September 8, 2017

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Cont. No.:VA17-01525

Mr. Mark Thompson
Vice President - Environmental Affairs
Montana Resources, LLP
600 Shields Avenue
Butte, Montana
USA, 59701

Dear Mark,

Re: Response by the Engineer of Record to Comments Submitted by Atlantic Richfield Company

1 – INTRODUCTION

Montana Resources, LLP (MR) is preparing a permit amendment application to provide for continued mining beyond 2020. The proposed amendment considers the YDTI with embankments constructed to a crest elevation of 6,450 ft (Anaconda Datum) and commencing operation of the West Embankment Drain (WED). The amendment will provide approximately 12 years of additional mine life. Knight Piésold Ltd. (KP) developed the YDTI Design Document to support the permit amendment application. The YDTI Design Document is comprised of a series of technical reports covering the subject areas and content specified in Montana Code Annotated (MCA) 82-4-376, which prescribes the design document requirements for a tailings storage facility and is the governing legislation for preparation of a design.

MR engaged an Independent Review Panel (IRP) for review of the Design Document, as mandated by MCA 82-4-377, early in the design process (beginning in July 2015) as it provided the opportunity for discussions of site investigation requirements, design concepts and alternative tailings management strategies prior to completion of the design. The IRP has statutory obligations to review the Design Document and provide any recommended modifications to MR and the Montana Department of Environmental Quality. The panel's determination in their review is conclusive, and the Engineer of Record (EOR) must modify the design document to address the recommendations of the panel and certify the completed design document. The final review of the completed YDTI Design Document is presently underway by the IRP.

2 – RESPONSE TO COMMENTS SUBMITTED BY ATLANTIC RICHFIELD COMPANY

MR was provided comments and recommendations from Atlantic Richfield Company (ARCO), an external stakeholder, during preparation of the final YDTI Design Document. The ARCO comments considered revisions of the reports comprising the Design Document that have since been superseded. Table A1 presents a summary of the ARCO key comments and recommendations, and the associated response from the EOR and references to information within the YDTI Design Document, where applicable. A complete copy of the ARCO comments and recommendations '*Final Report, Yankee Doodle Tailings Impoundment, Butte, Montana*' May 3, 2017 is presented in Appendix B with highlighting and labels that cross-reference to Table A1.

The IRP requested a summary of the EOR responses to the ARCO comments and recommendations, and a copy of this letter will be provided to them as supplemental information to support their review of the YDTI Design Document.

Yours truly,
Knight Piésold Ltd.

PROFESSIONAL PROVINCE OF R. S. STEWART # 35849 BRITISH COLUMBIA ENGINEER Sept 8, 2017

MONTANA KEN J. BROUWER 10020 PE REGISTERED PROFESSIONAL ENGINEER Sept 8, 2017

Prepared: ______________________ Reviewed: ______________________

Roanna Stewart, P.Eng.
Senior Engineer

Ken Brouwer, P.E.
President

Approval that this document adheres to Knight Piésold Quality Systems: KJB

Attachments:

Appendix A	Concordance Summary: Atlantic Richfield Company (ARCO) Comments/Recommendations, Yankee Doodle Tailings Impoundment
Appendix B	Annotated Version of the Final Report Yankee Doodle Tailings Impoundment, Butte, Montana; Davidson, Morgenstern, Hippley; May 3, 2017

Copy To: Leslie Smith, Jim Swaisgood, Dirk van Zyl

/ddf

Knight Piésold CONSULTING

APPENDIX A

CONCORDANCE SUMMARY: ATLANTIC RICHFIELD COMPANY (ARCO) COMMENTS/RECOMMENDATIONS, YANKEE DOODLE TAILINGS IMPOUNDMENT

(Pages A-1 to A-16)

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TABLE A1

MONTANA RESOURCES, LLP
AMENDMENT APPLICATION: YANKEE DOODLE TAILINGS IMPOUNDMENT

CONCORDANCE SUMMARY: ATLANTIC RICHFIELD COMPANY (ARCO) COMMENTS/RECOMMENDATIONS
FINAL REPORT YANKEE DOODLE TAILINGS IMPOUNDMENT (DAVIDSON, MORGENSTERN, HIPPLEY, 05/03/2017)

Section -Note #	CLASSIFICATION	ARCO COMMENTS / RECOMMENDATIONS	ENGINEER OF RECORD (EOR) RESPONSE / DISCUSSION
2.0 KEY FINDINGS AND RECOMMENDATIONS			
2-1	Comment	*Significant zones of saturation exist within the non-free draining rockfill, which appears to be more soil-like than rock-like.*	This interpretation is inconsistent with the geotechnical and hydrogeological models that have been determined for the East-West Embankment of the Yankee Doodle Tailings Impoundment (YDTI). Details presented in the Site Characterization Report (Rev 2) instead indicate the obliquely stratified heterogeneous rockfill embankment has been progressively developed by Montana Resources (MR) as a free draining structure that is generally unsaturated except for where isolated perched conditions exist in the rockfill and within the saturated drainage zone that exists in the bottom 50 to 120 feet of embankment rockfill and extends along the base of the East-West Embankment. The shear strength function adopted for rockfill in the Stability Assessment appropriately addresses the well graded characteristics of the embankment fill by using shear strength characteristics representative of angular sand instead of rockfill. This strength function was adopted for the analyses in recognition of the potential for site-wide variability and the potential for long-term degradation of the rockfill after closure.
2-2	Comment	*The rockfill also appears to be prone to weathering that may result in reduced shear strength. Additional embankment height may accelerate the reduction in strength.*	As described above, the shear strength function for embankment rockfill was selected in recognition of the potential for long-term degradation at current confining pressures and due to future increased loading. Use of this function is conservative, particularly for the East-West Embankment where historically the most durable rockfill materials have been placed.
2-3	Comment	*The waste rock has a history of being leached.*	An isolated portion of the rockfill was historically leached in the East-West Embankment. This leach area was primarily located to the west of the maximum embankment section as described in the Site Characterization Report (Rev 2). Leaching in this area ceased in the 1990s.
2-4	Comment	*The North-South Embankment was constructed on top of the leach pad.*	The North-South Embankment is constructed in a downstream manner and extends over historic leach areas. The entire leach area between the current mine haul ramp and Rampart Mountain may eventually be filled, which will substantially buttress the North-South Embankment enhancing long-term stability and improving surface reclamation potential.
2-5	Recommendation	*Alternative tailings disposal strategies should be evaluated.*	The Alternatives Assessment considered the most applicable and appropriate tailings disposal strategies and identified the best tailings storage alternative practicable for continued operation of the mine while

			limiting the potential of new environmental impacts or operational interruptions.
2-6	Comment	*Neither the design nor the operation of the embankment has precluded ingress of tailings and seepage into the structure.*	Placement of an alluvium facing on the upstream embankment slopes has been periodically conducted to prevent the migration of tailings into the rockfill embankment. The design drawings for the next stage include an alluvium facing layer, which is to be constructed on all embankment upstream slopes. Further discussion of this topic is presented in Responses 7-9 and 8-1.
2-7	Comment	*If undrained loading can occur, it will occur at some point in the life of the facility.*	Undrained loading has been assumed to occur locally at some point in the life of the facility without having an adverse impact on the short term stability of the impoundment and any excess pore pressures would also dissipate over time. Seismic loading is the only credible potential trigger to initiate an undrained response in the YDTI at a scale larger than just a localized pocket. The sensitivity analyses demonstrate that the embankment will remain stable even if lower bound undrained strengths were triggered. Historically during initial development of the YDTI embankments, an early slide on the upstream side of what is now the North-South Embankment indicated the potential for slope adjustments in the angle of repose rockfill dump initiating at the base of the dump due to rapid loading of the natural soils (Dames and Moore, 1963). This early instability was likely due to localized undrained loading of the foundation soils and was mitigated by stripping the foundation of shallow sage-brush and soil in advance of dumping. No new construction over saturated overburden is planned. The surficial materials in the vicinity of the West Embankment have been stripped from the foundation and stockpiled for reclamation purposes.
2-8	Comment	*Given the presence of a significant saturated zone of fill and the contractive nature during shear, the conditions for undrained failure are likely to exist given the nature of the fill.*	This comment is predicated on an incorrect assumption as indicated in the response to Note 2-1 above. Where the term “undrained failure” is used in the comment, the term “undrained loading” or phrase “behaving in an undrained manner” is used as a more appropriate description. There is a localized zone of saturation along the base of the East-West Embankment that has been present since at least the early 1980s. Drilling investigations indicate that interbedded fine-grained and coarse-grained zones are present within the fill. Localized saturated, fine grained material may behave in a contractive manner under shear. Undrained loading under static conditions could therefore be assumed to occur locally at some point in the life of the facility and the excess pore pressures would dissipate over time. The favorable orientation of the embankment fabric and the presence of well drained, stronger zones encountered during geotechnical investigations indicates that although weaker and stronger zones exist, a continuous weaker layer is not credible.
2-9	Recommendation	*The implications of undrained failure should be assessed for both current and future proposed sections under both static and dynamic loading*	The credibility and implications of undrained loading on the calculated factors of safety and maximum estimated earthquake-induced

