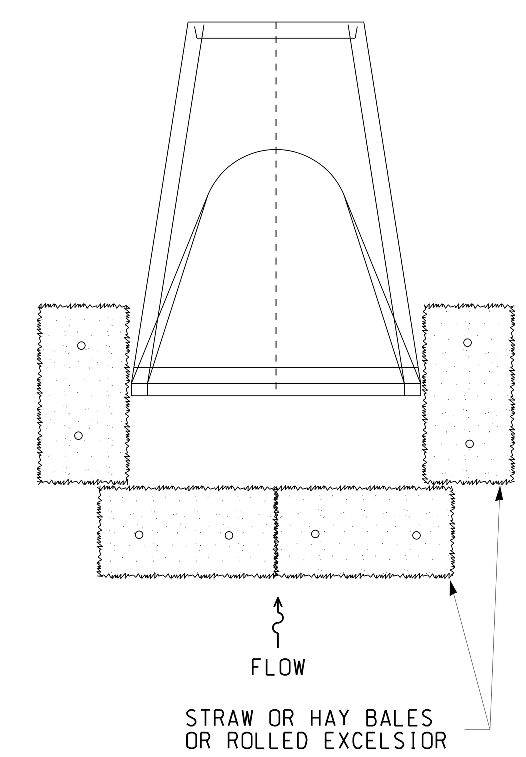
30x42



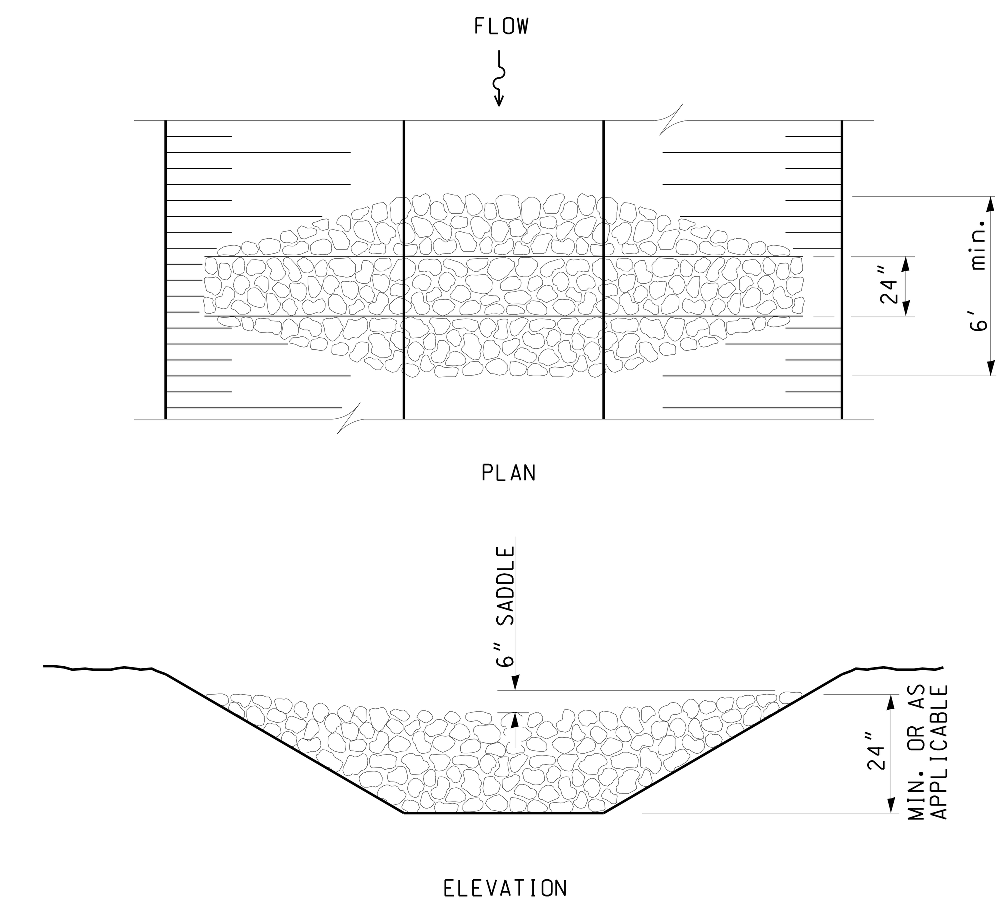




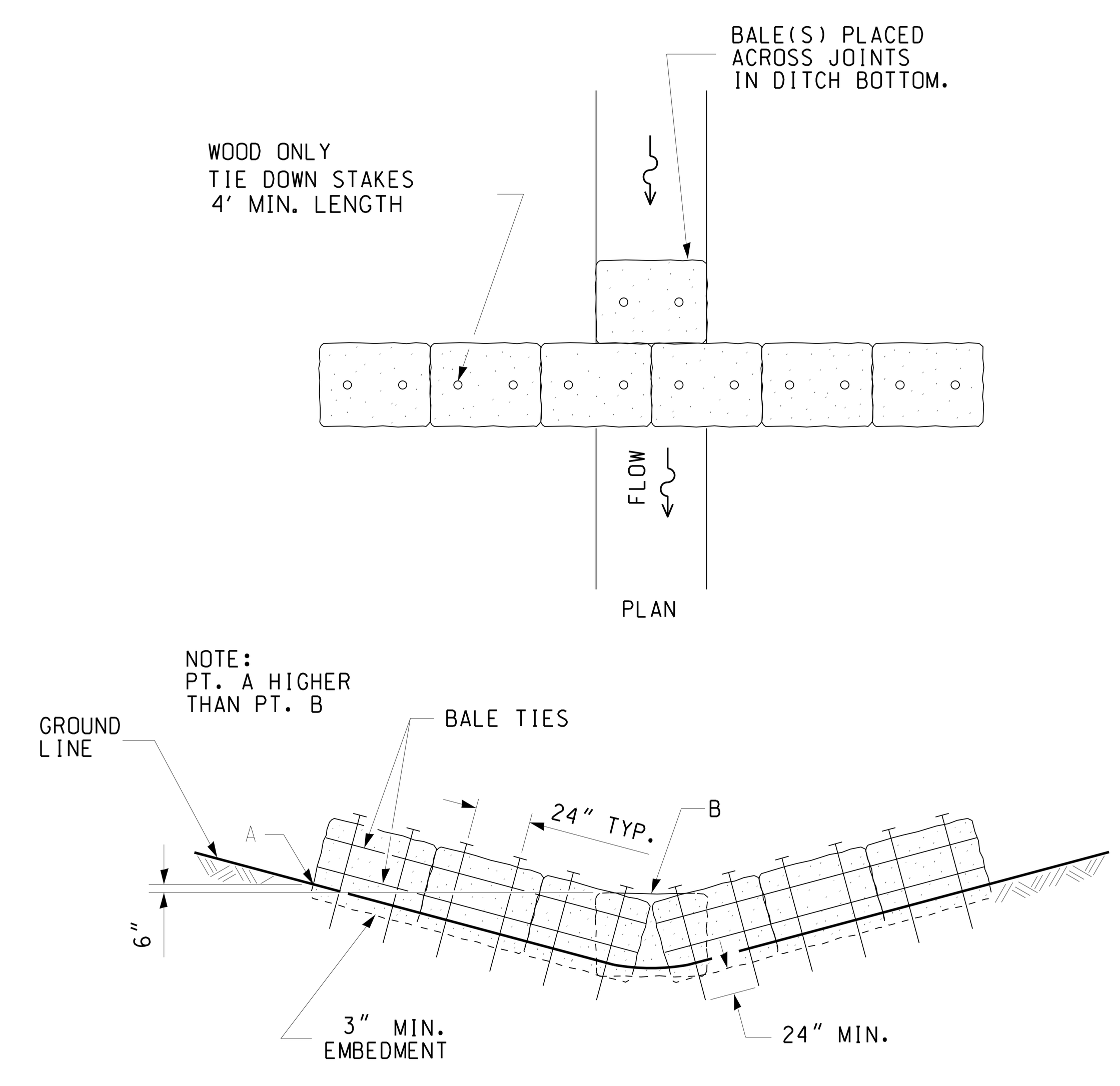
INLET PROTECTION



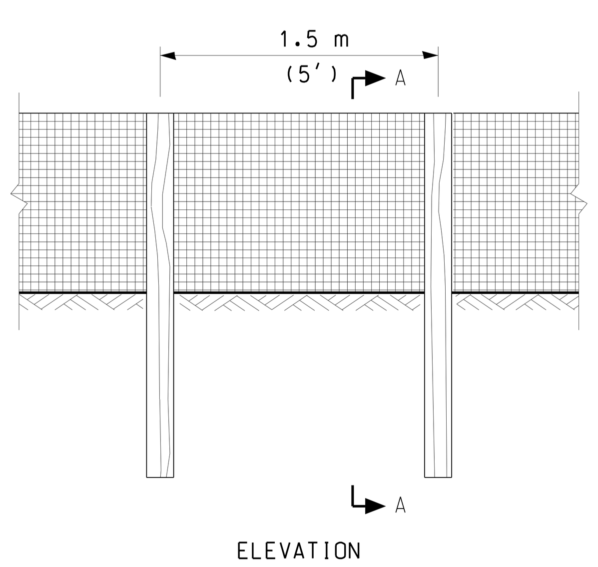
INLET PROTECTION

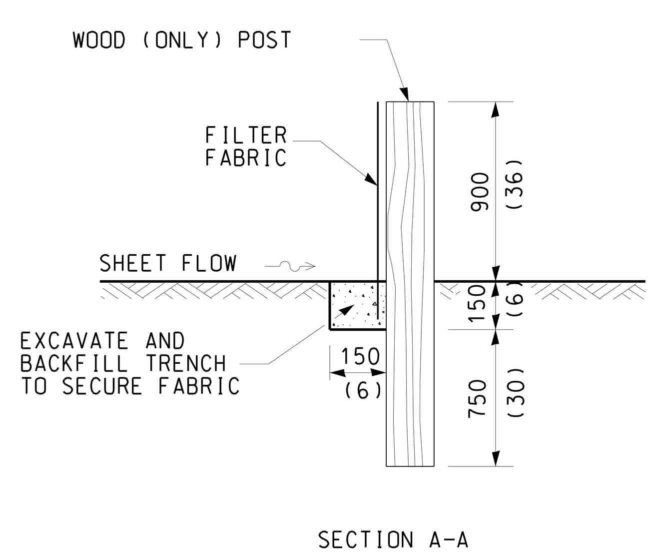


AGGREGATE DITCH CHECK



ROLLED EXCELSIOR OR STRAW BALES FOR DITCH CHECK





SILT FILTER FENCE AS A PERIMETER EROSION BARRIER

GENERAL NOTES

1. SEE OTHER PLAN SHEETS FOR STANDARD LEGEND.
2. SEE NOTES ON SHEET 2 REGARDING THE RESPONSIBILITY FOR EXISTING UTILITIES.
3. THE CONTRACTOR IS RESPONSIBLE FOR IMPLEMENTING EROSION CONTROL MEASURES BASED ON FIELD JUDGEMENT TO COMPLY WITH THE NPDES GENERAL STORM WATER PERMIT. INCLUDING ANY ADDITIONAL MEASURES NOT LISTED ON THE DRAWING.
4. EROSION CONTROL MEASURES SHALL BE LEFT IN PLACE BY CONTRACTOR & MAINTAINED BY FUTURE OPERATIONS CONTRACTOR.

SILT FENCE

SILT FENCE WITH ORANGE SNOW FENCING

-N-

0' 200' 400'

SCALE: 1" = 200'

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REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
2	12-22-10			TCJ					RECORD DRAWINGS

SCALE

LOC. NO.

CLASS

EROSION CONTROL PLAN & DETAILS

CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY

SITE: COFFEEN

Ameren Energy Generating

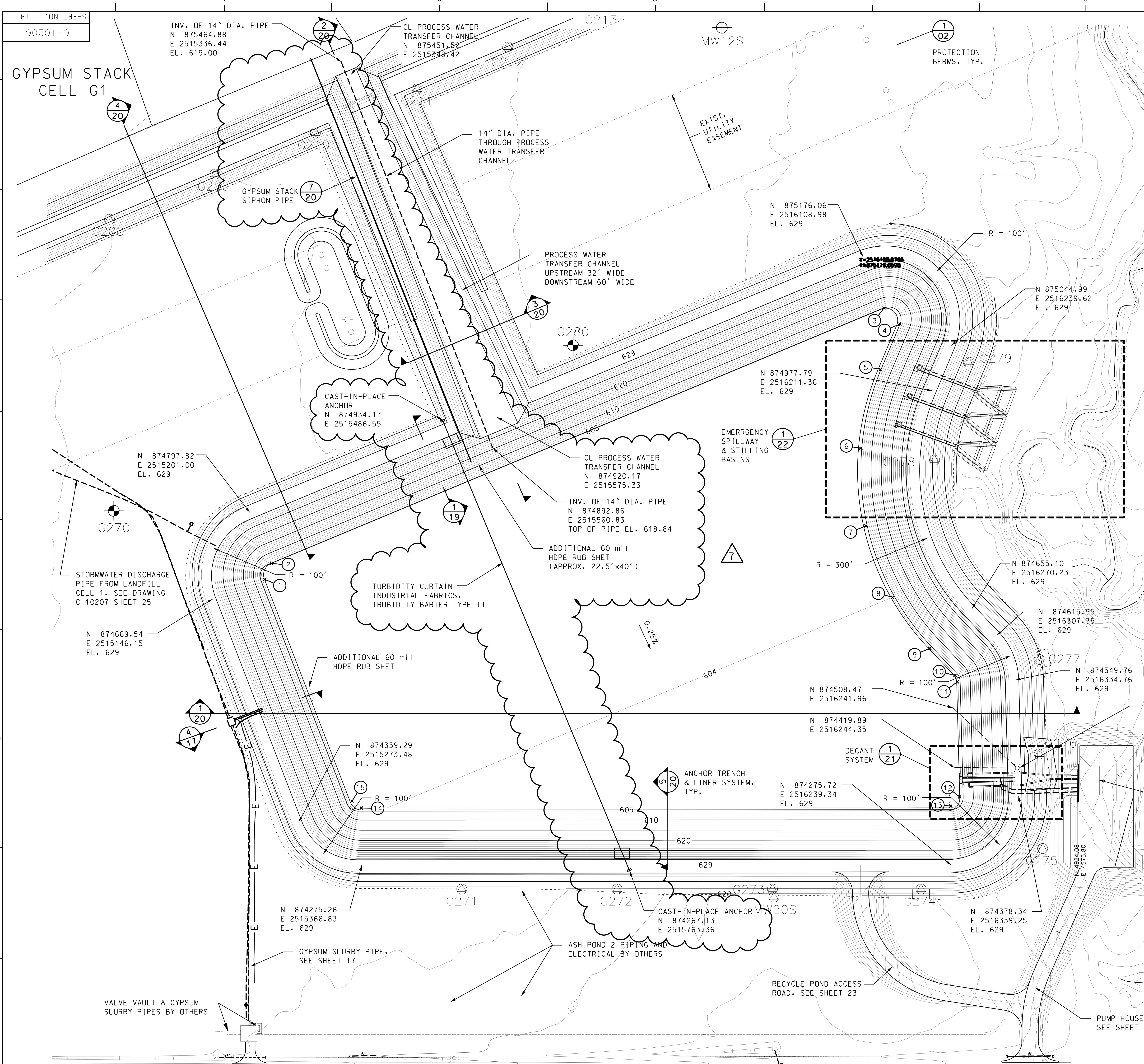
DRAWING NO. C-10206 REV. 2

SHEET NO. 08

SHEET NO. C-10206

30x42

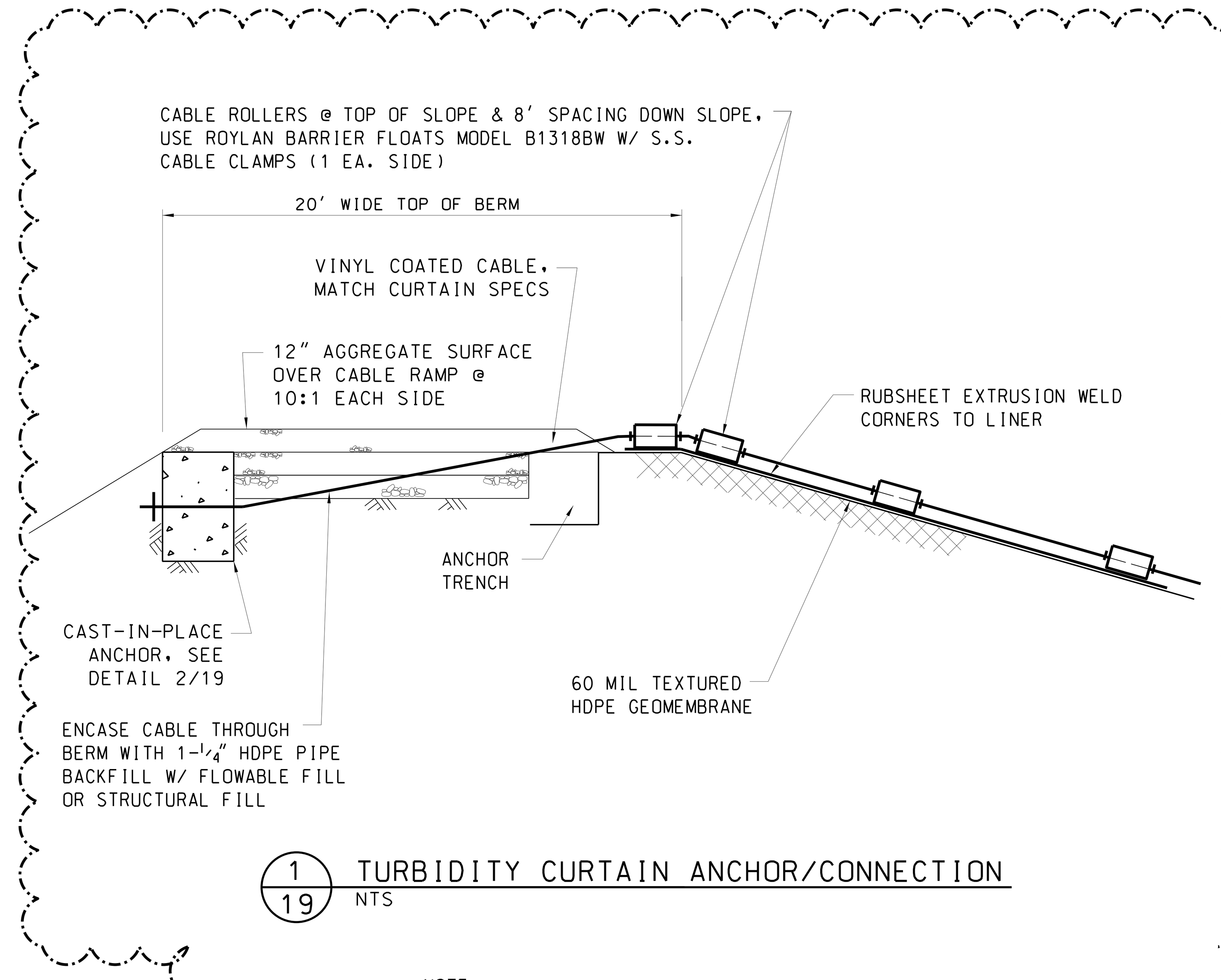
C-10206 SHEET NO. 19



-N-

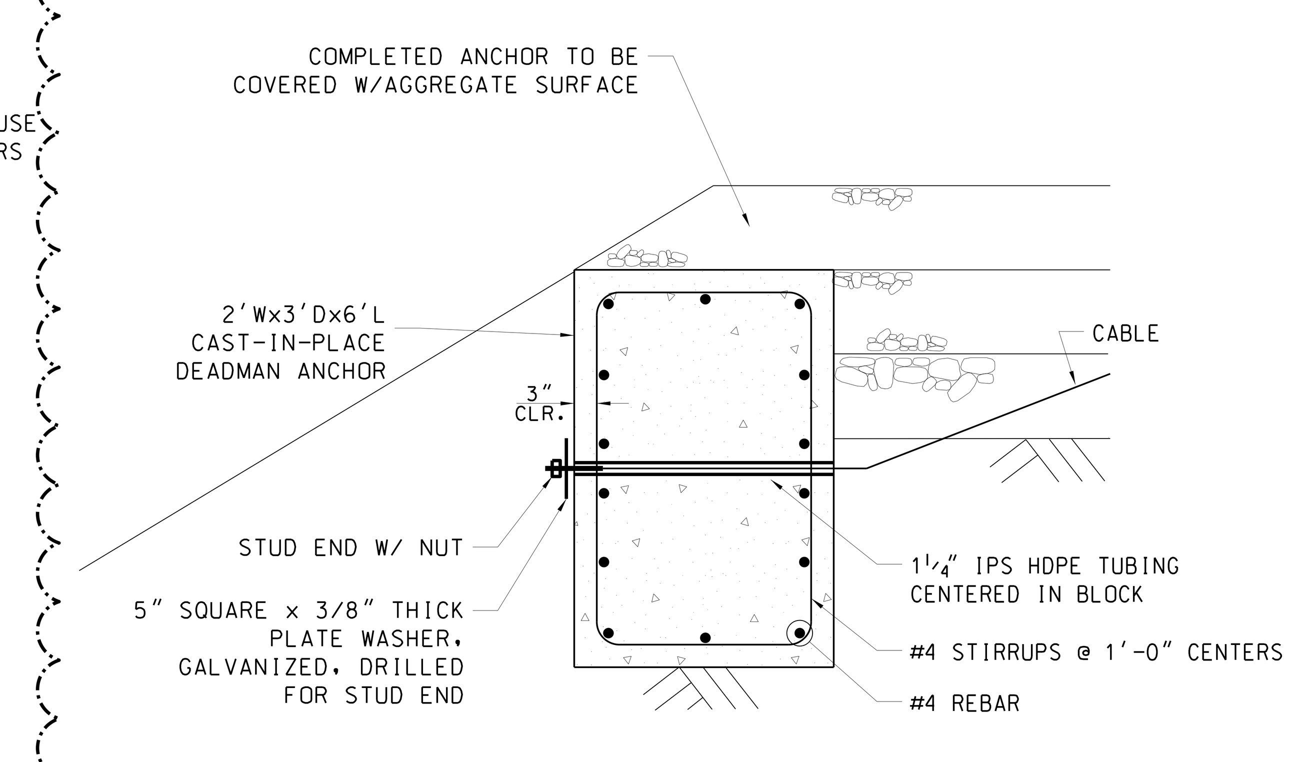
SCALE: 1" = 60'

RECYCLE POND - INTERIOR TOE			
POINT	N	E	ELEV.
1	874706.97	2515227.14	605.24
2	874723.70	2515241.70	605.02
3	875095.89	2516132.29	605.05
4	875069.26	2516159.88	604.92
5	875005.90	2516132.91	604.95
6	874909.29	2516107.54	604.91
7	874811.81	2516106.37	604.65
8	874717.55	2516129.35	604.25
9	874633.41	2516175.61	604.17
10	874555.24	2516246.12	604.22
11	874549.81	2516248.01	604.07
12	874377.99	2516248.77	602.44
13	874365.11	2516237.06	604.00
14	874359.95	2515366.65	604.25
15	874372.65	2515351.72	604.49



1/19 TURBIDITY CURTAIN ANCHOR/CONNECTION
NTS

NOTE:
ALL CABLE CONNECTIONS SHALL BE 316 S.S. WITH A STRENGTH RATING GREATER THAN CABLE.



2/19 CAST-IN-PLACE ANCHOR
NTS

HANSON
Hanson Professional Services Inc. 1525 South Sixth Street Springfield, Illinois 62703-2886
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REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRFTR	CHK'D	SUPV	AMEREN	OTHER	DESCRIPTION
0	04-30-08	-	-	SKB	DBH	JAD	-	SMB	ISSUED FOR BIDDING - NOT FOR CONSTRUCTION
1	07-11-08			SKB	DBH			SMB	ISSUED FOR CONSTRUCTION - HANSON PROFESSIONAL SERVICES
2	07-29-08			DBH	SKB			DBH	CLARIFY GEOMETRY OF RECYCLE POND BERM ALIGNMENT
3	04-03-09			SKB	DBH			DBH	REVISED POND BOTTOM ELEVATION
4	07-15-09			SKB	DBH			DBH	REMOVED PROCESS WATER CONTROL STRUCTURE FROM CONTRACT
5	07-23-09			SKB	DBH			DBH	ADDED 14" DIA. PIPE THROUGH TRANSFER CHANNEL
6	02-26-10			SKB	SMA				RECORD DRAWING CURRENT AS OF 02-26-10
7	01-03-11			SKB	WMR				RECORD DRAWING PER MWR MARKUPS

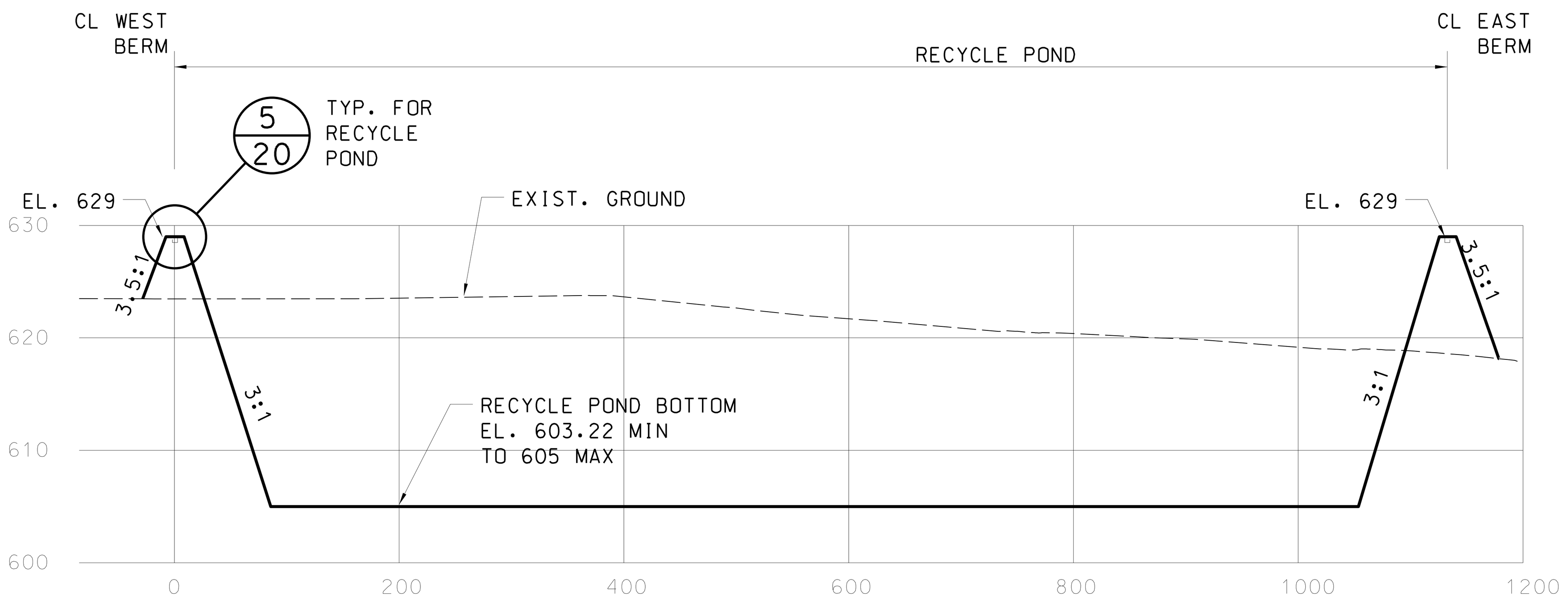
SCALE
LOC. NO.
CLASS

RECYCLE POND PLAN & CONTROL DATA
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY
SITE: COFFEEN
AmerenEnergy Generating
DRAWING NO. C-10206 REV. 7
SHEET NO. 19

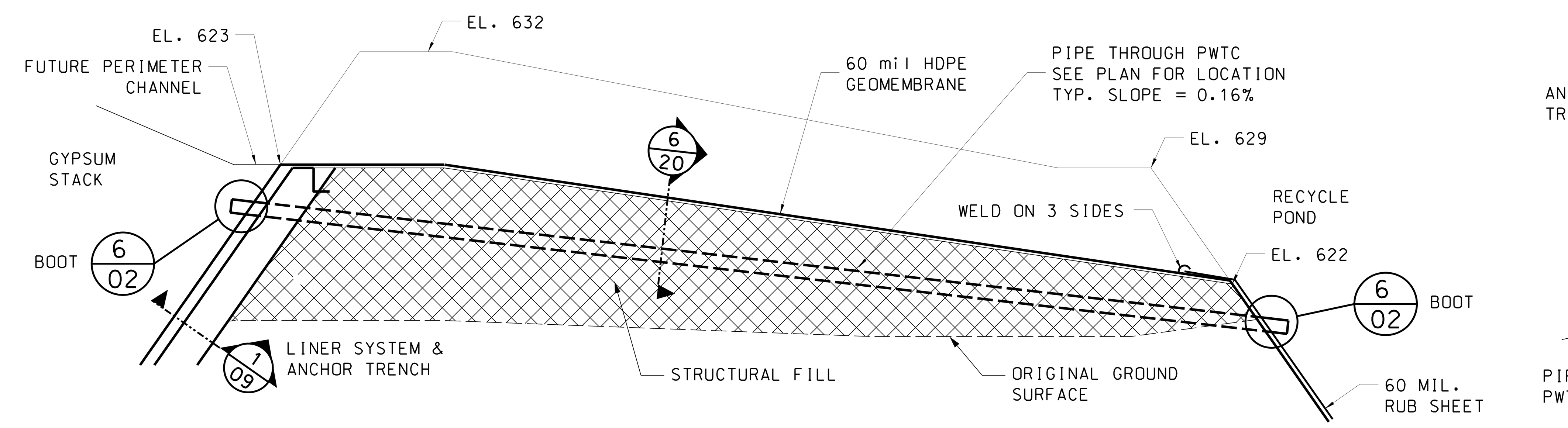
LAYOUT SKB 07-11-08
DRAWN SKB 01-03-11
REVIEWED MWR 11-29-01

30x42

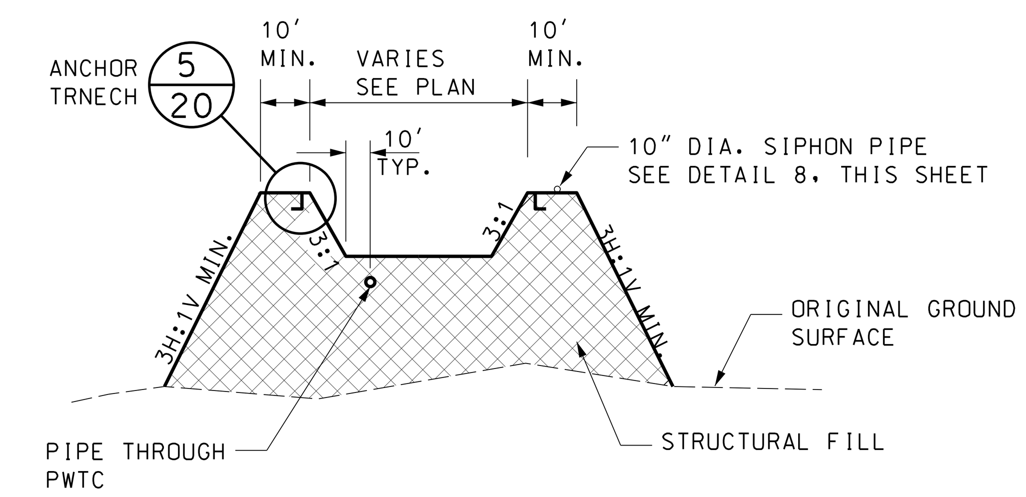
C-10206 SHEET NO. 20



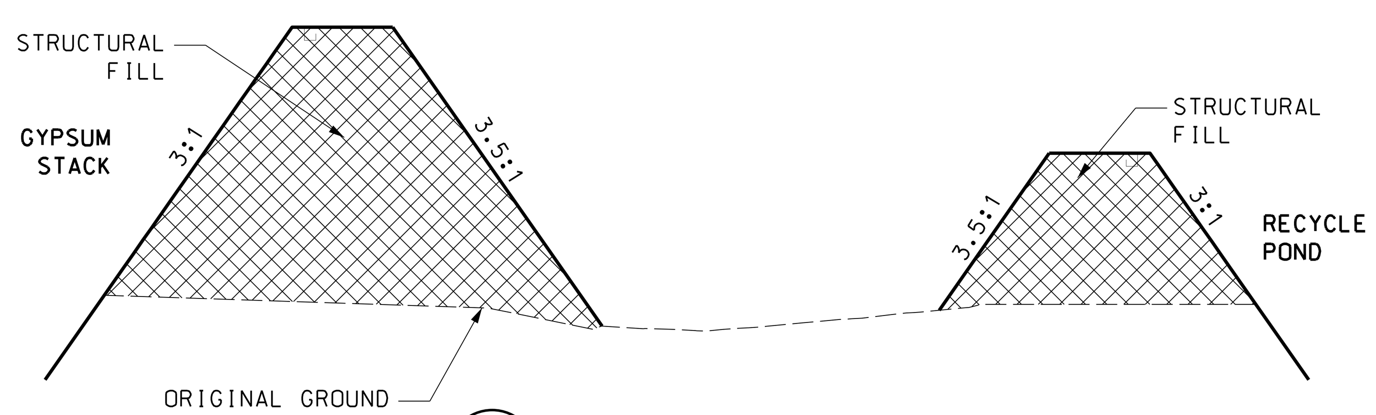
1/20 TYPICAL SECTION THROUGH RECYCLE POND
NTS



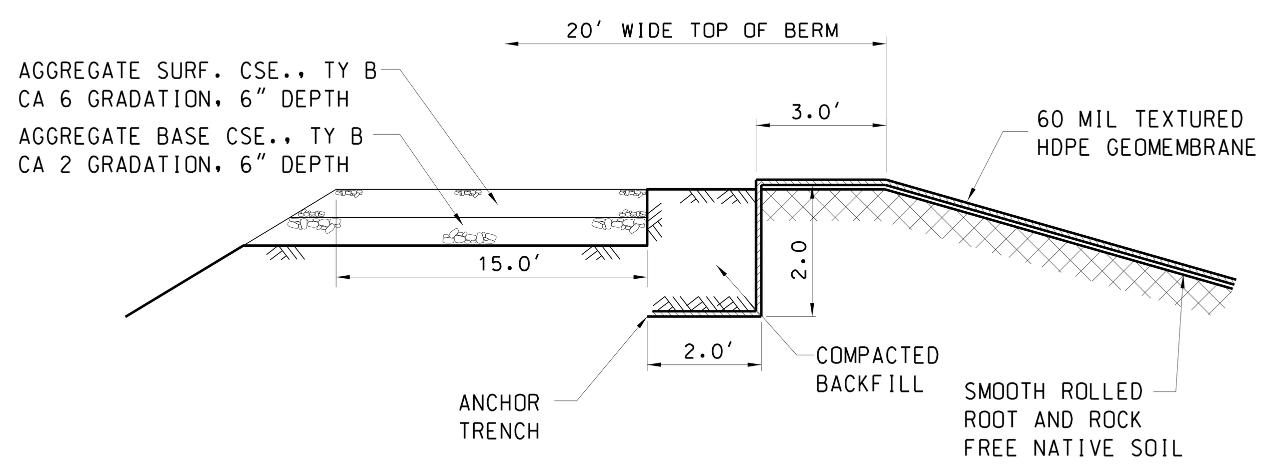
2/20 SECTION THROUGH PROCESS WATER TRANSFER CHANNEL
NTS



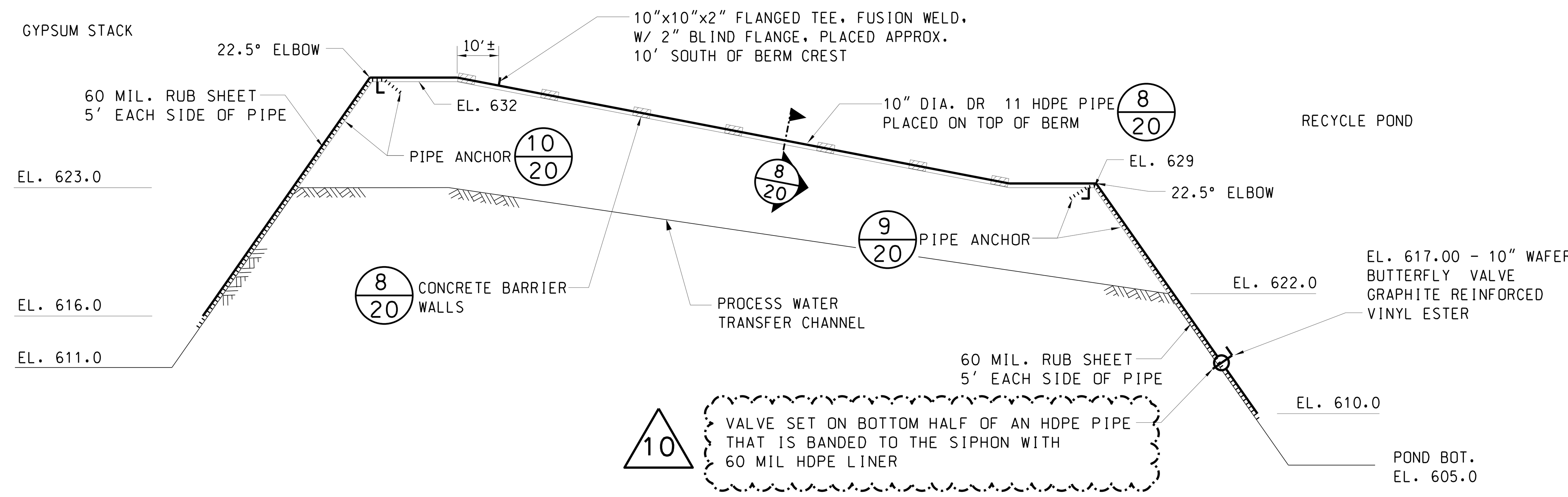
3/20 SECTION THROUGH PROCESS WATER TRANSFER CHANNEL
NTS



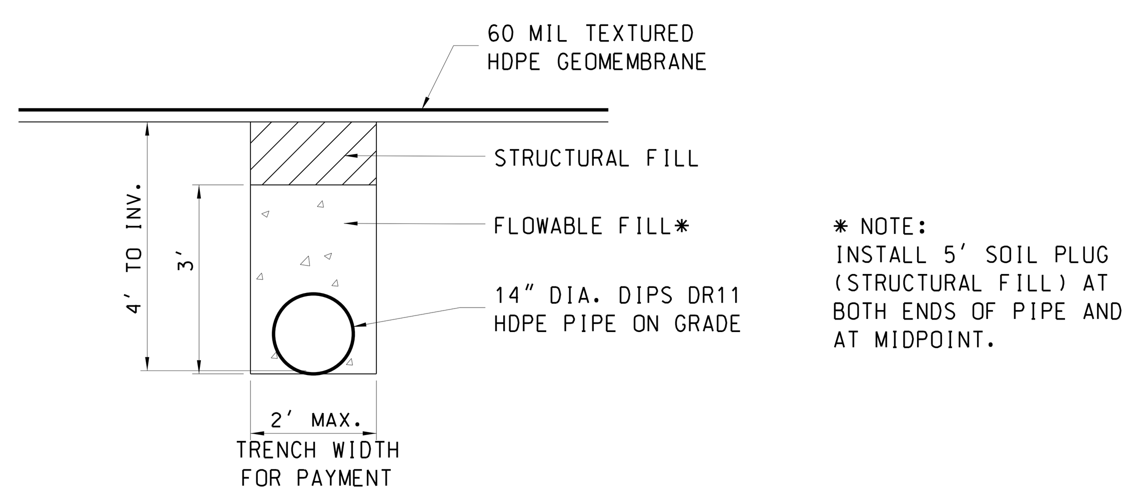
4/20 SECTION THROUGH BERMS
NTS



5/20 RECYCLE POND - LINER SYSTEM
NTS

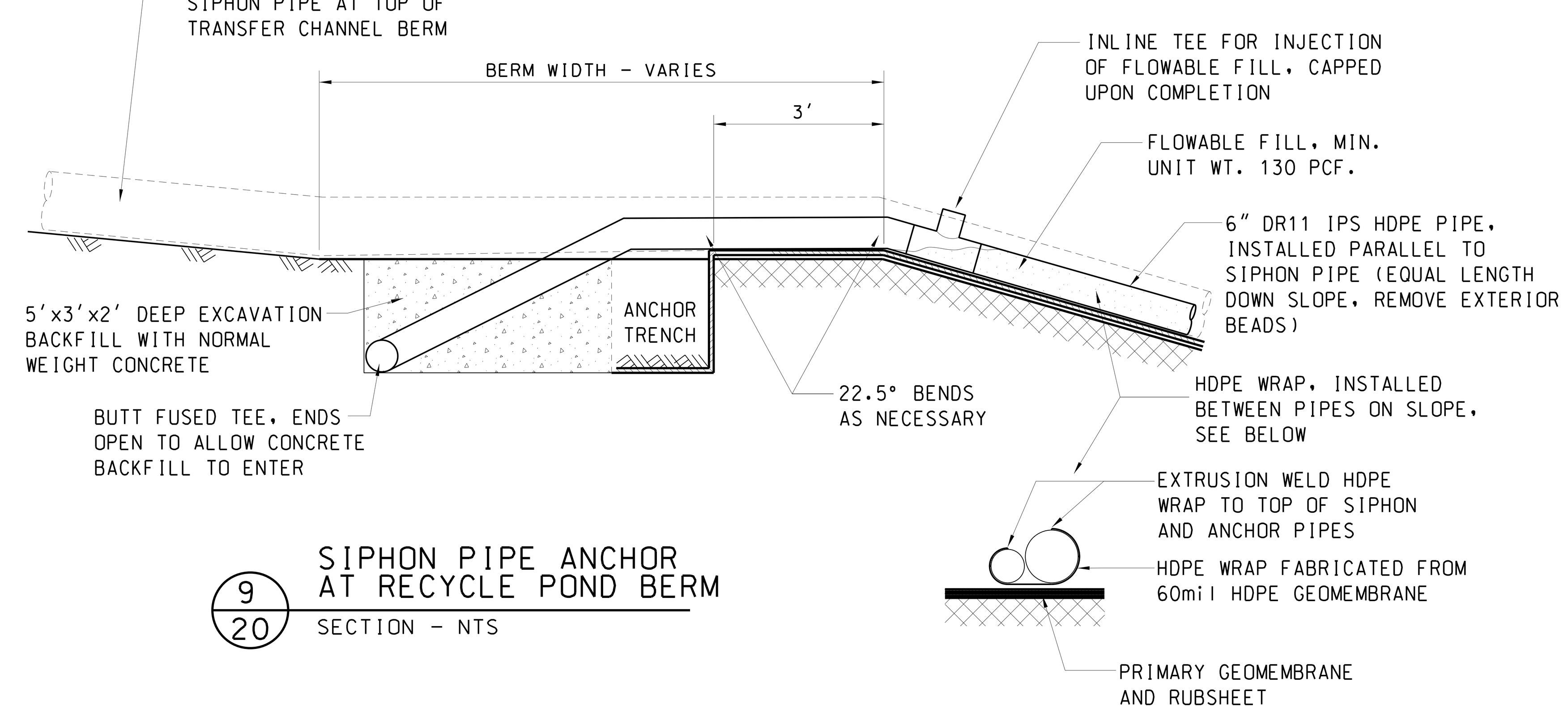


7/20 GYPSUM STACK SIPHON SYSTEM
SECTION THROUGH PROCESS WATER TRANSFER CHANNEL
NTS

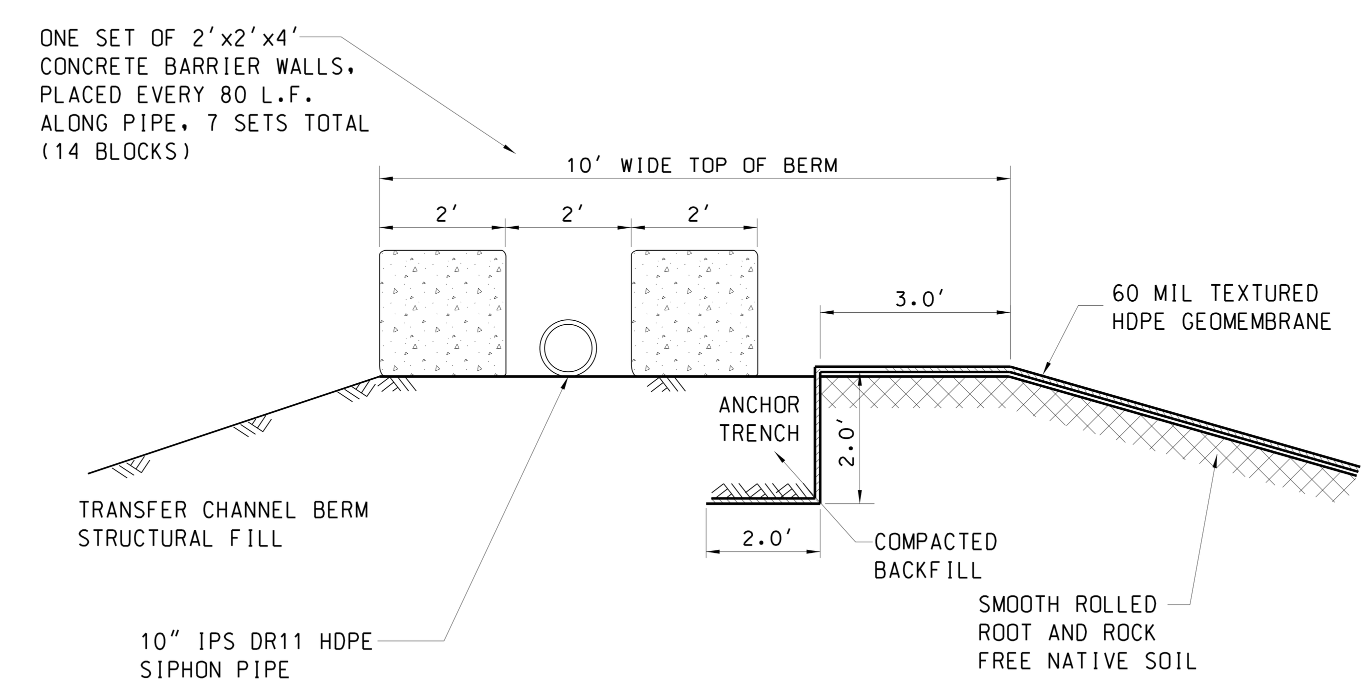


* NOTE:
INSTALL 5' SOIL PLUG (STRUCTURAL FILL) AT BOTH ENDS OF PIPE AND AT MIDPOINT.

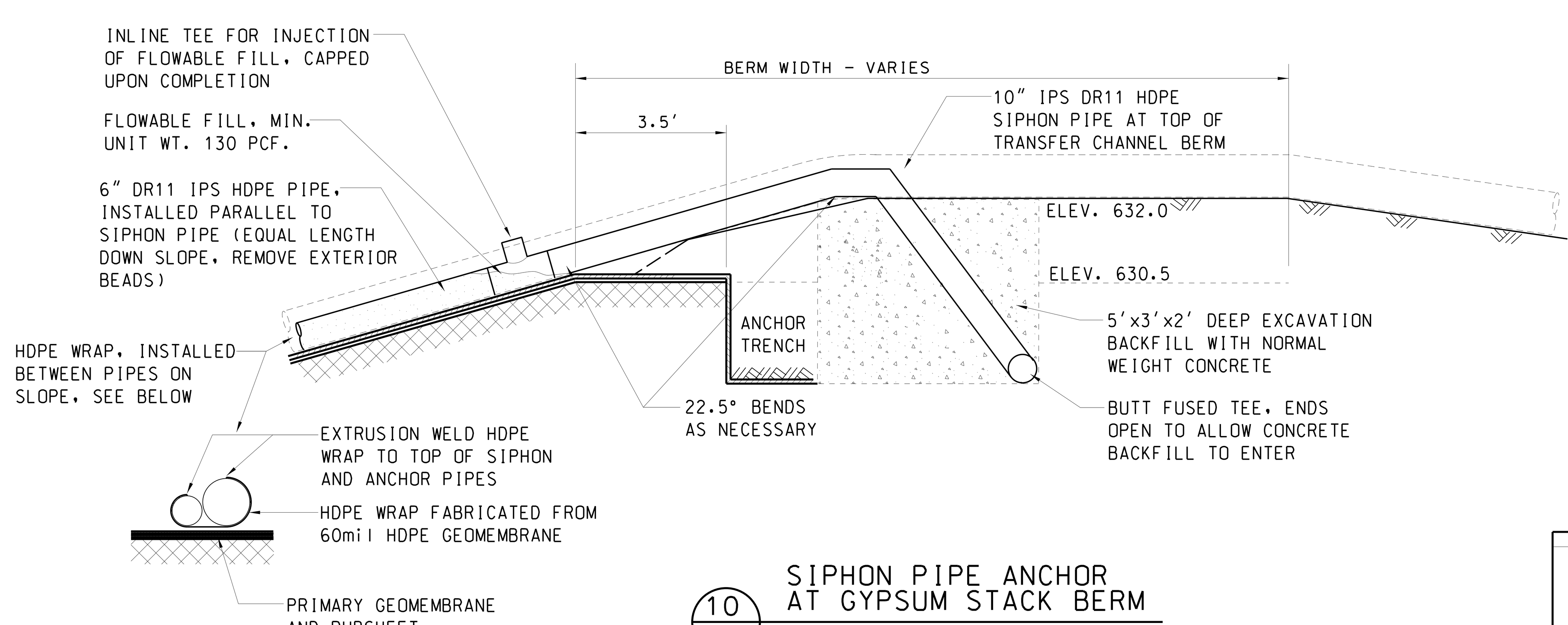
6/20 TYPICAL TRENCH SECTION
NTS



9/20 SIPHON PIPE ANCHOR AT RECYCLE POND BERM
SECTION - NTS



8/20 SIPHON PIPE INSTALLATION
SECTION - NTS



10/20 SIPHON PIPE ANCHOR AT GYPSUM STACK BERM
SECTION - NTS

REFERENCE DRAWINGS
C-10207 LANDFILL PLANS
C-10211 LANDFILL ACCEPTANCE PLANS
C-10212 GYPSUM STACK ACCEPTANCE PLANS
E-10850 SUBDRAINAGE POWER PLANS
E-10855 LEACHATE COLLECTION POWER PLANS

DRAWING RECORD

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
1	05-12-08			SKB	DBH	JAD		SMB	REVISED RECYCLE POND BERM WIDTH
2	06-03-08			SKB	DBH	JAD		SMB	ADDED ROCK CREST TO TOP OF RECYCLE POND BERM
3	07-11-08			SKB	DBH	JAD		DMB	ISSUED FOR CONSTRUCTION - HANSON PROFESSIONAL SERVICES
4	04-03-09			SKB	DBH			DBH	REVISED POND BOTTOM ELEVATION
5	07-05-09			SKB	DBH			DBH	REMOVED PROCESS WATER CONTROL STRUCTURE FROM CONTRACT
6	07-22-09			SKB	DBH			DBH	ADDED 14" DIA. PIPE THROUGH PROCESS WATER TRANSFER CHANNEL
7	02-26-10			SKB	SMA				DRAWING CURRENT AS OF 02-26-10
8	05-17-10			SKB	DBH			DBH	REVISED DETAIL 2 & 3 TO SHOW TRANSFER CHANNEL ANCHOR TRENCH
9	08-30-10			DBH	KNK			DBH	REVISED DETAILS 3&7, ADDED DETAILS 8,9&10 TO SHOW SIPHON SYSTEM MODIFICATIONS
10	01-03-11			SKB	WMR			-	RECORD DRAWING PER WMR MARKUPS

HANSON
Hanson Professional Services Inc.
1525 South Sixth Street
Springfield, Illinois 62703-2886
Phone: (217)788-2450 Fax: (217) 788-2503
Illinois Licensed Professional Service Corporation #184-001084

SCALE
LOC. NO.
CLASS

RECYCLE POND - PROCESS WATER TRANSFER CHANNEL DETAILS CONSTRUCTION DOCUMENTS CCB MANAGEMENT FACILITY

SITE: COFFEEN

AmerenEnergy Generating

DRAWING NO. C-10206 REV. 10
SHEET NO. 20

30x42

NOTES:

DESIGN BASIS: PROVIDE 1600 GPM CAPACITY WITH 70% BLOCKAGE (ONE INLET SUBMERGED)

ALL PARTS SHALL BE JOINED BY FUSION WELDING.

APPROX. WT. OF STRAINER IS 25.5 LB. AND WILL CREATE 1.2 LB. OF UPWARD BOUYANT FORCE WHEN SUBMERGED

DETAIL IS NOT TO SCALE

HANSON
Hanson Professional Services Inc. 1525 South Sixth Street Springfield, Illinois 62703-2886
Phone: (217)788-2450 Fax: (217) 788-2503 Illinois Licensed Professional Service Corporation #184-001084

NOTICE OF LIMITED RESPONSIBILITY
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REFERENCE DRAWINGS
C-10207 LANDFILL PLANS
C-10211 LANDFILL ACCEPTANCE PLANS
C-10212 GYPSUM STACK ACCEPTANCE PLANS
E-10850 SUBDRAINAGE POWER PLANS
E-10855 LEACHATE COLLECTION POWER PLANS

DRAWING RECORD

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRFTR	CHK'D	SUPV	AMEREN	OTHER	DESCRIPTION
0	04-30-08	-	-	SKB	DBH	JAD	-	SMB	ISSUED FOR BIDDING - NOT FOR CONSTRUCTION
1	05-12-08			SKB	DBH	JAD		SMB	ADDED DETAIL 2
2	07-11-08			SKB	DBH	JAD		SMB	ISSUED FOR CONSTRUCTION - HANSON PROFESSIONAL SERVICES, INC.
3	02-26-10			SKB	DCB	SMA			RECORD DRAWING CURRENT AS OF 02-26-10
4	01-03-11			SKB	WMR				RECORD DRAWING PER MWR MARKUPS

SCALE
LOC. NO.
CLASS

RECYCLE POND - PROCESS WATER DECANT SECTIONS & DETAILS CONSTRUCTION DOCUMENTS CCB MANAGEMENT FACILITY

SITE: COFFEEN

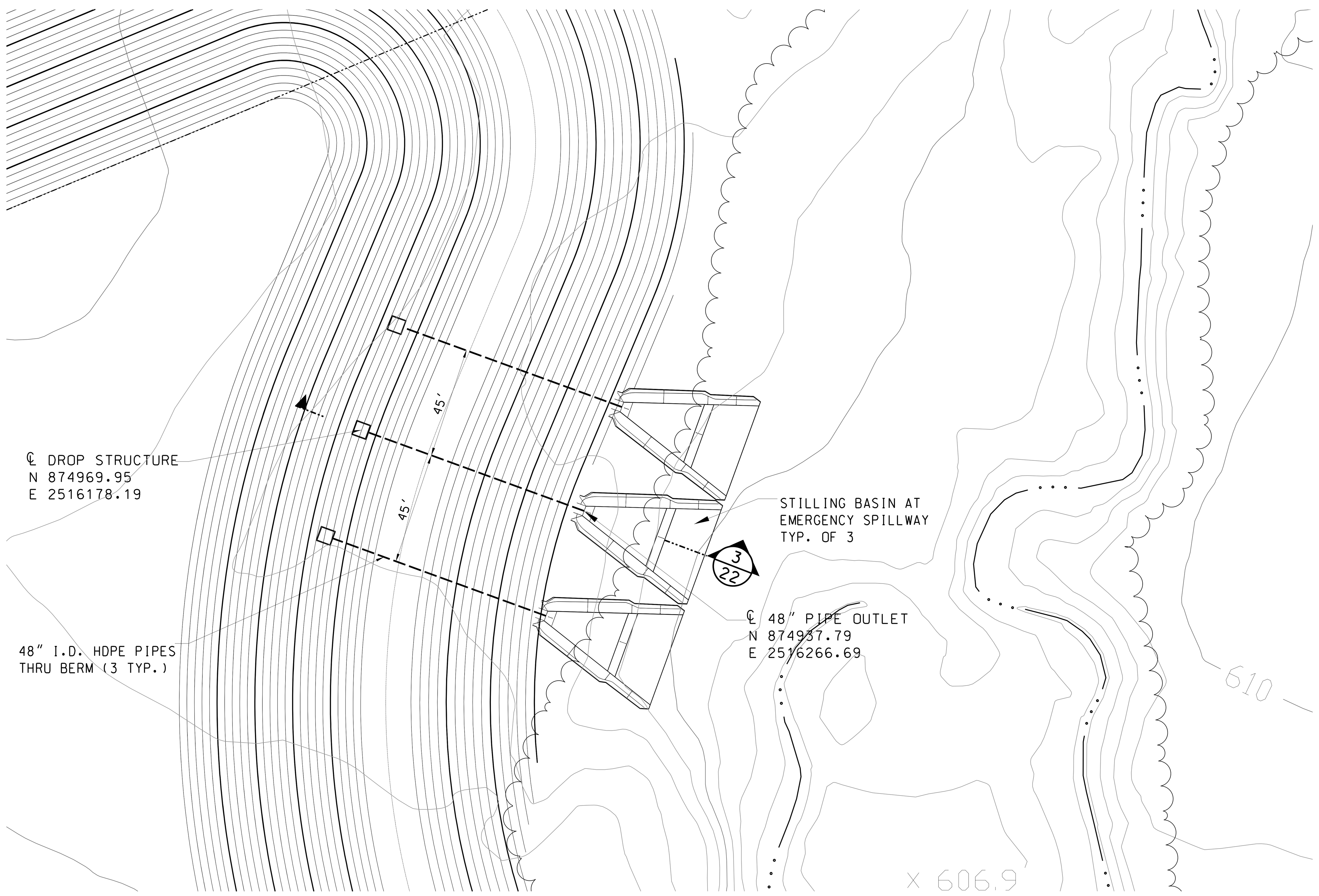
AmerenEnergy Generating

DRAWING NO. C-10206 REV. 4

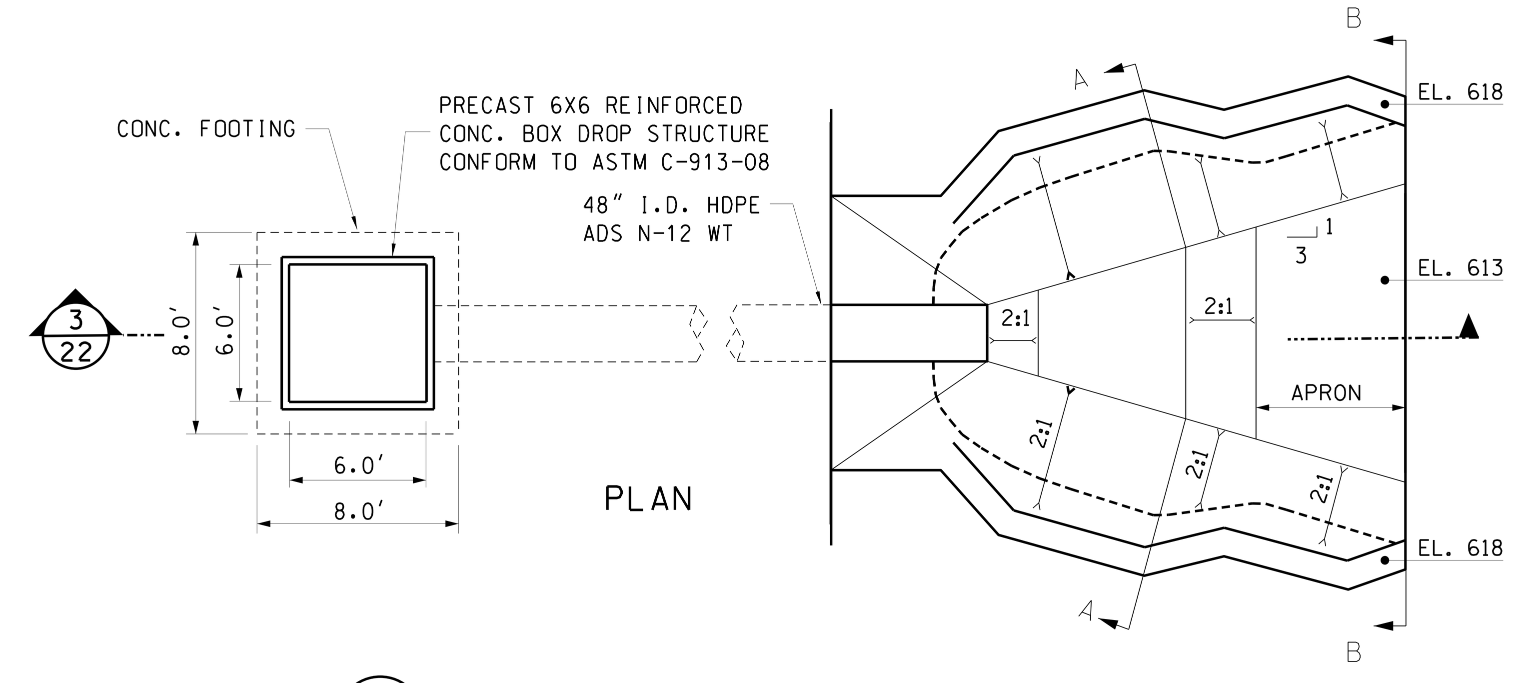
SHEET NO. 21

LAYOUT	SKB	01-10-08
DRAWN	SKB	01-03-11
REVIEWED	WMR	11-29-01

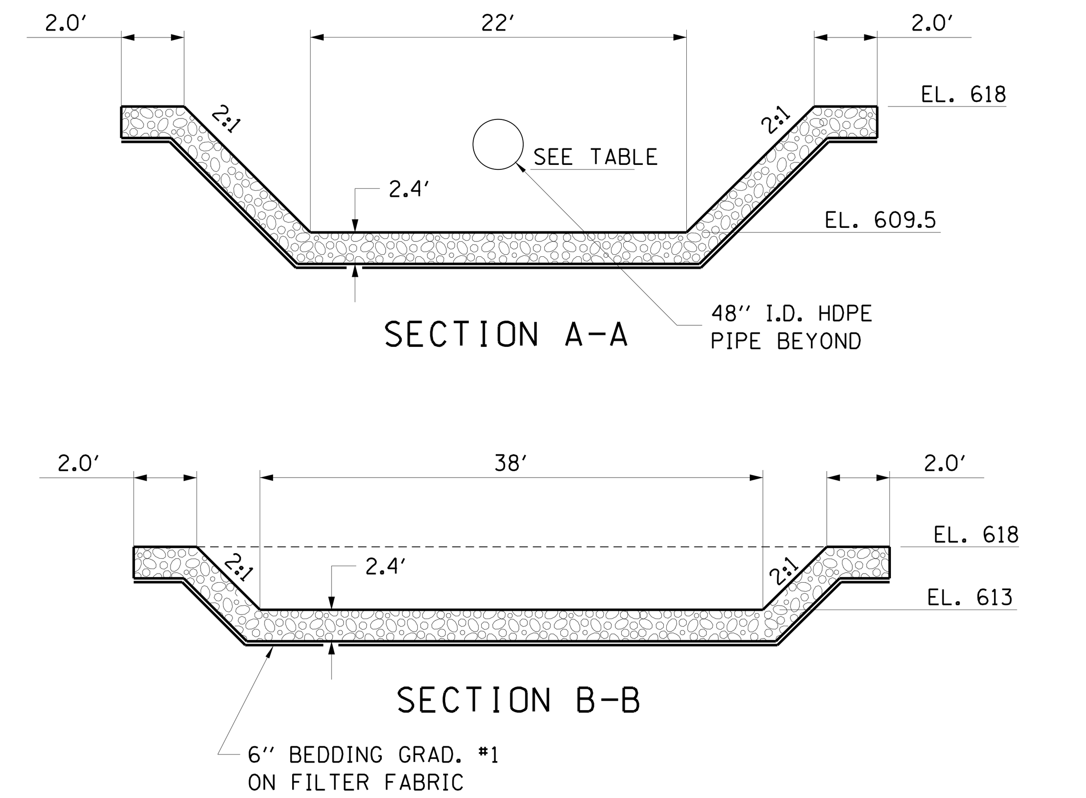
30x42

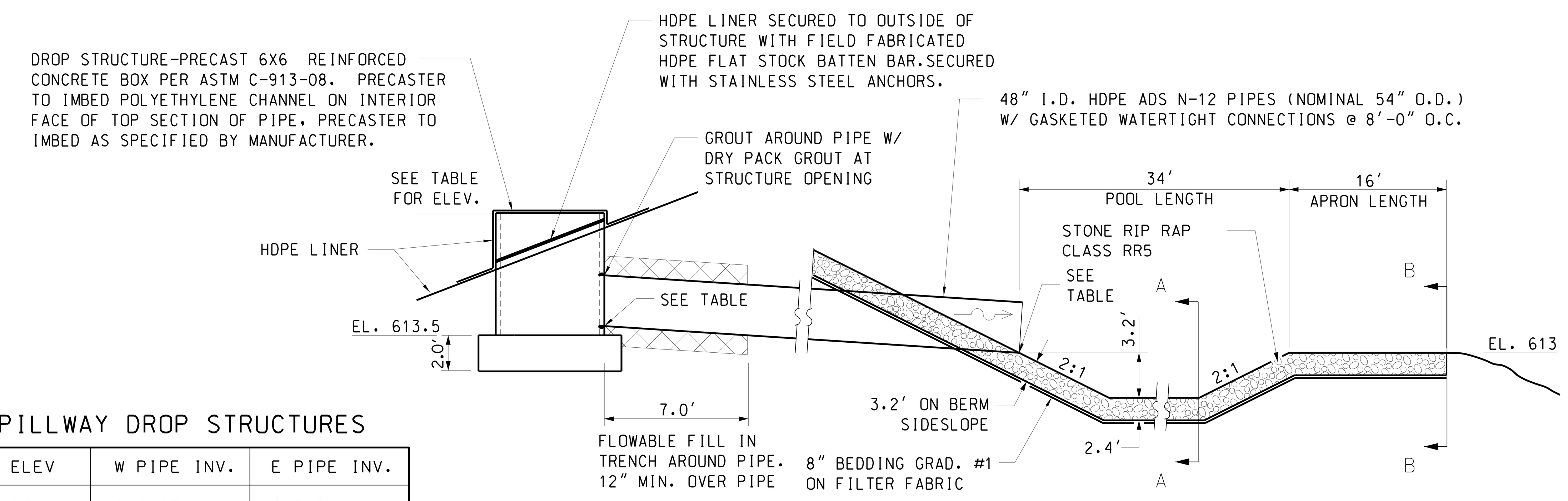


(1/22) STILLING BASIN PLAN AT EMERGENCY SPILLWAY
NTS



(2/22) RIPRAP STILLING BASIN PLAN
NTS

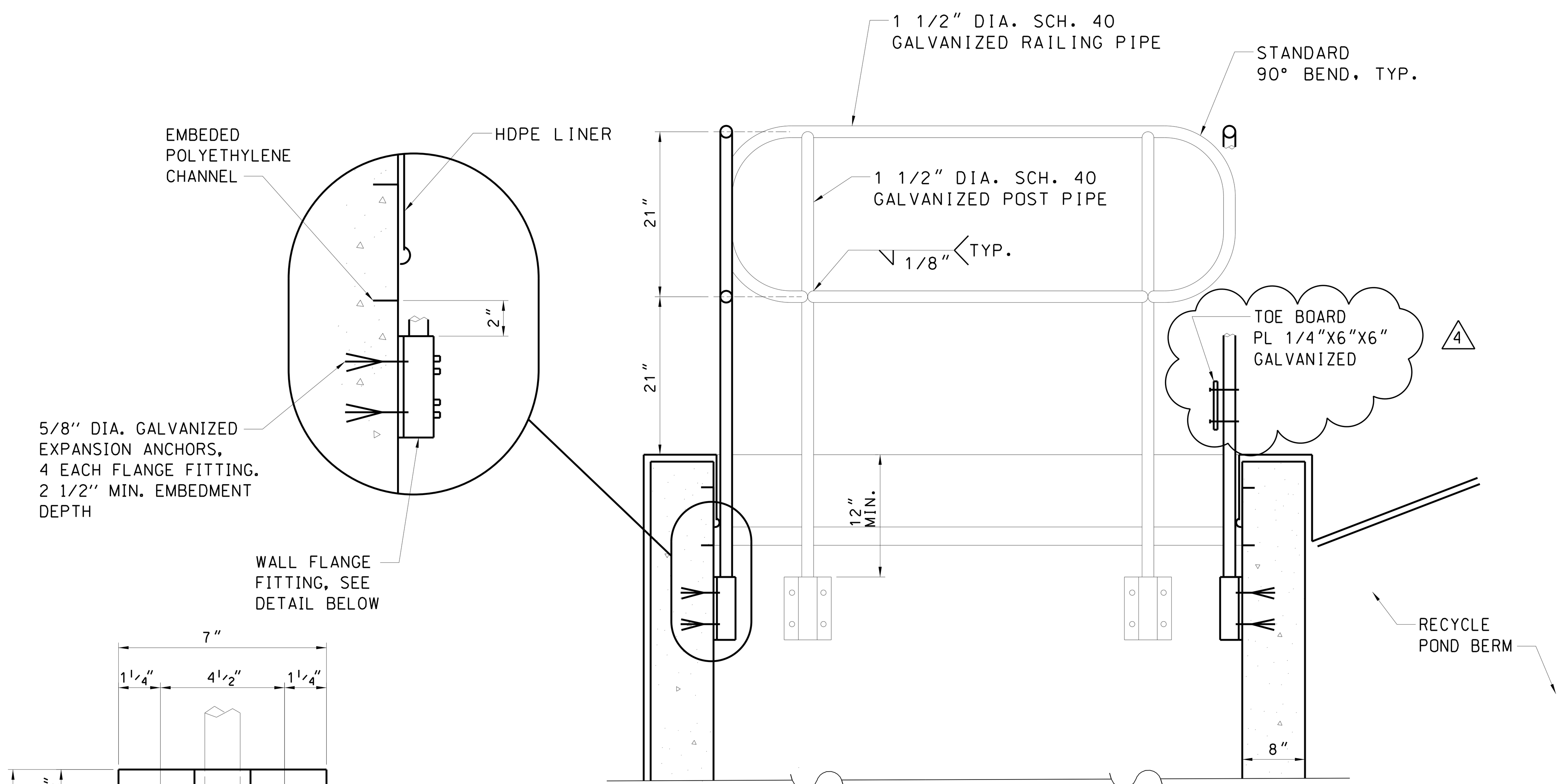




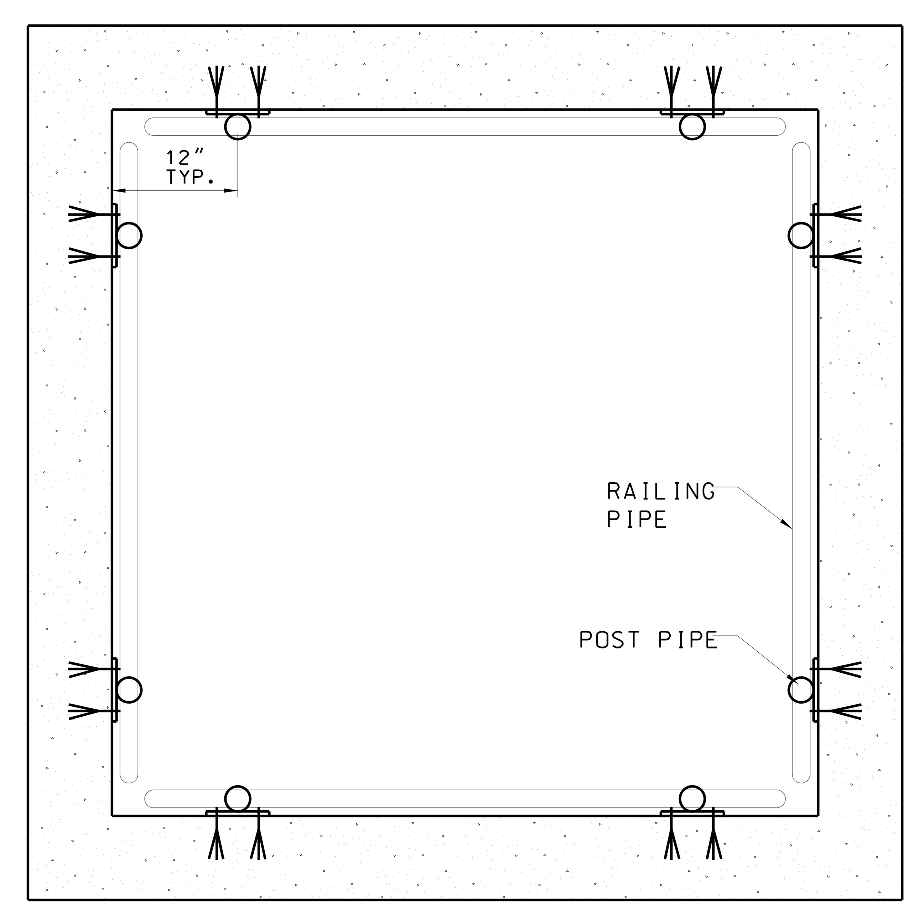
EMERGENCY SPILLWAY DROP STRUCTURES

STRUCTURE	TOP ELEV	W PIPE INV.	E PIPE INV.
NORTH	624.13	614.93	612.94
MIDDLE	624.15	614.95	613.00
SOUTH	624.11	614.03	613.06

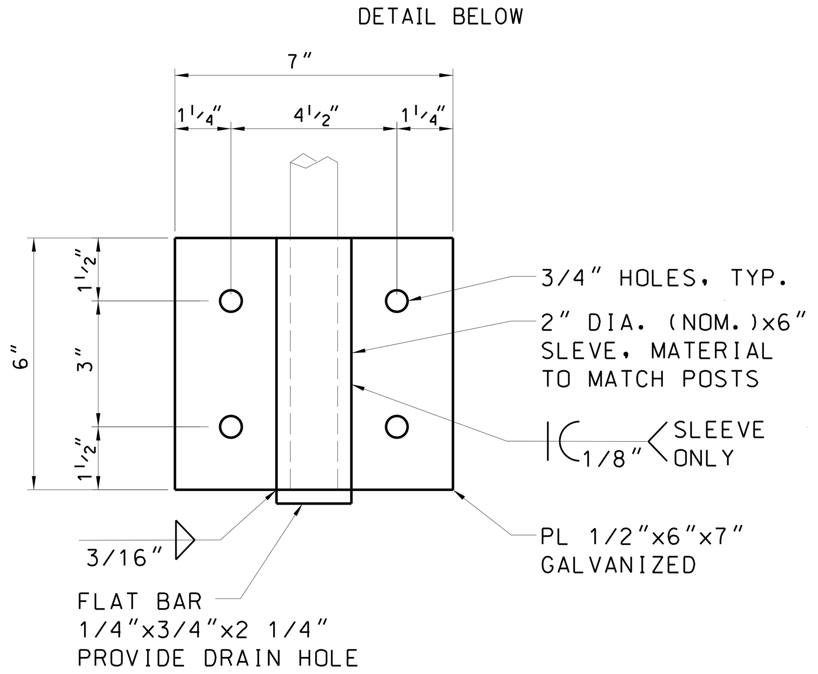
(3/22) RIPRAP STILLING BASIN SECTION
NTS



(4/22) DROP INLET HANDRAIL DETAIL
NTS



(5/22) DROP INLET HANDRAIL PLAN
NTS



WALL FLANGE FITTING
NTS

HANDRAIL NOTES

GT-1 COPE ALL INTERSECTIONS OF RAILS AND POSTS, WELD JOINTS, AND GRIND SMOOTH TO A PLEASING APPEARANCE, TAKING CARE TO NOT REMOVE EXCESSIVE AMOUNT OF WELDED MATERIALS.

GT-2 BUTT WELD END-TO-END JOINTS, OR USE WELDING CONNECTIONS.

GT-3 CLEAN WELDED AREAS USING A WIRE BRUSH TO REMOVE SLAG AND LOOSE PARTICULATE. WIPE AWAY DUST WITH A CLEAN DRY RAG AND CLEAN THE WELDED SUFACE IN ACCORDANCE WITH SSPC-SP 1.

GT-4 TREAT ALL WELD ZONES WITH TWO COATS OF COLD GALVANIZING COMPOUND.

GT-5 COAT THE WELDED HANDRAIL ASSEMBLY PER THE FOLLOWING:
1 - 4 MIL COAT OF KRYLON INDUSTRIAL GALVANIZED METAL PRIMER
2 - 3 MIL COATS OF KRYLON INDUSTRIAL RUST TOUGH DTM ALKYD ENAMEL - COLOR: OHSA SAFETY YELLOW

HANSON

NOTICE OF LIMITED RESPONSIBILITY

REFERENCE DRAWINGS
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C-10211 LANDFILL ACCEPTANCE PLANS
C-10212 GYPSUM STACK ACCEPTANCE PLANS
E-10850 SUBDRAINAGE POWER PLANS
E-10855 LEACHATE COLLECTION POWER PLANS

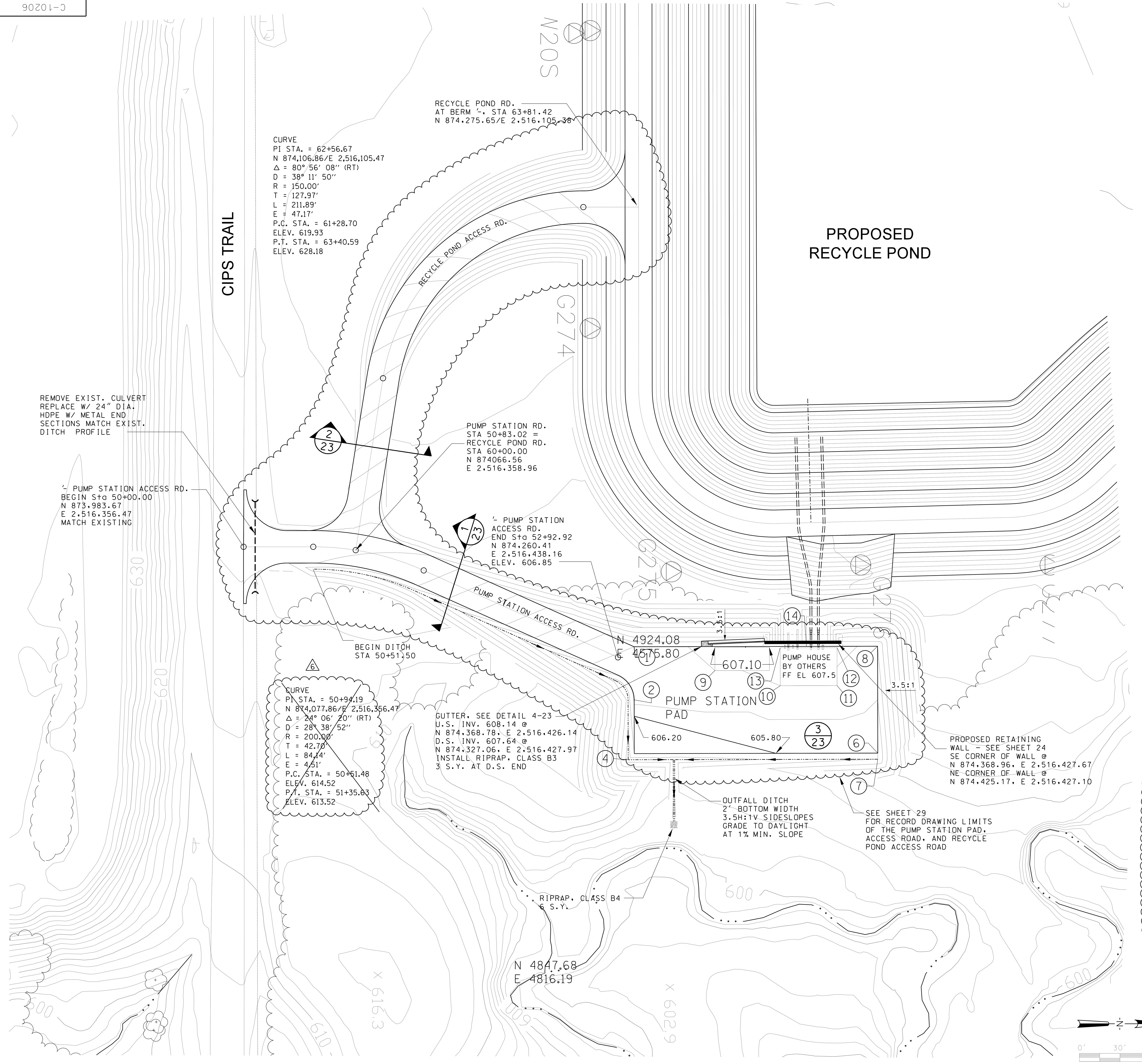
REV.	DATE	PROJECT NO.	AMEREN SUPV. ENGR	DRFTR	CHK'D	SUPV	AMEREN	OTHER	DESCRIPTION
4	12-22-10	-	-	TCJ			-		RECORD DRAWING

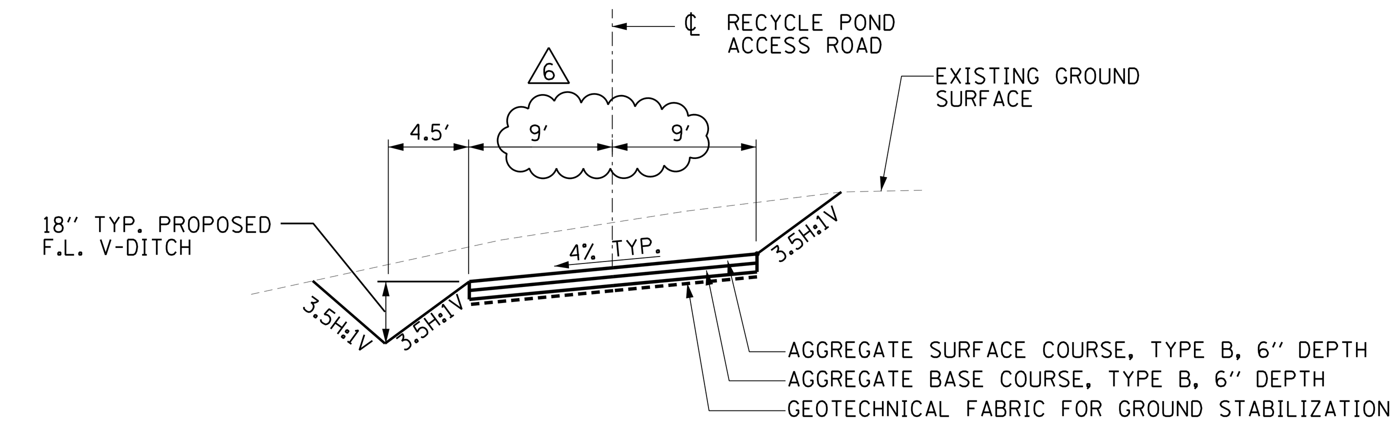
RECYCLE POND - EMERGENCY SPILLWAY SECTIONS & DETAILS
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY
SITE: COFFEEN

AmerenEnergy Generating

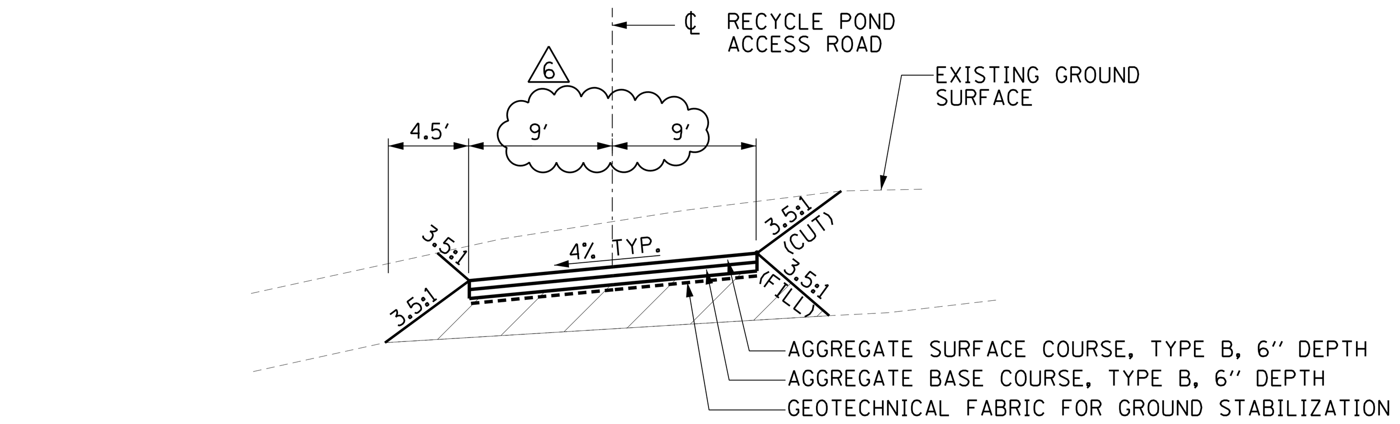
DRAWING NO. C-10206 REV. 4
SHEET NO. 22

30x42

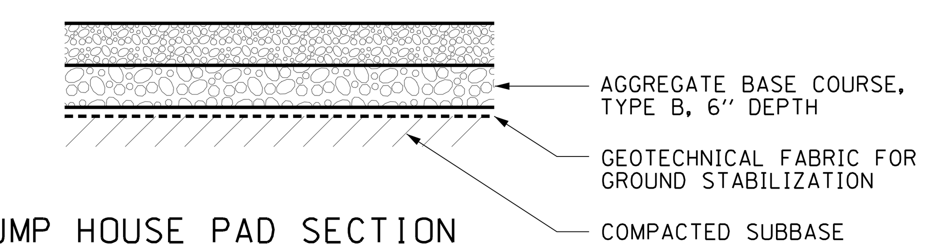




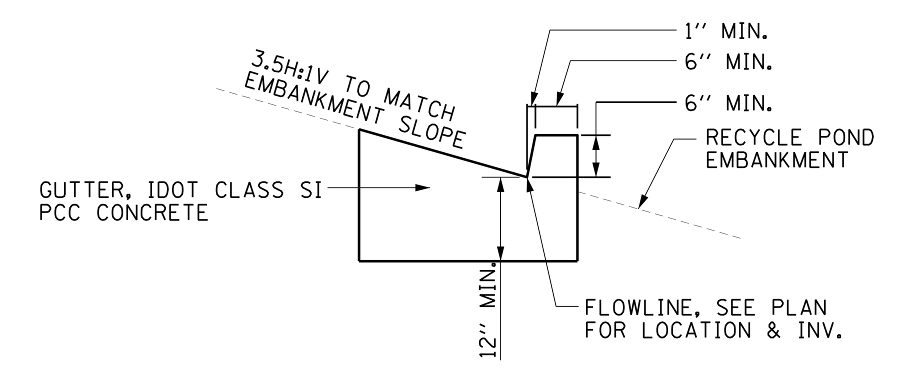
1 / 23 PUMP STATION ACCESS ROAD SECTION
NTS



2 / 23 RECYCLE POND ACCESS ROAD SECTION
NTS



3 / 23 PUMP HOUSE PAD SECTION
NTS



4 / 23 CONCRETE GUTTER SECTION
NTS

(1) TOP OF PAD N 874,272.32 E 2,516,430.34 ELEV. 607.00	(2) TOP OF PAD N 874,272.40 E 2,516,469.59 ELEV. 606.10	(3) ~~TOP OF PAD N 874,272.48 E 2,516,509.34 ELEV. 605.00~~	(4) DITCH FLOWLINE N 874,267.99 E 2,516,513.85 ELEV. 603.50
(5) ~~DITCH FLOWLINE N 874,301.76 E 2,516,513.78 ELEV. 603.35~~	(6) TOP OF PAD N 874,452.48 E 2,516,508.96 ELEV. 605.80	(7) DITCH FLOWLINE N 874,452.49 E 2,516,513.46 ELEV. 605.60	(8) TOP OF PAD N 874,452.32 E 2,516,429.96 ELEV. 606.80
(9) TOP OF PAD @ SE COR. OF BLDG. N 874,332.10 E 2,516,447.96 ELEV. 606.90	(10) TOP OF PAD @ SE COR. OF BLDG. N 874,380.38 E 2,516,459.11 ELEV. 606.80	(11) TOP OF PAD @ NE COR. OF BLDG. N 874,422.38 E 2,516,459.03 ELEV. 606.80	(12) TOP OF PAD @ NW COR. OF BLDG. N 874,422.32 E 2,516,431.03 ELEV. 607.10
(13) TOP OF PAD @ SW COR. OF BLDG. N 874,380.32 E 2,516,431.11 ELEV. 607.10	(14) HIGH POINT BETWEEN PUMPHOUSE AND RETAINING WALL ELEV. 607.30		

HANSON

NOTICE OF LIMITED RESPONSIBILITY

REFERENCE DRAWINGS
C-10207 LANDFILL PLANS
C-10211 LANDFILL ACCEPTANCE PLANS
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REV.	DATE	PROJECT NO.	AMEREN SUPV. ENGR	DRFTR	CHK'D	SUPV	AMEREN	OTHER	DESCRIPTION
6	12-22-10	-	-	TCJ			-		RECORD DRAWING

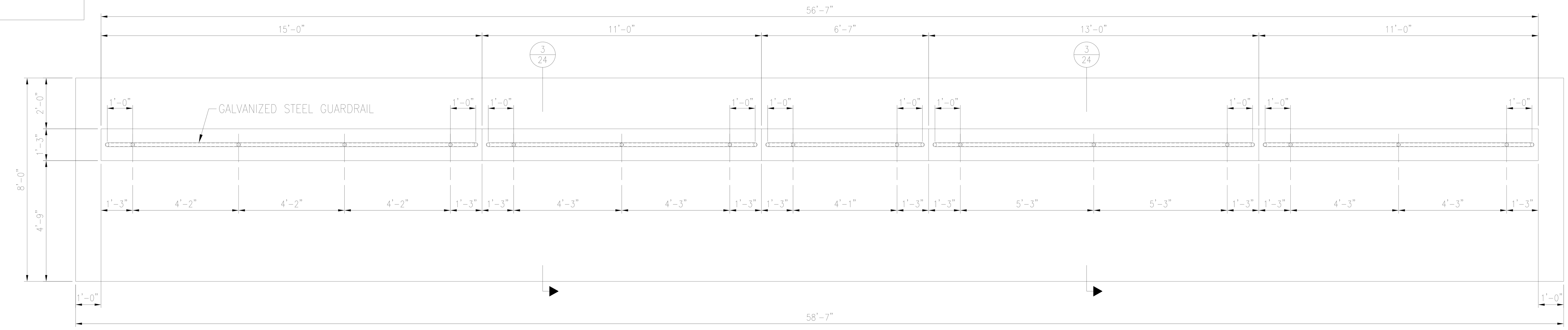
RECYCLE POND - ACCESS ROADS
PLAN & PROFILE
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY
SITE: COFFEEN

Ameren Energy Generating

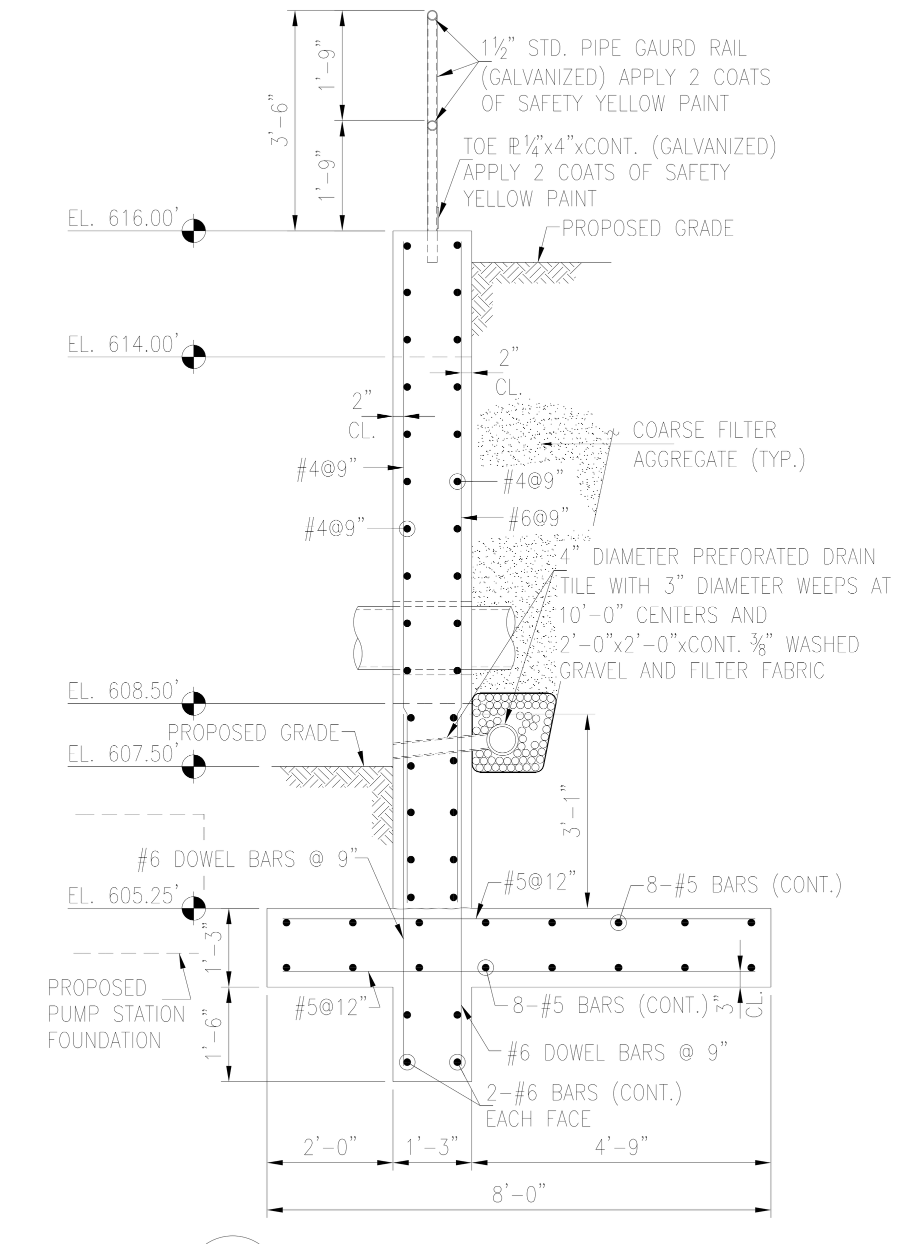
DRAWING NO. C-10206 REV. 6
SHEET NO. 23

LAYOUT	DBH	10-08-07
DRAWN	SKB	04-02-09
REVIEWED		

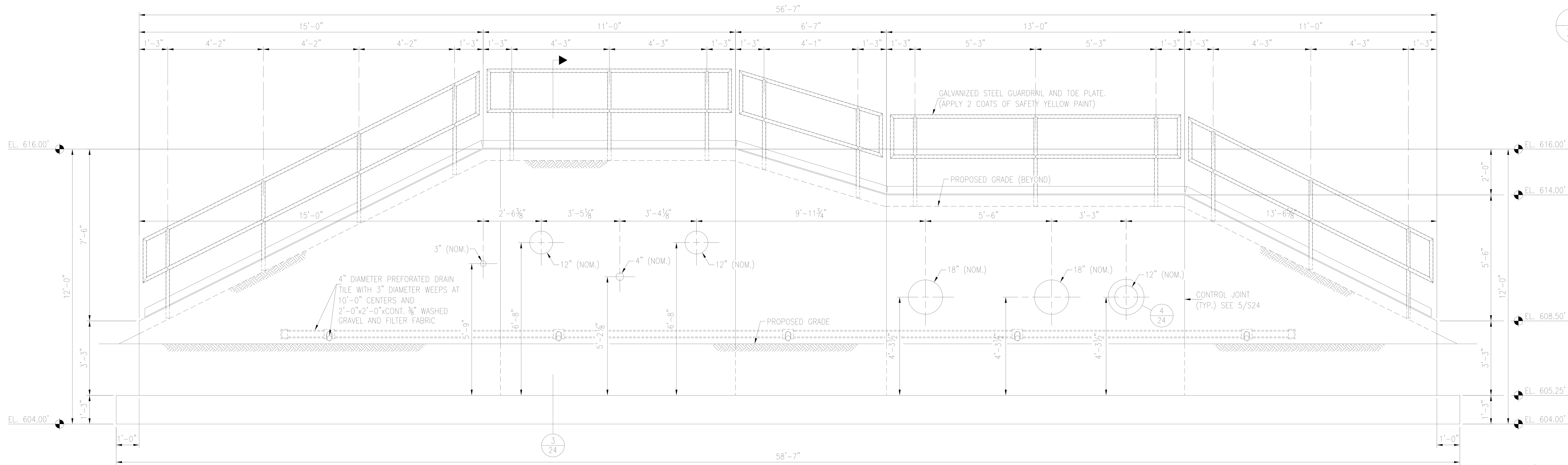
30x42



1/24 RETAINING WALL PLAN – RECYCLE POND
SCALE: ½"=1'-0"

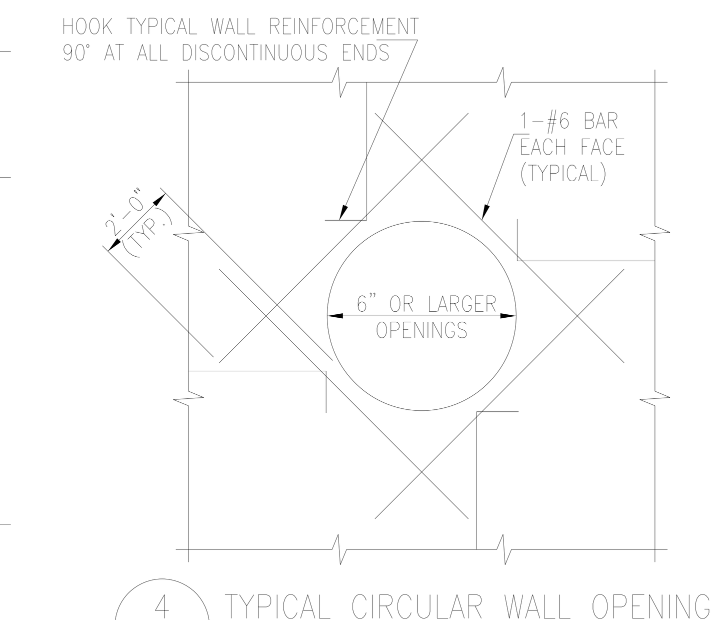


3/24 SECTION THRU RETAINING WALL
SCALE: ½"=1'-0"

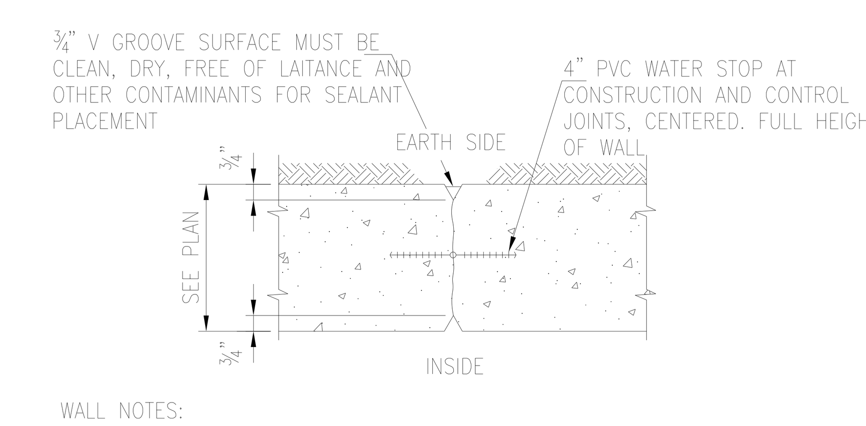


2/24 RETAINING WALL ELEVATION – RECYCLE POND
SCALE: ½"=1'-0"

NOTE: PIPE SIZES AND LOCATIONS ARE APPROXIMATE. CONTRACTOR TO COORDINATE REQUIRED WALL OPENINGS, PIPE SLEEVES, AND MECHANICAL WATERSTOPS (LINKSEAL) FOR ACTUAL PIPE DIAMETER AND TYPE.