		conditions both including the Maximum Credible Earthquake as well as including both the smaller and more frequent earthquakes.	deformation have been assessed and are reported in the Stability Assessment Report (Rev 2).
2-10	Comment	*Seepage supports our view that significant zones of saturation exist within the embankment. Perched zones of saturated material likely exist within the embankment contributing to downstream seepage.*	Seepage indicates that the embankments are functioning as intended. The embankments have been designed and constructed to facilitate and enhance drainage and seepage from the tailings mass, rather than to preclude it. Rockfill segregation during construction of the thick dump lifts results in sub-horizontal zones of coarser high conductivity rockfill along the base of the lifts which can represent preferred seepage pathway for fluids draining from the tailings impoundment and through the embankments. A relatively small zone of saturation is present along the base of the East-West Embankment where seepage from the tailings mass drains to Horseshoe Bend, as outlined in the Site Characterization Report. Extensive zone(s) of saturation are not indicated in the upper portions of the embankment. Relatively localized perched seepage flows, such as those observed at Seep 10, are expected during operations.
2-11	Comment	*Lack of consistent seepage control measures (i.e. filter zone on upstream slope) has allowed the introduction of tailings fines into the embankment reducing the intended free-draining characteristic of the embankment.*	Disagree. As detailed in Responses 7-9 and 8-1 below, alluvium facing has been placed periodically along the embankment upstream slopes as required (typically across the zones of coarse rockfill) to prevent tailings migration into the embankment. As noted in Response 7-10, the embankment rockfill VWP measurements and drilling observations indicate the embankment continues to be free-draining, and the draining characteristic of the rockfill material has not been compromised by ingress of tailings fines.
2-12	Recommendation	*We recommend the closure strategy be re-visited.*	This recommendation is noted, and additional responses to the specific recommendations are provided below in Responses 4-2, 10-1 and 10-2.
2-13	Comment	*There are uncertainties regarding local faults that may have considerable effects on seismic loading of the tailings impoundment.*	Concur, there is uncertainty in the activity of the Continental Fault; however, a conservative approach has been adopted for the design as detailed in Response 6-3.
2-14	Comment	*The water quantity currently retained within the embankment, combined with the infrastructure and activities downstream of the impoundment and in the town nearby, may result in severe consequences if a failure occurs.*	The consequences of a hypothetical failure (dam breach) involving release of water from the supernatant pond would potentially be severe and is classified as Major to Catastrophic in the Dam Breach Risk Assessment Report. The potential consequences of failure associated with undrained loading at the East-West Embankment are less severe, and additional details on the potential for limited flowability of some saturated tailings in this area of the impoundment are provided in Appendix A of the Dam Breach Risk Assessment (Rev 2).
2-15	Recommendation	*More instrumentation sections and monitoring devices are warranted to adequately monitor the facility in the future.*	The Engineer of Record (EOR) agrees with this recommendation. A phased site investigation program began in 2015 and is presently underway to supplement the existing embankment monitoring network. The monitoring network will be progressively expanded as required to meet the monitoring and surveillance requirements as stipulated by the

			EOR with input from the Independent Review Panel (IRP). Further detail is presented in Responses 12-1 and 12-5.
2-16	Comment	*Preliminary calculations presented to us by MR (April 21, 2017) indicate that the requirement of 1.5 for static loading is not likely to be satisfied for the current condition.*	Incorrect. The Stability Assessment Report (Rev 2) confirms the factor of safety (FoS) requirements for static loading are achieved for current and future normal operating conditions. The YDTI embankments are stable with a FoS of 2.0 or greater.
2-17	Comment	*Modelling performed by MR and KP, and presented to us, shows factors of safety considering the undrained conditions that do not meet Montana law or industry accepted standards.*	The Stability Assessment Report (Rev 2) presents the analysis of undrained conditions and assesses the credibility and implications of applying these theoretical conditions to the stability assessment of the YDTI. The extreme sensitivity analyses performed using lower bound undrained strengths indicate the embankment will remain stable even if large scale undrained loading is triggered. Seismic loading is the only credible potential trigger to initiate an undrained response for the YDTI at a scale more than local. Montana Code Annotated (MCA) 82-4-376 requires a FoS of at least 1.2 for post-earthquake conditions. This criteria is satisfied even if these lower bound undrained strengths were triggered at a large scale. Establishing this extreme condition as the base case for static normal operating conditions for the YDTI, while it would lead to a more conservative design, is not a reasonable and appropriate use of undrained strength analysis. Selective and strategic placement of rockfill to further improve embankment stability and to support reclamation objectives should be considered while evaluating options for storage of excess rockfill produced during mining of the Continental Pit.
3.0 GEOTECHNICAL CHARACTERIZATION			
3-1	Comment	*..from sonic drillholes DH15-S1 — DH15-S5, it appears that there are various perched water levels as well as the phreatic surface. Constant seepage is observed at the toe.*	Concur. Constant seepage at the toe of the embankment is a design objective for the free draining embankments, as is the zone of saturation along the base of the East-West Embankment as the majority of the drainage from the tailings mass reports to the seepage collections systems downstream of the toe at Horseshoe Bend. Routine seepage draining through the obliquely stratified heterogeneous rockfill embankments is expected to result in localized zones of saturation along the seepage flow paths. Drilling and piezometric monitoring confirm the presence of some localized perched water levels within the largely unsaturated embankment rockfill.
3-2	Comment	*There are no borehole permeability tests in the rockfill, but piezometric measurements suggest some perched conditions and a strong downward gradient.*	A limited number of permeability (falling head) tests were conducted in boreholes situated within the East-West Embankment in 1995 (Braun Intertec, 1995). These test results are summarized in Section 4.5 of the Site Characterization Report (Rev 2).

			We agree that a strong downward gradient is to be expected below any localized zones of saturation within the unsaturated/partially saturated rockfill mass.
3-3	Comment	*The questions to be addressed by the Engineer of Record (EOR) are whether the degraded rockfill is really free draining and does it possess a high enough degree of saturation and sufficient fines content to behave in an undrained manner near the base and elsewhere and be potentially vulnerable to the high seismic loading at the site.*	The EOR has conducted extensive investigations and analyses to evaluate the nature and characteristics of the free draining rockfill as reported in the Site Characterization Report (Rev 2), and has also considered site specific seismic loading and the potential for undrained conditions in the Stability Assessment Report (Rev 2).
4.0 ALTERNATIVES ASSESSMENT			
4-1	Recommendation	*It is our view that … additional stakeholders should have collaboration and input to the assessment.*	MR has been in communication and consultation with numerous stakeholders since September 2015. To date the following groups have been engaged: • MR Employees • EPA • Atlantic Richfield • Moulton Road Residents • Montana Standard • City Commissioners • Major Employers Group • State Legislative Delegation • Federal Legislators • Butte Local Development • School Board • MDEQ • KBOW (radio station) • Butte Sports.com • Montana Economic Revitalization and Development Corporation. • Butte Chief Executive • Butte Planning Director • LT Governor • Chamber of Commerce • Butte Kwanis – 2 • Butte Public Works Director • Butte Natural Resource Council • Rotary Club • Clark Fork Watershed Protection Program • Butte Realtors
4-2 4-2a 4-2b 4-2c 4-2d 4-2e	Comment	*A number of issues related to technological risk merit more detailed evaluation than is apparent in the Report. For example:* - *A dry closure has increased stability and benefit over the long term.* - *Is there merit in considering depyritization of the tailings to facilitate this objective?* - *could a capillary break be used instead to ensure vegetation does not wick metal-acid salts to the surface?* - *There might be merit in separating the sand from the slimes and only storing the slimes in the pond* - *Alternative tailings disposal strategies… One potential concept would be to utilize the Berkeley Pit for tailings disposal.*	The closure strategy is provided in the Reclamation Overview (Rev 1). The reclamation strategy includes a dry tailings impoundment surface with a small (8% of total impoundment area) stormwater management / evaporation pond. The reclamation activities includes placement of a surface cap and vegetative cover on the tailings beach surface, which is consistent with a typical dry non-flooded cover philosophy. Amending the reclamation strategy to eliminate the localized ponded water within the impoundment is not considered practicable, especially given that approximately 50% of all post-closure water entering the impoundment is from direct precipitation onto the impoundment surface. Tailings de-pyritization is not being considered, and specific cap structure details for closure capping have not yet been developed and are not the subject of the design documents. The tailings solids segregate within the impoundment after deposition using the multiple discharge points. Sandy tailings are deposited near

			the discharge points with finer slimes tailings migrating and settling closer to the supernatant pond. It is unclear from the comment where the reviewers are suggesting the sands be stored under present operating conditions. Tailings storage in the Berkeley Pit was discussed in the Alternatives Assessment; however, the present regulatory requirements and judicial commitments preclude it as a viable alternative. Selective disposal of a portion of the future tailings stream into Berkeley Pit could have merit for long range planning if jurisdictional and logistical issues can be resolved.
4-3	Recommendation	*The alternative evaluation should consider all available technologies and alternatives, and their risks, to address these concerns rather than just raising the impoundment.*	The Alternatives Assessment (Rev 2) considered the most applicable, appropriate, and current technologies and techniques that are practicable given site-specific conditions and concerns. The assessment included options other than raising the Yankee Doodle Tailings Impoundment such as off-site storage, thickened and filtered tailings.
5.0 DESIGN BASIS REPORT			
5-1	Recommendation	*BC Guidelines for the design of tailings dams should be adopted in the design basis criteria pursuant to MCA 82-4-376(2)(e) (requiring a design that uses the most applicable, appropriate and current technologies and techniques).*	Adherence to MCA 82-4-376 is a fundamental requirement for the design of the YDTI. The Design Basis Report (Rev 2) delineates the specific design objectives and requirements to comply with these regulations and other relevant guidelines. The Montana statute cannot be replaced by the statute or law of another state or country. The Design Basis Report (Rev 2) includes a comparison of the British Columbia (BC) Guidelines with MCA 82-4-376 in Section 1.8.3. The comparison shows the BC Guidelines are generally consistent with the Montana regulations, and at times the Montana regulations are more conservative. The BC Guidelines are considered as a useful reference only, as are guidelines and regulations from other relevant North American sources.
6.0 SEISMIC HAZARD ASSESSMENT			
6-1	Comment	*The SHA recommended that a fault study be performed to evaluate whether the Continental Fault is active or not. We have not found any evidence that such a study has been performed.*	The potential activity of the Continental Fault was examined in Section 2.4 of the Site Characterization Report, and relied on information compiled by the Montana Bureau of Mines and Geology and the Seismic Hazard Assessment performed for the project. The Continental Fault was included in the seismic hazard source models for the design of the embankments primarily due to the proximity to the YDTI site and because it was included as an active source in past studies. MR has examined the Continental Fault in areas of the Continental Pit highwalls where it has been exposed. The EOR and Jim Swaisgood of the IRP have also had the opportunity to examine an exposure of the Continental Fault in the Continental Pit highwall. These investigations have not determined conclusively the fault is inactive (nor that it is active). KP have therefore chosen to maintain a conservative approach and consider the fault to be potentially active for stability analyses conducted to date. Additional studies to evaluate fault activity or inactivity may be performed later to support future evaluations. The

			approach may be modified in the future if further investigations determine the fault to be inactive.
6-2	Comment	*Both of those fault sources* (Continental and Rocker Faults) *contribute substantially to the results of the probabilistic SHA (PSHA) and the Continental Fault dominates the results of the deterministic SHA (DSHA).*	Concur. This is to be expected.
6-3	Comment	*The precedent of assuming fault activity without field confirmation can lead to excessively conservative results.*	Agree, the YDTI stability analyses completed adopt a conservative approach. The stability analyses however demonstrate appropriate Factors of Safety and tolerable displacements, in spite of this conservative approach. It is not intended to form a precedent for other sites. As noted above in Response 6-1, the assumption that these faults were active was made as early as the 1980s by IECO and is currently included as an active source because it cannot presently be disproved.
6-4	Comment	*MR and their consultant have adopted the conservative position that the fault is active*	Correct.
6-5	Comment	*The 84th percentile design case corresponds to a return period of close to 100,000 years. The State of Montana may be open to discussion on a lower design ground motion.*	Agree, adopting the 84th percentile ground motion, which corresponds to a return period of close to 100,000 years is a very conservative approach for seismic design. The EOR and IRP have discussed this at length and concluded this is a reasonable approach at this time for closure conditions at the YDTI.
7.0 STABILITY ASSESSMENT REPORT			
7-1	Comment	*Portions of the rockfill embankment may not be free-draining. While undoubtedly heterogeneous, portions of the embankment are not free-draining.*	The historical YDTI was designed and constructed to allow the tailings mass to drain laterally and vertically into the more permeable rockfill embankment zones. The heterogeneous nature of the obliquely layered rockfill results in zones of high hydraulic conductivity that allow the overall embankment structure to drain freely by gravity. It is anticipated that some relatively smaller zones of finer grained material will drain more slowly due to the lower permeability as compared to the coarser stratifications within the embankment fill. These finer grained zones are still expected to be free-draining, albeit more slowly. The heterogeneous and obliquely stratified nature of the rockfill is described by Applied Geologic Services (2017), and as summarized in the Site Characterization Report (Rev 2).
7-2	Recommendation	(Embankment rockfill) *must be regarded as potentially loose, segregated compressible, and contractive when subjected to shear stress.*	Embankment rockfill has typically been placed in relatively loose end-dumped lifts ranging from about 30 feet to approximately 100 feet in height, in order to promote segregation and to incorporate highly permeable stratified zones of coarser rockfill and thus facilitate the free draining nature of the embankments. These rockfill materials have been compressed under self-weight loading, such that the deeper rockfill is considerably denser and more compact than the upper rockfill materials. The determination of appropriate shear strength parameters has considered both the nature and characteristics of the rockfill materials, as well as the free draining nature of the emplaced embankment fill, when considering the behavior of these materials when subjected to shear stresses.

7-3	Comment	*High pressure effects are expected to enhance the contractive nature during shear of the fill forming the YDTI embankment.*	High pressures occur in the deeper sections of the embankments, due to static self-weight loading caused by the progressive expansions to the facility. Similar gravitational processes have also occurred in the adjacent hydraulically emplaced tailings sands/silts within the impoundment, where in-situ CPTs (as discussed in the Site Characterization Report) have confirmed the increasing density with depth due to high pressures from self-weight loading and tailings drainage.
7-4	Comment	*The fill comprising the embankment is chemically reactive.*	The rockfill materials used for embankment construction, both historically and currently, is acid generating, as are other waste dumps at the mine site. The sulfide bearing rockfill materials have higher acid potential than the leached capping rockfill materials. The neutralization potential in most of the embankment rockfill is low. The potential for long-term physical and geochemical degradation of the embankment fill was a fundamental consideration when defining the shear strength function for rockfill that was used in the stability assessment. A conservative strength function was adopted for the analyses in recognition of the potential for site-wide variability and potential for long-term degradation in closure.
7-5	Comment	*High stress and geochemical processes affect the durability of the rockfill to a degree that its future geomechanical behavior is of concern.*	The nature and characteristics of the embankment rockfill materials, which are under high stress conditions and are prone to geochemical weathering processes have been considered, and factored into the designs and stability assessments.
7-6	Comment	*Any assessment of consequences of failure would result in an "extreme" rating.*	The risks and consequences of hypothetical embankment failure have been evaluated in the Dam Breach Risk Assessment (Rev 2). The consequences of an embankment failure could be considered to be ‘Extreme’ for certain locations within the YDTI, i.e. at the north end of the North-South Embankment under flooded conditions, where the hypothetical instability could allow for the sudden uncontrolled release of ponded water and fluid tailings slimes. The consequences of a hypothetical failure with a normal operating pond volume where the embankments are abutted by extensive drained tailings beaches i.e. along the East-West Embankment would receive a ‘moderate’ or ‘major’ rating as the consequences would be limited to localized deformation of the rockfill embankment and adjacent drained tailings beaches.
7-7	Comment	*Seepage History* *Neither the design nor the operation of the embankment has precluded ingress of tailings and seepage into the structure.*	The embankments have been designed and constructed to facilitate and enhance drainage and seepage from the tailings mass, rather than to preclude it. Rockfill segregation during construction of the thick dump lifts results in sub-horizontal zones of coarser high conductivity rockfill along the base of the lifts which can represent preferred seepage pathway for fluids draining from the tailings impoundment and through the embankments.
7-8	Comment	*A significant zone of saturation exists within the structure, particularly within the East-West Embankment.*	Incorrect. A relatively thin/shallow zone of saturation is present along the base of the East-West Embankment where seepage from the tailings mass drains to Horseshoe Bend, as outlined in the Site Characterization Report. Extensive zone(s) of saturation are not indicated in the upper