4/24 TYPICAL CIRCULAR WALL OPENING REINFORCEMENT DETAIL
SCALE: NONE



WALL NOTES:

1. LOCATE CONTROL JOINTS AS SHOWN.
2. DO NOT LAP SPLICE CONTINUOUS REINFORCEMENT AT CONTROL JOINTS.

5/24 TYPICAL VERTICAL WALL CONTROL JOINT OR CONSTRUCTION JOINT
SCALE: NONE

GENERAL:

G-1. GOVERNING CODE:
2006 INTERNATIONAL BUILDING CODE

G-2. THE CONTRACTOR SHALL FIELD VERIFY ALL DIMENSIONS, COORDINATES AND EXISTING CONDITIONS PRIOR TO CONSTRUCTION. NOTIFY THE OWNER'S REPRESENTATIVE OF ANY DISCREPANCY IMMEDIATELY.

G-3. ALL SUBTERRANEAN STRUCTURES, UTILITIES, PIPING, ETC. IN THE AREA OF ALL EXCAVATIONS TO BE LOCATED AND MARKED BY CONTRACTOR PRIOR TO EARTH REMOVAL WORK. FLAGS OR PAINT ARE ACCEPTABLE METHODS. CONTRACTOR TO MAINTAIN MARKERS UNTIL ALL EXCAVATION ACTIVITIES HAVE CEASED. COORDINATE WITH OWNER.

G-4. THE CONTRACTOR IS SOLEY RESPONSIBLE FOR ALL SITE SAFETY AND ALL ACCIDENTS WHICH RESULT IN DEATH, PERSONAL INJURY OR DAMAGE TO PROPERTY ARISING OUT OF OR IN CONNECTION WITH PERFORMANCE OF THE WORK, WHETHER ADJACENT TO OR AT THE SITE.

G-5. ALL SECTIONS, DETAILS AND NOTES SHOWN ON THE DRAWINGS ARE INTENDED TO BE TYPICAL AND SHALL APPLY TO SIMILAR SITUATIONS ELSEWHERE UNLESS OTHERWISE SHOWN.

ALL ASTM DESIGNATIONS SHALL BE THE LATEST UNLESS NOTED OTHERWISE.

G-6.

FOUNDATION:

F-1. NET ALLOWABLE SOIL BEARING PRESSURE = 3000 PSF.

F-2. ALL FOOTING EXCAVATIONS SHALL BE CLEAN AND FREE OF DEBRIS, STANDING WATER AND LOOSE SOIL AND BE INSPECTED AND APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO PLACEMENT OF CONCRETE.

F-3. ALL FILL MATERIAL SHALL BE APPROVED FOR USE IN ADVANCE OF PLACEMENT BY THE OWNER'S REPRESENTATIVE. NO FILL SHALL BE PLACED OVER FROZEN, MUDDY OR OTHER DELETERIOUS MATERIAL. LIFT THICKNESS SHALL BE MINIMIZED TO ALLOW EFFICIENT COMPACTION. NO FILL MAY BE PLACED OVER A PREVIOUS LIFT THAT HAS NOT BEEN ADEQUATELY COMPACTED AND ACCEPTED BY THE OWNERS REPRESENTATIVE.

F-4. COORDINATE WITH CIVIL DRAWINGS FOR MISCELLANEOUS FOUNDATIONS NOT SHOWN ON STRUCTUAL DRAWINGS.

F-5. A LEAN CONCRETE MUD SLAB 3" TO 4" THICK SHALL BE USED IN THE FOOTING EXCAVATIO IF THE BOTTOM OF THE EXCAVATION TENDS TO BECOME MUDDY AND SOFT DUE TO CONSTRUCTION ACTIVITY. LEAN CONCRETE SHALL HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 2,000 P.S.I.

CONCRETE:

C-1. MATERIAL PROPERTIES (U.N.O.)
COMPRESSIVE STRENGTH
FOOTINGS AND FOUNDATION WALLS – F'c = 4,000 PSI
CONCRETE REINFORCEMENT – Fy = 60 KSI (A615 GR 60)

C-2. PROTECTIVE COVERING FOR REINFORCEMENT BARS SHALL BE AS FOLLOWS UNLESS OTHERWISE NOTED ON THE PLANS:
FOOTINGS:
BOTTOM & SIDES = 3"
TOP = 2"
WALLS:
EXTERIOR EXPOSURE = 2"

C-3. ALL REINFORCEMENT BARS SHALL BE FABRICATED IN ACCORDANCE WITH THE LATEST CRSI MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES AND SHALL BE CLEAN AND FREE OF GREASE AND SCALING RUST.

C-4. WATER STOPS SHALL BE PROVIDED IN ALL HORIZONTAL AND VERTICAL JOINTS.

C-5. LAP ALL BARS AS FOLLOWS U.N.O. (CLASS B):

#3=1'-7"	#4=2'-1"	#5=2'-7"
#6=3'-1"	#7=4'-6"	#8=5'-2"
#9=5'-10"	#10=6'-7"	#11=7'-4"

FOR EPOXY COATED BARS, PROVIDE 1.3 TIMES THE INDICATED LAP LENGTH.
FOR TOP BARS, PROVIDE AN ADDITIONAL 1.3 TIMES THE INDICATED LAP LENGTH.

GUARDRAIL & TOE PLATE

GT-1. GUARDRAIL AND TOE PLATE SHALL BE CONSTRUCTED AS SHOWN OR AS REQIURED BY THE LA O.S.H.A. REQUIREMENTS.

GT-2. GUARDRAIL PIPE SHALL CONFORM TO ASTM A-53 TYPE E OR S, GRADE B.

GT-3. TOE PLATE SHALL CONFORM TO ASTM A-36.

GT-4. ALL WELDS SHALL BE GROUND FLUSH.

CALL JULIE TOLL FREE 1(800)892-0123
OPERATES 24 HOURS A DAY 365 DAYS A YEAR
WARNING
CALL BEFORE YOU DIG
48 HOURS BEFORE YOU DIG

NOTES

HANSON
Hanson Professional Services Inc.
1525 South Sixth Street
Springfield, Illinois 62703-2886

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
3	12-22-10	–	–	TCJ			–	–	RECORD DRAWING

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LICENSED STRUCTURAL ENGINEER
GARY L. CLACK
081-005210
SPRINGFIELD ILLINOIS
STATE OF ILLINOIS
EXPIRES 11/30/08 DATE 7/11/08

SCALE AS SHOWN
LOC. NO. –
CLASS –

RECYCLE POND – RETAINING WALL PLAN, ELEVATION, AND DETAILS CONSTRUCTION DOCUMENTS CCB MANAGEMENT FACILITY

SITE: COFFEEN

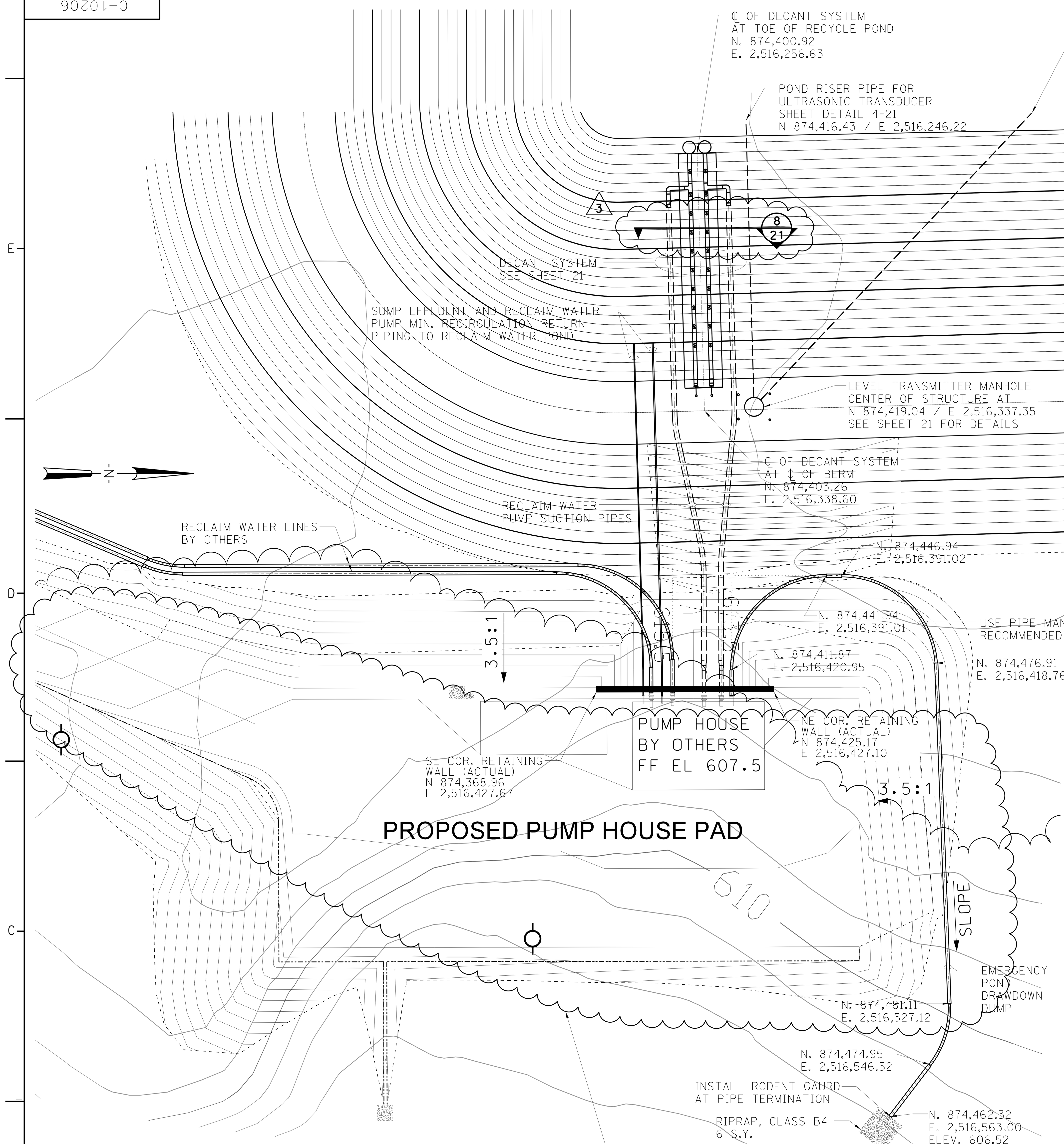
Ameren Energy Generating

DRAWING NO. C-10206
REV. 3
SHEET NO. 24

8/17/2016
I:\05 jobs\05S3004A\Gypsum Stacking\CADD\SHEETS\ccl0206_24.dgn

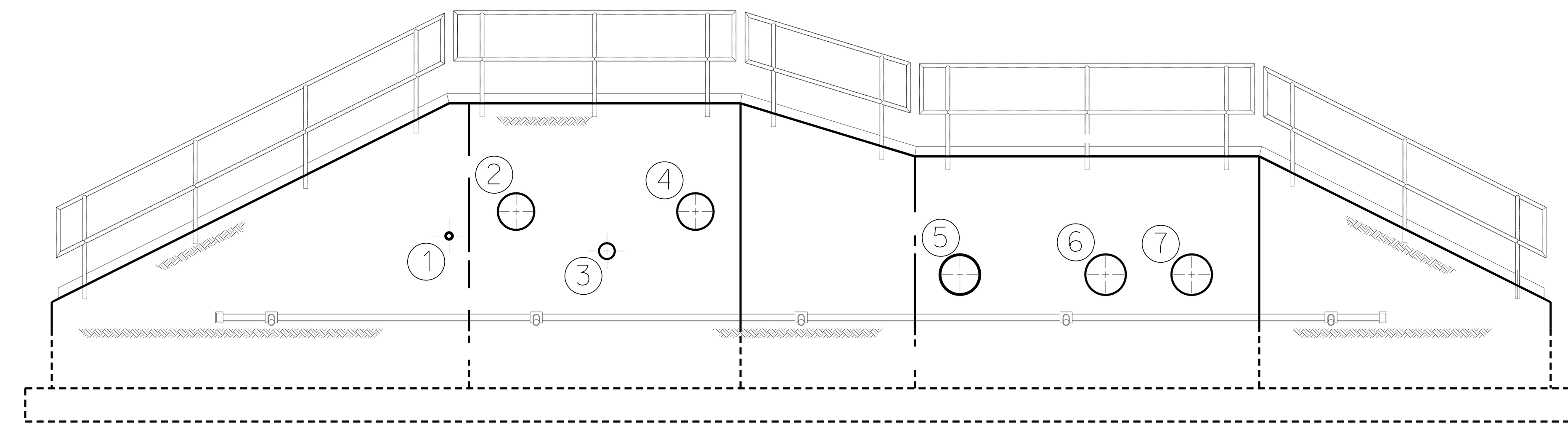
30x42

PROPOSED RECYCLE POND

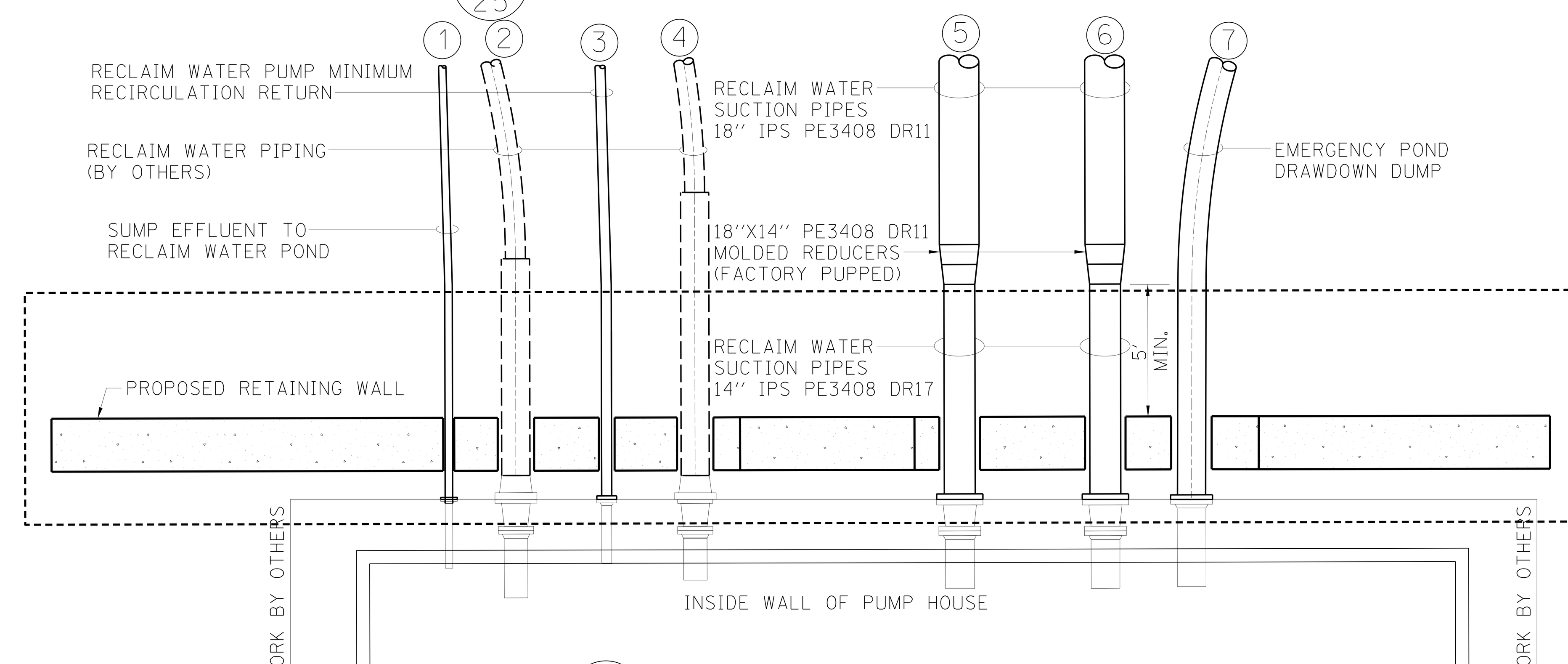


GENERAL NOTES:

1. ALL PIPING SHALL BE BUTT FUSED HDPE PIPE OF THE SAME TYPE, CLASS & SIZE SHOWN HEREON.
2. SEE AMEREN DRAWING SET C-10206, REV 1 FOR LOCATION OF THE WORK & INFORMATION REQUIRED FOR LAYOUT OF THE WORK (CONTROL POINTS, BENCHMARKS, ECT.)
3. THE EMERGENCY DRAWDOWN PIPE SHALL BE INSTALLED USING THE MANUFACTURERS RECOMMENDED BEND RADIUS. THE PIPE SHALL BE SLOPED TOWARD THE OUTFALL, PROVIDING POSITIVE DRAINAGE WHEN NOT IN USE.
4. DESIGN CONDITIONS LISTED FOR HANSON CONNECTION #3 ARE REDUCED FROM ACTUAL UPSTREAM PIPING DESIGN CONDITIONS BASED ON NO ISOLATION VALVES BEING INSTALLED IN HANSON PIPING. IF HANSON CHOOSES TO INSTALL MEANS OF SHUT OFF IN THIS PIPING THEN DESIGN CONDITIONS SHALL BE MATCHED TO THAT OF CONNECTIONS 2 & 4.



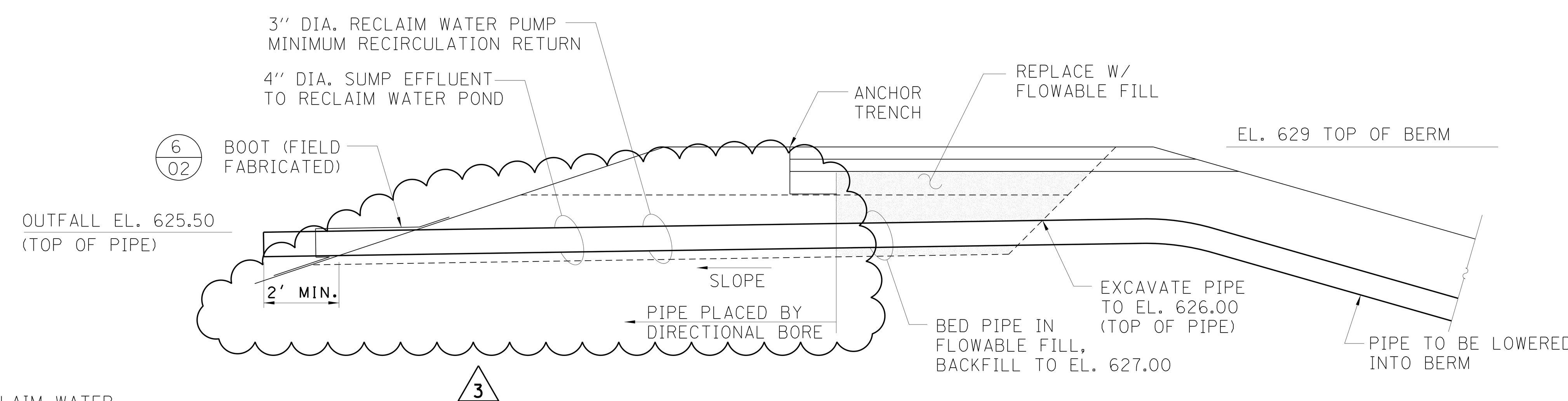
2/25 PIPE PENETRATIONS- ELEVATION VIEW



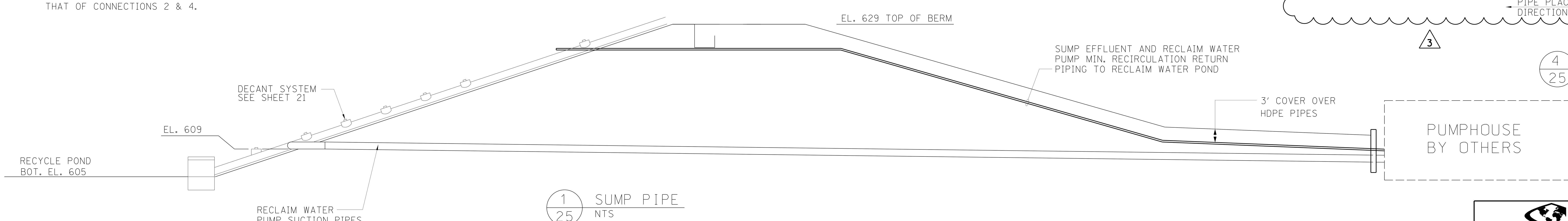
3/25 PUMP HOUSE CONNECTION DETAIL
NTS

CONNECTION #	PIPE DESCRIPTION	* DESIGN PRESSURE (psig)	* DESIGN TEMP. (DEG. F)	* MAX. OPERATING PRESSURE (psig)	* MAX. OPERATING TEMP . (DEG. F)	* FIELD TEST PRESSURE (psig)	DESCRIPTION OF EXISTING CONNECTION POINT	PROPOSED CONNECTION SPECIFICATION	PROPOSED CONNECTION LOCATION NORTHING	PROPOSED CONNECTION LOCATION EASTING	WALL PENETRATION SEAL
1	SUMP EFFLUENT TO RECLAIM WATER POND	50	100	40	95	75	3" FF FLANGE (ANSI B16.5 CLASS 150)	3" IPS PE3408 DR17 FLANGE ADAPTER w/ MARZOLF 2PC. BACKUP RING (T-316L S.S. - ANSI B16.5, CLASS 150)	874383.81	2516429.11	LINK-SEAL MODULAR SEAL, MODEL S-316 SIZED TO FIT PIPE THROUGH 8" DIA CAST OPENING
2, 4	RECLAIM WATER LINES (BY OTHERS)	148	100	141	100	222	12" FF FLANGE (ANSI B16.5 CLASS 150)	12" PE4710 DR11 FLANGE ADAPTER w/ MARZOLF 2PC. BACKUP RING (T-316L S.S. - ANSI B16.5, CLASS 150)	(2) 874386.34 (4) 874393.11	(2) 2516429.18 (4) 2516429.17	LINK-SEAL MODULAR SEAL, MODEL S-316 SIZED TO FIT PIPE THROUGH 16 1/2" DIA CAST OPENING
3	RECLAIM WATER PUMP MIN. RECIRCULATION RETURN	50 (NOTE 4)	100	40 (NOTE 4)	100	75	4" FF FLANGE (ANSI B16.5 CLASS 150)	4" IPS PE3408 DR17 FLANGE ADAPTER w/ MARZOLF 2PC. BACKUP RING (T-316L S.S. - ANSI B16.5, CLASS 150)	874389.77	2516429.17	LINK-SEAL MODULAR SEAL, MODEL S-316 SIZED TO FIT PIPE THROUGH 7 1/8" DIA CAST OPENING
5	RECLAIM WATER PUMP SUCTION #2	15	100	9	100	23	14" FF FLANGE (ANSI B16.5 CLASS 150)	14" IPS PE3408 DR17 FLANGE ADAPTER w/ MARZOLF 2PC. BACKUP RING (T-316L S.S. - ANSI B16.5, CLASS 150)	874403.11	2516429.15	LINK-SEAL MODULAR SEAL, MODEL S-316 SIZED TO FIT PIPE THROUGH 18 3/8" DIA CAST OPENING
6	RECLAIM WATER PUMP SUCTION #1	15	100	9	100	23	14" FF FLANGE (ANSI B16.5 CLASS 150)	14" IPS PE3408 DR17 FLANGE ADAPTER w/ MARZOLF 2PC. BACKUP RING (T-316L S.S. - ANSI B16.5, CLASS 150)	874408.61	2516429.14	LINK-SEAL MODULAR SEAL, MODEL S-316 SIZED TO FIT PIPE THROUGH 18 3/8" DIA CAST OPENING
7	EMERGENCY POND DRAWDOWN DUMP	15	100	9	100	23	12" FF FLANGE (ANSI B16.5 CLASS 150)	12" IPS PE3408 DR17 FLANGE ADAPTER w/ MARZOLF 2PC. BACKUP RING (T-316L S.S. - ANSI B16.5, CLASS 150)	874411.86	2516429.13	LINK-SEAL MODULAR SEAL, MODEL S-316 SIZED TO FIT PIPE THROUGH 16 1/2" DIA CAST OPENING

NOTE: PRESSURE/TEMPERATURE RATINGS PER AMEREN DRAWING M-10113, SHT. 1, REV. OG, DATED 01-08-08
NOTE: CONNECTION @ TERMINATION POINTS TO BE COMPLETED BY OTHERS.



4/25 PIPE FREEZE PROTECTION
NTS



1/25 SUMP PIPE
NTS

SCALE: 1" = 20'

HANSON
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1525 South Sixth Street
Springfield, Illinois 62703-2886
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Illinois Licensed Professional Service Corporation #184-001084

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REFERENCE DRAWINGS
C-10207 LANDFILL PLANS
C-10211 LANDFILL ACCEPTANCE PLANS
C-10212 GYPSUM STACK ACCEPTANCE PLANS
E-10850 SUBDRAINAGE POWER PLANS
E-10855 LEACHATE COLLECTION POWER PLANS

REV.	DATE	PROJECT NO.	AMEREN SUPV. ENGR	DRAFTING DRFTR	DRAFTING CHK'D	ENGR APPROVAL SUPV	AMEREN	OTHER	DESCRIPTION
3	12-22-10	-	-	TCJ	-	-	-	-	RECORD DRAWING

RECYCLE POND
PUMP HOUSE CONNECTION
CONSTRUCTION DOCUMENTS
CCB MANAGEMENT FACILITY

SITE: COFFEEN

SCALE / LOC. NO. / CLASS

Ameren Energy Generating

DRAWING NO. C-10206 REV. 3
SHEET NO. 25

C-10206 SHEET NO. 25

30x42

GENERAL NOTES:

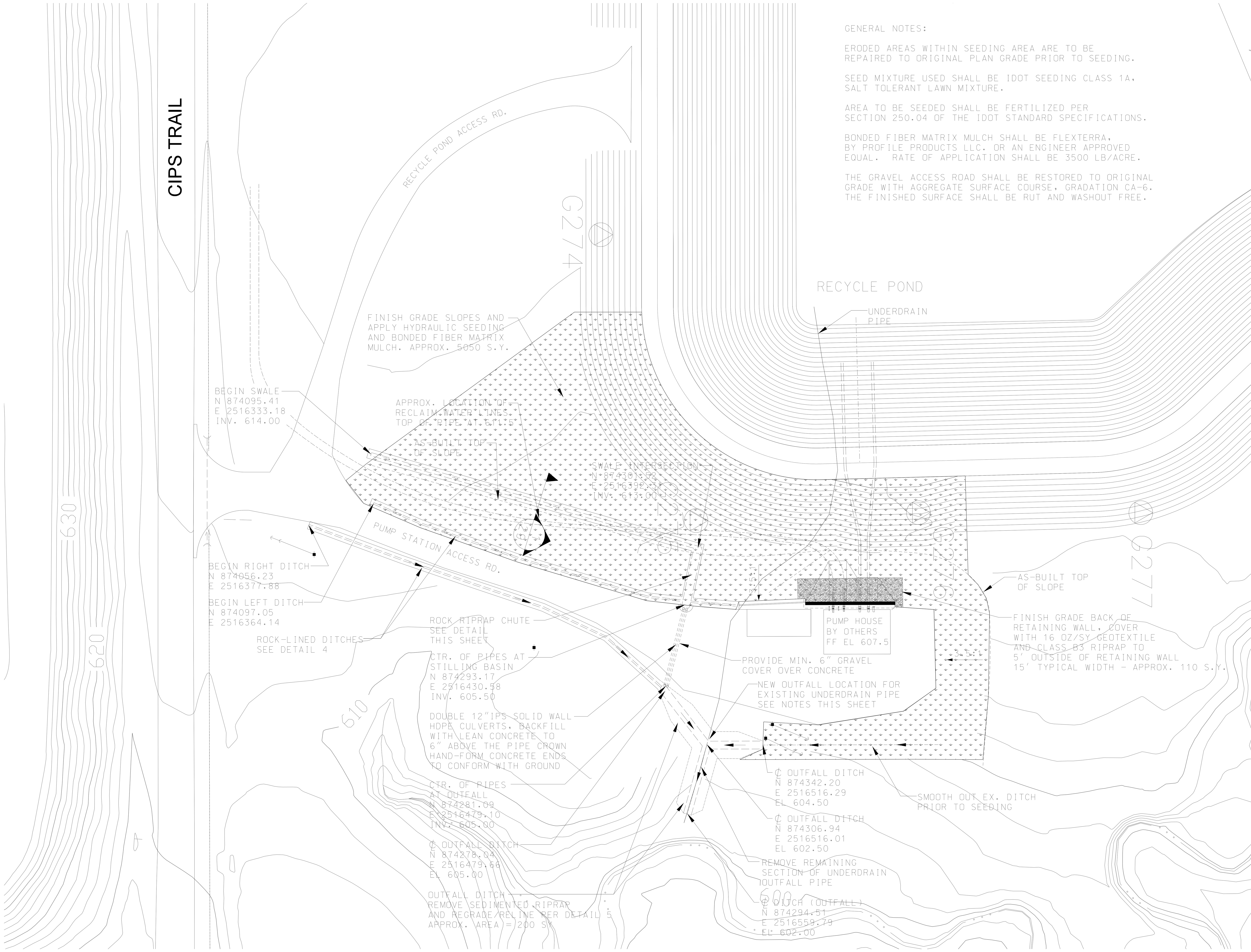
ERODED AREAS WITHIN SEEDING AREA ARE TO BE REPAIRED TO ORIGINAL PLAN GRADE PRIOR TO SEEDING.

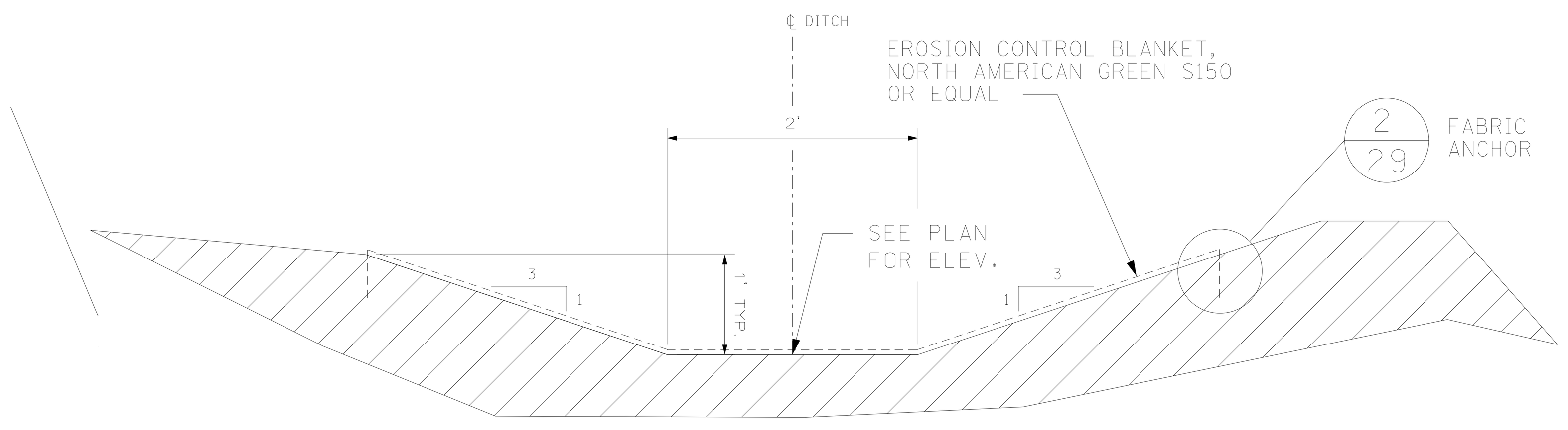
SEED MIXTURE USED SHALL BE IDOT SEEDING CLASS 1A. SALT TOLERANT LAWN MIXTURE.

AREA TO BE SEEDED SHALL BE FERTILIZED PER SECTION 250.04 OF THE IDOT STANDARD SPECIFICATIONS.

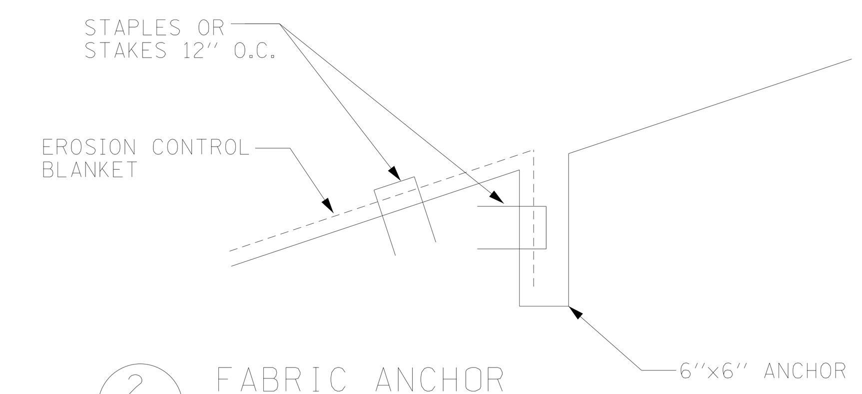
BONDED FIBER MATRIX MULCH SHALL BE FLEXTERRA. BY PROFILE PRODUCTS LLC. OR AN ENGINEER APPROVED EQUAL. RATE OF APPLICATION SHALL BE 3500 LB/ACRE.

THE GRAVEL ACCESS ROAD SHALL BE RESTORED TO ORIGINAL GRADE WITH AGGREGATE SURFACE COURSE, GRADATION CA-6. THE FINISHED SURFACE SHALL BE RUT AND WASHOUT FREE.

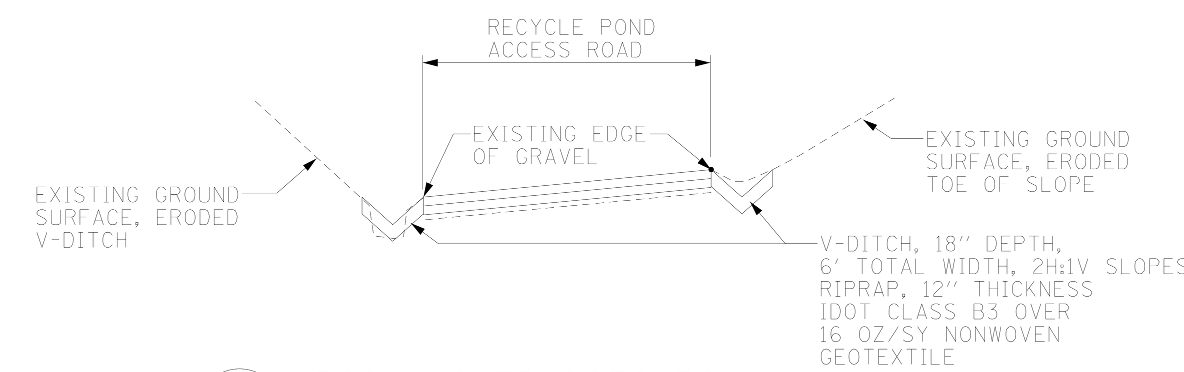




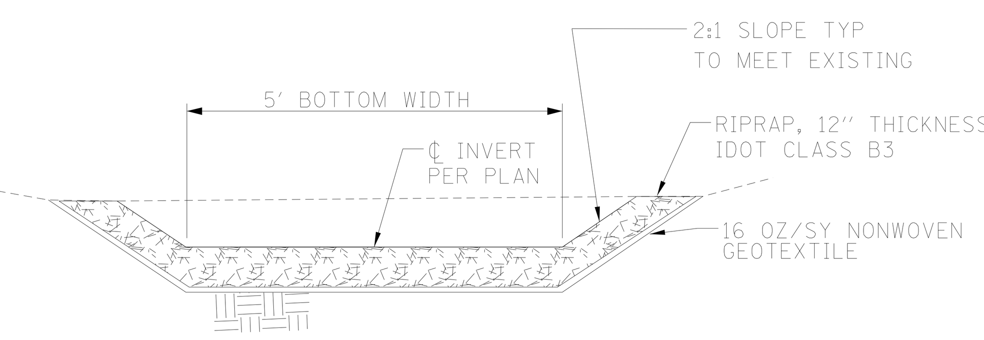
1/29 TYPICAL SWALE SECTION
NTS



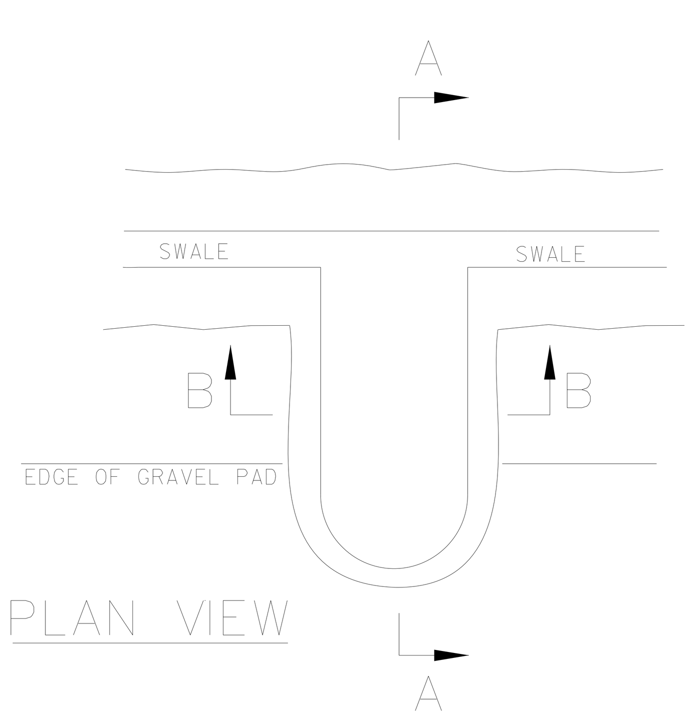
2/29 FABRIC ANCHOR
NTS



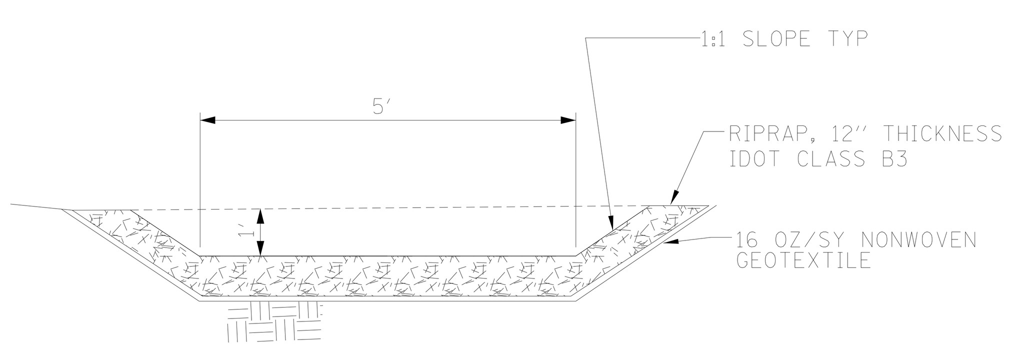
4/29 ROCK-LINED DITCHES
NTS



5/29 OUTFALL DITCH
NTS

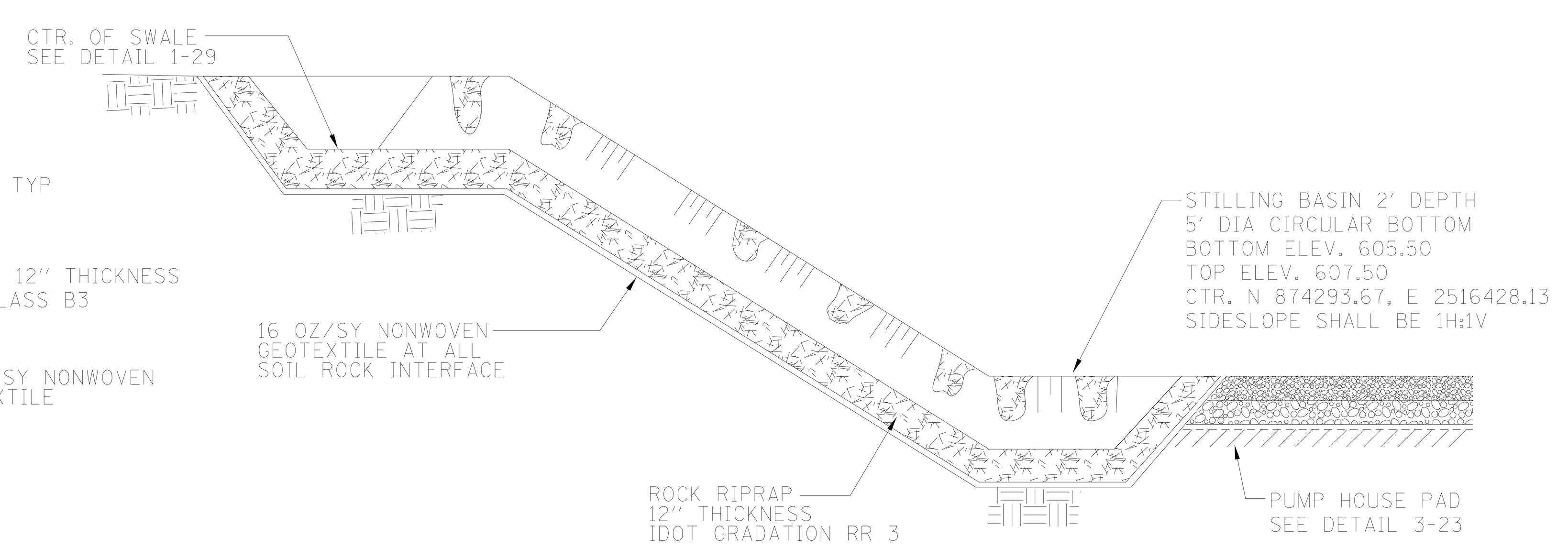


PLAN VIEW



SECTION B-B

3/29 ROCK RIPRAP CHUTE
NTS



SECTION A-A PROFILE CENTERLINE

N

0' 30' 60'
SCALE: 1" = 30'

Hanson Professional Services Inc.
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DRAWING RECORD

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
1	12-27-10	-	-	TCJ			-		RECORD DRAWING

RECYCLE POND - PUMPHOUSE PERMANENT EROSION CONTROL CONSTRUCTION DOCUMENTS CCB MANAGEMENT FACILITY

SITE: COFFEEN

SCALE
LOC. NO.
CLASS

AmerenEnergy Generating

DRAWING NO. C-10206 REV. 1
SHEET NO. 29

LAYOUT	DBH	10-08-07
DRAWN	SKB	04-02-09
REVIEWED		

SHEET NO. 23
C-10206

30x42

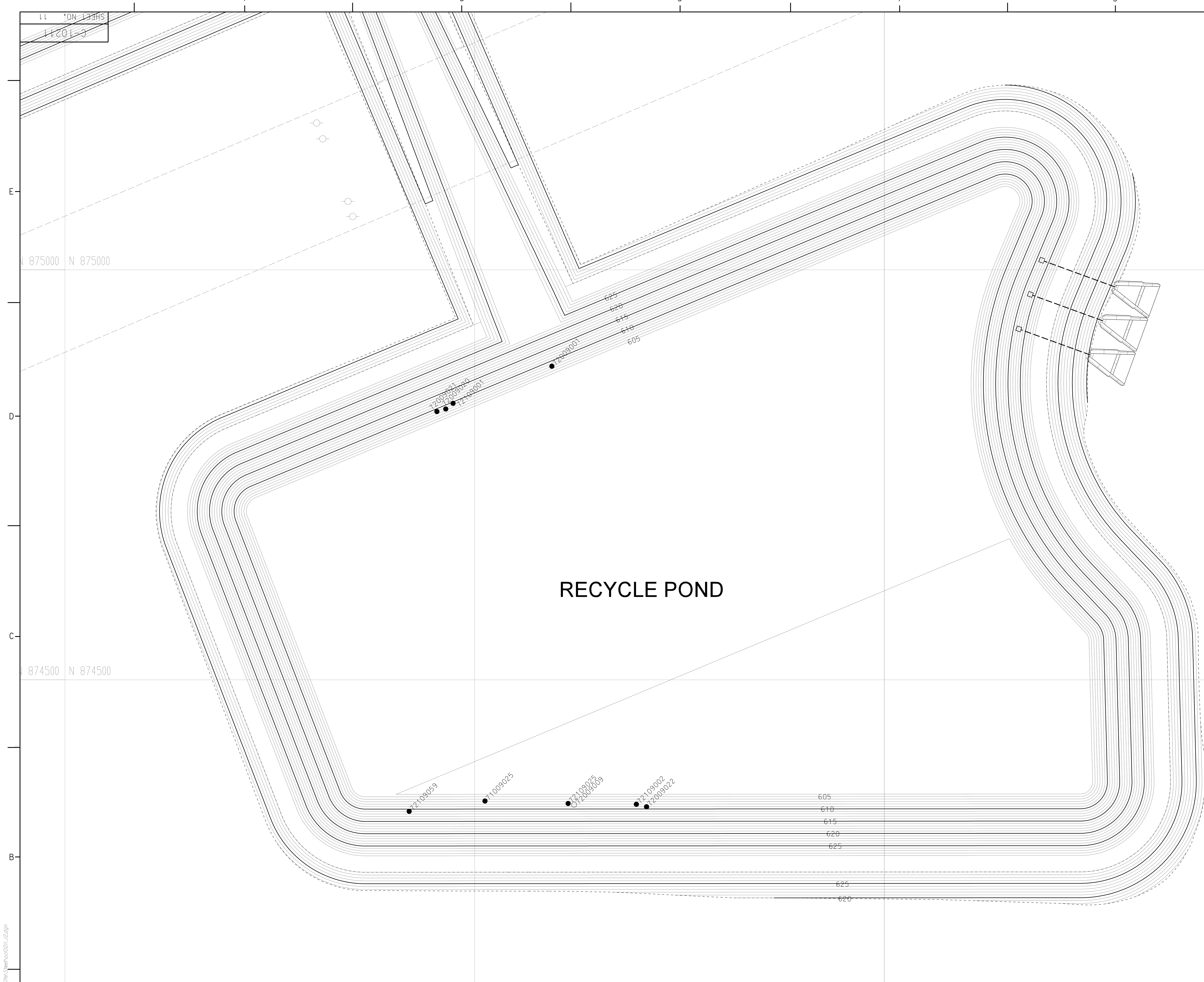
Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

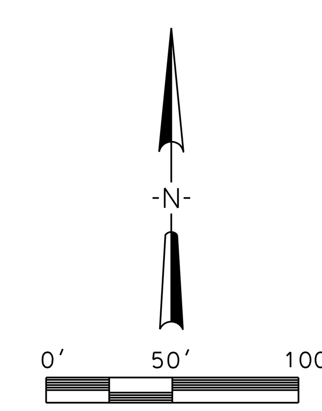
Appendix 2

Soil Data



LEGEND

- ● TROXLER TEST LOCATION – MEETS CRITERIA
- ⊕ TROXLER TEST LOCATION – FIELD APPROVED
- ○ TROXLER TEST LOCATION – DOES NOT MEET CRITERIA



SCALE: 1" = 50'

HANSON

NOTICE OF LIMITED RESPONSIBILITY

NOTES	REFERENCE DRAWINGS
	SEE DRAWING NUMBER C-10206 FOR GYPSUM STACK PLANS

DRAWING RECORD									
REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	CHK'D	SUPV	ENGR APPROVAL AMEREN	OTHER	DESCRIPTION
–	–	–	–	–	–	–	–	–	-

RECYCLE POND FOUNDATION COMPACTION TESTING

CCB MANAGEMENT FACILITY

SITE: COFFEEN

Ameren Energy Generating

DRAWING NO. C-10211 REV. A

SHEET NO. 12

LAYOUT	RLT	07/14/09
DRAWN	JDE	11/24/10
REVIEWED	TLW	11/24/10

30x42

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NOTES

REFERENCE DRAWINGS

SEE DRAWING NUMBER C-10206 FOR GYPSUM STACK PLANS

REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
-	-	-	-	-	-	-	-	-	-

SCALE: -

LOC. NO.: -

CLASS: -

RECYCLE POND BERM COMPACTION TESTING

CCB MANAGEMENT FACILITY

SITE: COFFEEN

Ameren Energy Generating

DRAWING NO.	REV.
C-10211	A

SHEET NO. 11

LAYOUT	RLT	07/14/09
DRAWN	JOE	11/24/10
REVIEWED	TLW	11/24/10

30x42

COFFEEN - TROXLER COMPACTION/MOISTURE TESTING - RECYCLE POND STRUCTURAL FILL

Date	Atlas Soils Test No.	Survey Point No.	Northing	Easting	Elevation	Percent Compaction (95% min.)	Pass / Fail	Percent Moisture (-2 to +2%)	Pass / Fail	Proctor Max. Dry Density (pcf)	Optimum Moisture Content (%)	Penetrometer (0.5 tsf min.)	Lift	Comments
8/20/2008	1	82008159	874439.1	2515234.8	622.5	87.5	Fail	21.3	Fail	116.2	13.6		1	RP - W Embankment
8/20/2008	2	82008160	874558.4	2515172.6	622.0	87.9	Fail	21.0	Fail	116.2	13.6		1	RP - W Embankment
8/20/2008	3	82008161	874540.3	2515157.1	622.3	85.9	Fail	19.5	Fail	116.2	13.6		-	RP - W Embankment - Existing Ground
8/20/2008	4	82008162	874267.1	2515604.6	622.6	82.6	Fail	27.6	Fail	116.2	13.6		2	RP - S Embankment
8/27/2008	4	82708177	874277.7	2516006.6	619.1	94.3	Fail	22.4	Fail	106.7	16.9		3	RP - S Embankment
8/27/2008	5	82708178	874302.0	2516007.9	618.8	86.9	Fail	27.4	Fail	106.7	16.9		3	RP - S Embankment
8/27/2008	6	82708179	874297.8	2515881.8	619.7	87.6	Fail	29.0	Fail	106.7	16.9		3	RP - S Embankment
8/27/2008	7	82708180	874274.0	2515897.8	620.0	94.0	Fail	22.8	Fail	106.7	16.9		3	RP - S Embankment
8/27/2008	9	82708182	874279.4	2515806.5	620.3	92.0	Fail	23.7	Fail	106.7	16.9		3	RP - S Embankment
8/27/2008	10	82708183	874519.3	2515194.8	622.6	101.8	Pass	18.2	Pass	106.7	16.9		3	RP - W Embankment
8/27/2008	11	82708184	874851.7	2515338.3	623.5	89.3	Fail	27.9	Fail	106.7	16.9		3	RP - N Embankment
8/27/2008	12	82708185	874921.1	2515445.7	623.9	96.1	Pass	22.3	Fail	106.7	16.9		3	RP - N Embankment
8/28/2008	13	82808192	875020.9	2515724.2	623.5	96.4	Pass	18.3	Pass	106.7	16.9		4	RP - N Embankment
8/28/2008	14	82808193	874760.0	2515163.4	623.6	103.2	Pass	17.7	Pass	106.7	16.9		4	RP - NW Corner Embankment
8/28/2008	15	82808194	874457.5	2515236.0	623.4	104.8	Pass	15.8	Pass	106.7	16.9		4	RP - W Embankment
8/29/2008	16	82908201	874286.5	2515462.0	623.9	99.8	Pass	20.4	Fail	106.7	16.9			RP - S Embankment
8/29/2008	18	82908203	874256.4	2516181.5	618.2	95.6	Pass	23.2	Fail	106.7	16.9			RP - S Embankment
8/29/2008	19	82908204	874284.8	2516183.1	618.2	96.0	Pass	22.6	Fail	106.7	16.9			RP - S Embankment
9/2/2008	27	90208221	874865.2	2515330.7	624.9	100.2	Pass	19.9	Fail	106.7	16.9			RP - N Berm
9/2/2008	28	90208222	874408.5	2515229.8	623.8	100.0	Pass	19.6	Fail	106.7	16.9			RP - W Berm
9/23/2008	29	No survey information available.			at grade	105.9	Pass	18.1	Pass	104.1	18.6			E of RP *(test location marked on map with DIR)
9/23/2008	30				at grade	105.1	Pass	18.4	Pass	104.1	18.6			E of RP *(test location marked on map with DIR)
9/24/2008	31	92408718	874276.3	2515679.5	621.4	104.6	Pass	14.6	Fail	104.1	18.6			RP - S Berm (there is an anomaly with the Easting; Atlas' documented Easting in the CQA Report is reported here but the surveyed Easting is 2516179.456)
9/24/2008	32	92408719	874800.7	2515207.9	626.7	108.3	Pass	16.6	Pass	104.1	18.6			RP - N Berm
9/25/2008	33	92508881	874283.3	2515605.8	626.9	105.2	Pass	17.1	Pass	106.7	16.9			RP - S Berm
9/25/2008	34	92508882	874580.2	2515180.1	627.6	98.7	Pass	21.0	Fail	106.7	16.9			RP - W Berm - Reprocessed
9/26/2008	36	No survey information available.				105.5	Pass	18.4	Pass	104.1	18.6			RP - N Berm *(test location marked on map with DIR) - Proctor changed/approved by CQAO in field
9/26/2008	37					103.7	Pass	19.4	Pass	104.1	18.6			RP - N Berm *(test location marked on map with DIR) - Proctor changed/approved by CQAO in field
9/26/2008	38					101.0	Pass	18.8	Pass	104.1	18.6			RP - W Berm *(test location marked on map with DIR) - Proctor changed/approved by CQAO in field
10/6/2008	44	100608954	874667.7	2516260.2	626.7	104.5	Pass	16.2	Pass	108.8	17.3			RP - E Berm *(test location marked on map with DIR)
10/6/2008	45	100608955	875163.9	2516098.2	626.7	102.5	Pass	14.6	Fail	108.8	17.3			RP - N Berm *(test location marked on map with DIR)
10/23/2008	57	1023081672	874607.9	2516310.1	629.0	99.6	Pass	22.0	Fail	106.7	16.9			RP - E Berm - Subgrade - Reprocess
5/6/2009	75	No survey information available.				96.2	Pass	19.7	Fail	108.8	17.3			RP - Trench for 6" pipe connected to interior toe drains See Retest 77 - Field Approved
5/7/2009	76					94.7	Fail	18.3	Pass	108.8	17.3			RP - Trench for 6" pipe connected to interior toe drains See Retest 77 - Field Approved
5/7/2009	77					98.3	Pass	16.4	Pass	108.8	17.3			RP - Trench for 6" pipe connected to interior toe drains Retest of 75 & 76
5/19/2009	83	519093023	874385.3	2516311.2	607.6	93.0	Fail	21.2	Fail	108.8	17.3			RP - Suction Trench Berm Backfill See Retest 90
5/19/2009	85	519093024	874382.5	2516277.7	607.5	95.7	Pass	19.6	Fail	108.8	17.3			RP - Suction Trench Berm Backfill See Retest 90

COFFEEN - TROXLER COMPACTION/MOISTURE TESTING - RECYCLE POND STRUCTURAL FILL														
Date	Atlas Soils Test No.	Survey Point No.	Northing	Easting	Elevation	Percent Compaction (95% min.)	Pass / Fail	Percent Moisture (-2 to +2%)	Pass / Fail	Proctor Max. Dry Density (pcf)	Optimum Moisture Content (%)	Penetrometer (0.5 tsf min.)	Lift	Comments
5/19/2009	86	No survey information available.				93.2	Fail	16.2	Pass	108.8	17.3			RP - Suction Trench Berm Backfill See Retest 90
5/19/2009	90	519093029	874380.4	2516297.3	607.2	98.1	Pass	15.7	Pass	108.8	17.3			RP - Suction Trench Berm Backfill Retest of 83, 85 & 86
5/19/2009	94	No survey information available.				94.1	Fail	21.2	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 95
5/20/2009	95	520093114	874383.8	2516324.9	608.2	96.9	Pass	17.8	Pass	108.8	17.3			RP - Suction Trench Backfill Retest of 94
5/20/2009	100	520093128	874435.3	2516323.6	606.2	98.5	Pass	19.8	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 110
5/20/2009	101	520093129	874437.7	2516314.6	606.2	98.5	Pass	19.5	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 110
5/20/2009	102	520093130	874417.1	2516308.9	606.7	100.4	Pass	19.1	Pass	108.8	17.3			RP - Suction Trench Backfill
5/20/2009	103	520093131	874418.6	2516280.9	606.0	96.1	Pass	19.3	Pass	108.8	17.3			RP - Suction Trench Backfill
5/20/2009	104	520093132	874461.7	2516292.3	605.3	96.1	Pass	19.7	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 110
5/20/2009	105	520093133	874425.4	2516339.2	607.0	97.8	Pass	17.5	Pass	108.8	17.3			RP - Suction Trench Backfill
5/20/2009	110	520093145	874470.9	2516283.0	605.5	99.0	Pass	19.0	Pass	108.8	17.3			RP - Suction Trench Backfill Retest of 100, 101 & 104
5/20/2009	111	520093146	874419.4	2516288.7	607.2	97.2	Pass	20.5	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 112
5/20/2009	112	520093147	874418.0	2516278.7	606.7	99.7	Pass	17.9	Pass	108.8	17.3			RP - Suction Trench Backfill Retest of 111
5/21/2009	117	521093175	874469.2	2516287.9	607.0	96.8	Pass	21.3	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 118
5/21/2009	118	521093176	874476.1	2516276.4	606.6	98.5	Pass	18.4	Pass	108.8	17.3			RP - Suction Trench Backfill Retest of 117
5/21/2009	123	521093181	874477.5	2516279.6	607.0	99.0	Pass	18.8	Pass	108.8	17.3			RP - Suction Trench Backfill
5/21/2009	124	521093182	874487.8	2516269.3	606.9	96.6	Pass	18.6	Pass	108.8	17.3			RP - Suction Trench Backfill
5/21/2009	129	521093202	874466.7	2516281.9	609.0	95.1	Pass	19.9	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 131
5/21/2009	130	521093203	874477.4	2516274.7	608.6	96.2	Pass	19.7	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 131
5/21/2009	131	521093227	874467.6	2516291.1	608.8	96.0	Pass	19.3	Pass	108.8	17.3			RP - Suction Trench Backfill Retest of 129 & 130
5/22/2009	136	522093251	874412.7	2516332.6	609.7	96.2	Pass	20.9	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 145
5/22/2009	137	522093252	874459.0	2516294.1	609.4	98.4	Pass	19.4	Fail	108.8	17.3			RP - Suction Trench Backfill See Retest 150
6/1/2009	145	0601093281	874402.3	2516313.2	610.6	99.9	Pass	15.4	Pass	108.8	17.3		3	RP - E Berm Suction Pipe Backfill Retest of 136
6/1/2009	146	0601093282	874451.3	2516299.7	609.7	92.0	Fail	21.2	Fail	108.8	17.3		2	RP - E Berm Suction Pipe Backfill See Retest 150
6/1/2009	147	0601093283	874377.6	2516323.0	609.4	94.0	Fail	21.9	Fail	108.8	17.3		1	RP - E Berm Suction Pipe Backfill See Retest 148
6/1/2009	148	0601093284	874377.8	2516319.7	609.4	89.5	Fail	25.1	Fail	108.8	17.3		1	RP - E Berm Suction Pipe Backfill Retest of 147 - See Retest 149
6/1/2009	149	0601093285	874375.7	2516314.5	609.5	95.7	Pass	17.2	Pass	108.8	17.3		1	RP - E Berm Suction Pipe Backfill Retest of 148
6/1/2009	150	0601093286	874453.8	2516301.3	609.7	98.9	Pass	16.2	Pass	108.8	17.3		2	RP - E Berm Suction Pipe Backfill Retest of 137 & 146
6/1/2009	151	0601093287	874376.8	2516317.8	610.1	95.9	Pass	20.2	Fail	108.8	17.3		2	RP - E Berm Suction Pipe Backfill See Retest 152
6/1/2009	152	0601093288	874377.0	2516326.3	610.3	93.7	Fail	21.4	Fail	108.8	17.3		2	RP - E Berm Suction Pipe Backfill Retest of 151 - See Retest 153
6/2/2009	153	0602093293	874378.4	2516314.6	610.1	93.6	Fail	20.5	Fail	108.8	17.3		2	RP - E Berm Suction Pipe Backfill Retest of 152 - See Retest 155

COFFEEN - TROXLER COMPACTION/MOISTURE TESTING - RECYCLE POND STRUCTURAL FILL														
Date	Atlas Soils Test No.	Survey Point No.	Northing	Easting	Elevation	Percent Compaction (95% min.)	Pass / Fail	Percent Moisture (-2 to +2%)	Pass / Fail	Proctor Max. Dry Density (pcf)	Optimum Moisture Content (%)	Penetrometer (0.5 tsf min.)	Lift	Comments
6/2/2009	154	0602093294	874459.6	2516299.9	610.5	90.3	Fail	23.4	Fail	108.8	17.3		3	RP - E Berm Suction Pipe Backfill See Retest 156
6/5/2009	155	060509501	874380.7	2516315.9	609.9	95.0	Pass	19.1	Pass	108.8	17.3	0.75	2	RP - E Berm Suction Pipe Backfill Retest of 153
6/5/2009	156	060509502	874449.2	2516295.0	610.2	95.4	Pass	19.6	Fail	108.8	17.3	1.25	3	RP - E Berm Suction Pipe Backfill Retest of 154 - See Retest 158
6/5/2009	157	060509521	874374.8	2516313.3	611.1	96.5	Pass	16.8	Pass	108.8	17.3	1.0	3	RP - E Berm Suction Pipe Backfill
6/5/2009	158	060509520	874447.6	2516305.2	610.3	96.0	Pass	18.1	Pass	108.8	17.3	1.25	3	RP - E Berm Suction Pipe Backfill Retest of 156
6/9/2009	159	060909501	874920.9	2516161.5	612.8	96.3	Pass	21.3	Fail	108.8	17.3	1.25	1	RP - E Berm Emergency Spillway S Structure Field Approved
6/9/2009	160	060909502	874935.3	2516165.5	612.0	99.8	Pass	18.3	Pass	108.8	17.3	1.5	2	RP - E Berm Emergency Spillway S Structure
6/9/2009	161	060909503	874963.6	2516176.1	613.2	96.7	Pass	20.7	Fail	108.8	17.3	1.5	1	RP - E Berm Emergency Spillway Middle Structure See Retest 167
6/9/2009	162	060909504	874976.2	2516180.5	612.0	100.0	Pass	15.0	Fail	108.8	17.3	2.5	2	RP - E Berm Emergency Spillway Middle Structure See Retest 165
6/9/2009	163	060909505	875017.8	2516196.7	612.9	98.4	Pass	16.7	Pass	111.7	16.0	2.0	1	RP - E Berm Emergency Spillway N Structure
6/9/2009	164	060909506	874430.3	2516316.8	611.2	99.3	Pass	18.7	Pass	108.8	17.3	1.75	4	RP - Suction Pipe Backfill
6/9/2009	165	060909507	874975.3	2516179.9	612.8	96.9	Pass	19.3	Pass	108.8	17.3	1.5	2	RP - E Berm Emergency Spillway Middle Structure Retest of 162
6/9/2009	166	060909508	874964.7	2516175.3	614.1	94.1	Fail	16.7	Pass	108.8	17.3	2.5	2	RP - E Berm Emergency Spillway Middle Structure See Retest 167
6/9/2009	167	060909509	874964.1	2516175.5	613.6	97.9	Pass	17.4	Pass	108.8	17.3	2.5	2	RP - E Berm Emergency Spillway Middle Structure Retest of 161 and 166
6/9/2009	168	060909510	874422.6	2516309.6	611.6	98.9	Pass	17.0	Pass	108.8	17.3	1.25	5	RP - Suction Pipe Backfill
6/9/2009	169	060909511	874933.8	2516165.4	614.3	94.8	Fail	12.2	Fail	108.8	17.3	1.5	3	RP - E Berm Emergency Spillway S Structure See Retest 170
6/9/2009	170	060909512	874914.3	2516210.7	614.3	100.0	Pass	15.5	Pass	108.8	17.3	1.75	3	RP - E Berm Emergency Spillway S Structure Retest of 169
6/9/2009	175	060909517	874963.4	2516178.0	614.4	100.1	Pass	16.3	Pass	108.8	17.3	2.5	3	RP - E Berm Emergency Spillway Middle Structure
6/9/2009	176	060909518	874975.1	2516182.4	614.2	97.8	Pass	18.6	Pass	108.8	17.3	1.8	3	RP - E Berm Emergency Spillway Middle Structure
6/9/2009	177	060909519	875007.0	2516190.2	612.4	96.5	Pass	17.7	Pass	108.8	17.3	2.0	1	RP - E Berm Emergency Spillway N Structure
6/9/2009	178	060909520	875017.9	2516196.0	612.7	98.0	Pass	17.3	Pass	108.8	17.3	2.0	1	RP - E Berm Emergency Spillway N Structure
6/10/2009	187	061009508	874414.0	2516310.2	612.4	98.1	Pass	17.4	Pass	108.8	17.3	1.25	6	RP - Suction Pipe Backfill
6/10/2009	188	061009511	875006.0	2516192.5	613.7	97.9	Pass	17.7	Pass	108.8	17.3	1.75	2	RP - E Berm Emergency Spillway Discharge Pipe N Structure Backfill
6/10/2009	193	061009514	874919.5	2516196.1	616.9	95.1	Pass	15.4	Pass	108.8	17.3	2.0	4	RP - E Berm Emergency Spillway Discharge Pipe S Structure Backfill
6/10/2009	194	061009515	874911.5	2516199.5	616.4	98.6	Pass	19.2	Pass	108.8	17.3	2.0	4	RP - E Berm Emergency Spillway Discharge Pipe S Structure Backfill
6/10/2009	203	061009524	874975.4	2516179.7	615.1	95.4	Pass	18.6	Pass	108.8	17.3	1.75	3	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill

COFFEEN - TROXLER COMPACTION/MOISTURE TESTING - RECYCLE POND STRUCTURAL FILL

Date	Atlas Soils Test No.	Survey Point No.	Northing	Easting	Elevation	Percent Compaction (95% min.)	Pass / Fail	Percent Moisture (-2 to +2%)	Pass / Fail	Proctor Max. Dry Density (pcf)	Optimum Moisture Content (%)	Penetrometer (0.5 tsf min.)	Lift	Comments
6/10/2009	204	061009525	874976.3	2516169.5	614.5	96.4	Pass	19.6	Fail	108.8	17.3	1.25	3	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill Field Approved
6/10/2009	205	061009526	875010.6	2516198.7	613.8	100.4	Pass	16.2	Pass	108.8	17.3	2.0	3	RP - E Berm Emergency Spillway Discharge Pipe N Structure Backfill
6/12/2009	218	061209011	874954.3	2516230.1	615.8	97.1	Pass	18.2	Pass	108.8	17.3		4	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill
6/12/2009	219	061209012	874956.4	2516205.2	616.7	98.5	Pass	17.3	Pass	108.8	17.3		4	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill
6/18/2009	231	061809112	874992.3	2516235.3	617.1	99.6	Pass	17.5	Pass	108.8	17.3	1.75	5	RP - E Berm Emergency Spillway Discharge Pipe N Structure Backfill
6/18/2009	232	061809113	874956.8	2516226.4	617.7	103.6	Pass	17.4	Pass	108.8	17.3	1.0	5	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill
6/18/2009	233	061809114	874953.4	2516209.8	617.8	98.0	Pass	18.6	Pass	108.8	17.3	2.0	5	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill
6/18/2009	234	061809115	875001.9	2516229.3	617.7	95.7	Pass	18.7	Pass	108.8	17.3	1.5	5	RP - E Berm Emergency Spillway Discharge Pipe N Structure Backfill
6/18/2009	235	061809116	874954.0	2516158.4	614.8	101.8	Pass	18.6	Pass	108.8	17.3	1.75	1	RP - E Berm Emergency Spillway Middle Structure Backfill
6/19/2009	237	061909001	874962.5	2516207.4	618.5	95.8	Pass	17.4	Pass	108.8	17.3	1.5	6	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill
6/19/2009	238	061909002	874945.7	2516216.5	617.7	97.6	Pass	20.8	Fail	108.8	17.3	2.0	6	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill See Retest 245
6/19/2009	239	061909003	874918.0	2516203.8	617.7	97.0	Pass	16.7	Pass	111.7	16.0	2.25	5	RP - E Berm Emergency Spillway Discharge Pipe S Structure Backfill
6/19/2009	240	061909004	874999.9	2516218.0	618.2	88.2	Fail	21.3	Fail	111.7	16.0	1.25	6	RP - E Berm Emergency Spillway Discharge Pipe N Structure Backfill See Retest 246
6/19/2009	241	061909005	875004.1	2516223.4	618.3	95.8	Pass	17.2	Pass	111.7	16.0	1.5	6	RP - E Berm Emergency Spillway Discharge Pipe N Structure Backfill
6/19/2009	242	061909006	874910.1	2516201.9	617.6	102.9	Pass	15.1	Pass	111.7	16.0	2.0	5	RP - E Berm Emergency Spillway Discharge Pipe S Structure Backfill
6/19/2009	243	061909015	874916.0	2516201.8	618.2	95.4	Pass	18.5	Fail	111.7	16.0	1.75	6	RP - E Berm Emergency Spillway Discharge Pipe S Structure Backfill See Retest 248
6/19/2009	244	061909016	874908.8	2516203.7	618.2	95.7	Pass	18.5	Fail	111.7	16.0	2.0	6	RP - E Berm Emergency Spillway Discharge Pipe S Structure Backfill See Retest 249
6/19/2009	245	061909017	874953.7	2516211.4	617.8	99.1	Pass	15.4	Pass	111.7	16.0	2.0	6	RP - E Berm Emergency Spillway Discharge Pipe Middle Structure Backfill Retest of 238
6/19/2009	246	061909018	874996.0	2516229.8	618.3	100.2	Pass	14.8	Pass	111.7	16.0		6	RP - E Berm Emergency Spillway Discharge Pipe N Structure Backfill Retest of 240
6/19/2009	247	061909019	874405.7	2516317.2	615.3	87.0	Fail	25.9	Fail	108.8	17.3		7	RP - E Berm Suction Pipe Backfill See Retest 259
6/19/2009	248	061909020	874908.1	2516226.7	618.1	96.9	Pass	17.8	Pass	111.7	16.0	1.5	6	RP - E Berm Emergency Spillway Discharge Pipe S Structure Backfill Retest of 243
6/19/2009	249	061909021	874903.7	2516220.5	618.0	99.0	Pass	16.8	Pass	111.7	16.0	3.0	6	RP - E Berm Emergency Spillway Discharge Pipe S Structure Backfill Retest of 244
6/22/2009	255	062209002	874958.6	2516235.1	619.1	96.8	Pass	15.6	Pass	111.7	16.0	1.25	7	RP - E Berm Emergency Spillway Discharge Pipe Backfill
6/22/2009	256	062209003	874961.2	2516232.4	620.4	101.9	Pass	17.2	Pass	111.7	16.0	1.75	8	RP - E Berm Emergency Spillway Discharge Pipe Backfill

COFFEEN - TROXLER COMPACTION/MOISTURE TESTING - RECYCLE POND STRUCTURAL FILL														
Date	Atlas Soils Test No.	Survey Point No.	Northing	Easting	Elevation	Percent Compaction (95% min.)	Pass / Fail	Percent Moisture (-2 to +2%)	Pass / Fail	Proctor Max. Dry Density (pcf)	Optimum Moisture Content (%)	Penetrometer (0.5 tsf min.)	Lift	Comments
6/22/2009	257	062209004	874989.2	2516172.3	615.1	95.7	Pass	17.7	Pass	111.7	16.0	1.5	2	RP - E Berm Emergency Spillway Discharge Pipe Backfill
6/23/2009	258	062309001	874958.1	2516226.5	621.5	99.2	Pass	17.8	Pass	111.7	16.0	1.75	9	RP - E Berm Emergency Spillway Discharge Pipe Backfill
6/23/2009	259	062309002	874415.5	2516322.8	615.4	90.3	Fail	24.2	Fail	108.8	17.3	0.25	7	RP - E Berm Suction Pipe Backfill Retest of 247 - See Retest 268
6/23/2009	260	062309003	874965.2	2516227.7	622.2	98.9	Pass	17.4	Pass	111.7	16.0	1.25	10	RP - E Berm Emergency Spillway Discharge Pipe Backfill
6/23/2009	261	062309004	874985.7	2516172.3	616.1	98.2	Pass	16.7	Pass	111.7	16.0	3.0	3	RP - E Berm Emergency Spillway Discharge Pipe Backfill
6/23/2009	268	062309007	874415.7	2516325.1	614.5	100.7	Pass	16.9	Pass	108.8	17.3	1.25	7	RP - E Berm Suction Pipe Backfill Retest of 259
6/24/2009	269	062409001	874414.5	2516379.8	615.7	95.0	Pass	18.9	Fail	111.7	14.2	1.75	8	RP - E Berm Suction Pipe Backfill See Retest 270
6/26/2009	270	062609008	874402.8	2516327.4	615.8	99.9	Pass	15.6	Pass	108.8	17.3	2.0	8	RP - E Berm Suction Pipe Backfill Retest of 269 (replaced with new material)
6/27/2009	271	062709001	874396.2	2516343.1	616.2	94.1	Fail	17.8	Pass	109.2	16.9	1.75	9	RP - E Berm Suction Pipe Backfill See Retest 272
6/27/2009	272	062709002	874397.2	2516338.8	616.3	94.2	Fail	20.9	Fail	109.2	16.9	1.75	9	RP - E Berm Suction Pipe Backfill Retest of 271 - See Retest 273
6/27/2009	273	062709015	874405.1	2516352.3	616.2	98.3	Pass	18.0	Pass	109.2	16.9	2.75	9	RP - E Berm Suction Pipe Backfill Retest of 272
6/27/2009	274	062709026	874397.6	2516350.1	616.4	102.5	Pass	15.1	Pass	109.2	16.9	2.5	10	RP - E Berm Suction Pipe Backfill
6/29/2009	275	062909042	874398.9	2516345.6	617.0	98.8	Pass	18.0	Pass	109.2	16.9	1.75	10	RP - E Berm Suction Pipe Backfill
6/30/2009	276	063009018	874389.3	2516346.9	617.5	97.6	Pass	19.1	Fail	109.2	16.9	1.25	11	RP - E Berm Suction Pipe Backfill See Retest 278
7/1/2009	278	070109009	874413.5	2516361.2	617.1	104.1	Pass	15.1	Pass	109.2	16.9	>5	11	RP - E Berm Suction Pipe Backfill Retest of 276
7/1/2009	279	070109019	874399.2	2516322.4	618.4	101.5	Pass	13.2	Pass	111.7	14.2	2.0	12	RP - E Berm Suction Pipe Backfill
7/1/2009	280	070109025	874426.9	2516363.6	618.3	97.9	Pass	16.6	Fail	111.7	14.2	1.75	13	RP - E Berm Suction Pipe Backfill See Retest 283
7/2/2009	283	070209001	874396.9	2516375.5	618.1	103.0	Pass	15.6	Pass	111.7	14.2	3.5	13	RP - E Berm Suction Pipe Backfill Retest of 280
7/2/2009	284	070209005	874387.3	2516333.8	619.0	101.9	Pass	15.4	Pass	111.7	14.2	3.5	14	RP - E Berm Suction Pipe Backfill
7/8/2009	286	070809004	874389.3	2516332.4	618.9	99.9	Pass	16.0	Pass	109.8	15.8	3.5	15	RP - E Berm Suction Pipe Backfill
7/9/2009	291	070909039	874428.4	2516355.6	619.9	98.5	Pass	17.3	Pass	112.1	15.3	1.5	16	RP - E Berm Suction Pipe Backfill
7/10/2009	292	071009020	874441.7	2516334.8	620.4	94.4	Fail	21.9	Fail	110.8	16.7	0.5	17	RP - E Berm Suction Pipe Backfill See Retest 301
7/10/2009	293	071009025	874354.7	2515511.9	606.3	101.6	Pass	8.5	Pass	130.7	8.0	>5	1	RP - Underdrain Backfill
7/20/2009	294	072009001	874884.9	2515593.5	609.6	100.6	Pass	7.6	Pass	130.7	8.0	>5	2	RP - Underdrain Backfill
7/20/2009	295	072009009	874350.2	2515620.6	607.8	96.0	Pass	11.1	Fail	130.7	8.0	1.5	2	RP - Underdrain Backfill See Retest 298
7/20/2009	296	072009020	874832.8	2515464.1	610.3	98.1	Pass	10.0	Pass	130.7	8.0	4.5	3	RP - Underdrain Backfill
7/20/2009	297	072009021	874829.7	2515453.3	610.5	98.9	Pass	9.0	Pass	130.7	8.0	>5	3	RP - Underdrain Backfill
7/20/2009	298	072009022	874347.6	2515709.1	608.7	98.4	Pass	9.4	Pass	130.7	8.0	4.5	2	RP - Underdrain Backfill Retest of 295
7/21/2009	299	072109001	874839.7	2515473.0	611.4	98.4	Pass	9.9	Pass	130.7	8.0	>5	4	RP - Underdrain Backfill
7/21/2009	300	072109002	874350.7	2515696.7	609.4	97.2	Pass	8.8	Pass	130.7	8.0	4.5	3	RP - Underdrain Backfill
7/21/2009	301	072109014	874390.5	2516336.5	620.4	100.6	Pass	15.5	Pass	110.8	16.7	>5	17	RP - E Berm Suction Pipe Backfill Retest of 292
7/21/2009	302	072109025	874351.7	2515613.4	609.4	103.0	Pass	7.9	Pass	130.7	8.0	4.0	4	RP - Underdrain Backfill
7/21/2009	303	072109059	874342.1	2515419.4	610.3	101.4	Pass	7.8	Pass	130.7	8.0	4.5	5	RP - Underdrain Backfill
7/22/2009	304	072209001	874986.7	2516192.5	617.6	92.6	Fail	22.5	Fail	111.2	16.2	1.25	7	RP - Emergency Spillway Structure Backfill See Retest 308
7/24/2009	307	072409018	874442.3	2516322.7	621.1	94.4	Fail	19.5	Fail	111.2	16.2	1.5	18	RP - E Berm Suction Pipe Backfill See Retest 311
7/24/2009	308	072409019	874948.2	2516169.8	617.3	95.6	Pass	15.1	Pass	111.2	16.2	1.75	7	RP - Emergency Spillway Structure Backfill Retest of 304

COFFEEN - TROXLER COMPACTION/MOISTURE TESTING - RECYCLE POND STRUCTURAL FILL														
Date	Atlas Soils Test No.	Survey Point No.	Northing	Easting	Elevation	Percent Compaction (95% min.)	Pass / Fail	Percent Moisture (-2 to +2%)	Pass / Fail	Proctor Max. Dry Density (pcf)	Optimum Moisture Content (%)	Penetrometer (0.5 tsf min.)	Lift	Comments
7/24/2009	310	072409021	874989.4	2516183.6	617.5	102.4	Pass	10.7	Fail	111.7	14.2	2.75	8	RP - Emergency Spillway Structure Backfill See Retest 313
7/24/2009	311	072409022	874390.9	2516362.0	621.1	99.3	Pass	6.5	Pass	129.9	8.4	>5	18	RP - E Berm Suction Pipe Backfill Retest of 307 (replaced with new material)
7/25/2009	313	072509001	874993.5	2516179.0	617.6	99.1	Pass	13.7	Pass	111.7	14.2	1.75	8	RP - Emergency Spillway Structure Backfill Retest of 310
7/25/2009	314	072509002	875037.7	2516237.8	620.5	102.9	Pass	16.8	Pass	110.8	16.7	2.75	7	RP - E Berm Emergency Spillway Road
7/25/2009	315	072509003	875047.3	2516230.1	620.3	98.6	Pass	17.5	Pass	110.8	16.7	3.25	8	RP - E Berm Emergency Spillway Road
7/25/2009	316	072509004	875038.3	2516236.7	621.5	97.4	Pass	15.6	Pass	110.8	16.7	2.25	9	RP - E Berm Emergency Spillway Road
7/27/2009	319	072709017	874413.6	2516359.0	622.4	96.2	Pass	7.1	Pass	129.9	8.4	>5	19	RP - E Berm Suction Pipe Backfill
7/27/2009	320	072709030	874990.1	2516190.3	618.7	99.5	Pass	18.0	Pass	111.2	16.2	3.75	9	RP - Emergency Spillway Structure Backfill
7/27/2009	321	072709141	874394.4	2516336.0	624.3	102.5	Pass	15.2	Pass	111.2	16.2	>5	20	RP - E Berm Suction Pipe Backfill
7/28/2009	323	072809001	874406.4	2516322.4	625.8	99.9	Pass	17.2	Pass	111.2	16.2	2.25	21	RP - E Berm Suction Pipe Backfill
7/28/2009	324	072809002	874946.6	2516170.4	619.4	95.6	Pass	10.1	Pass	128.4	9.7	>5	10	RP - Emergency Spillway Structure Backfill
7/28/2009	325	072809003	874395.5	2516358.8	625.7	100.8	Pass	18.2	Pass	111.2	16.2	3.25	22	RP - E Berm Suction Pipe Backfill
7/28/2009	328	072809006	874992.2	2516189.0	620.3	97.1	Pass	17.4	Pass	111.2	16.2	2.5	11	RP - Emergency Spillway Structure Backfill
7/29/2009	329	072909011	874393.5	2516336.6	626.9	103.0	Pass	14.8	Pass	111.2	16.2	>5	23	RP - E Berm Suction Pipe Backfill
7/29/2009	332	072909082	875144.5	2516218.4	624.7	102.2	Pass	17.5	Pass	111.2	16.2	2.25	10	RP - E Berm Emergency Spillway Road
7/30/2009	334	073009001	874401.5	2516258.3	605.1	91.1	Fail	13.0	Fail	111.2	16.2	1.5	1	RP Decant Pipe Anchor Backfill See Retest 339
7/30/2009	336	073009005	874408.8	2516352.3	627.4	93.1	Fail	20.9	Fail	111.2	16.2	2.25	24	RP - E Berm Suction Pipe Backfill See Retest 338
7/30/2009	337	073009006	874924.0	2516206.5	623.5	99.5	Pass	18.1	Pass	111.2	16.2	1.75	11	RP - E Berm Emergency Spillway Road
7/30/2009	338	073009127	874434.4	2516359.6	627.6	96.2	Pass	20.2	Fail	111.2	16.2	2.75	24	RP - E Berm Suction Pipe Backfill Retest of 336 - See Retest 340
7/31/2009	339	073109501	874403.4	2516272.5	609.9	98.9	Pass	14.3	Pass	111.2	16.2	4.5	1	RP Decant Pipe Anchor Backfill Retest of 334
7/31/2009	340	073109502	874403.1	2516336.8	627.4	101.4	Pass	17.1	Pass	111.2	16.2	3.5	24	RP - E Berm Suction Pipe Backfill Retest of 338
7/31/2009	341	073109503	875008.7	2516229.5	624.0	92.4	Fail	18.6	Fail	111.2	16.2	3.5	12	RP - E Berm Emergency Spillway Road See Retest 344
7/31/2009	342	073109615	874998.7	2516229.2	623.8	92.5	Fail	23.3	Fail	111.2	16.2	1.5	12	RP - E Berm Emergency Spillway Road See Retest 344
8/1/2009	344	080109002	875010.2	2516239.3	624.0	98.2	Pass	19.6	Fail	111.2	16.2	>5	12	RP - E Berm Emergency Spillway Road Retest of 341 & 342 - Field Approved
8/2/2009	346	080209001	874449.6	2516342.6	628.6	98.0	Pass	8.3	Pass	128.4	9.7	>5	25	RP - E Berm Suction Pipe Backfill
8/2/2009	348	080209003	875023.2	2516237.9	624.9	99.7	Pass	7.8	Pass	128.4	9.7	>5	13	RP - E Berm Emergency Spillway Road
8/3/2009	350	080309003	875005.0	2516214.8	625.8	97.1	Pass	7.0	Pass	130.7	8.0	>5	14	RP - E Berm Emergency Spillway Road
8/3/2009	353	080309007	875069.3	2516247.7	626.8	101.6	Pass	15.1	Pass	111.2	16.2	>5	15	RP - E Berm Emergency Spillway Road
8/3/2009	354	080309008	874966.5	2516202.8	627.0	97.6	Pass	13.0	Pass	114.8	14.2	>5	16	RP - E Berm Emergency Spillway Road
8/4/2009	355	080409001	875060.4	2516249.7	628.2	102.4	Pass	16.5	Pass	110.8	15.9	3.0	17	RP - E Berm Emergency Spillway Road
8/4/2009	356	080409522	874470.3	2516343.5	628.8	96.7	Pass	9.3	Pass	130.7	8.0	>5	18	RP - E Berm Emergency Spillway Road
9/15/2009	662	091509007	874378.0	2516374.9	621.3	95.5	Pass	15.7	Pass	111.2	16.2	1.5	1	RP - E Berm 3" Drain Line Backfill
9/15/2009	666	091509008	874381.5	2516363.7	625.6	98.0	Pass	16.1	Pass	111.2	16.2	>5	2	RP - E Berm 3" Drain Line Backfill
9/15/2009	668	091509015	874380.8	2516388.9	617.3	101.1	Pass	10.0	Fail	111.2	16.2	>5	3	RP - E Berm 3" Drain Line Backfill See Retest 684
9/16/2009	684	091609003	874380.9	2516387.1	617.7	100.6	Pass	14.6	Pass	111.2	16.2	3.0	3	RP - E Berm 3" Drain Line Backfill Retest of 668
9/21/2009	728	092109021	874378.7	2516379.0	620.9	99.3	Pass	14.0	Fail	111.2	16.2	1.5	4	RP - E Berm 3" Drain Line Backfill Field Approved
9/23/2009	735	092309053	874388.5	2516386.4	616.6	100.2	Pass	15.7	Pass	111.2	16.2	3.0	1	RP - E Berm 4" Pump Minimum Flow Recirculation Line Backfill
10/20/2009	822	102009018	874390.1	2516373.5	622.7	100.3	Pass	15.6	Pass	111.2	16.2	4.0	2	RP - E Berm 4" Pump Minimum Flow Recirculation Line Backfill
10/21/2009	827	102109010	874495.0	2515195.5	625.0	95.1	Pass	19.0	Fail	111.2	16.2	2.5	7	RP - W Berm Backfill at Valve Vault 1 Retest of 734 (replaced with new material) Field Approved
10/21/2009	833	102109022	874493.0	2515197.6	626.7	98.9	Pass	8.3	Pass	128.4	9.7	>5	8	RP - W Berm Backfill at Valve Vault 1

COFFEEN - TROXLER COMPACTION/MOISTURE TESTING - RECYCLE POND STRUCTURAL FILL														
Date	Atlas Soils Test No.	Survey Point No.	Northing	Easting	Elevation	Percent Compaction (95% min.)	Pass / Fail	Percent Moisture (-2 to +2%)	Pass / Fail	Proctor Max. Dry Density (pcf)	Optimum Moisture Content (%)	Penetrometer (0.5 tsf min.)	Lift	Comments
10/21/2009	836	102109025	874505.3	2515180.0	624.9	103.8	Pass	7.8	Pass	128.4	9.7	>5	9	RP - W Berm Backfill at Valve Vault 1
4/19/2010	979	041910006	874879.8	2515382.7	628.6	101.3	Pass	12.1	Fail	111.2	16.2	>4.5	1	RP - N Berm Road Construction Field Approved

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

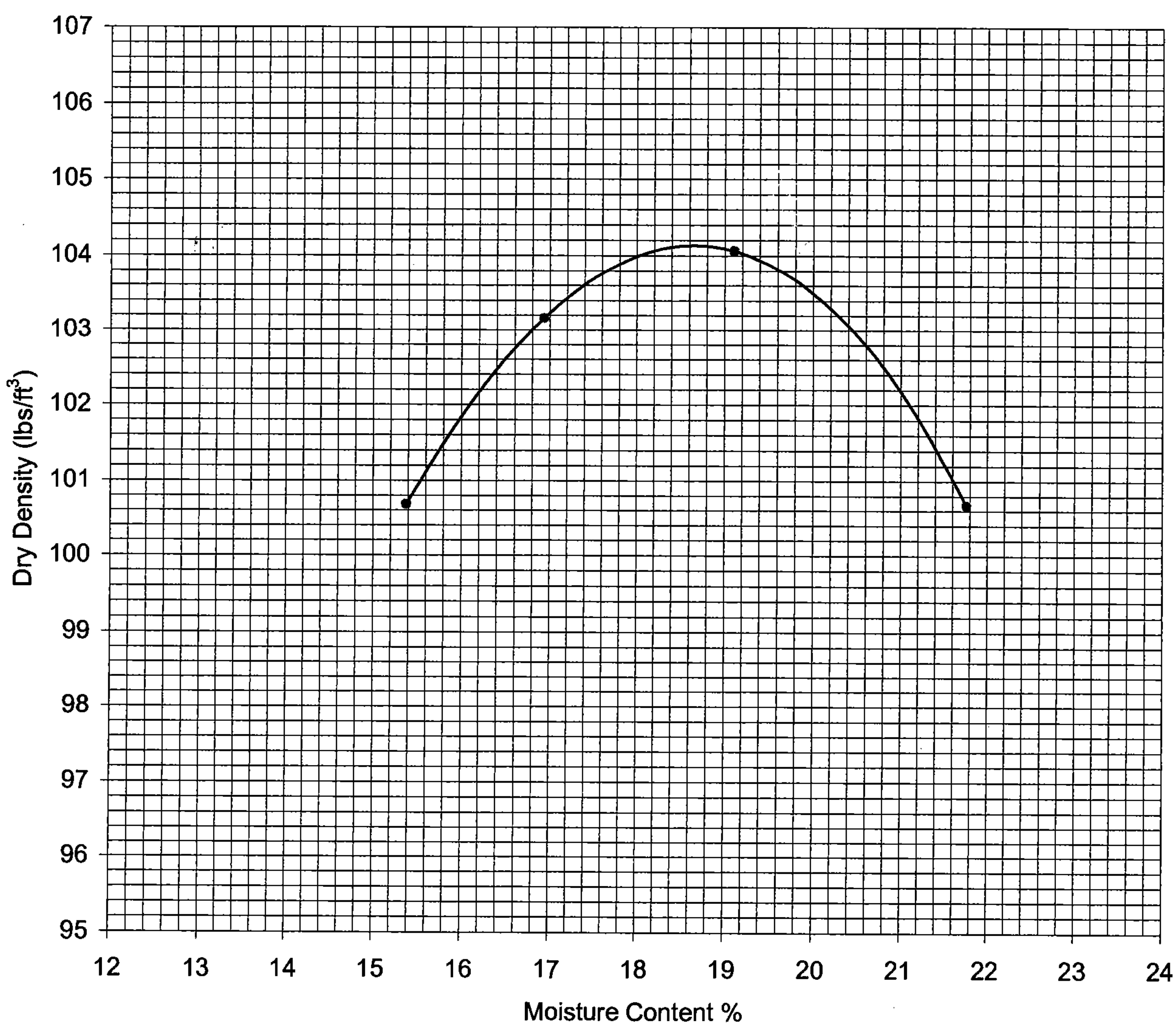
Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Sample No. 10206-RP-S12; Collected 8/27/08 9:55 am; South Side Recycle Pond

Method of Test: ASTM D698, Method A

MOISTURE - DENSITY RELATIONSHIP CURVE



Optimum Moisture 18.6 %

Max. Dry Density 104.1 lbs./cu.ft.

Corrected Optimum Moisture -- %

Corrected Max. Dry Density -- lbs./cu.ft.

Natural Moisture -- %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Sample No. 10206-RP-S12; Collected 8/27/08 9:55 am; South Side Recycle Pond

Method of Test: ASTM D698, Method A

Density Calculation

Point No.	1	2	3	4
Wet Sample + Mold Mass (g)	3780.58	3848.09	3898.31	3877.54
Mold Mass (g)	2023.24	2023.24	2023.24	2023.24
Wet Soil Mass (g)	1757.34	1824.85	1875.07	1854.30
Wet Density (pcf)	116.2	120.6	124.0	122.6
Dry Density (pcf)	100.7	103.1	104.1	100.7

Mold Volume 0.03335 cu ft.

Moisture Calculation

Point No.	1	2	3	4
wet mass + tare	155.7	162.62	152.88	165.97
dry mass + tare	139.49	143.75	133.94	142.37
tare	34.07	32.36	34.85	33.90
moisture	15.4	16.9	19.1	21.8

Percent retained on designated sieve (3/8): N/A %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

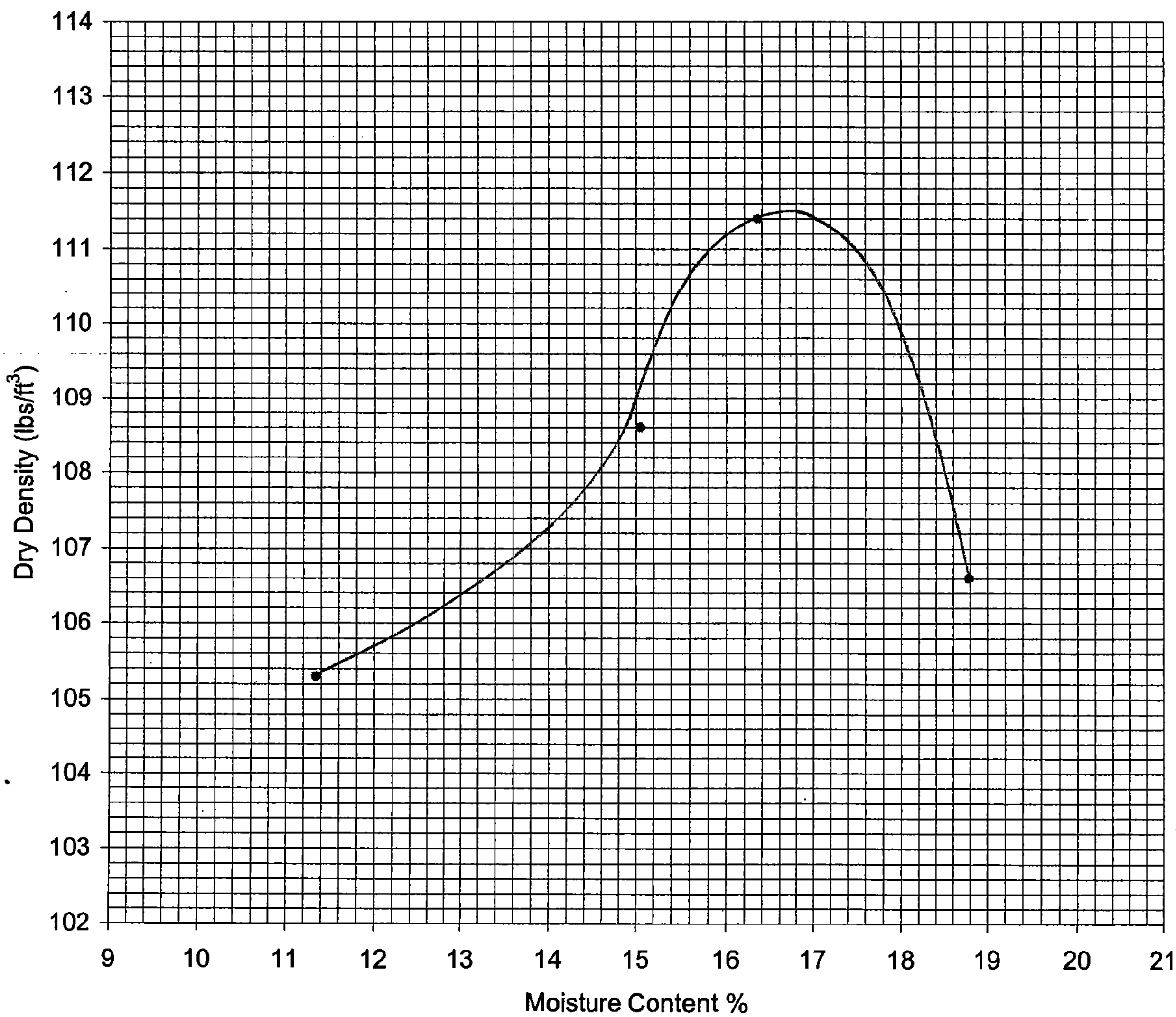
Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Silty Clay Till, Brown, Trace of Sand & Gravel; Sample No. C-10207-S12; Collected 10/23/08

Method of Test: ASTM D698, Method A

MOISTURE - DENSITY RELATIONSHIP CURVE



Optimum Moisture 16.8 %

Max. Dry Density 111.5 lbs./cu.ft.

Corrected Optimum Moisture -- %

Corrected Max. Dry Density -- lbs./cu.ft.

Natural Moisture -- %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Silty Clay Till, Brown, Trace of Sand & Gravel; Sample No. C-10207-S12; Collected 10/23/08

Method of Test: ASTM D698, Method A

Density Calculation

Point No.	1	2	3	4
Wet Sample + Mold Mass (g)	3796.66	3914.77	3983.85	3938.68
Mold Mass (g)	2023.50	2023.50	2023.50	2023.50
Wet Soil Mass (g)	1773.16	1891.27	1960.35	1915.18
Wet Density (pcf)	117.2	125	129.6	126.6
Dry Density (pcf)	105.3	108.6	111.4	106.6

Mold Volume 0.03335 cu ft.