			portions of the embankment. Relatively localized perched seepage flows, such as those observed at Seep 10, are expected during operations.
7-9	Comment	*Four separate incidents of seepage up to 1000 gpm and tailings flow through the North-South Embankment and related slumps were highlighted in the 2016 EOR inspection report*	Horizontal zones of coarse, high permeability rockfill are created by natural segregation of the rockfill during embankment construction and occur approximately every 50 ft horizontally in the embankment. The 2016 tailings seepage incidents occurred when the YDTI tailings beach and active discharge stream were at the same elevation as a coarse, high permeability zone. The active tailings stream was therefore able to migrate laterally into the coarse zone, through the embankment along the base of the rockfill lift and discharge at the downstream face of the embankment. Descriptions of the 2016 incidents and mitigation measure implemented are described in the 2016 EOR Annual Inspection Report (AIR). The design of the next stage includes construction of the YDTI embankments with an alluvium facing layer to mitigate tailings migration into these coarse rockfill zones in the future.
7-10	Comment	*The postulated phreatic surface, as well as additional water elevation data that show water levels elevated within the embankment, as supportive of our view that substantial zones of saturated fill exist within the embankment.*	The phreatic surface postulated by ARCO is not supported by drilling observations or piezometric records. Detailed inspection of continuous sonic drill core show the rockfill to be predominantly unsaturated (free-draining) above a relatively small basal saturated zone. Isolated perched saturated zones have been observed in drill core and by piezometers above the main phreatic surface; however, these are inferred to be localized occurrences and are disconnected from the basal saturated zone below. These observations preclude the delineation of the substantial zones of saturated fill as hypothesized by ARCO.
7-11a 7-11b	Comment	*Dawson, et al. (1998) have described liquefaction flow slides in Rocky Mountain coal mine waste dumps and Valenzuela, et al. (2011) discuss potential instability of high waste dumps undergoing leaching and subjected to earthquake loading…* *These papers support our view that even if zones of saturation are limited, undrained failure can develop.*	KP has considered the limited precedent outlined in these referenced papers and has commented on the relevance of the suggested precedent to the YDTI embankments in the Stability Assessment Report (Rev 2). The ARCO hypothesis for potential undrained loading conditions has been evaluated as part of the sensitivity analyses described in this report. Saturation does not mean a material will behave in an undrained manner, and behavior in an undrained manner does not imply failure has occurred. The extreme sensitivity analyses performed using lower bound undrained strengths indicate the embankment will remain stable even if large scale undrained loading is triggered.
7-12	Comment	*Given the presence of a significant saturated zone of fill and the contractive nature during shear, the conditions for undrained failure exist.*	The information presented in the Site Characterization Report indicates that this ARCO premise of significant zones of saturation in the rockfill is unsupported. There is a localized zone of saturation along the base of the East-West Embankment that has been present since at least the early 1980s. Interbedded fine-grained and coarse-grained zones are present within the fill. Coarse-grained zones are present even in zones of high pressure. Saturated, fine grained material may behave in a contractive

			manner under shear. Undrained loading therefore could theoretically occur locally at some point in the life of the facility without impacting the stability of the impoundment. Any excess pore pressures generated during the hypothetical undrained loading condition would dissipate over time. The favorable orientation of the embankment fabric and presence of well drained, stronger zones encountered during geotechnical investigations surrounding fine grained material indicates that although weaker and stronger zones exist, a continuous weaker layer is not credible.
7-13	Comment	*Undrained shear strength properties are required for stability analyses. Both of the references cited above and theoretical considerations suggest undrained strength ratios over the range of 0.25 to 0.3.*	Undrained stability analyses have been conducted as sensitivity analyses to the base case stability evaluations and are presented in the Stability Assessment Report in Section 5.4.3. Appropriate undrained shear strength properties have been selected based on site specific laboratory testwork as well as other appropriate precedents.
7-15 7-15a 7-15b 7-15c	Comment	*Performed screening-level analyses based on the cross-sections presented on Figure 5.2(c) and 5.2(d) of the Stability Assessment Report.* - *For Case 1, the calculated factors of safety range from 0.89 to 1.03 compared with 1.7 to 2.0 given in Table 5.2 of the Stability Assessment Report. A factor of safety of less than 1.0 would indicate failure.* - *For Case 2 the undrained strength ratio for the degraded rockfill is modeled with an anisotropic strength ranging from 0.25 for horizontal portions of the shear surface and 0.30 for the steeper portions of the failure surface…* - *For Case 2, the calculated factors of safety range from 0.95 to 0.96, which also indicate failure.*	The screening level stability analyses are based on the incorrect geotechnical and hydrogeological models of the East-West Embankment. The hydrogeological (pore pressure) conditions applied in the ARCO screening level assessment apply hydrostatic pore pressure conditions to the embankment fill below the piezometric line. This characterization of pore pressures is not supported by measured piezometric data or observations within the drill core during sonic drilling. A summary of the appropriate piezometric characterization for the East-West Embankment is provided in the Site Characterization Report (Rev 2) and the Stability Assessment Report (Rev 2). An incorrect application of undrained shear strengths has compounded the inaccuracy of the screening level calculations. ARCO has incorrectly applied undrained shear strengths to well drained rockfill materials below the incorrectly inferred piezometric line. These low shear strength values are unrealistic for the drained rockfill materials that have been utilized to construct the embankment. The ARCO FoS are based on a geotechnical model with embankment materials having undrained shear strength characteristics equivalent to a weak normally consolidated clay material. The analyses assume that these materials exist as a massive zone of embankment fill comprising approximately half of the embankment. ARCO has not properly accounted for the true nature of the embankment fill material, the orientation of the rockfill fabric, nor the free draining nature of the materials.
7-16	Recommendation	*We believe similar factors of safety may exist for the existing embankment and strongly encourage the Engineer of Record to perform those calculations for an undrained condition for existing conditions and geometry.*	ARCO's stability analyses are unrealistic as noted above in Response 7-15. The Stability Assessment Report (Rev 2) confirms the FoS requirements for static loading are achieved for current and future normal operating conditions. The YDTI embankments are stable with a FoS of 2.0 or greater.

			KP has completed sensitivity analyses evaluating undrained loading for the East-West Embankment for both the existing and future conditions and geometry using a conservative conceptual model that KP considers is more appropriate than the analysis presented by ARCO. These analyses confirm the stability of the current and proposed embankment will remain stable even if large scale undrained loading is triggered.
7-17	Comment	*…the Guidance Document for the Health, Safety, and Reclamation Code for Mines in British Columbia, which is becoming a leading reference for tailings dam designs, presents in their Table 3-2 a minimum static factor of safety of 1.5 for tailings dam design (2016a). We believe this reflects the most current applicable technology or techniques for safe dam design. This guidance, and Montana legal requirements to use the most current technologies and techniques under MCA 82-4-376(e), require a factor of safety of 1.5 for operating conditions at the YDTI.*	The Montana law cannot be replaced by guidance or law of another state or country. The controlling section of MCA 82-4-376 for factors of safety against slope instability in an existing facility is (l) which states " for expansion of an existing tailings storage facility, either an analysis showing the proposed expansion meets the minimum design requirements for a new tailings storage facility under this section or an analysis showing the proposed expansion does not reduce the tailings storage facility's original design factors of safety and seismic event design criteria;". The Stability Assessment Report (Rev 2) details the relevant MCA legislative requirements.
7-18	Recommendation	*It is our view that the implications of undrained failure should be assessed for both current and future proposed sections under both static and dynamic loading conditions.*	The Stability Assessment Report (Rev 2) presents sensitivity stability analyses that consider undrained loading conditions.
7-19	Comment	*If the ground motions include components that are somewhat oblique to the East-West Embankment they could tear the embankment apart. At this point it would not be able to contain the liquefied tailings.*	The Dam Breach Risk Assessment (Rev 2) considers the risk and consequences of a hypothetical transverse tear developing in the embankments from extreme seismic loading. Appendix A of the report also includes an assessment of the potential flowability of the in-situ tailings in the event of a hypothetical tear propagating deep into the embankment section. The assessment identifies the potential for very limited tailings liquefaction and no loss of containment in the YDTI as the nature and characteristics of the in-situ tailings would prohibit this from occurring.
7-20	Recommendation	*The implication of the adopted undrained failure mechanism will also have to be evaluated with respect to earthquake induced embankment deformation.*	The Stability Assessment Report (Rev 2) and the Dam Breach Risk Assessment (Rev 2) provide additional analyses and discussions with respect to undrained loading conditions and the potential implications on the estimated earthquake-induced embankment deformation. The analyses indicate the deformation will remain within design tolerances.
8.0 EOR 2015 ANNUAL INSPECTION REPORT			
8-1	Comment	*The alluvium separation zone has not been considered an integral part of the design of the embankment, but more as a mitigation measure when waste and tailings were observed to flow into the structure.*	The alluvium separation zone was historically selectively placed as required to mitigate migration of the active tailings stream into and through the more coarse zones in porous rockfill structure. The active tailings stream has occasionally found a low pressure drainage pathway and migrated through open rockfill layering that had been deliberately developed to promote pervious drainage pathways within the embankment. The flow that has migrated through periodically during these leak events, is from the tailings stream and is captured on the

			benches below. Downcutting or mobilization of tailings from the adjacent settled tailings beach within the impoundment has not been observed, nor has erosion within the embankment structure or in the base of the lift at the leak outlet. Localized and minor erosion of the downstream bench slope beyond the outlet of the leak has occasionally occurred. The alluvium separation zone, when placed, effectively mitigates and eliminates the potential for tailings flow through these pervious drainage pathways while still maintaining the free draining nature of the embankment fill.
8-2	Comment	*A particularly serious leakage event occurred on 16 November 2015… Seepage was observed from Station 13+00 to 20+00. Ponding developed on the 6300 Lift.*	The November 2015 tailings leakage event is described in detail in the 2015 AIR. It was considered carefully and treated as a serious dam safety event. The leak presented / daylighted on the embankment downstream slope and tailings solids accumulated on the EL. 6350 lift; however, the overall implications were largely cosmetic in nature. The event did initiate EOR recommendations in 2015 for advanced mitigation measures including placement of alluvium facing to reduce the likelihood of repeat occurrences. Further response regarding these tailings leak events and the mitigation measures implemented are presented in Responses 7-9 and 8-1, and detailed in the 2015 and 2016 AIRs.
8-3	Comment	*Considerable seepage is collected about 250 ft. above the toe and at the Horseshoe Bend (HSB).*	Seep 10 is a perched seepage flow comprising of clear water that is monitored and collected at a location situated approximately 250 feet above Horseshoe Bend (HsB), which is the lowest point in the valley. The Seep 10 flow monitoring weir indicates a relatively constant flow rate of approximately 220 gpm. All seepage flows from the free draining rockfill embankments ultimately report to the low point of the valley at HsB as per the design intent. The seepage flow rates have been monitored for several decades and are consistent with design expectations for this free draining heterogeneous tailings impoundment. These flow rates do not imply extensive zones of saturation within the embankment rockfill.
8-4	Comment	*Piezometers in the East-West Embankment indicate levels as high as 6300 ft.*	Incorrect. The piezometers do not suggest a phreatic surface elevated to 6300 ft in the East-West Embankment. The highest piezometric elevation recorded in East-West Embankment rockfill is approximately 6030 ft (DH15-S5, VW3). This value is from the central section near the embankment crest and is interpreted to be a perched water level. Piezometric elevations recorded elsewhere in the East-West Embankment rockfill range between 5,600 ft and 6030 ft; many of which are also interpreted to be perched water levels. The main phreatic surface within the embankment is expected to range in elevation between approximately 5,850 ft upstream to 5,650 ft at the downstream toe.

			There are a number of VWP instrumentation sites installed in the tailings mass adjacent to the East-West Embankment. These sites record piezometric elevations within the tailings ranging from 6,270 ft to 6,280 ft. Piezometric elevations in the rockfill drop off sharply due to the relatively higher hydraulic conductivity of rockfill material compared to tailings.
8-5	Comment	*All of the above supports our view that significant zones of saturation exist within the embankment.*	Incorrect. This view is not supported by design, construction records, drilling investigations, nor operational monitoring of piezometric data.
8-6	Comment	*The pattern of cracking, particularly in Photo 6, looks like a system of Riedel shears, that would be symptomatic of differential lateral deformation.*	The similarity in cracking pattern has been noted. The potential for differential lateral shear displacement was considered and discounted by the EOR. The cracking was deemed to have resulted from differential settlement within the rockfill lift and was locally influenced by settlements within tailings beach materials at this North-South Embankment location.
8-7	Recommendation	*Recommend that the cracking pattern be presented in plan and assessed as to whether any lateral displacements are likely, and if so, if they are of consequence.*	Concur.

9.0 DAM BREACH RISK ASSESSMENT			
9-1	Comment	*If a dam breach consequence report is not going to be prepared, information regarding the potential consequences of a breach is still needed to evaluate potential actions to mitigate the risk.*	Section (n) of MCA 82-4-376 (n) requires development of a dam breach analysis, a failure modes and effects analysis or other appropriate detailed risk assessment, and an observational method plan addressing residual risk. A detailed dam breach risk assessment was considered the most appropriate and applicable approach for the YDTI facility amendment application. The Dam Breach Risk Assessment (Rev 2) is part of the YDTI Design Document package.
9-2	Comment	*We draw attention to the merit of some of the alternatives for creation of a suitable dry closure landform.* *In the short-term other risk mitigation measures may be warranted including reduction of water in the tailings impoundment, development of alternative disposal locations, buttressing, and/or alternative disposal technologies.*	The current reclamation strategy includes an extensive tailings capping layer over the maximum extent of trafficable tailings beaches with a significantly reduced water pond that will vary seasonally. The closure water balance identified an average post-closure stormwater management/evaporation pond volume of approximately 500 ac-ft with an estimated surface area of 140 acres (8% of the total impoundment area). The reclamation activities includes placement of a surface cap and vegetative cover on the tailings beach surface to promote evapotranspiration, which is consistent with a typical dry non-flooded cover philosophy. Many other risk mitigation measures are already underway, as detailed below: • MR committed to gradually reduce the volume of supernatant water stored in the YDTI in 2015 and began reducing its use of Silver Lake Water in April 2016. A study to evaluate and optimize fresh water needs at the mill was completed in Q2 2017. The reduction in the freshwater

			use that has been achieved by MR to date, has surpassed expectations, and is therefore well ahead of target. In July 2017, MR maintained an overall average daily SLWS flowrate of 1.0 Mgpd for the entire month. • The tailings distribution system has been expanded from the single southern discharge point at the center of the impoundment to include 8 discharge points to develop extensive drained tailings beaches adjacent to all three embankments. New beach development is progressing well along West Embankment and at the end of the North-South Embankment while maintaining the robust beaches separating the East-West Embankment from the supernatant pond. • The static and seismic stability of the East-West Embankment has been improved by constructing the rockfill surcharge, which also acts as a lead off berm for the tailings discharge and has increased the thickness of the unsaturated tailings zone adjacent to the embankment and reduced perched pore pressure conditions measured in the embankment. • Selective and strategic placement of rockfill to further improve embankment stability and to support reclamation objectives will be considered while evaluating options for storage of excess rockfill produced during mining of the Continental Pit.
10.0 RECLAMATION OVERVIEW			
10-1	Comment	*A focus on feasibility of dry closure would clarify the options available, particularly for the long term.*	The current YDTI reclamation strategy is considered to be a dry closure with a small stormwater management /evaporation pond located on the north side of the facility. See Responses 4-2 and 9-2 above.
10-2	Recommendation	*We recommend that the closure strategy be re-visited… to further evaluate dry closure alternatives.*	See Responses 4-2 and 9-2 above.