Moisture Calculation

Point No.	1	2	3	4
wet mass + tare	145.71	162.61	167.83	169.75
dry mass + tare	134.32	145.77	149.14	148.05
tare	34	33.9	34.85	32.54
moisture	11.4	15.1	16.4	18.8

Percent retained on designated sieve (3/8): N/A %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

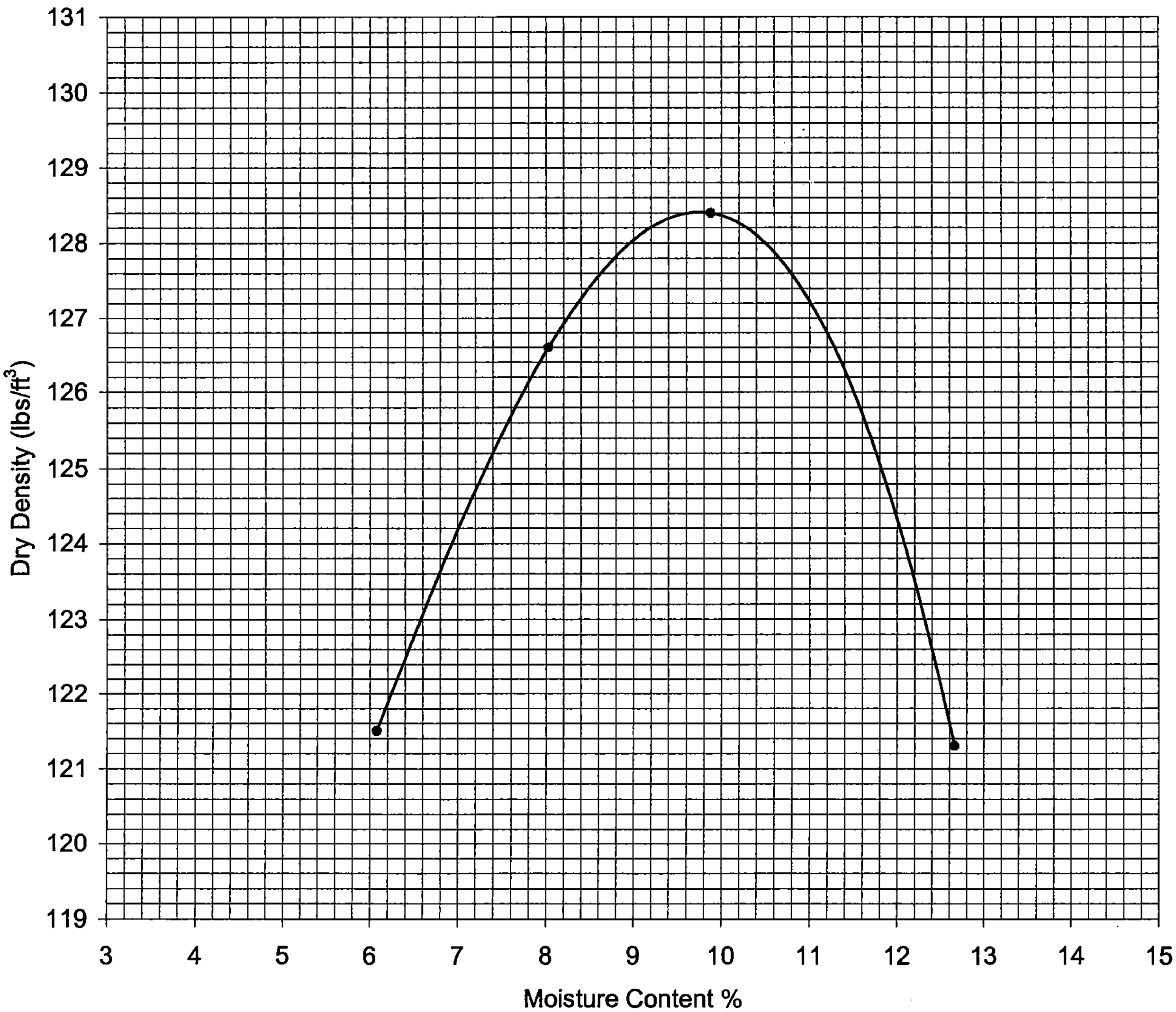
Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Silty Clay Loam Till, Brown, Few Sand, Trace of Gravel; Sample No. RP-000-001; Collected 6/5/09 from Ramp into Recycle Pond

Method of Test: ASTM D698, Method A

MOISTURE - DENSITY RELATIONSHIP CURVE



Optimum Moisture 9.7 %   Max. Dry Density 128.4 lbs./cu.ft.

Corrected Optimum Moisture -- %   Corrected Max. Dry Density -- lbs./cu.ft.

Natural Moisture -- %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Silty Clay Loam Till, Brown, Few Sand, Trace of Gravel; Sample No. RP-000-001; Collected 6/5/09 from Ramp into Recycle Pond

Method of Test: ASTM D698, Method A

Density Calculation

Point No.	1	2	3	4
Wet Sample + Mold Mass (g)	3972.56	4093.18	4157.36	4090.73
Mold Mass (g)	2023.08	2023.08	2023.08	2023.08
Wet Soil Mass (g)	1949.48	2070.10	2134.28	2067.65
Wet Density (pcf)	128.9	136.8	141.1	136.7
Dry Density (pcf)	121.5	126.6	128.4	121.3

Mold Volume 0.03335 cu ft.

Moisture Calculation

Point No.	1	2	3	4
wet mass + tare	203.09	201.63	177.1	230.53
dry mass + tare	193.28	189.15	164.09	208.45
tare	31.83	33.77	32.36	33.99
moisture	6.1	8.0	9.9	12.7

Percent retained on designated sieve (3/8): 4.6 %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

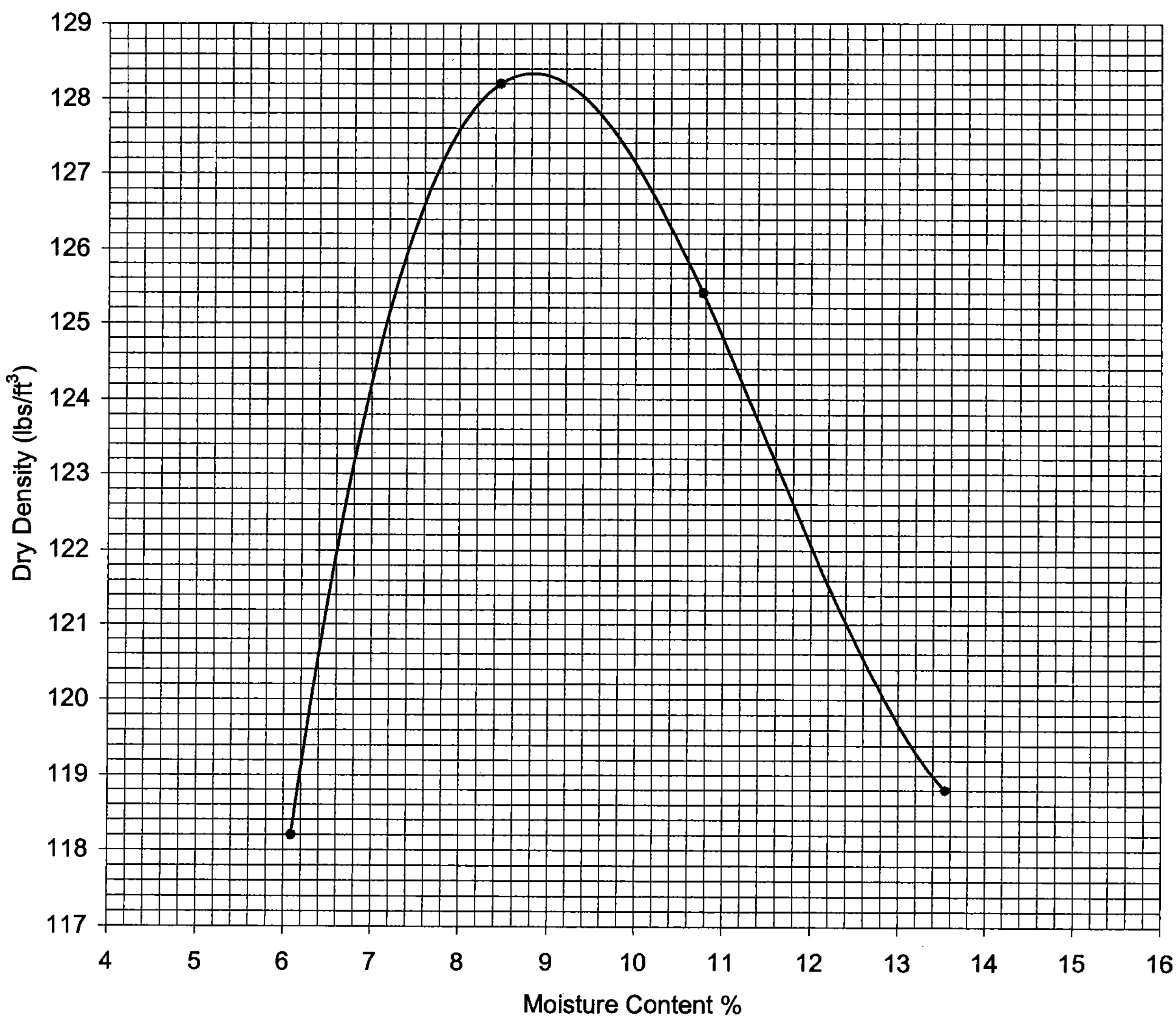
Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Silty Clay Loam Till, Gray and Reddish-Brown, Few Sand, Trace of Gravel; Sample No. RP-000-002; Collected 6/5/09 from Ramp into Recycle Pond

Method of Test: ASTM D698, Method A

MOISTURE - DENSITY RELATIONSHIP CURVE



Optimum Moisture 8.8 % Max. Dry Density 128.4 lbs./cu.ft.

Corrected Optimum Moisture 8.4 % Corrected Max. Dry Density 129.9 lbs./cu.ft.

Natural Moisture -- %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Silty Clay Loam Till, Gray and Reddish-Brown, Few Sand, Trace of Gravel; Sample No. RP-000-002; Collected 6/5/09 from Ramp into Recycle Pond

Method of Test: ASTM D698, Method A

Density Calculation

Point No.	1	2	3	4
Wet Sample + Mold Mass (g)	3921.62	4127.99	4126.13	4065.29
Mold Mass (g)	2024.92	2024.92	2024.92	2024.92
Wet Soil Mass (g)	1896.70	2103.07	2101.21	2040.37
Wet Density (pcf)	125.4	139.0	138.9	134.9
Dry Density (pcf)	118.2	128.2	125.4	118.8

Mold Volume 0.03335 cu ft.

Moisture Calculation

Point No.	1	2	3	4
wet mass + tare	189.50	191.67	202.05	202.83
dry mass + tare	180.57	179.38	185.56	182.68
tare	33.98	34.18	32.49	33.90
moisture	6.1	8.5	10.8	13.5

Percent retained on designated sieve (3/8): 5.5 %

MOISTURE DENSITY CORRECTION
(AASHTO T224/ASTM D4718)
(Lab dry density corrected to field dry density)

Project Name: CCB Management Facility
Project Number: 181-1988
Sample No RP-000-002

Procedure to be implemented when sample contains more than 5% retained designated on sieve (3/8 inch sieve).

MOISTURE CORRECTION

AASHTO T224, Section 4.1.5 (Equation No. 4)/ASTM D4718, Section 4.1.4
Corrected moisture: $MC_T = (MC_f*P_f)+(MC_c*P_c)$

P_c = percentage of oversized particles (total retained on designated sieve)	5.5%
P_f = percentage of fine particles (total passing designated sieve)	94.5%
MC_f = optimum moisture form AASHTO T99 or T180/ASTM D698 or D1557 (entered as percentage)	8.8%
MC_c = moisture content of oversized particles (material retained designated sieve, entered as percentage)	2.0%
MC_t = corrected optimum moisture	8.4%

Note: moisture content of oversized particles (MC_c) can be assumed to be 2.0% if actual moisture is not determined.

DENSITY CORRECTION

AASHTO T224, Section 4.1.5 (Equation No. 5)/ASTM D4718, Section 4.1.4
Corrected density: $D_d = (D_f*k)/[(D_f*P_c)+(k*P_f)]$ G_m = 2.60

D_f = maximum dry density from AASHTO T99 or T180/ASTM D4718 or D1557	128.4 pcf
P_c = percentage of oversized particles (total retained on designated sieve, entered as percentage)	5.5%
P_f = percentage of fine particles (total passing the designated sieve, entered as percentage)	94.5%
k = 62.4 x bulk specific gravity (G_m) for oversized particles	162.2 pcf
D_d = corrected maximum dry density	129.9 pcf

Note: bulk specific gravity can be determined by completing AASHTO T85 or ASTM C127. However, if not determined with test methods, the bulk specific gravity can be assumed to be 2.60 for most construction activities.

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

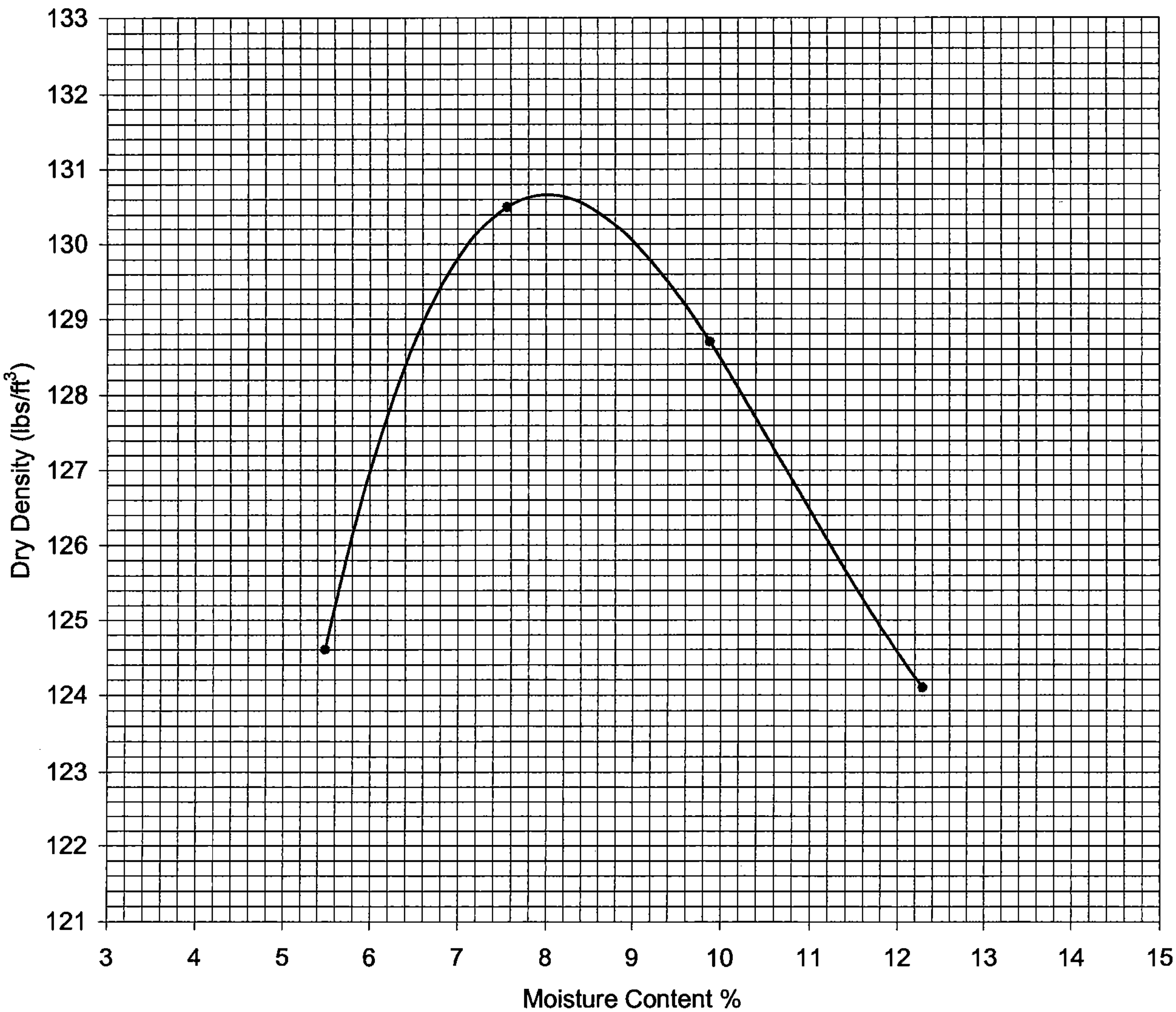
Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Silty Till, Gray, Few Sand, Trace of Gravel; Sample No. RP-000-003; Collected 6/5/09 from Recycle Pond

Method of Test: ASTM D698, Method A

MOISTURE - DENSITY RELATIONSHIP CURVE



Optimum Moisture 8.0 %

Max. Dry Density 130.7 lbs./cu.ft.

Corrected Optimum Moisture -- %

Corrected Max. Dry Density -- lbs./cu.ft.

Natural Moisture -- %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Silty Till, Gray, Few Sand, Trace of Gravel; Sample No. RP-000-003; Collected 6/5/09 from Recycle Pond

Method of Test: ASTM D698, Method A

Density Calculation

Point No.	1	2	3	4
Wet Sample + Mold Mass (g)	4011.42	4147.4	4161.86	4130.07
Mold Mass (g)	2023.14	2023.14	2023.14	2023.14
Wet Soil Mass (g)	1988.28	2124.26	2138.72	2106.93
Wet Density (pcf)	131.4	140.4	141.4	139.3
Dry Density (pcf)	124.6	130.5	128.7	124.1

Mold Volume 0.03335 cu ft.

Moisture Calculation

Point No.	1	2	3	4
wet mass + tare	194.61	194.74	194.76	217.57
dry mass + tare	186.17	183.44	180.31	197.49
tare	32.37	34.02	33.99	34.10
moisture	5.5	7.6	9.9	12.3

Percent retained on designated sieve (3/8): 4.0 %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

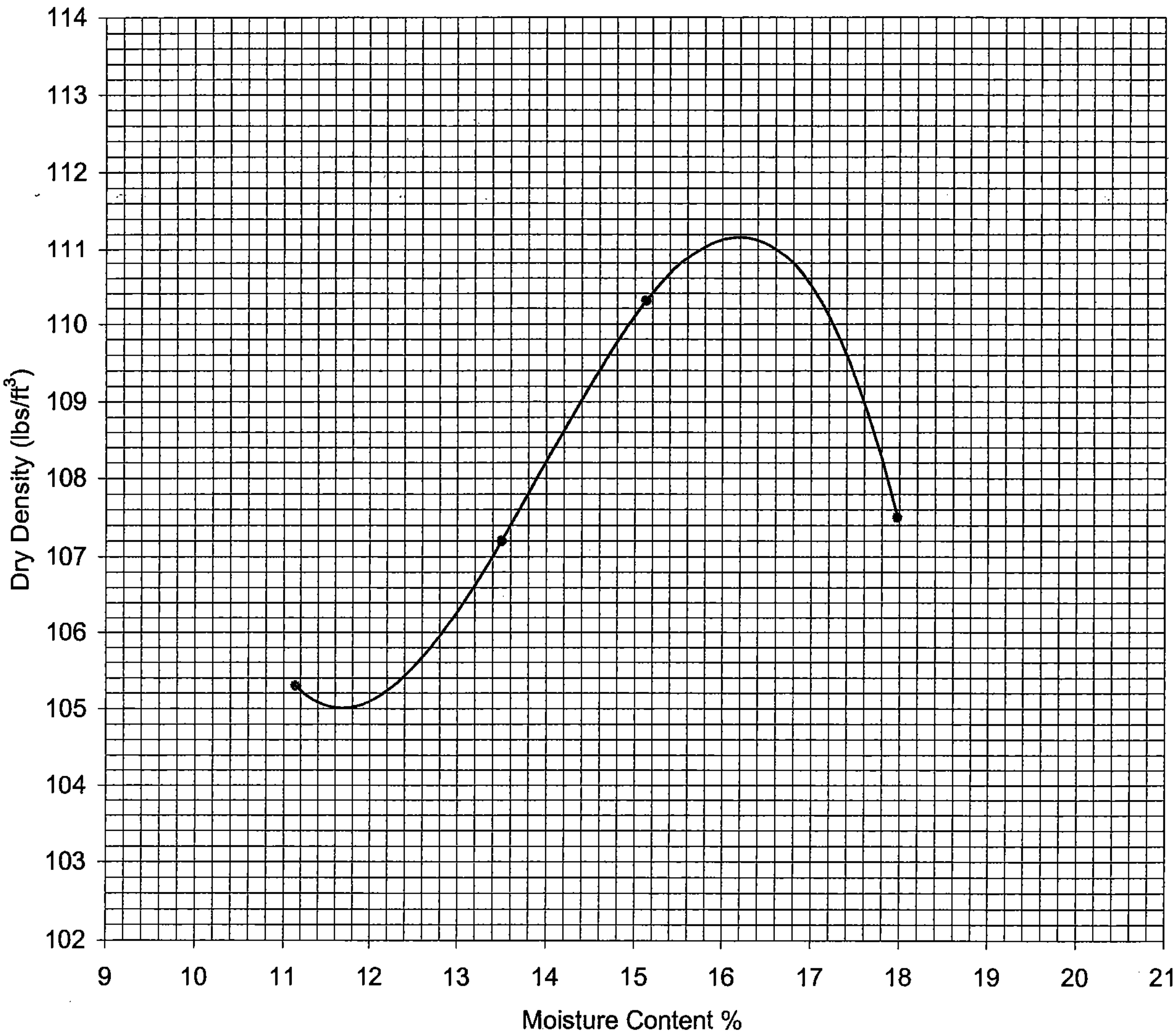
Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Clay, Brown, Trace of Sand; Sample No. RP-000-004; Collected on 6/19/09 Near Recycle Pond Spillway

Method of Test: ASTM D698, Method B

MOISTURE - DENSITY RELATIONSHIP CURVE



Optimum Moisture 16.2 %

Max. Dry Density 111.2 lbs./cu.ft.

Corrected Optimum Moisture -- %

Corrected Max. Dry Density -- lbs./cu.ft.

Natural Moisture -- %

REPORT OF
MOISTURE - DENSITY RELATIONSHIP OF SOIL

For: Hanson Professional Services, Inc.

Project: CCB Management Facility (181-1988)

Location: Coffeen, Illinois

Sample: Clay, Brown, Trace of Sand; Sample No. RP-000-004; Collected on 6/19/09 Near Recycle Pond Spillway

Method of Test: ASTM D698, Method B

Density Calculation

Point No.	1	2	3	4
Wet Sample + Mold Mass (g)	3792.65	3864.43	3944.53	3941.14
Mold Mass (g)	2023.24	2023.24	2023.24	2023.24
Wet Soil Mass (g)	1769.41	1841.19	1921.29	1917.90
Wet Density (pcf)	117	121.7	127	126.8
Dry Density (pcf)	105.3	107.2	110.3	107.5

Mold Volume 0.03335 cu ft.

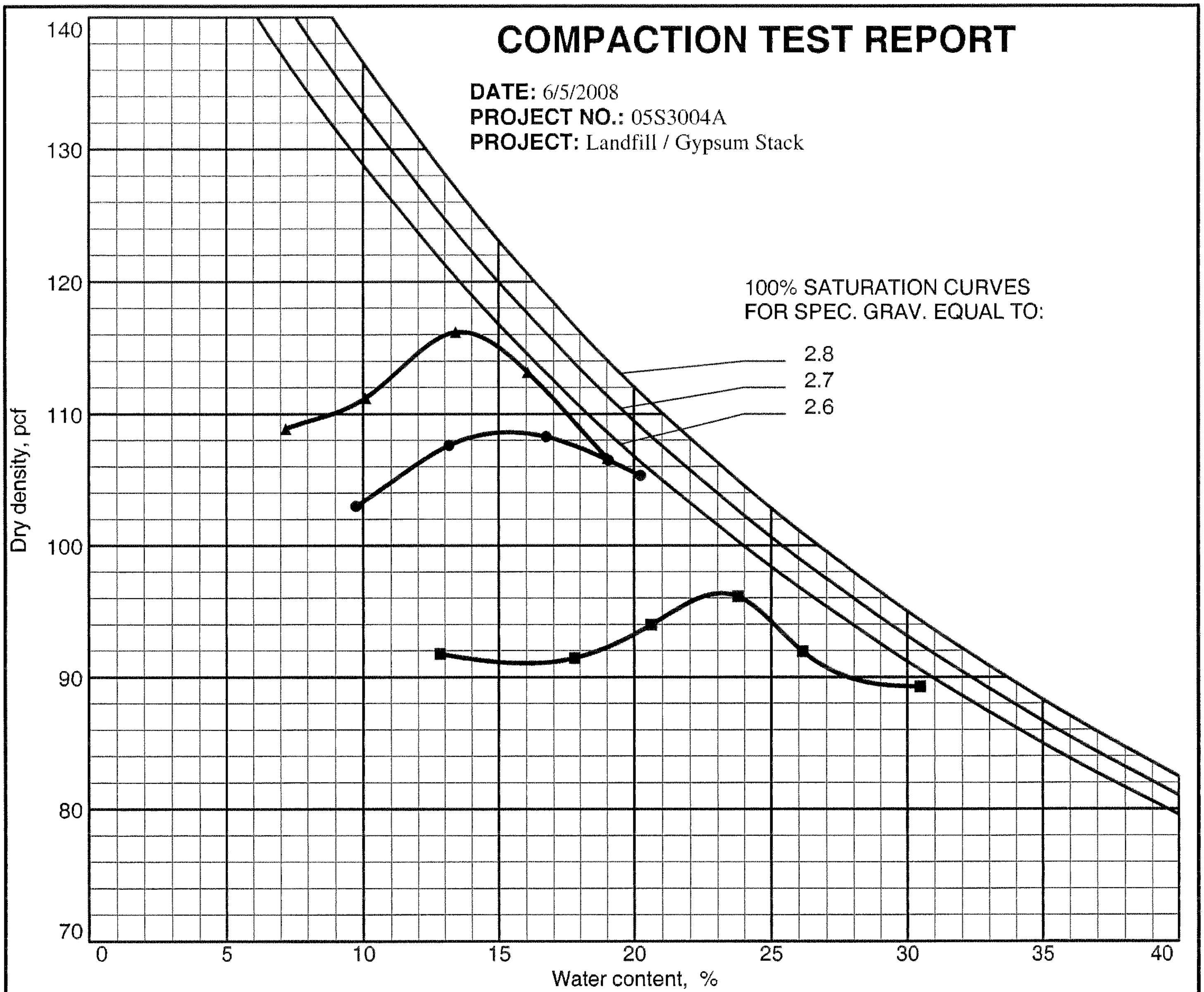
Moisture Calculation

Point No.	1	2	3	4
wet mass + tare	142.06	134.77	150.33	165.3
dry mass + tare	131.25	122.87	135.04	144.96
tare	34.18	34.69	33.98	31.86
moisture	11.1	13.5	15.1	18.0

Percent retained on designated sieve (3/8): N/A %

COMPACTION TEST REPORT

DATE: 6/5/2008
PROJECT NO.: 05S3004A
PROJECT: Landfill / Gypsum Stack



	No.	LOCATION AND DESCRIPTION	TEST SPECIFICATION
●		**Source:** Gypsum Stack **Sample No.:** SW Quad **Elev./Depth:** 8.0 Brn. & gray vf. sandy silty clay / ox. spots.	ASTM D698-00a Method A Mold HEI-3 Standard
■		**Source:** Gypsum Stack **Sample No.:** NW **Elev./Depth:** 4.0-5.0 Orange brn. & gray vf.-f. sandy silty clay (tr. sm. gravel) / ox. spots.	ASTM D698-00a Method A Mold HEI-3 Standard
▲		**Source:** Recycle Pond **Sample No.:** SE Quad **Elev./Depth:** 10.0 Orange brn. & gray vf.-f. sandy silty clay (tr.sm. gravel) / ox. spots & clayey sand	ASTM D698-00a Method A Mold HEI-3 Standard

	No.	USCS	LL	PI	NAT. MOIST.	OVERSIZE	%< No.200	MAX. DRY DEN.	OPT. MOIST.
●			40	26	22.1			108.6 pcf	15.4 %
■			60	39	31.8			96.4 pcf	23.2 %
▲			28	15	21.3			116.2 pcf	13.6 %

Figure

Hanson Professional Services, Inc.

MOISTURE DENSITY TEST DATA

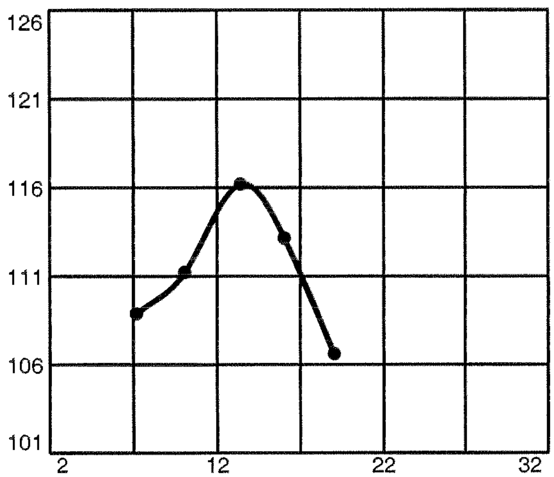
Client: Ameren Coffeen Generating Station
Project: Landfill / Gypsum Stack
Project Number: 05S3004A

Specimen Data

Source: Recycle Pond
Sample No.: SE Quad
Elev. or Depth: 10.0 **Sample Length(in./cm.):**
Location:
Description: Orange brn. & gray vf.-f. sandy silty clay (tr.sm. gravel) / ox. spots & clayey sand seams.
Water Content: 21.3 **Liquid Limit:** 28 **Plasticity Index:** 15
USCS: **AASHTO:**
Percent retained on No.4 sieve:
Percent passing No. 200 sieve: **Specific gravity:**

Test Data And Results

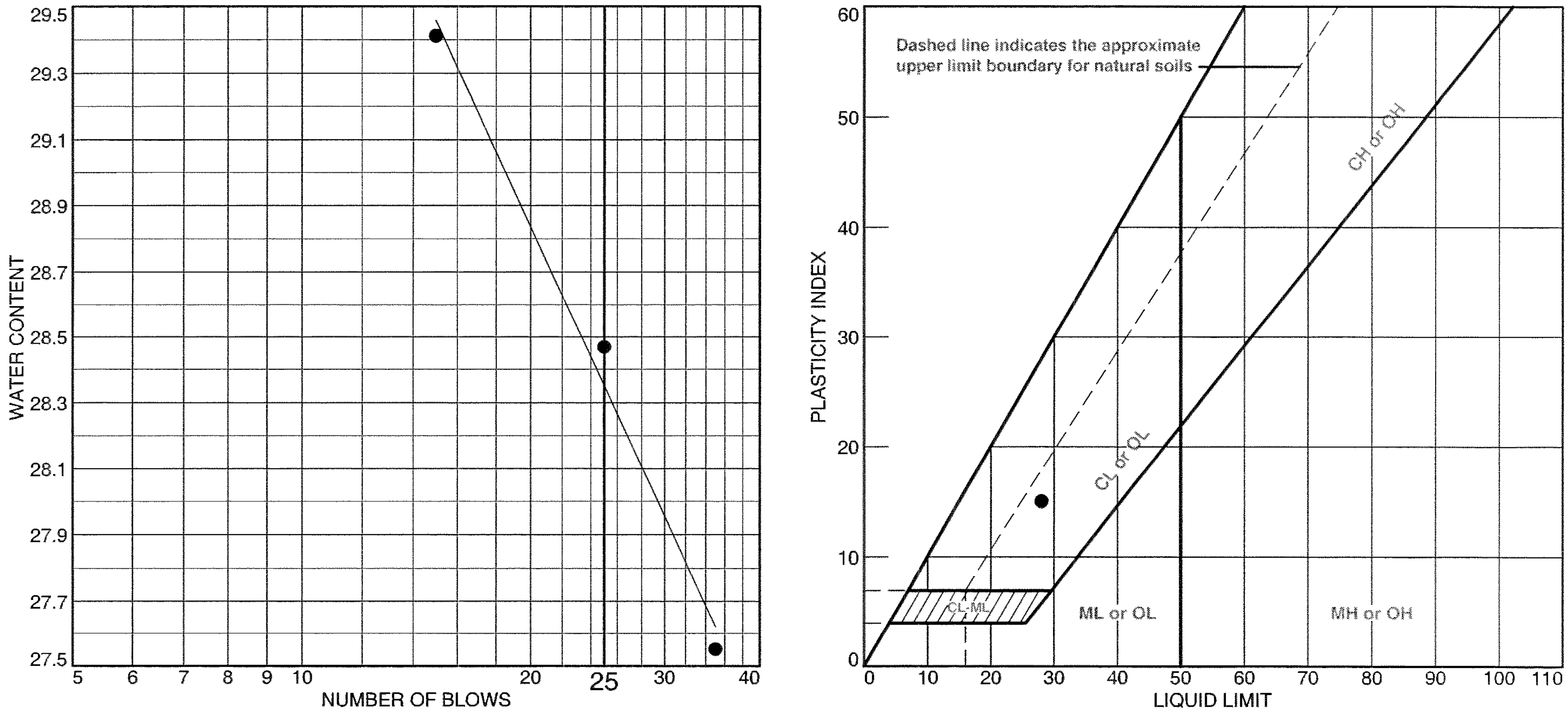
Type of test: ASTM D698-00a Method A Mold HEI-3 Standard
Mold Dia.: 3.99 in. **Hammer Wt.:** 5.5 **Drop:** 12
Layers: 3 **Blows per Layer:** 25



POINT NO.	1	2	3	4	5
WM + WS	13.05	13.24	13.55	13.53	13.39
WM	9.18	9.18	9.18	9.18	9.18
WW+T	118.40	119.50	116.20	124.40	126.30
WD+T	110.70	108.90	102.90	107.70	106.70
TARE	3.70	3.70	3.70	3.70	3.70
MOIST	7.2	10.1	13.4	16.1	19.0
MOISTURE	7.2	10.1	13.4	16.1	19.0
DRY DEN	108.9	111.2	116.2	113.1	106.6

Max dry den= 116.2 pcf **Opt moisture=** 13.6 %

LIQUID AND PLASTIC LIMITS TEST REPORT



	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	Recycle Pond	SE Quad	10.0	6-5-08		Orange brn. & gray vf.-f. sandy silty clay (tr.sm. gravel) / ox. spots & clayey sand seams.	21.3	28	15

Client Ameren Coffeen Generating Station

Project Landfill / Gypsum Stack

Project No. 05S3004A Figure

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Hanson Professional Services Inc.

Tested By: JCC **Checked By:** RIN

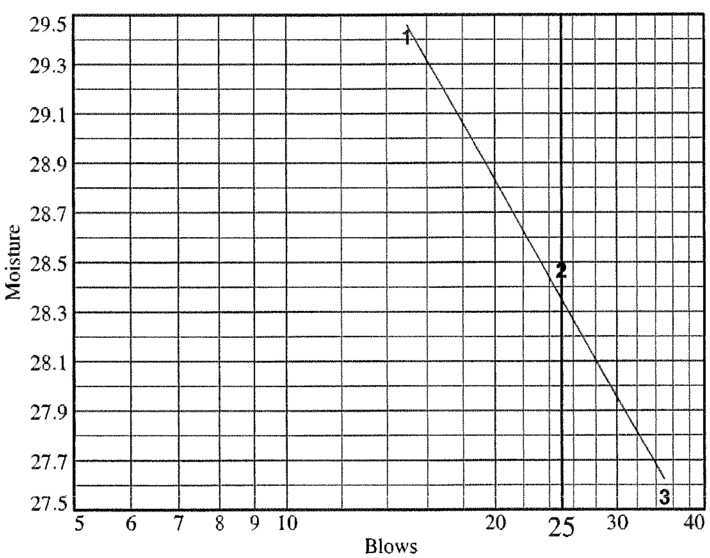
LIQUID AND PLASTIC LIMIT TEST DATA

6/5/2008

Client: Ameren Coffeen Generating Station
Project: Landfill / Gypsum Stack
Project Number: 05S3004A
Location: Recycle Pond
Depth: 10.0 **Sample Number:** SE Quad
Material Description: Orange brn. & gray vf.-f. sandy silty clay (tr.sm. gravel) / ox. spots & clayey sand seams.
Date: 6-5-08
Tested by: JCC **Checked by:** RIN

Liquid Limit Data

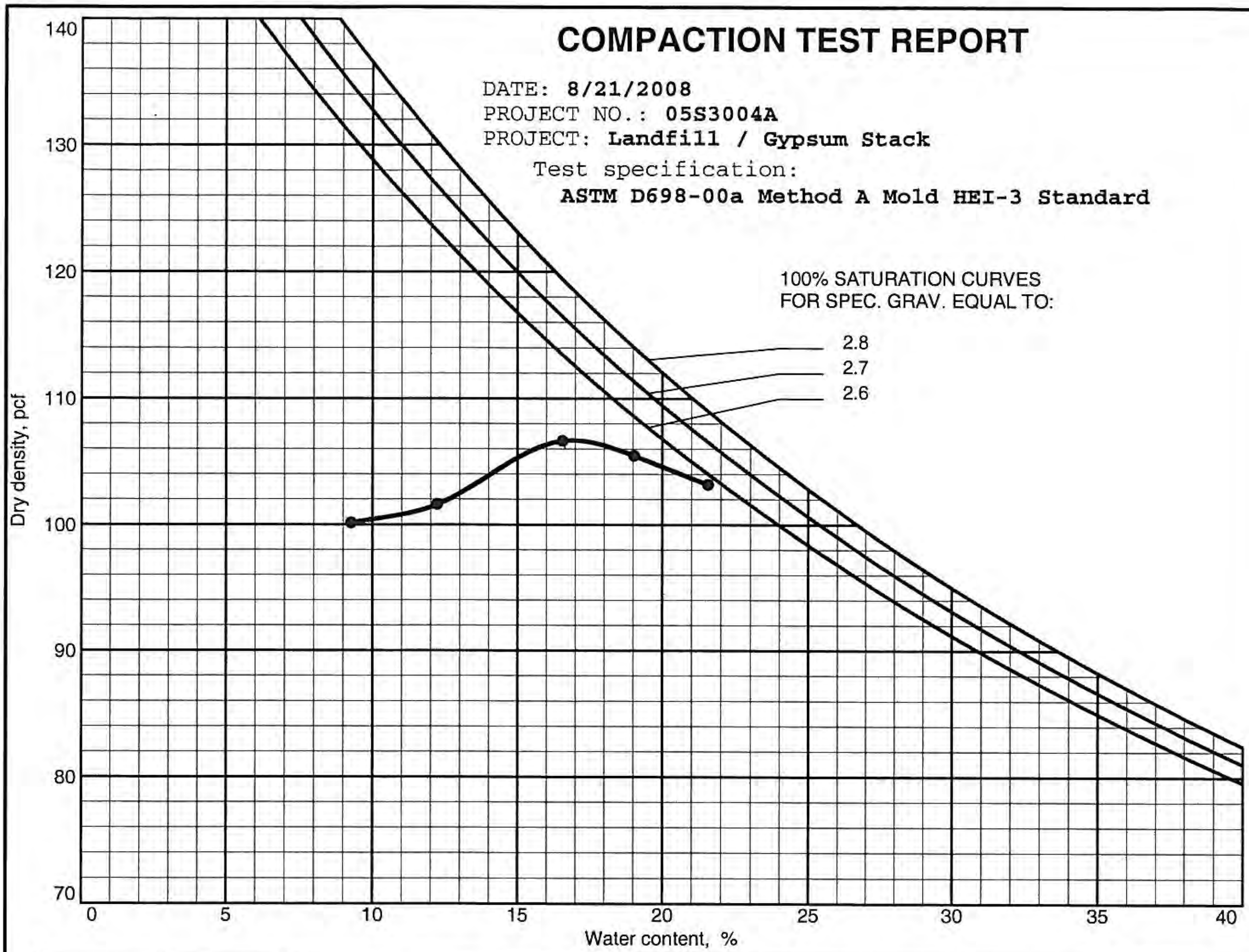
Run No.	1	2	3	4	5	6
Wet+Tare	31.23	29.94	28.98			
Dry+Tare	27.68	26.78	26.20			
Tare	15.61	15.68	16.11			
# Blows	15	25	35			
Moisture	29.4	28.5	27.6			



Liquid Limit= 28
Plastic Limit= 13
Plasticity Index= 15
Natural Moisture= 21.3
Liquidity Index= 0.6

Plastic Limit Data

Run No.	1	2	3	4
Wet+Tare	23.24	24.16		
Dry+Tare	22.35	23.22		
Tare	15.41	15.79		
Moisture	12.8	12.7		



COMPACTION TEST REPORT

DATE: **8/21/2008**
PROJECT NO.: **05S3004A**
PROJECT: **Landfill / Gypsum Stack**
Test specification:
ASTM D698-00a Method A Mold HEI-3 Standard

	Sample No.	Elev. or Depth	Material Description	SPECIFIC GRAVITY	LL	PL	OVERSIZE	% < #200
●	**RPS-001**		**Brn. vf. sandy silty clay.**					

Sample No.	**RPS-001**			
Natural water content, percent				
Optimum water content, percent	**16.9**			
Max dry density, pcf	**106.7**			

Remarks

Project **Landfill / Gypsum Stack** Project No. **05S3004A**

Location

Source **Recycle Pond**

Figure

Hanson Professional Services Inc.

MOISTURE DENSITY TEST DATA

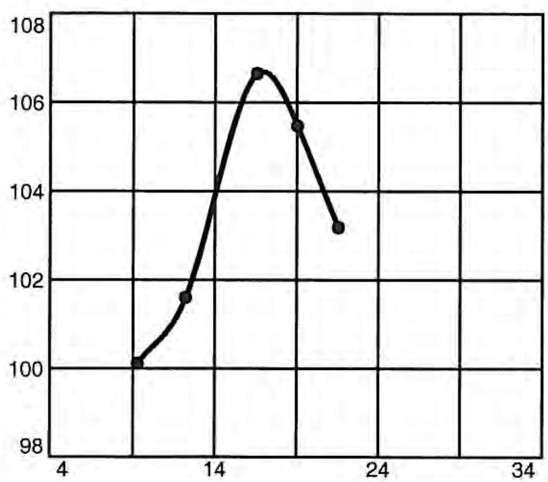
Client: Ameren Coffeen Generating Station
Project: Landfill / Gypsum Stack
Project Number: 05S3004A
Location:

Specimen Data

Source: Recycle Pond
Sample No.: RPS-001
Elev. or Depth: **Sample Length(in./cm.):**
Location:
Description: Brn. vf. sandy silty clay.
Natural Moisture: **Liquid Limit:** **Plastic Limit:**
Testing Remarks:
Percent retained on No.4 sieve:
Percent passing No. 200 sieve: **Specific gravity:**

Test Data And Results

Type of test: ASTM D698-00a Method A Mold HEI-3 Standard
Mold Dia.: 3.99 in. **Hammer Wt.:** 5.5 **Drop:** 12
Layers: 3 **Blows per Layer:** 25



POINT NO.	1	2	3	4	5
WM + WS	12.81	12.96	13.30	13.34	13.34
WM	9.18	9.18	9.18	9.18	9.18
WW+T	157.10	190.70	161.80	147.90	178.89
WD+T	151.91	180.38	152.45	139.60	164.19
TARE	96.00	96.00	96.00	96.00	96.00
MOIST	9.3	12.2	16.6	19.0	21.6
MOISTURE	9.3	12.2	16.6	19.0	21.6
DRY DEN	100.1	101.6	106.6	105.5	103.2

Max dry den= 106.7 pcf **Opt moisture=** 16.9 %

Chain of Custody Record

(Form CQAP 6.1, Revision 0)

Gypsum Management and CCB Landfill Facilities — Ameren

Client	Ameren Coffeen Generating Station
Address	134 CIPS Lane
City, State Zip Code	Coffeen, IL 62017
Phone / Facsimile No.	(217) 534-2363 / (217) 534-7681
Client Project	Recycle Pond
Location	West Embankment
Sampler(s) / Phone	Phifer / 217-741-1311
Turnaround Time	Standard [ ] Rush [X] Date Required:
P.O. # or Invoice To	05S3004A
Contact Person	Steve Phifer

Analysis and/or Method Requested: Standard Proctor

Sample Description	Sampling Date	Sampling Time	Sample Type[1]	# of Containers	Standard Proctor						Remarks or Observations
RPS-001	8-20-08	1325	S	1	✓						

(1) Sample Type: S = Soil; GM = Geomembrane; GT = Geotextile; GCL = Geosynthetic Clay Liner; DM = Drainage Media; O = Other

Relinquished By	Date	Time	Received By	Date	Time	Method of Shipment
Zack Hart	8-20-08	3:45 pm	[signature]	8-20-08	15:45	HAND

Special Instructions:

 Copies: White – CQA Officer Yellow – Testing Firm Pink – Sampler

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Hanson Professional Services Inc.

Springfield, Illinois

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ASTM D698-00a & ASTM D 1557-00

Moisture Density Test

(TestCurve #______)

Project Name COFFEEN ~~GYPSUM STACK~~ (OK) RECYCLE POND.

Project No. 05530004A 4500 Tested By RJN (JCC) Date 5-23-08 Chk'd By JCC Date 6-5-08.

Boring No. ______ Sample No. SE QUAD. Depth 10.0'

Description ORANGE BRN. & GRAY VF-F SANDY SILTY CLAY (TR. SM. GRAVEL) W/OX SPOTS W/CLAYEY SAND SEAMS.

** Balance No. 41468. Pan No. ______. Natural Moisture Content 21.3.

% of Material Retained on 3" Sieve ______. 3/4" Sieve ______. #4 Sieve ______.

Test Standard Used: ☑ ASTM D698 ☐ ASTM D1557 ☐ AASHTO T99 ☐ AASHTO T180 ☐ Other ______.

Method: ☑ A ☐ B ☐ C ☐ D Dia. Mold: 4". Rammer: ☐ Manual ☑ Mech.

Preparation Procedure: ☐ Moist ☑ Dry Curing Time ______ hrs.

Material Reused During Test ☐ Yes ☐ (No) Mold # HEI-3

Machine Serial # 662B 80.6.

BALANCE # D03371 *

* Trail No.	1	2	3	4	5	6	7	8
Water Added %	4%	7%	10%	13%	16%			
Wt. Mold + Comp. Soil	13.050	13.239	13.549	13.534	13.388			
Wt. Mold	9,180	———	———	———	———			
Wt. Comp. Soil								
Qu	+4.5	+4.5	2.5	1.0	0.25			

** Trial No.	1	2	3	4	5	6	7	8
Can No.	1	2	3	4	5			
Wt. Can + Comp. Soil	118.4	119.5	116.2	124.4	126.3			
Wt. Can + Dry Soil	110.7	108.9	102.9	107.7	106.7			
Wt. Can	3.7	3.7	3.7	3.7	3.7			
Water Content %								

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Hanson Professional Services Inc.

Springfield, Illinois

Moisture Density Test

(TestCurve #______)

Project Name AMEREN COFFEEN RECYCLE POND WEST EMBANKMENT.

Project No. 05530044 Tested By KDE Date 8/21/08 Chk'd By ______ Date ______

Boring No. — Sample No. RPS-001 Depth —

Description ______

Balance No. D03371 Pan No. ______ Natural Moisture Content ______

% of Material Retained on 3" Sieve ______ 3/4" Sieve ______ #4 Sieve ______

Test Standard Used: ☒ ASTM D698 ☐ ASTM D1557 ☐ AASHTO T99 ☐ AASHTO T180

☐ Other ______

Method: ☒ A ☐ B ☐ C ☐ D Dia. Mold: 4" Rammer: ☐ Manual ☒ Mech.

Preparation Procedure: ☐ Moist ☒ Dry Curing Time 0 hrs.

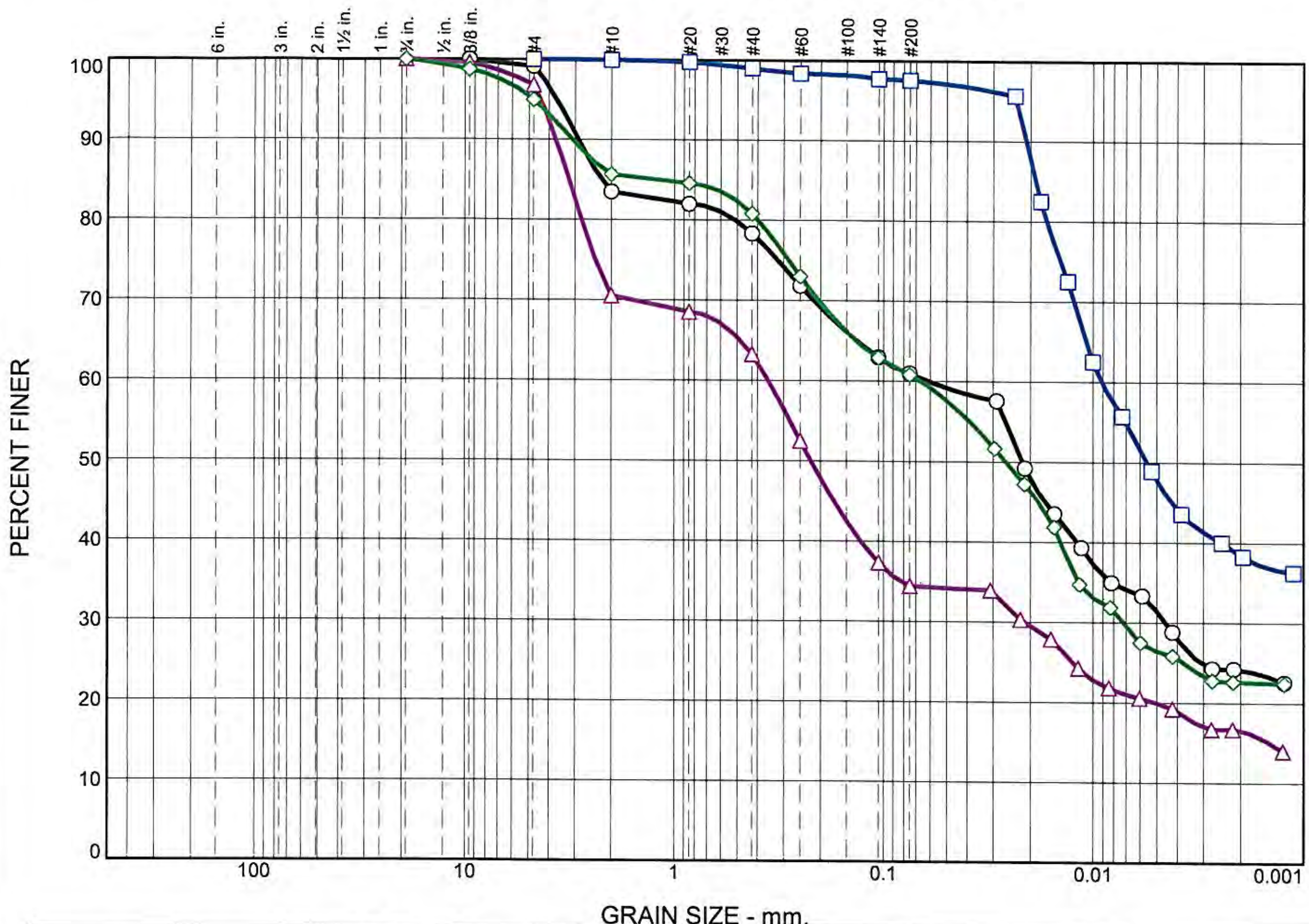
Material Reused During Test: ☐ Yes ☒ No

Machine Serial # 662B 80.6

Trail No.	1	2	3	4	5	6	7	8
Water Added %	7%	10%	14%	17%	19%			
Wt. Mold + Comp. Soil	12.807	12.960	13.301	13.342	13.338			
Wt. Mold	9.179	9.179	9.179	9.179	9.179			
Wt. Comp. Soil								
Qu	4.5+	4.5+	4.5+	2.8	1.6			

Trial No.	1	2	3	4	5	6	7	8
Can No.	1	1	1	1	1			
Wt. Can + Comp. Soil	157.1	190.7	161.8	147.9	178.89			
Wt. Can + Dry Soil	151.91	180.38	152.45	139.60	164.19			
Wt. Can	96.0	96.0	96.0	96.0	96.0			
Water Conten								

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.8	15.7	5.2	17.3	29.5	31.5
□	0.0	0.0	0.0	0.0	1.0	1.4	49.8	47.8
△	0.0	0.0	3.2	26.2	7.3	28.8	14.5	20.0
◇	0.0	0.0	5.0	9.3	4.9	20.0	34.3	26.5

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	Gypsum Stack	SW Quad	8.0	Brn. & gray vf. sandy silty clay / ox. spots.	CL
□	Gypsum Stack	NW Quad	4.0-5.0	Orange brn. & gray vf.-f. sandy silty clay (tr. sm. gravel) / ox. spots.	CH
△	Landfill	Center	8.0-10.0	Yel. brn. & gray vf.-f. sandy silty clay (tr. sm. gravel) / ox. spots.	SC
◇	Recycle Pond	SE Quad	10.0	Orange brn. & gray vf.-f. sandy silty clay (tr.sm. gravel) / ox. spots	CL
				& clayey sand seams.	

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Hanson Professional Services Inc.

Client: Ameren Coffeen Generating Station

Project: Landfill / Gypsum Stack

Project No.: 05S3004A **Figure**

Tested By: ○ Rin □ RIN △ RIN ◇ RIN **Checked By:** JCC

GRAIN SIZE DISTRIBUTION TEST DATA

6/11/2008

Client: Ameren Coffeen Generating Station
Project: Landfill / Gypsum Stack
Project Number: 05S3004A
Location: Recycle Pond
Depth: 10.0 **Sample Number:** SE Quad
Material Description: Orange brn. & gray vf.-f. sandy silty clay (tr.sm. gravel) / ox. spots & clayey sand seams.
USCS: CL
Tested by: RIN **Checked by:** JCC

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
393.40	0.00	0.00	3		
			2		
			1.5		
			1		
			.75	0.00	100.0
			.375	5.00	98.7
			#4	19.70	95.0
			#10	56.40	85.7
48.69	0.00	0.00	#20	0.60	84.6
			#40	2.76	80.8
			#60	7.18	73.0
			#140	12.93	62.9
			#200	14.11	60.8

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 85.7
Weight of hydrometer sample =50
Hygroscopic moisture correction:
Moist weight and tare = 48.40
Dry weight and tare = 47.22
Tare weight = 3.70
Hygroscopic moisture = 2.7%
Table of composite correction values:
Temp., deg. C: 18.0 28.0
Comp. corr.: -4.4 -2.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.7
Hydrometer type = 151H
Hydrometer effective depth equation: L = 16.294964 - 0.2645 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
2.00	23.8	1.0215	1.0185	0.0128	21.5	10.6	0.0296	51.7
4.00	23.5	1.0200	1.0169	0.0129	20.0	11.0	0.0214	47.3
8.00	23.8	1.0180	1.0150	0.0128	18.0	11.5	0.0154	41.9
15.00	23.6	1.0155	1.0124	0.0129	15.5	12.2	0.0116	34.8
30.00	23.5	1.0145	1.0114	0.0129	14.5	12.5	0.0083	31.9
60.00	23.2	1.0130	1.0098	0.0129	13.0	12.9	0.0060	27.5
123.00	22.8	1.0125	1.0093	0.0130	12.5	13.0	0.0042	25.9
303.00	22.4	1.0115	1.0082	0.0131	11.5	13.3	0.0027	22.8
480.00	22.2	1.0115	1.0081	0.0131	11.5	13.3	0.0022	22.7
1440.00	24.0	1.0110	1.0080	0.0128	11.0	13.4	0.0012	22.5

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	5.0	5.0	9.3	4.9	20.0	34.2	34.3	26.5	60.8

D_{10}	D_{15}	D_{20}	D_{30}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
			0.0072	0.0261	0.0662	0.3976	1.1681	3.0836	4.7538

Fineness Modulus
1.09

Hanson Professional Services Inc.

CONSTANT HEAD PERMEABILITY TEST

ASTM D5084

JOB NUMBER:	05S3004A	TEST DATE:	6/2/2008
CLIENT:	Ameren Coffeen Generating Station	BORING #:	N/A
JOB DESCRIPTION:	Coffeen Gypsum & Landfill Mgmt. Facility	SAMPLE #:	Recycle Pond SE Quad
SAMPLE DESCRIPTION:	Orange Brn. & gray vf.-f. sandy silty clay (tr. sm. gravel) /	DEPTH (FT):	N/A
	ox. spots & clayey sand.	FILE NAME:	Gypsum Stack 5-08

SPECIMEN WEIGHT (G)	914.27
SPECIMEN HEIGHT (IN)	4.289
DIAMETER (IN)	2.875
AREA (SQ IN)	6.492
VOLUME (CU IN)	27.843
WET DENSITY (PCF)	125.09
DRY DENSITY (PCF)	110.11
WT. DRY SOIL (G)	804.80
VOLUME DRY SOIL (CU IN	18.190
SP.GR. ASSUMED	2.70
POROSITY (%)	34.67
HEIGHT OF HEAD (PSI)	4.60
HYDRAULIC GRADIANT	29.7
1/4 PORE VOLUME	39.55

WATER CONTENT OF TRIMMINGS

	BEFORE TEST	AFTER TEST
TARE + WET SOIL (G)	211.49	997.30
TARE + DRY SOIL (G)	186.61	857.59
TARE (G)	3.70	50.22
WATER (G)	24.88	139.71
DRY SOIL (G)	182.91	807.37
WATER CONTENT (%)	13.60	17.30

STD. MAX. DEN.(LBS/CU.FT.)	116.20
OPTIMUM MOISTURE (%)	13.60
% COMPACTION	94.76
PRESSURE HEAD (CM H2O)	323.46
PANEL NUMBER	4

TEST METHOD USED: IEPA ASTM D5084

PERMEANT USED: TAP WATER

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Hanson Professional Services Inc.

CONSTANT HEAD PERMEABILITY TEST

JOB NUMBER: 05S3004A
CLIENT: Ameren Coffeen Generating Station
JOB DESCRIPTION: Coffeen Gypsum & Landfill Mgmt. Facility

TEST DATE: 6/9/2008
BORING #: N/A
SAMPLE #: Recycle Pond SE Quad
DEPTH (FT): N/A

SPECIMEN HEIGHT (IN) 4.289
DIAMETER (IN) 2.875
AREA (SQ IN) 6.492

HEIGHT OF HEAD (PSI) 4.60
PRESSURE HEAD (CM H2O) 323.46
PANEL NUMBER 4
FILE NAME: Gypsum Stack 5-08

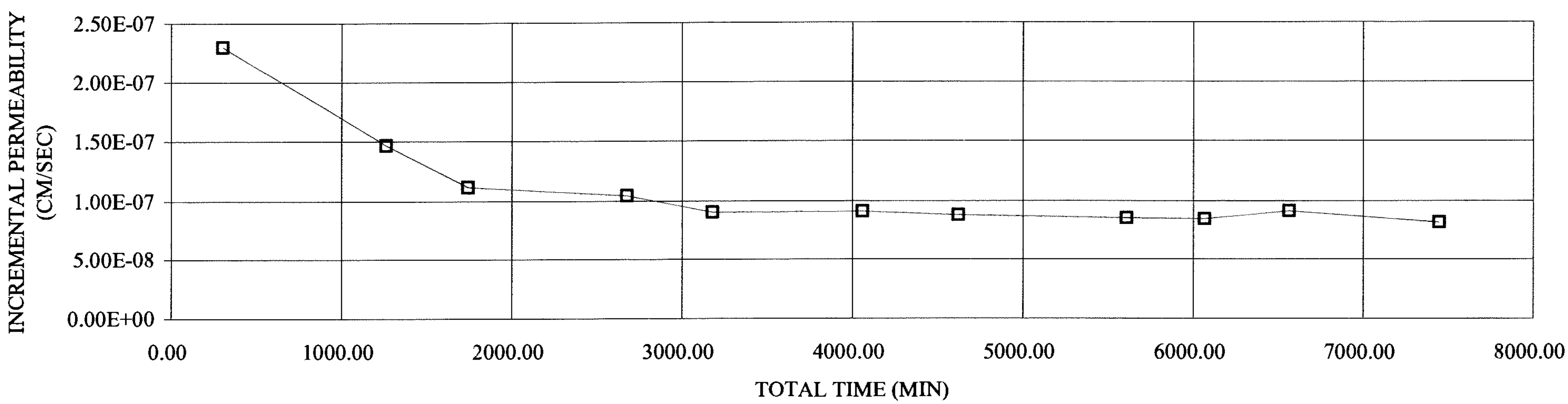
START DATE	START TIME	STOP DATE	STOP TIME	INCREMENT. FLOW (CC)	TOTAL FLOW (CC)	INCREMENT TIME (MIN)	TOTAL TIME (MIN)	INCREMENTAL PERMEABILITY (CM/SEC)	AVERAGE PERMEABILITY (CM/SEC)
6/9/2008	11:22:40	6/9/2008	16:25:20	5.20	5.2000	302.67	302.67	2.30E-07	2.30E-07
6/9/2008	16:27:00	6/10/2008	8:27:15	10.50	15.7000	960.25	1262.92	1.47E-07	1.88E-07
6/10/2008	8:27:15	6/10/2008	16:27:00	4.00	19.7000	479.75	1742.67	1.12E-07	1.63E-07
6/10/2008	16:27:55	6/11/2008	8:02:30	7.30	27.0000	934.58	2677.25	1.05E-07	1.48E-07
6/11/2008	8:02:30	6/11/2008	16:25:00	3.40	30.4000	502.50	3179.75	9.07E-08	1.13E-07
6/11/2008	16:28:00	6/12/2008	7:08:00	6.00	36.4000	880.00	4059.75	9.14E-08	9.96E-08
6/12/2008	7:08:00	6/12/2008	16:29:40	3.70	40.1000	561.67	4621.42	8.83E-08	9.38E-08
6/12/2008	16:29:40	6/13/2008	8:56:00	6.30	46.4000	986.33	5607.75	8.56E-08	8.90E-08
6/13/2008	8:56:00	6/13/2008	16:33:50	2.90	49.3000	457.83	6065.58	8.49E-08	8.75E-08
6/16/2008	8:09:00	6/16/2008	16:27:00	3.40	52.7000	498.00	6563.58	9.15E-08	8.76E-08
6/16/2008	16:29:00	6/17/2008	7:11:30	5.40	58.1000	882.50	7446.08	8.20E-08	8.60E-08

Hanson Professional Services Inc.

CONSTANT HEAD PERMEABILITY TEST

JOB NUMBER:	05S3004A	TEST DATE:	6/9/2008
CLIENT:	Ameren Coffeen Generating Station	BORING #:	N/A
JOB DESCRIPTION:	Coffeen Gypsum & Landfill Mgmt. Facility	SAMPLE #:	Recycle Pond SE Quad
		DEPTH (FT):	N/A

SPECIMEN HEIGHT (IN)	4.289	HEIGHT OF HEAD (PSI)	4.60
DIAMETER (IN)	2.875	PRESSURE HEAD (CM H2O)	323.46
AREA (SQ IN)	6.492	PANEL NUMBER	4
		FILE NAME:	Gypsum Stack 5-08



FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 2/26/2008
Finish: 2/26/2008
WEATHER: Overcast, cold

CONTRACTOR: TSC
Rig mfg/model: CME-650 Track Drill
Drilling Method: 3¼" HSA w/SS & CME samplers
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: S. Simpson

BOREHOLE ID: G270
Well ID: G270
Surface Elev: 622.92 ft. MSL
Completion: 18.27 ft. BGS
Station: 874,801.92N
2,514,996.84E

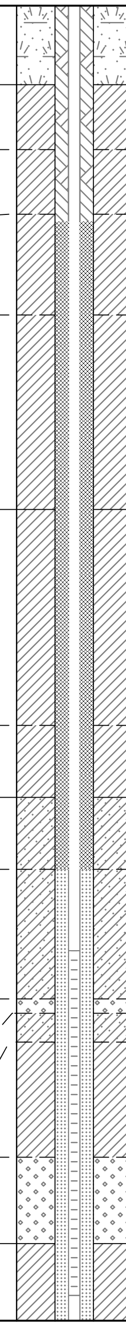
TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 16.00 - While drilling
▼ = 5.62 - 3/12/08
▽ =

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*
	20/24 *83%*	SS	*2-2 2-4* N=4			
1A				24		
2A	19/24 *79%*	SS	*3-4 5-9* N=9	22		2.33 *B*
2B				20		5.04 *Sh*
	20/24 *83%*	SS	*14-5 7-8* N=12			
3A				17		2.52 *Sh*
4A	24/24 *100%*	SS	*8-6 7-5* N=13	21		1.24 *BSh*
4B				21		1.20 *B*
	22/24 *92%*	SS	*2-3 4-4* N=7			
5A				21		1.36 *B*
6A	24/24 *100%*	SS	*1-2 2-3* N=4	21		0.74 *BSh*
6B				24		0.78 *B*
	17/24 *71%*	SS	*2-2 2-3* N=4			
7A				21		
8A				20		
	19/24 *79%*	SS	*1-3 5-6* N=8			
8B				17		4.46 *Sh*
9A	24/24 *100%*	SS	*6-8 30-35* N=38	20		
9B				8		

Depth ft. BGS	Lithologic Description
0 – 1.1	Dark grayish brown (10YR4/2), moist, firm, clayey SILT
1.1 – 2	Dark grayish brown (10YR4/2), moist, firm, silty CLAY
2 – 2.9	Dark grayish brown (10YR4/2) with 5% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, slight trace sand
2.9 – 4.3	Gray (10YR5/1) with 70% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, slight trace sand and gravel
4.3 – 7	Dark gray (10YR4/1) with 5% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, trace sand, slight trace gravel
7 – 10	Gray (10YR5/1) with 10% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, trace sand, slight trace gravel
10 – 11	Gray (10YR5/1) with 60% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, trace sand, slight trace gravel
11 – 12	Gray (10YR5/1), moist, soft, sandy CLAY
12 – 13.8	Gray (10YR5/1), moist, soft, sandy CLAY, trace gravel
13.8 – 14.4	Gray (10YR5/1), moist, soft, fine- to coarse-grained SAND, trace gravel
14.4 – 15	Dark yellowish brown (10YR4/4), moist, soft, sandy CLAY
15 – 16	Gray (10YR5/1) with 10% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, slight trace sand and gravel
16 – 17.2	Yellowish brown (10YR5/4), wet, soft, fine to coarse SAND
17.2 – 18.27	Gray (10YR5/1), moist, hard, silty CLAY, trace sand and gravel

Borehole Detail



Elevation ft. MSL	Remarks
622	
620	
618	
616	
614	
612	
610	
608	
606	

End of Boring = 18.27 ft. BGS

NOTE(S):

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 2/26/2008
Finish: 2/26/2008
WEATHER: Overcast, cold

CONTRACTOR: TSC
Rig mfg/model: CME-650 Track Drill
Drilling Method: 3¼" HSA w/SS & CME samplers
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: S. Simpson

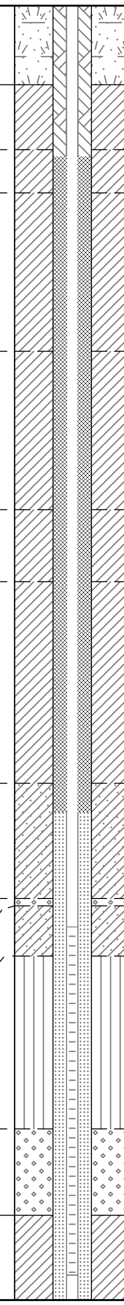
BOREHOLE ID: G280
Well ID: G280
Surface Elev: 622.95 ft. MSL
Completion: 17.98 ft. BGS
Station: 875,045.11N
2,515,679.48E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 15.60 - While drilling
▼ = 4.34 - 3/12/08
▽ =

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*
1A	24/24 *100%*	SS	*5-3 4-4* N=7	23		
1B				26		2.33 *B*
2A	24/24 *100%*	SS	*3-4 4-6* N=8	30		1.28 *BSh*
2B				25		
3A	19/24 *79%*	SS	*3-4 6-6* N=10	14		3.10 *Sh*
4A	22/24 *92%*	SS	*9-11 10-8* N=21	18		1.67 *BSh*
5A	19/24 *79%*	SS	*2-2 4-4* N=6	20		1.47 *B*
5B				21		1.28 *B*
6A	22/24 *92%*	SS	*2-3 3-3* N=6	20		
7A	23/24 *96%*	SS	*3-14 23-21* N=37	13		
8A	23/24 *96%*	SS	*12-17 24-26* N=41	9		
8B				15		
9A	24/24 *100%*	SS	*11-27 54-43* N=81	26		
9B				7		

Depth ft. BGS (approx.)	Lithologic Description
0 – ~1.1	Dark grayish brown (10YR4/2), moist, firm, clayey SILT
~1.1 – 2	Brown (10YR4/3) with 20% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY
2 – ~2.6	Dark yellowish brown (10YR4/4), moist, firm, silty CLAY
~2.6 – ~4.8	Dark gray (10YR4/1) with 40% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY
~4.8 – ~7	Dark gray (10YR4/1) with 40% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, slight trace sand
~7 – 8	Dark gray (10YR4/1) with 40% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, trace sand, slight trace gravel
8 – ~10.8	Dark gray (10YR4/1) with 40% yellowish brown (10YR5/8) mottles, moist, firm, silty CLAY, sand, trace gravel
~10.8 – ~12.4	Yellowish brown (10YR5/8) with 20% light gray (10YR6/1) mottles, moist, soft, sandy CLAY
~12.4 – ~13	Yellowish brown (10YR5/8), moist, soft, fine to coarse SAND, trace gravel
~13 – ~13.5	Yellowish brown (10YR5/8), moist, firm, sandy CLAY, trace gravel
~13.5 – ~15.6	Yellowish brown (10YR5/4), moist, firm, clayey SILT, trace sand and gravel
~15.6 – ~16.8	Yellowish brown (10YR5/4), wet, soft, fine- to coarse-grained SAND, trace gravel
~16.8 – 17.98	Gray (10YR5/1), moist, hard, silty CLAY, trace sand and gravel



Remarks

End of Boring = 17.98 ft. BGS

NOTE(S):

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/10/2006
Finish: 5/10/2006
WEATHER: Foggy to partly sunny, mild (hi-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS & CME samplers
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-12
Well ID: MW12D
Surface Elev: 622 ft. MSL
Completion: 50 ft. BGS
Station: 875,515.1N
2,515,900.6E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 12.00 - While drilling
▼ = 6.76 - MW12S on 6/1/06
▽ = 46.90 - MW12D on 6/1/06

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*
1A	24"/24	SS	*2-3 4-5* N=7	22		1.27 *Sh*
1B				27		2.33 *B*
2A	19"/24	SS	*2-4 5-7* N=9	24		2.91 *B*
3A	20"/24	SS	*2-2 3-4* N=5	21		2.13 *B*
4A	24/24 *100%*	SS	*4-5 5-6* N=10	21		1.36 *BSh*
5A	24"/24	SS	*1-2 2-5* N=4	20		1.47 *BSh*
6A	20"/24	SS	*0-1 3-3* N=4	21		0.62 *B*
7A	21"/24	SS	*2-2 3-5* N=5	22		0.19 *B*
7B				22		
7C				15		3.71 *B*
8A	24"/24	SS	*4-13 18-29* N=31	9		5.15 *BSh*
9A	24"/24	SS	*26-32 46-50* N=78	9		6.59 *Sh*
10A	24"/24	SS	*21-31 63-71* N=94	11		6.39 *Sh*

Depth ft. BGS	Lithologic Description	Elevation ft. MSL
0	Very dark gray (10YR3/1), clayey SILT, trace sand	622
	Dark gray (10YR4/1) with 15% yellowish brown (10YR5/6) mottles, lean CLAY	
2	Yellowish brown (10YR5/8) with 40% grayish brown (10YR5/2) mottles, lean CLAY	620
4	Gray (10YR5/1), lean CLAY, trace sand and gravel	618
6	Gray (10YR5/1) with 10% yellowish brown (10YR5/6) mottles, lean CLAY, trace sand	616
8	Yellowish brown (10YR5/8) with 20% gray (10YR6/1) mottles, lean CLAY, trace sand and gravel	614
10	Yellowish brown (10YR 5/8) with 25% gray (10YR6/1) mottles, clayey SAND, trace gravel	612
12	Gray (10YR6/1), clayey SAND, trace gravel, wet	610
	Dark yellowish brown (10YR4/6), clayey SAND, trace gravel, wet	
	Light yellowish brown (10YR6/4) with 30% brownish yellow (10YR6/6) mottles, clayey SILT, trace sand and gravel	
14	Dark greenish gray (N4/1), clayey SILT, trace sand and gravel	608
16		606
18		604
20		

Borehole Detail | Remarks

NOTE(S): MW12D installed in SB-12.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/10/2006
Finish: 5/10/2006
WEATHER: Foggy to partly sunny, mild (hi-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS & CME samplers

FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-12
Well ID: MW12D
Surface Elev: 622 ft. MSL
Completion: 50 ft. BGS
Station: 875,515.1N
2,515,900.6E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 12.00 - While drilling
▼ = 6.76 - MW12S on 6/1/06
▽ = 46.90 - MW12D on 6/1/06

SAMPLE: Number	Recov / Total (in) *% Recovery*	Type	TESTING: *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
										602	
11A	60/60 *100%*	CS		6			22, 24	Dark greenish gray (N4/1), clayey SILT, trace sand and gravel *[Continued from previous page]*		600, 598	
12A	60/60 *100%*	CS		7			26, 28, 30	Dark greenish gray (N4/1), sandy SILT, trace gravel		596, 594, 592	
13A	60/60 *100%*	CS		13			32, 34			590, 588	
14A	60/60 *100%*	CS		16			36, 38, 40	Very dark gray (N3/1), clayey SILT, trace sand and gravel		586, 584	

NOTE(S): MW12D installed in SB-12.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/10/2006
Finish: 5/10/2006
WEATHER: Foggy to partly sunny, mild (hi-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS & CME samplers
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-12
Well ID: MW12D
Surface Elev: 622 ft. MSL
Completion: 50 ft. BGS
Station: 875,515.1N 2,515,900.6E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 12.00 - While drilling
▼ = 6.76 - MW12S on 6/1/06
▽ = 46.90 - MW12D on 6/1/06

Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
										582	
15A	60/60 *100%*	CS		14			42–45	Very dark gray (N3/1), clayey SILT, trace sand and gravel *[Continued from previous page]*		580, 578	
							45–45.5	Very dark gray (N3/1), PEAT			
16A	60/60 *100%*	CS		45			45.5–50 (▽ at 46.90)	Gray (N5/1) with 30% yellowish brown (10YR5/6) mottles, lean CLAY		576, 574	

End of Boring = 50.0 ft. BGS

NOTE(S): MW12D installed in SB-12.

Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

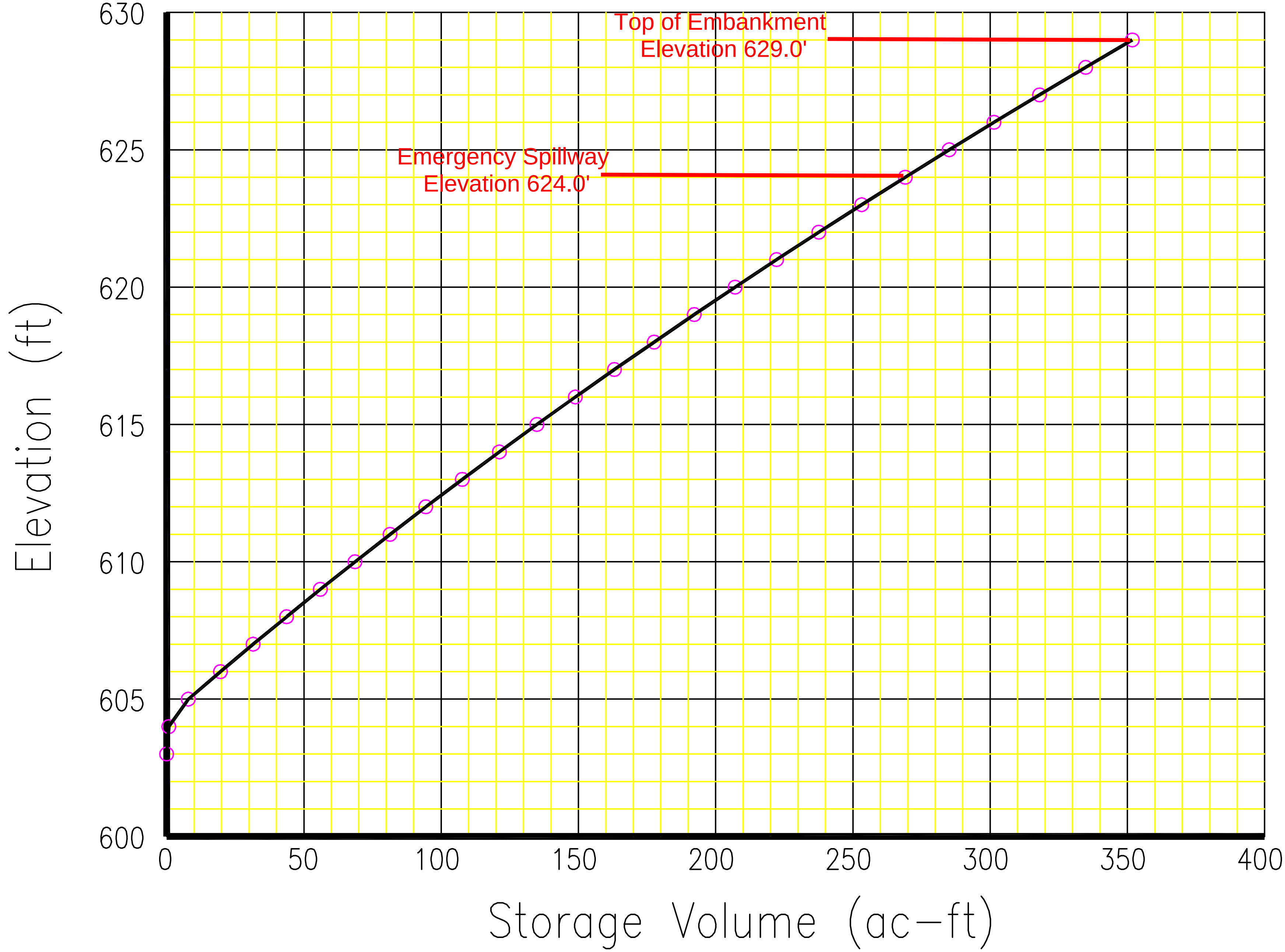
Appendix 3

Stage Storage Information

Coffeen Recycle Pond
As-Built Stage Storage Data
4/27/2010

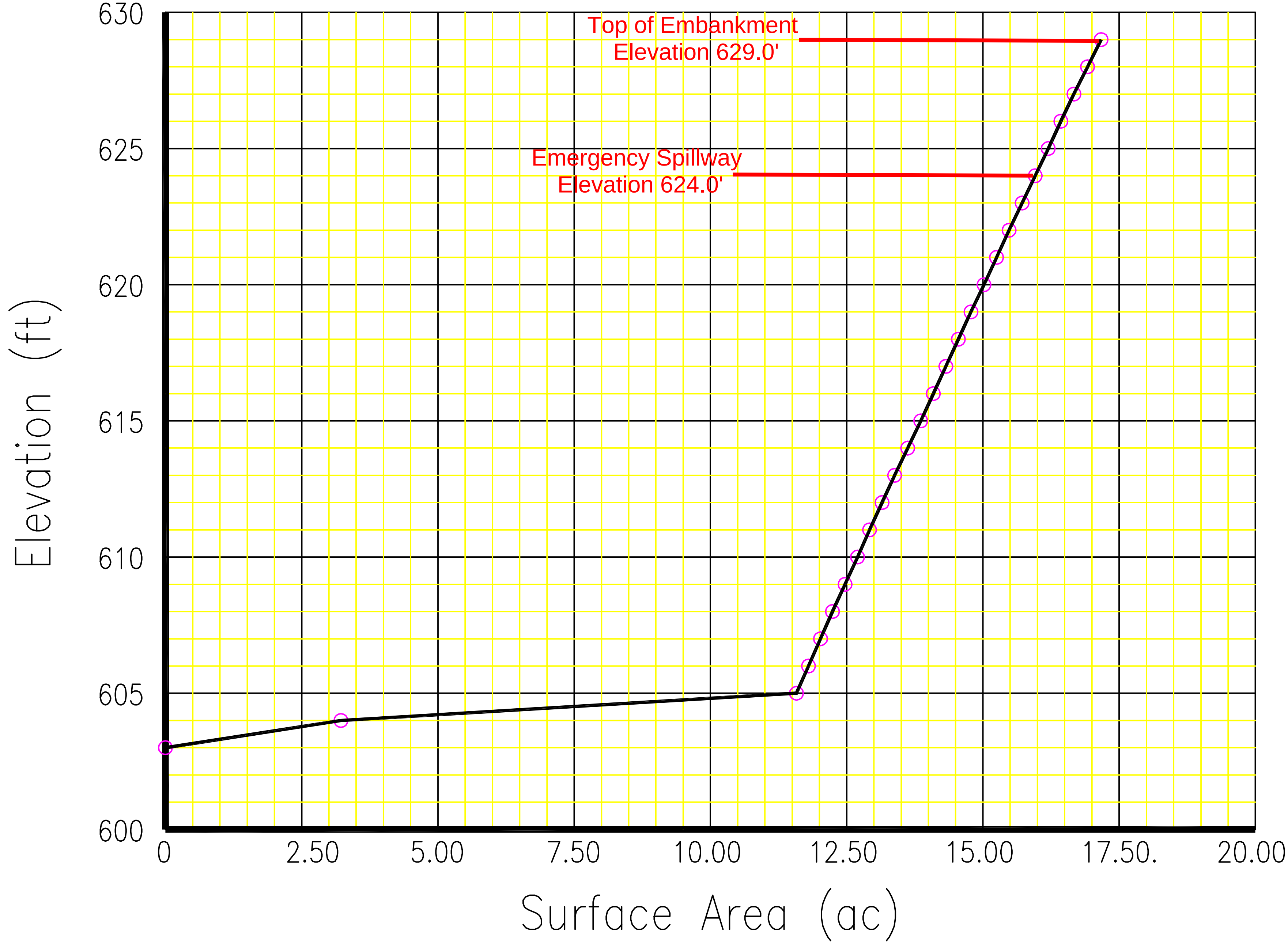
Elevation	Incremental Storage yd3	Cumulative Storage yd3	Cumulative Storage ac-ft	Cumulative Storage gallons	Cumulative Surface Area acres
603	0.13	0.13	0.0	26	0
604	1,307.72	1,307.85	0.8	264,150	3.22
605	11,498.83	12,806.68	7.9	2,586,610	11.58
606	18,850.09	31,656.77	19.6	6,393,829	11.80
607	19,210.29	50,867.06	31.5	10,273,798	12.02
608	19,571.08	70,438.14	43.7	14,226,637	12.24
609	19,934.02	90,372.15	56.0	18,252,780	12.47
610	20,299.09	110,671.25	68.6	22,352,659	12.70
611	20,666.31	131,337.55	81.4	26,526,705	12.92
612	21,035.66	152,373.22	94.4	30,775,352	13.15
613	21,407.16	173,780.38	107.7	35,099,031	13.38
614	21,780.81	195,561.19	121.2	39,498,178	13.62
615	22,156.67	217,717.86	134.9	43,973,238	13.86
616	22,534.49	240,252.34	148.9	48,524,606	14.09
617	22,913.12	263,165.46	163.1	53,152,450	14.32
618	23,288.44	286,453.90	177.6	57,856,097	14.55
619	23,661.08	310,114.98	192.2	62,635,009	14.78
620	24,035.26	334,150.24	207.1	67,489,493	15.02
621	24,411.32	358,561.56	222.2	72,419,933	15.25
622	24,789.28	383,350.84	237.6	77,426,711	15.48
623	25,169.22	408,520.06	253.2	82,510,226	15.72
624	25,551.00	434,071.06	269.1	87,670,851	15.96
625	25,934.59	460,005.65	285.1	92,908,951	16.20
626	26,319.99	486,325.64	301.4	98,224,891	16.43
627	26,707.19	513,032.82	318.0	103,619,035	16.67
628	27,096.19	540,129.02	334.8	109,091,748	16.92
629	27,484.09	567,613.11	351.8	114,642,806	17.17

Coffeen Recycle Pond
5-24-10



Coffeen Recycle Pond

5-24-10



Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

Appendix 4

Hydraulic Design Calculations

GMF RECYCLE POND - HYDRAULIC DESIGN REPORT

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GMF RECYCLE POND - HYDRAULIC DESIGN REPORT

INTRODUCTION

The GMF Pond embankment and the GMF Recycle Pond embankment are regulated in accordance with 17 Illinois Administrative Code (IAC) Part 3702, Construction and Maintenance of Dams. The GMF Pond embankment, which is lined with a high density polyethylene (HDPE) geomembrane system, will have a maximum embankment height of 13 ft. and a maximum impounding capacity of 442 acre-ft. (measured at the top of earthen embankment elevation 632 ft.). There is an additional 123 acre-ft. of incised storage.

The embankment for the GMF Recycle Pond, which is lined with a 60 mil HDPE geomembrane, will have a maximum embankment height of 16 ft. and a maximum impounding capacity of 243 acre-ft. (measured at the top of embankment elevation 629 ft.). There is an additional 99 acre-ft. of incised storage.

The GMF Pond was originally designed to “stack” gypsum above the height of the surrounding perimeter berm. This will no longer take place, and sluiced gypsum is deposited to an elevation no higher than approximately 3-feet of freeboard. However, the discharge from the GMF Pond to the GMF Recycle Pond has been based on the gypsum “stacking” condition. This is extremely conservative as the peak discharge will now be controlled by rising overall water levels due to the precipitation event, rather than rainfall cascading down the side slopes of the previously proposed gypsum stack. In addition, the transfer channel was originally designed with an adjustable spillway elevation to elevation 625.0’. This was also not constructed and the transfer channel discharge elevation is limited to a maximum of 623.0’. Finally, the hydraulic analysis assumed the addition of another GMF Pond cell which will not likely be built. Consequently, both the transfer channel spillway between the GMF Pond and the GMF Recycle Pond, and the emergency spillway system in the GMF Recycle Pond are significantly overdesigned.

The transfer channel, located between the GMF Pond embankment and the GMF Recycle Pond, has a trapezoidal cross-section with 3H:1V side slopes and is lined with HDPE. The 500 ft long transfer channel will transition from a 32-ft bottom width at an invert elevation of 623.0 ft at the upstream end to a 60-ft bottom width at an invert elevation of 622.0 ft at the downstream end.

The emergency spillway for the GMF Recycle Pond consists of three 6 ft. by 6 ft precast reinforced concrete risers (drop inlets) with a top elevation of 624 ft (5 ft below the top of the embankment). The GMF Recycle Pond’s HDPE liner is attached to the exterior sides of each riser. A 4-ft diameter HDPE outlet conduit was constructed at each riser with an upstream invert of 615.0 ft and a downstream invert of 613.0 ft. Assuming a normal pool elevation of 624 ft (control elevation of the risers), the emergency spillway has been designed to pass the 24-hour PMF storm event with adequate freeboard to prevent overtopping of the GMF Recycle Pond crest by wind generated waves. The emergency spillway has been provided in the event of accident or catastrophic rainfall only. It is not expected to be activated during the life of the facility. As designed, all discharges from the system are through the pump house located on the southeast corner of the GMF Recycle Pond.

HYDROLOGIC COMPUTATIONS

The U.S. Army Corps of Engineers, Hydrologic Engineer Center's Hydrologic Modeling System (HEC-HMS) was used to analyze runoff during various storm events. The runoff rates computed by the model are dependent on the watershed drainage area, precipitation amounts, precipitation distribution, unit hydrograph methodology and rainfall loss rates on the ground. The GMF Recycle Pond has a total watershed drainage area of approximately 57.5 acres, including the GMF Pond, the GMF Recycle Pond and the transfer channel connecting the two. However, it is important to note that the design of the spillway system is based on the capacity required for a possible future expansion of the gypsum management facility (GMF) to include an additional gypsum storage cell. Therefore, a total watershed drainage area of 77.3 acres was used in the design computations and modeling, which is more conservative.

Frequency precipitation values and distributions were obtained from the Illinois State Water Survey (ISWS) Circular 172 "Frequency Distributions of Heavy Rainstorms in Illinois" and Circular 173 "Time Distributions of Heavy Rainstorms in Illinois". The probable maximum precipitation was estimated based on NOAA Hydrometeorological Report No. 51. The Soil Conservation Service (SCS) Dimensionless Unit Graph was used to establish the runoff unit hydrograph and the SCS Curve Number Method was used to establish the loss rate. Based on Chapter 7, Hydrologic Soil Groups, of Part 630 of the USDA/NRCS National Engineering Handbook, gypsum was categorized as hydrologic soil group C. In accordance with USDA/NRCS TR-55, Urban Hydrology for Small Watersheds, a curve number of 91 was assigned to the gypsum to define the loss rate and a lag time of 7 minutes was computed to develop the runoff unit hydrograph.

HYDRAULIC COMPUTATIONS

The HEC-HMS generated rainfall runoff hydrographs for the gypsum stack watershed were routed through the gypsum stack ditches and transfer channel using the unsteady flow module of the U.S. Army Corps of Engineers, Hydrologic Engineer Center's River Analysis System (HEC-RAS). The time-variable pool elevation of the GMF Recycle Pond, as generated by HEC-HMS, was used as the downstream control in the HEC-RAS models. Since the pool elevation of the GMF Recycle Pond is dependent on the inflow from the GMF Pond, the HEC-HMS models must be run both before and after the HEC-RAS models.

The "CulvertMaster" computer software package was used to determine the depth of flow and outlet velocity in the outlet conduit from the GMF Recycle Pond emergency spillway. This information was then used in the design of the riprap lined plunge pool for energy dissipation.

SUMMARY

Table 1 describes the computed water surface elevation results for each pond assuming that the stop logs were installed up to elevation 625.0 ft in the transfer channel and that the starting pool elevation in the GMF Recycle Pond is at elevation 624.0 ft (the spillway control elevation). *Note that these are conservative estimates, since the stop log portion of the spillway was never constructed. Consequently, the actual water surface in the GMF Pond is assumed to be no greater than 623.0' and the water surface in the GMF Recycle Pond can be assumed to be no higher than 622.0'.* The normal pool in the GMF Recycle Pond will usually be maintained at a lower level in order to prevent discharges over the spillway.

Table 1: Peak Water Surface Elevations and Freeboard

	100-Year Peak Discharge (cfs)	PMF Peak Discharge (cfs)	100-Year Peak WSEL (ft)	PMF Peak WSEL (ft)	Top of Embankment Elev. (ft.)	Freeboard Above PMF (ft)	Wave Runup & Wind Setup (ft)
GMF Pond	92.6	1100.7	626.07	629.89	632.00	2.11	2.06
GMF Recycle Pond	95.8	586.9	624.63	627.45	629.00	1.55	1.20

In all cases, maximum wave runup is less than the calculated freeboard; therefore, water will not overtop any embankment for all storm events up to and including the Probable Maximum Flood.

Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

Appendix 4A

Hydrologic and Hydraulic Design Calculations

Gypsum Stack (2 Gypsum Cells) - Hydraulic Summary

Perimeter Ditches

Bottom Width	15.00	feet
Top Width	73.50	feet
Depth	9.00	feet
Outer Side Slope	3:1	H:V
Inner Side Slope	3:1	H:V
Upstream Invert	624.85	feet
Downstream Invert	623.00	feet
Ditch slope	0.00050	ft/ft
Bank Full Cross-sectional Area	378.00	sf
Length of Each Ditch (Centerline)	3710.00	feet
Bank Full Volume of Each Ditch	32.19	acre-ft
Total Ditch length (Centerline)	7420.00	feet
Total Ditch Bank Full Volume	64.39	acre-ft

Transfer Channel

Bottom Width	32.00	feet
Top Width	86.00	feet
Depth	9.00	feet
Upstream Invert	623.00	feet
Downstream Invert	622.00	feet
Weir Elevation	625.00	feet
Weir Length (at 2 ft height)	44.00	feet
Top of Dam Elevation	632	feet
Reservoir Surface Area	77.29	acres
Total Watershed Area	77.29	acres
Dam Length	7720	feet
Dam Height	13	feet

1.0 PMF Storm Event

Storm Duration	24	hours
Peak Runoff Discharge	1827.3	cfs
Peak Outflow Discharge	1100.7	cfs
Total Runoff Volume	212.86	acre-ft
Total Discharge Volume	228.83	acre-ft
Peak WSEL (HEC-RAS)	629.89	feet
Freeboard over Max WSEL	2.11	feet
Wave Runup/Wind Setup	2.06	feet
Adequate Freeboard?	YES	

0.5 PMF Storm Event

Storm Duration	24	hours
Peak Runoff Discharge	913.7	cfs
Peak Outflow Discharge	541.1	cfs
Total Runoff Volume	106.43	acre-ft
Total Discharge Volume	122.41	acre-ft
Peak WSEL (HEC-RAS)	628.23	feet
Freeboard over Max WSEL	3.77	feet
Wave Runup/Wind Setup	2.06	feet
Adequate Freeboard?	YES	

100-yr Storm Event - Critical Duration

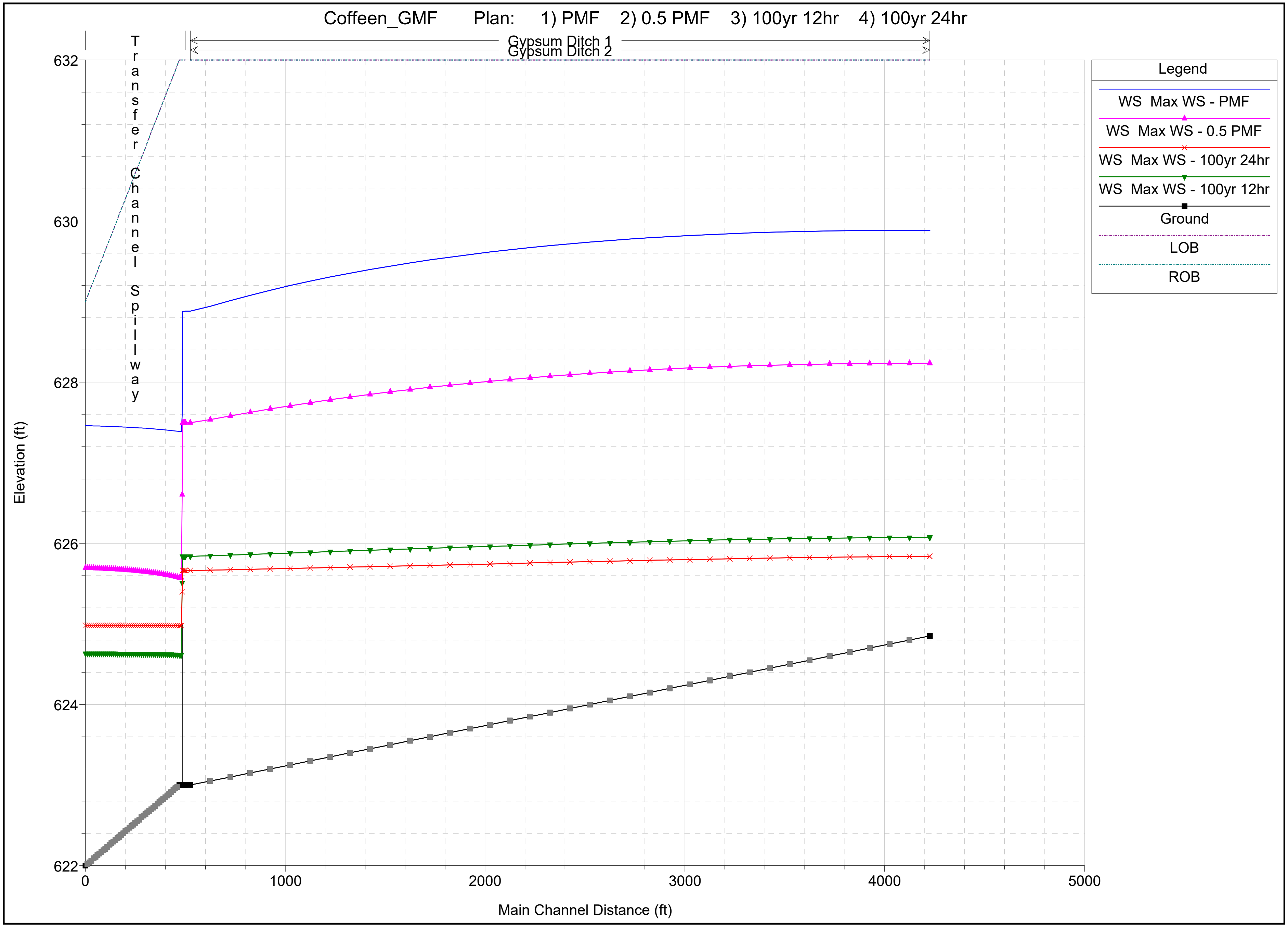
Storm Duration	12	hours
Peak Runoff Discharge	95.9	cfs
Peak Outflow Discharge	92.6	cfs
Total Runoff Volume	34.94	acre-ft
Total Discharge Volume	50.91	acre-ft
Computed WSEL (HEC-RAS)	626.07	feet
Freeboard over Max WSEL	5.93	feet
Wave Runup/Wind Setup	2.06	feet
Adequate Freeboard?	YES	

100-yr Storm Event - 24 Hour Duration

Storm Duration	24	hours
Peak Runoff Discharge	63.2	cfs
Peak Outflow Discharge	62.9	cfs
Total Runoff Volume	41.1	acre-ft
Total Discharge Volume	57.01	acre-ft
Computed WSEL (HEC-RAS)	625.84	feet
Freeboard over Max WSEL	6.16	feet
Wave Runup/Wind Setup	2.06	feet
Adequate Freeboard?	YES	

HEC-RAS Profile: Max WS

River	Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
					(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Transfer Channel	Spillway	500	Max WS	PMF	1146.40	623.00	628.88		629.12	0.000147	3.93	291.97	67.29	0.33
Transfer Channel	Spillway	500	Max WS	0.5 PMF	541.22	623.00	627.50		627.61	0.000090	2.65	204.55	58.98	0.25
Transfer Channel	Spillway	500	Max WS	100yr 12hr	93.23	623.00	625.84		625.85	0.000014	0.81	115.05	49.04	0.09
Transfer Channel	Spillway	500	Max WS	100yr 24hr	64.69	623.00	625.66		625.67	0.000009	0.61	106.53	47.98	0.07
Transfer Channel	Spillway	495	Max WS	PMF	1146.38	623.00	628.88		629.12	0.000148	3.93	291.90	67.28	0.33
Transfer Channel	Spillway	495	Max WS	0.5 PMF	541.21	623.00	627.50		627.60	0.000090	2.65	204.52	58.98	0.25
Transfer Channel	Spillway	495	Max WS	100yr 12hr	93.23	623.00	625.84		625.85	0.000014	0.81	115.04	49.04	0.09
Transfer Channel	Spillway	495	Max WS	100yr 24hr	64.68	623.00	625.66		625.67	0.000009	0.61	106.53	47.98	0.07
Transfer Channel	Spillway	490	Max WS	PMF	1146.36	623.00	628.88	626.08	629.12	0.000148	3.93	291.85	67.28	0.33
Transfer Channel	Spillway	490	Max WS	0.5 PMF	541.20	623.00	627.50	624.92	627.60	0.000090	2.65	204.49	58.97	0.25
Transfer Channel	Spillway	490	Max WS	100yr 12hr	93.23	623.00	625.84	623.62	625.85	0.000014	0.81	115.04	49.04	0.09
Transfer Channel	Spillway	490	Max WS	100yr 24hr	64.69	623.00	625.66	623.49	625.67	0.000009	0.61	106.53	47.98	0.07
Transfer Channel	Spillway	485			Inl Struct									
Transfer Channel	Spillway	480	Max WS	PMF	433.02	623.00	627.39		627.46	0.000063	2.18	198.30	58.34	0.21
Transfer Channel	Spillway	480	Max WS	0.5 PMF	310.94	623.00	625.58		625.72	0.000221	3.04	102.29	47.45	0.36
Transfer Channel	Spillway	480	Max WS	100yr 12hr	79.70	623.00	624.62		624.65	0.000074	1.34	59.63	41.71	0.20
Transfer Channel	Spillway	480	Max WS	100yr 24hr	51.47	623.00	624.98		624.99	0.000015	0.69	75.10	43.88	0.09
Transfer Channel	Spillway	475	Max WS	PMF	433.02	623.00	627.39		627.46	0.000063	2.18	198.28	58.34	0.21
Transfer Channel	Spillway	475	Max WS	0.5 PMF	307.12	623.00	625.57		625.71	0.000216	3.00	102.24	47.44	0.36
Transfer Channel	Spillway	475	Max WS	100yr 12hr	79.70	623.00	624.62		624.65	0.000074	1.34	59.62	41.71	0.20
Transfer Channel	Spillway	475	Max WS	100yr 24hr	51.47	623.00	624.98		624.99	0.000015	0.69	75.09	43.88	0.09
Transfer Channel	Spillway	470	Max WS	PMF	433.02	623.00	627.39		627.46	0.000063	2.18	198.27	58.34	0.21
Transfer Channel	Spillway	470	Max WS	0.5 PMF	307.12	623.00	625.57		625.71	0.000217	3.01	102.20	47.44	0.36
Transfer Channel	Spillway	470	Max WS	100yr 12hr	79.70	623.00	624.62		624.65	0.000074	1.34	59.60	41.70	0.20
Transfer Channel	Spillway	470	Max WS	100yr 24hr	51.47	623.00	624.98		624.99	0.000015	0.69	75.09	43.88	0.09
Transfer Channel	Spillway	0	Max WS	PMF	507.50	622.00	627.46	623.27	627.48	0.000012	1.15	442.72	102.13	0.10
Transfer Channel	Spillway	0	Max WS	0.5 PMF	373.70	622.00	625.69	623.02	625.72	0.000027	1.36	274.35	88.50	0.14
Transfer Channel	Spillway	0	Max WS	100yr 12hr	82.45	622.00	624.63	622.36	624.64	0.000004	0.45	184.78	80.32	0.05
Transfer Channel	Spillway	0	Max WS	100yr 24hr	51.58	622.00	624.98	622.28	624.98	0.000001	0.24	213.37	83.02	0.03
Gypsum Ditch	1	3711	Max WS	PMF	2.00	624.85	629.89		629.89	0.000000	0.01	179.37	56.21	0.00
Gypsum Ditch	1	3711	Max WS	0.5 PMF	2.00	624.85	628.23		628.23	0.000000	0.02	97.62	42.69	0.00
Gypsum Ditch	1	3711	Max WS	100yr 12hr	2.00	624.85	626.07		626.07	0.000003	0.08	24.49	25.02	0.01
Gypsum Ditch	1	3711	Max WS	100yr 24hr	2.00	624.85	625.84		625.84	0.000006	0.11	18.84	23.09	0.02
Gypsum Ditch	1	3710	Max WS	PMF	2.00	624.85	629.89		629.89	0.000000	0.01	179.37	56.21	0.00
Gypsum Ditch	1	3710	Max WS	0.5 PMF	2.00	624.85	628.23		628.23	0.000000	0.02	97.62	42.69	0.00
Gypsum Ditch	1	3710	Max WS	100yr 12hr	2.00	624.85	626.07		626.07	0.000003	0.08	24.49	25.02	0.01
Gypsum Ditch	1	3710	Max WS	100yr 24hr	2.00	624.85	625.84		625.84	0.000006	0.11	18.84	23.09	0.02
Gypsum Ditch	1	10	Max WS	PMF	573.20	623.00	628.88		629.01	0.000593	2.86	200.63	53.23	0.26
Gypsum Ditch	1	10	Max WS	0.5 PMF	270.61	623.00	627.50		627.56	0.000403	2.03	133.16	44.23	0.21
Gypsum Ditch	1	10	Max WS	100yr 12hr	46.61	623.00	625.84		625.85	0.000074	0.68	68.79	33.46	0.08
Gypsum Ditch	1	10	Max WS	100yr 24hr	32.34	623.00	625.66		625.67	0.000046	0.51	63.02	32.31	0.06
Gypsum Ditch	2	3711	Max WS	PMF	2.00	624.85	629.89		629.89	0.000000	0.01	179.37	56.21	0.00
Gypsum Ditch	2	3711	Max WS	0.5 PMF	2.00	624.85	628.23		628.23	0.000000	0.02	97.62	42.69	0.00
Gypsum Ditch	2	3711	Max WS	100yr 12hr	2.00	624.85	626.07		626.07	0.000003	0.08	24.49	25.02	0.01
Gypsum Ditch	2	3711	Max WS	100yr 24hr	2.00	624.85	625.84		625.84	0.000006	0.11	18.84	23.09	0.02
Gypsum Ditch	2	3710	Max WS	PMF	2.00	624.85	629.89		629.89	0.000000	0.01	179.37	56.21	0.00
Gypsum Ditch	2	3710	Max WS	0.5 PMF	2.00	624.85	628.23		628.23	0.000000	0.02	97.62	42.69	0.00
Gypsum Ditch	2	3710	Max WS	100yr 12hr	2.00	624.85	626.07		626.07	0.000003	0.08	24.49	25.02	0.01
Gypsum Ditch	2	3710	Max WS	100yr 24hr	2.00	624.85	625.84		625.84	0.000006	0.11	18.84	23.09	0.02
Gypsum Ditch	2	10	Max WS	PMF	573.20	623.00	628.88		629.01	0.000593	2.86	200.63	53.23	0.26
Gypsum Ditch	2	10	Max WS	0.5 PMF	270.61	623.00	627.50		627.56	0.000403	2.03	133.16	44.23	0.21
Gypsum Ditch	2	10	Max WS	100yr 12hr	46.61	623.00	625.84		625.85	0.000074	0.68	68.79	33.46	0.08
Gypsum Ditch	2	10	Max WS	100yr 24hr	32.34	623.00	625.66		625.67	0.000046	0.51	63.02	32.31	0.06


Coffeen_GMF Plan: 1) PMF 2) 0.5 PMF 3) 100yr 12hr 4) 100yr 24hr
Transfer Channel Spillway
Gypsum Ditch 1
Gypsum Ditch 2
Legend
WS Max WS - PMF
WS Max WS - 0.5 PMF
WS Max WS - 100yr 24hr
WS Max WS - 100yr 12hr
Ground
LOB
ROB
Elevation (ft)
632
630
628
626
624
622
0
1000
2000
3000
4000
5000
Main Channel Distance (ft)

Gypsum Stack - 2 Gypsum Cells
Computations for Ditch Geometry and Volume

Side Slope Dam Embankment:		3		Side Slope Gypsum Stack:	3
Elevation (ft)	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Cumulative Area (ft^2)	Cumulative Area (acres)
632	73.5	15	9.00	378	0.008678
631	67.0		8.00	312	0.007163
630	60.5		7.00	252	0.005785
629	54.0		6.00	198	0.004545
628	47.5		5.00	150	0.003444
627	41.0		4.00	108	0.002479
626	34.5		3.00	72	0.001653
625	28.0		2.00	42	0.000964
624	21.5		1.00	18	0.000413
623	15.0		0.00	0	0.000000
622	0.0		0.00	0	0.000000

Gypsum Stack
Ditch Cross-Section Geometry

DITCH 1

SLOPE 0.0005

Cross-section 3710

Station	Elevation
0.0	632.00
31.5	624.85
46.5	624.85
73.5	632.00

DS Reach Length: 3700

Interpolation Value: 185

cross-sections: 20

Cross-section 10

Station	Elevation
0.0	632.00
31.5	623.00
46.5	623.00
73.5	632.00

DITCH 2

SLOPE 0.0005

Cross-section 3710

Station	Elevation
0.0	632.00
31.5	624.85
46.5	624.85
73.5	632.00

DS Reach Length: 3700

Interpolation Value: 185

cross-sections: 20

Cross-section 10

Station	Elevation
0.0	632.00
31.5	623.00
46.5	623.00
73.5	632.00

TRANSFER CHANNEL

	upstream	downstream	
Bottom width =	32	60	⇐
Depth =	9.0	7.0	
Top of Dam =	632	629	
side slope	3	3	
Total Length of Transfer Channel		516	
Recycle Pond Embankment Slope		3	

Downstream Bottom Width < Max allowable DS width?
OK

α = acceptable channel convergence or divergence angle
tan α = 1/(3F) …equation 21 pg.385 Design of Small Dams

(from HEC-RAS)Froude #, F =	1.15	
tan(α) =	0.290	
max allowable downstream width, ft =	331	⇐

Spillway US 500

Station	Elevation
0.0	632.00
27.0	623.00
59.0	623.00
86.0	632.00

DS Reach Length
30

Interpolation Value
5

Spillway Middle 470

Station	Elevation
0.0	632.00
27.0	623.00
59.0	623.00
86.0	632.00

DS Reach Length
470

Interpolation Value
5

Spillway DS 0

Station	Elevation
0.0	629.00
27.0	622.00
87.0	622.00
114.0	629.00

DS Reach Length
0

Interpolation Value
5

Computations for Percentage of Gypsum Stack Watershed Area
Contributing to Each Perimeter Collection Ditch
(used in HEC-RAS Unsteady Flow Distribution)

Computations are based on 2 Gypsum Stack Cells

Ditch Top Width 73.5 feet

Distance along outer edge of ditch			Distance along centerline of ditch		
North	1310	feet	North	1236.5	feet
East	2260	feet	East	2186.5	feet
South	1390	feet	South	1316.5	feet
West	2760	feet	West	2686.5	feet
Total Length	7720	feet	Total Length	7426	feet
			USE	7420	feet
			(for ease of cross-section interpolation)		

		Acres	Percentage of Total Watershed Area
Total Gypsum Stack Watershed Area		77.29	100.0000%
Total Watershed Area (square miles)		0.1208	
Ditch 1	3710 ft	38.65	50.0000%
Ditch 2	3710 ft	38.65	50.0000%

Worksheet 3: Time of Concentration (Tc) of Travel Time (Tt)

Project: Coffeen Gypsum Stack Dam	By: SMA	Date: 8/23/2007	
Location: Ameren Coffeen Power Station	Checked: AKC	Date: 9/27/2007	

Check One: [ ] Present [X] Developed

Check One: [X] Tc [ ] Tt

Notes: Space for as many as two segments per flow type can be used for each worksheet.
Include a map, schematic, or description of flow segments.

SHEET FLOW (Applicable to Tc only)

Segment ID	AB	-
1. Surface description (table 3-1)	BARE SOIL/FALLOW	-
2. Manning's roughness coefficient, n (table 3-1)	0.025	0
3. Flow length, L (total L D 300 ft) .... ft^3	300	0
4. Two-year 24-hour rainfall, P2.. in	2.82	-
5. Land slope, s .... ft/ft	0.0040	0
6. Compute Tt…………….....hr	0.191	0.000
SUBTOTAL (hr)		0.191

$$T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{\ 0.5}\ s^{0.4}}$$

SHALLOW CONCENTRATED FLOW

Segment ID	BC	-
7. Surface description (paved or unpaved)	UNPAVED	-
8. Flow length, L ....ft	600	0
9. Watercourse slope, s .... ft/ft	0.3333	0
10. Average velocity, V (figure 3-1) .... ft/s	9.32	0.00
11. Compute Tt………………….……hr	0.018	0.000
SUBTOTAL (hr)		0.018

$$T_t = \frac{L}{3600\ V}$$

CHANNEL FLOW

Segment ID	CD	-
12. Cross sectional flow area, a .... ft^2	0	0
13. Wetted perimeter, Pw .... ft	0	0
14. Hydraulic radius, r = a / Pw Compute r .... ft	0.00	0.00
15 Channel slope, s .... ft/ft	0.0010065	0
16. Manning's roughness coefficient, n	0	0
17. Compute V ....ft/s	0.00	0.00
18. Flow length, L............................ ft	0	0
19. Compute Tt .... hr	0.000	0.000
SUBTOTAL (hr)		0.000

$$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$$

$$T_t = \frac{L}{3600\ V}$$

20. Watershed or subarea Tc or Tt (add Tt in steps 6, 11, and 19) TOTAL (hr)	0.209
NOTE: MIN Tc = 0.1 HR (6 MINUTES) Tc, TOTAL (min)	12.5
TLAG = 0.6Tc TLAG (min)	7.5

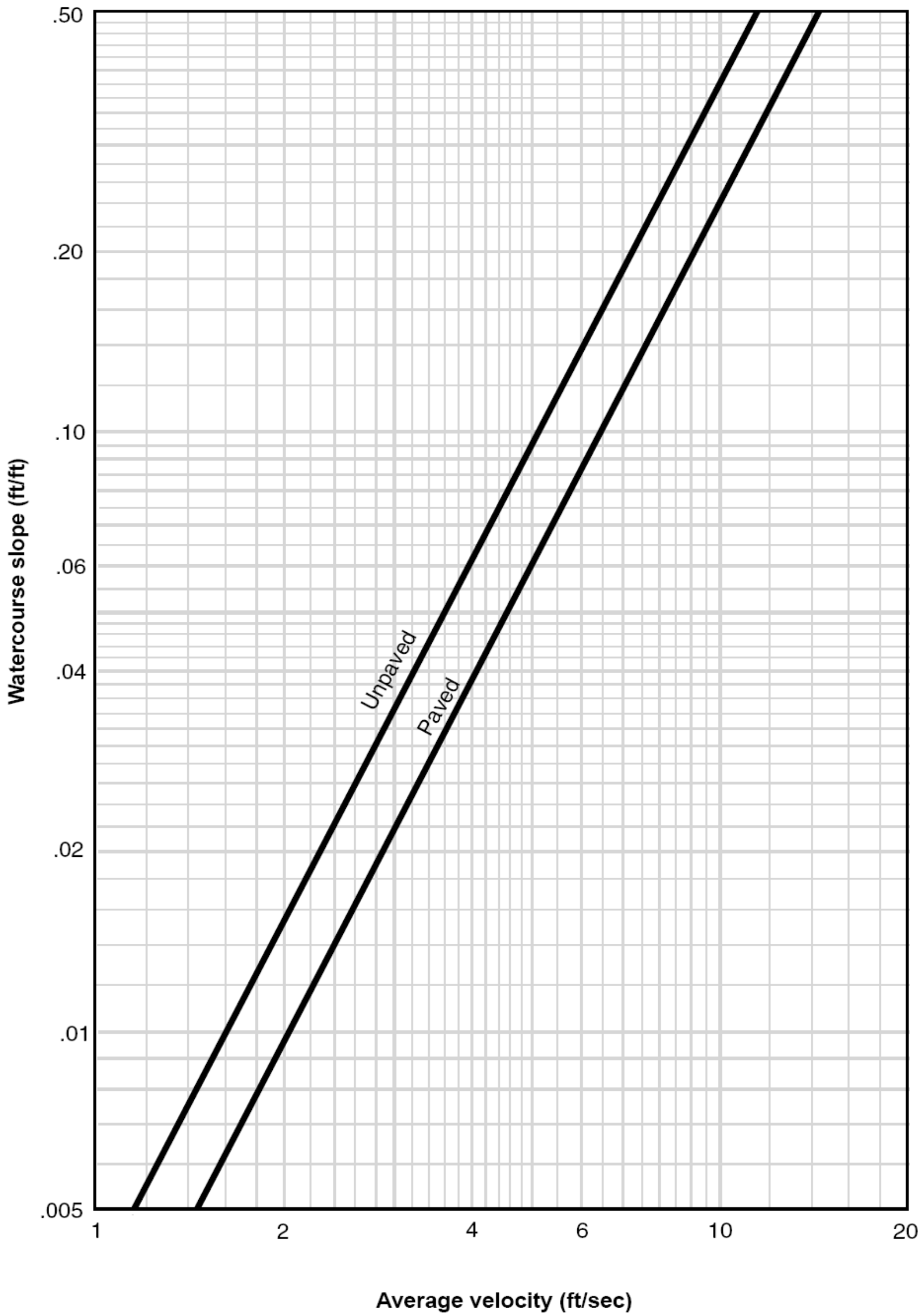
Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: [3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.



(210-VI-TR-55, Second Ed., June 1986)

For Slopes less than 0.005 ft/ft, use the following equations:

Unpaved	$V = 16.1345(S)^{1/2}$	S = Slope (ft/ft)
Paved	$V = 20.3282(S)^{1/2}$	V = Velocity (ft/s)

By: SMA Date: 8/31/07

Checked by: AKC Date: 10/1/07

HANSON

Sheet No.: 1 of: 1

Project No.: 05S3004A 4500

GMF - CN DETERMINATION FOR GYPSUM

SOURCE: CHAPTER 7, HYDROLOGIC SOIL GROUPS
PART 630 HYDROLOGY, NATIONAL ENGINEERING HANDBOOK

PERMEABILITY OF GYPSUM

$K_s = 1.18 \times 10^{-4}$ cm/s $\Rightarrow$ 0.167 in/hr

PERMEABILITY OF HYDROLOGIC SOIL GROUPS (FROM TABLE 7-2)

GROUP A $\rightarrow$ $K > 1.42$ in/hr

GROUP B $\rightarrow$ $K > 0.57$ in/hr

GROUP C $\rightarrow$ 0.06 in/hr $< K < 0.57$ in/hr

GROUP D $\rightarrow$ $K \leq 0.06$ in/hr

GYPSUM FALLS INTO SOIL GROUP C

FROM TR-55 MANUAL

BARE SOIL OF SOIL GROUP C HAS A CURVE NO. OF 91

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1/]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2/]	Hydrologic condition [3/]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

1 Average runoff condition, and I_a=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

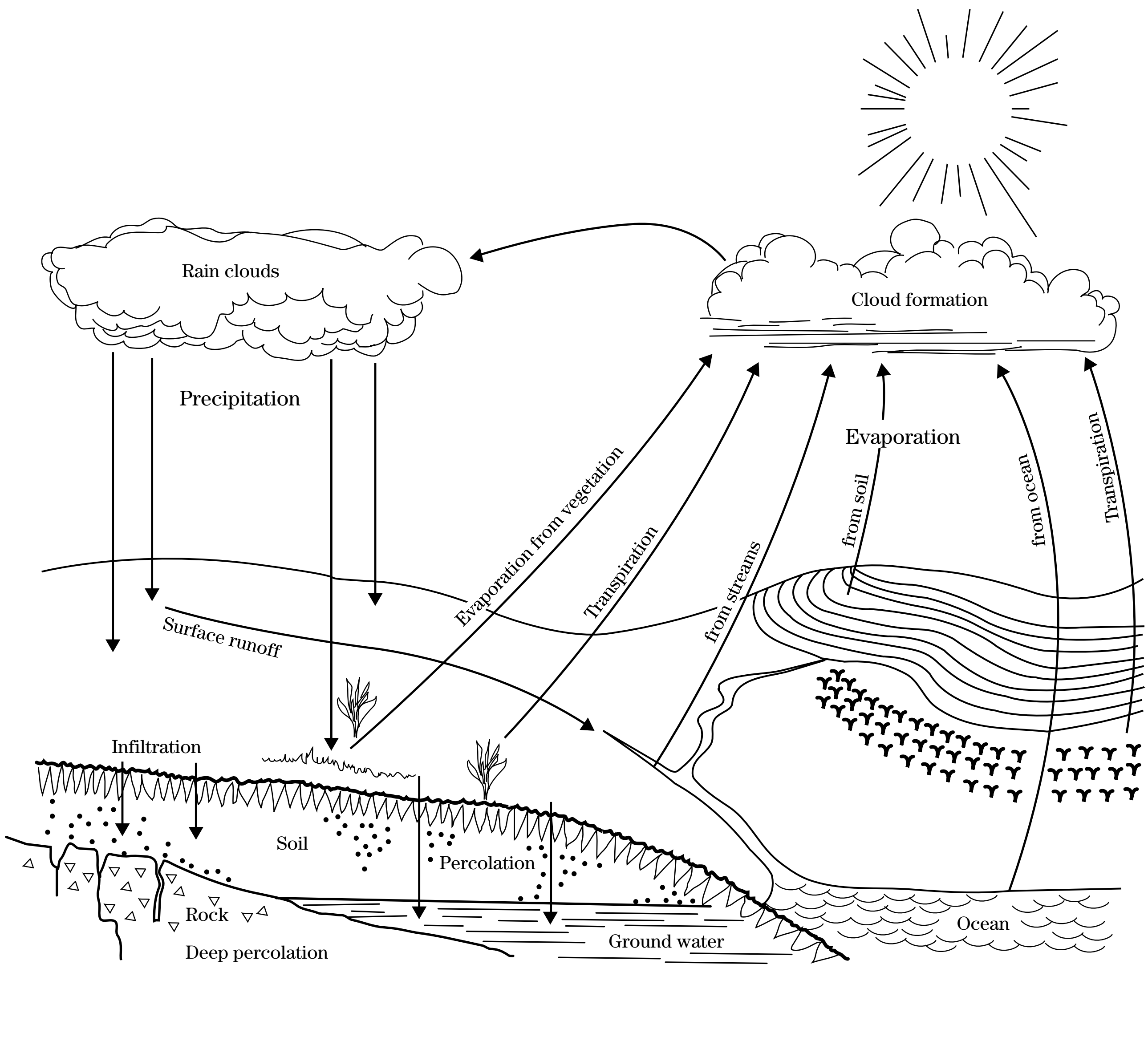
Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

United States
Department of
Agriculture

Natural Resources Conservation Service

Part 630 Hydrology
National Engineering Handbook

Chapter 7 Hydrologic Soil Groups



Chapter 7 Hydrologic Soil Groups

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Chapter 7 Hydrologic Soil Groups

630.0700 Introduction

This chapter defines four hydrologic soil groups, or HSGs, that, along with land use, management practices, and hydrologic conditions, determine a soil's associated runoff curve number (NEH630.09). Runoff curve numbers are used to estimate direct runoff from rainfall (NEH630.10).

A map unit is a collection of areas defined and named the same in terms of their soil components or miscellaneous areas or both (NSSH 627.03). Soil scientists assign map unit components to hydrologic soil groups. Map unit components assigned to a specific hydrologic soil group have similar physical and runoff characteristics. Soils in the United States, its territories, and Puerto Rico have been assigned to hydrologic soil groups. The assigned groups can be found by consulting the Natural Resources Conservation Service's (NRCS) Field Office Technical Guide; published soil survey data bases; the NRCS Soil Data Mart Web site (*http://soildatamart.nrcs.usda.gov/*); and/or the Web Soil Survey Web site (*http://websoilsurvey.nrcs.usda.gov/*).

The state soil scientist should be contacted if a soil survey does not exist for a given area or where the soils within a watershed have not been assigned to hydrologic groups.

630.0701 Hydrologic soil groups

Soils were originally assigned to hydrologic soil groups based on measured rainfall, runoff, and infiltrometer data (Musgrave 1955). Since the initial work was done to establish these groupings, assignment of soils to hydrologic soil groups has been based on the judgment of soil scientists. Assignments are made based on comparison of the characteristics of unclassified soil profiles with profiles of soils already placed into hydrologic soil groups. Most of the groupings are based on the premise that soils found within a climatic region that are similar in depth to a restrictive layer or water table, transmission rate of water, texture, structure, and degree of swelling when saturated, will have similar runoff responses. The classes are based on the following factors:

- intake and transmission of water under the conditions of maximum yearly wetness (thoroughly wet)
- soil not frozen
- bare soil surface
- maximum swelling of expansive clays

The slope of the soil surface is not considered when assigning hydrologic soil groups.

In its simplest form, hydrologic soil group is determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and depth to any layer that is more or less water impermeable (such as a fragipan or duripan) or depth to a water table (if present). The least transmissive layer can be any soil horizon that transmits water at a slower rate relative to those horizons above or below it. For example, a layer having a saturated hydraulic conductivity of 9.0 micrometers per second (1.3 inches per hour) is the least transmissive layer in a soil if the layers above and below it have a saturated hydraulic conductivity of 23 micrometers per second (3.3 inches per hour).

Water impermeable soil layers are among those types of layers recorded in the component restriction table of the National Soil Information System (NASIS) database. The saturated hydraulic conductivity of an impermeable or nearly impermeable layer may range from essentially 0 micrometers per second (0 inches per hour) to 0.9 micrometers per second (0.1 inches per hour). For simplicity, either case is considered impermeable for hydrologic soil group purposes. In some cases, saturated hydraulic conductivity (a quantitatively measured characteristic) data are not always readily available or obtainable. In these situations, other soil properties such as texture, compaction (bulk density), strength of soil structure, clay mineralogy, and organic matter are used to estimate water movement. Tables 7–1 and 7–2 relate saturated hydraulic conductivity to hydrologic soil group.

The four hydrologic soil groups (HSGs) are described as:

Group A—Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group A are as follows. The saturated hydraulic conductivity of all soil layers exceeds 40.0 micrometers per second (5.67 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a water impermeable layer are in group A if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 10 micrometers per second (1.42 inches per hour).

Group B—Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group B are as follows. The saturated hydraulic conductivity in the least transmissive layer between the surface and 50 centimeters [20 inches] ranges from 10.0 micrometers per second (1.42 inches per hour) to 40.0 micrometers per second (5.67 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a water impermeable layer or water table are in group B if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 4.0 micrometers per second (0.57 inches per hour) but is less than 10.0 micrometers per second (1.42 inches per hour).

Group C—Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group C are as follows. The saturated hydraulic conductivity in the least transmissive layer between the surface and 50 centimeters [20 inches] is between 1.0 micrometers per second (0.14 inches per hour) and 10.0 micrometers per second (1.42 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a restriction or water table are in group C if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 0.40 micrometers per second (0.06 inches per hour) but is less than 4.0 micrometers per second (0.57 inches per hour).

Group D—Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential. All soils with a depth to a water impermeable layer less than 50 centimeters [20 inches] and all soils with a water table within 60 centimeters [24 inches] of the surface are in this group, although some may have a dual classification, as described in the next section, if they can be adequately drained.

The limits on the physical diagnostic characteristics of group D are as follows. For soils with a water impermeable layer at a depth between 50 centimeters and 100 centimeters [20 and 40 inches], the saturated hydraulic conductivity in the least transmissive soil layer is less than or equal to 1.0 micrometers per second (0.14 inches per hour). For soils that are deeper than 100 centimeters [40 inches] to a restriction or water table, the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface is less than or equal to 0.40 micrometers per second (0.06 inches per hour).

Dual hydrologic soil groups—Certain wet soils are placed in group D based solely on the presence of a water table within 60 centimeters [24 inches] of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 60 centimeters [24 inches] below the surface in a soil where it would be higher in a natural state.

Matrix of hydrologic soil group assignment criteria—The decision matrix in tables 7–1 and 7–2 can be used to determine a soil's hydrologic soil group. Check both tables before making a final decision. If saturated hydraulic conductivity data are available and deemed to be reliable, then these data, along with water table depth information, should be used to place the soil into the appropriate hydrologic soil group. If these data are not available, the hydrologic soil group is determined by observing the properties of the soil in the field. Factors such as texture, compaction (bulk density), strength of soil structure, clay mineralogy, and organic matter are considered in estimating the hydraulic conductivity of each layer in the soil profile. The depth and hydraulic conductivity of any water impermeable layer and the depth to any high water table are used to determine correct hydrologic soil group for the soil. The property that is most limiting to water movement generally determines the soil's hydrologic group. In anomalous situations, when adjustments to hydrologic soil group become necessary, they shall be made by the NRCS state soil scientist in consultation with the state conservation engineer.

Table 7–1 Criteria for assignment of hydrologic soil groups when a water impermeable layer exists at a depth between 50 and 100 centimeters [20 and 40 inches]

Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>40.0 µm/s (>5.67 in/h)	≤40.0 to >10.0 µm/s (≤5.67 to >1.42 in/h)	≤10.0 to >1.0 µm/s (≤1.42 to >0.14 in/h)	≤1.0 µm/s (≤0.14 in/h)
	and	and	and	and/or
Depth to water impermeable layer	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	<50 cm [<20 in]
	and	and	and	and/or
Depth to high water table	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	<60 cm [<24 in]

Table 7–2 Criteria for assignment of hydrologic soil groups when any water impermeable layer exists at a depth greater than 100 centimeters [40 inches]

Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>10 µm/s (>1.42 in/h)	≤10.0 to >4.0 µm/s (≤1.42 to >57 in/h)	≤4.0 to >0.40 µm/s (≤0.57 to >0.06 in/h)	≤0.40 µm/s (≤0.06 in/h)
	and	and	and	and/or
Depth to water impermeable layer	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]
	and	and	and	and/or
Depth to high water table	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]

630.0702 Disturbed soils

As a result of construction and other disturbances, the soil profile can be altered from its natural state and the listed group assignments generally no longer apply, nor can any supposition based on the natural soil be made that will accurately describe the hydrologic properties of the disturbed soil. In these circumstances, an onsite investigation should be made to determine the hydrologic soil group. A general set of guidelines for estimating saturated hydraulic conductivity from field observable characteristics is presented in the Soil Survey Manual (Soil Survey Staff 1993).

630.0703 References

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Recycle Pond (2 Gypsum Cells) - Hydraulic Summary

Dam			3 Spillways- 5ft x 6ft inlet w/ 4ft dia outlet pipe		
Top of Dam Elevation	629	feet	Weir Length	22	feet
Invert of Reservoir Elevation	605	feet	Weir Elevation	624.00	feet
Reservoir Area at Invert	11.55	acres	Outlet Conduit Length	120	feet
Reservoir Area at Top of Dam	17.07	acres	Outlet Conduit Diameter (Inside)	48	inch
Total Reservoir Volume	341.91	acre-ft	Upstream Invert	615	feet
Volume at Elevation 624 ft	259.60	acre-ft	Downstream Invert	614	feet
Total Watershed Area	94.36	acres	Outlet Conduit Slope	0.00833	
Dam Length	3600	feet			
Dam Height	16	feet			

1.0 PMF Storm Event - Starting WSEL @ 624			1.0 PMF Storm Event - Starting WSEL @ 609		
Storm Duration	24	hours	Critical Storm Duration	24	hours
Peak Inflow	1261.6	cfs	Peak Inflow	1261.6	cfs
Peak Outflow	586.9	cfs	Peak Outflow	289.7	cfs
Total Inflow	277.35	acre-ft	Total Inflow	277.35	acre-ft
Total Outflow	276.66	acre-ft	Total Outflow	71.99	acre-ft
Peak Storage	315.47	acre-ft	Peak Storage	280.65	acre-ft
Peak WSEL (HEC-HMS)	627.45	feet	Peak WSEL (HEC-HMS)	625.34	feet
Freeboard over Peak WSEL	1.55	feet	Freeboard over Peak WSEL	3.66	feet
Wave Runup/Wind Setup	1.20	feet	Wave Runup/Wind Setup	1.20	feet
Adequate Freeboard?	YES		Water Released from Dam?	YES	
Discharge per Spillway	195.6	cfs			
Peak Spillway Outlet Velocity	18.54	fps			

0.5 PMF Storm Event - Starting WSEL @ 624			0.5 PMF Storm Event - Starting WSEL @ 613		
Storm Duration	24	hours	Critical Storm Duration	24	hours
Peak Inflow	608.4	cfs	Peak Inflow	608.4	cfs
Peak Outflow	413.6	cfs	Peak Outflow	0	cfs
Total Inflow	146.67	acre-ft	Total Inflow	146.67	acre-ft
Total Outflow	145.98	acre-ft	Total Outflow	0	acre-ft
Peak Storage	286.48	acre-ft	Peak Storage	255.83	acre-ft
Peak WSEL (HEC-HMS)	625.69	feet	Peak WSEL (HEC-HMS)	623.75	feet
Freeboard over Peak WSEL	3.31	feet	Freeboard over Peak WSEL	5.25	feet
Wave Runup/Wind Setup	1.20	feet	Wave Runup/Wind Setup	1.20	feet
Adequate Freeboard?	YES		Water Released from Dam?	NO	

100-yr Storm Event - Starting WSEL @ 624			100-yr Storm Event - Starting WSEL @ 619		
Critical Storm Duration	12	hours	Critical Storm Duration	24	hours
Peak Inflow	113.2	cfs	Peak Inflow	76.6	cfs
Peak Outflow	95.8	cfs	Peak Outflow	0	cfs
Total Inflow	59.96	acre-ft	Total Inflow	67.45	acre-ft
Total Outflow	60.9	acre-ft	Total Outflow	0	acre-ft
Peak Storage	269.36	acre-ft	Peak Storage	258.48	acre-ft
Peak WSEL (HEC-HMS)	624.63	feet	Peak WSEL (HEC-HMS)	623.94	feet
Freeboard over Peak WSEL	4.37	feet	Freeboard over Peak WSEL	5.06	feet
Wave Runup/Wind Setup	1.20	feet	Wave Runup/Wind Setup	1.20	feet
Adequate Freeboard?	YES		Water Released from Dam?	NO	

ELEVATION - VOLUME - AREA RELATIONSHIP

Recycle Pond Dam

Elevation (feet)	Incremental Volume (cy)	Incremental Volume (acre-ft)	Cumulative Volume (acre-ft)	area (acres)
605.0	0	0.0	0.0	11.55
606.0	18801	11.7	11.7	11.76
607.0	19150	11.9	23.5	11.98
608.0	19500	12.1	35.6	12.19
609.0	19853	12.3	47.9	12.42
610.0	20207	12.5	60.4	12.63
611.0	20564	12.7	73.2	12.86
612.0	20923	13.0	86.2	13.08
613.0	21284	13.2	99.3	13.31
614.0	21647	13.4	112.8	13.53
615.0	22012	13.6	126.4	13.76
616.0	22379	13.9	140.3	13.98
617.0	22748	14.1	154.4	14.22
618.0	23120	14.3	168.7	14.44
619.0	23493	14.6	183.3	14.68
620.0	23869	14.8	198.1	14.91
621.0	24246	15.0	213.1	15.15
622.0	24626	15.3	228.4	15.38
623.0	25008	15.5	243.9	15.62
624.0	25392	15.7	259.6	15.86
625.0	25778	16.0	275.6	16.10
626.0	26166	16.2	291.8	16.34
627.0	26556	16.5	308.3	16.58
628.0	26949	16.7	325.0	16.83
629.0	27343	16.9	341.9	17.07

Top of Dam Elevation =	629.0	ft
Spillway Control Elevation =	624.0	ft
Volume at Top of Dam =	341.9	acre-ft
Surface Area at Top of Dam =	17.1	acres
	0.0267	sqmi

RATING CURVE DERIVATION CHART FOR ONE SPILLWAY
AMEREN COFFEEN RECYCLE POND

By: SMA 8/31/2007
Checked By:

			DROP INLET			OUTLET CONDUIT		
Top of Dam (ft) =	629.00	CIRCULAR ⇨	D_o (dia) (ft) =	0.00	CIRCULAR ⇨	D_o (dia) (ft) =	4.00	U/S Invert (ft) = 615.00
Normal Pool (ft)=	624.00							D/S Invert (ft) = 72.00
Invert of Reservoir (ft) =	605.00	RECTANGULAR ⇨	Length (ft) =	6.00	RECTANGULAR ⇨	Height (ft) =		
Increment (ft) =	0.25		Width (ft) =	6.00		Width (ft) =		

Principal Spillway - 6'x6' concrete drop inlet with 48" diameter HDPE outlet conduit

Emergency Spillway - Trap X-sec

Drop Inlet Weir Control		Drop Inlet Orifice Control		Outlet Conduit Orifice Control		Outlet Conduit Outlet Control		Crest Control		Critical Depth
$Q_{overflow}$ = $CLH^{3/2}$ (from p.467 Design of Small Dams)		Q_{inlet} = $CA(2gH)^{1/2}$ (from p. 468, Eq(1) from Design of Small Dams)		Q_{inlet} = $CA(2gH)^{1/2}$ (from p. 468, Eq(1) from Design of Small Dams)		Q_{outlet} = $A(2gH_T/K_L)^{1/2}$ (from p. 456 eq(8) from Design of Small Dams 3rd Edition); (KL) = [29.1 n^2 L / R ^ 4/3] + Kent +Kext + Kother		Q_{crest} = $CbH^{3/2}$ (from p. 373, Eq (3) from Design of Small Dams)		Must input channel section shape for Q (Refer to bottom of spreadsheet for Q)
control elevation (ft)	624.00	control elevation (ft)	624.00	control elevation (ft)	617.00	control elevation (ft)	75.00	control elevation (ft)		Trapezoidal
C=	2.6	C= (usually 0.6)	0.6	C= (usually 0.6)	0.6	n=	0.012	C=		
L (ft) =	24.00	A (ft²) Circular =	0.00	A (ft²) Circular =	12.57	L (ft)=	100	b (ft)=		
		A (ft2) Rectangular =	36.00	A (ft2) Rectangular =	0.00	W_P (ft)=	12.57	side slope =		
the L value represents an average "weir" length for very low flow for analysis purposes only						R (ft)=	1.00	L (ft)=		
						K(ent)=	0.5	n=		
						K(exit)=	1.0			
						K(other)=	0.0			
						Total losses (K_L)	1.92			

Elevation (ft)	Drop Inlet Weir Control Discharge (cfs)	Drop Inlet Orifice Control Discharge (cfs)	Outlet Conduit Orifice Control Discharge (cfs)	Outlet Conduit Outlet Control Discharge (cfs)	Crest Control Discharge (cfs)	Critical Depth Discharge (cfs)	Elevation (ft)	1 Spillway Total Discharge (cfs)	3 Spillways Total Discharge (cfs)
629.00	697.65	387.60	209.60	1713.43	0.0	#DIV/0!	629.00	209.60	628.80
628.75	645.99	377.78	207.41	1713.04	0.0	#DIV/0!	628.75	207.41	622.22
628.50	595.67	367.71	205.19	1712.65	0.0	#DIV/0!	628.50	205.19	615.57
628.25	546.72	357.35	202.95	1712.27	0.0	#DIV/0!	628.25	202.95	608.84
628.00	499.20	346.68	200.68	1711.88	0.0	#DIV/0!	628.00	200.68	602.03
627.75	453.14	335.67	198.38	1711.49	0.0	#DIV/0!	627.75	198.38	595.15
627.50	408.59	324.29	196.06	1711.11	0.0	#DIV/0!	627.50	196.06	588.19
627.25	365.60	312.49	193.72	1710.72	0.0	#DIV/0!	627.25	193.72	581.15
627.00	324.24	300.23	191.34	1710.33	0.0	#DIV/0!	627.00	191.34	574.02
626.75	284.57	287.45	188.93	1709.94	0.0	#DIV/0!	626.75	188.93	566.80
626.50	246.66	274.07	186.49	1709.56	0.0	#DIV/0!	626.50	186.49	559.48
626.25	210.60	260.01	184.02	1709.17	0.0	#DIV/0!	626.25	184.02	552.07
626.00	176.49	245.14	181.52	1708.78	0.0	#DIV/0!	626.00	176.49	529.48
625.75	144.46	229.31	178.98	1708.39	0.0	#DIV/0!	625.75	144.46	433.37
625.50	114.64	212.30	176.41	1708.01	0.0	#DIV/0!	625.50	114.64	343.91
625.25	87.21	193.80	173.79	1707.62	0.0	#DIV/0!	625.25	87.21	261.62
625.00	62.40	173.34	171.14	1707.23	0.0	#DIV/0!	625.00	62.40	187.20
624.75	40.53	150.12	168.44	1706.84	0.0	#DIV/0!	624.75	40.53	121.59
624.50	22.06	122.57	165.70	1706.45	0.0	#DIV/0!	624.50	22.06	66.19
624.25	7.80	86.67	162.92	1706.07	0.0	#DIV/0!	624.25	7.80	23.40
624.00	0.00	0.00	160.09	1705.68	0.0	#DIV/0!	624.00	0.00	0.00
623.75	0.00	0.00	157.20	1705.29	0.0	#DIV/0!	623.75	0.00	0.00
623.50	0.00	0.00	154.26	1704.90	0.0	#DIV/0!	623.50	0.00	0.00
623.25	0.00	0.00	151.27	1704.51	0.0	#DIV/0!	623.25	0.00	0.00
623.00	0.00	0.00	148.21	1704.12	0.0	#DIV/0!	623.00	0.00	0.00
622.75	0.00	0.00	145.09	1703.73	0.0	#DIV/0!	622.75	0.00	0.00
622.50	0.00	0.00	141.90	1703.35	0.0	#DIV/0!	622.50	0.00	0.00
622.25	0.00	0.00	138.64	1702.96	0.0	#DIV/0!	622.25	0.00	0.00
622.00	0.00	0.00	135.30	1702.57	0.0	#DIV/0!	622.00	0.00	0.00
621.75	0.00	0.00	131.87	1702.18	0.0	#DIV/0!	621.75	0.00	0.00
621.50	0.00	0.00	128.35	1701.79	0.0	#DIV/0!	621.50	0.00	0.00

Summary Results for Subbasin "Watershed G1+G2"

Project : Coffeen_GMF   Simulation Run : GMF PMF   Subbasin: Watershed G1+G2

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF PMF
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 10:52:14	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Discharge :	1827.3 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 15:39
Total Precipitation :	220.33 (AC-FT)	Total Direct Runoff :	212.86 (AC-FT)
Total Loss :	7.47 (AC-FT)	Total Baseflow :	0.00 (AC-FT)
Total Excess :	212.86 (AC-FT)	Discharge :	212.86 (AC-FT)

Summary Results for Source "Discharge from Gypsum Stack"

Project : Coffeen_GMF   Simulation Run : GMF PMF   Source: Discharge from Gypsum Stack

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF PMF
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 10:52:14	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Discharge :	1100.7 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 15:50
Total Discharge :	228.83 (AC-FT)		

Summary Results for Subbasin "Watershed Recycle Pond"

Project : Coffeen_GMF   Simulation Run : GMF PMF   Subbasin: Watershed Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF PMF
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 10:52:14	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Discharge :	538.9 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 15:35
Total Precipitation :	48.70 (AC-FT)	Total Direct Runoff :	48.53 (AC-FT)
Total Loss :	0.17 (AC-FT)	Total Baseflow :	0.00 (AC-FT)
Total Excess :	48.53 (AC-FT)	Discharge :	48.53 (AC-FT)

Summary Results for Reservoir "Recycle Pond"

Project : Coffeen_GMF   Simulation Run : GMF PMF   Reservoir: Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF PMF
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 10:52:14	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Inflow :	1261.6 (CFS)	Date/Time of Peak Inflow :	01Jan2000, 15:45
Peak Outflow :	586.9 (CFS)	Date/Time of Peak Outflow :	01Jan2000, 16:17
Total Inflow :	277.35 (AC-FT)	Peak Storage :	315.47 (AC-FT)
Total Outflow :	276.66 (AC-FT)	Peak Elevation :	627.45 (FT)

Summary Results for Reservoir "Recycle Pond"

Project : Coffeen_GMF   Simulation Run : GMF PMF RP Limit   Reservoir: Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF PMF RP Limit
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	27Sep2007, 14:51:50	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Inflow :	1261.6 (CFS)	Date/Time of Peak Inflow :	01Jan2000, 15:45
Peak Outflow :	289.7 (CFS)	Date/Time of Peak Outflow :	01Jan2000, 18:01
Total Inflow :	277.35 (AC-FT)	Peak Storage :	280.65 (AC-FT)
Total Outflow :	71.99 (AC-FT)	Peak Elevation :	625.34 (FT)

Summary Results for Subbasin "Watershed G1+G2"

Project : Coffeen_GMF Simulation Run : GMF 0.5 PMF Subbasin: Watershed G1+G2

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 0.5 PMF
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 11:20:39	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ⦿ AC-FT

Computed Results

Peak Discharge :	913.7 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 15:39
Total Precipitation :	220.33 (AC-FT)	Total Direct Runoff :	212.86 (AC-FT)
Total Loss :	7.47 (AC-FT)	Total Baseflow :	0.00 (AC-FT)
Total Excess :	212.86 (AC-FT)	Discharge :	106.43 (AC-FT)

Summary Results for Source "Discharge from Gypsum Stack"

Project : Coffeen_GMF Simulation Run : GMF 0.5 PMF Source: Discharge from Gypsum Stack

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 0.5 PMF
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 11:20:39	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ⦿ AC-FT

Computed Results

Peak Discharge : 541.1 (CFS) Date/Time of Peak Discharge : 01Jan2000, 15:50
Total Discharge : 122.41 (AC-FT)

Summary Results for Subbasin "Watershed Recycle Pond"

Project : Coffeen_GMF Simulation Run : GMF 0.5 PMF Subbasin: Watershed Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 0.5 PMF
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 11:20:39	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ⦿ AC-FT

Computed Results

Peak Discharge :	269.5 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 15:35
Total Precipitation :	48.70 (AC-FT)	Total Direct Runoff :	48.53 (AC-FT)
Total Loss :	0.17 (AC-FT)	Total Baseflow :	0.00 (AC-FT)
Total Excess :	48.53 (AC-FT)	Discharge :	24.26 (AC-FT)

Summary Results for Reservoir "Recycle Pond"

Project : Coffeen_GMF Simulation Run : GMF 0.5 PMF Reservoir: Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 0.5 PMF
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 11:20:39	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ⦿ AC-FT

Computed Results

Peak Inflow :	608.4 (CFS)	Date/Time of Peak Inflow :	01Jan2000, 15:45
Peak Outflow :	413.6 (CFS)	Date/Time of Peak Outflow :	01Jan2000, 16:07
Total Inflow :	146.67 (AC-FT)	Peak Storage :	286.48 (AC-FT)
Total Outflow :	145.98 (AC-FT)	Peak Elevation :	625.69 (FT)

Summary Results for Reservoir "Recycle Pond"

Project : Coffeen_GMF Simulation Run : GMF 0.5 PMF RP Limit Reservoir: Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 0.5 PMF RP Limit
End of Run :	03Jan2000, 00:00	Meteorologic Model :	PMF
Compute Time :	14Sep2007, 11:20:57	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ⦿ AC-FT

Computed Results

Peak Inflow :	608.4 (CFS)	Date/Time of Peak Inflow :	01Jan2000, 15:45
Peak Outflow :	0.0 (CFS)	Date/Time of Peak Outflow :	01Jan2000, 00:00
Total Inflow :	146.67 (AC-FT)	Peak Storage :	255.83 (AC-FT)
Total Outflow :	0.00 (AC-FT)	Peak Elevation :	623.75 (FT)

Summary Results for Subbasin "Watershed G1+G2"

Project : Coffeen_GMF   Simulation Run : GMF 100-yr 12 hour   Subbasin: Watershed G1+G2

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 12hr
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 12hr
Compute Time :	14Sep2007, 12:20:23	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ○ IN ◉ AC-FT

Computed Results

Peak Discharge :	95.9 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 04:47
Total Precipitation :	41.72 (AC-FT)	Total Direct Runoff :	34.94 (AC-FT)
Total Loss :	6.78 (AC-FT)	Total Baseflow :	0.00 (AC-FT)
Total Excess :	34.94 (AC-FT)	Discharge :	34.94 (AC-FT)

Summary Results for Source "Discharge from Gypsum Stack"

Project : Coffeen_GMF   Simulation Run : GMF 100-yr 12 hour   Source: Discharge from Gypsum Stack

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 12hr
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 12hr
Compute Time :	14Sep2007, 12:20:23	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ○ IN ◉ AC-FT

Computed Results

Peak Discharge :	92.6 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 05:20
Total Discharge :	50.91 (AC-FT)		

Summary Results for Subbasin "Watershed Recycle Pond"

Project : Coffeen_GMF   Simulation Run : GMF 100-yr 12 hour   Subbasin: Watershed Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 12hr
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 12hr
Compute Time :	14Sep2007, 12:20:23	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ○ IN ◉ AC-FT

Computed Results

Peak Discharge :	22.7 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 04:45
Total Precipitation :	9.22 (AC-FT)	Total Direct Runoff :	9.05 (AC-FT)
Total Loss :	0.17 (AC-FT)	Total Baseflow :	0.00 (AC-FT)
Total Excess :	9.05 (AC-FT)	Discharge :	9.05 (AC-FT)

Summary Results for Reservoir "Recycle Pond"

Project : Coffeen_GMF   Simulation Run : GMF 100-yr 12 hour   Reservoir: Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 12hr
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 12hr
Compute Time :	14Sep2007, 12:20:23	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ○ IN ◉ AC-FT

Computed Results

Peak Inflow :	113.2 (CFS)	Date/Time of Peak Inflow :	01Jan2000, 05:15
Peak Outflow :	95.8 (CFS)	Date/Time of Peak Outflow :	01Jan2000, 05:52
Total Inflow :	59.96 (AC-FT)	Peak Storage :	269.36 (AC-FT)
Total Outflow :	60.90 (AC-FT)	Peak Elevation :	624.63 (FT)

Summary Results for Subbasin "Watershed G1+G2"

Project : Coffeen_GMF Simulation Run : GMF 100-yr 24 hour Subbasin: Watershed G1+G2

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 24hr
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 24hr
Compute Time :	14Sep2007, 12:20:26	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Discharge :	63.2 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 15:00
Total Precipitation :	47.98 (AC-FT)	Total Direct Runoff :	41.10 (AC-FT)
Total Loss :	6.88 (AC-FT)	Total Baseflow :	0.00 (AC-FT)
Total Excess :	41.10 (AC-FT)	Discharge :	41.10 (AC-FT)

Summary Results for Source "Discharge from Gypsum Stack"

Project : Coffeen_GMF Simulation Run : GMF 100-yr 24 hour Source: Discharge from Gypsum Stack

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 24hr
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 24hr
Compute Time :	14Sep2007, 12:20:26	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Discharge :	62.9 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 15:15
Total Discharge :	57.01 (AC-FT)		

Summary Results for Subbasin "Watershed Recycle Pond"

Project : Coffeen_GMF Simulation Run : GMF 100-yr 24 hour Subbasin: Watershed Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 24hr
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 24hr
Compute Time :	14Sep2007, 12:20:26	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Discharge :	14.4 (CFS)	Date/Time of Peak Discharge :	01Jan2000, 15:00
Total Precipitation :	10.60 (AC-FT)	Total Direct Runoff :	10.43 (AC-FT)
Total Loss :	0.17 (AC-FT)	Total Baseflow :	0.00 (AC-FT)
Total Excess :	10.43 (AC-FT)	Discharge :	10.43 (AC-FT)

Summary Results for Reservoir "Recycle Pond"

Project : Coffeen_GMF Simulation Run : GMF 100-yr 24 hour Reservoir: Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 24hr
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 24hr
Compute Time :	14Sep2007, 12:20:26	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Inflow :	76.6 (CFS)	Date/Time of Peak Inflow :	01Jan2000, 15:15
Peak Outflow :	55.9 (CFS)	Date/Time of Peak Outflow :	01Jan2000, 16:29
Total Inflow :	67.45 (AC-FT)	Peak Storage :	274.98 (AC-FT)
Total Outflow :	65.04 (AC-FT)	Peak Elevation :	624.98 (FT)

Summary Results for Reservoir "Recycle Pond"

Project : Coffeen_GMF Simulation Run : GMF 100-yr 24 hour RP Limit Reservoir: Recycle Pond

Start of Run :	01Jan2000, 00:00	Basin Model :	GMF 100yr 24hr RP
End of Run :	03Jan2000, 00:00	Meteorologic Model :	100yr 24hr
Compute Time :	14Sep2007, 12:20:29	Control Specifications :	48 hr, 1 min comp interval

Volume Units : ◯ IN ◉ AC-FT

Computed Results

Peak Inflow :	76.6 (CFS)	Date/Time of Peak Inflow :	01Jan2000, 15:15
Peak Outflow :	0.0 (CFS)	Date/Time of Peak Outflow :	01Jan2000, 00:00
Total Inflow :	67.45 (AC-FT)	Peak Storage :	258.48 (AC-FT)
Total Outflow :	0.00 (AC-FT)	Peak Elevation :	623.94 (FT)

Riprap Basin for Recycle Pond Spillway

Reference: FHWA Hydraulic Engineering Circular No. 14
"Hydraulic Design of Energy Dissipators for Culverts & Channels"

Given:

Storm Event	**0.5 PMF**	
Number of Pipes	1	
Spacing Between CL Pipes	0	ft
Pipe Diameter (Wo)	4	feet
Upstream Invert Elev	615	feet
Downstream Invert Elev	614	feet
Total Discharge	194.2	cfs
Discharge per Pipe	194.2	cfs
Culvert WSEL at Outlet	617.83	feet
Tailwater Elevation	616.81	feet
Depth of Flow at Oulet (yo)	3.83	feet
Velocity at Outlet (Vo)	15.68	fps
Φ	5.45	radians
Flow Area at Outlet (A)	12.38	sf
Riprap Size	RR-5	

Computations:

$y_e = (A/2)^{0.5}$ — Froude No. (F) = $V/(32.2*y_e)^{0.5}$

$y_e =$ 2.49 — F = 1.75

RR-5 has a d50 = 1.00 ft, and a dmax = 1.58 ft

d50/ye = 0.40 → From Figure XI-2 of FHWA HEC-14
hs/ye = 1.28

hs = 3.18
hs/d50 = 3.18 — 2 ≤ hs/d50 ≤ 4 **OK**

Length of Dissipator Pool (Greater of 10hs or 3Wo)

For 10hs, Lp = 31.85 — **USE Lp = 32.00 ft**
For 3Wo, Lp = 12.00

Length of Apron (Greater of 5hs or Wo)

For 5hs, La = 15.92 — **USE La = 16.00 ft**
For Wo, La = 4.00

Thickness of Riprap on downslope floor at entrance to Basin
(Greater of 3d50 or 2dmax)

3d50 = 3.00 — **USE Thickness = 3.17 ft**
2dmax = 3.17

Thickness of Riprap on floor and side slopes in all other parts of Basin
(Greater of 2d50 or 1.5dmax)

2d50 =	2.00	**USE Thickness =**	**2.38**	**ft**
1.5dmax =	2.38			

Invert Elevation of Basin = Pipe Invert - hs
Invert Elevation of Basin = 610.82 ft

Elevation of Riprap on side slopes of Basin

Elevation of Riprap on side slopes = WSEL at Outlet + 1 ft freeboard
Elevation of Riprap on side slopes = 618.83 ft

USE Elevation of Riprap on side slopes = 619.00 ft

Bottom Width of Basin at end of Apron (Section B-B) = 36.00 ft
(based on 3:1 expansion plus the total width of pipes if multiple pipes are used)
ex. (No. pipes - 1)*(distance between centerline of pipes) + 3:1 expansion from end pipes

Bottom Width of Basin at end of Dissipator Pool Floor (Section A-A) = 21.1 ft
(based on 3:1 expansion plus the total width of 4 pipes)
ex. (No. pipes - 1)*(distance between centerline of pipes) + 3:1 expansion from end pipes

TW Elevation =	616.81	(from below)
TW Depth =	2.81	
TW/yo =	0.73	

Since TW/yo > 0.75, there is potential for channel erosion downstream of the basin. Use Riprap Design for Pipe Spillway Outlets -1.0 ≤ TW/Do ≤ 0.7

MANNING'S EQ (Downstream Channel)

INPUT	Channel Invert (ft)	614.00	
	Manning's n	0.06	
	Bottom Width (ft)	10	
	Side Slopes (H:1)	3	
	Slope (ft/ft)	0.010	
	Q (cfs)	194.20	
OUTPUT	Area (ft^2)	51.7654712	
	Wet Perm	27.77	
	Hyd Radius	1.86	
	Depth (ft)	2.80915	Guess at depth until Q's match
	Q (cfs)	194.20	**MATCH**
	Velocity (ft/sec)	3.75	

Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

Appendix 4B

Wave Runup/Freeboard Calculations

Coffeen GMF - Recycle Pond Wave Runup Analysis

WAVE FORECASTING

Source: U.S. Army Corps of Engineers EM1110-2-1100, Coastal Engineering Manual (Change 1) July 31, 2003
Part II - Chapter 2, equations II-2-36 and II-2-39

U_f =	65	mph	U_f = fasted mile windspeed
t =	55.4	sec	t = time to travel one mile
$U_{t=55.4}/U_{t=3600}$ =	1.25		$U_{t=55.4}/U_{t=3600}$ = ratio fastest/1 hour duration wind
$U_{t=3600}$ =	51.9	mph	$U_{t=3600}$ = 1 hour duration windspeed
$U_{t=fetch}/U_{t=3600}$ =	1.05		$U_{t=fetch}/U_{t=3600}$ = ratio fetch limited/1 hour duration
$U_{t=fetch}$ =	54.3	mph	$U_{t=fetch}$ = fetch limited windspeed

	English		Metric		
g =	32.17	ft/s^2	9.81	m/s^2	g = gravitational constant
d =	24.00	ft	7.32	m	d = reservoir depth
U_{10} =	54.3	mph	24.28	m/s	U_{10} = wind speed at 10 m elevation
X =	1200	ft	366	m	X = straight line fetch distance

DEEP WATER WAVE FORECASTING

	English		Metric		
C_D =			0.00195		C_D = drag coefficient
u_* =			1.0720		u_* = friction velocity
$t_{x,u}$ =	641	sec	641	sec	$t_{x,u}$ = fetch limited wind duration
T_p Deep =	1.04	sec	1.04	sec	T_p = limiting wave period
H_{m0} =	0.89	ft	0.27	m	H_{m0} = energy-based significant wave height

If T_p shallow is less than T_p Deep, then T_p shallow should be used. H_{m0} should be adjusted by substituting the fetch

USE DEEP WATER WAVE FORECASTING

SHALLOW WATER WAVE FORECASTING

	English		Metric		
T_p Shallow =	8.45	sec	8.45	sec	T_p = limiting wave period
X Shallow =	643017	ft	195992	m	
H_{m0} =	14.40	ft	4.39	m	H_{m0} = energy-based significant wave height

Note: Depth, windspeed and fetch are input in english units and automatically converted to metric units. Computations are made in metric units and the results are reported in both english and metric units.

RESULTS: H_{m0} = 0.89 ft

Coffeen GMF - Recycle Pond Wave Runup Analysis (cont.)

WAVE RUNUP ON SMOOTH IMPEREABLE SLOPES

Source: U.S. Army Corps of Engineers EM1110-2-1100, Coastal Engineering Manual (Change 1) July 31, 2003
Part VI - Chapter 5, equations VI-5-2 & VI-5-3

T_p =	1.04	sec			T = wave period, from wave forecasting
H_s =	0.89	ft			Hs = significant wave height, from wave forecasting
L_o =	5.54	ft			wavelength, $L_o = gT^2/(2\pi)$
S =	3.0				slope of upstream face (_H:1V)
$\tan\alpha$ =	0.333				$\tan\alpha = (1/S)$
s_{op} =	0.160				deepwater wave steepness, $s_{op} = 2\pi H_s/(gT_p^2)$
ξ_{op} =	0.833				surf similarity parameter, $\xi_o = \tan\alpha/(s_{op})^{1/2}$
γ_r =	1				surface roughness (1 for smooth slopes)
γ_b =	1				influence of a berm (1 for no berm)
γ_h =	1				shallow water (1 for deep water)
γ_β =	1				angle of incidence (1 for head on)
$A_{u2\%}$ =	1.6	$C_{u2\%}$ =	0		from table VI-5-3 of Coastal Engineering Manual
A_{us} =	1.35	C_{us} =	0		from table VI-5-3 of Coastal Engineering Manual
$R_{ui\%} = H_s(A\xi + C)\gamma_r\gamma_b\gamma_h\gamma_\beta$					R = runup (equation VI-5-3)
$R_{u2\%}$ =	1.18				runup exceeded by 2% waves (R_{max})
R_{us} =	1.00				significant runup, $R_{us} = R_{u33\%}$

Table VI-5-3, Coastal Engineering Manual

ξ	$R_{u2\%}$	ξ - Limits	A	C
	$R_{u2\%}$	ξ E 2.5	1.6	0
		$2.5 < \xi < 9$	-0.2	4.5
ξ				
	R_{us}	ξ E 2.0	1.35	0
		$2.0 < \xi < 9$	-0.15	3.0

WIND SETUP

Source: U.S. Army Corps of Engineers EM1110-2-1420, Hydrologic Engineering Requirements for Reservoirs (equation 15-1)

Zeider Zee equation

U =	54.309344	mph	U = average wind velocity over the fetch
F =	0.23	miles	F = fetch length
d =	24.00	ft	d = average depth of water
S =	0.02	ft	wind setup, $S = U^2F/(1400d)$

RESULTS: Max Wave Runup + Wind Setup = 1.20 ft

Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

Appendix 4C

GMF Water Balance Assessment

APPENDIX 4C: GMF WATER BALANCE ASSESSMENT

1.1 DESCRIPTION OF PONDS AND APPURTENANCES

The GMF Pond and the GMF Recycle Pond are regulated in accordance with 17 Illinois Administrative Code (IAC) Part 3702, Construction and Maintenance of Dams. The GMF Pond perimeter embankment is lined with a 60 mil high density polyethylene (HDPE) geomembrane, has a maximum embankment height of 13 ft., and has a maximum impounding capacity of 442 acre-ft. (measured at the top of earthen embankment elevation 632 ft.). There is an additional 123 acre-ft. of incised storage.

The GMF Recycle Pond is lined with a 60 mil HDPE geomembrane, has a maximum embankment height of 16 ft., and has a maximum impounding capacity of 243 acre-ft. (measured at the top of embankment elevation 629 ft.). There is an additional 99 acre-ft. of incised storage.

The transfer channel between the GMF Pond and the GMF Recycle Pond has a trapezoidal cross-section with 3H:1V side slopes and is lined with HDPE. The 500 ft. long transfer channel transitions from a 32 ft. bottom width at an invert elevation of 623.0 ft. at the upstream end to a 60 ft. bottom width at an invert elevation of 622.0 ft. at the downstream end. To prevent degradation of the HDPE liner due to flow velocities, the transfer channel and a portion of the GMF Recycle Pond embankment incorporates an additional sacrificial layer of HDPE.

The emergency spillway for the GMF Recycle Pond consists of three 6 ft. by 6 ft. precast reinforced concrete risers (drop inlets) with a top elevation of 624 ft. (5 ft. below the top of the embankment). The GMF Recycle Pond's HDPE liner is attached to the exterior sides of each riser. A 4-ft diameter HDPE outlet conduit is constructed at each riser with an upstream invert of 615.0 ft. and a downstream invert of 613.0 ft. Assuming a normal pool elevation of 624 ft. (control elevation of the risers), the emergency spillway is designed to pass the 24-hour PMF storm event with adequate freeboard to prevent overtopping of the GMF Recycle Pond crest by wind generated waves. The emergency spillway was provided in the event of accident or catastrophic rainfall only. It is not expected to be activated during the life of the facility. As designed, all discharges from the system will be through the pump house located on the southeast corner of the GMF Recycle Pond.

The ponds are used to dewater, store and dispose of flue gas desulphurization sludge (gypsum) from the Coffeen Power Station (the Plant). Gypsum is transported to the GMF Pond in slurry form (approximately 20 percent solids) and allowed to settle. Clarified process water is decanted to the GMF Recycle Pond and returned to the Plant for reuse via a pipeline.

1.2 PERTINENT DATA

Pertinent data about the ponds and appurtenant works are presented in Table 3-1 and Table 3-2.

Table 0-1 Pertinent Data for the GMF Pond

GMF Settling Pond Dam

Top of Dam Elevation	632	feet
Reservoir Surface Area	77.3	acres
Total Watershed Area	77.3	acres
Dam Length	7720	feet
Maximum Dam Height	12	feet

Transfer Channel

Bottom Width	32.0	feet
Top Width	86.0	feet
Depth	9.0	feet
Upstream Invert	623.0	feet
Downstream Invert	622.0	feet
14" HDPE Low Flow Pipe Invert Elev.	619.0	feet

Table 0-2 Pertinent Data for the GMF Recycle Pond

GMF Recycle Pond Dam

Top of Dam Elevation	629	feet
Invert of Reservoir Elevation	605	feet
Reservoir Area at Invert	11.55	acres
Reservoir Area at Top of Dam	17.07	acres
Total Reservoir Volume	341.9	acre-ft
Volume at Spillway Elev. 624 ft	259.6	acre-ft
Total Watershed Area	94.36	acres
Dam Length	3600	feet
Maximum Dam Height	16	feet

3 Spillways- 6ft x 6ft inlet w/ 4ft dia outlet pipe

Weir Length	24	feet
Weir Elevation	624.0	feet
Outlet Conduit Length	120	feet
Outlet Conduit Diameter (Inside)	48	inch
Upstream Invert	615	feet
Downstream Invert	613	feet
Outlet Conduit Slope	0.0167	ft/ft
Normal Operating Pool	609-624	feet

1.3 INTRODUCTION

The operations plan describes the operation of the Coffeen Gypsum Management Facility (GMF) which includes the GMF Pond and the GMF Recycle Pond.

1.4 GYPSUM MANAGEMENT FACILITY COMPONENTS

The major components of the GMF consist of:

- The GMF Pond;
- The GMF Recycle Pond;
- A 14-inch O.D. HDPE low flow decant pipe that connects the two structures and through which process water will be decanted from the GMF Pond into the GMF Recycle Pond;
- The earthen transfer channel that connects the two structures and through which process water will be decanted from the GMF Pond into the GMF Recycle Pond during higher flows and/or stages in the GMF Pond; and
- The GMF Recycle Pond decant and pumphouse through which process water will be returned to the Plant for reuse.

After completion and startup of the GMF Pond, the impoundment contained a few feet of water in the bottom to prevent the high density polyethylene (HDPE) geomembrane from moving. The gypsum slurry (approximately 20 percent solids) was re-routed to the GMF Pond via piping. The piping is HDPE with a suitable pressure rating for the intended hydraulic and static head. The HDPE pipe discharges the slurry into the impoundment, and gypsum settles by gravity. After the water reaches elevation 623 ft., the process water flows into the GMF Recycle Pond via the HDPE-lined earthen transfer channel connecting the two impoundments recycled back to the Plant for reuse in the process.

1.5 WATER BALANCE

The capacity of the GMF Recycle Pond has been designed to accommodate all precipitation runoff from the entire GMF Pond/GMF Recycle Pond area during a 2-week complete maintenance outage at the Coffeen Power Station (the Plant) followed by a 12-week outage of one of the two units. The runoff and excess water accumulated during this time can be stored within the GMF Recycle Pond without discharging. The design is based on the maximum 3.5 month precipitation that has occurred in the area since 1950. This occurred in April, May, June and half of July, 1957 and consisted of 28.83 inches of rainfall.

The water balance has been carried out for the expected life of the Site. During the first nine or ten months of operation, the water balance was positive, meaning that there was more water entering the GMF Pond/GMF Recycle Pond system through process water and precipitation than was leaving the system through process water return and evaporation. There is 15 ft. of freeboard between the pump discharge and the emergency spillway elevations. With proper water-level management, the water surface will remain well below the emergency spillway discharge elevation.

1.5.1 Recommended Operating Water Surface Elevations

The water balance is of particular concern since the entire system is designed to be a closed loop with no discharges. *(As previously noted, the GMF Recycle Pond has been designed with an emergency spillway, but this is only to protect the structures in the event of an unforeseen accident or catastrophic rainfall event.)* In order to reduce the potential for discharges through the emergency spillway, the **normal operating water surface elevation in the GMF Recycle Pond is recommended to be in the range of 609 to 614 ft**.

1.5.2 Maximum Allowable Operating Water Surface Elevations

Table 4-1 lists the maximum operating water surface elevations allowed in the GMF Recycle Pond in order to prevent the discharge of water for the 100-year storm event, the 0.5 PMF storm event, and the 1.0 PMF storm event. The maximum allowable operating water surface elevations are predicted based on the pool elevation in the GMF Pond, the percentage of surface area used for dry stacking gypsum in the GMF Pond, and the quantity of rainfall. The stages computed for the GMF Pond and

Recycle Pond are to be used as an indicator risk associated with operating the Recycle pond at an elevation higher than elevation 614 ft. If the GMF Recycle Pond water surface elevation is higher than the maximum specified in the table for a particular GMF Pond configuration and rainfall amount, releases through the emergency spillway should be expected.

Table 0-3 Maximum Allowable Operating Water Surface Elevations

Initial WSEL Gypsum Settling Pond (ft)	Percent of Gypsum Settling Pond Surface Area used for Dry Stacking	Maximum Normal Operating WSEL Recycle Pond (ft)	Rainfall Event	Rainfall Amount	Peak Stage Gypsum Settling Pond (ft)	Peak Stage Recycle Pond (ft)	Post Storm Equalized Stage in Both Ponds (ft)
623	50%	614	PMF	34-inches	625.15	623.63	623.63
623	50%	620	0.5PMF	17-inches	624.22	623.92	623.92
623	50%	622	100Y24H	7.3-inches	623.53	623.53	623.53
623	25%	615	PMF	34-inches	624.79	623.83	623.83
623	25%	620	0.5PMF	17-inches	623.98	623.73	623.73
623	25%	623	100Y24H	7.3-inches	623.8	623.8	623.8
623	0%	616	PMF	34-inches	624.53	623.97	623.97
623	0%	621	0.5PMF	17-inches	623.91	623.91	623.91
623	0%	623	100Y24H	7.3-inches	623.66	623.66	623.66
619	50%	619	PMF	34-inches	624.12	623.86	623.86
619	50%	623	0.5PMF	17-inches	623.39	623.64	623.39
619	50%	623	100Y24H	7.3-inches	622.06	623.16	622.06
619	25%	621	PMF	34-inches	623.64	623.64	623.64
619	25%	623	0.5PMF	17-inches	622.54	623.64	622.54
619	25%	623	100Y24H	7.3-inches	621.46	623.16	621.46
619	0%	622	PMF	34-inches	623.2	623.92	623.2
619	0%	623	0.5PMF	17-inches	621.97	623.64	621.97
619	0%	623	100Y24H	7.3-inches	621.07	623.16	621.07

1.5.3 Important Considerations

It is critical to note that the design capacity of the GMF Recycle Pond has effectively been reduced since gypsum was sluiced directly to the GMF Recycle Pond during the initial startup period. The gypsum in the recycle pond should be excavated at the earliest opportunity to restore the capacity of the GMF Recycle Pond and to reduce the potential for discharges through the emergency spillway system.

During installation of the low flow HDPE decant pipe beneath the transfer channel, pipe floatation resulted in a crown along the longitudinal profile of the pipe. Consequently, the low flow decant pipe sometimes functions as a siphon, thus making it difficult to manage water levels in the GMF Recycle Pond. Since the water surface elevations in both the GMF Pond and the GMF Recycle Pond are critical to the prevention of releases through the emergency spillway system, the future installation of a valve on the low flow decant pipe under the transfer channel should be considered. If a valve is installed on the low flow decant pipe, the water surface elevation in the GMF Pond should not be raised above elevation 619 ft. (the upstream invert of the pipe) for extended periods of time. The valve should only be used to control siphoning immediately after rainfall events as required to maintain the GMF Recycle Pond water surface elevation within the normal operating pool range of 609 to 614 ft.

Immediately after large or consecutive rainfall events, the water surface elevation in both the GMF Pond and the GMF Recycle Pond are expected to rise. In order to prevent a discharge through the emergency spillway, it is imperative that the water surface elevations in both ponds be returned to their normal levels as quickly as natural and forced evaporation processes allow.

Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

Appendix 5

Specifications / Operation & Maintenance Plan

PROJECT SPECIFICATIONS
GYPSUM STACK AND RECYCLE POND CONSTRUCTION
GYPSUM MANAGEMENT FACILITY
COFFEEN POWER STATION
MONTGOMERY COUNTY, ILLINOIS

Prepared For:

ILLINOIS POWER GENERATING COMPANY

Prepared By:

HANSON PROFESSIONAL SERVICES INC.
1525 South Sixth Street
Springfield, Illinois 62703

January 2008

GYPSUM STACK AND RECYCLE POND CONSTRUCTION
GYPSUM MANAGEMENT FACILITY
COFFEEN POWER STATION
MONTGOMERY COUNTY, ILLINOIS

TABLE OF CONTENTS

PART 1. GENERAL

1.01 DESCRIPTION

A. This section pertains to the construction and maintenance of temporary erosion control systems to control erosion and sediment damage to adjacent properties and water resources, and the removal of erosion control devices when they are no longer required.

1.02 RELATED SECTIONS

The following sections contain items which are related to the work in this section:

02936 - Topsoil, Seeding, and Mulching.

1.03 REFERENCES

The following reference, or cited portions thereof, governs the work:

Illinois Department of Transportation (IDOT): Standard Specifications for Road and Bridge Construction, adopted January 1, 2007.

1.04 SUBMITTALS

A. Submittals shall follow the provisions of Section 01010.

B. Preconstruction Submittals: A storm water best management practices (BMP) plan shall be submitted that includes the following items:

1. Site drawing showing anticipated locations of structural erosion controls, areas of disturbed soils, and drainage patterns;
2. Inspection and record-keeping procedures; and
3. Maintenance procedures for erosion controls.

PART 2. PRODUCTS

2.01 EROSION CONTROL SYSTEMS

Materials for erosion control systems shall be in accordance with Article 280.02 of the IDOT Standard Specifications.

PART 3. EXECUTION

3.01 EXAMINATION

The site shall be examined to determine the extent of work required.

3.02 PRECONSTRUCTION JOBSITE INSPECTION

A. The person who shall be at the jobsite during construction and who shall be responsible for insuring that erosion control work is completed in a timely manner shall be identified at the preconstruction meeting.

B. A jobsite inspection shall be conducted with the Owner's Representative to review and designate the locations and types of erosion protection to be placed. The inspection shall be scheduled at the preconstruction conference and carried out on the job site before beginning any work that will disturb existing drainage or potentially create erodible conditions.

3.03 CONSTRUCTION

A. Temporary erosion control systems shall be constructed in accordance with IDOT Standard 280001 and Article 280.04 of the Standard Specifications and as directed by the Owner's Representative. Erosion control devices shall be in place and approved by the Owner's Representative prior to beginning other work.

B. Incorporate permanent erosion control features into the project at the earliest practicable time to minimize the need for temporary erosion controls.

3.04 MAINTENANCE

A. Temporary erosion control systems shall be maintained in accordance with Article 280.05 of the Standard Specifications, except that measurement and payment provisions shall not apply.

B. Temporary erosion control systems for unprotected disturbed areas shall be cleaned of trapped sediment and repaired immediately prior to project close out.

C. Temporary seeding shall be applied to all disturbed areas except the gypsum stack excavation and the future fill and topsoil stockpiles.

3.05 REMOVAL AND DISPOSAL

When the Owner's Representative deems that temporary erosion control systems are no longer needed, they shall be removed and properly disposed, and silt deposits shall be removed or regarded as directed by the Owner's Representative, and the area seeded. Non-biodegradable temporary erosion control materials shall be disposed of off site. Biodegradable erosion control devices may be disposed of in spoil areas designated by the Owner's Representative. All laws and regulations in disposing of the materials shall be obeyed.

END OF SECTION 01356

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PART 1. GENERAL

1.01 DESCRIPTION

This section pertains to stripping of topsoil and vegetation from areas of the site that are to be excavated.

1.02 RELATED SECTIONS

No related sections.

PART 2. PRODUCTS

No products used.

PART 3. EXECUTION

3.01 EXAMINATION

The Contractor shall examine the site to determine the extent of work required.

3.02 SITE PREPARATION - STRIPPING

A. All vegetation and topsoil encountered within the Gypsum Stack grading limits shall be stripped. Topsoil shall be kept clean and free of all foreign material, and stored in separate stockpiles from vegetation and common excavations. Stockpiles shall be located as indicated on the drawings or as directed by the Owner's Representative.

B. Payment for stripping shall be based upon removal of 24 inches of topsoil in areas that require stripping.

3.03 DISPOSAL

All materials resulting from site preparation operations shall be stockpiled in the designated spoil area. Contractor shall obey all laws and regulations when disposing of the materials.

END OF SECTION 02100

PART 1. GENERAL

1.01 DESCRIPTION

This section pertains to excavation, fill, and backfill required for foundation preparation, construction of low-permeability soil layer, anchor trench construction, miscellaneous site grading and berm construction.

1.02 RELATED SECTIONS

A. The following sections contain items which are related to the work in this section:

1. 01356 – Storm Water Pollution Prevention Measures
2. 02100 - Site Preparation
3. 02373 – Geotextiles
4. 02936 - Topsoil, Seeding, and Mulching

1.03 REFERENCES

The following references, or cited portions thereof, govern the work:

1. Illinois Department of Transportation (IDOT): Standard Specifications for Road and Bridge Construction, adopted January 1, 2007
2. Department of Sustainable Natural Resources, Soil Survey Standard Test Method, Unified Soil Classification System: Field Method (USCS).

1.04 MEASUREMENT AND PAYMENT

A. The Contractor shall be responsible for estimating the extent of excavation and fill required to complete the work, including, but not limited to, excavation to required elevations; loading, transporting, placing, and compacting low permeability soil; excavation and backfill of anchor trench; and miscellaneous site grading and berm construction. The Contractor shall include the dollar amount associated with all earthwork in his Lump Sum Bid amount.

B. Removal and replacement of unsuitable foundation material and subgrade stabilization measures directed by the Owner's Representative will be paid for on a time and material basis.

1.06 COORDINATION

Existing utilities or other plant facilities shall not be interrupted, except when permitted in writing by the Owner's Representative and then only after acceptable temporary services have been provided. A minimum 48-hour notice shall be provided prior to proceeding with an approved temporary interruption.

1.08 SUBMITTALS

A. Materials Handling Plan.

A materials handling plan shall be submitted for construction and protection of the low permeability soil liner. The plan shall describe the following:

1. Processing and placement of the low permeability soil type, model number, weight, and critical dimensions of equipment to be used for soil processing, compaction, scarification, and smooth rolling;
2. Method of protecting low permeability soil from changes in moisture content and freezing after placement.

B. Construction Access Ramp Layout.

Layout drawings shall be submitted showing alignment, profile, and typical section of the construction access ramps from the haul road into the bottom of the Gypsum Management Facility excavation. The minimum width of the ramp shall be 50 ft., and the longitudinal grade shall not exceed 8 percent.

PART 2. PRODUCTS

2.01 MATERIALS

A. Earth Fill Material

Earth Fill Material shall consist of a mixture of clay, silt, sand, and gravel-sized particles obtained from previously constructed subsoil stockpiles. These materials can be used separately or mixed as required for best results. When placed, Embankment Material shall have a USCS classification of SM, ML, or CL and shall be uniform. This material shall be free of ice, snow, organic matter, rubbish, and debris. Coarse-grained particles shall be well dispersed to prevent the development of segregated pockets or zones with insufficient fine material to fill the interstices.

B. Soil Liners

The Soil Liner for the Gypsum Management Facility is considered a Clay Liner, and shall be soil classification CL, CL-ML, or CH. The material shall be free of roots, debris, organic or frozen material, and shall have a maximum clod size no greater than the length of the compactor foot for the compaction equipment proposed by the Contractor. When compacted, the material shall have a hydraulic conductivity of less than 1×10^{-4} cm/sec.

C. Soil Stabilizers and Moisture Conditioning Agents

Additives to accelerate drying or to improve stability and workability of soil shall not be permitted unless approved in writing by the Owner's Representative.

2.02 EQUIPMENT

A. Compaction Equipment

1. Tamping foot rollers

Compaction equipment shall consist of tamping foot rollers which have a minimum weight of 40,000 pounds. At least one tamping foot shall be provided for each 110 square in. of drum surface. The length of each tamping foot, measured from the outside surface of the drum, shall be at least 1 in. longer than the loose lift thickness.

2. Steel-Wheeled Rollers

Equipment used to produce a smooth compacted surface shall be a smooth, non-vibratory steel wheeled roller weighing not less than 1,000 lb. per lineal ft.

B. Scarification Equipment

Discs, rotor tillers, or other equipment used to scarify the surface shall be capable of uniformly disturbing the upper 6 in. of surface to provide good bonding between lifts.

C. Mixing and Spreading Equipment

Discs, harrows, and motor graders or other similar equipment shall be available at the site for use in spreading, mixing, and drying Compacted Subsoil Stockpile Material.

PART 3. EXECUTION

3.01 PREPARATION

A. Control of Work

Benchmarks, monuments, and other reference points shall be maintained throughout the work area.

B. Utility Location

Before starting excavation, the location and extent of underground utilities in the work area shall be established.

3.02 EXCAVATION

A. General

Excavation consists of removal and redistribution of material encountered when establishing required grade and subgrade elevations. The Contractor shall be responsible for dewatering, protection, shoring, and disposal of excavated materials as necessary to complete the excavation.

B. Procedures

Excavation may be accomplished by any method and by use of any equipment that is suitable to the work, except that blasting will not be permitted. Based on previous construction experience at the site, it is recommended that excavation to the foundation grade be completed as far in advance of low permeability soil placement as possible to allow the foundation surface to dry and form a "crust" capable of sustaining compactive effort.

C. Overexcavation

All excavation shall be performed to the lines and grades indicated on the plans. Any overexcavation or excess excavation not requested by the Owner's Representative shall be at the expense of the Contractor.

D. Disposal of Excavated Materials

Contractor shall utilize excavated material as stockpile materials for future use as specified in paragraph E.

E. Stockpile Requirements

1. Excavated clay and silty clay materials are to be stockpiled in the short-term subsoil stockpile area.
2. Excess excavated materials are to be stockpile in the areas designated on the drawings.
3. Materials not suitable for use as fill or backfill shall be disposed of onsite in the locations specified by the Owner's Representative.
4. Spread fill material for use by others, topsoil, and low permeability soil are to be stockpiled in layers not to exceed 1 ft loose thickness.
5. Tops of stockpiles are to be graded to ensure positive drainage. Side slopes for stockpiles shall be no steeper than 3H:1V.
6. Perimeter ditches are to be excavated to intercept runoff flowing toward stockpile areas and to route it to outlet locations approved by the Owner's Representative.

3.03 SUBGRADE PREPARATION

A. Areas to receive fill shall be proof rolled under the observation of the Owner's Representative. Soft, loose, weak, or wet materials shall be removed and replaced with compacted fill or stabilized with geotechnical fabric or geogrid as directed by the Owner's Representative. Joints, fractures, and moisture seeps shall be repaired, and local sand deposits, if present at foundation grade, shall be removed and backfilled with compacted fill material as directed by the Owner's Representative.

B. The Owner's Representative may recommend additional drying time for soft, wet subgrade that has not been exposed long enough to permit "crust" formation. If approved by the Owner's Representative, the Contractor may install, at his own expense, geotechnical fabric or geogrid to stabilize the wet subgrade and expedite construction.

C. No fill shall be placed until the subgrade has been examined and approved.

3.04 GENERAL FILL

A. Placement

1. Unless otherwise indicated on the plans, all fill shall be composed of Earth Fill Material.
2. Fill materials used in embankment construction shall normally be placed in lanes parallel to the embankment axis and shall be placed in conformance with the lines, grades, and slopes as indicated on the plans. Placement of fill materials in lanes which are not parallel to the embankment will be allowed only where working room is too restricted for normal placement as determined by the Owner's Representative.
3. Fill shall be spread in approximately flat layers in such a manner as to obtain lifts of relatively uniform thickness without spaces between successively deposited loads. Segregation shall be prevented during placing and spreading. Hauling equipment shall be routed across the fill in such a way as to promote uniform compaction and to prevent the formation of ruts.
4. The maximum compacted thickness of each lift shall not exceed 8 in. where heavy compaction equipment will be used. The maximum compacted thickness shall not exceed 3 in. where power tampers or similar smaller equipment will be used. It may be necessary to reduce the thickness of lifts in order to obtain the required minimum density.
5. Where compacted earth fill is to be placed against existing slopes, each lift shall be keyed into existing slope by removing existing slope material in steps as each new lift is placed.
6. The surface of the fill shall be kept reasonably smooth. The fill surface shall be sloped transverse to the axis of the embankments to allow drainage. If the compacted surface is, in the opinion of the Owner's Representative, too smooth or too dry to bond properly with the

succeeding lift, it shall be roughened by scarifying, light discing, or other acceptable means, and it shall be sprinkled before the succeeding lift is placed thereon. If the surface becomes rutted or uneven subsequent to compaction, it shall be flattened and leveled before placing the next lift. This extra work shall be at the Contractor's expense.

7. Fill operations shall be suspended during periods of extended wet weather. Upon resuming operations, all fill materials that are excessively wet or soft shall be reprocessed in place or removed and stockpiled for reprocessing. The removal of soft material shall be carried to such depth as is necessary to expose firm materials. Fill shall not be placed on frozen surfaces.
8. When filling operations at any section will be suspended for any period in excess of 12 hours or in wet weather, the surface of the fill shall be rolled smooth to seal it against excessive absorption of moisture and to facilitate runoff. Prior to resuming fill placement and compaction, the fill surface shall be scarified and/or disced and moisture conditioned as required.
9. The Contractor will receive no additional compensation for any removal, reprocessing, stockpiling, recompaction, wasting, or similar operation related to suspensions or conditions due to weather or other causes unless caused by the Owner.
10. Earth fill access ramps shall not be constructed within the limits of the compacted embankments without prior approval. When such ramps are approved, they shall be constructed of low permeability soil (in-board of the perimeter berm) or compacted fill (out-board of the perimeter berm).

B. Compaction -

1. Fill materials shall be compacted to a dry density equal to or greater than the following:

   a. The Gypsum Management Facility: 95 percent of the maximum dry density obtained from the Standard Proctor Test, ASTM D698.

   In order to insure uniform coverage and to facilitate construction inspection and control, the compaction of each layer shall proceed in a systematic, orderly, and continuous manner. Rolling shall be parallel to the embankment axis, except where there is insufficient working room for such operations.

2. The moisture content of all earth fill materials shall be as uniform as practicable throughout each lift. Fill shall be compacted at a moisture content that is no more than 2 percent below and no more than 2 percent above optimum moisture content.
3. Moisture conditioning of fill materials shall be performed by discing, harrowing, plowing, blading, or other suitable means prior to excavation. Moisture conditioning where the fill is placed shall be limited to minor adjustments prior to compaction. Addition of moisture shall be by using a

pressure spray bar mounted in front of or to one side of a water tanker so that water will not collect in the tracks of the truck.

4. Compaction of fill materials shall not commence if the moisture content is not within the specified limits. Any materials that are placed but not compacted prior to drying out or becoming too wet shall be removed and replaced or reprocessed at the Contractor's expense.
5. No admixtures as drying agents or to improve the workability of the soil will be allowed.

3.05 SOIL LINERS

A. Sources

The Soil Liners for the Gypsum Management Facility shall be constructed from Soil Liner Material as described in paragraph 2.01(B) above.

B. Test Liner

A compacted low permeability soil test liner of the actual full scale liner shall be constructed in accordance with the following requirements:

1. Test liner will be constructed from the same soil material sources, to the same design specifications, and with similar equipment and procedures as are proposed for the full scale liner.
2. Test liner will be at least four times the width of the widest piece of equipment to be used.
3. Test liner will be no less than 100 ft long to allow equipment to reach normal operating speed before reaching a central 40-ft test area.
4. Test liner will be constructed with maximum 8-in. compacted lifts for a total liner thickness of 3 ft.
5. Test liner will be tested by the Owner's Testing Consultant as described below for each of the following physical properties:

    a. Multiple two-stage Boutwell permeameter tests will be used on the test liner to determine the hydraulic conductivity. The two-stage field hydraulic conductivity test is a falling head infiltration test conducted in a cased borehole, typically 4 in. in diameter. The test is cited in the U.S. EPA Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, September 1993 (EPA/600/R-93/182).
    b. Undisturbed samples (Shelby tubes) will be tested in the laboratory for hydraulic conductivity to determine if there is a statistical correlation to the field testing results.
    c. Other engineering parameters including, but not limited to, particle size analysis, liquid limits, plasticity, water content, and in-place density that are needed to evaluate the full scale liner will be determined.

6. Additional test fills will be constructed for each new soil type or for each change in equipment or procedures.

C. Full Scale Liner Construction:

1. Full scale liner construction shall not be commenced until the results of the in-place compaction testing and Boutwell permeameter tests on the test liner confirm that the construction procedures and specified compaction requirements produce a in-situ hydraulic conductivities as specified in Section 2.01(B) above.
2. The liner shall be constructed according to the placement and compaction requirements for general fill, except the material shall be compacted to a density of no less than 95 percent of maximum dry density at a moisture content between 100 percent and 105 percent of optimum. The same compaction procedures, such as number of passes, speed, and compaction equipment used on construction of the test liner shall be used. Grade stakes shall not be driven into the clay liner.
3. The completed liner shall be smooth rolled to limit moisture loss and promote run-off of surface water. Moisture content shall be maintained within the specified range and erosion or other damage that occurs in the soil liner shall be repaired as directed by the Owner's Representative until the geosynthetic liner is placed.
4. Repair of any rutting or other damage caused by the installation of the geosynthetic liner will be paid for on a time and material basis.
5. Voids created in the clay barrier layer during construction (including, but not limited to, penetrations for test samples, and other penetrations necessary for construction) shall be repaired by removing material that does not meet the requirements for low permeability soil, placing low permeability soil backfill, granular or pelletized bentonite, or a mixture of bentonite and low permeability soil in lifts no thicker than 2 in. and tamping each lift with a steel rod. Each lift shall be tamped a minimum of 25 times altering the location of the rod within the void for each blow. Other ruts and depressions in the surface of the lifts shall be scarified, filled, and then compacted to grade.

3.06 CUSHION DIRT

Cushion Dirt to be placed beneath the upper High Density Polyethylene (HDPE) Geomembrane is to be placed to the specifications for General Fill in Section 3.04 above, except fill materials for Cushion Dirt shall be compacted to a dry density equal to or greater than 90 percent of the maximum dry density obtained from the Standard Proctor Test, ASTM D698.

3.07 ANCHOR TRENCH CONSTRUCTION

A. Gypsum Management Facility

1. A ledge at the bottom of the anchor trench elevation shall be excavated. Low permeability soil shall be placed and compacted on the ledge as shown on the anchor trench details in the plans.

2. The anchor trench shall be excavated to the depth and width shown on the anchor trench details. The front edge of the trench shall be rounded to eliminate any sharp corners that could cause excessive stress to the geosynthetic liners. Loose soil shall be removed or compacted into the floor of the trench.

3. Subsequent to Geosynthetic Clay Liner (GCL), Bottom HDPE Geomembrane and Geotextile Cushion installation, it shall be verified that the liners cover the entire trench floor, but do not extend up the back of the trench wall. After the liner installation in the trench has been inspected and approved by the Owner's Representative, the trench shall be backfilled with 1 ft. of low permeability soil. The backfill shall be deposited and compacted according to the requirements for general fill in such a manner as to prevent damage to the GCL and liner materials.

4. Subsequent to installation of separation geotextile on top of drainage layer, it shall be verified that the fabric extends across the top of the initial 1 ft layer of trench backfill, but does not extend up the back of the trench wall. After the fabric installation in the trench has been inspected and approved by the Owner's Representative, the trench shall be backfilled with 1 ft of low permeability soil. The backfill shall be deposited and compacted according to the requirements for general fill in such a manner as to prevent damage to the geotextile fabric.

5. Subsequent to installation of the upper HDPE Geomembrane, verify that the liner extends across the top of the initial 1 ft layer of trench backfill, but does not extend up the back of the trench wall. After the liner installation in the trench has been inspected and approved by the Owner's Representative, backfill the remainder of the trench to the top of the low permeability soil layer. Deposit and compact the backfill according to the requirements for general fill in such a manner as to prevent damage to the HDPE Geomembrane.

3.08 TESTING

A. Construction Quality Assurance (CQA) compaction and permeability tests will be made by the Owner's Testing Consultant during the progress of the work as indicated in Appendix 2. The Contractor shall cooperate with the Testing Consultant and allow such tests to be performed.

B. If tests indicate that an area of fill or low permeability soil liner does not meet the specified requirements, additional tests shall be performed to determine the extent of non-compliance. The Contractor shall moisture condition and recompact that area until a passing test result is obtained.

3.08 FINISH GRADING

All excavated and filled areas shall be fine graded and leveled to provide a smooth finish free of debris, foreign matter, objectionable stones, clods, lumps, pockets, or high spots, properly drained and true to indicated elevations. Finish grading shall be only near completion of work or when requested. Any portions of the berm damaged by construction shall be restored. The berm ditch shall be finished to design grade, and the ditch side slopes shaped and trimmed to provide a uniform ditch cross section.

3.09 CONSTRUCTION TOLERANCES

A. The foundation grade and finished earthwork grades shall be no more than 0.4 ft below and not above plan grade.

B. The minimum thickness of low permeability soil layer shall be 3 ft.

END OF SECTION 02200

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PART 1. GENERAL

1.01 DESCRIPTION

This section pertains to the placement of riprap for erosion control.

1.02 RELATED SECTIONS

The following section contains items which are related to the work in this section:

02200 - Earthwork

1.03 REFERENCES

Specified references or cited portions thereof, current at date of bidding documents unless otherwise specified, govern the work.

A. Illinois Department of Transportation (IDOT): Standard Specifications for Road and Bridge Construction, adopted January 1, 2007.

1.04 SUBMITTALS

Product Data: Provide quarry name and material type prior to delivery.

PART 2. PRODUCTS

2.01 MATERIALS

A. Stone Riprap and Bedding materials according to Article 1005.01 of the Illinois Standard Specifications for Road and Bridge Construction.

B. Filter Fabric material for Stone Riprap according to Article 1080.03, with an AOS (Apparent Opening Size) as indicated on the plans.

C. Supplier shall be listed on the current IDOT Approved Aggregate Source List.

D. Gradation as indicated in the drawings. Quality shall be Class A.

PART 3. EXECUTION

3.01 CONSTRUCTION REQUIREMENTS

A. Stone Riprap and Bedding shall be installed in accordance with Section 281 of the Illinois Standard Specifications for Road and Bridge Construction for the placement of Stone Riprap. Measurement and payment provisions of Section 281 shall not apply.

B. Filter Fabric for Stone Riprap shall be installed in accordance with Section 282 of the Illinois Standard Specifications for Road and Bridge Construction.

C. The Owner's Representative shall be allowed to visually inspect Riprap for compliance with specifications prior to placement.

END OF SECTION 02275

PART 1. GENERAL

1.01 DESCRIPTION

A. Gypsum Management Facility

This section pertains to the following:

1. Furnishing and placing granular drainage materials for the drainage layer and leachate collection system.
2. Furnishing and placing coarse aggregate for encasement of the ring drain collection piping.
3. Furnishing and installing materials for roadbed construction related to the Gypsum Management Facility access roads and the McKinley Road relocation.
4. Recycle Pond Drain.

1.02 RELATED SECTIONS

The following sections contain items which are related to the work in this section:

1. 02300 - Earthwork
2. 02373 – Geotextiles
3. 02640 - HDPE Piping

1.03 REFERENCES

The following references, or cited portions thereof, govern the work:

1. Illinois Department of Transportation (IDOT): Standard Specifications for Road and Bridge Construction, adopted January 1, 2007.
2. American Society for Testing and Materials (ASTM):

    a. ASTM D 75 (2003) Practice for Sampling Aggregates.
    b. ASTM D 422 (1963; R 2002) Test Method for Particle-Size Analysis of Soils.
    c. ASTM D 2434 (1968, R 2000) Test Method for Permeability of Granular Soils (Constant Head).
    d. ASTM D 3042 (2003) Test Method for Insoluble Residue in Carbonate Aggregates.
    e. ASTM C 1260 (2005) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).

3. American Geological Institute (AGI). Geoscience Handbook AGI Data Sheets, 4th Edition.

1.04 MEASUREMENT AND PAYMENT

The Contractor shall be responsible for estimating the extent of granular materials required to complete the work including, but not limited to, construction of drainage layer, encasement of leachate collection piping, and road-bed construction. The Contractor shall include the dollar amount associated with furnishing and placing all granular materials in his Lump Sum Bid amount.

1.05 COORDINATION

A. The geosynthetic liner shall be covered with granular materials as soon as practicable after a section of liner has been approved by the Owner's Representative.

1.06 SUBMITTALS

A. Product Data:

1. Aggregate source list: Submit a list of proposed aggregate sources.

2. Shipping Tickets: Submit shipping tickets for the granular materials delivered to the site. Shipping tickets shall be according to paragraph 1004.01f of the IDOT Standard Specifications.

B. Test Reports.

1. Submit results of grain size analysis (ASTM D422) and hydraulic conductivity testing (ASTM D2434) for gradations established by the Contractor that provide the specified hydraulic conductivity. Test results are required for each proposed source and gradation. Submit test results for each source demonstrating compliance with reactivity, soundness, and abrasion requirements specified herein.

C. Samples:

1. Submit one sample per source for each gradation proposed for use on the project. Samples shall be at least one pound and shall be obtained and shipped according to ASTM D75. Submit samples at least 15 days prior to starting construction of the drainage layer and coarse aggregate encasement for leachate piping.

1.07 STORAGE AND HANDLING

A. Storage and handling of granular materials shall be according to paragraph 1004.01e of the IDOT Standard Specifications.

1.01

PART 2. PRODUCTS

2.01 MATERIALS

A. General

1. Unless otherwise approved by the Owner's Representative, granular materials shall be obtained from sources listed on the current IDOT Approved Aggregate Source List (www.dot.il.gov\materials\approvedaggregatesources.pdf).
2. Coarse Granular materials shall be meet the Description of Gravel, as described in Section 1004.01(a)(1) of the IDOT Standard Specifications, and shwll be spherical to sub-discoidal, sub-rounded to well rounded particles as defined by AGI Data Sheet, 4th Edition, Sheet 8.4 – Comparison Charts for Estimating Roundness and Sphericity.
3. Granular materials shall experience no more than 15 percent carbonate loss per ASTM D3042.
4. Granular materials shall be free of deleterious material, and shall meet the Na_2SO_4 soundness and Los Angeles Abrasion Specifications for Class B quality aggregate per paragraph 1004.01 of the IDOT Standard Specifications.
5. All material shall pass the 2 in. sieve, and no greater than 5 percent shall be retained on the No. 200 sieve.
6. Granular materials shall be innocuous to alkali-silica reactivity, and shall exhibit internal expansions of less than 0.10 percent at 16 days after casting as determined by ASTM C 1260.

B. Gypsum Management Facility Granular Materials

1. Granular Materials for Drainage Layer

Gradation for granular material for drainage layer shall be as required to provide a minimum hydraulic conductivity (ASTM D2434) of 1×10^{-3} cm/sec.

2. Coarse Aggregate around Ring Drain Collection Piping

Coarse Aggregate used to encase the ring drain collection piping shall be IDOT Gradation CA 7 material as outlined in Article 1004.01 of the IDOT Standard Specifications for Road and Bridge Construction.

3. Filter Sand

Filter Sand used for protective cover over the ring drain collection system shall be IDOT Gradation FA 1, Class B or better according to Article 1003 of the IDOT Standard Specifications for Road and Bridge Construction.

4. Aggregate Base Course, Type B

Aggregate Base Course, Type B used for base material for all new access roads and shall be IDOT Gradation CA 2, in accordance with Section 1004.04 of the IDOT Standard Specifications for Road and Bridge Construction. The material shall originate from an IDOT approved source. The Na_2SO_4 soundness and Los Angeles Abrasion Specifications for Class B quality aggregate per paragraph 1004.01 of the IDOT Standard Specifications shall not apply.

5. Aggregate Surface Course, Type B

Aggregate Surface Course, Type B used for surface material for all new access roads and the McKinley Road relocation shall be IDOT Gradation CA 6, in accordance with Section 1004.04 of the IDOT Standard Specifications for Road and Bridge Construction. The material shall originate from an IDOT approved source. The Na_2SO_4 soundness and Los Angeles Abrasion Specifications for Class B quality aggregate per paragraph 1004.01 of the IDOT Standard Specifications shall not apply.