11.0 POTENTIAL MITIGATIONS			
 11-1a	Mitigation Recommendation	*MR should consider…evaluating some high-level conceptual designs such as:* - *Add a buttress at the toe and along the downstream face as necessary.*	MR has evaluated rockfill disposal site layouts that would provide additional buttressing along the toe of the embankments. Selective and strategic placement of rockfill to further improve embankment stability and to support reclamation objectives will be considered while evaluating options for storage of excess rockfill produced during mining of the open pit.
11-1b 11-1c		- *Develop an "improving stability approach" by storing tailings in the Berkeley Pit or elsewhere while building the buttress.* - *Develop a "no harm" approach to expansion, such as constructing a buttress, or recognizing that as the impoundment is expanded the calculated factor of safety increases with time… It is recognized that the buttress construction would need to be a priority and proceed as soon as practicable, but incrementally, based on availability of material from the mine plan.*	The current design and construction philosophy is consistent with this proposed approach as described in the Stability Assessment Report (Rev 2). It is noted the surcharge loading along the East-West Embankment is one example of this staged development approach. MR continues to expound on their robust embankment design/construction philosophy – 'When in Doubt, Build it Stout'.
11-1d		- *Construct leadoff berms to allow for deposition further from the crest.*	The rockfill surcharge that has been developed over the last few years is an example where this type of tailings deposition strategy has already been implemented. MR has made significant advancements in their tailings deposition practices over the last several years and particular over the past several months as the multiple tailings discharge points have been commissioned.
12.0 RECENT DISCUSSIONS			
12-1	Recommendation	*Future monitoring of the performance of piezometers and observation wells is essential to confirming adequate slope stability under various types of loading…More instrumentation sections are warranted.*	Concur. A phased site investigation program is underway to supplement the existing embankment monitoring network as noted in Response 2-15 and 12-5a.
12-2a 12-2b	Comment Recommendation	*The saturated zone adopted for past stability studies is likely more complex than portrayed in the permit documents…* *Additional studies should be performed.*	The hydrogeological model continues to be refined as additional monitoring data and investigations are conducted. The refinements to the models and updates to the construction and operation programs are anticipated as part of the Observational Approach that will continue to be implemented.
12-3	Comment	*Undrained strength ratios that we have previously suggested appear to be reasonable but experimental data in KP records possibly indicate higher values.*	Noted. Similar to the previous comment, the geotechnical model for the YDTI will continue to be refined as additional data becomes available.
12-4	Comment	*KP have suggested that a factor of safety of 1.2 for the undrained condition analysis post earthquake may be acceptable but as summarized above this is inconsistent with the regulatory requirements.*	MCA 82-4-376 requires a FoS of at least 1.2 for post-earthquake conditions. This criteria is satisfied even if these lower bound undrained strengths were triggered at a large scale as demonstrated in the Stability Assessment Report (Rev 2).

12-5a 12-5b 12-5c	Comment	*It is our understanding that KP will undertake the following:* - *Drilling and sampling to further characterize the field material and its saturation* - *Geophysical techniques to evaluate the distribution of saturation.* - *Fast Lagrangian Analysis of Continua (FLAC) analyses to determine seismically induced deformations.*	KP/MR has developed a multi-year site investigation program. At the conclusion of the program, 12 monitoring sections will be enhanced along the North-South and East-West Embankments. The planned instrumentation planes are indicated in the design drawing package included in Appendix D of the Design Basis Report. The 2017 site investigation program will incorporate downhole geophysical testing (P-wave and S-wave suspension logging), and future site investigation programs may incorporate this technique provided the 2017 data is valuable. FLAC modelling is planned for confirmation of the construction and operating requirements during on-going staged development of the YDTI.
12-6a 12-6b 12-6c	Comment	*We note the following data gaps that also merit attention:* - *Foundation and seepage characteristics along the North-South embankment related to the leaching history or presence of buried leach dumps covered by the embankment.* - *Synthesize construction records based on all available information to portray the inclination of dump faces with time.* - *Empirical information to assess the degree of mobility that might develop in the design earthquake and any potential breaching mechanism.*	A number of drillholes have been proposed to investigate the North-South Embankment rockfill and foundation conditions. Two of the proposed locations will target the buried historic leach areas. All boreholes will be completed with VWP piezometric monitoring to advance characterization of piezometric conditions and seepage in this area. It is important to note the North-South Embankment is built along a historic topographic feature that tends to convey groundwater and seepage towards the YDTI following historic drainage patterns. Applied Geologic Services (Steve Czehura) has prepared a report outlining the construction history of the YDTI from 1955 through 1970. The final report from Applied Geologic Services is included in the Site Characterization Report (Appendix G1) and includes the chronology of early YDTI construction from 1952 through 1970. Additional details developed for the meetings with ARCO are included in Appendix G2. A study was performed to develop empirical information to assess the degree of mobility of the tailings through laboratory testing that can be considered along with tailings cone penetration testing data and conventional liquefaction assessment to analyze the risk associated with the YDTI. The study is included as Appendix A in the Dam Breach Risk Assessment (Rev 2). The study indicates the tailings below the inferred phreatic surface in the vicinity of the East-West Embankment are sufficiently dense to prevent flow in the event they become unconfined without a source of water to initiate erosion. The tailings may have sufficient moisture to flow in a viscous manner during active excitation (i.e. seismic loading) without confinement. Viscous flow is likely to stop without active shaking. The embankment deformation required to expose this zone of tailings is in excess of 60 ft, which is well above the estimated maximum displacement levels.

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Knight Piésold
CONSULTING

APPENDIX B

ANNOTATED VERSION OF THE FINAL REPORT YANKEE DOODLE TAILINGS IMPOUNDMENT, BUTTE, MONTANA; DAVIDSON, MORGENSTERN, HIPPLEY; MAY 3, 2017

(Pages B-1 to B-69)

The KP/MR response to the comments and recommendations are presented in Table 1 'Concordance Summary: Atlantic Richfield Company (ARCO) Comments/Recommendations'. Use the numbers in the right margin of this report to cross-reference the response.

Richard Davidson PE, CPEng
AECOM, Denver Colorado
richard.davidson@aecom.com

Dr. Norbert R. Morgenstern
Edmonton, Alberta Canada
norbertm@ualberta.ca

Dr. Brian Hippley, PE
AECOM, Denver Colorado
brian.hippley@aecom.com

Final Report
Yankee Doodle Tailings Impoundment
Butte, Montana

1.0 INTRODUCTION

AECOM and Emeritus Professor Norbert Morgenstern have been retained by Atlantic Richfield Company (AR) and Remediation Management Service Company to work with both in-house counsel and outside counsel to evaluate current environmental conditions and risks at the Yankee Doodle Tailings Impoundment (YDTI), and potential changes in those conditions and risks in the future.

Our response to this charge follows in the Technical Commentary. The Technical Commentary is based upon:

- Review of the documents provided to us in support of the application to raise the YDTI;
- Site Visit performed on 24 January 2017;
- Brief informal discussion with both Montana Resources (MR) and their consultant on issues that we had identified at that early stage on January 24, 2017 and subsequently on February 22, 2017;
- Meeting with MR and their consultant on March 27, 2017 in Denver where additional information was provided; and
- Meeting with MR and their consultant on April 21, 2017 in Vancouver where additional information was provided.

We anticipate further discussion with MR and its consultants before MR's Independent Review Panel finalizes their report. Our report is final, however, if additional information is identified or provided by MR, it will be considered and, if appropriate, an addendum to our report may be prepared.

The Project documents that we relied upon are listed in Attachment A. Documents that we reviewed and did not reference in Attachment A are regarded as having little to no bearing on the safety issues of primary concern to us. A glossary of selected terms is included as Attachment B.

2.0 KEY FINDINGS AND RECOMMENDATIONS

Key findings include the following:

- Significant zones of saturation exist within the non-free draining rockfill, which appears to be more soil-like than rock-like. 2-1

- The rockfill also appears to be prone to weathering that may result in reduced shear strength. Additional embankment height may accelerate the reduction in strength. 2-2
- The waste rock has a history of being leached. 2-3
- The North-South Embankment was constructed on top of the leach pad. 2-4
- Alternative tailings disposal strategies should be evaluated. 2-5
- Neither the design nor the operation of the embankment has precluded ingress of tailings and seepage into the structure. 2-6
- If undrained loading can occur, it will occur at some point in the life of the facility. 2-7
- Given the presence of a significant saturated zone of fill and the contractive nature during shear, the conditions for undrained failure are likely to exist given the nature of the fill. 2-8
- The implications of undrained failure should be assessed for both current and future proposed sections under both static and dynamic loading conditions both including the Maximum Credible Earthquake as well as including both the smaller and more frequent earthquakes. 2-9
- Seepage supports our view that significant zones of saturation exist within the embankment. Perched zones of saturated material likely exist within the embankment contributing to downstream seepage. 2-10
- Lack of consistent seepage control measures (i.e. filter zone on upstream slope) has allowed the introduction of tailings fines into the embankment reducing the intended free-draining characteristic of the embankment. 2-11
- We recommend that the closure strategy be re-visited after the other technical issues raised in this report have been addressed to further evaluate dry closure alternatives. 2-12
- There are uncertainties regarding local faults that may have considerable effects on seismic loading of the tailings impoundment. 2-13 *(North South)* - KP addition
- The water quantity currently retained within the embankment, combined with the infrastructure and activities downstream of the impoundment and in the town nearby, may result in severe consequences if a failure occurs. 2-14
- Monitoring of water levels within existing piezometers and observation wells is limited on the existing facility. Monitoring is essential to confirming adequate slope stability under various types of loading and more instrumentation sections and monitoring devices are warranted to adequately monitor the facility in the future. 2-15
- Montana regulations require a factor of safety of 1.5 for operating conditions, including consideration of undrained failure where applicable. Preliminary calculations presented to us by MR (April 21, 2017) indicate that the requirement of 1.5 for static loading is not likely to be satisfied for the current condition and is likely to decrease with the proposed raising. An addendum to the documents currently available for review by us is needed to evaluate the assessment in more detail. 2-16

These conditions within the embankment result in both static and seismic stability concerns. These types of stability concerns are well documented at other facilities that have experienced undrained failures. Modelling performed by MR and KP, and presented to us, shows factors of safety considering the undrained conditions that do not meet Montana law or industry accepted standards. 2-17 The proposed potential future expansion may reduce slope stability significantly. Therefore, short and long term management of the impoundment should be re-evaluated. In the short-term, other risk mitigation measures may be warranted including reduction of water in the tailings impoundment, development of alternative disposal locations, buttressing, and alternative disposal technologies. In the long term, dry closure should be considered as the safest and most viable closure alternative, possibly assisted by additional drainage measures.

3.0 GEOTECHNICAL CHARACTERIZATION

Our Technical Commentary has relied on the Knight Piésold (KP) (2017a) Site Characterisation Report. An essential observation from the Executive Summary of the Report follows:

> *"The recent drilling investigations collected continuous core samples of the embankment rockfill by sonic drilling through the existing embankment to natural ground beneath. The rockfill encountered was highly variable, and generally consisted of highly altered and weathered gravels, cobbles and boulders within a silty sand or sandy silt matrix. Particle strength of clasts ranged from hard competent rockfill to highly altered and friable. The variability encountered during the recent investigations, and recognition of the potential for site wide variability and long-term degradation after mine closure suggests that it would be appropriate to adopt conservative shear strength parameters for the rockfill in the static stability analyses."*

We concur with this assessment. However, KP has made a crucial judgement that the rockfill is *"inferred to be well drained and largely unsaturated"*. The data along Section 8+00W of the East-West Embankment indicates a phreatic surface in the lower 50 to 120 ft. of the rockfill. After reviewing the logs from sonic drillholes DH15-S1 – DH15-S5, it appears that there are various perched water levels as well as the phreatic surface. 3-1
Constant seepage is observed at the toe. The rockfill has degraded to a variable level with a fairly significant matrix of silt and clay, in addition to the sand, gravel, cobbles, and boulders as shown in Photo 1. Some of these zones are classified as loose, while others are dense to very dense. Most are dry to moist, but some are wet. There also is the original alluvial soil foundation, which although saturated appears to be dense.

Photo 1. Matrix dominated rockfill observed in 2012.

Unfortunately there are no borehole permeability tests in the rockfill, but piezometric measurements suggest some perched conditions and a strong downward gradient. 3-2

The questions to be addressed by the Engineer of Record (EOR) are whether the degraded rockfill is really free draining and does it possess a high enough degree of saturation and sufficient fines content to behave in an undrained manner near the base and elsewhere and be potentially vulnerable to the high seismic loading at the site. 3-3

On a positive note, the tailings beach deposited upstream of the East-West Embankment appears to be a relatively coarse sandy material. KP reports that the material is borderline contractive / dilative, and the cone penetration test (CPT) pore pressure profile falls below full hydrostatic conditions. In some of the southern-most soundings, at depth, the dynamic pore pressures are almost zero reflecting downward drainage and the dilatant response of the sandy tailings. More contractive behavior is indicated further upstream along the East-West Embankment and in the pond. Our interpretations of the CPT information are provided in Attachment C

4.0 ALTERNATIVES ASSESSMENT

This critique arises from a review of the submitted KP (2017b) Alternatives Assessment Report and our general experience with such matters. We find this study to be limited in two ways: Stakeholder Representation and Technology Risk.

4.1 Stakeholder Representation

We are not cognizant of the detailed custodial responsibilities over the full life cycle of the facility, but recognize its complexity as a Superfund site. We note that the perpetual long term management of the site is challenging, and those who may be responsible for it are significant stakeholders. It is our view that 4-1
those additional stakeholders should have collaboration and input to the assessment. Potential stakeholders include Atlantic Richfield Company, Butte Silver Bow County, Montana Department of Environmental Quality, and the US EPA.

4.2 Technology Risk

The technology risk implicit in the alternatives assessment is based on the view that the tailings dam is a free-draining rockfill structure and hence is robust in its safety when subjected to both static and dynamic loading. As discussed in further detail below we have questioned this assessment. Moreover, following the Mt. Polley incident, there is increased desire to reduce or eliminate wet covers in perpetuity. Therefore, a number of issues related to technological risk 4-2
merit more detailed evaluation than is apparent in the Report. For example:

- A dry closure has increased stability and benefit over the long term. A 4-2a
  vegetated and/or evaporative cover over the tailings designed to minimize infiltration would reduce potential acid mine drainage generation long term and benefit stakeholders. If a dry cover is attainable, is there merit 4-2b
  in considering depyritization of the tailings to facilitate this objective? Could a capillary break be used instead to ensure vegetation does not 4-2c
  wick metal-acid salts to the surface?
- Available data supports the view that significant zones of saturation exist within the non-free draining rockfill. If this undrained condition is included in the stability analysis, then raising the height of the impoundment may reduce stability significantly. Under these circumstances there might be merit in separating the sand from the slimes and only storing the slimes in 4-2d
  the pond.
- Alternative tailings disposal strategies should be developed. One 4-2e
  potential concept would be to utilize the Berkeley Pit for tailings disposal. However, this concept involves many challenges including upgrading the water treatment plant to discharge water, reducing connectivity between the underground workings and the Pit, and burying ore reserves beneath/adjacent to the Pit.

4.3 Recommendation

MR should consider revising the Alternatives Assessment to consider broader stakeholder representation and an expanded recognition of the concerns identified including the non-free draining embankment, particle breakdown, and potential for undrained failure. The alternative evaluation should consider all 4-3 available technologies and alternatives, and their risks, to address these concerns rather than just raising the impoundment.

5.0 DESIGN BASIS REPORT

This critique arises from a review of the KP (2016a) Design Basis Report and our general experience with such matters. We find that the design criteria cited in that report should be expanded to include recent improvements in best practice. This would be consistent with the declared intent that *"All components related to the on-going design, construction and operation of the YDTI will be prepared in accordance with the most recent and applicable design codes and regulations, where they exist."* This implies compliance with Montana Law Montana Code Annotated (MCA) 82-4-376(2)(e).

5.1 Best Practice

The State of Montana was quick to respond to recommendations arising from the investigation into the Mt. Polley failure in British Columbia and made revisions to their regulatory structure. Since that time, the Province of British Columbia has revised its tailings design guide to implement essentially all of the recommendations made by the Independent Panel (Morgenstern et al., 2015). This was achieved with multi-stakeholder input and represents, in our view and that of many others, the best design guide for tailings dams currently available. We are of the view that it should be recognized in Section 1.8 of the Report.

Appendix B of the Design Basis Report is concerned with probable maximum flood (PMF) estimates. Recently the State of Montana has issued for discussion the Summary Report of the Extreme Storm Working Group. KP provided an evaluation of this document in Appendix B2 of the *Design Basis Report Revision 1* (KP, March 7, 2017). This evaluation supports KPs original PMF calculation is appropriate and no further recommendations are made for future consideration of the Extreme Storm Working Group.