2.02 EQUIPMENT

Equipment for spreading and compacting granular materials shall be low ground pressure equipment to prevent damage to the underlying geosynthetic liners.

PART 3. EXECUTION

3.01 PROTECTION OF GEOSYNTHETICS

A. Protection of the geosynthetic liners is critically important. Approved geosynthetic liner shall be covered by granular material as soon as practicable. Granular material shall be placed to a minimum thickness of 1 ft before any heavy equipment or loaded trucks are allowed on the lined area.

B. No equipment will be permitted directly on the geosynthetic liner.

C. Any damage to the geosynthetic liner system shall be repaired, as directed by the Owner's Representative, at the expense of the Contractor.

3.02 GRANULAR DRAINAGE LAYER (GYPSUM MANAGEMENT FACILITY)

A. Placement on Cell Floor

1. The granular material shall be back-dumped on the geotextile cushion fabric in a sequence of operations beginning at the perimeter of the liner on the cell floor.
2. Placement of material on the fabric shall be accomplished by spreading dumped material off of previously placed material with a bulldozer blade or endloader, in such a manner as to prevent tearing or shoving of the cloth. Dumping of material directly on the fabric will only be permitted to establish an initial working platform. No vehicles or construction equipment shall be allowed on the fabric prior to placement of the granular blanket to a minimum thickness of 1 ft.

B. Placement on Cell Side Slopes

1. Placement of granular material on cell side slopes shall be accomplished using methods and equipment similar to that specified for placement of material on cell floor.
2. The Contractor may place gypsum underlain with separation geotextile fabric to buttress the granular material on the slope:

   a. The Construction Quality Assurance (CQA) survey to certify thickness of drainage material shall be completed within the footprint of the gypsum stack before gypsum placement.

b. Separation geotextile fabric shall extend beyond the toe of gypsum buttress a sufficient distance to prevent contamination of the granular drainage layer. See Sections 02373 and 02320 for construction of separation geotextile fabric and gypsum, respectively.

3.04 COARSE AGGREGATE FOR ENCASEMENT OF RING DRAIN COLLECTION PIPING (GYPSUM MANAGEMENT FACILITY)

A. The geotextile filter fabric for encasement of leachate collection piping shall be placed on the approved cushion geotextile fabric according to Section 02373 – Geotextiles.

B. The coarse aggregate shall be placed on the encasement fabric to the width shown on the plans to the level of the bottom of the ring drain collection piping.

C. Course aggregate shall be placed and tamped along the pipe during pipe installation. The coarse aggregate shall be placed longitudinally along the pipe in lifts not to exceed 8 in. thick to a height of at least the center of the pipe. The aggregate shall be maintained at equal elevation on each side of the pipe, and the first lift of material shall be mechanically tamped to ensure that the space under the pipe is completely filled. The top of pipe shall not be covered until the CQA survey certifies leachate piping grade has been completed.

C. After the CQA survey has been completed, coarse aggregate material shall continue to be placed in lifts not to exceed 8 in. thick, as specified in the previous paragraph until the minimum cover height shown in the plans is attained.

D. The running of trucks or heavy equipment over leachate piping shall be avoided until there is at least a 12 in. cover of Filter Sand over the completed geotextile envelop. Temporary ramps no steeper than 10H:1V transverse to the piping shall be provided for temporary equipment crossings until the first lift of gypsum is placed.

3.03 ROADWAY CONSTRUCTION

A. Prepare the roadway subgrade as shown on the plans, in accordance with Section 02200 – Earthwork.

B. Furnish Geotechnical Fabric for Ground Stabilization in accordance with Section 02373 – Geotextiles.

C. Furnish Aggregate Base Course, Type B in accordance with Article 351 of the IDOT Standard Specifications for Road and Bridge Construction.

D. Furnish Aggregate Surface Course, Type B in accordance with Article 402 of the IDOT Standard Specifications for Road and Bridge Construction.

3.04 TESTING

A. CQA gradation and permeability tests will be made by the Owner's Testing Consultant during the progress of the work as indicated in Appendix 2. The Contractor shall cooperate with the Testing Consultant and allow such tests to be performed.

B. If tests indicate that an area of granular material or coarse aggregate does not meet the specified requirements, then the Contractor shall remove the material and replace it with suitable material.

3.05 FINISH GRADING

The granular drainage layer shall be fine graded to provide a smooth finish before a CQA survey of the completed portion of the drainage layer is requested. Ruts or erosion damage shall be repaired before placement of the separation geotextile fabric.

3.06 CONSTRUCTION TOLERANCES

The minimum thickness of drainage layer shall be 1 ft.

END OF SECTION 02315

PART 1. GENERAL

1.01 DESCRIPTION

This section pertains to furnishing and installing geotextile fabrics on prepared surfaces.

1.02 RELATED SECTIONS

The following sections contain items which are related to the work in this section:

1. 02300 - Earthwork
2. 02315 - Granular Materials
3. 02800 – HDPE Geomembrane

1.03 REFERENCES

The following references, or cited portions thereof, govern the work:

1. Illinois Department of Transportation (IDOT): Standard Specifications for Road and Bridge Construction, adopted January 1, 2007.
2. American Society for Testing and Materials (ASTM):

    a. ASTM 3776 (1996; R 2002) Standard Test Method for Mass per Unit Area (Weight) of Fabric;
    b. ASTM D 3786 (2001) Test Method for Hydraulic Bursting Strength of Textile Fabrics – Diaphragm Bursting Strength Tester Method;
    c. ASTM D 4533 (2004) Test Method for Trapezoid Tearing Strength of Geotextiles;
    d. ASTM D 4632 (1991; R 2003) Test Method for Grab Breaking Load and Elongation of Geotextiles;
    e. ASTM D 4751 (2004) Test Method for Determining Apparent Opening Size of Geotextile;
    f. ASTM D 4833 (2000) Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products;
    g. ASTM D 4873 (2002) Guide for Identification, Storage, and Handling of Geosynthetic Rolls;
    h. ASTM D 4884 (1996; R 2003) Test Method for Strength of Sewn or Thermally Bonded Seams of Geotextiles;
    i. ASTM D5261-92(2003) Standard Test Method for Measuring Mass per Unit Area of Geotextiles

j. ASTM D6241-04 Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

1.04 MEASUREMENT AND PAYMENT

A. The Contractor shall be responsible for estimating the extent of geotextile fabric required to complete the work including fabric for laps, anchorage, repairs, and samples for Construction Quality Assurance (CQA) testing. The Contractor shall include the dollar amount associated with all geotextile construction in his Lump Sum Bid amount, except as specified in paragraph B.

B. Geotextile fabric for ground stabilization, when directed by the Owner's Representative, will be paid for on a time and materials basis.

C. No additional payment will be made for geotextile fabric for ground stabilization installed at the Contractor's discretion.

1.05 SUBMITTALS

A. Product Data

1. The manufacturer's list of guaranteed properties for each geotextile fabric or geogrid proposed for use on the project shall be submitted.
2. The manufacturer's installation guidelines shall be submitted.

B. Samples

Samples of geotextile fabrics shall be submitted for CQA prequalification testing. Sample size and sampling frequency are specified in Appendix 2.

C. Inventory

A copy of the roll inventory that identifies, as a minimum, manufacturer or supplier, product or style number, roll number, width, and length of roll as identified on the roll label shall be submitted.

1.06 STORAGE AND HANDLING

Geotextiles shall be stored and handled according to ASTM D4873.

PART 2. PRODUCTS

2.01 MATERIALS

A. Geotextile Fabric for Liner System

Geotextile fabrics for use in the cell liner system shall consist of non-woven filaments of polypropylene, polyester, or polyethylene. Stabilizers and/or inhibitors shall be added to the base polymer if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Non-woven fabric may be needle-punched, heat-bonded, or a combination thereof. The filaments shall be dimensionally stable (i.e., filaments shall maintain their relative position with respect to each other) and resistant to delamination. The edges of the geotextile shall be finished to prevent the outer fiber from pulling away from the geotextile. The filaments shall be free from any chemical treatment or coating that might significantly reduce porosity and permeability.

Fabric shall have the following physical properties:

Physical Properties(1)	4 oz. (Separation)	6 oz. (PWRS)	16 oz. (CA Envelope)
Mass/Unit Area (oz./yd^2) ASTM D5261	4.0	6.0	16.0
Grab Tensile Strength (lb.) ASTM D4632	115	160	380
Grab Elongation (%) ASTM D4632	50	50	50
Puncture Strength (lb.) ASTM D4833	65	85	240
Puncture (CBR) Strength (lb.) ASTM D6241	310	410	1025
Mullen Burst Strength (psi) ASTM D3786	210	280	750
Trapezoidal Tear Strength (lb.) ASTM D4533	50	60	150
Width (ft.)	15	15	15
Apparent Opening Size (AOS) Max. US Std. Sieve No. ASTM D4751	70	70	100
UV Resistance(2) (%) ASTM D4355	70	70	70
Roll Width (ft.)	15	15	15

Notes:

(1) All Values listed are Minimum Average Roll Values (MARV) unless otherwise noted, calculated as the typical minus two standard deviations..

(2) UV Resistance is a minimum value and not a MARV. Evaluation to be on 2.0 inch strip tensile specimens after 500 hours exposure.

A. Cushion Geotextile Fabric.

Cushion geotextile fabric shall consist of non-woven filaments of polypropylene, polyester, or polyethylene. Stabilizers and/or inhibitors shall be added to the base polymer if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Non-woven fabric may be needle-punched, heat-bonded, or a combination thereof. The filaments shall be dimensionally stable (i.e., filaments shall maintain their relative position with respect to each other) and resistant to delamination. The edges of the geotextile shall be finished to prevent the outer fiber from pulling away from the geotextile. The filaments shall be free from any chemical treatment or coating that might significantly reduce porosity and permeability.

Fabric shall have the following physical properties:

Physical Properties(1)	**10 oz. (Cushion)**
Mass per unit area (oz/yd^2) ASTM D5261	10
Grab Tensile Strength (lb.) ASTM D4632	230
Grab Tensile Elongation (%) ASTM D4632	50
Trapezoidal Tear Strength (lb.) ASTM D4533	95
Puncture (CBR) Strength (lb.) ASTM D6241	700
Puncture (CBR) Elongation (in.) ASTM D6241	1.5
UV Resistance(2) (%) ASTM D4355	70
Apparent Opening Size (Max.) (AOS) Sieve No. - ASTM D4751	---
Roll Width (ft.)	15

Notes:

(1) All Values listed are Minimum Average Roll Values (MARV) unless otherwise noted, calculated as the typical minus two standard deviations..

(2) UV Resistance is a minimum value and not a MARV. Evaluation to be on 2.0 inch strip tensile specimens after 500 hours exposure.

B. Geotechnical Fabric for Ground Stabilization

Geotechnical fabric for ground stabilization shall conform to Article 1080.02 of the IDOT Standard Specifications for Road and Bridge Construction.

C. Thread for Seams

High strength thread should be used such that seam test should conform to ASTM D4884. The thread shall meet the chemical, ultraviolet, and physical requirements of the geotextile, and the color shall be different from that of the geotextile.

D. Securing Devices

Pins, staples, and other devices that project through the geotextile fabric are not permitted for fabrics installed above the geomembrane. Sandbags, stone, or other appropriate means approved by the Owner's Representative shall be used to prevent movement of the geotextile.

2.02 EQUIPMENT

A. Equipment for spreading and compacting granular materials shall be low ground pressure equipment to prevent damage to the underlying geosynthetic liners.

PART 3. EXECUTION

3.01 SAMPLES FOR CQA TESTING

A. Geotextile fabric samples shall be obtained, identified and packaged from rolls designated by the Owner's Representative according to ASTM D4873.

B. Samples shall be 3 ft. wide by the full roll width.

3.02 BASE PREPARATION

A. Surface on which the geotextile will be placed shall be prepared to a relatively smooth surface condition, and shall be free from obstruction, debris, depressions, erosion features, or any irregularities that would prevent continuous, intimate contact of the geotextile with the entire surface. Rills, gullies, and ruts must be graded out of the surface before geotextile placement. Areas on which geotextile are to be placed shall be graded and/or dressed in accordance with Section 02200 – Earthwork and Section 02315 – Granular Drainage Materials. Immediately prior to placing the geotextile, the prepared base will be inspected by the Owner's Representative, and no material shall be placed thereon until that area has been approved.

B. Geotextile cushion fabric will be installed directly on the geosynthetic liner. Jointly inspect the liner with the Owner's Representative before commencing fabric installation each day. Notify the Owner's Representative promptly of any damage or defects observed in the liner as fabric installation progresses. Do not place fabric in the damaged or defective area until the liner has been repaired and approved by the Owner's Representative. Submit a daily inspection report identifying the area of fabric placement and certifying that there were no visible defects in the area of fabric placement.

C. Do not run heavy vehicle traffic directly on the geosynthetic liner or cushion geotextile. Use vehicles and equipment as specified in paragraph 2.02 to transport and deploy fabric on the liner. Operate the equipment with care, and place protective cover over the geomembrane, if necessary, to avoid damaging the liner. Route traffic and personnel over installed cushion fabric and use the installed fabric as a working platform to the greatest extent possible.

3.03 INSTALLATION

A. General Requirements:

1. Geotextile fabric shall be unrolled and laid out following these requirements to the greatest extent practical:

a. Orient panels with the longest dimension parallel to the slope.
b. Minimize the number of seams in corners and odd-shaped areas.
c. Extend panels on slopes a minimum of 5 ft onto a horizontal surface.

Geotextile panels shall be unrolled using methods that will not damage the fabric and will protect underlying surface from damage. While unrolling, the geotextile fabric shall be visually inspected for imperfections and faulty or suspect areas marked. Ballast shall be placed on fabric to prevent wind uplift. Expansion and contraction should be allowed for by leaving slack.

Heavy vehicle traffic shall not be run directly on geotextile fabric. Fabric in areas of heavy traffic shall be protected with protective cover over the fabric.

2. Laps

Individual panels of geotextile fabric shall be lapped according to manufacturer's instructions and as specified herein. Provide a minimum overlap of 3 in. unless otherwise specified herein or in the plans. Shingle overlaps so that water or other material cannot run down the slope between the two layers of fabric.

3. Field Seams

Continuously sew all laps on slopes steeper than 10H:1V. This requirement does not apply to the heavy geotextile fabric for envelopment of coarse aggregate around leachate piping.

4. Defects and Repairs

Examine the installed geotextile fabric for defects, holes discontinuous seams, puckered or separated laps, etc. Repair defective laps and seams. Patch holes and defects according to manufacturer's recommendations and as directed by the Owner's Representative. Do not cover suspect or patched areas until they have been inspected and approved by the Owner's Representative.

B. Geotextile Fabric for Separation

1. Use low ground pressure equipment to avoid rutting the granular material.
2. Horizontal seams (parallel to top of slope) will be permitted on cell side slopes to facilitate staged construction of the drainage layer on the side slope.
3. Extend separation geotextile fabric into and across the bottom of the anchor trench and complete backfill of the trench according to Section 02200.

C. Geotextile Fabric for Coarse Aggregate Envelope

1. Geotextile for coarse aggregate envelope will be installed directly on the cushion fabric. Remove any foreign materials from the cushion fabric within the footprint of the coarse aggregate leachate piping encasement before installing the geotextile envelope. Place sufficient width to completely envelop the coarse aggregate and provide a longitudinal lap of at least 6 in.
2. After the coarse aggregate encasement has been completed, according to Section 02315, wrap the geotextile around the mounded aggregate, and cover the lap with at least 6 in. of material before permitting vehicle or equipment on the fabric.
3. Any ballast material other than coarse aggregate, according to Section 02315, that is placed within the envelope will require removal during coarse aggregate construction.

D. Geotechnical Fabric for Ground Stabilization

1. Install Geotechnical Fabric for Ground Stabilization in accordance with Section 210 of the IDOT Standard Specifications for Road and Bridge Construction.

2. If approved by the Owner's Representative, the Contractor may, at his own expense, install geotextile or geogrid for ground stabilization outside the limits designated by the Owner's Representative.
3. Submit as-built drawings that clearly delineate limits and type of ground stabilization.

3.04 PROTECTION

A. Protect installed fabric until it is covered by at least 1 ft. of overlying material.

B. Any damage to the geotextile during its installation or during placement of overlying materials shall be replaced by the Contractor at no cost to the Owner. Unless otherwise noted, the work shall be scheduled so that the covering of the geotextile with a layer of the specified material is accomplished within 14 calendar days after placement of the geotextile. Failure to comply shall require replacement of geotextile. The geotextile shall be protected from damage prior to and during the placement of overlying materials. Before placement of overlying materials, the Contractor shall demonstrate that the placement technique will not cause damage to the geotextile.

3.05 TESTING AND INSPECTION

A. Prequalification Testing

Geotextiles are subject to CQA testing by the Owner's Testing Consultant to verify conformance with the manufacturer's list of guaranteed properties according to Appendix 2. The Contractor shall provide samples as specified herein. If tests indicate nonconformance to the list of guaranteed properties, provide additional samples as directed by the Owner's Representative to determine the extent of the non-conformance. Any fabric that does not conform to the list of guaranteed properties shall be removed from the site.

B. Installed fabric shall be inspected by the Owner's Representative. No material shall be placed on the fabric, other than ballast, until the installation has been approved by the Owner's Representative. Ballast shall not obscure seams or significant length of unseamed laps. The Owner's Representative may require removal of ballast to inspect suspect areas.

C. If the Owner's Representative suspects that completed work has been damaged by construction methods that do not conform to the specifications, he may require removal of completed work to verify the integrity of the underlying materials. The Contractor shall bear the cost of removal and subsequent repair as directed by the Owner's Representative.

END OF SECTION 02373

PART 1. GENERAL

1.01 DESCRIPTION

A. This section covers furnishing and installation of a reinforced needlepunched Geosynthetic Clay Liner (GCL) at the Gypsum Management Facility and the CCB Management Facility.

B. The work includes furnishing all equipment and materials, providing all labor, supervision, administration and management necessary to perform the work as specified herein and as shown on the plans.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

The following references, or cited portions thereof, govern the work

1. American Society for Testing and Materials (ASTM):

   a. ASTM D 4632 (1991; R 2003), Standard Test Method for Grab Breaking Load and Elongation of Geotextiles;
   b. ASTM D 4643 (2000), Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method;
   c. ASTM D 5084 (2003), Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter;
   d. ASTM D 5261 (1992; R 2003), Test Method for Measuring Mass Per Unit Area of Geotextiles;
   e. ASTM D 5321 (2002), Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method;
   f. ASTM D 5887 (2004), Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter;
   g. ASTM D 5888 (1995; R 2002), Practice for Storage and Handling of Geosynthetic Clay Liners;
   h. ASTM D 5889 (1997; R 2003), Practice for Quality Control of Geosynthetic Clay Liners;

i. ASTM D 5890 (2002), Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners;
j. ASTM D 5891 (2002), Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.

1.04 SUBMITTALS

A. With the bid, the Contractor shall furnish the following information:

1. Conceptual description of the proposed plan for placement of the GCL panels over the areas of installation.
2. GCL Manufacturer's Quality Control (MQC) Plan for documenting compliance with Sections 2.01 and 2.02 of these specifications.
3. GCL manufacturer's historical data for reinforced GCL of a) 10,000-hour creep shear testing per Section 2.01 D, and b) seam flow data at 2 psi confining pressure per Section 2.01 E.
4. A copy of GCL manufacturer's International Standards Organization (ISO) Quality Certificate of Registration.
5. Statement of experience from the proposed GCL supplier.
6. Statement of experience from the proposed GCL installer.

B. At the Owner Representative's or Owner's request, the Contractor shall furnish:

1. A representative sample of the GCLs.
2. A project reference list for the GCL(s) consisting of the principal details of at least ten projects totaling at least 10 million sq. ft (100,000 sq. meters) in size.

C. Upon shipment, the Contractor shall furnish:

1. The GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications to verify that the materials supplied for the project are in accordance with the requirements of this specification.
2. Inventory of materials received.

D. As installation proceeds, the Contractor shall submit certificates of subgrade acceptance, signed by the Contractor and Construction Quality Assurance (CQA) Inspector (see Sections 1.06 and 3.03) for each area that is covered by the GCL.

E. Warranty

After construction, the contractor shall submit material and installation warranty certificates.

1.05 QUALIFICATIONS

A. GCL Manufacturer must have produced at least 10 million sq. ft. (1 million sq. meters) of GCL, with at least 8 million sq. ft. (800,000 sq. meters) installed.

B. The GCL Installer must either have installed at least 1 million sq. ft. (100,000 sq. meters) of GCL, **or** must provide to the Engineer satisfactory evidence, through similar experience in the installation of other types of geosynthetics, that the GCL will be installed in a competent, professional manner.

1.06 CONSTRUCTION QUALITY ASSURANCE (CQA)

A. The Owner shall provide a third-party inspector for CQA of the GCL installation. The inspector shall be an individual or company who is independent from the manufacturer and installer and who shall be responsible for monitoring and documenting activities, related to the CQA of the GCL throughout installation.

B. Testing of the GCL as necessary to support the CQA effort shall be performed by a third party laboratory retained by the Owner and independent from the GCL manufacturer and installer.

WARRANTY

The geomembrane material shall be warranted, on a pro-rata basis against manufacturer's defects for a period of five (5) years from the date of liner installation. The installation shall be warranted against defects in workmanship for a period of (1) year from the date of liner completion.

PART 2. PRODUCTS

2.01 MATERIALS

A. Acceptable products for the GCL are GCL Bentomat® SDN, as manufactured by CETCO, 1350 West Shure Drive, Arlington Heights, Illinois 60004 USA (847-392-5800), or an engineer-approved reinforced needlepunched GCL material equal to Bentomat SDN.

B. The delineation of areas to receive GCL shall be agreed by the Installer and the Engineer prior to installation.

C. The GCL and its components shall have the properties shown in the GCL Certified Properties table at the end of this section.

D. The reinforced GCL shall have 10,000 hour test data for large-scale constant-load (creep) shear testing for related products under hydrated conditions. The displacement shall be 0.13 in. (3.3 mm) or less at a constant shear load of 250 psf (12 kPa) and a normal load of 500 psf (24 kPa).

E. The reinforced GCL shall have seam test data from an independent laboratory showing that the seam flow with a grooved cut in one of the nonwoven geotextiles is less than 1×10^{-8} $m^3/m^2/s$ at 2 psi hydraulic pressure.

F. The minimum acceptable dimensions of full-size GCL panels shall be 150 ft. (45.7 m) in length. Short rolls [(those manufactured to a length greater than 70 ft. (21 meters) but less than a full-length roll)] may be supplied at a rate no greater than three (3) per truckload or three (3) rolls every 36,000 sq. ft. (3,500 sq. meters) of GCL, whichever is less.

G. A 6-inch (150 mm) overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.

2.02 PRODUCT QUALITY DOCUMENTATION

The GCL manufacturer shall provide the Contractor or other designated party with manufacturing QA/QC certifications for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:

A. Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the swell index and fluid loss parameters shown in the GCL Certified Properties tables.

B. Manufacturer's test data for finished GCL product(s) of bentonite mass/area, GCL tensile strength and GCL peel strength (reinforced only) demonstrating compliance with the index parameters shown in the GCL Certified Properties tables.

C. GCL lot and roll numbers supplied for the project (with corresponding shipping information).

2.03 PRODUCT LABELING

A. Prior to shipment, the GCL manufacturer shall label each roll, identifying:

1. Product identification information (Manufacturer's name and address, brand product code).
2. Lot number and roll number.
3. Roll length, width and weight.

2.04 PACKAGING

A. The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.

B. All rolls shall be labeled and bagged in packaging that is resistant to photodegradation by ultraviolet (UV) light.

2.05 ACCESSORY BENTONITE

A. The granular bentonite sealing clay used for overlap seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer. Seaming of GCLs shall be conducted in accordance with the manufacturer's guidelines for each particular GCL. Please refer to the installation guidelines for Bentomat /Claymax GCLs.

PART 3. EXECUTION

3.01 SHIPPING AND HANDLING

A. The rolls of GCL shall be packaged and shipped by appropriate means to prevent damage to the material and to facilitate off-loading.

B. The Installation Supervisor shall be present during delivery and unloading of the GCL. A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage. The Installation Supervisor shall prepare and submit an inventory that includes lot and roll number for materials received.

C. The Installer is responsible for unloading the GCL. The Owner will make available equipment and operators employed at the site to assist with unloading. The Installer shall coordinate with the Owner to determine equipment availability and should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.

3.02 STORAGE

A. Storage of the GCL rolls shall be the responsibility of the Installer. A dedicated storage area shall be provided by the Owner at the job site. Submit storage area requirements (size and preferred location) with bid documents.

B. Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four).

C. All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.

D. The integrity and legibility of the labels shall be preserved during storage.

3.03 EARTHWORK

A. The low permeability soil layer upon which the GCL is installed shall be prepared and compacted prior to installation. The surface shall be smooth, firm, and unyielding, and free of:

1. Vegetation.
2. Construction debris.
3. Sticks.
4. Sharp rocks.
5. Void spaces.
6. Ice.
7. Abrupt elevation changes.
8. Standing water.
9. Cracks larger than 0.25 in. (6 mm) in width.
10. Any other foreign matter that could contact the GCL.

B. Immediately prior to GCL deployment, the low permeability soil layer shall be final-graded by the contractor to fill in all voids or cracks and then smooth-rolled to provide the best practicable surface for the GCL. At completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the subgrade. Furthermore, all protrusions extending more than 0.5 in. (12 mm) from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor.

C. On a continuing basis, the project CQA inspector shall certify acceptance of the subgrade before GCL placement.

D. It shall be the Installer's responsibility thereafter to indicate to the Owner's Representative any change in the condition of the low permeability soil layer that could cause the subgrade to be out of compliance with any of the requirements listed in this Section. The Installation Supervisor shall certify in the daily report that no GCL was placed over visibly defective low permeability soil surface.

E. At the top of sloped areas of the job site, an anchor trench for the GCL shall be excavated by the contractor in accordance with the project plans. The trench shall be excavated and approved by the CQA Inspector prior to GCL placement. No loose soil shall be allowed at the bottom of the trench and no sharp corners or protrusions shall exist anywhere within the trench.

3.04 GCL PLACEMENT

A. GCL rolls shall be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging shall be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) shall be in accordance with the Owner Representative's recommendations.

B. Equipment which could damage the GCL, shall not be allowed to travel directly on it. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.

C. Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering commonly known as a slip sheet or rub sheet may be used to reduce friction damage during placement.

D. The GCL panels shall be placed parallel to the direction of the slope.

E. All GCL panels shall lie flat on the underlying surface, with no wrinkles or folds, especially at the exposed edges of the panels.

F. Only as much GCL shall be deployed as can be covered at the end of the working day with soil, a geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, the Installer shall remove and replace the hydrated material as directed by the Owner Representative.

3.05 ANCHORAGE

A. As directed by the project drawings and specifications, the end of the GCL roll shall be placed in an anchor trench at the top of the slope. The front edge of the trench shall be rounded so as to eliminate any sharp corners. Loose soil shall be removed from the floor of the trench. The GCL shall cover the entire trench floor, but shall not extend up the rear trench wall.

3.06 SEAMING

A. The GCL seams shall be constructed by overlapping their adjacent edges according to the manufacturer's recommendations. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.

B. The minimum dimension of the longitudinal overlap should be 6 in. (150 mm) for Bentomat SDN. If the GCL is manufactured with a grooved cut in the nonwoven geotextile that allows bentonite to freely extrude into the longitudinal overlap then no bentonite-enhanced seam is required for this overlap. If the GCL does not have a grooved cut in one of the nonwoven geotextiles in the longitudinal overlap, then bentonite-enhanced seams are required as described below.

C. End-of-roll overlapped seams shall be constructed with a minimum overlap of 24 in. (600 mm) for Bentomat SDN. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone. End-of-roll overlapped seams for all reinforced GCL seams require bentonite-enhanced seams as described below.

D. Bentonite-enhanced seams shall be constructed between the overlapping adjacent panels as follows. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6-inch (150 mm) line. The granular bentonite shall be applied at a minimum application rate of one quarter pound per lineal ft. (0.4 kg/m). A similar bead of granular sodium bentonite is applied at the end-of-roll overlap.

3.07 DETAIL WORK

A. There shall be no penetrations through the GCL.

B. Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid damage to the geotextile components of the GCL during the cutting process.

3.08 DAMAGE REPAIR

A. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible, if approved by the Owner's Representative, to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 in. (300 mm) is achieved around all of the damaged area. Granular bentonite or bentonite mastic shall be applied around the damaged area prior to placement of the patch. It may be desirable to use an adhesive to affix the patch in place so that it is not displaced during cover placement. Patching shall be observed and approved by the Owner's Representative.

GCL CERTIFIED PROPERTIES

MATERIAL PROPERTY	TEST METHOD	TEST FREQUENCY $ft^2 (m^2)$	REQUIRED VALUES
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft^2 (4,000 m^2)	0.75 lb/ft^2 (3.6 kg/m^2) min
GCL Grab Strength[3]	ASTM D 6768	200,000 ft^2 (20,000 m^2)	30 lbs/in (53 N/cm) MARV
GCL Peel Strength[3]	ASTM D 6496	40,000 ft^2 (4,000 m^2)	2.5 lbs/in (4.4 N/cm) min
GCL Index Flux[4]	ASTM D 5887	Weekly	1 x 10^{-8} m^3/m^2/sec max
GCL Hydraulic Conductivity[4]	ASTM D 5887	Weekly	5 x 10^{-9} cm/sec max
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321 ASTM D 6243	Periodic	500 psf (24 kPa) typ @ 200 psf

Notes

[1] Bentonite property tests performed at a bentonite processing facility before shipment the manufacturer's production facilities.

[2] Bentonite mass/area reported at 0 percent moisture content.

[3] All tensile strength testing is performed in the machine direction using ASTM D 6768. All peel strength testing is performed using ASTM D 6496. Upon request, tensile and peel results can be reported per modified ASTM D 4632 using 4 inch grips.

[4] Index flux and permeability testing with deaired distilled/deionized water at 80 psi (551kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of $5x10^{-9}$ cm/sec for typical GCL thickness. Actual flux values vary with field condition pressures. The last 20 weekly values prior the end of the production date of the supplied GCL may be provided.

[5] Peak values measured at 200 psf (10 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

END OF SECTION 02376

PART 1. GENERAL

1.01 DESCRIPTION

This section pertains to construction of the HDPE (High Density Polyethylene) Piping at the Gypsum Management Facility and the CCB Management Facility.

1.02 RELATED SECTIONS

None.

1.03 REFERENCES

The following references, or cited portions thereof, govern the work

A. American Society of Testing and Materials:

1. ASTM D 2683 (2004); Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
2. ASTM D 3261 (2003); Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
3. ASTM D 3350 (2005); Specification for Polyethylene Plastics Pipe and Fittings Materials.
4. ASTM F 412 (2001a); Terminology Relating to Plastic Piping System.
5. ASTM F 1055 (1998); Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
6. ASTM F 1056 (2004); Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings.

1.04 SUBMITTALS

A. Qualifications

Submit qualifications of the Welding Supervisor who will be responsible for construction quality control of the pipe joining process.

B. Material Certifications

Submit manufacturer certifications that the pipe provided complies with the requirements herein.

C. Product Data

1. Submit product data and operating instructions for pipe joining equipment.
2. Submit pipe manufacturer's recommended procedures for storing, handling, and installing pipe and fittings.

1.05 QUALIFICATIONS

A. The Contractor or Subcontractor performing the work under this section shall have in his employ a Welding Supervisor who has completed a minimum of 1,000 ft of pipe joining work using the type of equipment proposed for use in this work. The Welding Supervisor shall be on site at all times during pipe line installation, and shall provide direct supervision over other employees.

1.06 WARRANTY

A. The pipe and fittings shall be warranted, on a pro-rata basis, against manufacturer's defects for a period of five (5) years from the date of pipe installation. The installation shall be warranted against defects in workmanship for a period of one (1) year from the date of completion of the leachate collection piping system.

PART 2. PRODUCTS

2.01 MATERIALS

A. Pipe

1. Pipe material shall be High Density Polyethylene (HDPE) PE 3408, according to ASTM F412, with a cell class designation of 345464C, according to ASTM D3350. Iron pipe size (IPS) and standard dimension ratio (SDR) shall be as indicated in the plans.
2. Size and spacing of holes in perforated pipe shall be as indicated in the plans.

B. Fittings

1. Fittings shall be made of the same material, and shall have a pressure rating no less than 160 psi. Butt fusion, socket, or electrofusion fittings, according to ASTM D3261, ASTM D2683, and ASTM F1055, respectively, are acceptable.

2.02 EQUIPMENT

A. Butt Fusion Machine

The butt fusion machine shall include the following features:

1. Facer with rotating planer block design.
2. Heater faces coated by the manufacturer to prevent molten plastic from adhering to the heater face.
3. Hydraulic-operated jaws suitable for use with the pipe sizes indicated in the plans.

B. Socket Fusion Equipment

Socket fusion heating tools and depth gauges shall be of the same manufacturer, unless they are all marked F1056, indicating compliance with ASTM F1056.

C. All equipment shall conform to any requirements specified in the pipe and socket manufacturer's installation instructions, and shall be approved by the Owner's Representative.

PART 3. EXECUTION

3.01 MATERIAL DELIVERY, STORAGE, AND HANDLING

A. HDPE pipe and fittings shall be packaged and shipped by appropriate means to prevent damage to the material and to facilitate off-loading. The Owner will provide an on-site storage site. Storage site requirements (size and preferred location) shall be submitted with the bid documents.

B. Storage and handling shall be according to manufacturer's recommendations.

3.02 BASE PREPARATION

All HDPE piping shall be installed on a layer of coarse aggregate placed by the Contractor in accordance with the plans. The grade of the coarse aggregate base shall be verified before installing the piping.

3.03 INSTALLATION

All pipe and fittings shall be installed according to the manufacturer's recommendations. Removal of weld beads is not required. Contractor shall place coarse aggregate along the pipe to provide lateral stability. Welds shall not be obscured until they have been approved by the Owner's Representative, the top of pipe shall not be covered until the Construction Quality Assurance (CQA) survey has been completed to verify conformance with specified tolerances.

3.04 INSPECTIONS

A. The Owner's Representative shall shall be visually inspect pipe materials to verify that each pipe material is properly stamped (by the manufacturer) for ASTM acceptance before installation. Defective or damaged materials shall be removed from the site.

B. Each weld and connection shall be visually inspected by the Owner's Representative. Defective welds shall be repaired as directed by the Owner's Representative and according to manufacturer's recommendations. Welds and connections shall not be covered until they have been approved by the Owner's Representative.

3.05 TOLERANCES

A. HDPE piping shall be located within 0.5 ft. of plan location, and elevation shall be within 0.1 ft. of plan elevation with no adverse slopes.

END OF SECTION 02936

PART 1. GENERAL

1.01 DESCRIPTION

A. This section includes manufacturing, furnishing, and installing High Density Polyethylene (HDPE) Geomembranes for the Gypsum Management Facility and the Gypsum Management Facility Recycle Pond.

B. The work includes furnishing all equipment and materials and providing all labor, supervision, administration and management necessary to perform the work as shown on the plans.

1.02 RELATED SECTIONS

A. The following sections contain items which are related to the work in this section:

1. 02373 – Geotextiles
2. 02376 – Geosynthetic Clay Liner

1.03 REFERENCES

A. The following references, or cited portions thereof, govern the work:

1. American Society for Testing and Materials (ASTM):

a. D 638, Standard Test Method for Tensile Properties of Plastics.
b. D 751, Standard Test Methods for Coated Fabrics.
c. D 792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
d. D 1004, Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
e. D 1204, Standard Test Method for Linear Dimensional Changes of Non Rigid Thermoplastic Sheeting or Film at Elevated Temperature.
f. D 1238, Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
g. D 1505, Standard Test Method for Density of Plastics by Density-Gradient Technique.
h. D 1603, Standard Test Method for Carbon Black in Olefin Plastics.
i. D 3895, Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis.
j. D 4218, Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.

k. D 4437, Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
l. D 4833, Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
m. D 5199, Standard Test Method for Measuring Nominal Thickness of Smooth Geomembranes.
n. D 5397, Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefins using Notched Constant Tensile Load Test.
o. D 5596, Standard Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds.
p. D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
q. D 5721, Practice for Air-Oven Aging of Polyolefin Geomembranes.
r. D 5820, Test Method for Air Testing.
s. D 5885, Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry.
t. D 5994, Standard Test Method for Measuring Nominal Thickness of Textured Geomembranes
u. D 6365, Standard Practice for the Nondestructive Testing of Geomembrane Seams using The Spark Test

2. Geosynthetic Research Institute (GRI):

a. GRI GM 6, Pressurized Air Channel Test for Dual Seamed Geomembranes
b. GRI GM 9, Cold Weather Seaming of Geomembranes
c. GRI GM 10, Specification for Stress Crack Resistance of HDPE Geomembrane Sheet
d. GRI GM 13, Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
e. GRI GM 14, Test Frequencies for Destructive SeamTesting

1.04 SUBMITTALS

A. Submit the following to the Engineer or Owner, for review and approval, within a reasonable time so as to expedite shipment or installation of the Geomembrane:

1. Documentation of manufacturer's qualifications as specified in subsection 1.05A of this Section.
2. Manufacturer's Quality Control program manual or descriptive documentation.
3. A material properties sheet, including at a minimum all properties specified in GRI GM 13, including test methods used.
4. Sample of the material.

5. Documentation of Installer's qualifications, as specified below and in subsection 1.05B of this Section.
   a. Submit a list of at least ten completed facilities. For each name and type of facility; its location; the date of installation; number of contact at the facility; type and thickness of geomembrane and; surface area of the installed geomembrane.
   b. Submit resumes or qualifications of the Installation Supervisor, Master Seamer and Technicians to be assigned to this project.
   c. Quality Control Program.
6. Example Material Warranty and Liner Installation Warranty complying with subsections 1.07 and 1.08 of this Section.
7. Resin Supplier's name, resin production plant identification, resin brand name and number, production date of the resin, resin Manufacturer's quality control certificates, and certification that the properties of the resin meet the requirements

B. Shop Drawings

1. Submit copies of shop drawings for engineer's approval within a reasonable time so as not to delay the start of geomembrane installation. Shop drawings shall show the proposed panel layout identifying seams and details. Seams should generally follow direction of the slope. Butt seams or roll-end seams should not occur on a slope unless approved by the Owner's Representative. Butt seams on a slope, if allowed, should be staggered.
2. Placement of geomembrane will not be allowed to proceed until Owner's Representative has received and approved the shop drawings.

C. Additional Submittals (In-Progress and at Completion)

1. Manufacturer's warranty (refer to subsection 1.08).
2. Geomembrane installation warranty (refer to subsection 1.09).
3. Daily written acceptance of subgrade surface (refer to subsection 3.01.C).
4. Low-temperature seaming procedures if applicable (refer to subsection 3.03.A)
5. Prequalification test seam samples (refer to subsection 3.05.A.6).
6. Field seam non-destructive test results (refer to subsection 3.05.B.1).
7. Field seam destructive test results (refer to subsection 3.05.C.6).
8. Daily field installation reports (refer to subsection 3.05.G).
9. Installation record drawing, as discussed in subsection 3.05.G).

1.05 QUALITY CONTOL

A. Manufacturer's Qualifications:

The manufacturer of geomembrane of the type specified or similar product shall have at least five years experience in the manufacture of such geomembrane. In addition, the geomembrane manufacturer shall have manufactured at least

10,000,000 sq. ft. of the specified type of geomembrane or similar product during the last five years.

B. Installer's Qualifications:

1 The Geomembrane Installer shall be the Manufacturer, approved Manufacturer's Installer or a contractor approved by the Owner's Representative to install the geomembrane.

2 The Geomembrane Installer shall have at least three years experience in the installation of the specified geomembrane or similar. The Geomembrane Installer shall have installed at least 10 projects involving a total of 5,000,000 sq. ft. of the specified type of geomembrane or similar during the last three years.

3 Installation shall be performed under the direction of a field Installation Supervisor who shall be responsible throughout the geomembrane installation, for geomembrane panel layout, seaming, patching, testing, repairs, and all other activities of the Geomembrane Installer. The Field Installation Supervisor shall have installed or supervised the installation and seaming of a minimum of 10 projects involving a total of 5,000,000 sq. ft. of geomembrane of the type specified or similar product.

4 Seaming shall be performed under the direction of a Master Seamer (who may also be the Field Installation Supervisor or Crew Foreman) who has seamed a minimum of 3,000,000 sq. ft. of geomembrane of the type specified or similar product, using the same type of seaming apparatus to be used in the current project. The Field Installation Supervisor and/or Master Seamer shall be present whenever seaming, patching, other welding operations, and testing is performed.

5 All seaming, patching, other welding operations, and testing shall be performed by qualified technicians employed by the Geomembrane Installer.

1.06 DELIVERY, STORAGE AND HANDLING

A. Each roll of geomembrane delivered to the site shall be labeled by the manufacturer. The label shall be firmly affixed and shall clearly state the manufacturer's name, product identification, material thickness, roll number, roll dimensions and roll weight.

B. Geomembrane shall be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.

C. Rolls shall be stored away from high traffic areas. Continuously and uniformly support rolls on a smooth, level prepared surface.

D. Rolls shall not be stacked more than three high.

1.07 PROJECT CONDITIONS

Geomembrane shall not be installed in the presence of standing water, while precipitation is occurring, during excessive winds, or when material temperatures are outside the limits specified in Section 3.03.

1.08 MATERIAL WARRANTY

As required by specification, or as required in GRI GM 13 (attachment A)

1.09 GEOMEMBRANE INSTALLATION WARRANTY

The Geomembrane Installer shall guarantee the geomembrane installation against defects in the installation and workmanship for 1 year commencing with the date of final acceptance.

1.10 GEOMEMBRANE PRE-CONSTRUCTION MEETING

A. Geomembrane Pre-Construction Meeting shall be held at the site prior to installation of the geomembrane. At a minimum, the meeting shall be attended by the Geomembrane Installer, Owner, Owner's representative (Engineer and/or CQA Firm), and the General Contractor.

B. Topics for this meeting shall include:

1. Responsibilities of each party.
2. Lines of authority and communication. Resolution of any project document ambiguity.
3. Methods for documenting, reporting and distributing documents and reports.
4. Procedures for packaging and storing archive samples.
5. Review of time schedule for all installation and testing.
6. Review of panel layout and numbering systems for panels and seams including details for marking on geomembrane.
7. Procedures and responsibilities for preparation and submission of as-built panel and seam drawings.
8. Temperature and weather limitations. Installation procedures for adverse weather conditions. Defining acceptable subgrade, geomembrane, or ambient moisture and temperature conditions for working during liner installation.
9. Subgrade conditions, dewatering responsibilities and subgrade maintenance plan.
10. Deployment techniques including allowable subgrade for the geomembrane.
11. Plan for controlling expansion/contraction and wrinkling of the geomembrane.
12. Covering of the geomembrane and cover soil placement.
13. Measurement and payment schedules.
14. Health and safety.

C. The meeting shall be documented by the Owner's Representative and minutes shall be transmitted to all parties.

PART 2. PRODUCTS

2.01 SOURCE QUALITY CONTROL

Manufacturing Quality Control

A. The test methods and frequencies used by the manufacturer for quality control/quality assurance of the above geomembrane prior to delivery, shall be in accordance with GRI GM 13, or modified as required for project specific conditions.

B. The manufacturer's geomembrane quality control certifications, including results of quality control testing of the products, as specified in subsection 2.01.C of this Section, must be supplied to the Owner's Representative. The certification shall be signed by a responsible party employed by the manufacturer, such as the QA/QC Manager, Production Manager, or Technical Services Manager. Certifications shall include lot and roll numbers and corresponding shipping information.

C. The Manufacturer will provide Certification that the geomembrane and welding rod supplied for the project have the same base resin and material properties.

2.02 GEOMEMBRANE

A. The geomembrane shall consist of new, first quality products designed and manufactured specifically for the purpose of this work which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes. The geomembrane rolls shall be seamless, high density polyethylene (HDPE- Density >0.94g/cm) containing no plasticizers, fillers or extenders and shall be free of holes, blisters or contaminants, and leak free verified by 100% in line spark or equivalent testing. The geomembrane shall be supplied as a continuous sheet with no factory seams in rolls. The geomembrane will meet the property requirements as shown in Table A. (GRI GM 13)

B. Material shall be reviewed for conformance to the project specifications by the Owner's Representative

C. The geomembrane seams shall meet the property requirements as shown in Table 2, (Attachment B).

PART 3. EXECUTION

3.01 SUBGRADE PREPARATION

A. Geomembrane installed over geosynthetic clay liner (GCL).

The area of GCL to be covered with geomembrane shall be jointly inspected daily with the Owner's Representative before commencing geomembrane installation for the day, and the condition of the GCL shall be continuously observed as geomembrane installation progresses. Rocks, stones, sticks, sharp objects and debris of any kind shall be removed from the surface of the GCL. The Owner's Representative shall be notified of any discontinuities, premature hydration, or otherwise defective GCL. Geomembrane shall not be placed over suspect areas until they have been repaired to the satisfaction of the Owner's Representative. The Installation Supervisor shall certify daily in writing that the GCL surface was acceptable at the time of geomembrane installation.

B. Geomembrane installed over cushion dirt.

The area of cushion dirt to be covered with geomembrane shall be prepared in accordance with the Section 02200 – Earthwork. The surface shall be smooth and free of ruts and holes, rocks, stones, sticks, sharp objects and debris of any kind.

C. The Geomembrane installer shall provide daily written acceptance for the surface to be covered by the geomembrane in that day's operations. The surface shall be maintained in a manner, during geomembrane installation, to ensure subgrade suitability.

D. All subgrade damaged by construction equipment and deemed unsuitable by the Owner's Representative for geomembrane deployment shall be repaired prior to placement of the geomembrane. All repairs shall be reviewed by the Owner's Representative and approved by the Geomembrane Installer. This damage, repair, and the responsibilities of the contractor and Geomembrane Installer shall be defined in the preconstruction meeting.

3.02 GEOMEMBRANE PLACEMENT

A. No geomembrane shall be deployed until the applicable certifications and quality control certificates listed in subsection 1.04 of this Section are submitted to and approved by the Owner's Representative. Should geomembrane material be deployed prior to approval by the Owner's Representative it will be at the sole risk of the Geomembrane Installer and/or Contractor. If the material does not meet project specifications it shall be removed from the work area at no cost to the owner.

B. The geomembrane shall be installed to the limits shown on the project drawings and essentially as shown on approved panel layout drawings.

C. No geomembrane material shall be unrolled and deployed if the material temperatures are lower than 0 degrees C (32 degrees F). Temperature limitations should be defined in the preconstruction meeting. Typically, only the quantity of geomembrane that will be anchored and seamed together in one day should be deployed.

D. No vehicular traffic shall travel on the geomembrane other than an approved low ground pressure All Terrain Vehicle or equivalent.

E. Sand bags or equivalent ballast shall be used as necessary to temporarily hold the geomembrane material in position under the foreseeable and reasonably - expected wind conditions. Sand bag material shall be sufficiently close- knit to prevent soil fines from working through the bags and discharging on the geomembrane.

F. Geomembrane placement shall not be done if moisture prevents proper subgrade preparation, panel placement, or panel seaming. Moisture limitations should be defined in the preconstruction meeting.

G. Damaged panels or portions of the damaged panels which have been rejected shall be marked and their removal from the work area recorded.

H. The geomembrane shall not be allowed to "bridge over" voids or low areas in the subgrade. In these areas, the subgrade shall be prepared to allow the geomembrane to rest in intimate contact with the subgrade.

I. Wrinkles caused by panel placement or thermal expansion should be minimized in accordance with section 1.10 B. 11.

J. Considerations on Site Geometry: In general, seams shall be oriented parallel to the line of the maximum slope. In corners and odd shaped geometric locations, the total length of field seams shall be minimized. Seams shall not be located at low points in the subgrade.

K. Overlapping: The panels shall be overlapped prior to seaming to whatever extent is necessary to effect a good weld and allow for proper testing. In no case shall this overlap be less than 75mm (3 in.).

3.03 SEAMING PROCEDURES

A. Cold weather installations should follow guidelines as outlined in GRI GM9.

B. No geomembrane material shall be seamed when liner temperatures are less than 0 degrees C (32 degrees F).

C. No geomembrane material shall be seamed when the sheet temperature is above 75 degrees C (170 degrees F) as measured by an infrared thermometer or surface thermocouple.

D. Seaming shall primarily be performed using automatic fusion welding equipment and techniques. Extrusion welding shall be used where fusion welding is not possible such as at pipe penetrations, patches, repairs and short (less than a roll width) runs of seams.

E. Fishmouths or excessive wrinkles at the seam overlaps, shall be minimized and when necessary cut along the ridge of the wrinkles back into the panel so as to effect a flat overlap. The cut shall be terminated with a keyhole cut (nominal 10 mm (1/2 in) diameter hole) so as to minimize crack/tear propagation. The overlay shall subsequently be seamed. The key hole cut shall be patched with an oval or round patch of the same base geomembrane material extending a minimum of 150 mm (6 in.) beyond the cut in all directions.

3.04 PIPE AND STRUCTURE PENETRATION SEALING SYSTEM

A. Provide penetration sealing system as shown in the Project Drawings.

B. Penetrations shall be constructed from the base geomembrane material, flat stock, prefabricated boots and accessories as shown on the Project Drawings. The pre-fabricated or field fabricated assembly shall be field welded to the geomembrane as shown on the Project Drawings so as to prevent leakage. This assembly shall be tested as outlined in section 3.05.B. Alternatively, where field non destructive testing can not be performed, attachments will be field spark tested by standard holiday leak detectors in accordance with ASTM 6365 Spark testing should be done in areas where both air pressure testing and vacuum testing are not possible.

1. Equipment for Spark testing shall be comprised of but not limited to: A

hand held holiday spark tester and conductive wand that generates a high voltage.

2. The testing activities shall be performed by the Geomembrane Installer by placing an electrically conductive tape or wire beneath the seam prior to welding. A trial seam containing a non welded segment shall be subject to a calibration test to ensure that such a defect (non welded segment) will be identified under the planned machine settings and procedures. Upon completion of the weld, enable the spark tester and hold approximately 25mm (1 in) above the weld moving slowly over the entire length of the weld in accordance with ASTM 6365. If there is no spark the weld is considered to be leak free.
3. A spark indicates a hole in the seam. The faulty area shall be located, repaired and retested by the Geomembrane Installer.
4. Care should be taken if flammable gases are present in the area to be tested.

3.05 FIELD QUALITY CONTROL

The Owner's Representative shall be notified prior to all pre qualification and production welding and testing, or as agreed upon in the pre construction meeting.

A. Prequalification Test Seams

1. Test seams shall be prepared and tested by the Geomembrane Installer to verify that seaming parameters (speed, temperature and pressure of welding equipment) are adequate.
2. Test seams shall be made by each welding technician and tested in accordance with ASTM D 4437 at the beginning of each seaming period. Test seaming shall be performed under the same conditions and with the same equipment and operator combination as production seaming. The test seam shall be approximately 3.3 meters (10 feet) long for fusion welding and 1 meter (3 feet) long for extrusion welding with the seam centered lengthwise. At a minimum, tests seams should be made by each technician 1 time every 4–6 hours; additional tests may be required with changes in environmental conditions.
3. Two 25 mm (1 in) wide specimens shall be die-cut by the Geomembrane Installer from each end of the test seam. These specimens shall be tested by the Geomembrane Installer using a field tensiometer testing both tracks for peel strength and also for shear strength. Each specimen shall fail in the parent material and not in the weld, "Film Tear Bond"(F.T.D. failure). Seam separation equal to or greater than 10% of the track width shall be considered a failing test.
4. The minimum acceptable seam strength values to be obtained for all specimens tested are listed in Subsection 3.05.C.4 of this Section. All four specimens shall pass for the test seam to be a passing seam.
5. If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not used for production seaming until the deficiencies are

corrected and a successful test seam can be produced.

6. A sample from each test seam shall be labeled. The label shall indicate the date, geomembrane temperature, number of the seaming unit, technician performing the test seam and pass or fail description. The sample shall then be given to the Owner's Representative for archiving.

B. Field Seam Non-destructive Testing

1. All field seams shall be non-destructively tested by the Geomembrane Installer over the full seam length before the seams are covered. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester and outcome of all non-destructive testing shall be recorded and submitted to the Owner's Representative.
2. Testing should be done as the seaming work progresses, not at the completion of all field seaming. All defects found during testing shall be numbered and marked immediately after detection. All defects found should be repaired, retested and remarked to indicate acceptable completion of the repair.
3. Non-destructive testing shall be performed using vacuum box, air pressure or spark testing equipment.
4. Non-destructive tests shall be performed by experienced technicians familiar with the specified test methods. The Geomembrane Installer shall demonstrate to the Owner's Representative all test methods to verify the test procedures are valid.
5. Extrusion seams shall be vacuum box tested by the Geomembrane Installer in accordance with ASTM D 4437 and ASTM D 5641 with the following equipment and procedures:
   a. Equipment for testing extrusion seams shall be comprised of but not limited to: a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the base, port hole or valve assembly and a vacuum gauge; a vacuum pump assembly equipped with a pressure controller and pipe connections; a rubber pressure/vacuum hose with fittings and connections; a plastic bucket; wide paint brush or mop; and a soapy solution.
   b. The vacuum pump shall be charged and the tank pressure adjusted to approximately 35 kPa (5 psig).
   c. The Geomembrane Installer shall create a leak tight seal between the gasket and geomembrane interface by wetting a strip of geomembrane approximately 0.3m (12 in) by 1.2m (48 in) (length and width of box) with a soapy solution, placing the box over the wetted area, and then compressing the box against the geomembrane. The Geomembrane Installer shall then close the bleed valve, open the vacuum valve, maintain initial pressure of approximately 35 kPa (5 psig) for approximately 5 seconds. The geomembrane should be continuously examined through the viewing window for the presence of soap bubbles, indicating a leak. If no bubbles appear after 5 seconds, the area shall be

considered leak free. The box shall be depressurized and moved over the next adjoining area with an appropriate overlap and the process repeated.

d. All areas where soap bubbles appear shall be marked, repaired and then retested.

e. At locations where seams cannot be non destructively tested, such as pipe penetrations, alternate nondestructive spark testing (as outlined in section 3.04.B) or equivalent should be substituted.

f. All seams that are vacuum tested shall be marked with the date tested, the name of the technician performing the test and the results of the test.

6. Double Fusion seams with an enclosed channel shall be air pressure tested by the Geomembrane Installer in accordance with ASTM D 5820 and ASTM D 4437 and the following equipment and procedures:

a. Equipment for testing double fusion seams shall be comprised of but not limited to: an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of 210 kPa (30 psig), mounted on a cushion to protect the geomembrane; and a manometer equipped with a sharp hollow needle or other approved pressure feed device.

b. The Testing activities shall be performed by the Geomembrane Installer. Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld. The air pump shall be adjusted to a pressure of 210 kPa (30 psig), and the valve closed,. Allow 2 minutes for the injected air to come to equilibrium in the channel, and sustain pressure for 5 minutes. If pressure loss does not exceed 28 kPa (4 psig) after this five minute period the seam shall be considered leak tight. Release pressure from the opposite end verifying pressure drop on needle to ensure testing of the entire seam. The needle or other approved pressure feed device shall be removed and the feed hole sealed.

c. If loss of pressure exceeds 28 kPa (4 psig) during the testing period or pressure does not stabilize, the faulty area shall be located, repaired and retested by the Geomembrane Installer.

d. Results of the pressure testing shall be recorded on the liner at the seam tested and on a pressure testing record.

C. Destructive Field Seam Testing

1. One destructive test sample per 150 linear m (500 linear ft) seam length or another predetermined length in accordance with GRI GM 14 shall be taken by the Geomembrane Installer from a location specified by the Owner's Representative. The Geomembrane Installer shall not be informed in advance of the sample location. In order to obtain test results prior to completion of geomembrane installation, samples shall be cut by the Geomembrane Installer as directed by the Owner's Representative as seaming progresses.

2. All field samples shall be marked with their sample number and seam number. The sample number, date, time, location, and seam number shall be recorded. The Geomembrane Installer shall repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum box tested or spark tested. If a patch cannot be permanently installed over the test location the same day of sample collection, a temporary patch shall be tack welded or hot air welded over the opening until a permanent patch can be affixed.
3. The destructive sample size shall be 300 mm (12 in) wide by 1 m (36 in) long with the seam centered lengthwise. The sample shall be cut into three equal sections and distributed as follows: one section given to the Owner's Representative as an archive sample; one section given to the Owner's Representative for laboratory testing as specified in paragraph 5 below; and one section retained by the Geomembrane Installer for field testing as specified in paragraph 4 below.
4. For field testing, the Geomembrane Installer shall cut 10 identical 25 mm (1 in) wide replicate specimens from his sample. The Geomembrane Installer shall test five specimens for seam shear strength and five for peel strength. Peel tests will be performed on both inside and outside weld tracks. To be acceptable, 4 of 5 test specimens must pass the stated criteria in section 2.02 with less than 10% separation. If 4 of 5 specimens pass, the sample qualifies for testing by the testing laboratory if required.
5. If independent seam testing is required by the specifications it shall be conducted in accordance with ASTM 5820 or ASTM D4437 or GRI GM 6.
6. Reports of the results of examinations and testing shall be prepared and submitted to the Owner's Representative.
7. For field seams, if a laboratory test fails, that shall be considered as an indicator of the possible inadequacy of the entire seamed length corresponding to the test sample. Additional destructive test portions shall then be taken by the Geomembrane Installer at locations indicated by the Engineer, typically 3 m (10 ft) on either side of the failed sample and laboratory seem tests shall be performed. Passing tests shall be an indicator of adequate seams. Failing tests shall be an indicator of non-adequate seams and all seams represented by the destructive test location shall be repaired with a cap-strip extrusion welded to all sides of the capped area. All cap-strip seams shall be non-destructively vacuum box tested until adequacy of the seams is achieved. Cap strip seams exceeding 50 M in length (150 FT) shall be destructively tested.

D. Identification of Defects

1. Panels and seams shall be inspected by the Installer and Owner's Representative during and after panel deployment to identify all defects, including holes, blisters, undispersed raw materials and signs of contamination by foreign matter.

E. Evaluation of Defects: Each suspect location on the liner (both in geomembrane seam and non-seam areas) shall be non-destructively tested using one of the methods described in Section 3.05.B. Each location which fails non-destructive testing shall be marked, numbered, measured and posted on the daily "installation" drawings and subsequently repaired.

1. If a destructive sample fails the field or laboratory test, the Geomembrane Installer shall repair the seam between the two nearest passed locations on both sides of the failed destructive sample location.
2. Defective seams, tears or holes shall be repaired by reseaming or applying a extrusion welded cap strip.
3. Reseaming may consist of either:
   a. Removing the defective weld area and rewelding the parent material using the original welding equipment; or
   b. Reseaming by extrusion welding along the overlap at the outside seam edge left by the fusion welding process.
4. Blisters, larger holes, and contamination by foreign matter shall be repaired by patches and/or extrusion weld beads as required. Each patch shall extend a minimum of 150 mm (6 in) beyond all edges of the defects.
5. All repairs shall be measured, located and recorded.

F. Verification of Repairs on Seams: Each repair shall be non-destructively tested using either vacuum box or spark testing methods. Tests which pass the non-destructive test shall be taken as an indication of a successful repair. Failed tests shall be reseamed and retested until a passing test results. The number, date, location, technician and test outcome of each patch shall be recorded.

G. Daily Field Installation Reports: At the beginning of each day's work, the Installer shall provide the Engineer with daily reports for all work accomplished on the previous work day. Reports shall include the following:
1. Total amount and location of geomembrane placed;
2. Total length and location of seams completed, name of technicians doing seaming and welding unit numbers;
3. Drawings of the previous day's installed geomembrane showing panel numbers, seam numbers and locations of non-destructive and destructive testing;
4. Results of pre-qualification test seams;
5. Results of non-destructive testing; and
6. Results of vacuum testing of repairs.

H. Destructive test results shall be reported prior to covering of liner or within 48 hours.

3.06 LINER ACCEPTANCE

A. Geomembrane liner will be accepted by the Owner's Representative when:

1. The entire installation is finished or an agreed upon subsection of the installation is finished;

2. All Installer's QC documentation is completed and submitted to the owner
3. Verification of the adequacy of all field seams and repairs and associated geomembrane testing is complete.

3.07 ANCHOR TRENCH

A. Construct as specified on the project drawings.

3.08 DISPOSAL OF SCRAP MATERIALS

A. On completion of installation, the Geomembrane Installer shall dispose of all trash and scrap material in a location approved by the Owner, remove equipment used in connection with the work herein, and shall leave the premises in a neat acceptable manner. No scrap material shall be allowed to remain on the geomembrane surface.

PART 4. GRI GM13 SPECIFICATIONS

Geosynthetics Research Institute (GRI) Test Method GM13 – "Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes", Revision 8, Dated July 10, 2006.

ATTACHMENT A:

Minimum Average Weld Properties for Smooth and Textured HDPE Geomembranes (English units)								
Property	**Test Method**	**30 mil**	**40 mil**	**50 mil**	**60 mil**	**80 mil**	**100 mil**	**120 mil**
Peel strength (fusion & extrusion) lb/in.	ASTM 4437	39	52	65	78	104	130	156
Shear strength (fusion & extrusion) lb/in.	ASTM 4437	60	80	100	120	160	200	239

END OF SECTION 02800

PART 1. GENERAL

1.01 DESCRIPTION

This section pertains to seeding and placing mulch or erosion control blanket over seeded areas.

1.02 RELATED SECTIONS

A. Specified elsewhere:

1. 02200 - Earthwork

1.03 REFERENCES

The following reference or cited portions thereof, current at date of bidding documents unless otherwise specified, governs the work.

A. Illinois Department of Transportation (IDOT): Standard Specifications for Road and Bridge Construction, adopted January 1, 2007.

1.04 SPECIFICATIONS

A. Work shall conform to the applicable requirements of Sections 250 and 251 of Standard Specifications for Road and Bridge Construction and to the requirements hereinafter specified.

B. Exceptions: All references in the IDOT specifications to methods of measurement and payment shall not apply.

1.05 WARRANTY

A. Warranty for one (1) year plus one growing season from date of substantial completion shall be provided.

PART 2. PRODUCTS

2.01 MATERIALS

A. Seed: Seed shall conform to Article 1081.04 of the IDOT Standard Specifications. The composition of the Illinois Power Generating Company hay seeding mix shall be as follows:

Seed Type	Pounds/Acre
Vernal Alfalfa	12
Wrangler Alfalfa	8
Medium Red Clover	6
Timothy	4

B. Mulch Material and Erosion Control Blanket: Mulch material shall conform to Article 1081.06 and the excelsior blanket/knitted straw mat shall conform to Article 1081.10 of the IDOT Standard Specifications.

C. Fertilizer and agricultural ground limestone will not be permitted.

PART 3. EXECUTION

3.01 CONSTRUCTION

A. Seed bed preparation and seeding methods shall conform to Section 250 of the IDOT Specifications. Seeding of areas disturbed by construction activities after September 30, 2008 may be deferred until Spring 2009.

B. Seed shall be applied to the perimeter berm ditch, to disturbed portions of the perimeter berm, and to all disturbed earth surfaces outside of the existing perimeter berm. IDOT seeding mixture 7 shall be used on stockpiles. IDOT seeding mixture 1A shall be used on the gypsum stack perimeter earthen berm, the recycle pond dam embankment and on slopes that are 4H:1V or steeper. The hay seed mix shall be used on slopes flatter that 4H:1V.

C. Application rates for IDOT seed mixtures shall be as specified in Section 250 of the IDOT Specifications. The application rate for the Illinois Power Generating Company’s seed mix shall be as specified in the Illinois Power Generating Company’s hay seeding mix.

D. Seeded areas shall be mulched in accordance with Article 251.03. The Contractor may use either Method 2 or Method 3.

3.02 MAINTENANCE OF COMPLETED WORK

A. All areas seeded by the Contractor shall be maintained by the Contractor during the period between completion of such work and final completion and acceptance of the Contractor's work by the Owner. This maintenance shall be such that the completed work, at time of acceptance, complies in all respects with the requirements herein specified.

B. The areas seeded will be required to germinate. If the seed does not germinate, the Contractor will be required to regrade and reseed at no additional cost.

END OF SECTION 02936

PART 1. GENERAL

1.01 WORK INCLUDES

A. The complete installation of the formwork for cast-in-place concrete, with shoring, bracing and anchorage, openings for other work, form accessories, form stripping.

1.02 RELATED SECTIONS

A. Section 03200 - Concrete Reinforcement.

B. Section 03300 - Cast-In-Place Concrete.

C. Section 03400 – Concrete Embedment Liner.

1.03 REFERENCES

A. ACI 347 - Recommended Practice For Concrete Formwork.

B. ACI 301 - Specifications For Structural Concrete For Buildings.

1.04 DESIGN REQUIREMENTS

A. Design, engineer and construct formwork, shoring and bracing to conform to design and code requirements; resultant concrete to conform to required shape, line and dimension.

1.05 QUALITY ASSURANCE

A. Perform Work in accordance with ACI 347 and 301.

1.06 REGULATORY REQUIREMENTS

A. Conform to applicable code for design, fabrication, erection and removal of formwork.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store off ground in ventilated and protected manner to prevent deterioration from moisture.

1.08 COORDINATION

A. Coordinate this Section with other Sections of work which require attachment of components of formwork.

B. If formwork is placed which results in insufficient concrete cover over reinforcement, request instructions from Owner's Representative before proceeding.

PART 2. PRODUCTS

2.01 WOOD FORM MATERIALS

A. Softwood Plywood: 3/4 in. PS 1-83 "B-B" (concrete form) plywood, Class I, exterior grade or better, mill-oiled and edge sealed with each piece bearing legible inspection trademark.

B. Architectural Plywood: 3/4 in. PS 1-83 "B-B" plyform, Class I, with High Density smooth overlay, 1 surface, edge sealed with each piece bearing legible inspection trademark.

2.02 MANUFACTURERS - PREFABRICATED FORMS

A. Weyerhauser Concrete Form.

B. Georgia Pacific, G-P Exterior Soft Wood Plywood Product.

C. Plywood and Door Corporation's Finn-Form.

2.03 PREFABRICATED FORMS

A. Preformed Steel Forms: Minimum 16 gage matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.

B. Glass Fiber Fabric Reinforced Plastic Forms: Matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished concrete surfaces.

2.04 FORMWORK ACCESSORIES

A. Form Ties: Snap-off type, galvanized metal, adjustable length, 1 in. back break dimension, free of defects that could leave holes larger than 1 in. in concrete surface; Dayton-Sure Grip snap-in-form ties, as manufactured by Dayton Superior

Corp., Symons Ties as manufactured by Symons Corporation, Snap-Tys as manufactured by Richmond Corporation. Ties shall be removed after forms are removed, and holes filled with mortar that matches the adjacent surfaces.

B. Form Release Agent: Colorless mineral oil which will not stain concrete, or absorb moisture; by Magic Kote manufactured by Symons Manufacturing Co., Form Coat manufactured by Concrete Services Co., Formcel manufactured by Lambert Corp.

C. Corners: Chamfered, wood strip type; 3/4 x 3/4 in. size on all exterior corners, 3 x 3 in. size where shown on the drawings; maximum possible lengths.

D. Nails, Spikes, Lag Bolts, Through Bolts, Anchorages: Sized as required, of sufficient strength and character to maintain formwork in place while placing concrete.

E. Concrete Embedment Liner, where required, shall be installed in accordance with Section 03400 – Concrete Embedment Liner.

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify lines, levels and centers before proceeding with formwork. Ensure that dimensions agree with drawings.

3.02 EARTH FORMS

A. Earth forms are not permitted, except for footings.

3.03 ERECTION - FORMWORK

A. Erect formwork, shoring and bracing to achieve design requirements, in accordance with requirements of ACI 301. Metal forms shall be installed in strict accordance with manufacturer's directions and specifications.

B. Provide bracing to ensure stability of formwork. Shore or strengthen formwork subject to overstressing by construction loads.

C. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores.

D. Align joints and make watertight. Keep form joints to a minimum.

E. Obtain approval before framing openings in structural members which are not indicated on drawings.

3.04 APPLICATION - FORM RELEASE AGENT

A. Apply form release agent on formwork in accordance with manufacturer's recommendations.

B. Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.

C. Do not apply form release agent where concrete surfaces will receive special finishes or applied coverings which are affected by agent.

3.05 INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Provide formed openings where required for items to be embedded in or passing through concrete work.

B. Locate and set in place items which will be cast directly into concrete.

C. Coordinate work of other Sections in forming and placing openings, slots, reglets, recesses, chases, sleeves, bolts, anchors, and other inserts.

D. Install accessories in accordance with manufacturer's instructions, straight, level, and plumb. Ensure items are not disturbed during concrete placement.

E. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.

F. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

3.06 FORM CLEANING

A. Clean and remove foreign matter within forms as erection proceeds.

B. Clean formed cavities of debris prior to placing concrete.

C. Flush with water or use compressed air to remove remaining foreign matter. Ensure that water and debris drain to exterior through clean-out ports.

D. During cold weather, remove ice and snow from within forms. Do not use de-icing salts or water to clean out forms. Use compressed air or other means to remove foreign matter.

3.07 FORMWORK TOLERANCES

A. Construct formwork to maintain tolerances required by ACI 301.

3.08 FIELD QUALITY CONTROL

A. Inspect erected formwork, shoring, and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and items are secure.

B. Do not reuse wood formwork more than three times for concrete surfaces to be exposed to view. Do no patch formwork.

3.09 FORM REMOVAL

A. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and imposed loads.

B. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finished concrete surfaces scheduled for exposure to view.

C. Store removed forms in manner that surfaces to be in contact with fresh concrete will not be damaged. Discard damaged forms.

END OF SECTION 03100

PART 1. GENERAL

1.01 WORK INCLUDES

A. The complete installation of the reinforcing steel bars and accessories for cast-in-place concrete.

1.02 RELATED SECTIONS

A. Section 03100 - Concrete Formwork.

B. Section 03300 - Cast-in-Place Concrete.

1.03 REFERENCES

A. ACI 301 - Structural Concrete for Buildings.

B. ACI 318 - Building Code Requirements For Reinforced Concrete.

C. ACI SP-66 - American Concrete Institute - Detailing Manual.

D. ASTM A615 - Deformed and Plain Billet Steel Bars for Concrete Reinforcement.

E. CRSI - Concrete Reinforcing Steel Institute Manual of Practice.

1.04 SUBMITTALS

A. Submit under provisions of Section 01010.

B. Shop Drawings: Indicate bar sizes, spacings, locations, and quantities of reinforcing steel, and bending and cutting schedules. Contract drawings shall not be reproduced as the basis for shop drawings.

C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

1.05 QUALITY ASSURANCE

A. Perform Work in accordance with CRSI Manual of Standard Practice.

B. Submit certified copies of mill test report of reinforcement materials analysis.

1.06 COORDINATION

A. Coordinate with placement of formwork, formed openings and other work.

PART 2. PRODUCTS

2.01 REINFORCEMENT

A. Reinforcing Steel: ASTM A615, 60 ksi yield grade; deformed billet steel bars.

2.02 ACCESSORY MATERIALS

A. Tie Wire: Minimum 16 gage, annealed steel wire, epoxy coated when used with epoxy-coated reinforcement.

B. Chairs, Bolsters, Bar Supports, Spacers: Sized and shaped for strength and support of reinforcement during concrete placement conditions.

C. Special Chairs, Bolsters, Bar Supports, Spacers Adjacent to Weather Exposed Concrete Surfaces: Plastic coated steel type; size and shape as required.

2.03 FABRICATION

A. Fabricate concrete reinforcing in accordance with CRSI Manual of Standard Practice and ACI SP-66.

B. Splice reinforcement on at locations indicated on drawings. Indicate location of splices on shop drawings.

PART 3. EXECUTION

3.01 PLACEMENT

A. Place, support and secure reinforcement against displacement. Do not deviate from required position. Clean reinforcement of foreign particles or coatings.

B. Accommodate placement of formed openings.

C. Conform to ACI 318 code for concrete cover over reinforcement.

3.02 FIELD QUALITY CONTROL

A. Contractor shall notify the Owner's Representative at least 24 hrs. in advance of concrete placement. Placement of reinforcing shall occur in such sequence that the Owner's Representative has sufficient time to inspect the correctness of the reinforcing within the placement area. The Owner's Representative retains the right to require necessary revisions be made before concrete is placed.

END OF SECTION 03200

PART 1. GENERAL

1.01 WORK INCLUDES

A. The complete installation of cast-in-place concrete structures, including joint sealants.

1.02 RELATED SECTIONS

A. Section 03100 - Concrete Formwork: Formwork and accessories.

B Section 03200 - Concrete Reinforcement.

C. Section 03400 – Concrete Embedment Liner

1.03 REFERENCES

A. ACI 301 – Structural Concrete for Buildings.

B. ACI 302 - Guide for Concrete Floor and Slab Construction.

C. ACI 304 - Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete.

D. ACI 305R - Hot Weather Concreting.

E. ACI 306R - Cold Weather Concreting.

F. ACI 308 - Standard Practice for Curing Concrete.

G. ACI 318 - Building Code Requirements for Reinforced Concrete.

H. ASTM C31 - Concrete Test Specimens.

I. ASTM C33 - Concrete Aggregates.

J. ASTM C94 - Ready-Mixed Concrete.

K. ASTM C150 - Portland Cement.

L. ASTM C260 - Air Entraining Admixtures for Concrete.

M. ASTM C494 - Chemical Admixtures for Concrete.

1.04 SUBMITTALS

A. Product Data: Provide data on joint devices, attachment accessories, admixtures.

1.05 QUALITY ASSURANCE

A. Perform Work in accordance with ACI 301.

B. Acquire cement and aggregate from same source for all work.

C. Conform to ACI 305R when concreting during hot weather.

D. Conform to ACI 306R when concreting during cold weather.

1.06 COORDINATION

A. Coordinate this Section with other Sections which require embedment of components in cast-in-place concrete.

1.07 PRODUCT DATA

A. Submit proposed mix design to Owner's Representative for review prior to commencement of work. Identify source and provide material certificates for cement, fine and coarse aggregates. Provide recent laboratory gradation for fine and coarse aggregates and mix design information in accordance with ACI 301.

B. Submit Construction joint plan.

PART 2. PRODUCTS

2.01 CONCRETE MATERIALS

A. Cement: ASTM C150, Type I - Normal Portland Type, Gray Color.

B. Fine and Coarse Aggregates: ASTM C33.

C. Water: Potable.

2.02 ADMIXTURES

A. Air Entrainment: ASTM C260.

B. Chemical: ASTM C494. Maximum 0.05% Chloride Ion Contents.

C. The use of calcium chloride in any concrete is not permitted.

2.03 ACCESSORIES

A. Non-Shrink Grout: Premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 2,400 psi in 48 hours and 7,000 psi in 28 days.

B. Curing Compound: Dress and Seal No. 18 by L&M Construction Chemicals, MB-429 by Master Builders, or Sikagard Cure/Hard by the Sika Corporation.

C. Epoxy Grouted Adhesive Anchors: Hilti, Red Head, Simpson, or Rawl.

2.04 CONCRETE MIX

A. Mix concrete in accordance with ACI 304. Deliver concrete in accordance with ASTM C94.

B. Select proportions for normal weight concrete in accordance with ACI 301.

C. Provide normal weight concrete of the following characteristics:

1. Compressive strength at 28 days: 4,000 psi.

2. Slump: 4 in. - A tolerance of up to 1 in. above the maximum shall be allowed for one batch in any five consecutive batches tested.

3. Water/cement ratios: 0.4 (max).

D. Use accelerating admixtures in cold weather only when approved by Owner's Representative. Use of admixtures will not relax cold weather placement requirements.

E. Use set-retarding admixtures during hot weather only when approved by Owner's Representative.

F. Water-reducing admixtures may be used in all concrete except footings and in strict compliance with the manufacturer's directions.

G. Add air-entraining agent to concrete mix for air content of 6% (± 1%).

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify requirements for concrete cover over reinforcement.

B. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not cause hardship in placing concrete.

3.02 PLACING CONCRETE

A. Place concrete in accordance with ACI 301.

B. Notify Owner's Representative minimum of 24 hours prior to commencement of operations.

C. Ensure reinforcement, inserts, and embedded parts are not disturbed during concrete placement.

D. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.

E. Place concrete continuously between predetermined expansion, control, and construction joints.

F. When air temperature is between 80°F and 90°F, reduce the mixing and delivery time specified in ASTM C94 from 1-1/2 hours to 75 minutes. When the air temperature is above 90°F, reduce the mixing and delivery time to 60 minutes.

G. Cold weather concreting. Comply with ACI 306 except as follows:

1. In freezing weather, provide suitable means for maintaining concrete temperature at a minimum of 70°F for three days, or 50°F for five days after placing.

2. Cooling of concrete to outside temperature: Not faster than 1° per hour for first day and 2° per hour thereafter until outside temperature is reached.

3. Maximum temperature of concrete produced with heated aggregated, heated water, or both, at any time during its production or transportation: 90°F.

4. Do not mix chemicals or other foreign materials in concrete to prevent freezing or to accelerate hardening of concrete, unless approved in writing by Owner's Representative.

H. Hot weather concreting. Comply with ACI 305R.

1. ACI recommendations shall be observed when any combination of high air temperature, low relative humidity and wind velocity tend to impair the quality of fresh or hardened concrete.

2. Retarding and water reducing admixtures shall be approved in writing for each concrete mix design prior to placement.

3.03 CONCRETE FINISHING

A. Provide exterior concrete formed surfaces to be left exposed with smooth rubbed finish in accord with ACI 301. All other formed surfaces shall have fins, projections and offsets removed.

B. Provide Class A tolerances to exterior concrete slabs according to ACI 301.

1. Broom finish all exterior slabs. Broom out all tool marks.

C. Pitch slabs to drain.

3.04 CURING AND PROTECTION

A. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.

B. Maintain concrete with minimal moisture loss at relatively constant temperature for a period necessary for hydration of cement and hardening of concrete in accordance with ACI 308.

C. Cure and protect finished concrete slabs in accordance with ACI 308.

3.05 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed in accordance with ACI 301 and under provisions of Section 01010, paragraph 8.0.

B. Testing firm will take cylinders, perform slump and air entrainment tests in accordance with ACI 301.

C. Provide free access to Work and cooperate with appointed firm.

D. Submit proposed concrete mix design to Owner's Representative firm for review 14 days prior to commencement of Work.

E. Testing frequency shall be as specified in Section 01010, paragraph 8, except that one additional test cylinder will be taken during cold weather concreting, cured on job site under same conditions as concrete it represents.

3.06 PATCHING

A. Defective Concrete: Concrete not conforming to required lines, details, dimensions, tolerances or specified requirements.

B. Repair or replacement of defective concrete will be determined by Owner's Representative and performed by the Contractor at no additional cost to the project.

C. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Owner's Representative for each individual area.

END OF SECTION 03300

PART 1. GENERAL

1.01 WORK INCLUDES

A. Specifications and guidelines for manufacturing and installing high-density polyethylene embedment liners.

1.02 RELATED SECTIONS

A. Section 03100 - Concrete Formwork.

B. Section 03300 - Cast-in-Place Concrete.

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
2. D 1603 Test Method for Carbon Black in Olefin Plastics
3. D 5199 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
4. D 5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
5. D 6693 Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
6. D 1204 Standard Test Method for Linear Dimensional Changes of Nongrid Thermoplastic Sheeting or Film at Elevated Temperature
7. D 696 Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C With a Vitreous Silica Dilatometer
8. D 746 Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
9. D 570 Standard Test Method for Water Absorption of Plastics
10. E 96 Standard Test Method for Water Vapor Transmission of Material

1.04 SUBMITTALS

A. All work for and in connection with the installation of the lining, field seaming and welding joints shall be completed in strict conformity with all applicable instructions and recommendations of the liner manufacturer.

B. Included with the shipment of liner, submit certified test reports that the liner and material are manufactured in accordance with standards specified herein.

1.05 QUALIFICATIONS

A. The HDPE liner specified in this section shall be furnished by a manufacturer who is fully experienced, reputable and qualified in the manufacturing of the materials. The manufacturer must at least 10 years of manufacturing experience.

B. Locking devices must be extruded to the sheet as a one step process.

C. Liner shall be GSE StudLiner as manufactured by GSE Lining Technology, Inc.

D. Liner shall be 8 feet in width.

E. Liner shall demonstrate a minimum pull-out strength of 14,000 psf.

1.06 COORDINATION

A. Coordinate with placement of formwork, formed openings and other work.

PART 2. PRODUCTS

2.01 ROLL DIMENSIONS

A. Embedment sheets shall be produced in rolls that are 8.0 ft (2.4 m) in width and a thickness range of 80 mils (2.0 mm) to 200 mils (5.0 mm) in thickness. Roll lengths vary according to thickness.

B. Locking studs of the same material as that of the liner shall be integrally extruded with the sheet. Stud spacing shall be on approximate 1.25 in (30 mm) centers, such that there are approximately 110 studs per square foot (1200 per square meter).

2.02 MATERIAL PROPERTIES

A. The material used in the embedment liner and in all welding strips shall be made from 97-98% virgin high density polyethylene and 1.5-3% carbon black or pigmentation for the purpose of an otherwise specified color.

B. Plasticizer shall not be added to the resin formulation.

C. Embedment sheet and welding strips shall be free of holes, pinholes, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.

D. The HDPE cap strips shall be made from HDPE, have good impact resistance and have an elongation sufficient to bridge up to 1/4 inch settling cracks.

E. Cap strips shall be approximately 4 inches wide or greater and shall be equivalent to that of the liner.

F. Material shall maintain a repairable state through it's lifecycle by methods approved and recommended by the manufacturer.

G. Embedment sheets shall have the following physical properties when tested in accordance with Table 1.

H. Raw resin shall have the following properties when tested in accordance with Table 2.

Table 1: Material Properties

Property	**Test Method**	**Nominal Value**				**Testing Frequency**
Thickness, mm (mil)	ASTM D 5199	2.00 (80)	3.00 (120)	4.00 (160)	5.00 (200)	Every 5th roll
Density, g/cm^3	ASTM D 1505	0.94	0.94	0.94	0.94	1/100,000 ft^2
Tensile Properties Strength@Yield,lb/in^2 (MPa) Elongation @ Break, %	ASTM D 6693 Type IV, Dumbell G.L.= 2.0in.	2,200 (14.5) 500	2,200 (14.5) 500	2,200 (14.5) 500	2,200 (14.5) 500	1/100,000 ft^2
Stud Pull-Out Strength[1], lb/ft^2 (kN/m^2)		>14,000 (669.89)	>14,000 (669.89)	>14,000 (669.89)	>14,000 (669.89)	1/ product
Carbon Black Content/ Pigment Content, % Black Liner Gray Liner	ASTM D 1603, mod. ASTM D 5630, mod.	2-3 1.5 – 2.5	2-3 1.5 – 2.5	2-3 1.5 – 2.5	2-3 1.5 – 2.5	1/100,000 ft^2
Carbon Black Dispersion[2]	ASTM D 5596	Note 2	Note 2	Note 2	Note 2	1/100,000 ft^2
Notched Constant Tensile Load, hours	ASTM D 5397	400	400	400	400	1/ formulation
Coefficient of Linear Thermal Expansion, per °C	ASTM D 696	1.20E-04	1.20E-04	1.20E-04	1.20E-04	1/ product
Low Temperature Brittleness, °C	ASTM D 746	-77	-77	-77	-77	1/ product
Dimensional Stability, % (each direction)	ASTM D 1204	± 1.0	± 1.0	± 1.0	± 1.0	1/ product
Water Absorption, %	ASTM D 570	0.1	0.1	0.1	0.1	1/ product
Water Vapor Transmission, (g/m^2/day)	ASTM E 96	<0.01	<0.01	<0.01	<0.01	1/ product

[1]Note: Concrete must have a compressive strength of at least 5,000 lb/in^2 (34,500 kPa).
[2]Note: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view for category 3.

Table 2: Raw Material Properties

Property	Test Method	Value	Testing Frequency
Density, g/cm3	ASTM D 1505	0.932	1/ resin lot
Melt Flow, g/10 min	ASTM D 1238 (190/2.16)	≤ 1.0	1/ resin lot
OIT, minutes	ASTM D 3895 (1atm/200°C)	100	1/ formulation

2.03 MATERIAL SUPPLY

A. Embedment sheets shall be supplied in roll form, sheets, pre-fabricated tubes or panels.

B. Cap strips shall be supplied in 4 inch widths or greater.

PART 3. EXECUTION

3.01 PLACEMENT

A. Place, support and secure reinforcement against displacement. Do not deviate from required position. Clean reinforcement of foreign particles or coatings.

B. Accommodate placement of formed openings.

C. Conform to ACI 318 code for concrete cover over reinforcement.

3.02 FIELD QUALITY CONTROL

A. Contractor shall notify the Owner's Representative at least 24 hrs. in advance of concrete placement. Placement of the Concrete Embedment Liner shall occur in such sequence that the Owner's Representative has sufficient time to inspect the correctness of the placement within the concrete formwork area. The Owner's Representative retains the right to require necessary revisions be made before concrete is placed.

END OF SECTION 03200

Operation and Maintenance Manual
Coffeen Power Station
Gypsum Management Facility
Montgomery County, Illinois

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OPERATION AND MAINTENANCE MANUAL
COFFEEN POWER STATION
GYPSUM MANAGEMENT FACILITY
MONTGOMERY COUNTY, ILLINOIS

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SECTION 1.0
GENERAL

This operation and maintenance (O&M) manual outlines objectives, proposed policies, responsibilities, and procedures for personnel who are responsible for the management of the Coffeen Power Plant Gypsum Management Facility (GMF). The GMF incorporates two reservoirs, the Gypsum Stack and the Recycle Pond, for processing and storing gypsum.

1.1 REASONS FOR DEVELOPMENT AND DISSEMINATION OF THE O&M MANUAL

The State of Illinois Rivers, Lakes and Streams Act, (615 ILCS 5) Paragraph 23a includes the statement "The Department is authorized to carry out inspections of any dam within the State, and to establish standards and issue permits for the safe construction of new dams and the reconstruction, repair, operation and maintenance of all existing dams." (emphasis added).

Part 3702 of Section 17 of the Illinois Administrative Code, Chapter I entitled the "Construction and Maintenance of Dams" details the requirements to obtain a permit for the construction, operation, and maintenance of a dam. Section 3702.40 b) includes the following statements:

> "4) An applicant for a Class I or II dam shall submit an operational plan specifying the method and schedule for the operation of the dam and the routine operating procedures to keep the dam in good working order, including an emergency warning plan." and
>
> "5) As a condition of each permit, the dam owner shall submit a maintenance plan detailing the procedures and schedules to be followed to maintain the dam and its appurtenances in a reasonable state of repair."

Thus, it is a requirement of all dam owners who have dams which fall under the jurisdiction of the Illinois Department of Natural Resources Office of Water Resources (IDNR-OWR) to operate and maintain them safely.

As a dam owner, Dynegy is responsible for the safety of the public and for maintaining the structures at the facility for both safety and economy. The overall public interest is served by providing a document to serve as a basis for the safe and economical operation and maintenance of the dam during both emergency and day-to-day conditions.

1.2 GENERAL RESPONSIBILITIES CONCERNING DAMS

Dynegy is responsible for the operation and maintenance of the Gypsum Stack Dam and the Recycle Pond Dam. These responsibilities include general maintenance (mowing, removing debris from decants, placing riprap where needed, etc.), operation, inspection and emergency action decisions.

SECTION 2.0
DEFINITIONS

Appurtenant Works - The structures or machinery auxiliary to dams which are built to operate and maintain dams; such as outlet works, spillways, gates, valves, channels, etc.

Boil - A stream of water discharging from the ground surface downstream of the dam carrying with it a volume of soil which is distributed around the hole formed by the discharging water.

Berm - A horizontal step or bench in the sloping profile of an embankment dam.

Breach - A break, gap, or opening (failure) in a dam which releases impoundment water.

Dam - A barrier built for impounding or diverting the flow of water.

Dike (Levee) - An embankment, usually applied to embankments or structures built to protect land from flooding.

Drain, Layer or Blanket - A layer of pervious material in a dam to facilitate the drainage of the embankment including such items as a toe drain, a weephole, and a chimney drain.

Drawdown - The resultant lowering of the water surface level due to the release of water from the impoundment.

Embankment - Fill material, usually rock or earth, placed with sloping sides.

Earthen Dam - Any dam constructed of excavated natural materials.

Emergency Action Plan - A predetermined plan of action to be taken to reduce the potential for property damage and loss of lives.

Failure - An incident resulting in the uncontrolled release of water from the dam.

Freeboard - The vertical distance between a stated water level and the top of the dam.

Gate or Valve - In general, a device in which a leaf or member is moved across the waterway to control or stop the flow.

Groin - The junction of the upstream or downstream face of the dam with the valley wall.

Maintenance - The upkeep, involving labor and materials, necessary for efficient operation of dams and their appurtenant works.

Operation - The administration, management, and performance needed to operate the dam and appurtenant works.

Operation and Maintenance Inspection - Inspections conducted by the dam operator. These inspections are frequent visual "Walk-around" inspections of the dam surface and appurtenant works.

Outlet - An opening through which water can freely discharge for a particular purpose from an impoundment.

Phreatic Surface - The upper surface of saturation in an embankment.

Piping - The progressive development of internal erosion by seepage, appearing downstream as a hole or seam, discharging water that contains soil particles.

Riprap - A layer of large stones, broken rock or precast blocks placed in a random fashion usually on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel as a protection against wave and ice action.

Silt/Sediment - Soil particles and debris in an impoundment.

Slump/Slide Area - A portion of earth embankment which moves downslope, sometimes suddenly, often with cracks developing.

Spillway System - A structure or structures over or through which flows are discharged. If the flow is controlled by gates, it is considered a controlled spillway. If the elevation of the spillway crest is the only control of the flows, it is considered an uncontrolled spillway.

Emergency Spillway - A spillway designed to operate very infrequently, only during exceptionally large floods, usually constructed of materials expected to erode slowly.

Principal Spillway - The main spillway which controls both normal and flood flows and is usually constructed of non-erodable materials.

Auxiliary Spillway - A spillway which works in conjunction with the principal spillway to control flood flows and is usually constructed of non-erodable materials.

Stilling Basin - A basin constructed to dissipate the energy of fast flowing water, such as from a spillway, and to protect the streambed from erosion.

Toe of Embankment - The junction of the face of the dam with the ground surface in the floodplain upstream or downstream of the dam.

SECTION 3.0
INFORMATION ABOUT THE DAMS

3.1 LOCATION

The Gypsum Stack Dam and Recycle Pond Dam are located in the NW 1/4 of Section 11, Township 7 North, Range 3 West of the Third Principal Meridian in Montgomery County, Illinois. More specifically, the dams are located approximately 1.5 miles south of Coffeen, Illinois. A map showing the location of the dams is included in Appendix A.

3.2 DESCRIPTION OF DAM AND APPURTENANCES

The gypsum stack perimeter earthen dam, the gypsum stack "gypsum" dam, and the recycle pond dam will all be regulated in accordance with 17 Illinois Administrative Code (IAC) Part 3702, Construction and Maintenance of Dams. The gypsum stack perimeter earthen dam, which will be lined with a dual high density polyethylene (HDPE) geomembrane system, will have a maximum embankment height of 13 ft and a maximum impounding capacity of 442 acre-ft (measured at the top of earthen dam elevation 632 ft). There will be an additional 123 acre-ft of incised storage. After the volume provided by the earthen embankment is filled, gypsum will then be "stacked" with an upstream-type embankment construction method, yielding a maximum completed gypsum embankment height of approximately 100 ft (elevation 715 ft). The total volume of gypsum stored within the completed gypsum stack dams will be approximately 2,478 acre-ft.

The dam for the recycle pond, which will be lined with a 60 mil HDPE geomembrane, will have a maximum embankment height of 16 ft and a maximum impounding capacity of 243 acre-ft (measured at the top of dam elevation 629 ft). There will be an additional 99 acre-ft of incised storage.

The gypsum stack will be divided into two sub-cells for the containment of scrubber sludge (gypsum). Discharges to the site will switch back and forth between the two sub-cells so that one sub-cell can be dewatered and raised while the other is in use. There will be two fixed decant pipes constructed in the gypsum stack – one for each sub-cell - which will discharge to stilling wells located adjacent to the perimeter ditches. The control elevation on the decant pipes will be maintained 5.0 ft below the lowest point on the stack cell crest. The decant pipes will enable the cells to be dewatered after storm events so that a minimum of 5.0 ft of freeboard will be maintained in each cell. A minimum of 4.7 ft of freeboard is required above the decant inlet to contain the Probable Maximum Flood (PMF) storm event in addition to peak wind generated waves.

The gypsum stack dam perimeter ditches will be located on the interior sides of the earthen dam. Runoff from the stack will be conveyed through the ditches to a transfer channel which will discharge into the recycle pond. The ditches will be trapezoidal in shape with a 15 ft bottom width, a maximum depth of 9 ft and a longitudinal slope of 0.0005 ft/ft. Side slopes will be 3H:1V. During operation, the ditches will be monitored for erosion. If erosion of the designed ditch geometry occurs, a geogrid will be used for stabilization.

The transfer channel between the gypsum stack dam and the recycle pond have a trapezoidal cross-section with 3H:1V side slopes will be lined with HDPE. The 500 ft long transfer channel will transition from a 32-ft bottom width at an invert elevation of 623.0 ft at the upstream end to a 60-ft bottom width at an invert elevation of 622.0 ft at the downstream end. The transfer channel will be fitted with stop logs capable of raising the discharge control elevation to 625.0 ft. To prevent degradation of the HDPE liner due to flow velocities, the transfer channel and a portion of the recycle pond dam will incorporate an additional sacrificial layer of HDPE.

The emergency spillway for the recycle pond will consist of three 6 ft by 6 ft precast reinforced concrete risers (drop inlets) with a top elevation of 624 ft (5 ft below the top of the dam). The recycle pond's HDPE liner will attach to the exterior sides of each riser. A 4-ft diameter HDPE outlet conduit will be constructed at each riser with an upstream invert of 615.0 ft and a downstream invert of 613.0 ft. Assuming a normal pool elevation of 624 ft (control elevation of the risers), the emergency spillway has been designed to pass the 24-hour PMF storm event with adequate freeboard to prevent overtopping of the recycle pond crest by wind generated waves. The emergency spillway has been provided in the event of accident or catastrophic rainfall only. It is not expected to be activated during the life of the facility. As designed, all discharges from the system will be through the pump house located on the southeast corner of the recycle pond.

3.3 SIZE AND HAZARD CLASSIFICATION

If a worst case failure of the gypsum stack dam were to occur, and the entire volume of the stack is released easterly into Coffeen Lake, the Coffeen Lake reservoir has adequate freeboard to accept this additional volume without overtopping the dam during flood events up to and including the 60 percent PMF. However, the power plant and several residences could potentially be impacted if the gypsum stack dam were to fail in a westerly direction. Considering the regulatory criteria established in Part 3702, the gypsum stack perimeter earthen dam and the gypsum stack "gypsum" dam are classified as intermediate-size Class I (high hazard potential) dams.

A failure of the recycle pond dam would discharge water to Coffeen Lake but it is not anticipated to result in loss of life or any significant economic damage. Breach analyses indicate that a failure of the recycle pond dam during a PMF event would be expected to result in an increase in the Coffeen Lake water surface elevation of not more than ½ inch. Accordingly, the recycle pond dam is classified as a small-size Class III (low hazard potential) dam.

3.4 PURPOSE OF THE DAMS

The dams will be used to dewater, store and dispose of flue gas desulphurization sludge (gypsum) from the Coffeen Power Station (the Plant). Gypsum will be transported to the Gypsum Stack Dam in slurry form (approximately 20 percent solids) and allowed to settle. Clarified process water will then be decanted to the recycle pond and returned to the Plant for reuse via a pipeline.

3.5 PERTINENT DATA

Pertinent data about the dams, appurtenant works, and reservoirs are presented in Table 3-1 and Table 3-2.

Table 3-1 Pertinent Data for the Gypsum Stack Earthen Dam
(Based on the Construction of 2 Gypsum Cells)

Perimeter Ditches		
Bottom Width	15.00	feet
Top Width	73.50	feet
Depth	9.00	feet
Outer Side Slope	3:1	H:V
Inner Side Slope	3:1	H:V
Upstream Invert	624.85	feet
Downstream Invert	623.00	feet
Ditch slope	0.00050	ft/ft
Bank Full Cross-sectional Area	378.00	sf
Length of Each Ditch (Centerline)	3710.00	feet
Bank Full Volume of Each Ditch	32.19	acre-ft
Total Ditch length (Centerline)	7420.00	feet
Total Ditch Bank Full Volume	64.39	acre-ft

Transfer Channel		
Bottom Width	32.00	feet
Top Width	86.00	feet
Depth	9.00	feet
Upstream Invert	623.00	feet
Downstream Invert	622.00	feet
Weir Elevation	625.00	feet
Weir Length (at 2 ft height)	44.00	feet

Dam		
Top of Dam Elevation	632	feet
Reservoir Surface Area	77.29	acres
Total Watershed Area	77.29	acres
Dam Length	7720	feet
Dam Height	13	feet

1.0 PMF Storm Event		
Storm Duration	24	hours
Peak Outflow Discharge	1100.7	cfs
Total Discharge Volume	228.83	acre-ft
Peak WSEL in Perimeter Ditches	629.89	feet
Freeboard over Max WSEL	2.11	feet
Wave Runup/Wind Setup	2.06	feet
Adequate Freeboard?	**YES**	

0.5 PMF Storm Event		
Storm Duration	24	hours
Peak Outflow Discharge	541.1	cfs
Total Discharge Volume	122.41	acre-ft
Peak WSEL in Perimeter Ditches	628.23	feet
Freeboard over Max WSEL	3.77	feet
Wave Runup/Wind Setup	2.06	feet
Adequate Freeboard?	**YES**	

100-yr Storm Event - Critical Duration		
Storm Duration	12	hours
Peak Outflow Discharge	92.6	cfs
Total Discharge Volume	50.91	acre-ft
Peak WSEL in Perimeter Ditches	626.07	feet
Freeboard over Max WSEL	5.93	feet
Wave Runup/Wind Setup	2.06	feet
Adequate Freeboard?	**YES**	

100-yr Storm Event - 24 Hour Duration		
Storm Duration	24	hours
Peak Outflow Discharge	62.9	cfs
Total Discharge Volume	57.01	acre-ft
Peak WSEL in Perimeter Ditches	625.84	feet
Freeboard over Max WSEL	6.16	feet
Wave Runup/Wind Setup	2.06	feet
Adequate Freeboard?	**YES**	

Note: The Critical Storm Duration is the duration of the rainfall event which produces the highest reservoir water surface elevation in the Gypsum Stack Perimeter Ditches for the given storm frequency. In each case, the starting normal pool elevation of the Recycle Pond is considered to be at elevation 624 ft.

Table 3-2 Pertinent Data for the Recycle Pond Dam
(Based on the Construction of 2 Gypsum Cells)

Dam		
Top of Dam Elevation	629	feet
Invert of Reservoir Elevation	605	feet
Reservoir Area at Invert	11.55	acres
Reservoir Area at Top of Dam	17.07	acres
Total Reservoir Volume	341.91	acre-ft
Volume at Elevation 624 ft	259.60	acre-ft
Total Watershed Area	94.36	acres
Dam Length	3600	feet
Dam Height	16	feet

3 Spillways- 6ft x 6ft inlet w/ 4ft dia outlet pipe		
Weir Length	22	feet
Weir Elevation	624.00	feet
Outlet Conduit Length	120	feet
Outlet Conduit Diameter (Inside)	48	inch
Upstream Invert	615	feet
Downstream Invert	614	feet
Outlet Conduit Slope	0.00833	

1.0 PMF Storm Event - Normal Pool at Elev. 624 ft		
Storm Duration	24	hours
Peak Inflow	1261.6	cfs
Peak Outflow	586.9	cfs
Peak Storage	315.47	acre-ft
Peak WSEL (HEC-HMS)	627.45	feet
Freeboard over Peak WSEL	1.55	feet
Wave Runup/Wind Setup	1.20	feet
Adequate Freeboard?	**YES**	

1.0 PMF Storm Event - Normal Pool at Elev. 609 ft		
Critical Storm Duration	24	hours
Peak Inflow	1261.6	cfs
Peak Outflow	289.7	cfs
Peak Storage	280.65	acre-ft
Peak WSEL (HEC-HMS)	625.34	feet
Freeboard over Peak WSEL	3.66	feet
Wave Runup/Wind Setup	1.20	feet
Water Released from Dam?	**YES**	

0.5 PMF Storm Event - Normal Pool at Elev. 624 ft		
Storm Duration	24	hours
Peak Inflow	608.4	cfs
Peak Outflow	413.6	cfs
Peak Storage	286.48	acre-ft
Peak WSEL (HEC-HMS)	625.69	feet
Freeboard over Peak WSEL	3.31	feet
Wave Runup/Wind Setup	1.20	feet
Adequate Freeboard?	**YES**	

0.5 PMF Storm Event - Normal Pool at Elev. 613 ft		
Critical Storm Duration	24	hours
Peak Inflow	608.4	cfs
Peak Outflow	0	cfs
Peak Storage	255.83	acre-ft
Peak WSEL (HEC-HMS)	623.75	feet
Freeboard over Peak WSEL	5.25	feet
Wave Runup/Wind Setup	1.20	feet
Water Released from Dam?	**NO**	

100-yr Storm Event - Normal Pool at Elev. 624 ft		
Critical Storm Duration	12	hours
Peak Inflow	113.2	cfs
Peak Outflow	95.8	cfs
Peak Storage	269.36	acre-ft
Peak WSEL (HEC-HMS)	624.63	feet
Freeboard over Peak WSEL	4.37	feet
Wave Runup/Wind Setup	1.20	feet
Adequate Freeboard?	**YES**	

100-yr Storm Event - Normal Pool at Elev. 619 ft		
Critical Storm Duration	24	hours
Peak Inflow	76.6	cfs
Peak Outflow	0	cfs
Peak Storage	258.48	acre-ft
Peak WSEL (HEC-HMS)	623.94	feet
Freeboard over Peak WSEL	5.06	feet
Wave Runup/Wind Setup	1.20	feet
Water Released from Dam?	**NO**	

Note: The above variation in normal pool elevations for the Recycle Pond is for the purpose of documenting the water surface elevation which must be maintained in the recycle pond in order to prevent the release of water from the GMF for the above described storm events.

SECTION 4.0
OPERATIONS ACTIVITIES

4.1 INTRODUCTION

The operations plan describes the proposed operation of the Coffeen Gypsum Management Facility (GMF) which includes the gypsum stack and the recycle pond.

4.2 SITE OPERATIONS AND PERSONNEL

4.2.1 Site Operations

The GMF will receive gypsum slurry 24 hours per day, seven days per week. Routine facility maintenance and construction activities will generally be conducted during day shift hours. The crest widths for both the gypsum stack earthen dam and the recycle pond dam are 20 ft. In addition, multi-directional ramps are being provided for both structures so that they are readily accessible by inspection, maintenance and gypsum recovery equipment.

The Plant is a restricted access location. Additional fencing around the perimeter of the active sedimentation cells of the gypsum stack and the recycle pond will be erected to prevent unauthorized access to the GMF, which is also under surveillance by security personnel.

4.2.2 Personnel

The proposed GMF will be owned and operated by Illinois Power Generating Company Corporate offi ces are located in St. Louis, Missouri. Overall responsibility for the GMF operation lies with management personnel.

4.3 GYPSUM MANAGEMENT FACILITY STARTUP

The major components of the proposed GMF consist of:

- The gypsum stack dam/impoundment;
- The recycle pond;
- The earthen transfer channel that connects the two structures and through which process water will be decanted from the gypsum stack into the recycle pond; and
- The recycle pond decant and pumphouse through which process water will be returned to the Plant for reuse.

Both the recycle pond and the gypsum stack dam will be constructed before gypsum is placed within the gypsum stack dam/impoundment.

Upon startup, it is likely that the gypsum stack impoundment will have no more than a few feet of water in the bottom to prevent the high density polyethylene (HDPE) geomembrane from moving. The gypsum slurry (approximately 20 percent solids) will be pumped from the

Plant to the gypsum stack via piping. The piping will be HDPE with a suitable pressure rating for the intended hydraulic and static head. The HDPE pipe will discharge the slurry into the impoundment, and gypsum will settle by gravity.

It will take approximately 10 months before the gypsum stack impoundment is filled to elevation 623 ft, the point where process water may begin flowing into the recycle pond via the HDPE-lined earthen channel connecting the two structures. As soon as water begins to fill the recycle pond, it will be pumped back to the Plant for reuse.

4.4 WATER BALANCE

The capacity of the recycle pond has been designed to accommodate all precipitation runoff from the entire gypsum stack/recycle pond area during a 2-week complete maintenance outage at the Coffeen Power Station (the Plant) followed by a 12-week outage of one of the two units. The runoff and excess water accumulated during this time can be stored within the recycle pond without discharging. The design is based on the maximum 3.5 month precipitation that has occurred in the area since 1950. This occurred in April, May, June and half of July, 1957 and consisted of 28.83 inches of rainfall.

The water balance has been carried out for the expected life of the Site. During the first nine or ten months of operation, the water balance is positive, meaning that there is more water entering the gypsum stack/recycle pond system through process water and precipitation than is leaving the system through process water return and evaporation. However, there is 15 ft of freeboard between the pump discharge and the emergency spillway. With proper water-level management, the water surface will remain well below discharge elevation. After this initial startup period, the water balance is negative, meaning that other water sources will need to be continually added to the process water makeup stream to maintain the volume necessary for transport of the gypsum slurry.

The water balance is of particular concern since the entire system is designed to be a closed loop with no discharges. *(As previously noted, the recycle pond has been designed with an emergency spillway, but this is only to protect the structures in the event of an unforeseen accident or catastrophic rainfall event.)* Table 3.5-2 lists the maximum water surface elevation allowed in the recycle pond in order to prevent the discharge of water for the 100-year storm event and the 0.5 PMF storm event.

4.5 GYPSUM MANAGEMENT FACILITY OPERATION

4.5.1 Routine Operations

Gypsum slurry will initially be discharged at the southwestern corner of the gypsum stack impoundment. Settled gypsum will gradually create a plane of material sloping gently towards the north end of the impoundment. Depending on the slope of the settled gypsum, the discharge pipe may be moved to other corners of the impoundment to evenly distribute the material. Care must be taken during the initial filling period so to ensure that the sand layer covering the ring drains is not disturbed. If necessary, the sand may be armored with larger washed aggregate or the impoundment may be gradually filled with water to cover the sand prior to the discharge of gypsum slurry into the impoundment.

Once the gypsum plane reaches approximately elevation 627 ft (5 ft below the earthen dam crest), a track excavator or similar piece of equipment will be used to create the first gypsum berm and to form the perimeter ditch. Each gypsum berm will be approximately 10 ft in height and will effectively create a two-compartment impoundment within its perimeter. Gypsum for construction of the gypsum berm will be obtained from the settled material on the inside of the berm, creating an inner ditch. Gypsum slurry will then be discharged alternately into the inner ditch of each compartment. Gypsum will settle out into the inner ditch and clarified process water will flood the compartment to a depth of several feet. This water will be decanted to the perimeter ditch by way of an HDPE decant pipe which will discharge to a stilling well located at the toe of the gypsum stack.

As each compartment fills with settled gypsum, the discharge piping will be moved to the alternate compartment. The compartment, or sub-cell, that is not in service will be allowed to dewater and another gypsum berm will be constructed on top of the previous gypsum berm, effectively raising the gypsum stack another 10 ft. This alternating cycle of gypsum discharge, compartment dewatering and berm construction will continue until the stack is approximately 100 ft in total height. Gypsum will be deposited in the stack with an average dry density of approximately 74 lb/ft$^{3.}$ Drawing No. C-10201-25 provides a visual description of this process.

4.5.2 Piezometer Installation and Monitoring

The side slopes of the gypsum stack will be constructed with 3:1 side slopes. After consolidation of the settled gypsum over time, the final slopes should approach 3.75:1. The stability of each gypsum stack slope is critically dependent on the location of the phreatic surface which is anticipated to develop within the stack. Ring drains are intended to lower the phreatic surface so that it is located an adequate distance from the surface of the slope in order to maintain slope stability. In order to monitor the phreatic surface within the stack, piezometers will be installed on each side of the gypsum stack. The piezometers will be installed every 15 vertical feet up the slope (45 horizontal feet based on 3:1 side slopes) and will extend to a depth of at least 15 feet below the anticipated phreatic water surface elevation as shown in Figure 4-1. At the time of installation, each piezometer will be labeled with the “critical elevation” corresponding to the anticipated phreatic surface elevation at that location. The anticipated phreatic surface elevation is the water surface elevation which was used in the slope stability analysis of the gypsum stack. The water level in each piezometer will be read and recorded on a monthly basis. If at any time a reading is recorded higher than “critical elevation” for that specific peizometer, the design engineer must be contacted immediately for evaluation of the reading. Any readings above the “critical elevation” may be indicative of improper ring drain function and/or slope instability which could lead to a failure of the gypsum stack. Therefore, it is critical that the piezometers are installed in accordance with the construction plans and specifications and monitored in accordance with this manual. It may be necessary to install additional subdrainage to maintain the phreatic surface at the desired level within the gypsum stack.

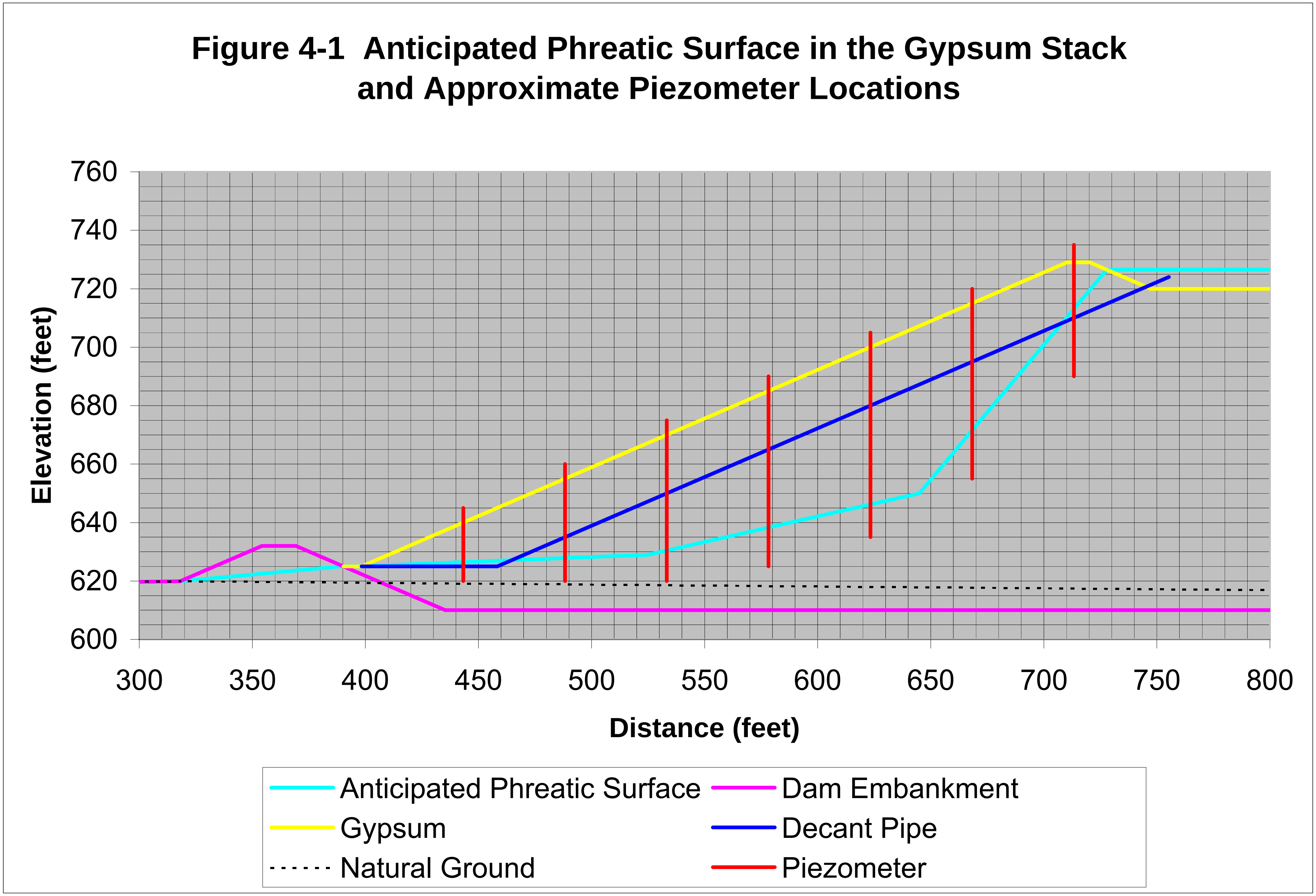


Figure 4-1 Anticipated Phreatic Surface in the Gypsum Stack
and Approximate Piezometer Locations
760
740
720
700
680
660
640
620
600
Elevation (feet)
300
350
400
450
500
550
600
650
700
750
800
Distance (feet)
Anticipated Phreatic Surface
Dam Embankment
Gypsum
Decant Pipe
Natural Ground
Piezometer

4.6 DAM INSPECTIONS

The inspection program includes two types of dam inspections. The first is regularly conducted by the dam operator and is referred to as an Operation and Maintenance Inspection. The second type of inspection, referred to as the Engineering Inspection, is conducted by a qualified engineer approved by IPGC. All engineering inspection reports must be signed and sealed by an Illinois Registered Professional Engineer.

The dam operator will perform monthly Operation and Maintenance Inspections of the gypsum stack perimeter earthen dam and the gypsum berms and side slopes during the operating life of the structure. During these inspections, the gypsum stack ditches and the transfer channel will also be examined for signs of erosion and liner degradation. The "operating life of the structure" will be considered to cease upon covering of the gypsum with an HDPE/soil cover. Engineering Inspections will be conducted on an annual basis during the operating life of the structure and will continue after covering of the gypsum stack until authorization to abandon the structure is received from IDNR/OWR.

4.6.1 Operation and Maintenance Inspection

Occasional "walk-around" inspections of the dams and appurtenant works are to be made by the dam operator. During these inspections, a checklist of items to be maintained and items to be observed should be recorded. Appendix A provides an example of the Operation and Maintenance Inspection Checklist to be utilized for these inspections. **If any of the following items are found to be unusual or are cause for concern, the IPGC Shift Supervisor should be notified and the Emergency Action Plan should be immediately consulted for guidance on an appropriate course of action.**

Frequency: Operation and maintenance inspections will be performed by the dam operator on a monthly basis and also during and after unusual events such as heavy rainfall or an earthquake.

Inspection Items: During each inspection the following items should be noted in particular.

1. Water Level - Maximum reservoir levels as a result of heavy rainfall should be recorded.

2. Earth Embankment - Walk the crest, side slopes and downstream toe of the dam concentrating on surface erosion, seepage, cracks, settlement, slumps, slides, and animal burrows. These are described as follows:

   - Surface Erosion - Removal of vegetative cover by water action or pedestrian or vehicle usage forming deep ruts or gullies.

   - Seepage - The passage of water through and/or underneath the earth embankment abutment and natural groundline or at the contact between the embankment and outlet works. It can be indicated by cattails or other wet environmental vegetation, erosion, channelization, or slumping on the embankment face.

- Cracks - Deep cracks usually indicate the movement of the dam and/or the foundation and can be in either the longitudinal (along the length of the dam) or transverse (across the dam) directions. Cracking can be an indicator of the beginning of slumps. Shallow cracks may develop during the summer when the surface soils of the embankment become severely dried and are usually of no concern in regard to the safety of the dam.

- Settlement - Settlement is indicated by depressions or low spots and can be signs of consolidation of the dam or foundation or the loss of material beneath the settlement area.

- Slumps/Slides - A slow or sudden movement of the earth embankment slope on either face toward the toe of the dam.

- If seepage indicates the presence of soil particles, or if deep cracks, settlement, slumps, or slides are noticed, a qualified engineer should be contacted immediately for consultation.

- Animal Burrows - Animal burrows result in a loss of earth embankment material and can provide seepage paths for water through the embankment.

3. Gypsum Embankment - Walk the crest, side slopes and downstream toe of the dam concentrating on surface erosion, seepage, cracks, settlement, slumps, slides and animal burrows. The descriptions for these are the same as for earth embankment.

4. Vegetation - Grass should be a thick vigorous growth to stabilize the earth embankment soils and prevent erosion from occurring. Note the height of the grass; if greater than 1 foot a mowing of the area should be scheduled before the next inspection. There should be NO trees on the earth embankment and NONE within a minimum of 20 feet of the embankment toes or other structures. The gypsum embankment will not be seeded and is not expected to have any vegetation.

5. Gypsum Stack piezometers should be inspected for any damage or loss of function. Damaged piezometers must be promptly repaired or replaced since their function is critical to ensuring stability of the gypsum stack.

6. The water level in each Gypsum Stack piezometer must be measured and recorded during each monthly inspection. If the water level in any piezometer is above the "critical elevation" as discussed in Section 4.5.2 of this plan, the IPGC Technical Services Superintendent should be notified and the **Emergency Action Plan should be immediately consulted for guidance on an appropriate course of action**.

7. Gypsum Stack LD/LCRS Drains - The change in location or amount of flows discharging from the Leak Detection/Leachate Collection Recovery System (LD/LCRS) should be recorded. If a significant change has occurred, a qualified engineer should be contacted for consultation.

8. Gypsum Stack Ring Drains - The change in location or amount of flows discharging from the Ring Drains should be recorded. If a significant change has occurred, a qualified engineer should be contacted for consultation.

9. Gypsum Stack Fixed Decant – Check the alignment and supports for the pipe. Record the amount of flows discharging from the pipe and any erosion or scour around the discharge point.

10. Gypsum Stack Perimeter Ditch – The perimeter ditch should have a consistent prismatic shape for the entire length. Inspect the perimeter ditch for evidence of erosion, sediment deposition and irregularity in channel geometry, especially in the vicinity of siphon, decant or ring drain outfall structures. If irregularities are noted, repairs should be scheduled and completed.

11. Stop Logs - Check to make sure that the stop logs in the transfer ditch are undamaged, operating well and allowing for the free flow of water over them.

12. Transfer Channel - Check for any debris or other obstructions which may block or restrict the free flow of water. Check for any pools or undulation of the floor of the channel.

13. Recycle Pond Decant - Check for any debris or other obstructions around the Recycle Pond decant which may block or restrict the free flow of water. The emergency dewatering valve should be lubricated. If there is no return water in the pipe, the emergency dewatering valve should be exercised. Record the physical and operating conditions of the system.

14. Recycle Pond Drop Inlet Spillways - Check for any debris or other obstructions around the inlet crest and at the bottom of the drop inlet which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete, and seepage, cracking, breaking, or spalling of the concrete. Check for settlement or cracking of the crest. Check for any debris in the pipes which may restrict the flow of water. Check for any tears or leaks in the HDPE liner covering the concrete.

15. Recycle Pond Rip Rap Basin - Check for any debris or other obstructions in the riprap basin which may block or restrict the free flow of water. Check to make sure that the rip rap is remaining in a uniform position. Freeze/thaw action or flow over the rip rap may tend to lift or fracture, thus requiring replacement or leveling to maintain the necessary level of protection. NO trees or woody vegetation should be growing through the rip rap.

16. Fences - Check for damage, accumulated debris, operation of gates and locks, and adequacy of locations (this may change with time as people access the area or development occurs in the area).

17. Perimeter - Check the perimeter of the dams for a distance of at least 100 feet beyond the toe for signs of seepage or boils.

18. HDPE Liner – Wherever exposed, the HDPE Liner should be inspected for tears, gouges, protrusions under the liner and abrasion.

Records: A log book of activities occurring at the dam is to be kept current by the dam operator. The log book should be reviewed during the Engineering Inspection. This book should contain at the least the following documentation:

1. Completed operation and maintenance inspection checklists
2. Readings from all piezometers on the Gypsum Stack
3. Additional visual observations
4. A list of maintenance performed
5. A list of any unusual occurrences at the dam
6. Copies of the engineering inspection reports

4.6.2 Engineering Inspection

The engineering inspection is to be conducted by a qualified engineer approved by IPGC. The inspection will provide a thorough evaluation of the dam condition and appurtenances. Appendix B is an example of the inspection report form which is to be utilized for these inspections.

Frequency: The Gypsum Stack Dam is a Class I, High Hazard Potential dam and is to be inspected by an Illinois Registered Professional Engineer at least once per year. The Recycle Pond Dam is classified as a Class III, Low Hazard Potential dams and is to be inspected by an Illinois Registered Professional Engineer at least once every five years.

Inspection Items: The engineer will thoroughly inspect all of the items noted in Section 4.6.1 Operation and Maintenance Inspection.

Records: The Dam Inspection Report form from IDNR-OWR "Guidelines and Forms for Inspection of Illinois Dams" (a copy of which is included in Appendix B), will be completed by the inspecting engineer and will be signed and sealed by an Illinois Registered Professional Engineer. This report will document problem areas and deficiencies; recommend remedial actions for problem areas; and establish time requirements for dealing with the problems. The original report will be retained in IPGC's file and a copy of the report will be submitted to the Illinois Department of Natural Resources, Office of Water Resources.

4.6.3 Review of Emergency Action Plan

The emergency action plan should be reviewed annually to assure that all contacts, addresses and telephone numbers are current. Changes in the adjacent land use should also be noted and may dictate the need for revisions to the plan. Changes to the plan should be made as appropriate but only with the concurrence of the Montgomery County Emergency Services and Disaster Agency and of the Illinois Department of Natural Resources, Office of Water Resources. Copies of any revisions should also be forwarded to all IPGC personnel and known emergency responders that possess previous versions the plan.

SECTION 5.0
MAINTENANCE ACTIVITIES

Timely repairs are a must after problem areas have been identified. The dam operator is to perform the work required to correct items noted in the operation and maintenance inspections and engineering inspections. Such items include repairing erosion of the gypsum slopes, mowing, seeding, tree and brush removal, replacing rip rap, repairing fences and locks, clearing debris, etc. The maintenance activities specified in the following sections are minimum requirements. NOTE: NO alterations or repairs to structural elements should be made without the assistance of the IPGC Chief Dam Safety Engineer and the concurrence of the Illinois Department of Natural Resources, Office of Water Resources.

Debris: Remove all trash, logs and other debris which may obstruct flow into the principal spillway pipes and drop inlets, or block passage from their discharge channels.

Rip Rap: Replenish rip rap as needed to provide adequate protection against erosion.

Vegetation Control

1. Maintain a good grass cover on the embankment by seeding, fertilizing and mulching areas which are refilled, barren, or thinly vegetated. Seeding mixtures used for maintenance reseeding shall result in a cover compatible with adjacent cover. The seeding mixture specified at the time of the dam's construction was IDOT Standard Specifications Class 1A (Salt Tolerant Lawn Mixture) as follows:

   IDOT Class 1A Salt Tolerant Lawn Mixture
   Bluegrass..........................60 lb/acre
   Perennial Ryegrass...........20 lb/acre
   Dawsons Red Fescue ....20 lb/acre
   Scaldis Hard Fescue.........20 lb/acre
   Fults Salt Grass ....60 lb/acre

2. Grassed areas such as the embankment and the areas beyond the embankment toes for a distance of at least 20 feet should be mowed at least twice annually or at any time the height of the grass exceeds 1 foot.

3. All erosion areas will be filled and compacted, reseeded, fertilized and mulched to establish a thick erosion resistant cover.

4. Remove all trees and brush growing on the dam embankment to prevent development of a root system which could provide seepage paths. Herbicides utilized for tree and brush control are discussed in Appendix D.

5. Keep the riprap basin clear of weeds, brush, and trees.

6. Clear all brush and trees for a distance of approximately 20 feet beyond the toe of each dam.

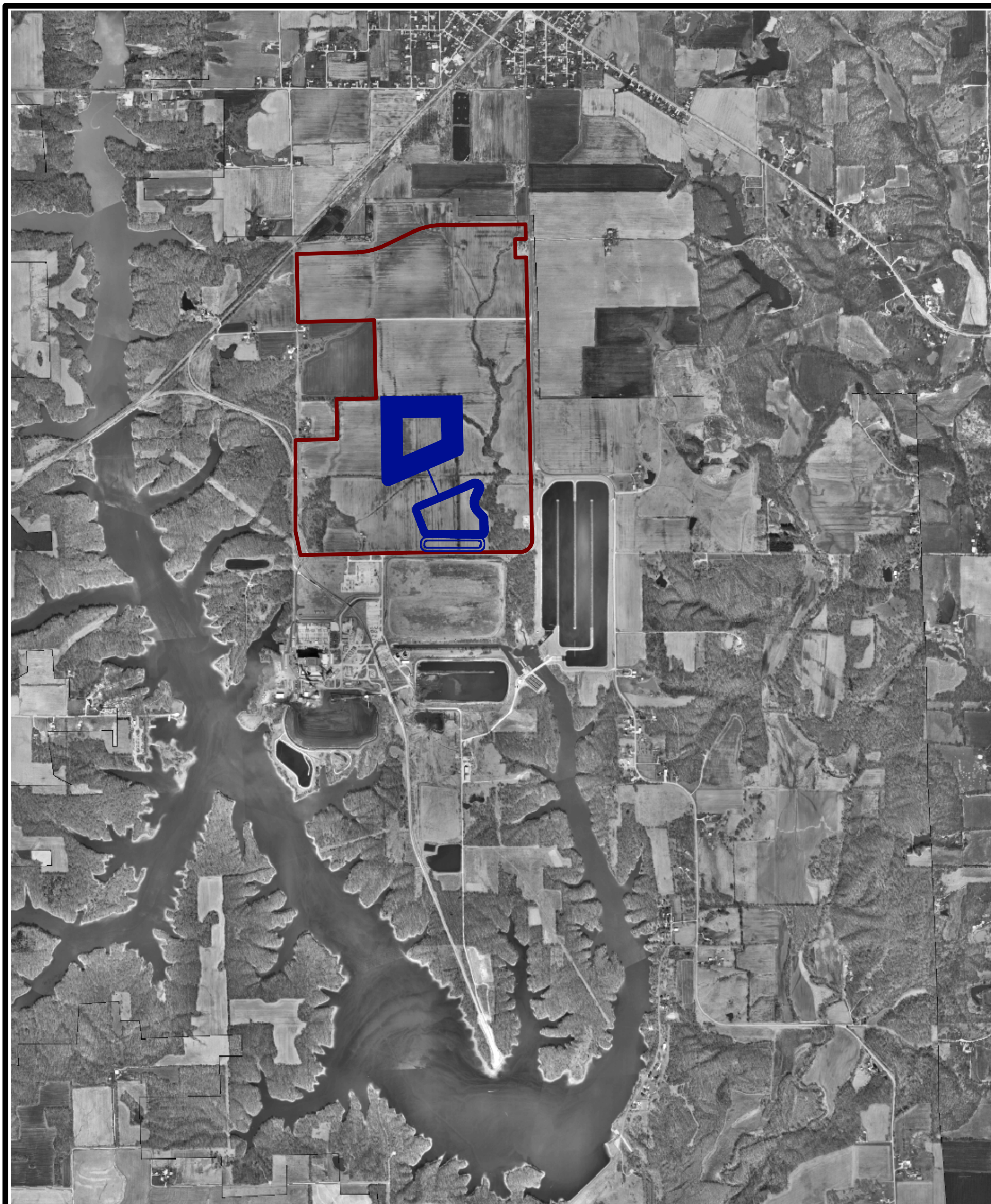
Animal Damage: Fill rodent holes and other animal burrows with compacted clayey soil and reseed. If rodents become a nuisance, an effective rodent control program as approved by the Illinois Department of Natural Resources District Wildlife Biologist should be implemented.

Signs: All warning signs shall be maintained (repaired, painted, or replaced) as needed.

Gypsum Slopes: Erosion of the gypsum slopes will be evident with the presence of erosion rills. Erosion rills should be filled with additional gypsum material and graded to conform with the design slope.

Piezometers: All piezometers on the gypsum stack shall be inspected for signs of damage or displacement. Non-functioning piezometers shall immediately be replaced.

APPENDIX A
LOCATION MAP



Hanson Professional Services Inc.

LOCATION MAP

GYPSUM MANAGEMENT FACILITY
COFFEEN POWER GENERATING STATION
MONTGOMERY COUNTY, ILLINOIS

Job Number 05S3004A

I:\JobNumber.mxd

APPENDIX B
OPERATION AND MAINTENANCE INSPECTION CHECKLIST

OPERATION AND MAINTENANCE INSPECTION CHECKLIST

Dam Name (circle one): Gypsum Stack Dam Recycle Pond Dam

Date: ___________________________ Time: __________________________

Name of Inspector: ____

Reservoir Elevation: _______________ feet

ITEM	NO	YES	IF YES
Record Piezometer Readings for Gypsum Stack. Are any readings above the critical level? (see section 4.5.2 of O&M Manual)			Contact Technical Services Superintendent and notify Hanson Professional Services
Note the condition of the Piezometers on the Gypsum Stack. Any damage?			Contact Technical Services Superintendent
Deep Surface Cracks			Contact Technical Services Superintendent
Slump or Slide on the upstream or downstream face			Contact Technical Services Superintendent
Erosion from runoff, wave action or traffic			Repair and stabilize
Embankment, abutment or spillway seepage			Contact Technical Services Superintendent
Seepage or flows of muddy water			Contact Technical Services Superintendent
Uneven settlement			Contact Technical Services Superintendent
Trees, brush or burrow holes on the embankment or in the riprap basin			Remove trees and brush, fill holes
Transfer channel or Spillway pipes blocked			Clear immediately
Damage to stop logs			Repair or replace
Damage to HDPE Liner			Repair and schedule engineer inspection
Settlement or displacement of Gypsum Stack fixed decant pipes or outlets			Schedule engineer inspection
Discharge from Gypsum Stack LD/LCRS Drains?			Record discharge rate for each outlet (time to fill bucket)
Discharge from Gypsum Stack Ring Drains?			Record discharge rate for each outlet (time to fill bucket)
Gypsum Stack Perimeter Ditch erosion			Schedule repair
Problems with Recycle Pond spillways			Contact Technical Services Superintendent
Problems with Recycle Pond decant			Contact Technical Services Superintendent
Height of grass (inches)	inches		If more than 1 foot, schedule mowing

Comments: ____

____

APPENDIX C
ENGINEERING INSPECTION FORMS

Dam Inspection Report

Name of Dam ____________________ Dam Identification Number ____________________

Permit Number ____________________ Class of Dam ____________________

Location NW 1/4 Section 11 Township 7N Range 3W 3rd P.M.

Owner ____________________ ____________________
Name Telephone Number (Day)

____________________ ____________________
Street Telephone Number (Night)

____________________ County Montgomery
City Zip Code

Type of Dam ____________________

Type of Spillway ____________________

Date(s) Inspected ____________________

Weather When Inspected ____________________

Temperature When Inspected ____________________

Pool Elevation When Inspected ____________________

Tailwater Elevation When Inspected ____________________

Inspection Personnel:

____
Name Title

____
Name Title

____
Name Title

____
Name Title

Professional Engineer's Seal

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5 (1994 State Bar Edition). Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 702.160 of the "Rules for Construction and Maintenance of Dams". This form has been approved by the State Forms Management Center.

CONDITION CODES

EC	-	Emergency Condition. A serious dam safety condition exists that needs immediate action. Emergency measures implemented as instructed by Chief Dam Safety Engineer; such as, pool draw down, work stoppage, plant stoppage.
NE	-	No evidence of a problem
GC	-	Good condition
MM	-	Item needing minor maintenance and/or repairs within the year, the safety or integrity of the item is not yet imperiled
IM	-	Item needing immediate maintenance to restore or ensure its safety or integrity. Remediation should be completed within 1 month.
EC	-	Emergency condition which if not immediately repaired or other appropriate measures taken could lead to failure of the dam
OB	-	Condition requires regular observation to ensure that the condition does not become worse
NA	-	Not applicable to this dam
NI	-	Not inspected - list the reason for non-inspection under deficiencies
EC	-	Emergency Condition. A serious dam safety condition exists that needs immediate action. Emergency measures implemented as instructed by Chief Dam Safety Engineer; such as, pool draw down, work stoppage, plant stoppage.

GYPSUM STACK - EARTH EMBANKMENT

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Surface Cracks			
Vertical and Horizontal Alignment of Crest			
Unusual movement or Cracking at or Beyond Toe			
Sloughing or Erosion of Outer Embankment Slopes			
Upstream Face Slope Protection (HDPE Liner)			
Seepage			
Animal Damage			

GYPSUM STACK - EARTH EMBANKMENT
(Continued)

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Vegetative Cover			

GYPSUM STACK - GYPSUM EMBANKMENT

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Surface Cracks			
Vertical and Horizontal Alignment of Crest			
Unusual movement or Cracking at or Beyond Toe			
Sloughing or Erosion of **Outside** Embankment Slopes			
Sloughing or Erosion of **Inside** Embankment Slopes			
Seepage			
Animal Damage			

GYPSUM STACK - GYPSUM EMBANKMENT
(Continued)

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Condition of Piezometers on Gypsum Stack			
Piezometer Readings on Gypsum Stack Above Critical Level?			

GYPSUM STACK – PERIMETER DITCH

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Ditch Geometry (15 ft bottom width, 3:1 slopes, 8-9 ft depth)			
Concrete Apron at ring drain outlets			
Ring Drain Discharge Pipes			
Stilling Wells for Fixed Decants			

TRANSFER CHANNEL - (between gypsum stack and recycle pond)

[ ] Drop Inlet Structure   [X] Overflow Spillway Structure   [ ] Gated

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Debris			
Side Slope Stability			
HPDE Liner			
HDPE Liner Welds			
Stop Logs			
Differential Settlement			

RECYCLE POND - EMBANKMENT

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Surface Cracks			
Vertical and Horizontal Alignment of Crest			
Unusual movement or Cracking at or Beyond Toe			
Sloughing or Erosion of Outer Embankment Slopes			
Upstream Face Slope Protection (HDPE Liner)			
Seepage			
Animal Damage			

RECYCLE POND - EMBANKMENT

(Continued)

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Vegetative Cover			

RECYCLE POND - PRINCIPAL SPILLWAY (Left, Looking Downstream)

[X] Drop Inlet Structure [ ] Overflow Spillway Structure [ ] Gated

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Alignment of Structure Walls			
Construction Joints			
Differential Settlement			
Erosion, Spalling, Cavitation			
Joint Separation			
Seepage Around or into Conduit			
Surface Cracks			

RECYCLE POND - PRINCIPAL SPILLWAY (Left, Looking Downstream)

(Continued)

[X] Drop Inlet Structure   [ ] Overflow Spillway Structure   [ ] Gated

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Structural Cracks			

RECYCLE POND - PRINCIPAL SPILLWAY (Center)

[X] Drop Inlet Structure [ ] Overflow Spillway Structure [ ] Gated

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Alignment of Structure Walls			
Construction Joints			
Differential Settlement			
Erosion, Spalling, Cavitation			
Joint Separation			
Seepage Around or into Conduit			
Surface Cracks			

RECYCLE POND - PRINCIPAL SPILLWAY (Center)

(Continued)

X Drop Inlet Structure ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Structural Cracks			

RECYCLE POND - PRINCIPAL SPILLWAY (Right, Looking Downstream)

X Drop Inlet Structure ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Alignment of Structure Walls			
Construction Joints			
Differential Settlement			
Erosion, Spalling, Cavitation			
Joint Separation			
Seepage Around or into Conduit			
Surface Cracks			

RECYCLE POND - PRINCIPAL SPILLWAY (Right, Looking Downstream)

(Continued)

[X] Drop Inlet Structure   [ ] Overflow Spillway Structure   [ ] Gated

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Structural Cracks			

RECYCLE POND - ENERGY DISSIPATOR

[X] Principal Spillway   [ ] Outlet Works   Type: FHWA HEC-14, Riprap Basin

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Riprap			
Outlet Channel			
Debris			

RECYCLE POND - DECANT STRUCTURE

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Alignment			
Connection to Bollard			
Debris in Inlets			
Condition of Pipe			
Condition of Liner Beneath Pipe			
Connection to Ballast			
Connection of Pipe Boot to Liner			

RECYCLE POND - DECANT STRUCTURE

(continued)

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE
Seepage Around or into Conduit			

RECYCLE POND – WATER LEVEL GAGE STRUCTURE

ITEM	CONDITION	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES & SCHEDULE

APPENDIX D
HERBICIDES

HERBICIDES

Site personnel should check with the Illinois Department of Natural Resources, Regional Fisheries Biologist and the Regional Wildlife Biologist before using any herbicide. Read the product label prior to use and follow the use directions and precautions accordingly.

On March 1, 1979 the U.S. Environmental Protection Agency (U.S.E.P.A.) halted the use of the herbicide 2, 4, 5-T in parks and recreation areas. The use of silvex (2, 4, 5-TP) around water has also been banned.

The Agronomy Department at the University of Illinois and the Aquatic Biology Section of the Department of Natural Resources, Office of Scientific Research and Analysis indicate that the herbicides containing the 2, 4-D or 2, 4-DP are legal for use in parks and recreation areas and effective for controlling brush and woody growth. Some examples of approved herbicides are:

1. Tordon RTU by DOW Chemical. (Can be obtained with blue dye.)
2. WEEDONE 170 by Union Carbide
3. WEEDONE, 2, 4-DP by Union Carbide
4. A 1% to 2% solution of ROUNDUP
5. Garlon by DOW Chemical
6. Banvel by Sandoz

Your distributor may carry brand name herbicides other than those listed above. Be certain that the product does not contain the ingredients 2, 4, 5-T or 2, 4, 5-TP. An example of an unacceptable product is ESTERON 2, 4, 5 by DOW Chemical.

APPENDIX E
CONSTRUCTION DRAWINGS

Coffeen Power Station

GMF Recycle Pond

Supporting Documentation

Appendix 6

Recycle Pond Geotechnical Design

By: SPK Date: 10/7/16 **HANSON** Sheet No.: ______ of: ______

Checked by: ______ Date: ______ Engineering | Architecture | Planning | Allied Services Project No.: 16E0098

COFFEEN GMF - RECYCLE POND

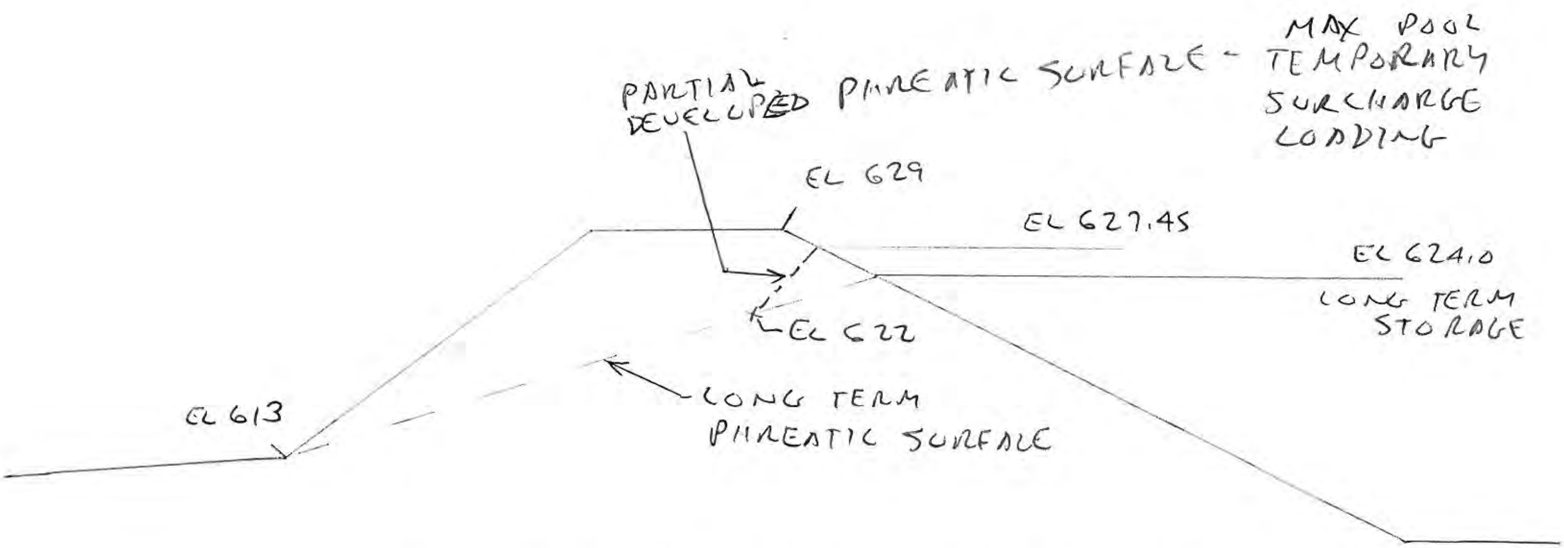
ADDITIONAL ANALYSIS TO INCLUDE "MAXIMUM POOL SURCHARGE LOADING" CASE

USE ORIGINAL SECTION } SOIL PARAMETERS WITH REVISED PHREATIC SURFACE FOR TEMPORARY WATER LEVEL INCREASE IN POND

MAX STAGE LONG TERM STORAGE = EL 624.0

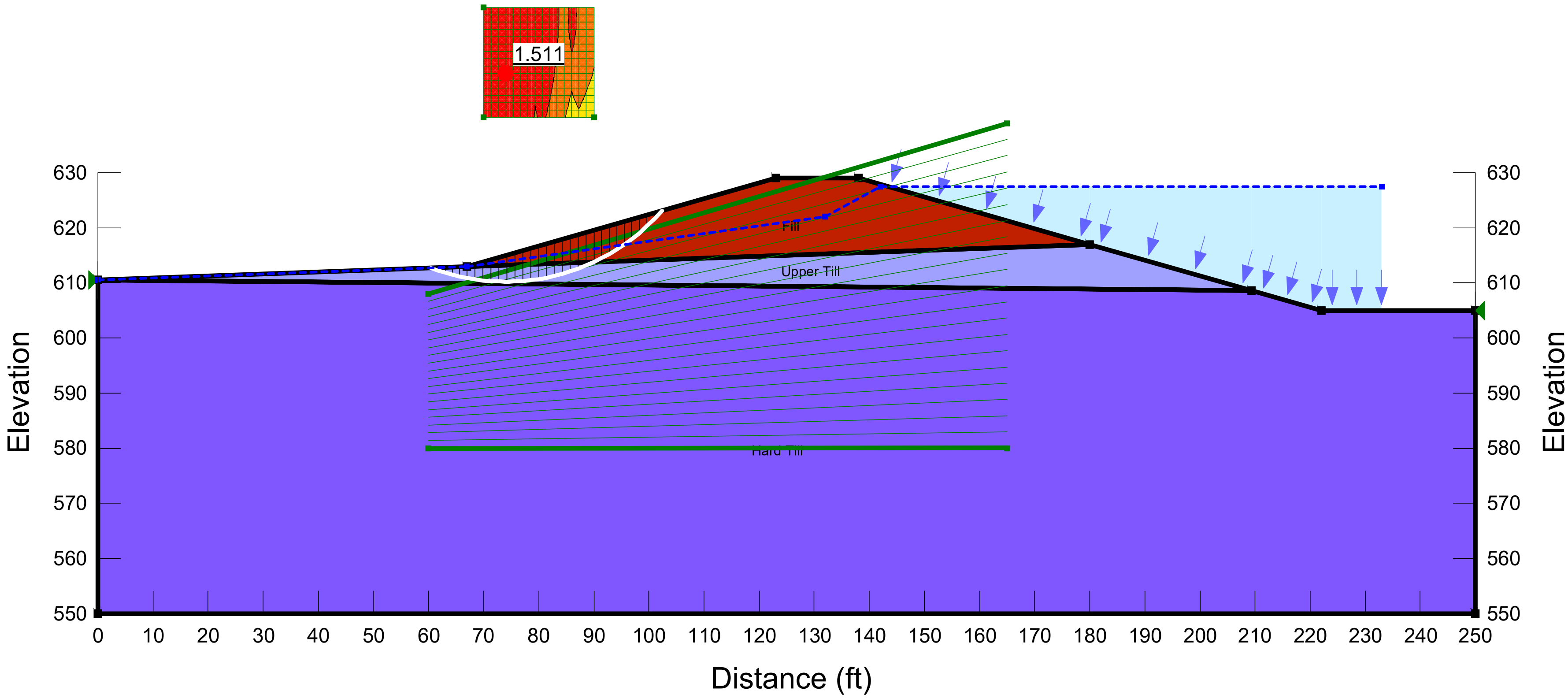
MAX POOL SURCHARGE LOADING = EL 627.45

* POOL IS LINED - ORIGINAL ANALYSIS ALLOWED PHREATIC SURFACE TO DEVELOP IN EMBANKMENT - CONSERVATIVE



CONVERT PC STABLE FILE TO GEOSLOPE - EFFECTIVE STRESS PARAMETERS

FOS = 1.51



FS = 1.511

Material Properties
Name: Hard Till Model: Mohr-Coulomb Unit Weight: 137.7 pcf Cohesion': 0 psf Phi': 34 °
Name: Upper Till Model: Mohr-Coulomb Unit Weight: 126.3 pcf Cohesion': 0 psf Phi': 26 °
Name: Fill Model: Mohr-Coulomb Unit Weight: 121.2 pcf Cohesion': 0 psf Phi': 28.3 °

File Information

- File Version: 8.15
- Title: Coffeen Gypsum Stack Recycle Pond
- Created By: JPK
- Last Edited By: James Knutelski
- Revision Number: 179
- Date: 10/7/2016
- Time: 11:17:09 AM
- Tool Version: 8.15.5.11777
- File Name: RP CCR.gsz
- Directory: I:\05jobs\05S3004A\Gypsum Stacking\Geotechnical\Stability Analyses\CCR Permit Calculation\
- Last Solved Date: 10/7/2016
- Last Solved Time: 11:17:23 AM

Project Settings

- Length(L) Units: Feet
- Time(t) Units: Seconds
- Force(F) Units: Pounds
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D
- Element Thickness: 1

Analysis Settings

Slope Stability - Spencer's Circle

- Description: CCR Calculations - Spencer's Circle
- Kind: SLOPE/W
- Method: Spencer
- Settings
  - PWP Conditions Source: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Grid and Radius
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution
  - F of S Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - F of S Tolerance: 0.01
  - Minimum Slip Surface Depth: 0.1 ft
  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3
  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

Hard Till

- Model: Mohr-Coulomb
- Unit Weight: 137.7 pcf
- Cohesion': 0 psf

Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Upper Till

Model: Mohr-Coulomb
Unit Weight: 126.3 pcf
Cohesion': 0 psf
Phi': 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Fill

Model: Mohr-Coulomb
Unit Weight: 121.2 pcf
Cohesion': 0 psf
Phi': 28.3 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (70, 660) ft
Lower Left: (70, 640) ft
Lower Right: (90, 640) ft
Grid Horizontal Increment: 15
Grid Vertical Increment: 15
Left Projection Angle: 0 °
Right Projection Angle: 0 °

Slip Surface Radius

Upper Left Coordinate: (60, 608) ft
Upper Right Coordinate: (165, 639) ft
Lower Left Coordinate: (60, 580) ft
Lower Right Coordinate: (165, 580) ft
Number of Increments: 20
Left Projection: No
Left Projection Angle: 135 °
Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (0, 610.5) ft
Right Coordinate: (250, 605) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	610.5
Coordinate 2	67	613
Coordinate 3	132	622
Coordinate 4	142	627.45
Coordinate 5	233	627.45

Seismic Coefficients

Horz Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	0	610.5

Point 2	67	613
Point 3	123	629
Point 4	138	629
Point 5	180	617
Point 6	209.4	608.6
Point 7	222	605
Point 8	250	605
Point 9	0	550
Point 10	250	550

Regions

	Material	Points	Area (ft²)
Region 1	Fill	2,3,4,5	882
Region 2	Upper Till	1,2,5,6	858.8
Region 3	Hard Till	1,6,7,8,10,9	14,725

Current Slip Surface

Slip Surface: 2,082
F of S: 1.511
Volume: 170.84561 ft³
Weight: 21,014.839 lbs
Resisting Moment: 281,851.92 lbs-ft
Activating Moment: 186,715.82 lbs-ft
Resisting Force: 6,912.6018 lbs
Activating Force: 4,568.3618 lbs
F of S Rank (Analysis): 1 of 5,376 slip surfaces
F of S Rank (Query): 1 of 5,376 slip surfaces
Exit: (60.42455, 612.75465) ft
Entry: (102.4157, 623.11877) ft
Radius: 37.769402 ft
Center: (74, 648) ft

Slip Slices

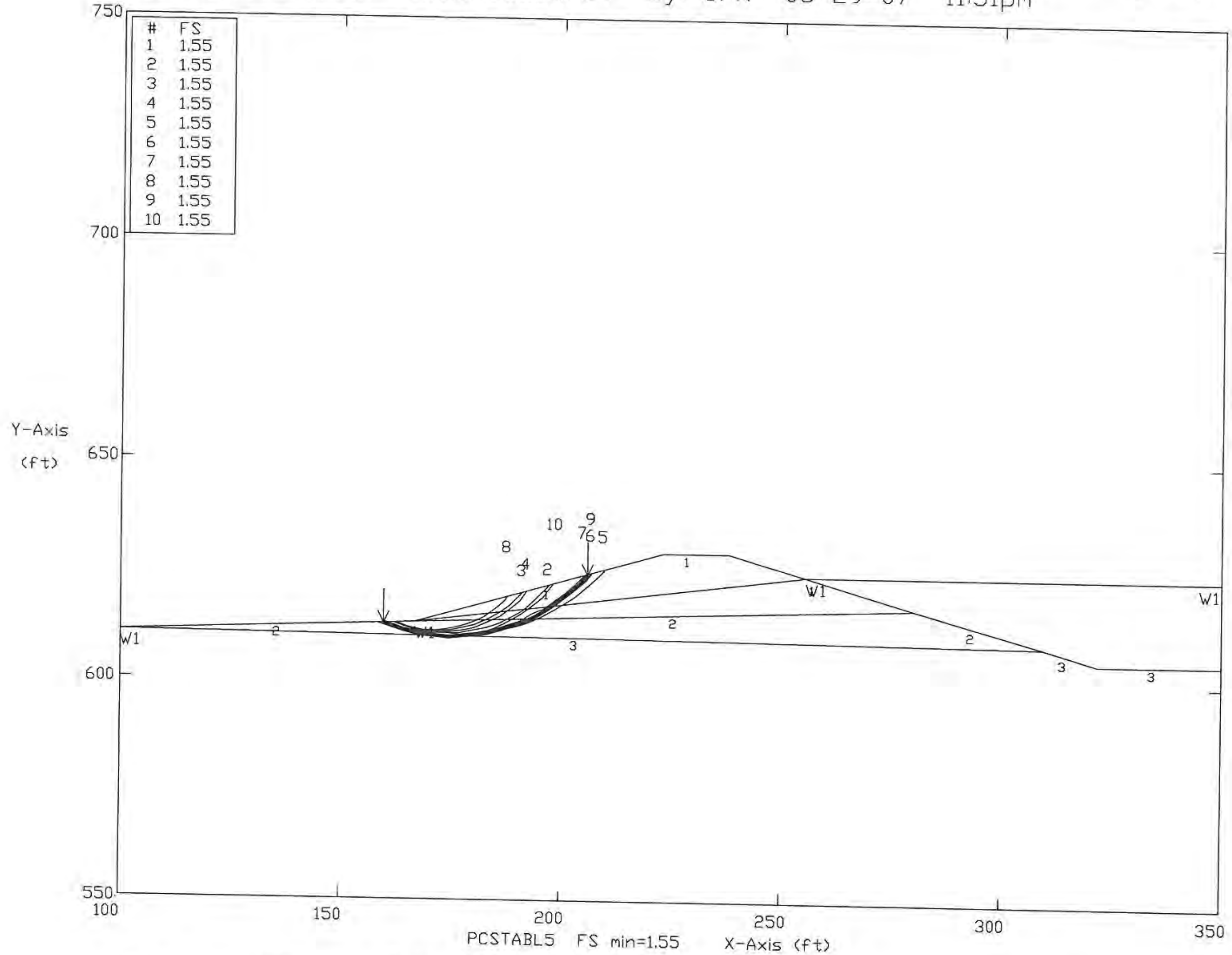
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	61.082095	612.51527	16.467908	41.893608	12.400942	0
Slice 2	62.397185	612.0636	47.714465	118.5033	34.52602	0
Slice 3	63.712275	611.66512	75.641429	183.6978	52.702615	0
Slice 4	65.027365	611.31811	100.35715	238.64295	67.44649	0
Slice 5	66.342455	611.0211	121.95217	284.2852	79.17511	0
Slice 6	67.720707	610.76341	145.79043	348.28195	98.761712	0
Slice 7	69.16212	610.54877	171.63741	428.69871	125.37717	0
Slice 8	70.603533	610.39059	193.96201	498.18168	148.37785	0
Slice 9	72.044947	610.28814	212.80864	557.48925	168.11196	0
Slice 10	73.48636	610.24097	228.20565	607.24539	184.87003	0
Slice 11	74.927773	610.24888	240.16599	647.96397	198.89636	0
Slice 12	76.369187	610.3119	248.68748	680.06713	210.39791	0

Slice 13	77.8106	610.4303	253.7528	703.89948	219.55121	0
Slice 14	79.252013	610.60462	255.32908	719.73881	226.50776	0
Slice 15	80.693427	610.83564	253.36714	727.80428	231.39845	0
Slice 16	82.13484	611.12443	247.80037	728.26262	234.3371	0
Slice 17	83.576253	611.47237	238.54313	721.23259	235.42338	0
Slice 18	85.017667	611.88115	225.48859	706.78804	234.74543	0
Slice 19	86.45908	612.35289	208.50587	684.95968	232.38205	0
Slice 20	87.900493	612.89013	187.43633	655.73569	228.40486	0
Slice 21	89.341907	613.49592	162.08864	619.06104	222.88033	0
Slice 22	90.742055	614.15245	133.21854	574.53695	237.62548	0
Slice 23	92.10094	614.85963	100.83142	528.2856	230.16036	0
Slice 24	93.459824	615.63931	63.920075	475.23611	221.47086	0
Slice 25	94.818708	616.49689	22.147636	415.17365	211.6227	0
Slice 26	96.189905	617.44832	-25.37468	350.37398	188.65695	0
Slice 27	97.573416	618.5036	-79.270335	281.91562	151.79592	0
Slice 28	98.956927	619.66575	-139.83493	207.80286	111.89031	0
Slice 29	100.34044	620.94863	-207.93289	128.08956	68.969124	0
Slice 30	101.72395	622.37049	-284.70348	42.894235	23.096166	0

Coffeen Recycle Pond Section C-C Steady State, c=0

Ten Most Critical. J:CRPCSS01.PLT By: JPK 08-29-07 11:51pm

8/29/07



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	0	28.3	0	0	1
2	126.3	126.3	0	26	0	0	1
3	137.7	137.7	0	34	0	0	1

** PCSTABL5 **

by
Purdue University

1

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

Run Date:	08-29-07
Time of Run:	11:51pm
Run By:	JPK
Input Data Filename:	J:CRPCSS01
Output Filename:	J:CRPCSS01.OUT
Plotted Output Filename:	J:CRPCSS01.PLT

PROBLEM DESCRIPTION Coffeen Recycle Pond
Section C-C Steady State, c=0

BOUNDARY COORDINATES

7 Top Boundaries
9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	60.50	67.00	63.00	2
2	67.00	63.00	123.00	79.00	1
3	123.00	79.00	138.00	79.00	1
4	138.00	79.00	180.00	67.00	1
5	180.00	67.00	209.40	58.60	2
6	209.40	58.60	222.00	55.00	3
7	222.00	55.00	250.00	55.00	3
8	67.00	63.00	180.00	67.00	2
9	.00	60.50	209.40	58.60	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.

1	121.2	121.2	.0	28.3	.00	.0	1
2	126.3	126.3	.0	26.0	.00	.0	1
3	137.7	137.7	.0	34.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	60.50
2	67.00	63.00
3	155.50	74.00
4	250.00	74.00

1

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

2000 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 50.00 ft.
and X = 75.00 ft.

Each Surface Terminates Between X = 80.00 ft.
and X = 125.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

COFEEN GYPSUM MANAGEMENT FACILITY
RECYCLE POND
GEOTECHNICAL DESIGN

INTRODUCTION

The fundamental design criteria of the recycle pond dam is based on the need to provide for safe operation and maintenance of the dam and the minimization of potential failure mechanisms common to earthen dams. The geotechnical and structural evaluations of the dam embankment is required in order to ensure the structure will be stable for the life of the dam and its intended use. Additionally, the design must also incorporate hydrologic and hydraulic evaluations to ensure that the dimensions of the dam and appurtenances are adequate to prevent damage to the dam during normal operations and extreme rainfall events.

GEOTECHNICAL EVALUATION

Stability analyses were performed for the proposed recycle pond design. The analyses were performed using the program PCSTABL5 that was developed at Purdue University. At the location of the proposed recycle pond, the critical elements for stability are the earthen berms.

The soil parameters used for the preliminary stability analyses were selected using data obtained during the geotechnical investigation of the recycle pond (the Site). Soil parameters for the interfaces between proposed manufactured lining materials and soils, at the interfaces between layers of manufactured lining materials, and within lining materials were selected based on values obtained from engineering literature.

During the analyses for the recycle pond, the location of the phreatic surface was modeled assuming that there is no synthetic lining within the proposed construction (a highly conservative assumption). For this assumption, the phreatic surface would develop through the embankment sections over time.

In the above condition, the development of the phreatic surface through the earthen materials is highly unlikely since the inside of the recycle pond will be lined with highly impermeable synthetic materials.

SELECTION OF CRITICAL EMBANKMENT SECTION

At the proposed recycle pond location, the section which would have the highest embankment height, Section C-C, was judged to be the most critical. The location and geometry of Section C-C are shown on Figure 4-3.

STABILITY OF EARTHEN BERM (SECTION C-C)

At Section C-C, analyses were performed for a long term steady-state-seepage condition (drained soil parameters), and a seismic loading condition using rapid load soil parameters for the downstream slope.

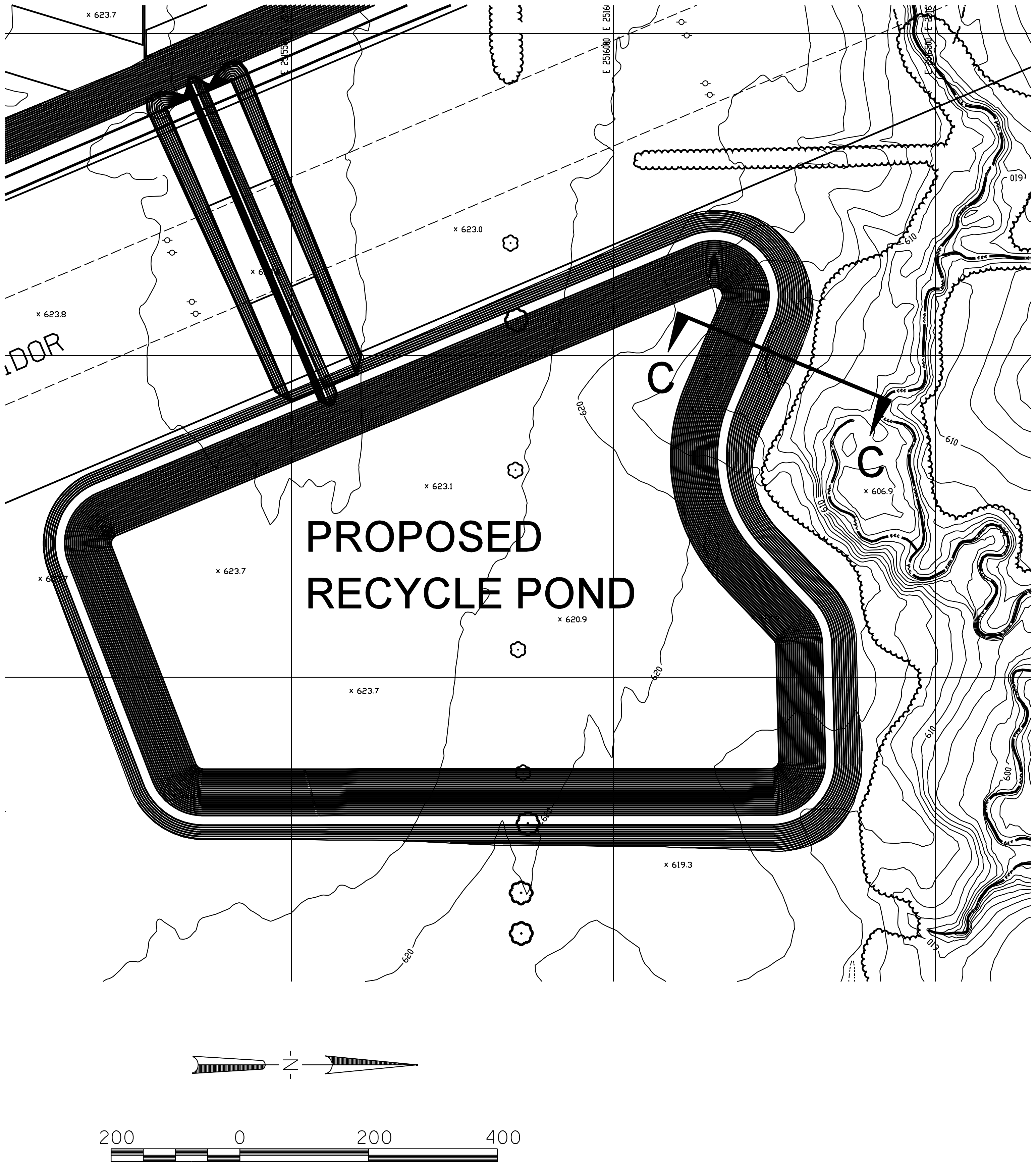
Analyses assessing the stability for short term conditions (end of construction, undrained soil parameters) were performed for the upstream and downstream slopes.

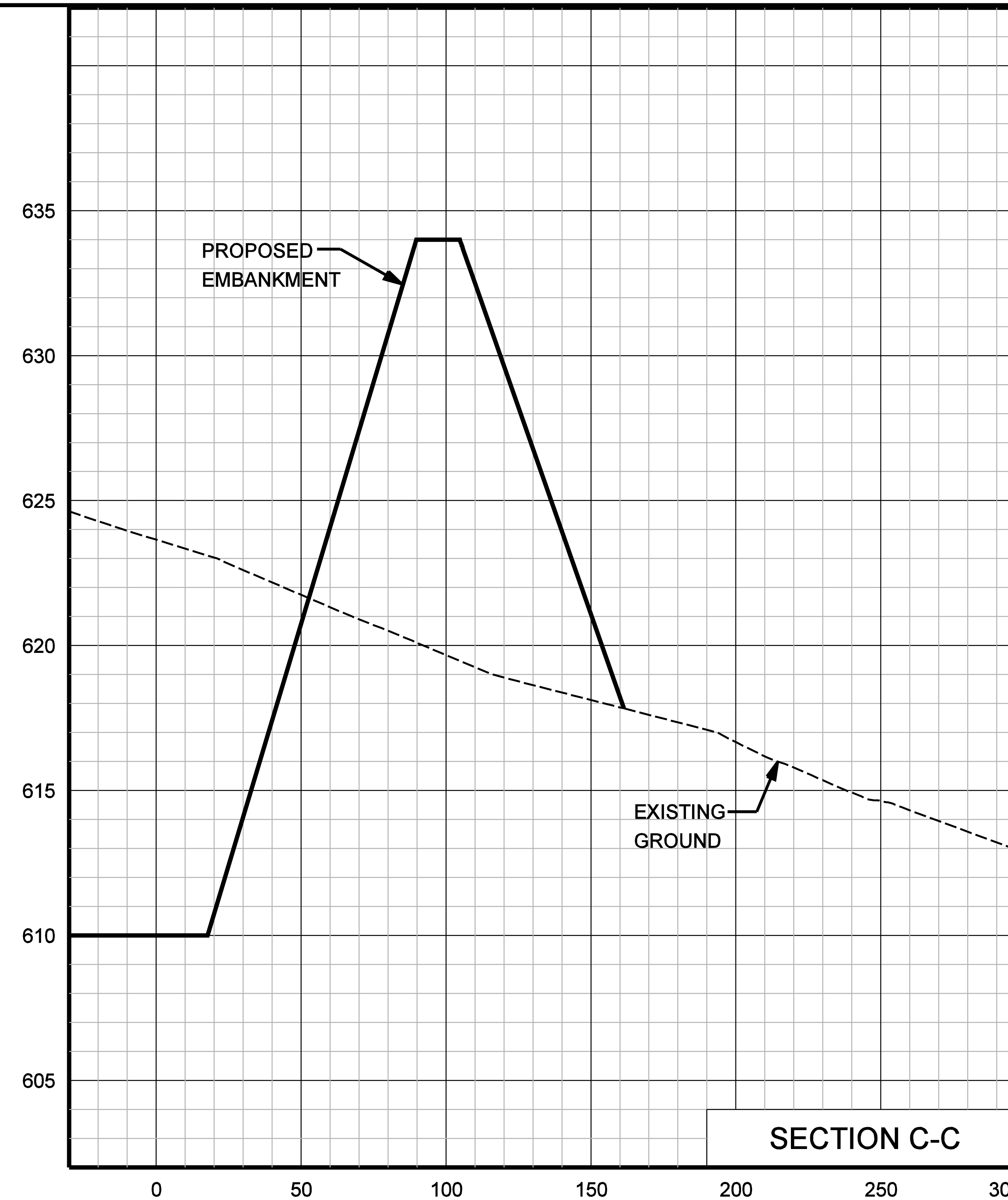
A final analysis modeling a rapid drawdown condition of Section C-C was also performed. For this condition, rapid load soil parameters were used in the analysis. Although possible, this condition is highly unlikely at this location since the inside of the recycle pond will be lined with highly impermeable synthetic materials.

A summary of the factors of safety for the global stability analyses for Section C-C is provided in Table . An expanded summary of the stability analyses for Section C-C and figures showing the analyzed cross sections are included in Appendix A.

TABLE 1: Recycle Pond Earthen Berm (Section C-C) Stability Analyses Factors of Safety

File Name	Failure Condition	Strength Duration	F.S.
CRPCSS01	Steady-State (Static) c=0	Long-Term	1.55 > 1.5
CRPCSS02	Steady-State (Static) ϕ=0	Short-Term	8.75 > 1.5
CRPCSZ01	Steady-State (Seismic)	Rapid Load	1.80 > 1.0
CRPCECD1	End of Construction (Static) => DSslope	Short-Term	8.75 > 1.3
CRPCECU1	End of Construction (Static) => USslope	Short-Term	8.49 > 1.3
CRPCRD01	Rapid Drawdown (Static)	Rapid Load	3.27 > 1.2





HANSON
Hanson Professional Services Inc.

RECYCLE POND - SECTION C-C

GYPSUM MANAGEMENT FACILITY
COFFEEN POWER GENERATING STATION
MONTGOMERY COUNTY, ILLINOIS

HANSON NO. 05S3004A

FIGURE 4-3

08/30/2007, 03:09 PM
i:\05Jobs\05s3004a\Gypsum Stacking\CADD\SHEETS\Section 4 - App A - Sections.dgn

Coffeen Power Station Gypsum Management Facility

Recycle Pond

Information Required by 40 CFR 257.73(e)(1)

Appendix A

Stability Calculations

Ameren Coffeen Final Summary for Stability of Recycle Pond - Cross-Section C-C

Material Type	Soil Type	γ_{sat} (pcf)	Undrained		Drained		Rapid Load	
			c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)	c (psf)	ϕ (deg)
Fill (Silty Clay)	1 (Embankment)	121.2	1950	0	0	28.3	500	14.8
Upper Till	2 (Foundation)	126.3	1810	0	0	26.0	590	14.9
Hard Till	3 (Foundation)	137.7	5300	0	0	34.0	2000	22.0

File Name	Failure Condition	Strength Duration	F.S.
CRPCSS01	Steady-State (Static) c=0	Long-Term	1.55 > 1.5
CRPCSS02	Steady-State (Static) ϕ=0	Short-Term	8.75 > 1.5
CRPCSZ01	Steady-State (Seismic)	Rapid Load	1.80 > 1.0
CRPCECD1	End of Construction (Static) => DSslope	Short-Term	8.75 > 1.3
CRPCECU1	End of Construction (Static) => USslope	Short-Term	8.49 > 1.3
CRPCRD01	Rapid Drawdown (Static)	Rapid Load	3.27 > 1.2

Assumptions:

For the stability of the recycle pond, the following assumptions were made while performing the analyses:

The end of construction analyses were performed using the short term soil conditions.

The steady state analyses were performed using short term and long term soil soncditions.

The seismic and rapid drawdown analyses were performed using rapid load soil conditions.

Rapid loading soil condition = consolidated undrained strength parameters.

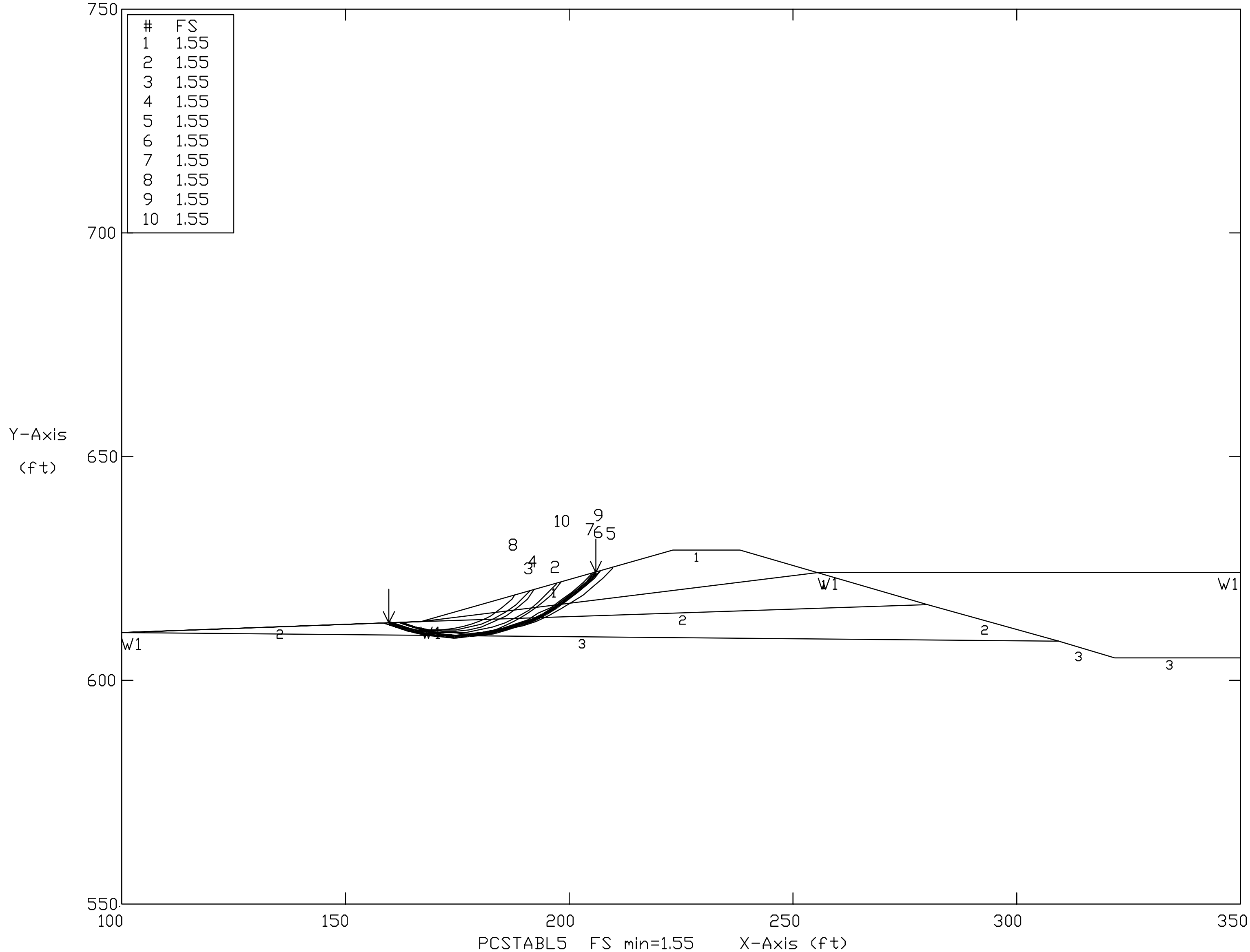
a = 0.23g for 2% in 50 yr exceedance - USGS 2003 Hazard Map

Section C-C critical for pond => Tallest compacted embankment

Section C-C => 3.5:1 Earth Slopes

Coffeen Recycle Pond Section C-C Steady State, c=0

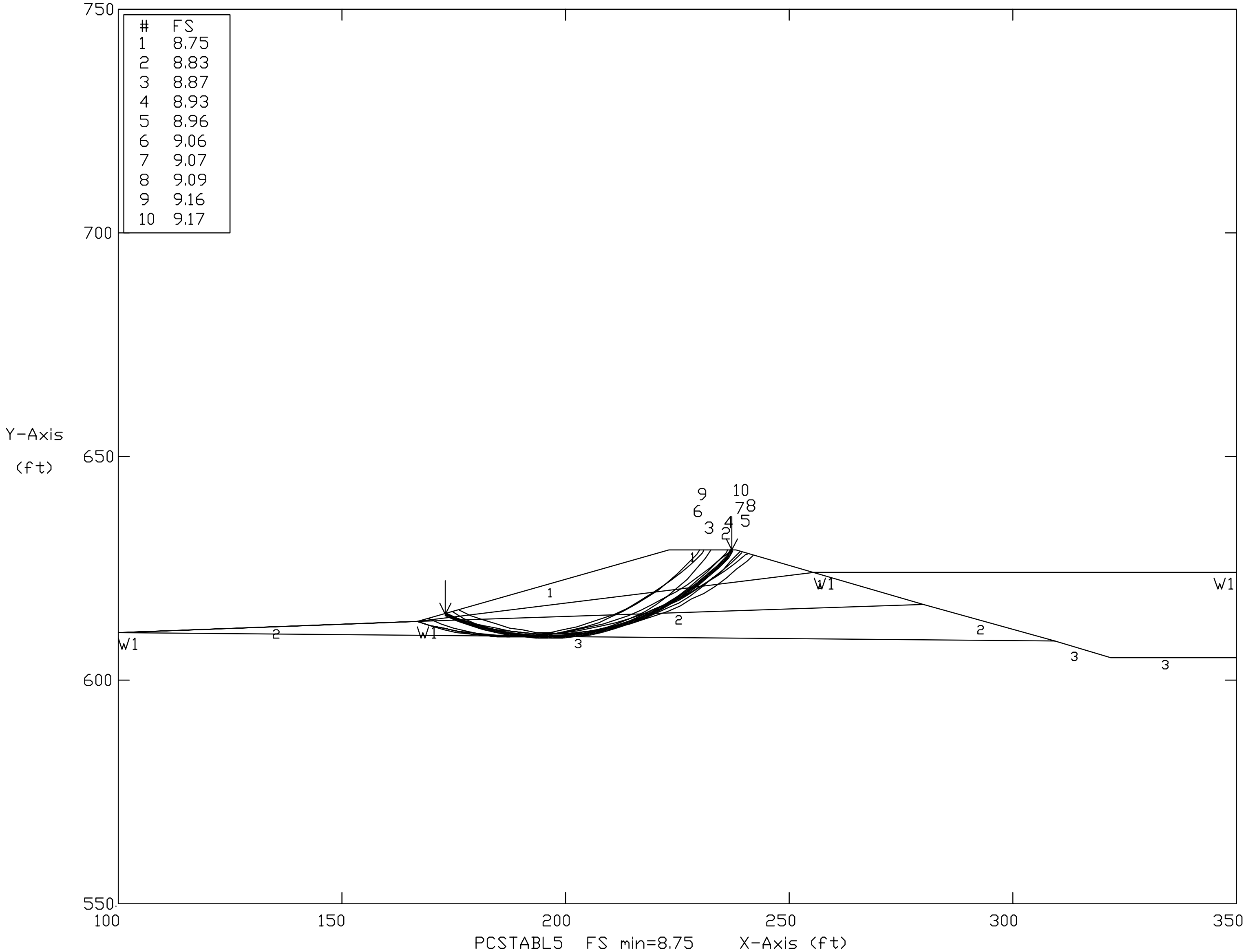
Ten Most Critical. J:CRPCSS01.PLT By: JPK 08-29-07 11:51pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	0	28.3	0	0	1
2	126.3	126.3	0	26	0	0	1
3	137.7	137.7	0	34	0	0	1

Coffeen Recycle Pond Section C-C Steady State, phi=0

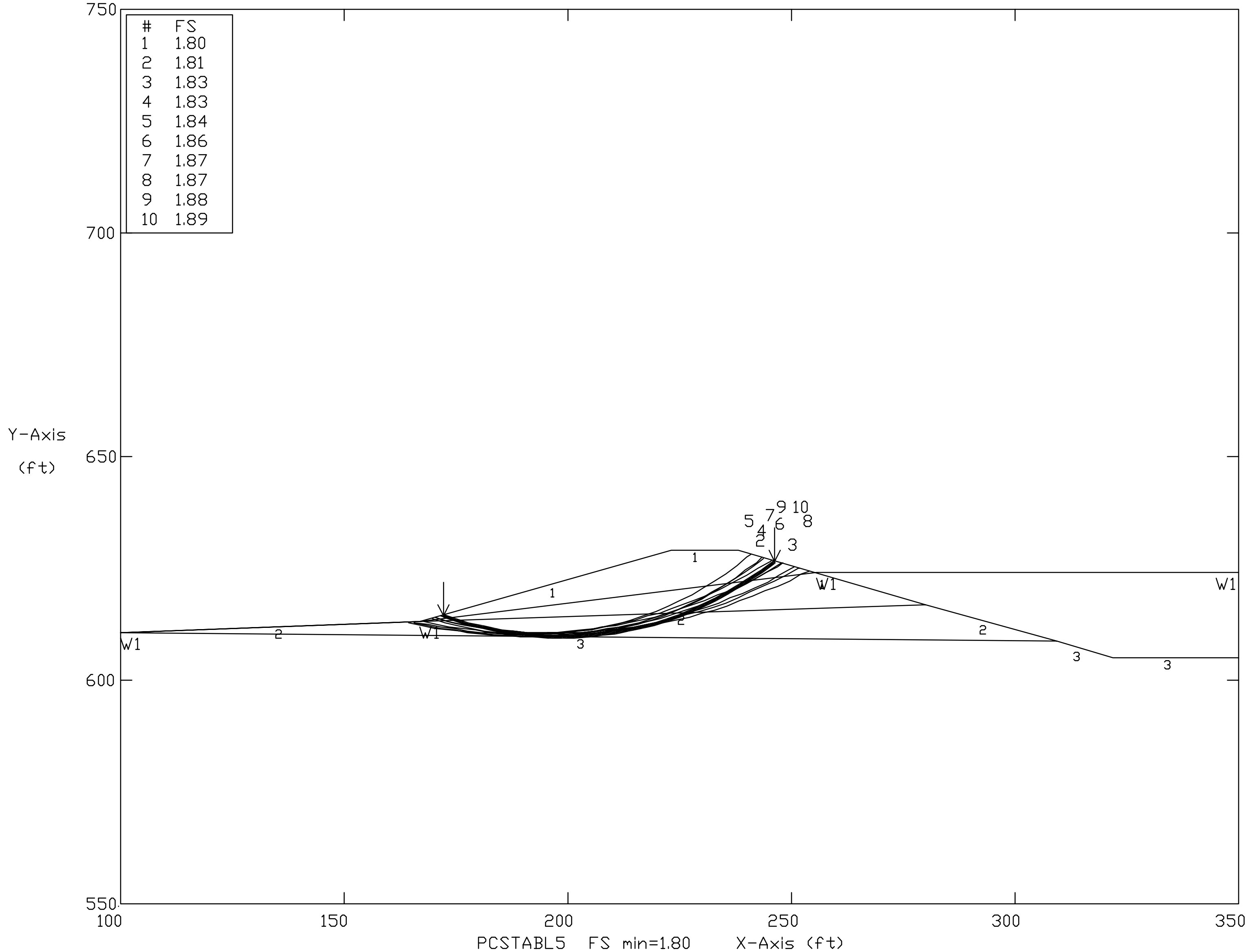
Ten Most Critical. J:CRPCSS02.PLT By: JPK 08-29-07 11:56pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	1950	0	0	0	1
2	126.3	126.3	1810	0	0	0	1
3	137.7	137.7	5300	0	0	0	1

Coffeen Recycle Pond Section C-C Seismic

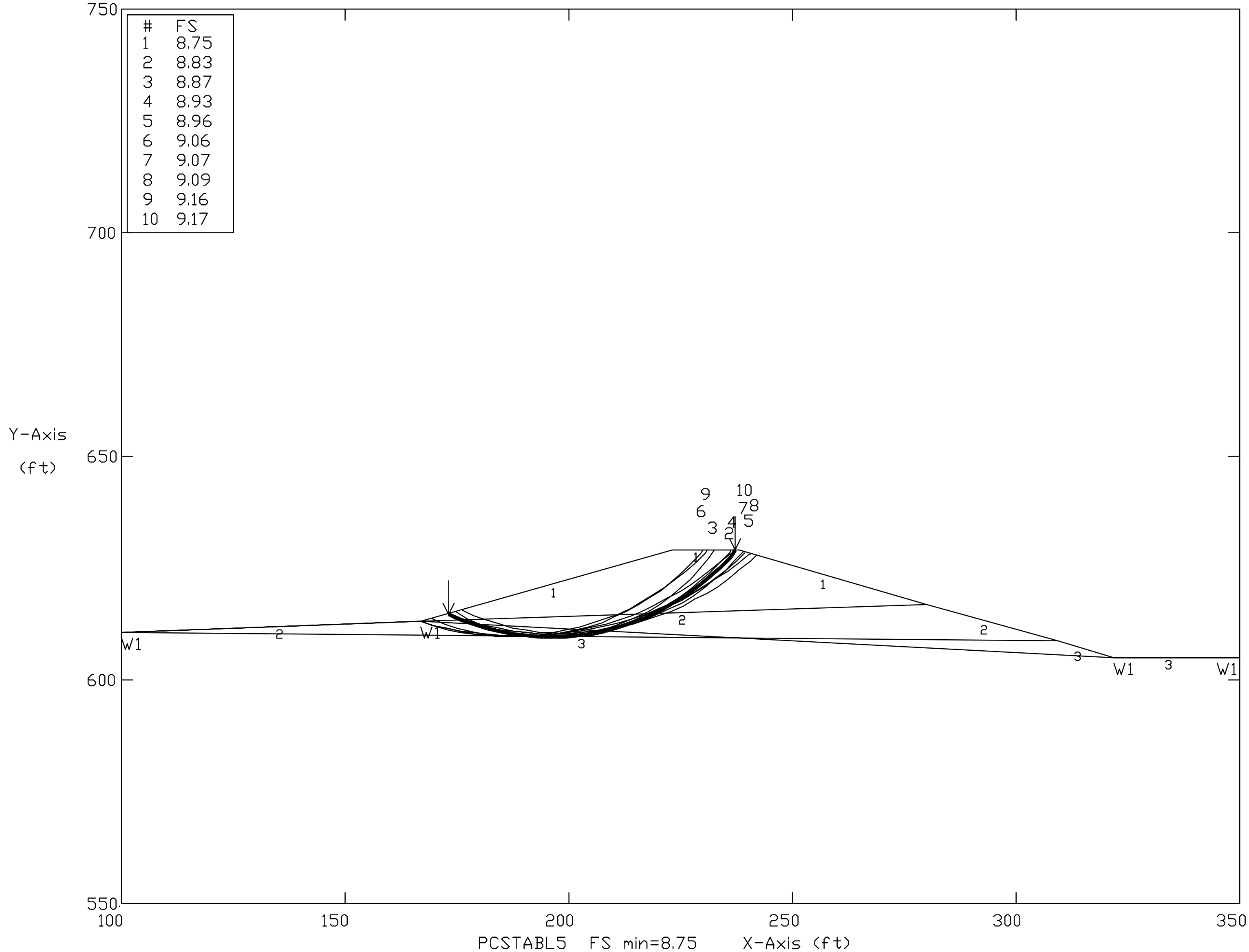
Ten Most Critical. J:CRPCSZ01.PLT By: JPK 08-29-07 11:58pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	500	14.8	0	0	1
2	126.3	126.3	590	14.9	0	0	1
3	137.7	137.7	2000	22	0	0	1

Coffeen Recycle Pond Section C-C EOC, Downstream Slope

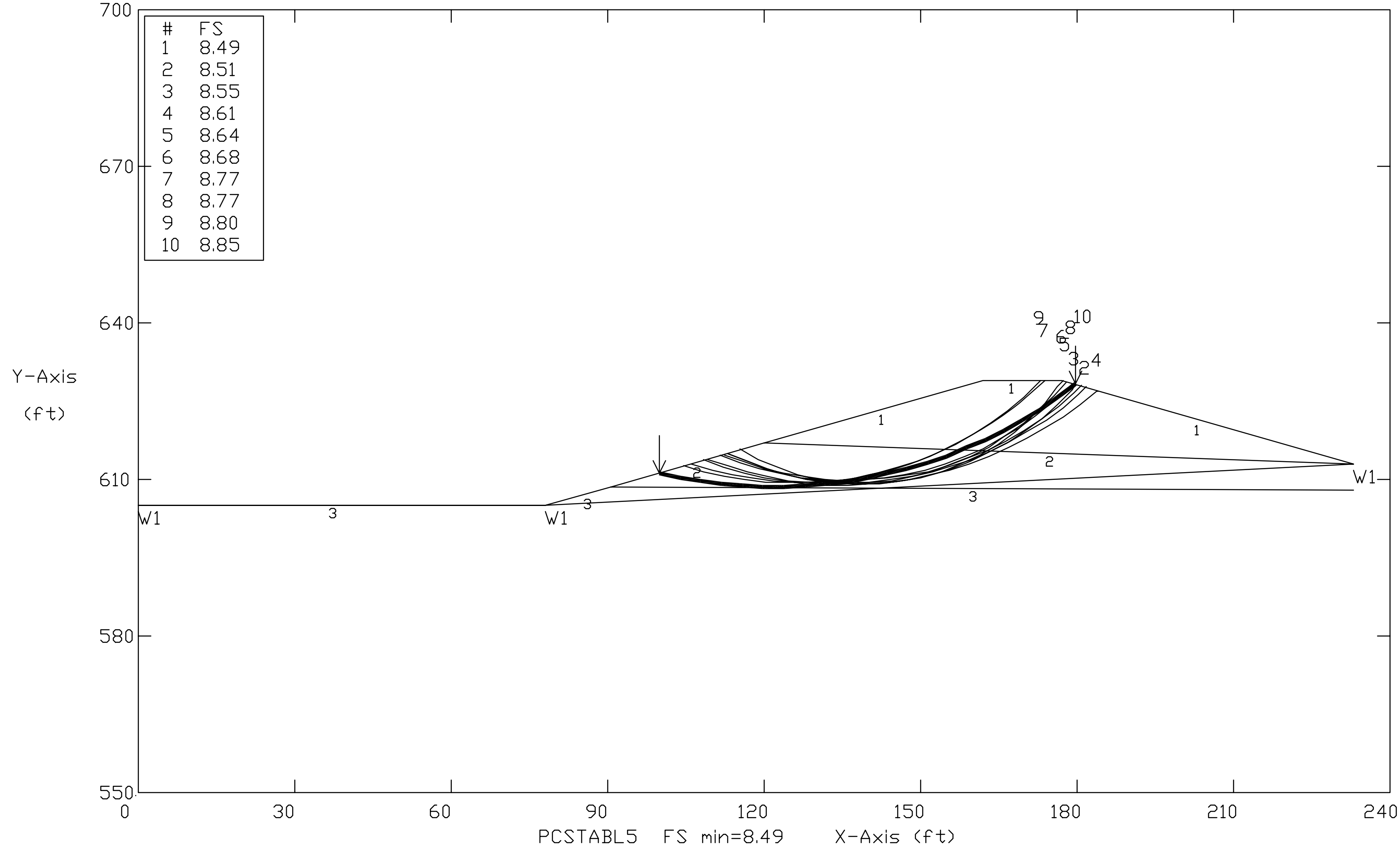
Ten Most Critical. J:CRPCECD1.PLT By: JPK 08-29-07 11:01pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	1950	0	0	0	1
2	126.3	126.3	1810	0	0	0	1
3	137.7	137.7	5300	0	0	0	1

Coffeen Recycle Pond Section C-C EOC Upstream Slope

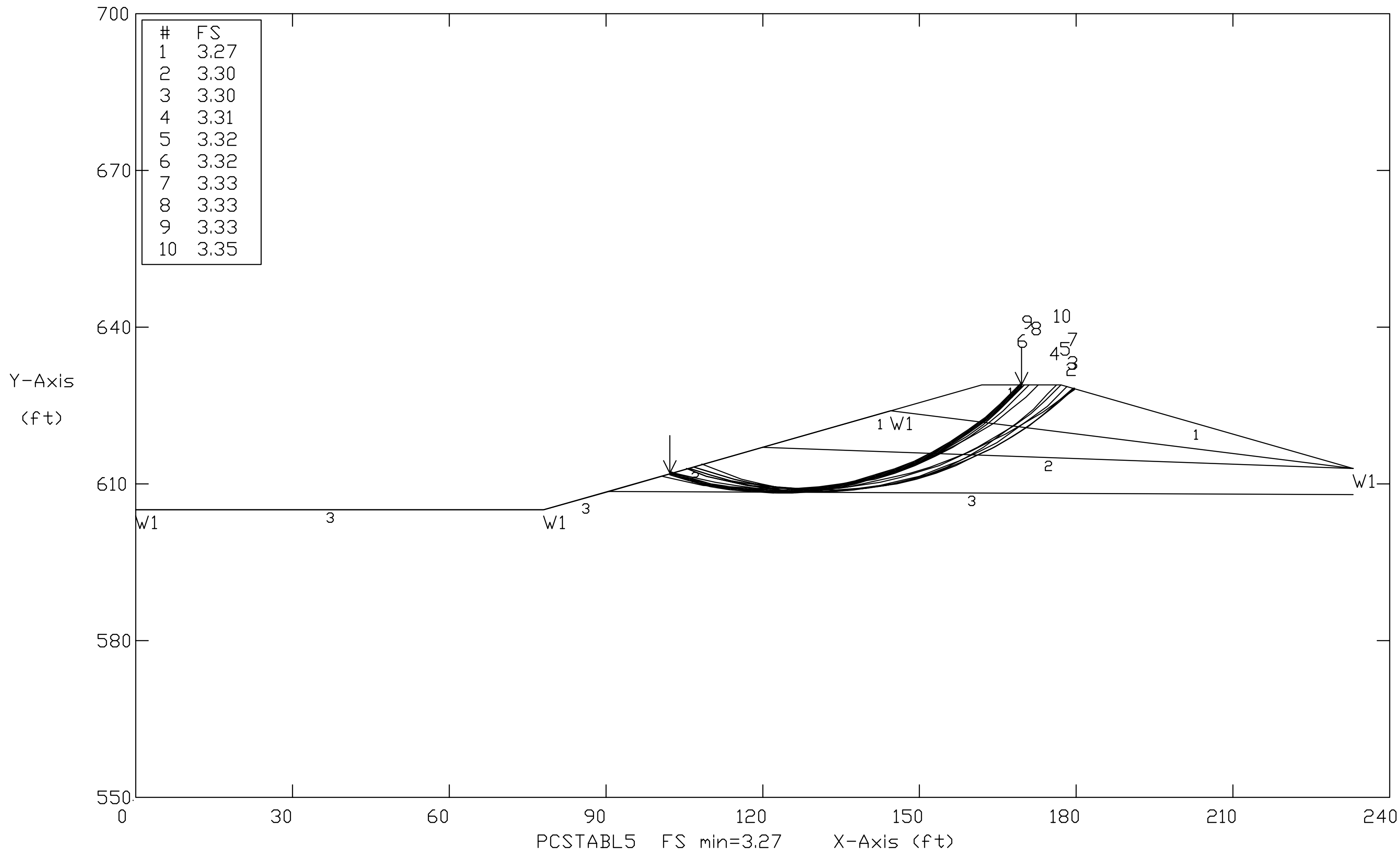
Ten Most Critical. J:CRPCECU1.PLT By: JPK 08-29-07 10:58pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	1950	0	0	0	1
2	126.3	126.3	1810	0	0	0	1
3	137.7	137.7	5300	0	0	0	1

Coffeen Recycle Pond Section C-C Rapid Drawdown

Ten Most Critical. J:CRPCRD01.PLT By: JPK 08-29-07 11:33pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	500	14.8	0	0	1
2	126.3	126.3	590	14.9	0	0	1
3	137.7	137.7	2000	22	0	0	1

Coffeen Power Station Gypsum Management Facility

Recycle Pond

Information Required by 40 CFR 257.73(e)(1)

Appendix B

Liquefaction Analysis

COFFEEN RECYCLE POND - LIQUEFACTION

ANALYSIS REQUIRED FOR CCR RULE CHANGES

2475 YR EVENT @=0.202g M=7.7

SOIL PROFILE: SB-20 @ POND NOT DRILLED / SB-12 @ G.S. CLOSEST BORING ⇒ ONLY 20' OF GEOTECH SOIL PARAMETERS / SB-1 GROUND SURFACE BELOW LOW POINT IN CRITICAL SECTION OUTSIDE POND - (STABILITY ANALYSIS SECTION C-C) / SB-15 HAS GEOTECH PARAMETERS TO EOB @ 84' DEPTH

* USE SB-12 AS STARTING POINT FOR PROFILE & SUPPLEMENT WITH OTHER DATA

SB-12 0-10' NO LIQ ⇒ Qu > 1.0

10-13.6 CLAYEY SAND Qu 0.19 & 0.62 - MARGINAL

13.6-20 NO LIQ ⇒ Qu > 3.0

20-50 NO LIQ ⇒ CLAYEY SILT

50-84 NO LIQ ⇒ Qu > 3.0 IN SB-15

AT SB-13 SILTY SAND N=18 Qu=1.55 12.5-15.0 FT > NO LIQ
SANDY SILT N>50 15.0-16.0

AT SB-15 SILTY SAND N=9 Qu=1.22 13.8-14.0 > NO LIQ
SILTY SAND N>50 16-17.8

* LAYER FROM 10-13.6 @ SB-12 APPEARS TO BE ISOLATED & IS ≈ 400' FROM CRITICAL DAM SECTION

* AVG STRENGTH OF CLAYEY SAND = 0.40 TSF & IS > THAN POST LIQUEFACTION STRENGTH OF SAND WITH N<10.

* STABILITY ANALYSIS FOR RECYCLE POND ASSUMED C=950 FOR THIS LAYER = BASED ON SOIL PARAMETERS FOR SITE

* LIQUEFACTION ANALYSIS FOR SAND WITH N=4 & N=5 SHOWS FOS < 1.0 FOR SB-12 PROFILE, WITH N=9 (SB-15) FOS > 1.0

** PROFILE @ RECYCLE POND CRITICAL SECTION NOT CONSIDERED LIQUEFIABLE DUE TO COHESION, % FINES & SINGLE DATA POINT WITH LOW STRENGTH

Liquefaction Spreadsheet **Boring B-12 & 15**

Rig		
$\gamma_{avg.\ (pcf)}$	125.1	
$\gamma_{w\ (pcf)}$	62.4	
D_{GWTDD} (ft)	7.0	
D_{GWTDE} (ft)	7.0	
SPT $_{HEC}$ - C_{60}	1.00	
Ground Surface El.	622.0	
M =	7.700	
MSF =	0.935	
a_{max} =	0.202	

$D_{(ft)}$	N	% Fines	$\sigma_{v\ (ksf)}$	$\sigma_v'{}_{dd}$ (ksf)	EFF. O/B CORR. Cn	$N_{1(60)}$	$N1_{(60CF)}$	$\sigma_v'{}_{eq\ (ksf)}$	$CRR_{7.5}$	K_C	CRR_{COR}	r_d	Ave. CSR	FOS
10.0	4	35.0	1.25	1.06	1.37	5	11	1.06	0.119	1.00	0.111	0.977	0.151	**0.74**
12.0	5	35.0	1.50	1.19	1.30	6	12	1.19	0.130	1.00	0.121	0.972	0.161	**0.75**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!	1.000	######	**######**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!	1.000	######	**######**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!	1.000	######	**######**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!	1.000	######	**######**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!	1.000	######	**######**

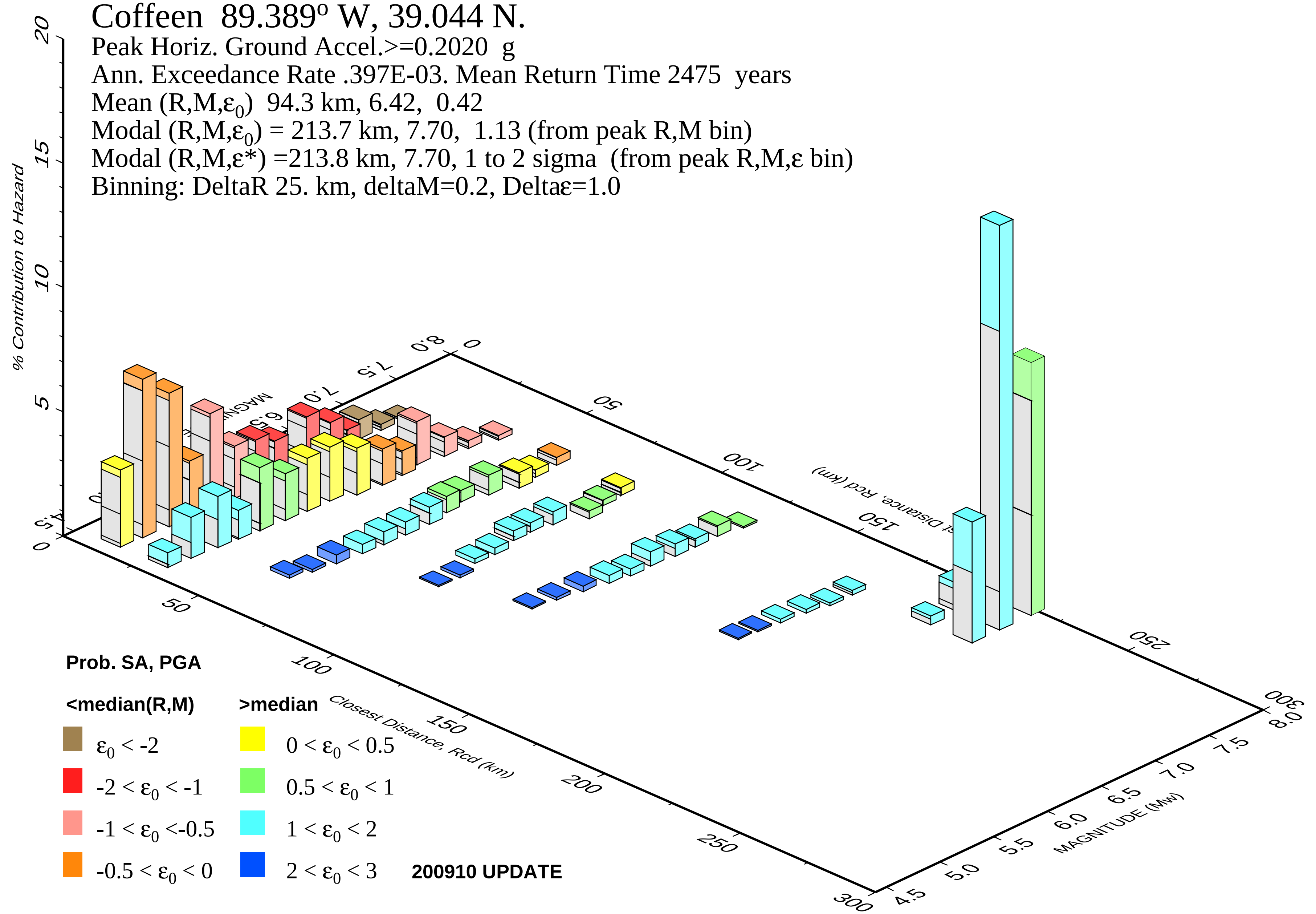
Liquefaction Spreadsheet **Boring B-12 & 15**

Rig			D_{GWTDD} (ft)				7.0							M =	7.700
$\gamma_{avg.\ (pcf)}$		125.1	D_{GWTDE} (ft)				7.0							MSF =	0.935
$\gamma_{w\ (pcf)}$		62.4	SPT $_{HEC}$ - C_{60}				1.00		Ground Surface El.				622.0	a_{max} =	0.202
$D_{(ft)}$	N	% Fines	$\sigma_{v\ (ksf)}$	σ'_{vdd} (ksf)	EFF. O/B CORR. Cn	$N_{1(60)}$	$N1_{(60CF)}$	$\sigma'_{veq\ (ksf)}$	$CRR_{7.5}$	K_C	CRR_{COR}		r_d	Ave. CSR	FOS
10.0	9	35.0	1.25	1.06	1.37	12	19	1.06	0.205	1.00	0.192		0.977	0.151	**1.27**
12.0	9	35.0	1.50	1.19	1.30	12	19	1.19	0.205	1.00	0.192		0.972	0.161	**1.19**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!		1.000	######	**######**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!		1.000	######	**######**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!		1.000	######	**######**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!		1.000	######	**######**
			0.00	0.00	#DIV/0!	######	######	0.00	######	1.00	#DIV/0!		1.000	######	**######**

PSH Deaggregation on NEHRP BC rock

Coffeen 89.389° W, 39.044 N.

Peak Horiz. Ground Accel.>=0.2020 g
Ann. Exceedance Rate .397E-03. Mean Return Time 2475 years
Mean (R,M,ε_0) 94.3 km, 6.42, 0.42
Modal (R,M,ε_0) = 213.7 km, 7.70, 1.13 (from peak R,M bin)
Modal (R,M,ε^*) =213.8 km, 7.70, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0



GMT 2016 Jan 25 15:42:11 Distance (R), magnitude (M), epsilon (E0,E) deaggregation for a site on rock with average vs= 760. m/s top 30 m. USGS CGHT PSHA2008 UPDATE Bins with lt 0.05% contrib. omitted

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/3/2006
Finish: 5/3/2006
WEATHER: Overcast, mild (mid-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS sampler
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-01
Well ID: MW1D
Surface Elev: 607 ft. MSL
Completion: 40 ft. BGS
Station: 874,972.6N
2,513,478.0E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 10, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 34.00 - While drilling
▼ =
▽ = 36.28 - MW01D on 6/1/06

SAMPLE: Number	Recov / Total (in) *% Recovery*	Type	TESTING: Blows / 6 in *N - Value* **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
1A	16/24 *67%*	SS	*1-1 1-2* N=2	22		0.78 *B*	0–1.7	Very dark gray (10YR3/1), clayey SILT, trace sand	606	
2A	20/24 *83%*	SS	*2-3 5-5* N=8	13		3.71 *BSh*	1.7–4	Light gray (10YR7/1) with 40% yellowish brown (10YR5/8) mottles, clayey SILT, trace sand and gravel	604	
3A	22/24 *92%*	SS	*2-2 3-6* N=5	14		2.62 *BSh*	4–6	Gray (10YR5/1) with 25% yellowish brown (10YR5/6) mottles, clayey SILT, trace sand and gravel	602	
4A	23/24 *96%*	SS	*8-12 19-19* N=31	13		3.30 *BSh*	6–8	Yellowish brown (10YR5/6) with 20% black (10YR2/1) mottles, clayey SILT, little sand and gravel	600	
5A	24/24 *100%*	SS	*4-9 13-19* N=22	13		4.80 *BSh*	8–12	Yellowish brown (10YR5/6) with 40% gray (N5/1) mottles, clayey SILT, trace sand and gravel	598	
6A	22/24 *92%*	SS	*3-6 12-15* N=18	12		8.73 *B*			596	
7A	24/24 *100%*	SS	*14-19 23-30* N=42	12		7.86 *B*	12–16	Dark gray (N4/1) with 25% yellowish brown (10YR5/6) mottles, clayey SILT, trace sand and gravel	594	
8A	24/24 *100%*	SS	*4-8 12-14* N=20	13		7.56 *B*			592	
9A	24/24 *100%*	SS	*16-16 20-21* N=36	14		7.01 *B*	16–20	Dark gray (N4/1), clayey SILT, trace sand and gravel	590	
10A	24/24 *100%*	SS	*3-5 8-11* N=13	14		5.24 *B*			588	

NOTE(S): MW01D installed in SB-01.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/10/2006
Finish: 5/10/2006
WEATHER: Foggy to partly sunny, mild (hi-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS & CME samplers

FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-12
Well ID: MW12D
Surface Elev: 622 ft. MSL
Completion: 50 ft. BGS
Station: 875,515.1N
2,515,900.6E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 12.00 - While drilling
▼ = 6.76 - MW12S on 6/1/06
▽ = 46.90 - MW12D on 6/1/06

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING Blows / 6 in N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
1A	24"/24	SS	*2-3 4-5* N=7	22		1.27 *Sh*	0–1.2	Very dark gray (10YR3/1), clayey SILT, trace sand	622	
1B				27		2.33 *B*	1.2–2	Dark gray (10YR4/1) with 15% yellowish brown (10YR5/6) mottles, lean CLAY		
2A	19"/24	SS	*2-4 5-7* N=9	24		2.91 *B*	2–4	Yellowish brown (10YR5/8) with 40% grayish brown (10YR5/2) mottles, lean CLAY	620	
3A	20"/24	SS	*2-2 3-4* N=5	21		2.13 *B*	4–6	Gray (10YR5/1), lean CLAY, trace sand and gravel	618	
4A	24/24 *100%*	SS	*4-5 5-6* N=10	21		1.36 *BSh*	6–8	Gray (10YR5/1) with 10% yellowish brown (10YR5/6) mottles, lean CLAY, trace sand	616	
5A	24"/24	SS	*1-2 2-5* N=4	20		1.47 *BSh*	8–10	Yellowish brown (10YR5/8) with 20% gray (10YR6/1) mottles, lean CLAY, trace sand and gravel	614	
6A	20"/24	SS	*0-1 3-3* N=4	21		0.62 *B*	10–12	Yellowish brown (10YR 5/8) with 25% gray (10YR6/1) mottles, clayey SAND, trace gravel	612	
7A	21"/24	SS	*2-2 3-5* N=5	22		0.19 *B*	12–12.7	Gray (10YR6/1), clayey SAND, trace gravel, wet	610	
7B				22			12.7–13.6	Dark yellowish brown (10YR4/6), clayey SAND, trace gravel, wet		
7C				15		3.71 *B*	13.6–14	Light yellowish brown (10YR6/4) with 30% brownish yellow (10YR6/6) mottles, clayey SILT, trace sand and gravel	608	
8A	24"/24	SS	*4-13 18-29* N=31	9		5.15 *BSh*	14–20	Dark greenish gray (N4/1), clayey SILT, trace sand and gravel	606	
9A	24"/24	SS	*26-32 46-50* N=78	9		6.59 *Sh*			604	
10A	24"/24	SS	*21-31 63-71* N=94	11		6.39 *Sh*	20			

NOTE(S): MW12D installed in SB-12.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/10/2006
Finish: 5/10/2006
WEATHER: Foggy to partly sunny, mild (hi-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS & CME samplers

FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-12
Well ID: MW12D
Surface Elev: 622 ft. MSL
Completion: 50 ft. BGS
Station: 875,515.1N
2,515,900.6E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 12.00 - While drilling
▼ = 6.76 - MW12S on 6/1/06
▽ = 46.90 - MW12D on 6/1/06

Number	Recov / Total (in) *% Recovery*	Type	Blows / 6 in N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*
11A	60/60 *100%*	CS		6		
12A	60/60 *100%*	CS		7		
13A	60/60 *100%*	CS		13		
14A	60/60 *100%*	CS		16		

Depth ft. BGS	Lithologic Description	Elevation ft. MSL
20–25	Dark greenish gray (N4/1), clayey SILT, trace sand and gravel *[Continued from previous page]*	602–597
25–35	Dark greenish gray (N4/1), sandy SILT, trace gravel	597–587
35–40	Very dark gray (N3/1), clayey SILT, trace sand and gravel	587–582

Depth scale: 22, 24, 26, 28, 30, 32, 34, 36, 38, 40
Elevation scale: 602, 600, 598, 596, 594, 592, 590, 588, 586, 584

Borehole Detail | Remarks

NOTE(S): MW12D installed in SB-12.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/10/2006
Finish: 5/10/2006
WEATHER: Foggy to partly sunny, mild (hi-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS & CME samplers
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

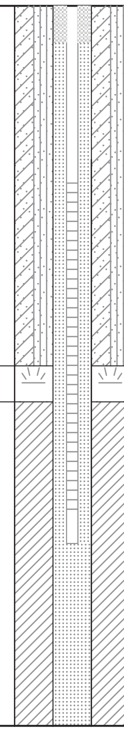
BOREHOLE ID: SB-12
Well ID: MW12D
Surface Elev: 622 ft. MSL
Completion: 50 ft. BGS
Station: 875,515.1N
2,515,900.6E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 12.00 - While drilling
▼ = 6.76 - MW12S on 6/1/06
▽ = 46.90 - MW12D on 6/1/06

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
15A	60/60 *100%*	CS		14			40–45	Very dark gray (N3/1), clayey SILT, trace sand and gravel *[Continued from previous page]*		582–577	
							45–45.5	Very dark gray (N3/1), PEAT			
16A	60/60 *100%*	CS		45			45.5–50 (▽ 46.90)	Gray (N5/1) with 30% yellowish brown (10YR5/6) mottles, lean CLAY		576–572	

Depth scale: 42, 44, 46, 48, 50. Elevation scale: 582, 580, 578, 576, 574.



End of Boring = 50.0 ft. BGS

NOTE(S): MW12D installed in SB-12.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/9/2006
Finish: 5/9/2006
WEATHER: Overcast, mild (mid-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS sampler & 4¼" HSA overdrill

FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-13
Well ID: MW13D
Surface Elev: 623 ft. MSL
Completion: 55 ft. BGS
Station: 874,694.3N
2,513,929.9E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 10, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 12.40 - While drilling
▼ = 8.24 - MW12S on 6/1/06
▽ = 56.03 - MW13D on 6/1/06

SAMPLE: Number	Recov / Total (in) *% Recovery*	Type	TESTING: *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Failure Type*
1A	22/24 *92%*	SS	*4-5 4-4* N=9	21		
1B				15		
1C				28		2.13 *B*
2A	21/24 *88%*	SS	*3-4 5-8* N=9	25		2.13 *BSh*
3A	24/24 *100%*	SS	*4-5 6-8* N=11	22		2.84 *Sh*
3B				21		2.91 *BSh*
4A	24/24 *100%*	SS	*9-12 10-10* N=22	23		2.33 *B*
5A	24/24 *100%*	SS	*3-4 6-7* N=10	21		2.72 *Sh*
6A	19/24 *79%*	SS	*1-3 6-8* N=9	23		1.94 *Sh*
7A	21/24 *88%*	SS	*6-8 10-12* N=18	18		1.94 *Sh*
7B				13		1.55 *BSh*
8A	22/24 *92%*	SS	*7-21 29-30* N=50	11		
8B				9		
9A	23/24 *96%*	SS	*25-28 28-45* N=56	9		9.16 *Sh*
10A	24/24 *100%*	SS	*18-27 31-36* N=58	8		12.00 *Sh*

Depth ft. BGS: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20
Elevation ft. MSL: 622, 620, 618, 616, 614, 612, 610, 608, 606, 604

Lithologic Description	Borehole Detail	Remarks
Grayish brown (10YR5/2), clayey SILT, trace sand		
Light gray (10YR7/2), clayey SILT, trace sand		
Light brownish gray (10YR6/2) with 15%yellowish brown (10YR5/6) mottles, lean CLAY, trace sand		
Gray (10YR6/1) with 40% yellowish brown (10YR5/6) mottles, lean CLAY, trace sand		
Dark gray (10YR4/1), lean CLAY, trace sand and gravel		
Gray (10YR5/1) with 25% yellowish brown (10YR5/6) mottles, lean CLAY, trace sand and gravel		
Yellowish brown (10YR5/6), silty SAND, trace gravel, wet		
Yellowish brown (10YR5/8) with 30% light brownish gray (10YR6/2) mottles, sandy SILT, trace gravel		
Dark gray (10YR4/1), sandy SILT, trace gravel		

NOTE(S): MW13D installed in SB-13.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 5/1/2006
Finish: 5/2/2006
WEATHER: Sunny, mild (mid-60's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS sampler

FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-14
Well ID: n/a
Surface Elev: 625 ft. MSL
Completion: 60 ft. BGS
Station: 875,740.0N
2,514,130.0E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 10, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 14.00 - While drilling
▼ = 4.49 - MW14S on 6/1/06
▽ =

Number	Recov / Total (in) % Recovery	Type	Blows / 6 in N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Failure Type*
1A	23/24 *96%*	SS	*2-3 2-3* N=5	16		
1B				26		2.33 *B*
2A	24/24 *100%*	SS	*3-4 5-7* N=9	23		3.10 *B*
3A	23/24 *96%*	SS	*3-3 5-5* N=8	19		2.33 *B*
4A	24/24 *100%*	SS	*5-6 5-7* N=11	23		2.68 *BSh*
5A	24/24 *100%*	SS	*2-2 3-4* N=5	26		1.83 *B*
6A	19/24 *79%*	SS	*2-2 3-5* N=5	17		2.18 *B*
7A	20/24 *83%*	SS	*2-3 3-3* N=6	22		1.16 *B*
8A	24/24 *100%*	SS	*5-14 14-20* N=28	16		1.36 *B*
8B				11		5.77 *BSh*
9A	12/24 *50%*	SS	*57-65*	10		
10A	24/24 *100%*	SS	*6-8 16-18* N=24	12		5.04 *BSh*

Depth ft. BGS	Lithologic Description	Elevation ft. MSL
0–1.2	Grayish brown (10YR5/2), clayey SILT, trace sand	624
1.2–2	Gray (10YR6/1) with 30% yellowish brown (10YR6/8) mottles, lean CLAY, trace sand	
2–4	Light gray (10YR7/1) with 30% yellowish brown (10YR6/8) mottles, lean CLAY, trace sand	622
4–10	Light gray (10YR7/1) with 15% yellowish brown (10YR6/8) mottles, lean CLAY, trace sand	620, 618, 616
10–14	Yellowish brown (10YR5/8) with 50% light gray (10YR7/1) mottles, sandy CLAY	614, 612
14–14.6	Yellowish brown (10YR5/6), silty, fine SAND, trace medium sand and gravel, wet	
14.6–16	Yellowish brown (10YR5/6), sandy SILT, trace gravel	610
16–18	Yellowsh brown (10YR5/6) with 40% gray (10YR6/1) mottles, sandy SILT, trace gravel	608
18–20	Dark gray (10YR4/1), clayey SILT, trace sand and gravel	606

Borehole Detail | Remarks

NOTE(S): Borehole abandoned using bentonite grout pumped from bottom of borehole.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 4/24/2006
Finish: 4/25/2006
WEATHER: Overcast, cool (lo-50's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS sampler

FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-15
Well ID: n/a
Surface Elev: 624 ft. MSL
Completion: 84 ft. BGS
Station: 875,970.0N
2,515,080.0E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 13.40 - While drilling
▼ = 4.99 - MW15S on 6/1/06
▽ = 5.24 - MW15D on 6/1/06

SAMPLE: Number	Recov / Total (in) % Recovery	Type	TESTING: Blows / 6 in N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
							0	Dark brown (10YR3/3), clayey SILT	624	
1A	24/24 *100%*	SS	*2-2 3-4* N=5	19				Dark grayish brown (10YR3/2), clayey SILT, trace sand		
1B				27		1.94 *B*	2	Grayish brown (10YR5/2), with 50% very dark gray (10YR3/1) mottles, lean CLAY, trace sand	622	
2A	24/24 *100%*	SS	*2-2 4-6* N=6	25		3.10 *B*		Gray (10YR6/1), lean CLAY, trace sand		
							4		620	
3A	20/24 *83%*	SS	*2-3 3-5* N=6	29		2.10 *B*		Yellowish brown (10YR5/6) with 40% gray (10YR6/1) mottles, lean CLAY, trace sand		
							6		618	
4A	24/24 *100%*	SS	*4-6 5-5* N=11	24		1.75 *B*		Gray (10YR6/1), lean CLAY, trace sand		
							8		616	
5A	22/24 *92%*	SS	*1-2 3-4* N=5	26		1.55 *B*	10	Gray (10YR6/1) with 50% yellowish brown (10YR5/6) mottles, lean CLAY, little sand, trace gravel	614	
6A	22/24 *92%*	SS	*2-3 3-4* N=6	22		1.85 *B*				
	19/24 *79%*	SH					12		612	Shelby tube taken from shallow well borehole at indicated depth.
7A	24/24 *100%*	SS	*4-4 5-5* N=9	23		1.22 *B*		Gray (10YR6/1) with 30% yellowish brown (10YR5/6) mottles, silty, fine to medium SAND, trace coarse sand and gravel, wet		
7B				17			14		610	
8A	21/24 *88%*	SS	*2-6 15-19* N=21	11		3.22 *BSP*		Pale brown (10YR6/3), clayey SILT, little sand, trace gravel		
							16	Yellowish brown (10YR5/4), silty, fine to coarse SAND, wet	608	
9A	24/24 *100%*	SS	*18-29 40-50* N=69	20				Yellowish brown (10YR5/4) silty fine SAND, wet		
9B				21				Gray (10YR6/1), sandy SILT, trace medium to coarse sand and trace gravel		
9C				9			18		606	
10A	17/24 *71%*	SS	*11-43 59/5"*	7		7.42 *B*		Dark gray (10YR4/1), clayey SILT, little sand, trace gravel		
							20		604	

NOTE(S): Borehole abandoned using bentonite grout pumped from bottom of borehole.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 4/24/2006
Finish: 4/25/2006
WEATHER: Overcast, cool (lo-50's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS sampler

FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-15
Well ID: n/a
Surface Elev: 624 ft. MSL
Completion: 84 ft. BGS
Station: 875,970.0N
2,515,080.0E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 13.40 - While drilling
▼ = 4.99 - MW15S on 6/1/06
▽ = 5.24 - MW15D on 6/1/06

Number	Recov / Total (in) / % Recovery	Type	Blows / 6 in / N - Value / **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) / Failure Type	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
11A	14/24 *58%*	SS	*14-55 45/2"*	8				Dark gray (10YR4/1), clayey SILT, little sand, trace gravel *[Continued from previous page]* (to 36)		
							22		602	
12A	8/24 *33%*	SS	*100/8"*	8		6.76 *SP*				
							24		600	
13A	23/24 *96%*	SS	*12-28 43-57/5"* N=71	5						
							26		598	
14A	8/24 *33%*	SS	*59-41/2"*	6		7.95 *BSh*				
							28		596	
15A	16/24 *67%*	SS	*11-26 74/4"*	12		4.74 *BSh*				
							30		594	
16A	12/24 *50%*	SS	*39-61*	7						
							32		592	
17A	10/24 *42%*	SS	*49-51/4"*	9		5.43 *B*				
							34		590	
18A	11/24 *46%*	SS	*100-95*	11						
							36	Dark gray (10YR4/1), silty, fine to medium SAND, trace coarse sand and gravel, wet (36–38)	588	
19A	8/24 *33%*	SS	*61-39/2"*	10						
							38	Very dark gray (10YR3/1), clayey SILT, little sand, trace gravel	586	
20A	24/24 *100%*	SS	*21-41 21-24* N=62	12		16.00 *None*				
20B				13		9.38	40	Very dark gray (10YR3/1) with 20% dark grayish brown (10YR4/2) mottles, clayey SILT, trace sand and gravel	584	

NOTE(S): Borehole abandoned using bentonite grout pumped from bottom of borehole.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 4/24/2006
Finish: 4/25/2006
WEATHER: Overcast, cool (lo-50's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS sampler

FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-15
Well ID: n/a
Surface Elev: 624 ft. MSL
Completion: 84 ft. BGS
Station: 875,970.0N
2,515,080.0E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 13.40 - While drilling
▼ = 4.99 - MW15S on 6/1/06
▽ = 5.24 - MW15D on 6/1/06

SAMPLE Number	Recov / Total (in) *% Recovery*	Type	TESTING *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
						BSh				
21A	22/24 *92%*	SS	*3-7 11-18* N=18	19		6.11 *BSh*	42	Dark gray (10YR4/1), clayey SILT, trace sand and gravel	582	
22A	24/24 *100%*	SS	*4-7 8-10* N=15	23		4.46 *B*	44	Dark greenish gray (5GY4/1) with 30% dark gray (N4/1) mottles, lean CLAY, trace sand	580	
23A				21						
	24/24 *100%*	SS	*3-6 6-10* N=12							
23B				16		3.69 *B*	46		578	
24A	24/24 *100%*	SS	*10-12 10-15* N=22	16		4.58 *B*	48	Dark gray (N4/1), lean CLAY, trace sand and gravel	576	
25A	24/24 *100%*	SS	*2-4 7-9* N=11	16		4.65 *B*	50		574	
26A	19/24 *79%*	SS	*3-5 7-13* N=12	21		3.88 *B*	52		572	
27A	24/24 *100%*	SS	*8-10 8-13* N=18	25		3.49 *BSh*	54	Dark yellowish brown (10YR3/4) with 50% dark grayish brown (10YR4/2) mottles, lean CLAY, trace sand and gravel	570	
28A	24/24 *100%*	SS	*4-5 8-12* N=13	22		3.49 *BSh*	56	Greenish gray (10YR5/1) with 20% dark yellowish brown (10YR4/4) mottles, lean CLAY, trace sand and gravel	568	
29A	24/24 *100%*	SS	*5-9 15-18* N=24	20			58		566	
30A	24/24 *100%*	SS	*8-9 14-18* N=23	18		5.82 *BSh*	60	Olive (5Y4/3) with 15% greenish gray (10GY5/1) mottles, lean CLAY, trace sand and gravel	564	

NOTE(S): Borehole abandoned using bentonite grout pumped from bottom of borehole.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 4/24/2006
Finish: 4/25/2006
WEATHER: Overcast, cool (lo-50's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS sampler
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-15
Well ID: n/a
Surface Elev: 624 ft. MSL
Completion: 84 ft. BGS
Station: 875,970.0N 2,515,080.0E

TOPOGRAPHIC MAP INFORMATION:
Quadrangle: Coffeen, IL
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 13.40 - While drilling
▼ = 4.99 - MW15S on 6/1/06
▽ = 5.24 - MW15D on 6/1/06

Number	Recov / Total (in) *% Recovery*	Type	*Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft³)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Elevation ft. MSL	Remarks
31A	24/24 *100%*	SS	*4-7 13-15* N=20	18		5.42 *BSh*	62	Olive (5Y4/3) with 15% greenish gray (10GY5/1) mottles, lean CLAY, trace sand and gravel *[Continued from previous page]*	562	
32A	24/24 *100%*	SS	*10-15 11-16* N=26	20		4.74 *BSh*	64		560	
33A	24/24 *100%*	SS	*6-10 11-13* N=21	16		6.98 *BSh*	66	Greenish gray (10Y5), lean CLAY, trace sand and gravel	558	
34A	24/24 *100%*	SS	*11-14 18-31* N=32	18		6.98 *BSh*	68	Dark yellowish brown (10YR4/4), lean CLAY, trace sand and gravel	556	
35A	23/24 *96%*	SS	*9-18 27-40* N=45	15		11.95 *BSh*	70		554	
36A	24/24 *100%*	SS	*4-12 18-24* N=30	16		7.15 *BSh*	72		552	
37A	24/24 *100%*	SS	*17-29 36-47* N=65	17		8.24 *BSh*	74		550	
38A	20/24 *83%*	SS	*12-18 23-28* N=41	17		6.59 *BSh*	76		548	
39A	9/24 *38%*	SS	*29-39 48-66* N=87	16			78		546	
40A	24/24 *100%*	SS	*5-9 13-18* N=22	18		6.21 *B*	80		544	

NOTE(S): Borehole abandoned using bentonite grout pumped from bottom of borehole.

FIELD BORING LOG

HANSON

CLIENT: AEG Coffeen Power Station
Site: CCB Management Facility
Location: Coffeen, Illinois
Project: 05S3004A
DATES: Start: 4/24/2006
Finish: 4/25/2006
WEATHER: Overcast, cool (lo-50's)

CONTRACTOR: Testing Service Corporation
Rig mfg/model: CME-650 Track Rig
Drilling Method: 3¼" HSA w/SS sampler
FIELD STAFF: Driller: B. Williamson
Helper: R. Keedy
Eng/Geo: R. Hasenyager

BOREHOLE ID: SB-15
Well ID: n/a
Surface Elev: 624 ft. MSL
Completion: 84 ft. BGS
Station: 875,970.0N
2,515,080.0E

TOPOGRAPHIC MAP INFORMATION:
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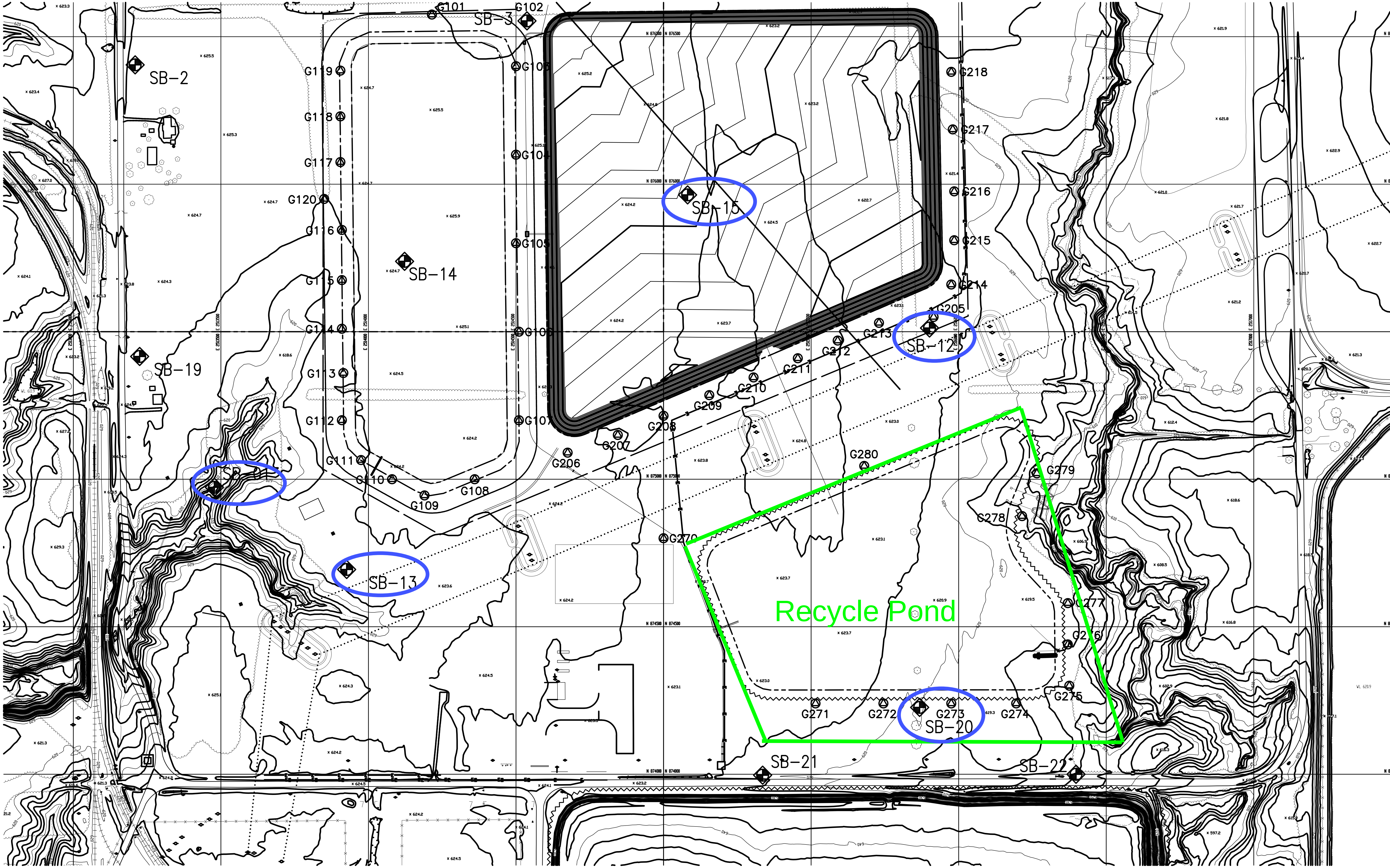
Township: East Fork
Section 11, **Tier** 7N; **Range** 3W

WATER LEVEL INFORMATION:
▼ = 13.40 - While drilling
▼ = 4.99 - MW15S on 6/1/06
▽ = 5.24 - MW15D on 6/1/06

SAMPLE: Number	Recov / Total (in) *% Recovery*	Type	TESTING: *Blows / 6 in* N - Value **RQD**	Moisture (%)	Dry Den. (lb/ft^3)	Qu (tsf) *Failure Type*	Depth ft. BGS	Lithologic Description	Borehole Detail	Elevation ft. MSL	Remarks
41A	24/24 *100%*	SS	*6-8 13-16* N=21	17		5.82 *B*	82	Dark yellowish brown (10YR4/4), lean CLAY, trace sand and gravel *[Continued from previous page]*		542	
42A	24/24 *100%*	SS	*18-28 25-25* N=53	18		5.82 *BSh*	84			540	

End of Boring = 84.0 ft. BGS

NOTE(S): Borehole abandoned using bentonite grout pumped from bottom of borehole.



Recycle Pond
SB-2
SB-3
SB-12
SB-13
SB-14
SB-15
SB-19
SB-20
SB-21
SB-22
G101
G102
G103
G104
G105
G106
G107
G108
G109
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G280

By: JPK Date: 8/24/07

HANSON

Sheet No.: 1 of:

Checked by: Date:

Project No.: 05S3004A

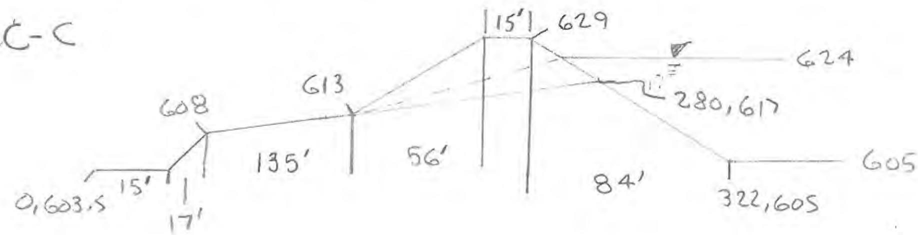
COFFEEN RECYCLE POND - STABILITY ANALYSES

* TYPICAL SECTION - TOP OF BERM EL 629 POOL EL 624 TOP CREST 15FT
3.5:1 SLOPES, BOTTOM EL 605

* USE SB-12 FOR PROFILE OF SOILS ≈ 18FT OF CUT NECESSARY EXCEPT @ EAST SIDE

* TWO SECTIONS C-C & F-F WERE CONSIDERED - PRELIMINARY - AND C-C WAS FOUND TO BE THE CRITICAL SECTION

C-C



* a_{max} = 0.23g - OWR 2002 MAP

* SOIL PARAMETERS FOR ALL SOIL EXCEPT LOESS SHOWN ON SHEET 2

LOESS	SHORT TERM	LONG TERM	RAPID LOAD
	$\phi = 0$	$\phi = 35.2$	$\phi = 24.8$
	C = 900 PSF	C = 0	C = 450 PSF
	$\gamma = 123$	$\gamma = 123$	$\gamma = 123$
		ESTIMATED	ESTIMATED

FILES		
	CRPCECU1	EOC UPSTREAM
	CRPCECD1	EOC DOWNSTREAM
	CRPCSS01	S.S. C=0
	CRPCSS02	S.S. $\phi = 0$
	CRPCRD01	R.D.
	CRPCSZ01	SEISMIC

By: ______ Date: ______ **HANSON** Sheet No.: ______ of: ______

Checked by: ______ Date: ______ Project No.: ______

SOIL PARAMETERS FOR STABILITY ANALYSES

SB 15 & 16 - REMOLDED - FILL - 10-14' DEPTH

C.U. DATA $\phi = 14.8$, $C = 20$ PSF

$\phi' = 28.3°$, $c' = 0$

> $\gamma = 121.2$

U.U. DATA $\phi = 15.0$ $C = 1950$ PSF $\gamma = 121.2$

SHORT TERM	LONG TERM	RAPID LOAD
C = 1950	C = 0	C = 500
$\phi = 0$	$\phi = 28.3$	$\phi = 14.8$
$\gamma = 121.2$	$\gamma = 121.2$	$\gamma = 121.2$

(1) C = 500 PSF ESTIMATED COHESION FOR RAPID LOADING
ϕ & C ARE BOTH LOW FOR THIS MATERIAL

SB-15 11.0-12.5 BRN VF SANDY SILT, TR CLAY - UPPER TILL

U.U. DATA $\phi = 0$ $C = 1810$ PSF $\gamma = 126.5$

(2) SHORT TERM - UPPER TILL
C = 1810
$\phi = 0$
$\gamma = 126.3$

SB-3 12.2-13.7 FT BRN VF. SANDY SILT & MED. SILTY SAND

C.U. DATA $\phi = 43.4$ $C = 0$ $\gamma = 134.6$

$\phi' = 35.8$ $c' = 0$

SAND / SILTY SAND (?)
C = 0
$\phi = 35.8$ → ALL LOAD CONDITIONS
$\gamma = 134.6$

SB-16 10.5-12.0 GRAY-BRN F-C. SANDY SILT SOME CLAY - UPPER TILL (2)

C.U. DATA $\phi = 14.9°$ $C = 590$ PSF $\gamma = 126.2$

ϕ' 26.0 $c' = 155$ PSF

LONG TERM	RAPID LOADING
C = 155 PSF	C = 590
$\phi = 26.0$	$\phi = 14.9$
$\gamma = 126.3$	$\gamma = 126.3$

U.C. TEST DATA - COHESION

4940 PSF - SB 12 35-40
5660 PSF - SB 12 40-45

6140 PSF SB 13 20-25
3620 PSF SB 13 30-35
7310 PSF SB 13 35-40
5420 PSF SB 13 40-45
5310 PSF SB 13 45-50
6000 PSF SB 13 50-55
3000 PSF SB 13 50-55

10830 PSF SB16 32-35

2570 PSF SB17 29-34
2870 PSF SB17 39-44

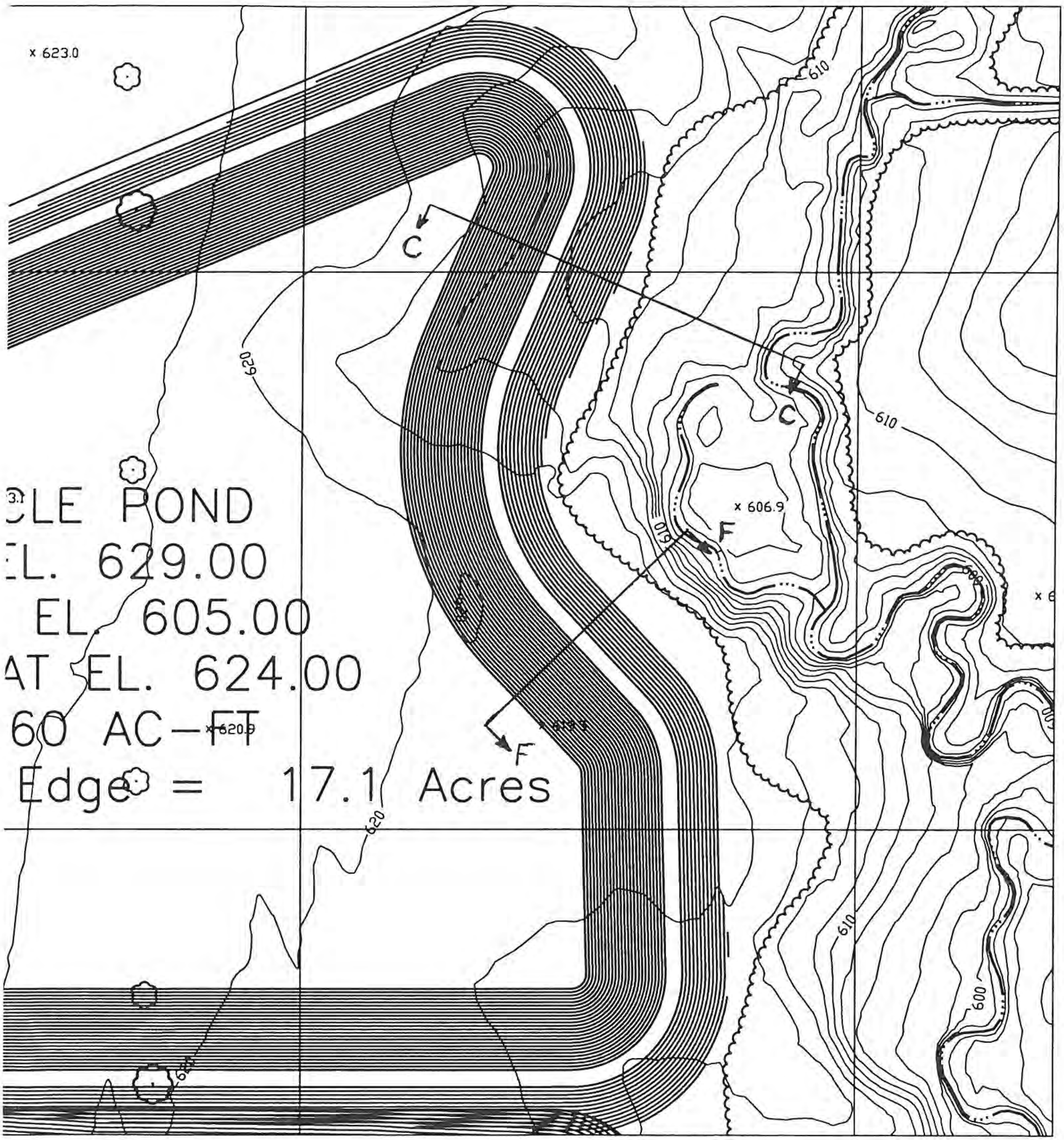
4940 PSF SB12 35-40
5660 PSF SB12 40-45

ALL HARD TILL (3)

AVG ⇒ 5305 PSF

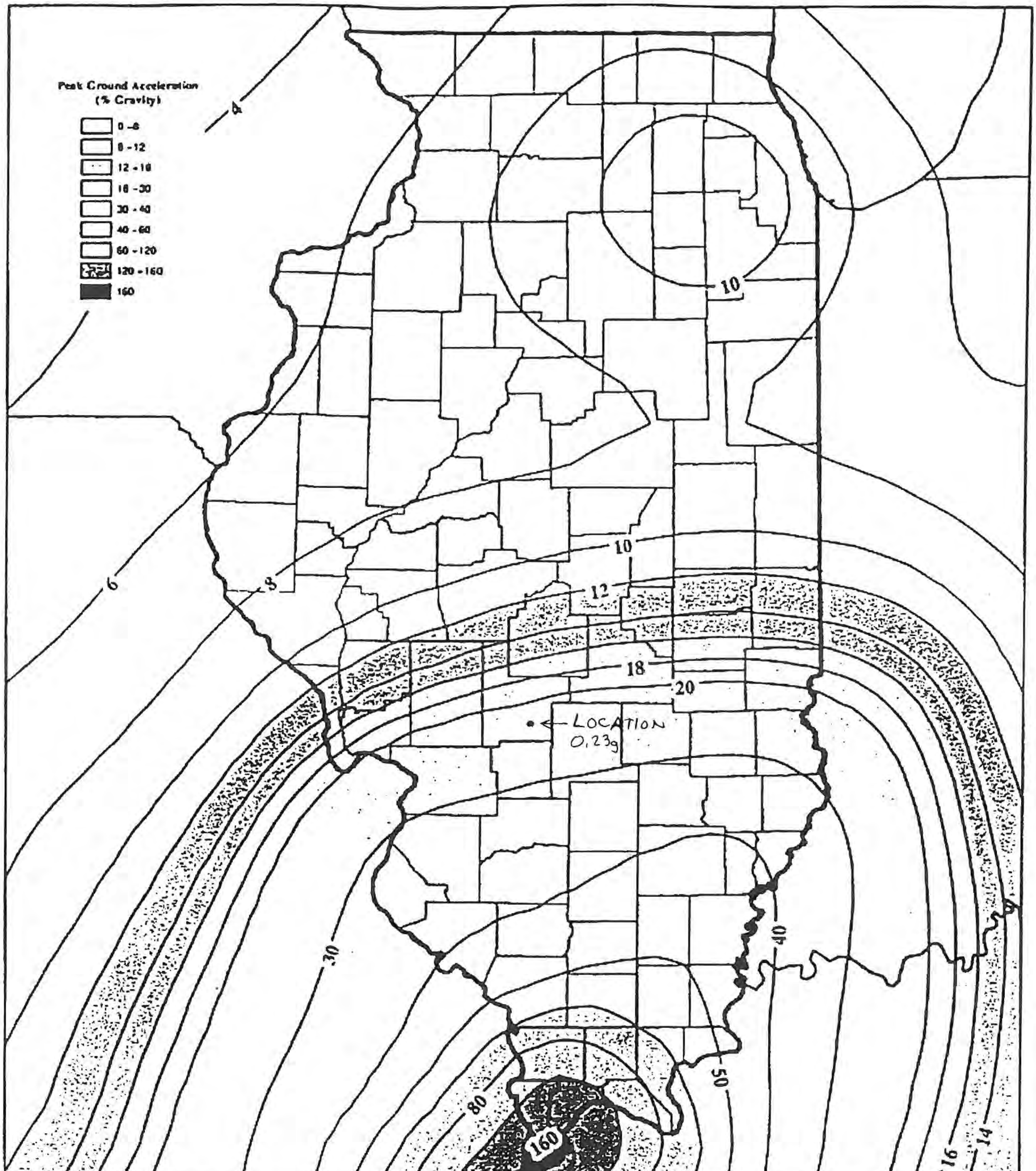
* C = 5.3 KSF = 5300 PSF

SHORT TERM	LONG TERM	RAPID LOAD
C = 5300	C = 0	C = 2000
$\phi = 0$	$\phi = 34$	$\phi = 22$
$\gamma = 137.7$	$\gamma = 137.7$	$\gamma = 137.7$
	EST.	EST.



× 623.0
C
C
620
610
610
× 606.9
F
F
610
600
CLE POND
L. 629.00
EL. 605.00
AT EL. 624.00
60 AC—FT
× 620.9
Edge = 17.1 Acres
620
610
600

1"=120'



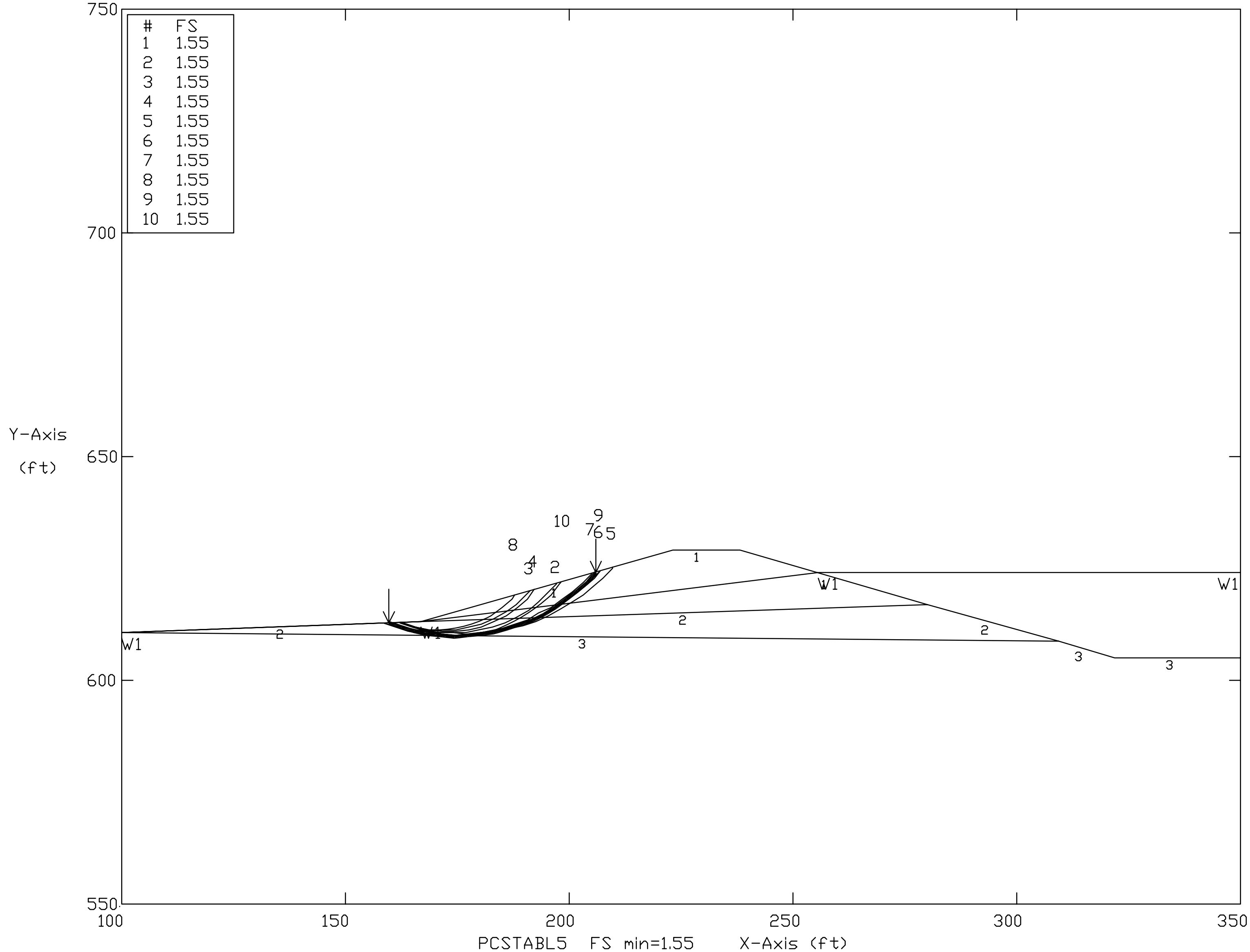
Peak Ground Acceleration (Percent Gravity)
Two Percent Probability of Exceedance in 50 Years

Source: US Geological Survey
National Seismic Hazard Mapping Project
(Open-file Report 97-131) November, 1996

Office of
Water Resources
October 4, 2002

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Coffeen Recycle Pond Section C-C Steady State, c=0
Ten Most Critical. J:CRPCSS01.PLT By: JPK 08-29-07 11:51pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	0	28.3	0	0	1
2	126.3	126.3	0	26	0	0	1
3	137.7	137.7	0	34	0	0	1

** PCSTABL5 **

by
Purdue University

1

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

Run Date: 08-29-07
Time of Run: 11:51pm
Run By: JPK
Input Data Filename: J:CRPCSS01
Output Filename: J:CRPCSS01.OUT
Plotted Output Filename: J:CRPCSS01.PLT

PROBLEM DESCRIPTION Coffeen Recycle Pond
Section C-C Steady State, c=0

BOUNDARY COORDINATES

7 Top Boundaries
9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	60.50	67.00	63.00	2
2	67.00	63.00	123.00	79.00	1
3	123.00	79.00	138.00	79.00	1
4	138.00	79.00	180.00	67.00	1
5	180.00	67.00	209.40	58.60	2
6	209.40	58.60	222.00	55.00	3
7	222.00	55.00	250.00	55.00	3
8	67.00	63.00	180.00	67.00	2
9	.00	60.50	209.40	58.60	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.

1	121.2	121.2	.0	28.3	.00	.0	1
2	126.3	126.3	.0	26.0	.00	.0	1
3	137.7	137.7	.0	34.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	60.50
2	67.00	63.00
3	155.50	74.00
4	250.00	74.00

1

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

2000 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 50.00 ft.
and X = 75.00 ft.

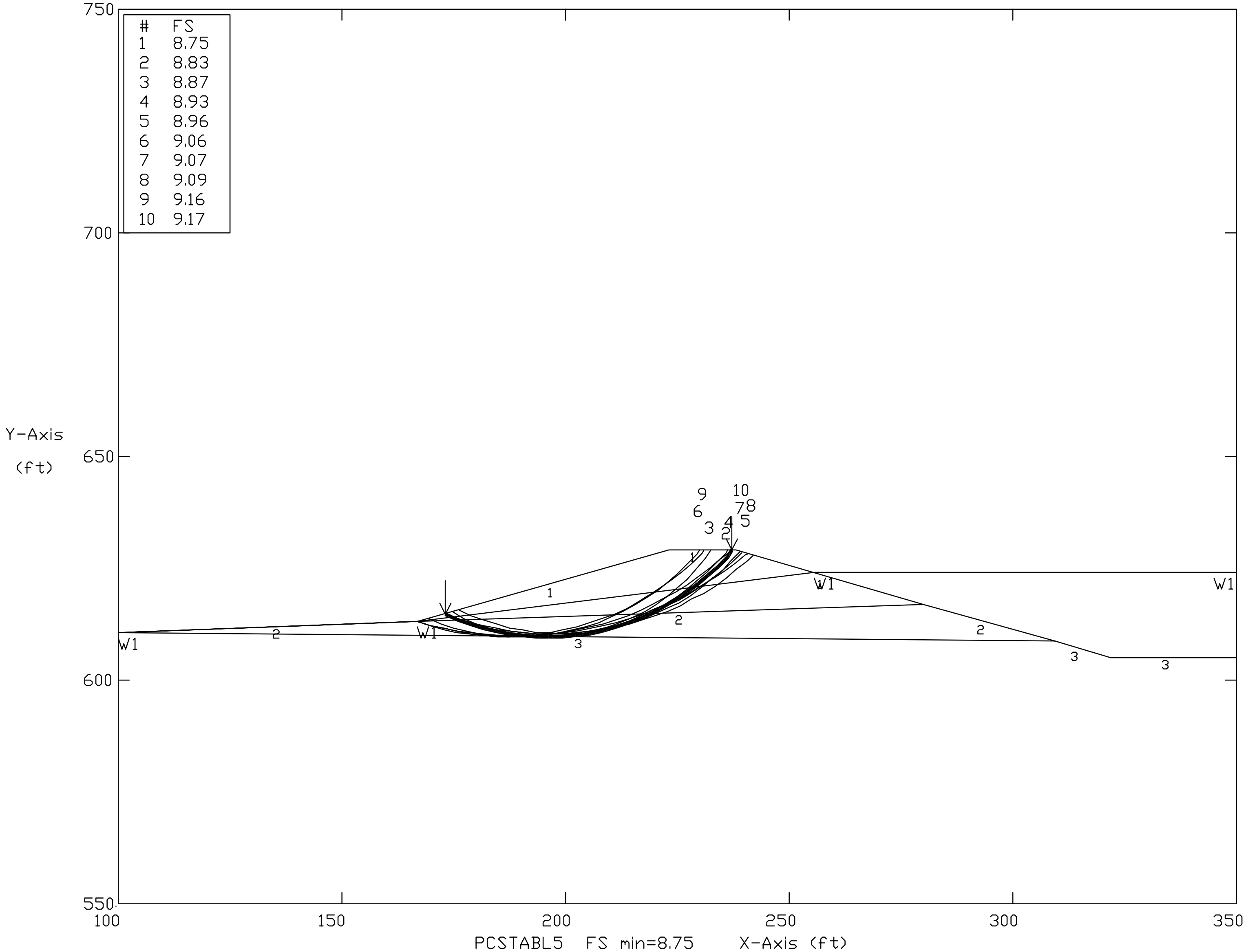
Each Surface Terminates Between X = 80.00 ft.
and X = 125.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

Coffeen Recycle Pond Section C-C Steady State, phi=0

Ten Most Critical. J:CRPCSS02.PLT By: JPK 08-29-07 11:56pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	1950	0	0	0	1
2	126.3	126.3	1810	0	0	0	1
3	137.7	137.7	5300	0	0	0	1

** PCSTABL5 **

by
Purdue University

1

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

Run Date:	08-29-07
Time of Run:	11:56pm
Run By:	JPK
Input Data Filename:	J:CRPCSS02
Output Filename:	J:CRPCSS02.OUT
Plotted Output Filename:	J:CRPCSS02.PLT

PROBLEM DESCRIPTION   Coffeen Recycle Pond
Section C-C Steady State, phi=0

BOUNDARY COORDINATES

7 Top   Boundaries
9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	60.50	67.00	63.00	2
2	67.00	63.00	123.00	79.00	1
3	123.00	79.00	138.00	79.00	1
4	138.00	79.00	180.00	67.00	1
5	180.00	67.00	209.40	58.60	2
6	209.40	58.60	222.00	55.00	3
7	222.00	55.00	250.00	55.00	3
8	67.00	63.00	180.00	67.00	2
9	.00	60.50	209.40	58.60	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.

1	121.2	121.2	1950.0	.0	.00	.0	1
2	126.3	126.3	1810.0	.0	.00	.0	1
3	137.7	137.7	5300.0	.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	60.50
2	67.00	63.00
3	155.50	74.00
4	250.00	74.00

1

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

2000 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 60.00 ft.
and X = 90.00 ft.

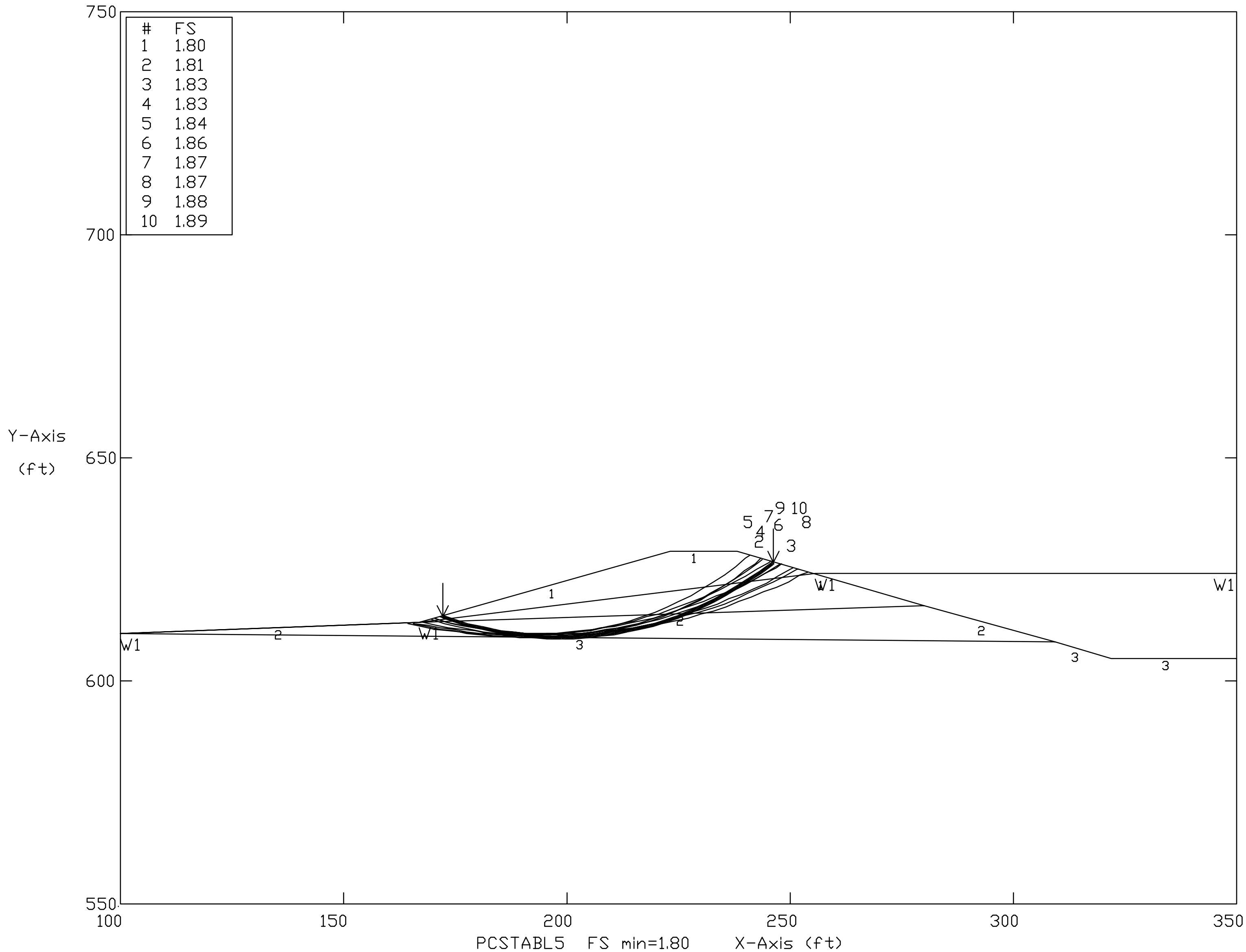
Each Surface Terminates Between X = 125.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

Coffeen Recycle Pond Section C-C Seismic

Ten Most Critical. J:CRPCSZ01.PLT By: JPK 08-29-07 11:58pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	500	14.8	0	0	1
2	126.3	126.3	590	14.9	0	0	1
3	137.7	137.7	2000	22	0	0	1

** PCSTABL5 **
by
Purdue University

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

Run Date: 08-29-07
Time of Run: 11:58pm
Run By: JPK
Input Data Filename: J:CRPCSZ01
Output Filename: J:CRPCSZ01.OUT
Plotted Output Filename: J:CRPCSZ01.PLT

PROBLEM DESCRIPTION Coffeen Recycle Pond
Section C-C Seismic

BOUNDARY COORDINATES

7 Top Boundaries
9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	60.50	67.00	63.00	2
2	67.00	63.00	123.00	79.00	1
3	123.00	79.00	138.00	79.00	1
4	138.00	79.00	180.00	67.00	1
5	180.00	67.00	209.40	58.60	2
6	209.40	58.60	222.00	55.00	3
7	222.00	55.00	250.00	55.00	3
8	67.00	63.00	180.00	67.00	2
9	.00	60.50	209.40	58.60	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	500.0	14.8	.00	.0	1
2	126.3	126.3	590.0	14.9	.00	.0	1
3	137.7	137.7	2000.0	22.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	60.50
2	67.00	63.00
3	155.50	74.00
4	250.00	74.00

A Horizontal Earthquake Loading Coefficient
Of .230 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 psf

1

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

2000 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 60.00 ft.
and X = 85.00 ft.

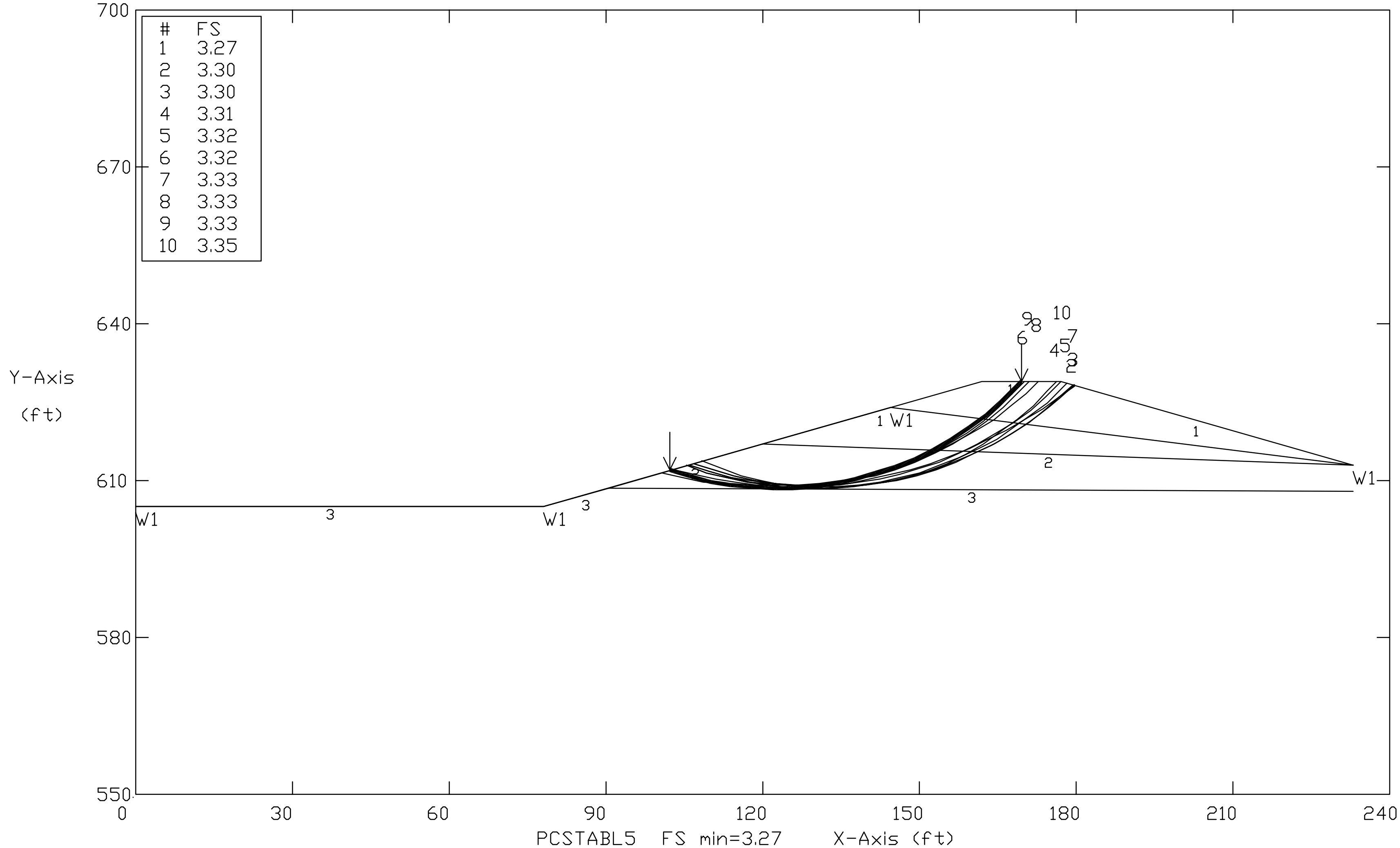
Each Surface Terminates Between X = 90.00 ft.
and X = 175.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = .00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

Coffeen Recycle Pond Section C-C Rapid Drawdown

Ten Most Critical. J:CRPCRD01.PLT By: JPK 08-29-07 11:33pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	121.2	121.2	500	14.8	0	0	1
2	126.3	126.3	590	14.9	0	0	1
3	137.7	137.7	2000	22	0	0	1

** PCSTABL5 **

by
Purdue University

1

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

Run Date: 08-29-07
Time of Run: 11:33pm
Run By: JPK
Input Data Filename: J:CRPCRD01
Output Filename: J:CRPCRD01.OUT
Plotted Output Filename: J:CRPCRD01.PLT

PROBLEM DESCRIPTION Coffeen Recycle Pond
Section C-C Rapid Drawdown

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	55.00	78.00	55.00	3
2	78.00	55.00	90.60	58.60	3
3	90.60	58.60	120.00	67.00	2
4	120.00	67.00	162.00	79.00	1
5	162.00	79.00	177.00	79.00	1
6	177.00	79.00	233.00	63.00	1
7	120.00	67.00	233.00	63.00	2
8	90.60	58.60	233.00	58.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.

1	121.2	121.2	500.0	14.8	.00	.0	1
2	126.3	126.3	590.0	14.9	.00	.0	1
3	137.7	137.7	2000.0	22.0	.00	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	55.00
2	78.00	55.00
3	144.50	74.00
4	233.00	63.00

1

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

2000 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 90.00 ft.
and X = 120.00 ft.

Each Surface Terminates Between X = 160.00 ft.
and X = 180.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Attachment B

Illinois Power Generating Company

COFFEEN POWER PLANT
MONTGOMERY COUNTY, ILLINOIS

Emergency Action Plan (EAP)

40 CFR § 257.73(a)(3), 35 Ill. Adm. Code 845.520
Coal Combustion Residual (CCR) Impoundments & Related Facilities

- Gypsum Management Facility (GMF) Pond (NID # IL50579) (IEPA # W1350150004-03)
- GMF Recycle Pond (NID # IL50578) (IEPA # W1350150004-04)
- Ash Pond No. 1 (NID # IL50722) (IEPA # W1350150004-01)
- Ash Pond No. 2 (NID # IL50723) (IEPA # W1350150004-02)

Revision Date: September 16, 2021

Qualified Professional Engineer Certification; Emergency Action Plan for the Coffeen Power Plant GMF Pond, GMF Recycle Pond, Ash Pond 1 and Ash Pond 2

In accordance with 40 C.F.R. § 257.73(a)(3)(iv) and 35 Ill. Adm. Code 845.520(e), the owner or operator of a CCR unit that is required to prepare a written Emergency Action Plan under 40 C.F.R. § 257.73(a)(3) and 35 Ill. Adm. Code 845.520(a) must obtain a certification from a qualified professional engineer stating that the written Emergency Action Plan meets the requirements of 40 C.F.R. § 257.73(a)(3) and 35 Ill. Adm. Code 845.520.

I, Phil Morris, being a Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that:

1. the information contained in this Emergency Action Plan was prepared in accordance with the accepted practice of engineering; and

2. this Emergency Action Plan meets the requirements of 40 C.F.R. § 257.73(a)(3) and 35 Ill. Adm. Code 845.520.

Phil Morris
Senior Director, Corporate Environmental

9/27/21
Date

PHIL L. MORRIS
062-058763
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS
9/27/21

COFFEEN POWER PLANT
EMERGENCY ACTION PLAN
CCR IMPOUNDMENTS & RELATED FACILITIES

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COFFEEN POWER PLANT
EMERGENCY ACTION PLAN
CCR IMPOUNDMENTS & RELATED FACILITIES

1 STATEMENT OF PURPOSE

The Coffeen Power Plant (Power Plant) is located near the town of Coffeen in Montgomery County, Illinois. The location of the Power Plant is shown in Figure 1-1. The Power Plant is a coal-fired electricity producing power plant owned and operated by the Illinois Power Generating Company (IPGC), a subsidiary of Dynegy. This Emergency Action Plan (EAP) was prepared in accordance with 40 CFR **§** 257.73(a)(3) and 35 Ill. Adm. Code 845.520 and covers the following Coal Combustion Residual (CCR) surface impoundments located at the site:

- Gypsum Management Facility (GMF) Pond (NID # IL50579) (IEPA # W1350150004-03)
- GMF Recycle Pond (NID # IL50578) (IEPA # W1350150004-04)
- Ash Pond No. 1 (NID # IL50722) (IEPA # W1350150004-01)
- Ash Pond No. 2 (Capped/Closed) (NID # IL50723) (IEPA # W1350150004-02)

The locations of these impoundments are shown in Figure 1-2. Section 6 of this EAP includes a description of each impoundment.

The purpose of this Emergency Action Plan (EAP) is to:

1. Safeguard the lives, as well as to reduce property damage, of citizens living within potential downstream flood inundation areas of CCR impoundments and related facilities at the Coffeen Power Plant.
2. Define the events or circumstances involving the CCR impoundments and related facilities at the Coffeen Power Plant that pose a safety hazard or emergency and how to identify those conditions.
3. Define responsible persons, their responsibilities, and notification procedures in the event of a safety emergency.
4. Provide list of emergency responders.
5. Identify emergency actions in the event of a potential or imminent failure of the impoundments.
6. Identify the downstream area that would be affected by failure of the impoundments.
7. Provide for effective facility surveillance, prompt notification to local Emergency Management Agencies, citizen warning and notification responses, and preparation should an emergency occur.

Information provided by Illinois Power Generating Company was utilized and relied upon in preparation of this Emergency Action Plan.

Notes
1. Coordinate System: NAD 1983 StatePlane Illinois West FIPS 1202 Feet
2. Aerial Source: 2015 NAIP Imagery
3. Impoundment Boundaries Provided by Client (Dated 9/9/2015)

0 5,000 Feet
1:60,000 (At original document size of 11x17)

Stantec DYNEGY

Project Location 175605019
Latitude: 39.059113
Longitude: -89.403293
Montgomery County, Illinois
Prepared by RMGB on 3/29/2017
Technical Review by NS on 3/29/2017
Independent Review by MM on 3/29/2017

Client/Project
Coffeen Power Station
Emergency Action Plan

Figure No.
1-1

Title
Location Map

V:\1756\active\175605019\gis\mxd\004_coffeen\Figure1-1.mxd Revised: 2017-04-13 By: thsmith

Legend

CCR Surface Impoundment Boundary

0 2,000 Feet

1:24,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 StatePlane Illinois West FIPS 1202 Feet
2. Aerial Source: 2015 NAIP Imagery
3. Impoundment Boundaries Provided by Client (Dated 9/9/2015)

Stantec DYNEGY

Project Location 175605019
Latitude: 39.059113
Longitude: -89.403293
Montgomery County, Illinois

Prepared by RMGB on 3/29/2017
Technical Review by NS on 3/29/2017
Independent Review by MM on 3/29/2017

Client/Project
Coffeen Power Station
Emergency Action Plan

Figure No.
1-2

Title
CCR Impoundments

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

V:\1756\active\175605019\gis\mxd\004_coffeen\Figure1-2.mxd Revised: 2017-04-13 By: thsmith

2 COMMUNICATION

To facilitate understanding among everyone involved in implementing this EAP, four response levels are used to identify the condition of an impoundment. These are:

Response Levels:

- **Level 0:** Normal conditions and routine operations, including surveillance and initial investigation of unusual conditions and effects of storm events.
- **Level 1:** Potentially hazardous condition exists, requiring investigation and possible corrective action.
- **Level 2:** Potential failure situation is developing; possible mode of failure is being assessed; corrective measures are underway.
- **Level 3:** Failure is occurring or is imminent, public protective actions are required.

The 4-Step Incident Response Process is outlined in Figure 2-1.This should be used in conjunction with the Notification Flowchart (Figure 2-2) and EAP Decision Tree (Figure 2-3). Section 4 provides guidance tables for determining Response Levels and a table providing emergency actions to be taken given various situations. Table 2-1 lists contact information for the emergency responders.

Figure 2-1. Summary/Sequence of Tasks 4-Step Incident Response Process

Step 1: Detection, Evaluation, and Response Level Determination

Sequence of Tasks:

- Notify EAP Coordinator, Plant Manager, and Dam Safety Manager of unusual condition detected and confer on next steps needed.
- Conduct technical evaluation of conditions as needed.
- Determine Response Level based on evaluation. **(Table 4-1)**
- Reset Response Level as revised evaluations warrant.

Step 2: Notification

Sequence of Tasks:

- Notify authorities, designated personnel, and external response partners of change in Response Level, using the Notification Flowchart. **(Figure 2-2)**
- *Re-notify authorities, designated personnel, and external response partners as Response Level is changed.*

Step 3: Emergency Actions

Sequence of Tasks:

- Perform emergency actions with goal of saving the impoundment and minimizing impacts to life, property, and environment. **(Table 4-3)**
- Take continuous actions to include situation assessment, information sharing, remediation, and public safety advisories or warnings, as warranted.
- *Revise action plan as changes in conditions warrant.*

Step 4: Follow-up

Sequence of Tasks:

- Document conditions and decisions in the Emergency Incident Log.
- Notify authorities, designated personnel, and external response partners that condition is stabilized, limit incident termination declarations to conditions at the site.
- Conduct and document after-action review of incident and response.

Figure 2-2. Notification Flowchart

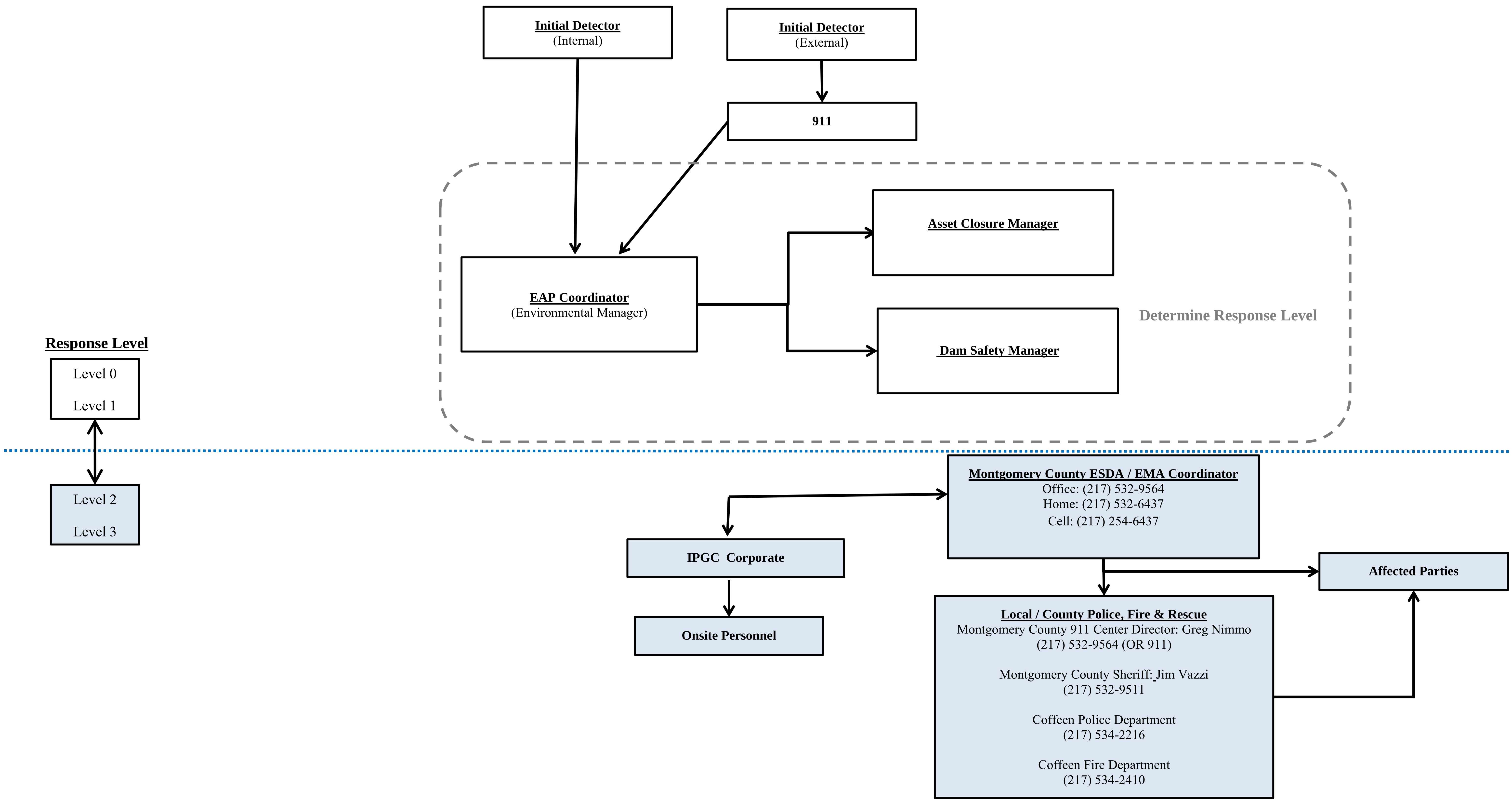


Figure 2-3. EAP Response Process Decision Tree

Note: At any given below, if failure is imminent or actively occurring **CALL 911 IMMEDIATELY** to notify emergency responders and then continue with process afterwards.

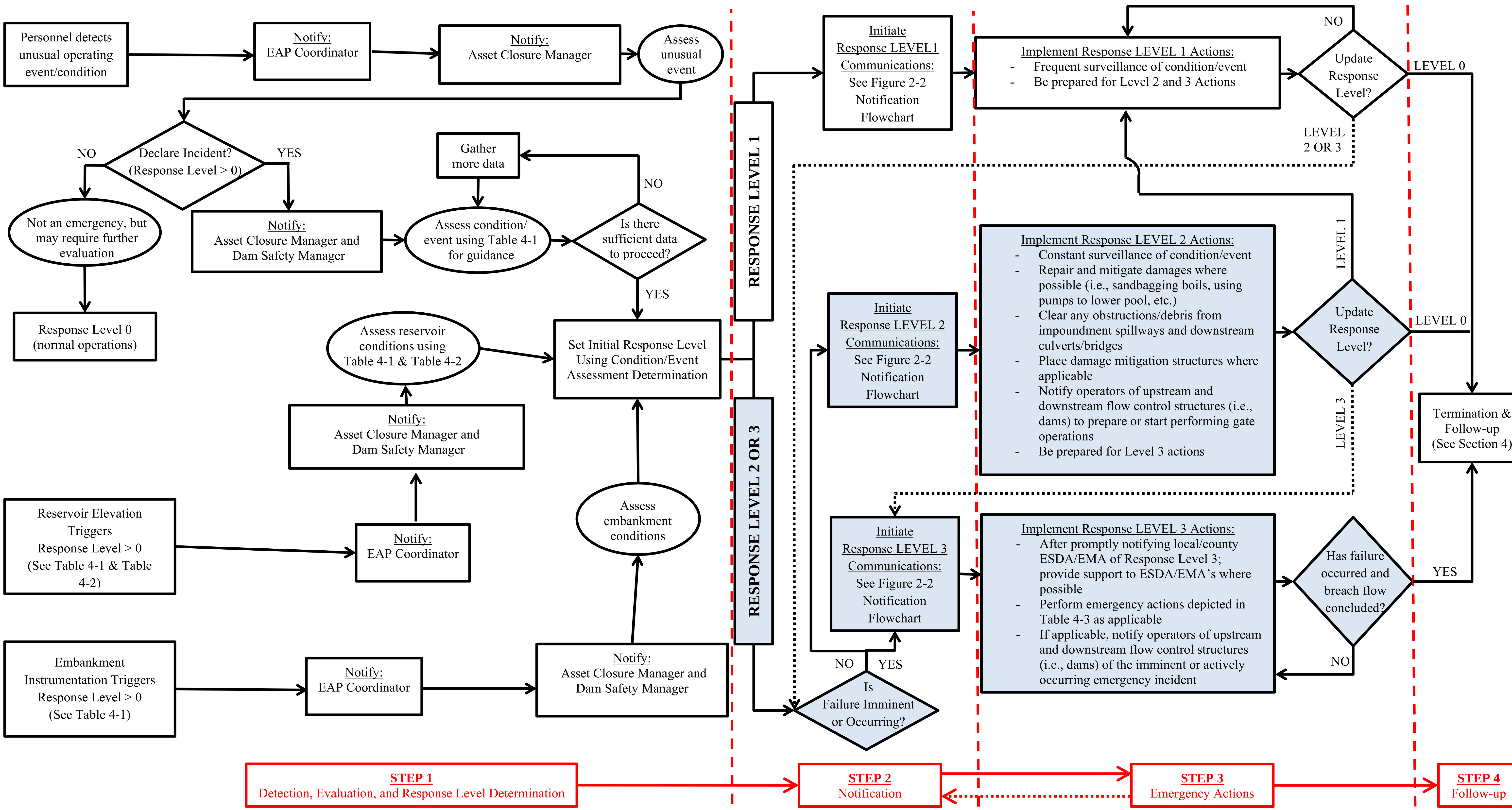


Table 2-1. EAP Emergency Responders

Position / Entity	Contact Information	
Internal Contacts		
Coffeen Power Plant	**Phone #**	
Asset Closure Manager	(903) 577-5207	
Environmental Manager (EAP Coordinator)	(217) 341-7319	
Control Room	(217) 534-7621	
IPGC Corporate Operations	**Contact**	
Dam Safety Manager		(618) 792-8488
External Contacts		
Local/County ESDA/EMA, Police, & Fire	**Phone #**	**Alternate Phone #**
Montgomery County 911 Emergency Communication Center	911	(217) 532-9564
Montgomery County Sheriff	(217) 532-9511	
Montgomery County ESDA/EMA Coordinator	(217) 532-9564	(217) 254-6437
Coffeen Police Department	(217) 534-2216	
Coffeen Fire Department	(217) 534-2410	
Montgomery County Ambulance	(217) 532-9562	
Montgomery County Engineer	(217) 532-6109	
State Emergency Management Agencies & Organizations	**Contact Phone #**	
IDNR-OWR Dam Safety Section Manager	(217) 782-4427	
Coffeen Lake State Fish & Wildlife Area	(217) 537-3351	
Illinois Conservation Police	(309) 338-1017	
Illinois State Police	(309) 833-4046	

3 EAP ROLES AND RESPONSIBILITIES

Table 3-1 provides a summary of the EAP roles during an emergency event.

Table 3-1. Summary of EAP Roles

Entity	Role Description
IPGC Emergency Response Team (ERT)	**ERT: IPGC** personnel responsible for EAP implementation, distribution, updates/maintenance, and training activities. The *ERT* is comprised of the following roles: 1. **IPGC Corporate:** IPGC corporate entity, committee, team, or position with relevant responsibility for a given generating power plant. 2. **Asset Closure Management:** Personnel responsible for the management of the closure of the Power Plant. 3. **Dam Safety Manager:** Personnel that is most knowledgeable about the design and technical operation of facilities at a given power plant. 4. **EAP Coordinator:** Personnel responsible for implementing the EAP and associated activities. **Emergency Event – EAP Responsibilities** 1. Respond to emergencies at the Power Plant. 2. Verify and assess emergency conditions. 3. Notify and coordinate as appropriate with participating emergency services disaster agencies or emergency management agencies (ESDA/EMA's), emergency responders, regulatory agencies, and all other entities involved or affected by this EAP. 4. Take corrective action at the Power Plant. 5. Declare termination of emergencies at the Power Plant.
Montgomery County ESDA/EMA	1. Receive Response Level reports from *IPGC Corporate* through *EAP Coordinator*. 2. Coordinate emergency response activities with local/county authorities: police, fire and rescue, etc. 3. Coordinate notification of public as necessary through established channels, which may include door-to-door contact. 4. Coordinate notification activities to affected parties within inundation areas. 5. Evaluate risk to areas beyond the inundation areas, communicate needs to the *IPGC Corporate* and/or *EAP Coordinator*, and coordinate aid as appropriate. 6. Responsible for declaring termination of an emergency condition off-site upon receiving notification of an emergency status termination from the *IPGC Corporate*. 7. If necessary, coordinate with *State ESDA/EMA*.
Local/County Police, Fire & Rescue	1. Receive alert status reports from the *ERT* or the Montgomery County *ESDA/EMA*. 2. If necessary, notify affected parties and general public within inundation areas (see Section 7). 3. Render assistance to Montgomery County *ESDA/EMA*, as necessary. 4. Render assistance to *IPGC Corporate* and *Power Plant Management*, as necessary.

4 EAP RESPONSE

The 4-Step Incident Response Process is shown in Figure 2-1. The Decision Tree shown in Figure 2-3 provides a flowchart for the various elements of the response process. Upon reaching Step 4 of the response process (termination and follow-up), the EAP Coordinator is responsible for notifying the ESDA/EMA's that the condition of the dam/impoundment has been stabilized. The purpose of this section is to provide specific information that can be used during a response. This information is provided in the following tables:

- Table 4-1 provides guidance for determining the response level.
- Table 4-2 provides impoundment pool level trigger elevations.
- Table 4-3 lists emergency actions to be taken depending on the situation.

Table 4-1. Guidance for Determining the Response Level

Event	Situation	Response Level
Spillway flow (See Table 4-2 for relevant elevations)	Primary spillway flow is not causing active erosion and impoundment water surface elevation is below auxiliary spillway crest elevation (if equipped).	Level 0
	Impoundment water surface elevation is at or above auxiliary spillway crest elevation (if equipped). No active erosion caused by spillway flow.	Level 1
	Spillway flow actively causing minor erosion that is not threatening the control section or dam/impoundment stability.	Level 2
	Spillway flow that could result in flooding of people downstream if the reservoir level continues to rise.	Level 2
	Abnormal operation of the spillway system due to blockage or damage that could lead to flooding.	Level 2
	Spillway flow actively eroding the soil around the spillway that is threatening the control section (e.g., undermining) or dam/impoundment stability.	Level 3
	Spillway flow that is flooding people downstream.	Level 3
Embankment Overtopping (See Table 4-2 for relevant elevations)	Impoundment water surface elevation at or below typical normal pool fluctuation elevation.	Level 0
	Impoundment water surface elevation above typical high pool fluctuation elevation.	Level 1
	Impoundment water surface elevation within 2 feet of the embankment crest elevation	Level 2
	Impoundment water surface elevation at or above embankment crest elevation.	Level 3
Seepage	New seepage areas in or near the dam/impoundment with clear flow.	Level 1
	New seepage areas with cloudy discharge or increasing flow rate.	Level 2
	Heavy seepage with active erosion, muddy flow, and/or sand boils.	Level 3
Sinkholes	Observation of new sinkhole in impoundment area or on embankment.	Level 2
	Rapidly enlarging sinkhole and/or whirlpool in the impoundment.	Level 3
Embankment cracking	New cracks in the embankment greater than ¼ inch wide without seepage.	Level 1
	Any crack in the embankment with seepage.	Level 2
	Enlarging cracks with muddy seepage.	Level 3

Table 4-1. Guidance for Determining the Response Level

Event	Situation	Response Level
Embankment movement	Visual signs of movement/slippage of the embankment slope.	Level 1
	Detectable active movement/slippage of the embankment slope or other related effects (tension cracking, bulges/heaves, etc.) that could threaten the integrity of the embankment.	Level 2
	Sudden or rapidly proceeding slides of the embankment slopes.	Level 3
Embankment Monitoring Equipment (piezometers, inclinometers, surface displacement mounts, etc.)	Instrumentation readings beyond historic normal.	Level 1
	Instrumentation readings indicate the embankment is susceptible to failure.	Level 2
	Instrumentation readings indicate embankment is at threshold of failure or is currently failing.	Level 3
Earthquake or another event	Measurable earthquake felt or reported on or within 100 miles of the impoundment.	Level 1
	Earthquake or other event resulting in visible damage to the impoundment or appurtenances.	Level 2
	Earthquake or other event resulting in uncontrolled release of water or materials from the impoundment.	Level 3
Security threat	Verified bomb threat or other physical threat that, if carried out, could result in damage to the impoundment.	Level 2
	Detonated bomb or other physical damage that has resulted in damage to the impoundment or appurtenances.	Level 3
Sabotage/ vandalism	Damage to impoundment or appurtenance with no impact to the functioning of the impoundment.	Level 1
	Modification to the impoundment or appurtenances that could adversely impact the functioning of the impoundment. This would include unauthorized operation of spillway facilities.	Level 2
	Damage to impoundment or appurtenances that has resulted in seepage flow.	Level 2
	Damage to impoundment or appurtenances that has resulted in uncontrolled water release.	Level 3

Table 4-2. Impoundment Trigger Elevations

Impoundment	Embankment Crest Elevation	Auxiliary Spillway Crest Elevation	Normal Pool Fluctuation	
			Typical	High
GMF Pond	632.0 ft.	N/A	621 ft.	626 ft.
GMF Recycle Pond	629.0 ft.	624.1 ft.	610 ft.	623 ft.
Ash Pond No.1	637.5 ft.	631.0 ft.	629 ft.	633 ft.
Ash Pond No.2	638.0 ft.	N/A	N/A	N/A

Notes:Elevations are in reference to NAVD88

Table 4-3. Step 3: Emergency Actions

Condition	Description of Condition	Action to be Taken
High Water Level/ Large Spillway Release	Not applicable to capped impoundments. See Table 4-1 and Table 4-2 for elevations and triggering water levels associated with the impoundments and spillways covered by this EAP.	1. Assess cause of increased reservoir stage, especially during fair weather conditions. 2. Determine Response Level. 3. Make proper notifications as outlined in the Figure 2-2 Notification Flowchart. 4. Perform additional tasks as determined through consultation with the ERT. 5. Make notifications if condition worsens such that downstream flooding is imminent. **Response Level 0**: require enhanced surveillance 3 times per day **Response Level 1**: contact internal chain of command and external response partners as necessary; inspect impoundment minimum 1 time per hour **Response Level 2**: contact internal chain of command; notify ESDA/EMA's and notify external response partners. ESDA/EMA's notify affected parties. **Response Level 3**: contact internal chain of command; notify ESDA/EMA's and notify external response partners. ESDA/EMA's notify affected parties of emergency incident.
Seepage	Localized new seepage or boil(s) observed along downstream face / toe of earthen embankment with muddy discharge and increasing but controllable discharge of water.	1. Measure and record feature dimensions, approximate flow rate, and relative location to existing surface features. Take photos. Document location on a site plan and in inspection notes. 2. Determine Response Level. 3. Make proper notifications as outlined in the Figure 2-2 Notification Flowchart. 4. ERT (with Dam Safety Manager as lead) to determine mitigation actions. The following actions may apply: a) Place a ring of sandbags with a weir at the top towards the natural drainage path to monitor flow rate. If boil becomes too large to sandbag, place a blanket filter over the area using non-woven filter fabric and pea gravel. Attempt to contain flow in such a manner (without performing any excavations) that flow rates can be measured. Stockpile gravel and sand fill for later use, if necessary. b) Inspect the embankment and collect piezometer, water level and seepage flow data daily unless otherwise instructed by the Dam Safety Manager. Record any changes of conditions. Carefully observe embankment for signs of depressions, seepage, sinkholes, cracking or movement. c) Maintain continuous monitoring of feature. Record measured flow rate and any changes of condition, including presence or absence of muddy discharge. 5. Make notifications as outlined in the lower portion of the Notification Flowchart (Figure 2-2) if condition worsens such that failure is imminent.

Table 4-3. Step 3: Emergency Actions

Condition	Description of Condition	Action to be Taken
Sabotage and Miscellaneous Other Issues	Criminal action with significant damage to embankment or structures where significant repairs are required and the integrity of the facility is compromised—condition appears stable with time.	1. Contact law enforcement authorities and restrict all access (except emergency responders) to impoundment. Restrict traffic on embankment crest to essential emergency operations only. 2. Determine Response Level. 3. Make internal notifications as outlined in the upper portion of the Notification Flowchart (Figure 2-2). 4. In conjunction with the Dam Safety Manager, assess extent of damage and visually inspect entire embankment and ancillary structures for additional less obvious damage. Based on inspection results, confirm if extent of damage to various components of the impoundment warrants a revised Response Level and additional notifications. 5. Perform additional tasks as directed by the ERT. 6. Make notifications if conditions worsen.
Embankment Deformation	**Cracks:** New longitudinal (along the embankment) or transverse (across the embankment) cracks more than 6 inches deep or more than 3 inches wide or increasing with time. New concave cracks on or near the embankment crest associated with slope movement.	1. Measure and record feature dimensions, approximate flow rate, and relative location to existing surface features. Take photos. Document location on a site plan and in inspection notes. 2. Restrict traffic on embankment crest to essential emergency operations only. 3. Determine Response Level. 4. Make notifications as outlined in the Figure 2-2 Notification Flowchart. 5. ERT (with Dam Safety Manager as lead) to determine mitigation actions. The following actions may apply: a) Place buttress fill against base of slope immediately below surface feature. Stockpile additional fill. b) Place sandbags as necessary around crack area to divert any storm water runoff from flowing into crack(s). 6. As directed by the Dam Safety Manager, additional inspection and monitoring of the dam may be required. Items may include: inspect the dam on a schedule determined by the Dam Safety Manager; collect piezometer and water level data; and record any changes of condition. Carefully observe dam for signs of depressions, seepage, sinkholes, cracking or movement. 7. Make notifications as outlined in the Figure 2-2 Notification Flowchart if conditions worsen such that failure is imminent.
	Slides / Erosion: Deep slide / erosion (greater than 2 feet deep) on the embankment that may also extend beyond the embankment toe but does not encroach onto the embankment crest and appears stable with time.	1. Measure and record feature dimensions, approximate flow rate, and relative location to existing surface features. Take photos. Document location on a site plan and in inspection report. 2. Restrict traffic on embankment crest to essential emergency operations only. 3. Determine the Response Level. 4. Make notifications as outlined in the Figure 2-2 Notification Flowchart. 5. ERT (with Dam Safety Manager as lead) to determine mitigation actions. Additional actions may include the following items. a) Place sandbags as necessary around slide area to divert any storm water runoff from flowing into slide(s). b) Increase inspections of the dam; collect piezometer and water level data; and record any changes of condition. During inspections, carefully observe dam for signs of depressions, seepage, sinkholes, cracking or movement. 6. Make notifications as outlined in the Figure 2-2 Notification Flowchart if conditions worsen such that failure is imminent.

Table 4-3. Step 3: Emergency Actions

Condition	Description of Condition	Action to be Taken
Embankment Deformation (cont.)	**Sinkholes:** Small depression observed on the embankment or within 50 feet of the embankment toe that is less than 5 feet deep and 30 feet wide or which is increasing with time.	1. Slowly open drain gates to lower pool elevation. 2. Measure and record feature dimensions, approximate flow rate, and relative location to existing surface features. Take photos. Document location on a site plan and in inspection notes. 3. Restrict traffic on embankment crest to essential emergency operations only. 4. Determine Response Level. 5. Make notifications as outlined in the Figure 2-2 Notification Flowchart. 6. ERT (with Dam Safety Manager as lead) to determine mitigation actions. Additional actions may include the following items: a) Backfill the depression with relatively clean earth fill (free of organic materials) generally even with surrounding grade and slightly mounded (6 to 12 inches higher) in the center in order to shed storm water away from the depression. Stockpile additional fill. b) Increase inspections of the dam; collect piezometer and water level data daily unless otherwise instructed by Dam Safety Manager; and record any changes of condition. Carefully observe dam for signs of depressions, seepage, sinkholes, cracking or movement. 7. Make notifications as outlined in the Figure 2-2 Notification Flowchart if conditions worsen such that failure is imminent.
Gate Malfunction or Failure	Sluice gate damaged structurally (sabotage, debris, etc.) with uncontrolled release of water at a constant volume. Condition appears stable.	1. Close any other gates, if open. 2. Determine Response Level. 3. Make notifications as outlined in the Figure 2-2 Notification Flowchart. 4. Obtain instructions from the Dam Safety Manager to determine if there are other methods to stop or slow down the flow of water. 5. If conditions worsen such that failure is imminent, make notifications as outlined in the lower portion of the Figure 2-2 Notification Flowchart.

5 PREPAREDNESS

The intent of this section is to provide information that will be utilized during a response. Established emergency supplies and locations, suppliers, and equipment are provided in Table 5-1. Supplier contact information is listed in Table 5-2.

A coordination meeting shall be conducted annually between representatives of the Illinois Power Generating Company and local emergency responders. This meeting may be in the form of a face-to-face meeting, tabletop exercise, or additional training regarding the EAP.

Table 5-1. Emergency Supplies and Equipment

Item	On-site (Yes/No/Occasionally)	Remarks
Flashlights	Yes	Contact EAP Coordinator for location(s).
Generator	Yes	Contact EAP Coordinator for location(s). Contact Grand Rental Station for additional generators (see Table 5-2).
Extension Cords	Yes	Contact EAP Coordinator for location(s).
Fire extinguishers	Yes	Contact EAP Coordinator for location(s).
Floodlights	Yes	Contact EAP Coordinator for location(s). Contact Grand Rental Station for additional emergency lighting (see Table 5-2).
Backhoe	Yes	Backhoe/tractor and 650 John Deere Track hoe available. Contact EAP Coordinator for location(s).
Dozer	Yes	D7 & D10 Crawler Tractors and two rubber-tired dozers (844B & 834B). Contact EAP Coordinator for location(s).
Dump Truck	Yes	Contact EAP Coordinator for location(s).
Large Equipment Rental (excavating equipment, large earth moving, etc.)	Occasionally	Contact EAP Coordinator for availability and location(s). Contact United Rentals (see Table 5-2) and/or other nearby large equipment rental providers for additional large equipment as necessary.
Pump and Hoses	Yes	Contact EAP Coordinator for location(s). Contact The Curry Companies or Rain for Rent for high-capacity portable pumps (see Table 5-2).
Sandbags	Yes	Contact EAP Coordinator for location(s). Contact Great Western Bag Co. for additional sandbags (see Table 5-2).
Fill (Stone, aggregate, sand)	Yes	Contact EAP Coordinator for location(s). Contact listed suppliers in Table 5-2 for gravel, sand, and riprap fill as necessary.
Concrete/grout	Yes	Contact EAP Coordinator for location(s). Contact Vandalia Ready Mix and/or Greenville Ready Mix for additional concrete (see Table 5-2).
Geotextile Filter Fabric	Yes	Two rolls of 10-ounce, non-woven filter fabric available. Contact EAP Coordinator for location(s).
Plastic Sheeting	Yes	Contact EAP Coordinator for location(s).
Rope	Yes	Contact EAP Coordinator for location(s). Should be maintained in close proximity to any features that might require immediate access.
Personal Flotation Devices	Yes	Contact EAP Coordinator for location(s).

Table 5-2. Supplier Addresses

Supply/Rental Item(s)	Supplier Contact Information	Distance from Site (miles)	Address
Sandbags	**Great Western Bag Co.** (314) 421-0498 (days) (314) 993-5287 (nights/weekends)	66	1416 N. Broadway St. Louis, MO
Gravel, Sand, & Riprap	**Fuller Brothers Ready Mix** (217) 532-2422	11	935 Ash Street Hillsboro, IL
Gravel, Sand, & Riprap	**Vandalia Sand and Gravel** (618) 283-4029	20	Route 140 Vandalia, IL
Gravel, Sand, & Riprap	**Central Illinois Materials** (618) 283-3259	20	RR 2 Vandalia, IL
Gravel, Sand, Riprap & High-Capacity Portable Pumps	**The Curry Companies** Brian Fenton: (217) 854-3101	40	21149 Route 4 Carlinville, IL
High-Capacity Portable Pumps	**Rain for Rent** Mark ByBee: (618) 931-0901	60	3711 Horseshoe Lake Road Granite City, IL
High-Capacity Portable Pumps	**Linden and Company** (800) 383-4811	145	800 W. Deerbrook Peoria, IL 61615
High-Capacity Portable Pumps	**Heartland Pumps** (618) 985-5110	120	1800 Supply Road, Suite A Carterville, IL 62918
Emergency Lighting, 5,000 to 8,500watt Generators, Concrete Mixers, Compact Excavators, Skid Steers, Portable Pumps, & Plate Compactors	**Grand Rental Station Fairview Heights, IL** (618) 277-7750 (866) 645-0218 (after hours)	60	5612 N. Illinois Street Fairview Heights, IL
Emergency Lighting, 4,000watt Generators, Concrete Mixers, Tractor Backhoes/Loaders, Compact Excavators, Skid Steers, Portable Pumps, & Compactors (Plate & Vibratory)	**Grand Rental Station Litchfield, IL** (217) 324-4000 (866) 645-0218 (after hours)	20	1105 West Weir Street Litchfield, IL 62056
Concrete (Ready Mix Concrete Supplier)	**Vandalia Ready Mix** (618) 283-1600	20	1021 Janette Drive Vandalia, IL 62471
Concrete (Ready Mix Concrete Supplier)	**Greenville Ready Mix** (618) 664-1340	17	1311 S. 4th Street Greeneville, IL 62246
Large Earthmoving Equipment (25,000 to 50,000 lb. Track hoe Excavators & 3.0 to 3.4 CY Wheel Loaders)	**United Rentals** (618) 345-6050	60	5076 Mid America Court Collinsville, IL 62234

6 FACILITY/IMPOUNDMENT DESCRIPTION

The impoundments included in this EAP are described as follows and illustrated in Figure 1-2. Table 6-1 contains additional geometric details for each impoundment.

The Coffeen Power Plant is located in Montgomery County, Illinois approximately 1.5 miles south of Coffeen, Illinois. The plant is located on the east bank of Coffeen Lake, which is an impoundment created by Coffeen Lake Dam.

The GMF Pond is located northeast of power plant and north of the GMF Recycle Pond. The GMF Pond consists of a single pond formed by an earthen embankment around its perimeter. The earthen embankment crest elevation is currently 13-feet above grade; however, its final design has a crest elevation 100-feet above grade. The final design was used in the breach analysis and corresponding inundation map because the final design is more conservative than existing conditions (larger volume, greater dam height, etc.). The GMF Pond is used to dewater, store and dispose of gypsum from the Power Plant’s flue gas desulphurization system. The GMF Pond discharges via a HDPE lined transfer channel into the GMF Recycle Pond. The transfer channel has a trapezoidal cross section with 3H:1V side slopes, a bottom width of 32 feet, a depth of 9-feet, and is 500-feet long.

The GMF Recycle Pond is located northeast of the power plant and south of the GMF Pond. The GMF Recycle Pond consists of a single pond formed by an earthen embankment around its perimeter. The pond is used to dewater, store and dispose of gypsum. It also is used to retain stormwater discharge from the GMF Pond transfer channel. The pool level is controlled by a recycle pump system that is located at the southeast corner. There is an emergency spillway located at the northeast corner that discharges into a creek that runs along the east side of the pond and discharges into the eastern cove of Coffeen Lake (Eastern Cove).

Ash Pond No. 1 is located east of the power plant and consists of a single pond formed by earthen embankments around the perimeter. The pool level is controlled by a recycle pump system that is located at the northwest corner. The emergency spillway consists of a pipe that connects to the top of the recycle pump intake pipe. The emergency spillway discharges into the cooling water discharge channel to the north which feeds into the eastern cove of Coffeen Lake. The stored material settled in the bottom of the pond consists of primarily bottom ash and boiler slag.

Ash Pond No. 2 is located east of the power plant, north of Ash Pond No. 1 and west of the Cooling Water Pond. Ash Pond No. 2 was closed by leaving CCR in place and constructing a final cover system. The boundaries of these impoundments encompass a total area of approximately 60 acres.

Table 6-1. Power Plant Impoundment Characteristics

Feature/Parameter	GMF Pond	GMF Recycle Pond	Ash Pond No.1	Ash Pond No.2
Maximum Embankment Height	13.0 feet	20.0 feet	41.5 feet	28.0 feet
Length of Dam	5,060 feet	3,600 feet	4,300 feet	6,400 feet
Crest Width	20 feet	20 feet	N/A	N/A
Crest Elevation	632.0 feet	629.0 feet	637.5 feet	638.0 feet
Reservoir Area at Top of Dam	37.6 acres	17.0 acres	N/A	N/A
Storage Capacity at Top of Dam	442 acre-feet	324 acre-feet	N/A	N/A
Primary Spillway Type	Trapezoidal Channel	Recycle Pump	Recycle Pump (48" dia. steel intake pipe)	Stormwater let-down structures are now the spillways
Primary Spillway Crest Elevation	623.0 feet	610.0 feet	N/A	N/A
Storage Capacity at Primary Spillway Elevation	1,150 acre-feet	49.7 acre-feet	N/A	N/A
Reservoir Area at Normal Water Surface Elevation	27.0 acres	10.4 acres	N/A	N/A
Auxiliary Spillway Type	None	(3x) 6'x6' conc. risers to (3x) 4'dia. HDPE pipes	N/A	N/A
Auxiliary Spillway Crest Elevation	N/A	624.1 feet	N/A	N/A

Notes:
Elevations are in reference to NAVD88

7 BREACH INUNDATION MAPS AND POTENTIAL IMPACTS

Inundation maps for GMF Pond, GMF Recycle Pond, Ash Pond No.1, and Ash Pond No.2 potential breach scenarios are provided in the following pages. It is the Montgomery County ESDA/EMA's responsibility to keep a current list of affected parties/properties to contact in the case of emergencies that result in Response Level 2 or 3. This list should encompass all properties within and adjacent to the probable inundation extents shown in the provided inundation maps.

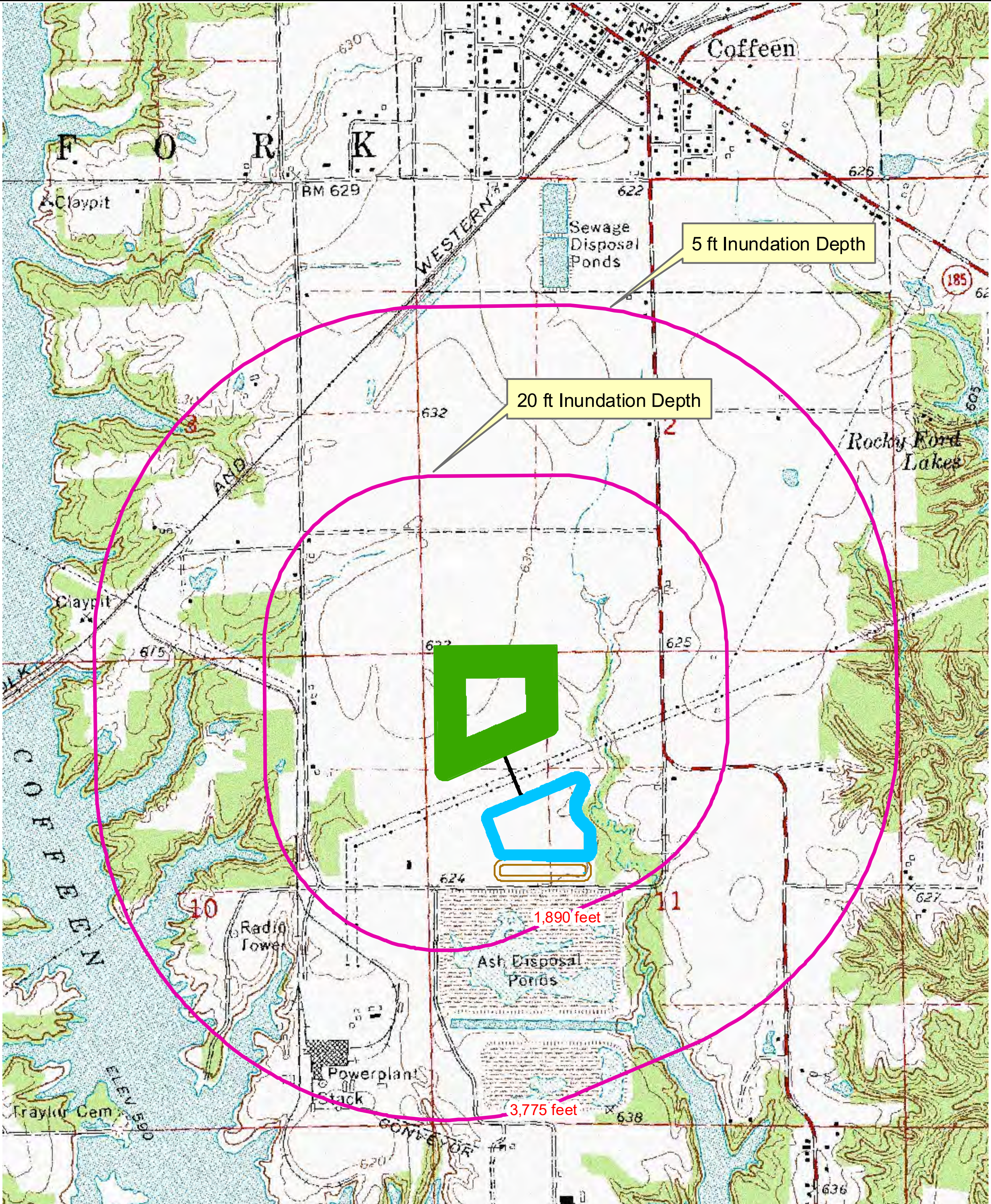
The methodology used to identify probable inundation extents for potential breach scenarios varied as a function of the impoundment size, location, surrounding topography, and surrounding structures/facilities/waterbodies.

The GMF Pond inundation map was developed by Hanson Professional Services Inc. (2007) using final design conditions (100-feet tall and 2,478 acre-feet of stored volume) and an approximate method of computing the inundation limits of gypsum slurry by computing a runout distance on a constant slope. It was assumed that a breach of the earthen perimeter embankment would cause saturated gypsum material to liquefy and release towards downstream areas in a semi-circular pattern. This breach scenario was simulated at multiple locations along the earthen perimeter dike and the corresponding results were used to create the inundation map shown as Figure 7-1.

The GMF Recycle Pond breach analysis consisted of a Probable Maximum Precipitation (PMP) failure scenario at the eastern embankment. The resultant breach discharges were modeled downstream using 1D and 2D capabilities of HEC-RAS. The approximate inundation area is illustrated in the inundation map shown as Figure 7-2.

The Ash Pond No. 1 breach analysis consisted of PMP failure scenarios of the embankment near the northwest and northeast corners of the pond. The breach discharges were modeled downstream using 1D and 2D capabilities of HEC-RAS. The approximate inundation area is illustrated in the inundation map shown as Figure 7-2.

The Ash Pond No. 2 breach analysis consisted of a failure scenario where the stored volume liquefies and breaches the embankment near the southwest corner of the pond. The breach discharge was modeled downstream using 2D capabilities of HEC-RAS. The approximate inundation area is illustrated in the inundation map shown as Figure 7-2.



N

W E

S

0 700 1,400 2,800

Feet

GYPSUM BREACH INUNDATION MAP

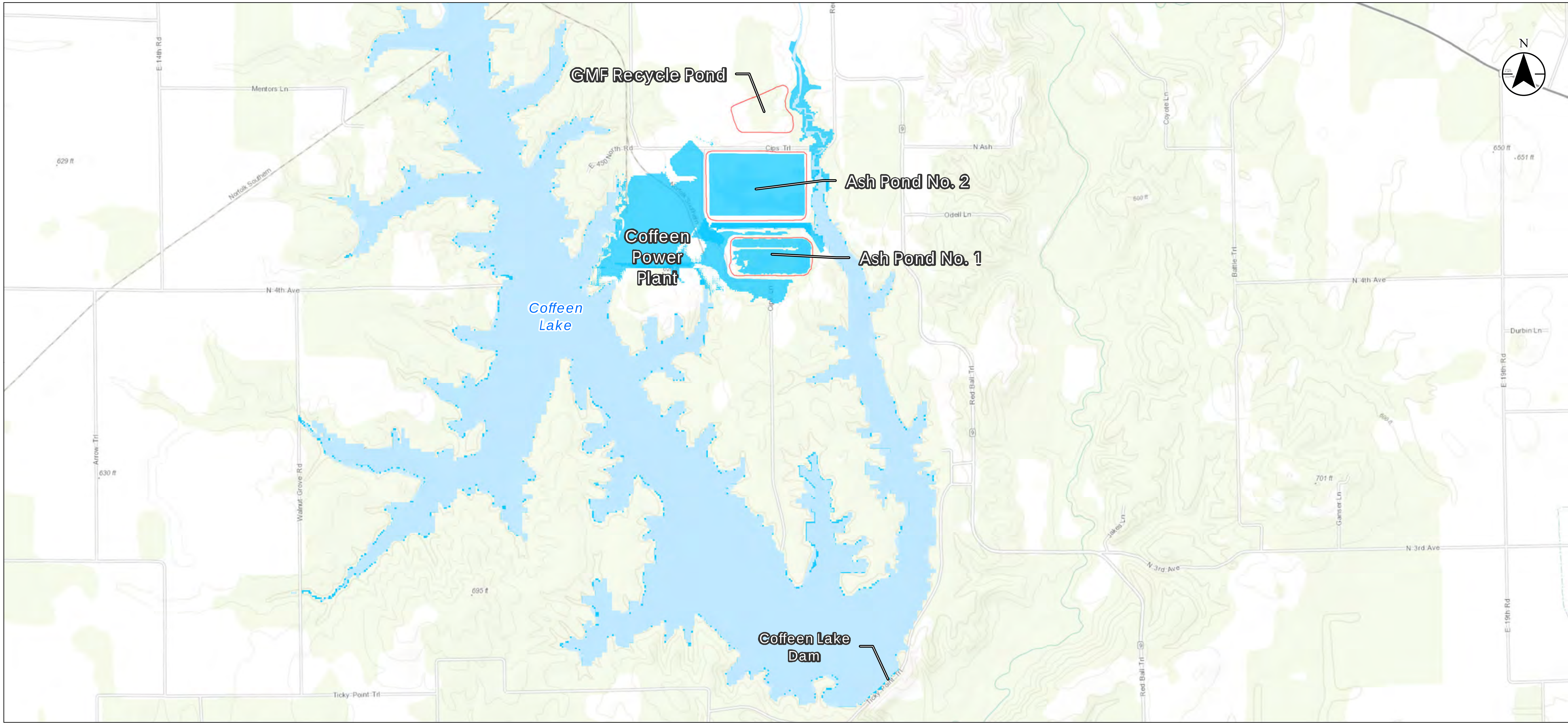
Hanson Professional Services Inc.

GYPSUM MANAGEMENT FACILITY
COFFEEN POWER GENERATING STATION
MONTGOMERY COUNTY, ILLINOIS

Job Number 05S3004A

Figure Appendix C - 1

I:\05jobs\05s3004A\GIS\Projects\IDNR-OWR Schematic.mxd



Legend

- CCR Surface Impoundment Boundary
- 100-year Storm Event Inundation Approximate Limits
- Expected Breach Inundation Area

0 2,000 Feet

1:24,000 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 StatePlane Illinois West FIPS 1202 Feet
2. Aerial Source: 2015 NAIP Imagery
3. Impoundment Boundaries Provided by Client (Dated 9/9/2015)

Stantec DYNEGY

Project Location 175605019
Latitude: 39.059113
Longitude: -89.403293
Montgomery County, Illinois

Prepared by RMGB on 3/29/2017
Technical Review by NS on 3/29/2017
Independent Review by MM on 3/29/2017

Client/Project
Coffeen Power Station
Emergency Action Plan

Figure No.
7-2

Title
Inundation Map
GMF Recycle Pond, Ash Pond No.1, Ash Pond No.2

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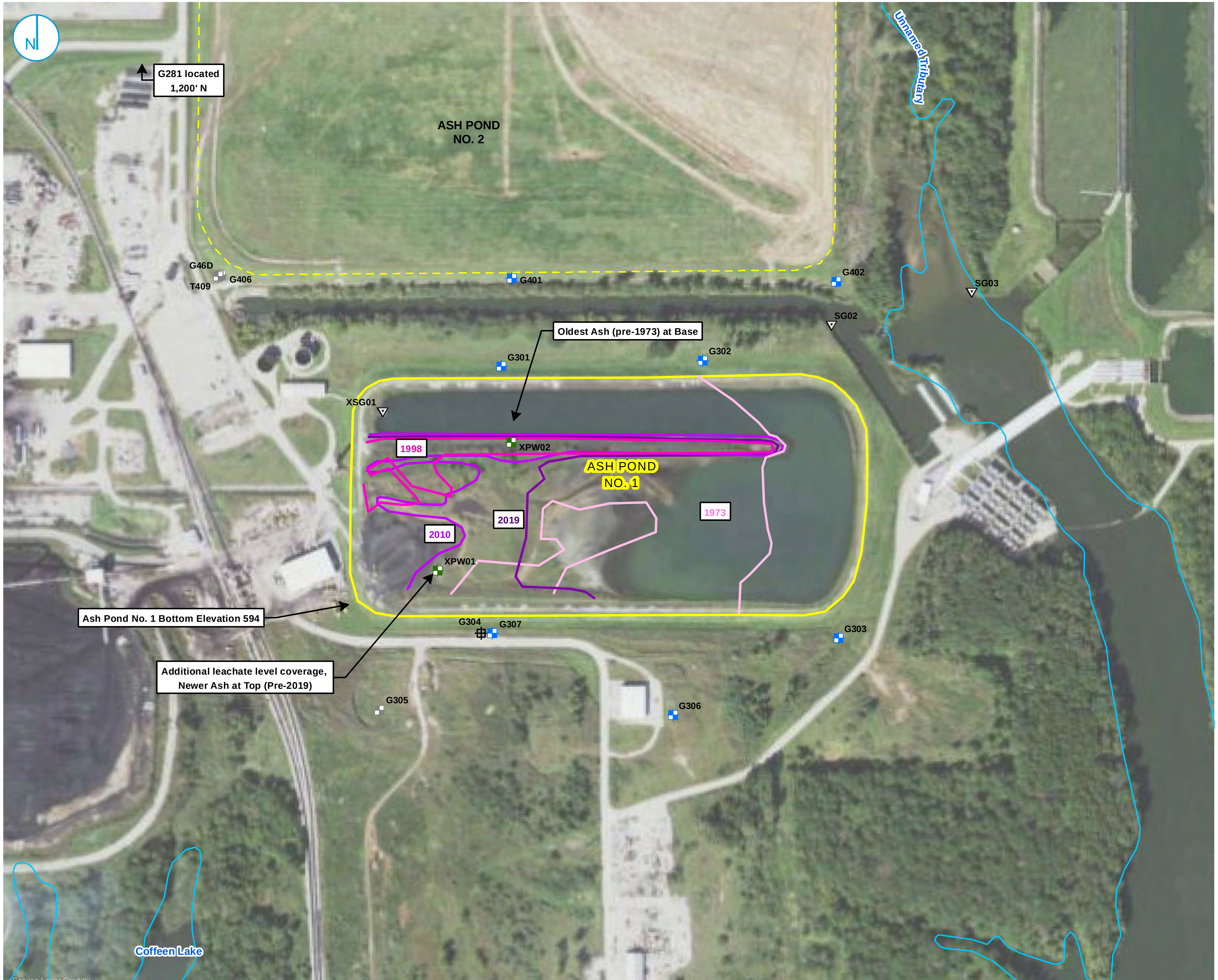
Attachment C



PROPOSED LEACHATE WELL LOCATION
PROPOSED STAFF GAUGE LOCATION
CCR RULE MONITORING WELL
NON-CCR RULE MONITORING WELL
ABANDONED MONITORING WELL
APPROXIMATE LIMITS OF ASH BASED ON 1973 AERIAL
APPROXIMATE LIMITS OF ASH BASED ON 1998 AERIAL
APPROXIMATE LIMITS OF ASH BASED ON 2010 AERIAL
APPROXIMATE LIMITS OF ASH BASED ON 2019 AERIAL
CCR UNIT BOUNDARY, SUBJECT SITE
CCR UNIT BOUNDARY
SURFACE WATER FEATURE

0 150 300 Feet

CCR CHARACTERIZATION MAP

COFFEEN ASH POND NO. 1 (UNIT ID: 101)

COFFEEN POWER STATION
COFFEEN, ILLINOIS

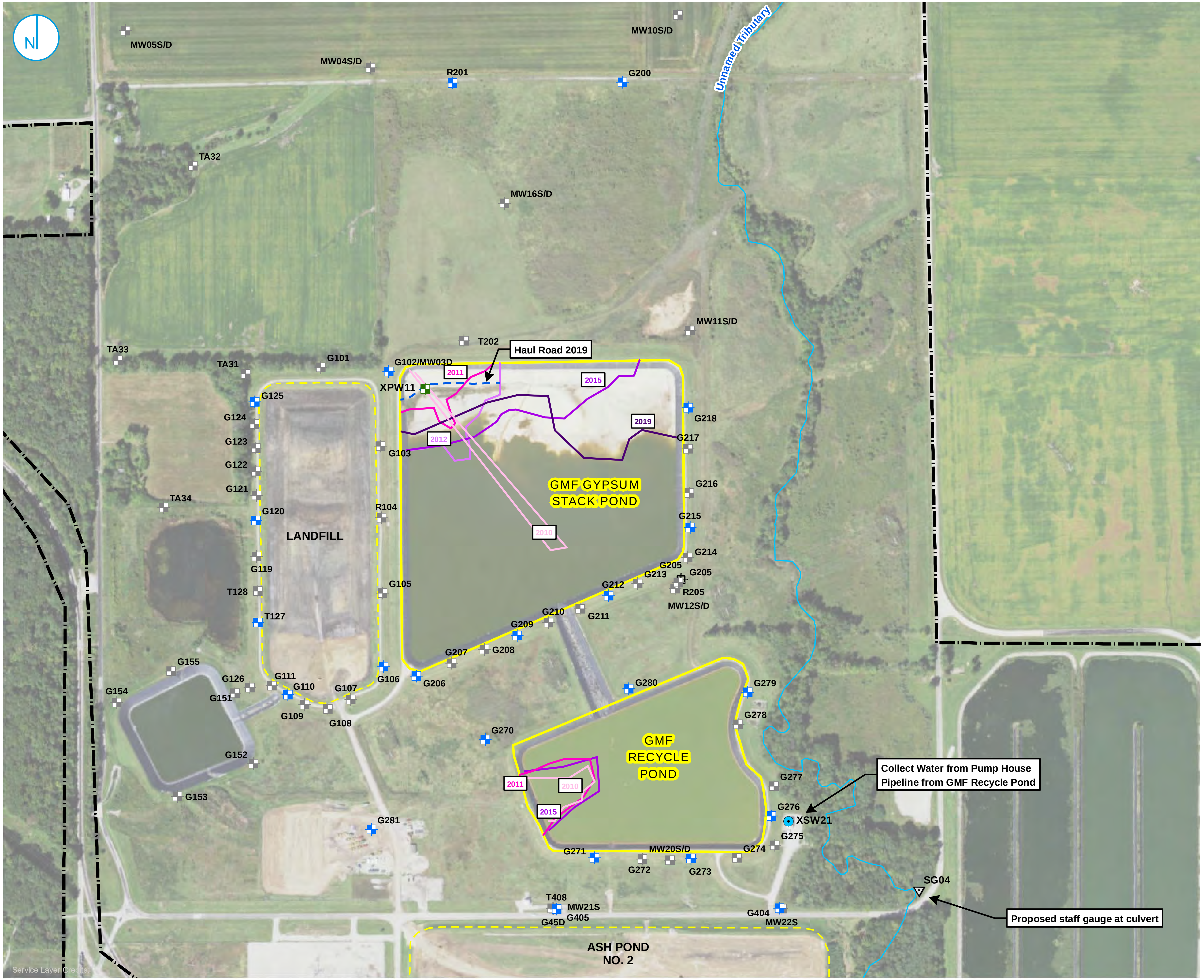
FIGURE - 1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\845\Coffeen\AP1\Figure 5_Proposed CCR Characterization Points.mxd

PROJECT: 169000XXXX | DATED: 11/18/2020 | DESIGNER: galarnmc



Y:\Mapping\Projects\22\2285\MXD\845\Coffeen\GMF\Figure 5_Proposed CCR Characterization Points.mxd

PROJECT: 169000XXXX | DATED: 11/13/2020 | DESIGNER: STOLZSD

PROPOSED LEACHATE WELL LOCATION
PROPOSED STAFF GAUGE LOCATION
PROPOSED POREWATER/SOURCE WATER SAMPLE LOCATION
CCR RULE MONITORING WELL
NON-CCR RULE MONITORING WELL
ABANDONED MONITORING WELL
APPROXIMATE LIMITS OF ASH BASED ON 2010 AERIAL
APPROXIMATE LIMITS OF ASH BASED ON 2011 AERIAL
APPROXIMATE LIMITS OF ASH BASED ON 2012 AERIAL
APPROXIMATE LIMITS OF ASH BASED ON 2015 AERIAL
APPROXIMATE LIMITS OF ASH BASED ON 2019 AERIAL
HAUL ROAD 2019
CCR UNIT BOUNDARY, SUBJECT SITE
CCR UNIT BOUNDARY
SURFACE WATER FEATURE
COFFEEN OWNED PROPERTY

0 225 450 Feet

CCR CHARACTERIZATION MAP

COFFEEN GMF GYPSUM STACK POND (UNIT ID: 103) AND GMF RECYCLE POND (UNIT ID: 104)

COFFEEN POWER STATION
COFFEEN, ILLINOIS

FIGURE - 2

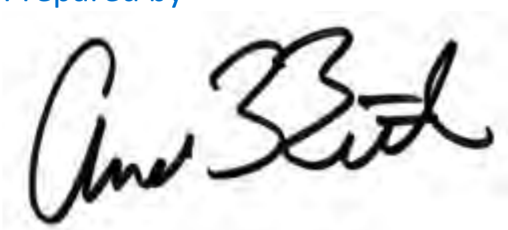
RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

Attachment D

Closure Alternatives Analysis Groundwater Modeling Review at the Coffeen Power Plant, Edwards Power Plant, Newton Power Plant, and Hennepin Power Plant

Expert Report of Andrew Bittner, P.E.

Prepared by



Andrew Bittner, M.Eng., P.E.

Prepared for
ArentFox Schiff LLP
233 South Wacker Drive, Suite 7100
Chicago, IL 60606

January 24, 2024

GRADIENT
www.gradientcorp.com
One Beacon Street, 17th Floor
Boston, MA 02108
617-395-5000

Table of Contents

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List of Tables

Abbreviations

AP1	Ash Pond 1
CAA	Closure Alternatives Analysis
CBR	Closure By Removal
CCR	Coal Combustion Residual
CIP	Closure In Place
DMG	Dynegy Midwest Generation, LLC
EAP	East Ash Pond
GMF GSP	Gypsum Management Facility Gypsum Stack Pond
GMF RP	Gypsum Management Facility Recycle Pond
GWPS	Groundwater Protection Standards
HELP	Hydrologic Evaluation of Landfill Performance
ID	Identification
IEPA	Illinois Environmental Protection Agency
IPGC	Illinois Power Generating Company
IPRG	Illinois Power Resources Generating, LLC
K_d	Distribution Coefficient
mL/g	Milliliters Per Gram
NID	National Inventory of Dams
No.	Number
PAP	Primary Ash Pond
PE	Professional Engineer
SIs	Surface Impoundments
TDS	Total Dissolved Solids

1 Introduction and Background

1.1 Scope and Objectives

On behalf of Dynegy Midwest Generation, LLC (DMG); Illinois Power Resources Generating Company (IPRG); and Illinois Power Generating Company (IPGC), I have been retained to provide opinions related to the Illinois Environmental Protection Agency (IEPA) Initial Review Letters (IEPA, 2023a, 2023b, 2023c, 2023d) in response to the Construction Permit Applications for coal combustion residual (CCR) surface impoundments (SIs) at the Coffeen Power Plant, the Edwards Power Plant, the Newton Power Plant, and the Hennepin Power Plant (Golder Associates USA Inc., 2022a, 2022b, 2022c; IngenAE, LLC 2022; HDR Inc., 2022; Geosyntec Consultants, 2022). Specifically, my opinions relate to groundwater models that were developed in support of the Closure Alternatives Analysis (CAA). In their Initial Review Letters (IEPA, 2023a, 2023b, 2023c, 2023d), IEPA raised concerns regarding the adequacy of groundwater modeling that was conducted related to current and former CCR SIs located at each facility. Specifically, IEPA raised concerns regarding the sufficiency of only modeling selected CCR-related constituents at each facility, as opposed to modeling all CCR-related constituents. IEPA's Initial Review Letters indicate that "all constituents listed in Section 845.600 that have been found to be present in the CCR surface impoundment" must "be assessed in the groundwater model" (IEPA, 2023a, 2023b, 2023c, 2023d).

The opinions presented in this report are based on the information that I have reviewed and cited as of the date of this report, as well as my education and experience. I reserve the right to modify my opinions based on additional information that may become available.

1.2 Background

Part 845 of the Illinois Administrative Code (Title 35, Subtitle G, Chapter I, Subchapter j; IEPA, 2021), hereafter referred to as "Part 845", sets standards and requirements pertaining to the design, construction, operation, groundwater monitoring, corrective action, closure, and post-closure care of certain CCR SIs in the State of Illinois. In particular, Part 845 (IEPA, 2021) requires the development of a CAA (Section 845.710) prior to undertaking closure activities. One specific requirement of the CAA [845.710(d)(2)] is that the time to achieve groundwater protection standards (GWPS) must be evaluated for each closure alternative:

> The analysis for each alternative completed pursuant to this Section must… contain the results of groundwater contaminant transport modeling and calculations showing how the closure alternative will achieve compliance with the applicable groundwater protection standards (IEPA, 2021)

In response to this requirement, Ramboll developed groundwater models at selected facilities (Ramboll, 2022a, 2022b, 2022c, 2022d, 2022e) that evaluate the duration required for each closure alternative to achieve the GWPSs. In these models, selected CCR-related constituents were evaluated. Specific CCR SIs for which groundwater models were developed, and that were addressed in IEPA Initial Review Letters (IEPA, 2023a, 2023b, 2023c, 2023d), include the following:

- Ash Pond 1 (AP1; Vistra Identification [ID] Number [No.] 101, Illinois Environmental Protection Agency [IEPA] ID No. W1350150004-01, and National Inventory of Dams [NID] No. IL50722) at the Coffeen Power Plant in Coffeen, IL;
- The Gypsum Management Facility Gypsum Stack Pond (GMF GSP; Vistra ID No. 103, IEPA ID No. W1350150004-03, and NID No. IL50579) and the Gypsum Management Facility Recycle Pond (GMF RP; Vistra ID No. 104, IEPA ID No. W1350150004-04, and NID No. IL50578) at the Coffeen Power Plant in Coffeen, IL;
- The Ash Pond (Vistra ID No. 301, IEPA ID No. W1438050005-01, and NID No. IL50710) at the Edwards Power Plant near Bartonville, IL;
- The Primary Ash Pond (PAP; Vistra ID No. 501, IEPA ID No. W0798070001-01, NID No. IL50719) at the Newton Power Plant, in Newton, IL; and
- The East Ash Pond (EAP); Vistra ID No. 803, IEPA ID No. W1550100002-05, NID No. IL50363) at the Hennepin Power Plant in Hennepin, IL.

A summary of the groundwater modeling results, including an estimate of the time by which each closure alternative is expected to achieve the GWPSs, was provided to IEPA in the CAA (Gradient, 2022a; Gradient 2022b; Gradient 2022c; Gradient 2022d; Gradient 2021a) and the Groundwater Modeling Report (Ramboll, 2022a, 2022b, 2022c, 2022d, 2022e) for each facility, which in turn was included as part of the Construction Permit Application for each facility (Golder Associates USA Inc., 2022a, 2022b, 2022c; IngenAE, LLC, 2022; HDR Inc., 2022; Geosyntec Consultants, 2022).

1.3 Qualifications

I am a Principal at Gradient, an environmental consulting firm located in Boston, Massachusetts, and a licensed professional engineer (PE). With over 25 years of professional experience, I have consulted and testified regarding a variety of projects related to the fate and transport of constituents in the environment, hydrogeology, groundwater and surface water modeling, site characterization, and remediation system design. I have a master's degree in environmental engineering from the Massachusetts Institute of Technology and bachelor's degrees in environmental engineering and physics from the University of Michigan. A copy of my *curriculum vitae* is provided in Appendix A.

I have published and presented on a variety of topics, including groundwater and surface water fate and transport modeling of coal ash constituents, assessments of former coal-fired power plants, mass flux and mass discharge of constituents in groundwater, remedial system optimization, and the impact of environmental regulations in the United States and abroad. As a consultant during the past 25 years, I have applied my knowledge of fate and transport processes to address a range of complex challenges in the electric power, oil and gas, chemical manufacturing, pharmaceutical, mining, agrichemical, and waste disposal sectors. In particular, for the electric power industry, my experience includes projects involving regulatory comment, closure assessments, fate and transport modeling, and risk assessment. Moreover, I have worked on and been involved with projects at approximately 70 different CCR SIs.

I have served as a testifying expert and provided expert testimony, both in deposition and in front of regulatory bodies, on range of coal ash matters, including coal ash surface impoundment closure standards and the fate and transport of CCR-related constituents in the environment. A list of my prior testimony experience is provided in my *curriculum vitae* in Appendix A.

2 Summary of Opinions

A summary of my opinions that are provided in this report is provided below.

2.1 Modeling surrogate constituents is an appropriate approach to achieve model objectives in support of the CAA

Modeling selected constituents is a common approach for evaluation of environmental systems and is sufficient to achieve the model objectives in support of the CAA. All environmental models are, in some regard, simplifications of complex systems; one common model simplification is to use one or more surrogate constituents to conservatively represent the potential behavior of a larger group of constituents. During the selection of surrogate constituents, a model's objectives must be considered.

For the groundwater modeling performed in support of the CAA at the AP1, the GMF GSP, and the GMF RP at the Coffeen Power Plant, the Ash Pond at the Edwards Power Plant, the PAP at the Newton Power Plant, and the EAP at the Hennepin Power Plant, model objectives were to evaluate the effects of various closure alternatives (*i.e.*, source control measures) on groundwater quality and to specifically predict for each closure alternative the time at which GWPSs will be achieved for constituents with GWPS exceedances that are attributable to the unit. A reasonable approach to achieve this model objective is to select, as a surrogate, the constituent at each site that will likely require the longest time to achieve its GWPS. The constituents that have been detected in groundwater at the highest concentrations relative to their GWPSs and with the highest frequency of GWPS exceedances are the constituents that will likely take the longest time to achieve their GWPSs. For these objectives, it is not necessary to model all constituents that have been detected at lower concentrations relative to their GWPSs and with lower frequencies of GWPS exceedances, because these constituents will likely achieve their GWPSs faster than the selected surrogate constituent.

Based on this approach, sulfate was selected as the constituent to evaluate in the groundwater model at the AP1, the GMF GSP, and the GMF RP at the Coffeen Power Plant, and at the PAP at the Newton Power Plant; and boron was selected as the constituent to evaluate in the groundwater model at the Ash Pond at the Edwards Power Plant and at the EAP at the Hennepin Power Plant. These surrogate constituents have similar groundwater transport characteristics as the other constituents that have been detected with potential GWPS exceedances; therefore, subsurface transport during closure conditions would be similar for all of the constituents that have been detected with potential GWPS exceedances. Because each of these constituents is expected to behave in a similar manner during closure, it is appropriate to only model the surrogate constituents and use the surrogate constituents to determine when each closure alternative will likely achieve the GWPSs for all constituents.

2.2 Part 845 does not require that all constituents listed in Section 845.600 be evaluated in a groundwater model

Part 845 does not require that groundwater models developed in support of the CAA, as required by Section 845.710(d)(2) (IEPA, 2021), evaluate "all constituents listed in Section 845.600 that have been found to be present in the CCR surface impoundment" (IEPA, 2023a, 2023b, 2023c, 2023d). Part 845 requires only that groundwater modeling evaluate "how the closure alternative will achieve compliance with the applicable groundwater protection standards" (IEPA, 2021). There is no language in Part 845 suggesting that the groundwater model must evaluate all constituents that have been detected in an SI.

The surrogate constituents that were selected for evaluation in the groundwater models are the constituents that will likely take the longest under each closure scenario to decline to levels below the GWPS and, thus, are appropriate constituents to determine when each closure alternative will achieve the GWPSs, as required in Section 845.710(d)(2) (IEPA, 2021).

2.3 It would be a costly and data-intensive endeavor to model all constituents, and it wouldn't provide any additional useful information

The process of modeling all constituents in an SI would be costly and data-intensive and, ultimately, would not provide any additional information beyond that provided by only modeling the surrogates for evaluating how the closure alternative will achieve compliance with the GWPS. There are a number of CCR-related constituents that have been identified in literature. For example, Appendix III and IV of the 2015 Federal CCR Rule list 22 CCR-related constituents that must be monitored as part of detection and assessment monitoring (US EPA, 2015). Part 845.600 lists 20 CCR-related constituents for which GWPSs have been established (IEPA, 2021).

Building a groundwater model that evaluates all of these potential constituents would be an onerous process. First of all, an extensive amount of groundwater data and evaluation would be required for each constituent, including an evaluation of background groundwater quality and an evaluation of individual partitioning coefficients for each constituent. Subsequently, individual groundwater solute transport models would be need to be developed and calibrated for each constituent. Finally, separate model simulations would need to be evaluated for each closure alternative and for each constituent. Despite the significantly increased effort, the models would not result in any additional useful information for evaluating closure alternatives.

3 Overview of Groundwater Modeling

US EPA's Guidance on the Development, Evaluation, and Application of Environmental Models (US EPA, 2009) defines a model as "a simplification of reality that is constructed to gain insights into select attributes of a particular physical, biological, economic, or social system." In the case of a groundwater model, the physical system being simulated is the subsurface flow of water and the model is "a simplified representation of the complex hydrogeologic conditions in the subsurface" (Anderson *et al*., 2015). There are a variety of different types of models (NRC, 2007):

- Physical models are usually smaller-scale physical versions of the systems being modeled (*e.g*., using laboratory tanks or columns packed with sand or other porous material) (Anderson *et al*., 2015);
- Conceptual models use visual (*e.g*., schematics, flow-charts) or verbal descriptions of important processes and medium properties (US EPA, 1992);
- Empirical models use "statistical equations derived from the available data to calculate an unknown variable" (Anderson *et al*., 2015); and
- Numerical models, which are the types of models that were used to simulate conditions at the Coffeen Power Plant, the Edwards Power Plant, the Newton Power Plant, and the Hennepin Power Plant, involve mathematical representations of processes that govern physical processes.

Different types of numerical groundwater models are used for different applications. Groundwater flow models simulate flow of groundwater through a transmissive media (*e.g*., soil or bedrock). Examples include hydrologic models used to manage water resources and evaluate water supply, rainfall-runoff models that simulate streamflow generation and routing, and models that simulate groundwater-surface water interactions, *etc*. (Anderson *et al*., 2015). Contaminant fate and transport models simulate movement (or "transport") of contaminants through the subsurface due to advection and dispersion[1], and their chemical alteration (or "fate") due to sorption[2] and other chemical reactions or biological processes (OhioEPA, 2007). Contaminant fate and transport models usually rely upon, and work in coordination with, a calibrated groundwater flow model (OhioEPA, 2007). Contaminant fate and transport models are often used to simulate subsurface contaminant migration from a source (*e.g*., a waste disposal facility or a contaminant release) toward potential downgradient receptors (*e.g*., surface water or groundwater supply well) or to support forensic investigations, (*i.e*., to determine sources and age of contaminants present in groundwater).

"The starting point of every groundwater modeling application is to identify the purpose of the model" (Anderson *et al*., 2015). "The purpose of modeling can vary widely, and the approach used may depend on site-specific needs, current understanding of the hydrogeologic system, availability of input data, and expectation and use of the model results" (OhioEPA, 2007). Numerical groundwater models are often used for two primary purposes – to "diagnose" (*i.e*., to re-create the conditions for a past event); or to "forecast"

[1] Advection describes contaminant transport in the primary groundwater flow direction. Mechanical dispersion describes the multidirectional movement of constituents due to differences in flow paths along pore channels or other subsurface heterogeneities (Ramaswami *et al*., 2005).

[2] Sorption (chemical interaction between a contaminant and soil particles) leads to a reduction in the average travel velocity of a contaminant relative to groundwater (Ramaswami *et al*., 2005). The effects of sorption can be quantified using a soil-water partition coefficient, or K_d, which is the constituent concentration that is sorbed to soil particles divided by the concentration that is freely dissolved in groundwater.

(*i.e.*, to predict the effect of a future events) (US EPA, 2009; Anderson *et al*., 2015). Some examples of groundwater modeling objectives (OhioEPA, 2007; US EPA, 1992) are listed below:

- evaluation of groundwater flow direction and velocity;
- evaluation of interaction between hydrogeologic systems;
- evaluation of potential impacts of contamination to wells or surface water;
- estimation of the extent of a contaminant plume;
- estimation of well capture zones and wellhead protection areas;
- development of water supply systems;
- evaluation of physical or hydraulic containment systems; and
- design and assessment of corrective action alternatives.

"The objectives dictate which features of the investigated problem should be represented in the model, and to what degree of accuracy" (US EPA, 1992). Thus, the modeling objective determines the level of complexity required in the model.

US EPA's guidance specifically states that "models are based on simplifying assumptions and cannot completely replicate the complexity inherent in environmental systems" (US EPA, 2009). Different simplifying assumptions can be made in a model based on the model objectives and availability of data. As noted in US EPA's guidance, "[t]he scope (*i.e.*, spatial, temporal and process detail) of models that can be used for a particular application can range from very simple to very complex depending on the problem specification and data availability, among other factors." (US EPA, 2009). Generally, "parsimony (economy or simplicity of assumptions) is desirable in a model" because "model complexity influences uncertainty" (US EPA, 2009). As discussed further in US EPA's guidance, "[m]odels tend to uncertainty as they become increasingly simple or increasingly complex. Thus complexity is an important parameter to consider… [and] the optimal choice generally is a model that is no more complicated than necessary" (US EPA, 2009).

Common simplifications made in a model relate to "the geometry of the investigated domain, the way various heterogeneities [are] smoothed out, the nature of the porous medium (*e.g.*, its homogeneity, isotropy)[3]," as well as the physical and chemical processes being simulated, and the number of constituents considered (US EPA, 1992). Some examples of simplifications that can be made in a model are listed below:

- Numerical models can either be transient (time-varying) or steady state (time-invariant). Steady state models assume that groundwater levels and/or constituent concentrations remain approximately constant over time, whereas transient models account for changing hydraulic or chemical conditions over time (Ramaswami *et al*., 2005). Steady state conditions are often assumed in models if the model is being used to represent average, long-term conditions.
- Models can be one-, two-, or three-dimensional depending "on the purpose of the model, the complexity of the hydrostratigraphy, and the flow system" (Anderson *et al*., 2015).

[3] A porous medium is called homogeneous when its properties are constant throughout the medium. A porous medium is called isotropic if its properties are the same in all directions.

- Homogeneous and isotropic conditions are often used in groundwater models (*i.e.*, aquifer properties are assumed to be constant throughout the aquifer and in all directions, respectively).
- The number of chemical constituents modeled can be limited depending on the model objective. For example, a model application discussed in US EPA's Ground-Water Modeling Compendium (US EPA, 1994) modeled chloride to determine the maximum extent of contamination in the aquifer because chloride "is most mobile and non-retarded" and "its plume would represent the outermost limits of the plumes of the other contaminants of interest."

4 Summary of Site-Specific Groundwater Modeling for Closure Alternatives Analysis

Part 845 (IEPA, 2021) requires the development of a CAA (Section 845.710) prior to undertaking closure activities at certain SIs that contain CCRs. One specific requirement of the CAA [845.710(d)(2)] is that the time to achieve GWPSs must be evaluated for each closure alternative:

> The analysis for each alternative completed pursuant to this Section must… contain the results of groundwater contaminant transport modeling and calculations showing how the closure alternative will achieve compliance with the applicable groundwater protection standards (IEPA, 2021)

In response to this requirement, Ramboll developed groundwater flow and contaminant transport models at selected facilities (Ramboll, 2022a, 2022b, 2022c, 2022d, 2022e) to evaluate the duration required for each closure alternative to achieve the GWPSs.

The three models used by Ramboll for groundwater modeling at these sites (HELP, MODFLOW, and MT3DMS) are widely used, industry-standard models. Brief descriptions of the three models are provided below:

- Hydrologic evaluation of landfill performance (HELP) is a model developed by US EPA that simulates "water movement across, into, through and out of landfills" and "is useful for predicting the amounts of runoff, drainage, and … the buildup of leachate above the [landfill] liner" (Schroeder *et al*., 1994).
- MODFLOW is a finite difference groundwater flow model developed by USGS (Harbaugh, 2005). It is used to simulate two- or three-dimensional, "transient ground-water flow in anisotropic, heterogeneous, layered aquifer systems. It calculates piezometric head distributions, flow rates and water balances" (US EPA, 1994).
- MT3DMS is a contaminant transport model and an update to the modular three-dimensional transport model, MT3D (Zheng and Wang, 1999). MT3DMS simulates changes in contaminant concentrations in groundwater due to "advection, dispersion, diffusion and some basic chemical reactions" (Zheng and Wang, 1999).

A summary of each of these site-specific groundwater models is provided below.

4.1 Ash Pond 1 at the Coffeen Power Plant

The Coffeen Power Plant is a retired electric power generating facility operated by IPGC with coal-fired units located approximately two miles south of the City of Coffeen, Illinois. The plant operated as a coal-fired power plant from 1964 until November 2019 and has five CCR management units. AP1 is a 23-acre, unlined SI with a total storage capacity of 300 acre-feet that was used to manage CCR and non-CCR waste streams (Ramboll, 2022a; Gradient, 2022e).

Based on groundwater monitoring data collected between 2015 and 2021, potential GWPS exceedances of boron, sulfate, and total dissolved solids (TDS) were identified at groundwater monitoring wells near and downgradient of AP1 (Ramboll, 2022a)[4,5]. For boron, sulfate, and TDS, the maximum detected concentrations (based on data collected between 2015 and 2021 from 17 wells near and downgradient of AP1) were 7.5 mg/L, 2,400 mg/L, and 4,000 mg/L, respectively (Gradient, 2022e). Sulfate was the constituent detected at the highest concentration relative to its GWPS.

Ramboll prepared a groundwater modeling report (Ramboll, 2022a) for AP1 that was submitted to IEPA as part of the Construction Permit Application (Golder Associates USA Inc., 2022a). The objective of the groundwater modeling was "to evaluate the effects of closure (source control measures) for AP1 on groundwater quality," and, specifically, to predict the time to meet GWPS in the compliance wells under two proposed closure scenarios – closure in place (CIP) and closure by removal (CBR) (Ramboll, 2022a). The CIP scenario considered would involve "removal of CCR from the eastern portion of AP1, consolidation into the western portion of AP1, and construction of a cover system over the remaining CCR," whereas CBR would involve "removal of all CCR and regrading of the removal area" (Ramboll, 2022a).

Ramboll's modeling approach involved using the HELP model to estimate recharge under the different closure scenarios, using MODFLOW 2005 to simulate groundwater flow in three dimensions, and using MT3DMS model to simulate the three-dimensional transport of sulfate (Ramboll, 2022a). "Sulfate was selected for transport modeling … because: (i) it is commonly present in coal ash leachate; and (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater" (Ramboll, 2022a). Sulfate was modeled as a conservative substance that does "not significantly sorb or chemically react with aquifer solids (distribution coefficient [Kd] was set to 0 milliliters per gram [mL/g])" (Ramboll, 2022a).

4.2 GMF Gypsum Stack Pond and Recycle Pond at the Coffeen Power Plant

The GMF GSP and the GMF RP at the Coffeen Power Plant were put in operation in 2010 and were used to manage CCR and non-CCR waste streams. The GMF GSP is a 77-acre lined SI and the GMF RP is a 17-acre lined SI (Ramboll 2022b; Gradient, 2022f).

Based on groundwater monitoring data collected between 2015 and 2021, potential GWPS exceedances of boron, sulfate, and TDS were identified at groundwater monitoring wells near and downgradient of the GMF GSP and the GMF RP (Ramboll, 2022b)[6]. The maximum detected concentrations (based on data collected between 2015 and 2021 from 43 wells near and downgradient of the GMF GSP and the GMF RP) for boron, sulfate, and TDS were 4.6 mg/L, 1,800 mg/L, and 3,400 mg/L, respectively (Gradient, 2022f). Sulfate was the constituent detected at the highest concentration relative to its GWPS.

Ramboll prepared a groundwater modeling report (Ramboll, 2022b) for the GMF GSP and the GMF RP that was submitted to IEPA as part of the Construction Permit Application (Golder Associates USA Inc., 2022b, 2022c). The objective of the groundwater modeling was "to evaluate the effects of closure (source

[4] Cobalt and pH were also detected in groundwater downgradient of AP1 at concentrations in excess of their respective GWPSs, but investigations provided at the time of modeling concluded that these constituents are not related to AP1 (Ramboll, 2022a).

[5] Due to the conservative nature of the site-specific risk assessment that was conducted at AP1 and the attempt to "screen-in" rather than "screen-out" constituents (Gradient, 2022e), risks were calculated for constituents at concentrations that may not be associated with AP1 and may not have been identified as potential groundwater exceedances, which are based on statistical evaluations of the full dataset rather than single measurements.

[6] Due to the conservative nature of the site-specific risk assessment that was conducted at GMF GSP and GMF RP and the attempt to "screen-in" rather than "screen-out" constituents (Gradient, 2022f), risks were calculated for constituents at concentrations that may not be associated with GMF GSP and GMF RP, and may not have been identified as potential groundwater exceedances, which are based on statistical evaluations of the full dataset rather than single measurements.

control measures) for the GMF GSP and GMF RP on groundwater quality," and, specifically, to predict the time to meet GWPS in the compliance wells under two proposed closure scenarios – CIP and CBR (Ramboll, 2022b). The CIP scenario considered would involve "removal of CCR from the GMF RP and the southern portion of the GSP, consolidation into the northern portion of the GSP, and construction of a cover system over the remaining CCR," whereas CBR would involve "removal of all CCR and SI liner and regrading of the removal area for both GMF GSP and GMF RP" (Ramboll, 2022b).

Ramboll's modeling approach involved using HELP to estimate recharge under the different closure scenarios, using MODFLOW 2005 to simulate groundwater flow in three dimensions, and using MT3DMS to simulate the three-dimensional transport of sulfate (Ramboll, 2022b). "Sulfate was selected for transport modeling … because: (i) it is commonly present in coal ash leachate; and (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater" (Ramboll, 2022b). Sulfate was modeled as a conservative substance that does "not significantly sorb or chemically react with aquifer solids (distribution coefficient [Kd] was set to 0 milliliters per gram [mL/g])" (Ramboll, 2022b).

4.3 Ash Pond at the Edwards Power Plant

The Edwards Power Plant is a retired electric power generating facility operated by IPRG with coal-fired units located near Bartonville, Illinois. The plant began operations in 1960 and ceased operations in December 2022. The facility has one SI for CCR storage known as the Ash Pond which covers approximately 91 acres (Ramboll, 2022c; Gradient, 2022g).

Based on groundwater monitoring data collected between 2015 and 2021, potential GWPS exceedances of boron, sulfate and TDS were identified at groundwater monitoring wells near and downgradient of the Ash Pond (Ramboll, 2022c)[7,8]. For boron, sulfate, and TDS, the maximum detected concentrations (based on data collected between 2015 and 2021 from 28 wells near and downgradient of the Ash Pond) were 12 mg/L, 570 mg/L and 2,600 mg/L, respectively (Gradient, 2022g). Boron was the constituent detected at the highest concentration relative to its GWPS.

Ramboll prepared a groundwater modeling report (Ramboll, 2022c) for the Ash Pond that was submitted to IEPA as part of the Construction Permit Application (IngenAE, LLC 2022). The objective of the groundwater modeling conducted by Ramboll was to "evaluate the effects of closure (source control) measures (CCR consolidation and CIP and CBR scenarios) for the Ash Pond on groundwater quality following initial corrective action measures, which includes removal of free liquids from the Ash Pond" (Ramboll, 2022c). More specifically, the objective of groundwater modeling was to predict the time to meet GWPS under two proposed closure scenarios – CIP and CBR. The CIP scenario considered would involve "CCR removal from the northwest areas of the Ash Pond, consolidation to the northeast, central and southern areas of the Ash Pond, and construction of a cover system over the remaining CCR" (Ramboll, 2022c).

Ramboll's modeling approach involved using HELP to estimate recharge under the two closure scenarios, using MODFLOW 2005 to simulate groundwater flow in three dimensions and using MT3DMS to simulate the three-dimensional transport of boron (Ramboll, 2022c). "Boron was selected for transport modeling …

[7] Barium, lithium, and chloride were also detected in groundwater downgradient of the Ash Pond at concentrations in excess of their respective GWPSs, but investigations provided at the time of modeling concluded that these constituents are not related to the Ash Pond (Ramboll, 2022c).

[8] Due to the conservative nature of the site-specific risk assessment that was conducted at the Ash Pond and the attempt to "screen-in" rather than "screen-out" constituents (Gradient, 2022g), risks were calculated for constituents at concentrations that may not be associated with the Ash Pond and may not have been identified as potential groundwater exceedances, which are based on statistical evaluations of the full dataset rather than single measurements.

because: (i) it is commonly present in coal ash leachate; (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater; and (iii) it is less likely than other constituents to be present in background groundwater from natural or other anthropogenic sources. The only significant source of boron is the Ash Pond" (Ramboll, 2022c). Boron was modeled as a conservative substance that does "not significantly sorb or chemically react with aquifer solids (distribution coefficient [Kd] was set to 0 mL/g)" (Ramboll, 2022c).

4.4 Primary Ash Pond at the Newton Power Plant

The Newton Power Plant is an electric power generating facility operated by IPGC with coal-fired units located near Newton, Illinois. The plant began operating in approximately 1977 and has one SI for CCR storage known as the PAP which covers approximately 404 acres (Ramboll, 2022d; Gradient, 2022h).

Based on groundwater monitoring data collected between 2015 and 2021, potential GWPS exceedances of lithium, sulfate, and TDS were identified at groundwater monitoring wells near and downgradient of the PAP (Ramboll, 2022d)[9,10]. For lithium, sulfate, and TDS, the maximum detected concentrations (based on data collected between 2015 and 2021 from 29 wells near and downgradient of the PAP) were 0.3 mg/L, 3,200 mg/L, and 5,500 mg/L, respectively (Gradient, 2022h). Sulfate was the constituent detected at the highest concentration relative to its GWPS.

Ramboll prepared a groundwater modeling report (Ramboll, 2022d) for the PAP that was submitted to IEPA as part of the Construction Permit Application (HDR Inc., 2022). The objective of the groundwater modeling conducted by Ramboll was "to evaluate the effects of Closure (source control measures) for the PAP on groundwater quality," and specifically, to predict the time to meet GWPS in the compliance wells under two proposed closure scenarios – CIP and CBR (Ramboll, 2022d). The CIP scenario considered would involve "removal of CCR from the southern portion of the PAP, consolidation into the northern portion of the PAP, and construction of a cover system over the remaining CCR," whereas CBR would involve "removal of all CCR and regrading of the removal area" (Ramboll, 2022d).

Ramboll's modeling approach involved using HELP to estimate recharge under the different closure scenarios, using MODFLOW 2005 to simulate groundwater flow in three dimensions, and using MT3DMS to simulate the three-dimensional transport of sulfate (Ramboll, 2022d). "Sulfate was selected for transport modeling … because: (i) it is commonly present in coal ash leachate; and (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater" (Ramboll, 2022d). Sulfate was modeled as a conservative substance that does "not significantly sorb or chemically react with aquifer solids (distribution coefficient [Kd] was set to 0 milliliters per gram [mL/g])" (Ramboll, 2022d).

4.5 East Ash Pond at the Hennepin Power Plant

The Hennepin Power Plant is a retired electric power generating facility operated by DMG with coal-fired units located in Hennepin, Illinois. The plant began operations in the early 1950s and was retired in 2019.

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9 pH was also detected in groundwater downgradient of the PAP outside of its acceptable range, but investigations provided at the time of modeling concluded that pH impacts to groundwater are not related to the PAP (Ramboll 2022d).

10 Due to the conservative nature of the site-specific risk assessment that was conducted at the PAP and the attempt to "screen-in" rather than "screen-out" constituents (Gradient, 2022h), risks were calculated for constituents at concentrations that may not be associated with the PAP and may not have been identified as potential groundwater exceedances, which are based on statistical evaluations of the full dataset rather than single measurements.

CCRs associated with plant operation were stored in several ponds including the EAP, which covers approximately 21 acres (Ramboll, 2022e; Gradient, 2021b).

Based on groundwater monitoring data collected between 2015 and 2021 at 13 wells near and downgradient of the EAP, no potential GWPS exceedances attributable to the EAP were identified (Ramboll, 2022e; Gradient, 2021b)[11]. Ramboll prepared a groundwater modeling report (Ramboll, 2022e) for the EAP that was submitted to IEPA as part of the Construction Permit Application (Geosyntec Consultants, 2022). The objective of the groundwater modeling conducted by Ramboll was "to simulate future conditions and groundwater concentrations of boron for proposed closure alternatives for the EAP. Boron was selected for modeling because it is one of the most common and mobile CCR-related constituents. A total of three scenarios were simulated: no action, EAP CIP, and EAP CBR" (Ramboll, 2022e). The no action scenario assumed "no closure at the EAP (current conditions retained)" (Ramboll, 2022e). Under the CIP scenario, the EAP was assumed to "be graded and covered with a geomembrane and soil layers," whereas the CBR scenario assumed that "CCR materials from the EAP will be removed" and "[t]he existing liner system and 1 foot of material beneath the side slope and bottom liner will be excavated" (Ramboll, 2022e). The three scenarios also assumed closure of the Coal Combustion Waste Landfill, which is located adjacent to and north of the EAP (Ramboll, 2022e).

Ramboll's modeling approach involved using HELP to estimate recharge under the different closure scenarios, using MODFLOW to simulate groundwater flow in three dimensions and using MT3DMS to simulate the three-dimensional transport of boron (Ramboll, 2022e). "Boron was selected for groundwater transport modeling … because: (i) it is commonly present in coal ash leachate; (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater; and (iii) it is less likely than other constituents to be present in background groundwater from natural or other anthropogenic sources" (Ramboll, 2022e). Boron was modeled as a conservative substance that "minimally adsorbs and does not decay, and mixing and dispersion are the primary attenuation mechanisms in groundwater" (Ramboll, 2022e).

[11] Due to the conservative nature of the site-specific risk assessment that was conducted at the EAP and the attempt to "screen-in" rather than "screen-out" constituents (Gradient, 2021b), risks were calculated for constituents at concentrations that may not be associated with the EAP and may not have been identified as potential groundwater exceedances, which are based on statistical evaluations of the full dataset rather than single measurements.

5 Modeling surrogate constituents is an appropriate approach to achieve model objectives in support of the CAA.

All environmental models are, in some regard, simplifications of complex systems, and it is common to make simplifications to models based on the model objectives. Using one or more surrogate constituents to represent the potential behavior of a larger group of constituents, with the surrogate constituents selected in accordance with the model objectives, is a simplification that is commonly made in environmental models.

For the groundwater modeling performed in support of the CAAs at AP1, the GMF GSP, and the GMF RP at the Coffeen Power Plant, the Ash Pond at the Edwards Power Plant, the PAP at the Newton Power Plant, and the EAP at the Hennepin Power Plant, the model objectives were to evaluate the effects of various closure alternatives on groundwater quality and to specifically predict the time at which GWPSs will be achieved for each closure alternative. For each of these SIs, the constituent with the highest concentration relative to its GWPS (*i.e.*, "Exceedance Ratio"; Table 5.1) was selected for transport modeling because it will likely be the constituent that takes the longest time to achieve its GWPS. It is not necessary to model other constituents that have been detected at lower concentrations relative to their GWPSs because these constituents will likely achieve their GWPSs faster than the surrogate constituent. Thus, the approach of modeling the constituent with the highest concentration relative to its GWPS is reasonable and sufficient to achieve the model objectives.

Table 5.1 Summary of Potential GWPS Exceedances at Downgradient Monitoring Wells Between 2015 and 2021

Constituents with a Detected Potential GWPS Exceedance	Maximum Detected Concentration (mg/L)	GWPS (mg/L)	Exceedance Ratio	Surrogate Constituent (Modeled in Support of CAA)
Coffeen Ash Pond 1				
Boron	7.5	2	3.8	Sulfate
Sulfate	2,400	400	**6.0**	
TDS	4,000	1,200	3.3	
Coffeen GMF Gypsum Stack Pond and Recycle Pond				
Boron	4.6	2	2.3	Sulfate
Sulfate	1,800	400	**4.5**	
TDS	3,400	1,200	2.8	
Edwards Ash Pond				
Boron	12	2	**6.0**	Boron
Sulfate	570	400	1.4	
TDS	2,600	1,200	2.2	
Newton Primary Ash Pond				
Lithium	0.3	0.04	7.5	Sulfate
Sulfate	3,200	400	**8.0**	
TDS	5,500	1,200	4.6	

Constituents with a Detected Potential GWPS Exceedance	Maximum Detected Concentration (mg/L)	GWPS (mg/L)	Exceedance Ratio	Surrogate Constituent (Modeled in Support of CAA)
Hennepin East Ash Pond				
Boron[a]	1.41	2	0.7	Boron

Notes:

Sources: Ramboll (2022a, 2022b, 2022c, 2022d, 2022e); Gradient (2022e, 2022f, 2022g, 2022h, 2021b).

CAA = Closure Alternatives Analysis; CCR = Coal Combustion Residual; GMF = Gypsum Management Facility; GWPS = Groundwater Protection Standards; TDS = Total Dissolved Solids.

(a) No GWPS exceedances were identified for the Hennepin East Ash Pond but Boron was selected as the constituent for transport modeling because boron is one of the most common and mobile CCR-related constituents (Ramboll, 2022e).

Model surrogate constituent selection also considered the number of locations where a GWPS was exceeded and the size of each constituent's footprint in groundwater. In general, constituents with the highest frequency of GWPS exceedances correlated with constituents that were detected at the highest concentrations relative to their GWPSs. Thus, the approach of modeling the constituent with the highest concentration relative to its GWPS is reasonable and sufficient to achieve the model objectives.

Based on this approach, the following constituents were selected as the surrogate constituents to be evaluated in the groundwater model:

- sulfate at the AP1 at the Coffeen Power Plant;
- sulfate at the GMF GSP, and the GMF RP at the Coffeen Power Plant;
- boron at the Ash Pond at the Edwards Power Plant;
- sulfate at the PAP at the Newton Power Plant; and
- boron at the EAP at the Hennepin Power Plant.

Moreover, the other constituents with potential GWPS exceedances that have been identified – boron and TDS at AP1, the GMF GSP, and the GMF RP at the Coffeen Power Plant; sulfate and TDS at the Ash Pond at the Edwards Power Plant; and lithium and TDS at the PAP at the Newton Power Plant (Table 5.1) – have similar groundwater transport characteristics to the selected surrogate constituents. Specifically, the surrogate constituents have a similar propensity to sorb to soils as the other constituents with potentially identified GWPS exceedances (*i.e.*, all constituents have relatively small values of K_d; Table 5.2); therefore, subsurface transport during closure conditions would be similar for all of the constituents that have been detected with potential GWPS exceedances. Because each of these constituents is expected to behave in a similar manner during closure, it is appropriate to only model the surrogate constituents and use the surrogate constituents to determine when each closure alternative will achieve the GWPSs for all constituents.

Table 5.2 Soil-Water Partition Coefficient (K_d) for Constituents with GWPS Exceedances

Chemical Constituent	Soil-Water Partition Coefficient, K_d (L/kg)
Boron[a]	1.1×10^{-5}
Lithium[b]	0
Sulfate[c]	0
TDS[c]	0

Notes:
GWPS = Groundwater Protection Standards; TDS = Total Dissolved Solids; US EPA = United States Environmental Protection Agency.
(a) US EPA (2014) reported select percentiles of chemical-specific K_d values for SIs containing combined ash. The 50th percentile value of K_d in saturated zone is used here.
(b) US EPA (2014) noted that "lithium does adsorb weakly to clay soils" but "sufficient information was not available to develop chemical-specific K_d values for lithium," and a K_d of 0 was used "to estimate lithium fate and transport".
(c) Ions such as "[c]alcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate, and silica typically make up most of the dissolved solids in water" (USGS, 2014). These ions do not significantly sorb to soil and their K_d is generally assumed to be zero. For example, US EPA (2014) used a K_d of 0 for chloride.

6 Part 845 does not require that all constituents listed in Section 845.600 be evaluated in CAA models.

In its Initial Review Letters, IEPA raised concerns regarding the sufficiency of only modeling selected constituents at each facility by noting that "[t]he Agency requires all constituents listed in Section 845.600 that have been found to be present in the CCR surface impoundment to be assessed in the groundwater model" (IEPA, 2023a, 2023b, 2023c, 2023d; emphasis added). However, there is no language in Part 845 suggesting that the groundwater model must evaluate all constituents that have been detected in an SI. Part 845 requires only that groundwater modeling evaluate "how the closure alternative will achieve compliance with the applicable groundwater protection standards" for each closure alternative (Section 845.710(d)(2) in IEPA, 2021).

The surrogate constituents that were selected for evaluation in the groundwater model for each SI are the constituents that will likely take the longest time to achieve their GWPS and, thus, are appropriate choices to achieve the CAA modeling objectives and to fulfill the requirements of Section 845.710(d)(2) (IEPA, 2021). All of the other constituents that have been detected in the SI are either already at levels below their respective GWPSs or will likely achieve their GWPSs faster than the surrogate constituent. Therefore, for each SI, the groundwater modeling performed by Ramboll predicted the time at which all of the constituents will likely have achieved compliance with the GWPSs for each closure alternative (*i.e.*, the time at which each closure alternative will achieve compliance with GWPSs), thereby satisfying Part 845 requirements.

7 It would be a costly and data-intensive endeavor to model all constituents, and it would not provide any additional useful information.

A number of CCR-related constituents have been identified in literature. For example, Part 845.600 lists 20 CCR-related constituents for which GWPSs have been established (IEPA, 2021) and Appendix III and IV of the 2015 Federal CCR Rule list 22 CCR-related constituents that must be monitored as part of detection and assessment monitoring (US EPA, 2015). The process of modeling all of these constituents would be significantly more data-intensive and costly than the process of modeling a single constituent.

Building a groundwater model that evaluates the time to achieve GWPSs for all constituents detected in an SI would involve collection of a large amount of data for each constituent (*e.g.*, to evaluate background groundwater quality, to determine whether observed concentrations are related to the SI or to an alternative source, to evaluate individual partitioning coefficients, *etc*.). Subsequently, individual groundwater solute transport models would need to be developed and calibrated for each constituent, and separate model simulations would need to be performed for each closure alternative with each constituent. The overall effort will likely scale with the number of constituents being considered (*i.e.*, the effort will be 20 times higher if 20 constituents are being evaluated instead of one), and the process would be onerous.

Despite the significantly increased effort, the models would not result in any additional useful information for meeting the CAA objectives that could not be obtained by modeling just the surrogate constituent. The predicted time to achieve GWPSs will likely be the longest for the constituent detected at the highest concentration relative to its GWPS (*i.e.*, the surrogate constituent) as the other constituents will either already be present at levels below their GWPSs or will likely achieve their GWPSs faster than the surrogate constituent. Thus, the additional information obtained from modeling all constituents (*i.e.*, the predicted time to achieve GWPSs for each constituent) will likely not affect the time at which all the constituents achieve compliance with the GWPSs for each closure alternative, which is the primary objective of the groundwater modeling performed in support of the CAA.

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Gradient. 2021b. "Human Health and Ecological Risk Assessment, East Ash Pond, Hennepin Power Plant, Hennepin, Illinois (Draft)." 46p., November 8.

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Appendix A

***Curriculum Vitae* and Testimony History of**
Andrew Bittner, M.Eng., P.E.

GRADIENT

Andrew B. Bittner, M.Eng., P.E.
Principal
(he/him)
abittner@gradientcorp.com

Areas of Expertise

Contaminant fate and transport in porous and fractured media, migration of coal ash combustion products in groundwater and surface water, non-aqueous phase liquid (NAPL) transport, surface water and groundwater hydrology, groundwater and surface water modeling, remedial investigation design, remedy evaluation and optimization, cost allocation, international regulatory compliance and remediation.

Education & Certifications

M.Eng., Environmental Engineering and Water Resources, Massachusetts Institute of Technology, 2000

B.S.E., Environmental Engineering, University of Michigan, 1997

B.S., Physics, University of Michigan, 1997

Licensed Professional Engineer: Idaho, New Hampshire

Professional Experience

2000 – Present GRADIENT, Boston, MA
Environmental Engineer. Specializes in the fate and transport of contaminants in groundwater and surface water, coal combustion products, groundwater hydrology, groundwater flow and contaminant transport modeling, NAPL transport, and remedial investigation and design. Has served as principal-in-charge, testifying expert, and consulting expert on large, multi-disciplinary projects at coal combustion product surface impoundments and landfills, pharmaceutical facilities, automotive facilities, manufacturing plants, dry cleaning facilities, and Superfund sites. Extensive experience in South America and at other international sites.

1997 – 1999 PARSONS ENGINEERING SCIENCE, Canton, MA
Environmental Engineer. Specialized in industrial wastewater treatability. On-site supervisor for bioremediation bench scale treatment and laboratory study for a major pharmaceutical company. Built hydraulic models for pharmaceutical wastewater treatment facilities. Designed hazardous waste treatment systems for a major pharmaceutical company. Performed site investigations to delineate NAPL plumes and design remedial recovery plans.

12/7/2022

Professional Affiliations

National Ground Water Association; Chi Epsilon – Environmental Engineering Honor Society

Technical Session Chair:

- World of Coal Ash Conference. Lexington, KY. May 8-11, 2017. Session title: "Groundwater."
- Battelle Conference on Remediation of Chlorinated and Recalcitrant Compounds. Palm Springs, CA. May 23-26, 2016. Session title: "Coal Ash Facility Restoration".
- Battelle Conference on Remediation of Chlorinated and Recalcitrant Compounds. Monterey, CA. May 21-24, 2012. Session title: "Environmental Remediation in Emerging Markets."
- Defense Research Institute. Panelist for session titled "Groundwater-Surface Water Connectivity and the Clean Water Act." New Orleans, LA. May 13-14, 2019.
- World of Coal Ash Conference. St. Louis, MO. May 13-16, 2019. Session title: "Project-Specific Case Studies."
- World of Coal Ash Conference. Covington, KY. May 16-19, 2022. Session title: "Regulatory."

Projects – *Coal Combustion Products*

Electric Power Research Institute: Modeled groundwater impacts from coal combustion product (CCP) surface impoundments with intersecting groundwater conditions and evaluated hydrogeological factors and other characteristics that influence risks to human health and the environment (HHE).

Utility Client: Served as litigation consulting expert regarding the fate and transport of metal constituents in groundwater from 18 different coal combustion residual (CCR) disposal facilities at 7 sites in the Midwest.

Utility Client: Prepared expert report and provided testimony related to the fate and transport of metal constituents in groundwater from 11 different coal combustion residual (CCR) disposal facilities at 6 sites in West Virginia, Virginia, and Ohio.

Utility Client: Prepared expert report in support of "Petition for a Finding of Inapplicability or, in the Alternative, an Adjusted Standard from 35 ILL. Admin. Code Part 845". Report assessed current risks to human and environmental receptors and evaluated net environmental benefits (*i.e.*, NEBA) of potential closure options at a former CCR disposal facility.

Utility Client: Prepared Closure Alternatives Assessment (CAA), Corrective Measures Assessment (CMA), and Corrective Action Alternatives Analysis (CAAA) for multiple CCR surface impoundments located at a series of Midwestern power plants. Reports were prepared consistent with requirements of 35 ILL. Admin. Code Part 845.

Utility Client: Evaluated risks to human health and the environment associated with CCR surface impoundments at six coal fired power plants in the Southern US. Evaluations included assessing CCR constituent migration in groundwater and the flux of constituents into nearby surface waters.

Utility Client: Calculated alternative groundwater protection standards (GWPSs) at a coal fired power plant facility in the Midwestern US. Alternative standards were calculated based on site-specific human and ecological receptors and attenuation factors.

Utility Client: Prepared expert report and testified before state pollution control board regarding proposed coal ash disposal regulations.

Electric Power Research Institute: Evaluated the performance of alternative liners, including engineered clay liners, natural clay liners, and geomembrane composite-lined systems at CCP impoundments. Used a probabilistic approach to model the flux of CCP constituents through each liner and the subsequent transport of constituents through the underlying vadose and saturated zone.

Industry Research Group: Developed methodology to evaluate performance equivalency of various surface impoundment liner systems. The methodology, which was submitted to US EPA in order to inform future rulemakings, presented a process to evaluate and compare hydraulic flux and travel times through different liner systems including geocomposite, compacted clay, and natural clay liners.

Confidential Client: Developed a screening level risk assessment for a manufacturing facility beneficially using coal fly ash as a soil stabilizer. The risk assessment compared estimated coal ash constituent exposure concentrations in soil, groundwater, and surface water to relevant benchmarks protective of human health and the environment.

Manufacturing Client: Performed beneficial use risk assessments consistent with US EPA Federal Coal Combustion Residual (CCR) Rule and Secondary Use Guidance for multiple commercial and construction products containing coal ash – including carpet backing, interior and exterior trim, and backer board. Analysis evaluated risks to groundwater, surface water, indoor air, and soil. Evaluation also considered exposure pathways for residents, construction workers, and landfill workers associated with installation of products, active life of the installed products, and post-life disposal in a landfill.

Electric Power Research Institute: Developed framework for creating alternative groundwater standards at CCP storage sites. The framework considers the development of alternative standards for the protection of human health and the environment, current and future uses of groundwater near CCP management units, and potential attenuation that may occur between the current point of compliance and a relevant point of exposure.

Utility Client: Prepared expert report and provided testimony related to the fate and transport of metal constituents in groundwater, including sulfate, boron, and arsenic, from over 30 different coal combustion residual surface impoundments at 15 sites in North Carolina and South Carolina.

Industry Research Group: Prepared technical comments regarding proposal to add boron to list of Appendix IV constituents to the Federal CCR Rule. Evaluated technical practicability and cost implications associated with the potential boron addition.

Industry Research Group: Prepared technical comments regarding portion of Federal CCR Rule that requires the groundwater protection standard (GWPS) of Appendix IV constituents with no MCL to be the background concentration. Evaluated technical practicability, cost implications, and potential benefits associated with the requirement for the four current Appendix IV constituents with no established MCL - cobalt, lithium, molybdenum, and lead.

Confidential Client: Developed a screening level risk assessment for a steel production and recycling facility that is beneficially using coal fly ash as a soil stabilizer. The risk assessment addressed a requirement in the Federal Coal Combustion Residuals (CCR) Disposal Rule for a characterization of risk from unencapsulated beneficial use of CCR. Used the Industrial Waste Evaluation Model (IWEM) to evaluate potential transport of coal ash constituents, including arsenic, in groundwater as a result of the beneficial reuse.

Utility Client: Prepared expert report interpreting data produced during a field investigation performed at a large Midwestern coal ash landfill.

Utility Client: For litigation support, modeled the fate and transport of arsenic and other coal ash related constituents in groundwater and surface water downgradient of a large Midwestern coal ash surface impoundment located in a karst environment. Model simulations compared potential impacts to groundwater and surface water resulting from potential surface impoundment closure scenarios.

Manufacturing Client: Performed beneficial use risk assessments consistent with US EPA Federal Coal Combustion Residual (CCR) Rule and Secondary Use Guidance for multiple commercial and construction products containing coal ash. Analysis evaluated risks to groundwater, surface water, indoor air, worker safety, and residential safety. Evaluation also considered exposure pathways associated with installation of products, active life of the installed products, and post-life disposal in a landfill. Used the Industrial Waste Evaluation Model (IWEM) to evaluate potential transport of coal ash constituents, including arsenic, in groundwater as a result of the beneficial reuse.

Industry Research Group: Developed a groundwater fate and transport model to evaluate the level of groundwater protection provided by various coal ash surface impoundment closure options, including closure in place and closure by removal. Model simulated transport of arsenic (III) and arsenic (V) in groundwater downgradient of coal ash disposal facilities. Model results are being used by utilities in support of closure planning which is required by Federal Coal Combustion Residual Rule.

Confidential Client: Prepared expert report on human health and ecological risks due to a potential spill of barged coal combustion byproducts (CCBs) on a large Midwestern river. Modeled the fate and transport of key CCB constituents, including arsenic, in surface water for a range of spill scenarios and river flow conditions and estimated potential downstream concentrations at drinking water intake locations.

Industry Research Group: Evaluated technical approach used by United States Environmental Protection Agency (US EPA) to simulate the migration of arsenic, selenium, and other metals in groundwater from overlying coal combustion storage units. Model analyses were included in regulatory comments submitted in response to US EPA's 2010 Coal Combustion Product Risk Assessment.

Industry Research Group: Developed relative risk framework to assess impacts to groundwater associated coal combustion product (CCP) surface impoundment closure scenarios. Framework identified potential deterministic and probabilistic modeling approaches to simulate potential migration of CCP constituents, including arsenic, boron, selenium, and molybdenum through the vadose and saturated zones for each closure alternative.

Industry Research Group: Modeled the downward migration of leachate from unlined coal combustion product surface impoundments using a probabilistic framework for a wide range of climatic and site conditions. Model results provided estimated durations for interactions between the impoundment leachate and nearby surface and groundwater.

Industry Research Group: As part of a relative risk framework, performed detailed sensitivity analysis of all factors associated with a coal ash surface impoundment closure that may impact the fate and transport of constituents in groundwater. Factors analyzed included surface impoundment characteristics (*e.g.*, volume, depth, and leachate quality), hydrogeological conditions (*e.g.*, hydraulic conductivity, hydraulic gradient, soil type, depth to groundwater, and surface water proximity), climatic characteristics (*e.g.*, precipitation), and closure details (*e.g.*, closure type and duration).

Projects – *Fate & Transport and Modeling*

Manufacturing Client: Consulting expert for a class certification case. Evaluated PFAS transport from known and potential sources.

Natural Gas Processing Facility: Prepared an expert report evaluating the hydrogeological conditions at and downgradient of a natural gas processing plant and provided assessment of the fate and transport over time of light non-aqueous phase liquids (LNAPLs) released from the plant and associated pipelines.

Confidential Client, Rhode Island: Designed and calibrated a groundwater flow and solute transport model for multiple chlorinated organic constituents at a Northeastern Superfund Site. Used one year long tracer test to calibrate model. Model was used to predict the future effectiveness of various remedial alternatives.

Confidential Client: Designed and calibrated a groundwater flow and solute transport model for a Superfund site that has groundwater impacted with volatile organic compounds including benzene, tetrachloroethylene, trichloroethylene, and vinyl chloride. The model was used successfully to present the case to US EPA for shutting down the source remedy.

Confidential Client, Brazil: Developed 3-D numerical groundwater and solute transport model using MODFLOW and MT3D for volatile organic compounds and pesticides. Used model to evaluate and design remediation alternatives. Managed multiple site investigation and characterization studies. Projects involved calculation of risks to human health from exposure to soils, groundwater, indoor air, and outdoor air.

Savage Well Superfund Site: For a potentially responsible party (PRP) group, managed the development of a 3-D numerical groundwater and solute transport model for tetrachloroethylene (PCE) at a Superfund site in New Hampshire. Calibrated the model using approximately 10 years of data with review and oversight by US EPA and United States Geological Survey (USGS). Designed an optimization algorithm to develop the optimal groundwater pump and treat system.

Confidential Client, Massachusetts: Developed a 2-D contaminant transport model for PCE to demonstrate that contaminant contribution from a dry cleaning operation to the town water supply wells was insignificant compared to contribution from other potential sources. Managed the installation and operation of a pump and treat system at the Site.

Confidential Client, Argentina: Developed a 2-D numerical groundwater and solute transport model using MODFLOW and MT3D. Used the calibrated model to design a hydraulic barrier system to control off-site migration.

Confidential Client: Performed site-specific vapor intrusion modeling using the Johnson-Ettinger model at a pharmaceutical facility. Performed a detailed sensitivity analysis for each model input parameter.

Confidential Client: Performed NAPL transport and travel time calculations through porous media vadose and saturated zones and clay confining layers.

Confidential Client: Wrote critique of US EPA geochemistry model.

Projects – *Remediation*

Confidential Client: Evaluated potential liabilities related to range of issues including waste surface impoundment closure, groundwater remediation, and regulatory compliance at sites around the world that were involved in a corporate transaction.

Manufacturing Client, New Hampshire: Served as consulting expert for a case related to a failed groundwater remedy. Evaluated remedy design and installation and performed probabilistic modeling to determine appropriate design factors.

PRP Group, Nevada: Provided hydrogeological support at an industrial site with groundwater impacts due to benzene, chlorobenzene, chloroform, perchlorate, and chromium. Evaluated and critiqued a Remedial Investigation (RI) Report related to a neighboring property and developed a conceptual site model (CSM) describing the fate and transport mechanisms of constituents in groundwater. Prepared submittals and presented conclusions at meetings with the State Environmental Agency.

Confidential Client, Brazil: Designed and implemented nano-scale zero valent iron remedy to prevent off-site arsenic migration. Upon completion of remedy, negotiated site closure with state of Rio de Janeiro environmental agency.

Confidential Client, Brazil: Designed and implemented a pilot scale enhanced *in-situ* bioremediation remedy for groundwater impacted with chlorinated organic compounds at a former agricultural product manufacturing facility.

Confidential Client, New Hampshire: As an independent third party, performed a review of a proposed Electrical Resistive Heating remedy for a chlorinated solvent dense non-aqueous phase liquid (DNAPL) source zone.

Confidential Client, New York: Provided regulatory comments regarding a US EPA Proposed Remedial Action Plan at a Region II Superfund Site on Long Island. Provided support during mediation and during negotiations with US EPA.

Confidential Client, New Jersey: Provided regulatory comments regarding a US EPA Proposed National Priorities List (NPL) listing at a Region II Superfund Site.

Confidential Client, Brazil: Managed multiple conceptual and detailed engineering remedial design projects for a soil vapor extraction system, dual-phase extraction system, and a pump and treat system. Remediation efforts focused on soil and groundwater contamination by pesticides and chlorinated solvents.

Confidential Client, Brazil: Managed site remediation projects to operate and maintain a soil vapor extraction system, dual-phase extraction system, and a hydraulic barrier system.

Confidential Client, Argentina: Managed conceptual and detailed engineering remedial design project for dual-phase extraction system focused on the remediation of volatile organic compounds in soil and groundwater.

Confidential Client: On-site supervisor for bioreactor bench scale study at a pharmaceutical wastewater treatment plant. Performed an in-depth investigation on the bio-inhibitory effects due to the chronic exposure of biomass to manganese. Performed laboratory work required to support the bioreactors including tests for mixed liquor volatile suspended solids (MLVSS), total suspended solids (TSS), chemical oxygen demand (COD), dissolved oxygen (DO), ammonia (NH_3), and respirometry.

Confidential Client: Lead environmental engineer for a belt filter press replacement project for a pharmaceutical company wastewater treatment plant. Designed and sized polymer addition system.

Projects – *Site Characterization*

Confidential Client, Brazil: Provided strategic oversight for a series of environmental investigations, remedial actions, and agency negotiations for an automotive facility located in São Paolo.

Confidential Client: Managed large-scale cost allocation at a Midwestern Superfund site. Forensically evaluated the sources of tar to river sediments considering site industrial operational history, contaminant fate and transport, chemistry, site modification and filling history, and observed contaminant patterns. Calculated the mass of tar present in the environment using both visual observations and analytical data.

Confidential Client, Brazil: Managed large-scale site investigations and human health risk assessment projects at a former pharmaceutical facility located in São Paulo. Key compounds were petroleum hydrocarbons and volatile organic compounds.

Confidential Client, New York: Served as consulting expert for large cost allocation involving over 16 responsible parties and chlorinated organic groundwater plumes extending for nearly 2 miles. Evaluated lateral and vertical groundwater flow direction, chemical usage history, and groundwater chemistry to support a *de minimis* contribution argument for our client.

Confidential Client, Ohio: Served as consulting expert for cost allocation project at a Midwestern landfill. Evaluated differences in toxicity and risk associated with municipal solid waste and industrial hazardous waste. Used data to devise risk-weighted allocation approach for remedy costs.

Confidential Client, Brazil: Managed site investigation to evaluate groundwater responses due to seasonal precipitation events and their effect on potential contaminant fate & transport.

Confidential Client: Managed site investigation project identifying sources of PCE present at a former electrical resistor manufacturing facility. Soil, groundwater, and soil gas data were evaluated and used to identify individual sources of PCE to the subsurface. The impact of each source on remediation costs related to the site was evaluated and successfully used as a tool to mediate between responsible parties. Served as consulting expert during mediation between responsible parties.

Confidential Client, New Jersey: Delineated NAPL plumes and investigated spill history, sewer maps, and gas chromatography fingerprint results at East Coast Superfund Site. Designed French Drain to recover NAPL from subsurface.

City of Pittsfield, Massachusetts: Technical consultant to the city for mediation between General Electric (GE) and governmental agencies. Evaluated reports and clean-up standards, and attended mediation sessions on behalf of the city.

Projects – *Clean Water Act*

Municipal Client, Ohio: Consulting expert for significant nexus evaluation to determine whether wetlands and surface water tributaries are jurisdictional waters of the United States.

Publications/Presentations

Radloff, KA; Lewis, AS; Bittner, AB; Zhang Q; Minkara, R. 2022. "A Risk Evaluation of Controlled Low-Strength Materials (CLSM) Containing Coal Combustion Products (CCPs) in Construction Projects." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY. May 17.

Kondziolka, J; Radloff, KA; Bittner, AB. 2022. "Emerging Clean Water Act Issues for CCR Surface Impoundments." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY. May 17.

Bittner, AB; Kondziolka, J. 2022. "Alternative Liner Performance Demonstrations – A Science-Based Approach to Inform Policy Development ." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY. May 18.

Bittner, AB. 2022. "Decision Analysis Applied to CCR Surface Impoundment Closure and Corrective Action." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY. May 18.

Lewis, AS; Bittner, AB; Radloff, KA. 2022. "Using Human Health and Ecological Risk Assessment at Coal Combustion Product (CCP) Sites to Meet Closure Objectives ." Presented at the World of Coal Ash (WOCA) Conference, Covington, KY. May 18.

Radloff, KA; Lewis, AS; Bittner, AB. 2021. "Challenges Using Data Generated by LEAF Methods in Risk Evaluations." Presented at the USWAG CCR Webinar. August 5.

Register, JR; Bittner A. 2020. "USEPA Reconsideration of CCR Regulations Impacting the Geosynthetic Industry." Presented to the Fabricated Geomembrane Institute. October 8.

Dale, A, Kondziolka, J, de Lassus, C, Bittner, A, Hensel, B. 2020. "Probabilistic Modeling of Leaching from Coal Ash Impoundment Liners: A Case Study in Science Informing Policy Development." Presented at the International Society of Exposure Science Virtual Meeting, California, September 21.

Briggs, N; Lewis, AS; Bittner, AB. 2020. "Evaluating Climate Change Impacts on CCP Surface Impoundments and Landfills." Presented at the World of Coal Ash (WOCA) Conference, St. Louis, Missouri, May 16.

Bittner, AB; Lewis, AS. 2020. "Beneficial use assessment of building materials containing CCPs." *Gradient Trends: Risk Science and Application* 77 (Winter):3,5.

Register, JR; Bittner A. 2019. "Insane in the Geomembrane." Presented to the Fabricated Geomembrane Institute. August 6..

Bittner, AB; Spak, MS; Cox, WS. 2019. "Carving out the Contours: The Clean Water Act and the Migration of Affected Groundwater to Waters of the United States." *For the Defense* 61(6):55-59.

Bittner, A. Lewis, A. 2019. "CCP Beneficial Use Risk Assessment: Case Studies for Three Different Applications." Presented at the World of Coal Ash (WOCA) Conference, St. Louis, Missouri, May 14.

Lewis, A. Bittner, A. 2019. "Risk Based Considerations for Establishing Alternative Groundwater Standards at Coal Combustion Product Sites." Presented at the World of Coal Ash (WOCA) Conference, St. Louis, Missouri, May 15.

Lewis, AS; Bittner, A. 2018. "Risk-Based Approaches for Establishing Alternative Standards at Coal Combustion Sites." Presented at the World of Coal Ash (WOCA) Ponded Ash Workshop, Louisville, Kentucky, October 30-31.

Lewis, AS; Bittner, A. 2017. "The Relative Impact Framework for Evaluating Coal Combustion Residual Surface Impoundment Closure Options: Application and Lessons Learned." *Coal Combustion and Gasification Products (CCGP)* 9:1-3.

Lewis, AS; Dube, EM; Bittner, A. 2017. "Key role of leachate data in evaluating CCP beneficial use." *ASH at Work* 1:32-34.

Lewis, AS; Bittner, AB; Lemay, JC. 2017. "Achieving Groundwater Protection Standards for Appendix IV Constituents: The Problem with Using Background Concentrations in the Absence of Maximum Contaminant Levels (MCLs)." Presented at the 2017 World of Coal Ash Conference (WOCA), Lexington, KY, May 8-11.

Bittner, A. 2017. "Evaluation of Groundwater Protectiveness of Potential Surface Impoundment Closure Options." Presented at the American Coal Ash Association's 7th Annual World of Coal Ash Conference, Lexington, KY, May 11.

Lewis, A; Bittner A; Radloff, K; Hensel, B. 2017. "Storage of coal combustion products in the United States: Perspectives on potential human health and environmental risks." In *Coal Combustion Products (CCPs): Characteristics, Utilization and Beneficiation, 1st Edition*. Woodhead Publishing, May 2.

Bittner, AB; Kondziolka, JM; Lewis, A; Hensel, B; Ladwig, K. 2016. "Groundwater Assessment Framework for Evaluating the Relative Impacts of Coal Ash Surface Impoundment Closure Options." Presented at Battelle's Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Palm Springs, CA, May 22-26.

Bittner, AB; Kondziolka, JM; Sharma, M; Nangeroni, P; McGrath, R. 2016. "Using Tracer Test Data to Calibrate a Groundwater Flow and Solute Transport Model." Presented at Battelle's Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Palm Springs, CA, May 22-26.

Bittner, A. 2016. "A Retrospective Look at Remediation in the State of Rio de Janeiro, Brazil: And What Lessons We Can Apply to Remediation Projects in Other Emerging International Markets." Presented at Battelle's Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Palm Springs, CA, May 22-26. 17p.

Bittner, A. 2016. "The Federal CCR Rule and How it is Impacting Coal Ash Disposal." Presented at Battelle's Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Palm Springs, CA, May 22-26. 17p.

Bittner, A. 2016. "Coal Ash Beneficial Reuse Assessment Consistent with Requirements of the 2015 Federal CCR Rule." Presented at EUCI's Sixth Annual Coal Combustion Residuals and Effluent Limitation Guidelines Conference, Charlotte, NC, March 30-31. 30p.

Herman, K; Flewelling, S; Bittner, AB; Tymchak, M; Swamy, M. 2015. "Alternate Endpoints for Remediating NAPL-Impacted Sites." Presented at the EPRI/AWMA Env-Vision Conference, Crystal City, VA, May 14.

Lewis, A; Bittner, AB; Herman, K; Dubé, E; Long, C; Hensel, B; Ladwig, K. 2015. "Framework for Evaluating Relative Impacts for Surface Impoundment Closure Options." Presented at the 2015 World of Coal Ash Conference, Nashville, TN, May 8.

Bittner, AB. Lewis, A; Herman, K; Dubé, E; Long, CM; Kondziolka, K, Hensel, B; Ladwig, K. 2015 "Groundwater Assessment Framework to Evaluate Relative Impacts of Surface Impoundment Closure Options." Presented at the 2015 World of Coal Ash Conference, Nashville, TN, May 7.

Bittner, AB. 2014. "Evolving environmental regulations in Brazil." *Gradient Trends: Risk Science and Application* 59 (Winter):4.

Bittner, AB. 2013. "Modeling Mass Discharge from the Source Zone." Presented at Second International Symposium on Bioremediation and Sustainable Environmental Technologies, Jacksonville, FL, June 11.

Bittner, AB. 2013. "Successful Implementation of a Risk-based Remedial Solution in Brazil." Presented at the 2013 NGWA Groundwater Summit, San Antonio, TX, April 28.

Bittner, AB. 2013. "Evolving methods for evaluating vapor intrusion." *Gradient Trends: Risk Science and Application* 57(Spring): 4.

Esakkiperumal, C; Bittner, A. 2013. "Use of Mass-Flux Based Approach to Optimize the Design of a Hydraulic Containment System." Presented at the 2013 NGWA Groundwater Summit, San Antonio, TX, April 28.

Bittner, A. 2010. "A Weight-of-Evidence Approach to Assess NAPL Mobility." Presented at the 7th International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 27.

Herman, K; Bittner, A. 2010. "How Much Tar is In the Mud? – Reducing Uncertainty in Characterizing the Distribution and Mass of DNAPL in Sediments." Presented at the EPRI MGP 2010 Symposium, January 28.

Bittner, AB. 2009. "Is your NAPL mobile?" *Gradient Trends: Risk Science & Application* 45(Spring):3.

Herman, K; Bittner, A. 2008. "Reducing Uncertainty in DNAPL Characterization." Presented at the 24th Annual International Conference on Soils, Sediments, and Water, October 23.

Bittner, AB; Baffrey, RN; Esakkiperumal, C. 2006. "Using Sediment Transport Modeling to Support Environmental Forensic PCB Analyses." Presented at Society of Environmental Toxicology and Chemistry Conference, Montreal, Canada, November 8.

Bittner, AB. 2006. "Groundwater and Air Modeling Used to Support Forensic Analyses." Presented at the Gradient Breakfast Seminar Titled: Forensic Chemistry – The Intersection of Science and Law, May 16.

Bittner, AB. 2006. "M&A emerging issues and requirements." *Gradient Trends: Risk Science & Application* 36(Spring):4.

Sharma, M; Saba, T; Bittner, A. 2003. "Optimization of Groundwater Pump and Treat Systems." Presented at the 19th Annual International Conference on Contaminated Soil, Sediments and Water, Amherst, MA, October 23.

Sharma, M; Saba, T; Bittner, A. 2003. "Optimization of Groundwater Pump and Treat Systems Using Numerical Modeling and the Monte Carlo Approach." Presented at the National Ground Water Association Mid-South Focus Conference, Nashville, TN, September 19.

Bittner, AB; Halsey, P; Khayyat, A; Luu, K; Maag, B; Sagara, J; Wolfe, A. 2002. "Drinking water quality assessment and point-of-use treatment in Nepal." *Civil Eng. Practice* 17:5-24.

Bittner, AB. 2000. "Drinking Water Quality Assessment in Nepal: Nitrates and Ammonia [Thesis]." Submitted to Massachusetts Institute of Technology.

ANDREW BITTNER, P.E.
Testimony Experience

Mr. Bittner has provided testimony in the following matters.

1. MACTEC Engineering & Consulting, Inc. v. Hitchiner Manufacturing Co., Inc., and Thomas & Betts Corporation vs. Dragin Drilling, Inc. and Windham Environmental Corporation, d/b/a Remede Products and d/b/a Redux Technology. American Arbitration Association No. 111920064106. Provided testimony (2007) in deposition related to contaminant fate and transport and groundwater flow modeling.

2. Ernest Hardy, et al. v. Cheshire Oil Company, Inc. and Gabrielle Realty, LLC. Prepared expert report (2008) regarding the fate and transport of methyl tertiary butyl ether in groundwater. Case settled prior to deposition.

3. Sierra Club v. Pennsylvania Department of Environmental Protection and FirstEnergy Generation, LLC, Permittee. Commonwealth of Pennsylvania, Environmental Hearing Board Docket No. 2015-093-R. Prepared expert report (2017) in support of permittee regarding the fate and transport coal combustion constituents in surface water. Case settled prior to deposition.

4. Davis Gas Processing, Inc. *et al*. v. Western Gas Resource, Inc. *et al*. Railroad Commission of Texas Hearings Division. Oil and Gas Docket No. 09-0304555. Prepared expert report (2018) titled "Evaluation of Groundwater Hydrogeology and LNAPL Fate and Transport at the Davis Gas Processing Plant and Surrounding Area in Bowie, Texas." Case Settled prior to deposition.

5. The Estate of Bobby Clary *et al*., v. American Electric Power Co. Inc. *et al*. Gavin Landfill Litigation. Circuit Court of Raleigh County, West Virginia. Civil Action No. 16-C-8000. Prepared expert report (2018) titled "Assessment of January 2017 Field Investigation and Results at the Gavin Landfill in Cheshire, Ohio." Case Settled prior to deposition.

6. Duke Energy Carolinas, LLC and Duke Energy Progress, LLC *v*. AG Insurance SA/NV (f/k/aL'Etoile S.A. Belge d'Assurances) *et al*. Prepared export report (April 2020), rebuttal report (May 2020), and surrebuttal report (June 2020). Provided testimony (September 2020) in deposition related to fate and transport of coal combustion product constituents at multiple coal ash disposal facilities and coal-fired power plants.

7. Provided pre-filed testimony (August 2020) related to the Illinois Environmental Protection Agency (IEPA) Proposed Part 845 Rulemaking of the Illinois Administrative Code (Title 35, Subtitle G, Chapter I, Subchapter j). Provided oral testimony (September 2020) related to the proposed rule before the Illinois Pollution Control Board.

8. Draft Allocation for the Lower Passaic River. Prepared expert rebuttal report "Comments on the Draft Allocation Recommendation for TFCFA" (November 2020).

9. Expert Report submitted in support of "Petition for a Finding of Inapplicability or, in the Alternative, an Adjusted Standard from 35 ILL. Admin. Code Part 845." "Human Health and Ecological Risk Evaluation and Relative Impact Assessment. Joppa Generating Station – Joppa West, Joppa, Illinois" (May 11, 2021).

10. AEP Generation Resources Inc. *et al*. *v*. AG Insurance SA/NV (f/k/a AG de 1830 Compagnie Belge and as Successor to L'Etoile S.A. Belge d'Assurances and Transferor to Bothnia International

Insurance Company Ltd.) *et al*. Prepared export report (June 2022) and rebuttal report (September 2022) related to fate and transport of coal combustion product constituents at multiple coal ash disposal facilities and coal-fired power plants. Provided testimony (October and November 2022) in deposition.