Our views on the seismic hazard assessed and design seismic loads will be presented in Section 6, below.

5.2 Recommendations

The recently revised BC Guidelines for the design of tailings dams should be adopted in the design basis criteria pursuant to MCA 82-4-376(2)(e) (requiring a design that uses the most applicable, appropriate and current technologies and techniques), and KP should be requested to advise MR of the implications of doing so. 5-1

6.0 SEISMIC HAZARD ASSESSMENT

The Al Atik and Gregor (2016) Report was prepared for KP. Although not subject matter experts in the field of Seismic Hazard Assessment (SHA), we have considerable experience with receiving SHA's, reviewing them based on this experience, and integrating them into earthquake resistant design.

We are content that this study was conducted to the current state of practice.

6.1 Commentary

The SHA is clear on the influence of fault sources on the results of the SHA and emphasizes the role of the Continental and Rocker Faults, which are assumed to be active in the analysis based on precedent, but with limited evidence to confirm their seismogenic capability. As stated in the SHA: *"there is no conclusive evidence that the faults are active; particularly the Continental Fault."* The SHA recommended that a fault study be performed to evaluate whether the Continental Fault is active or not. We have not found any evidence that such a study has been performed. 6-1

The Montana Bureau of Mines and Geology published a report in May 1992 summarizing selected neotectonic features in Montana. The Continental and Rocker Faults are described as having movement in the late Pleistocene or Holocene epochs. The Holocene epoch is the current epoch and began 0.0117 million years ago. The late Pleistocene came before.

Both of those fault sources contribute substantially to the results of the probabilistic SHA (PSHA) and the Continental Fault dominates the results of the deterministic SHA (DSHA). 6-2

We question the wisdom on relying on these results without the recommended field study. The impact on the design is substantial and the precedent of assuming fault activity without field confirmation can lead to excessively conservative results. 6-3

Compliance with the Montana requirements leads to the conclusion that the results of the DSHA will be adopted in the design, with substantial implications. The SHA draws attention to the guidance provided by the California Division of Safety of Dams (DSOD) for selecting DSHA peak ground acceleration (PGA) levels for design. Based on our interpretation of this guidance, the 84th percentile ground motion is appropriate for the consequence classification of the facility. This appears to be in conflict with the adopted design ground motions of 50th percentile maximum credible earthquake (MCE) for normal operating conditions and 84th percentile MCE for long term conditions. While we understand the desire to accommodate epistemic uncertainty in the deterministic ground motion estimates, Montana Code Annotated (MCA 82-4-376(e)), and guidance from the States of Utah or Idaho, or similar tectonic Basin and Range locations, may lead to questioning the adoption of the 84th percentile MCE as the long-term design criterion.

6.2 Recommendations

We are of the view that the judgments that go into prescribing the design ground motions will be better informed by:

- While we would prefer that the fault study as recommended be undertaken to demonstrate whether the Continental fault is active or not, we understand that MR and their consultant have adopted the conservative position that the fault is active. 6-4
- The consequence classification for selecting DSHA ground motions does not distinguish between normal operating conditions and long term

conditions. In our view, the consequence classification is extreme, regardless.

- As pointed out in the SHA, the 84th percentile design case corresponds to a return period of close to 100,000 years. The State of Montana may be open to discussion on a lower design ground motion. 6-5

7.0 STABILITY ASSESSMENT REPORT

The KP (2016b) Stability Assessment Report is the most important document relied upon to demonstrate that the stability of the embankment raised from its current level to an elevation of 6500 ft., can be assured to meet design criteria, both under static and earthquake loading conditions during operations and closure. Design criteria in terms of factor of safety (FOS) are established by Montana regulations and other design guidelines that have been relied upon. Under extreme earthquake loading, some deformations are tolerated provided safe performance is not jeopardized, either during or subsequent to shaking. These criteria are discussed in the Stability Assessment Report. Other potential failure modes, such as overtopping and piping due to internal erosion are discussed in the Stability Assessment Report on Dam Break Risk Assessment and found not to be consequential.

The Stability Assessment Report concludes that the design criteria in terms of prescribed FOS have been met and that the design earthquake is not expected to induce deformations that could potentially lead to an uncontrollable release of impounded materials.

We are not yet convinced that these conclusions are correct because of the behavior of the material composing the embankment may not be sufficiently free-draining and dense in critical areas which could lead to instability.

7.1 Commentary on Existing Conditions and Slope Stability Analyses of Proposed Conditions

General

Many descriptions of the YDTI refer to it as composed of free-draining rockfill. Based on visual observations, photographic records, and the results of drillholes provided to us, portions of the rockfill embankment may not be free-draining. 7-1
While undoubtedly heterogeneous, portions of the embankment are not free-draining. We regard the characterization to contain sufficient fines / sand sizes to result in impeded drainage, as summarized in Section 3, above.

Placement is by thick end-dumped lifts without any extra compaction, and hence must be regarded as potentially loose, segregated, compressible, and contractive 7-2
when subjected to shear stress.

The embankment is already over 700 ft. high and with the addition of the proposed 100+ ft. raise, will likely be the second highest tailings structure in North America. At these pressures both experiments and field data indicate that particle (clast) breakdown occurs. Materials that are dilatant at low stresses can become contractive at high stresses. Hence high pressure effects are expected 7-3
to enhance the contractive nature during shear of the fill forming the YDTI embankment.

The fill comprising the embankment is chemically reactive. In addition, some of the embankment was constructed over the top of existing leach dumps. Temperature data within the rockfill indicates that oxidation processes are proceeding and the low pH of seepage water emanating from the embankment reveals that this oxidation is being accompanied by leaching. Both the high stress and geochemical processes affect the durability of the rockfill to a degree that its future geomechanical behavior is of concern because the feldspars found in the Berkeley material may have potential to fully decompose to a clay material. 7-4 7-5

The design, consistent with Montana regulations, requires the consideration of very large ground motion from a nearby M6.5 earthquake with a PGA = 0.84g.

(East West) - KP addition

Substantial infrastructure exists near the toe of the embankment with the community not far away. Hence any assessment of consequences of failure would result in an "extreme" rating. 7-6

Seepage History

We regard the original design of the YDTI embankment to be of a legacy nature. Given the fill available, current design would have incorporated filter control to avoid migration of tailings into the facility and an engineered drainage system to ensure that no zones of saturation would develop in the fill if left uncompacted. There is evidence that MR did not consistently apply the filter control since 1986. Compaction at the base of the fill may also have been specified under current design considerations. Neither the design nor the operation of the embankment has precluded ingress of tailings and seepage into the structure. We understand that the alluvium separation zone has not been incorporated systematically as an engineered barrier. Details summarized in Section 8, below, indicate evidence of substantial inflow and through flow in the embankment. It is our view that a significant zone of saturation exists within the structure, particularly within the East-West Embankment which has the low point of the facility which is influenced by several independent flow paths. Four separate incidents of seepage up to 1000 gpm and tailings flow through the North-South Embankment and related slumps were highlighted in the 2016 EOR inspection report (see Photo 2). 7-7 7-8 7-9

The Stability Assessment Report under consideration summarizes the piezometric information available and previous interpretations that defined a zone over which a phreatic surface could be located. KP indicates that the early interpretation is corroborated by more recent data and they suggest piezometric lines to be used in the stability analyses. We have not been able to find any analyses of the impact of the proposed raise of the embankment and the associated three dimensional flow path. However, we accept the postulated phreatic surface, as well as additional water elevation data that show water levels elevated within the embankment, as supportive of our view that substantial zones of saturated fill exist within the embankment. 7-10

Photo 2. Seepage incident on North-South Embankment reported in 2016 KP EOR report.

Antecedent Experience

Dawson, et al. (1998) have described liquefaction flow slides in Rocky Mountain coal mine waste dumps and Valenzuela, et al. (2011) discuss potential instability of high waste dumps undergoing leaching and subjected to earthquake loading. They provide an example of a high mobility slide of a waste rock dump in a copper mine in Chile, without an earthquake triggering mechanism. Unfortunately, few details are available to facilitate interpretation of this case history. 7-11a

These papers support our view that even if zones of saturation are limited, undrained failure can develop, and the associated factors of safety will be less than expected from calculations that ignore undrained failure. The triggering of undrained failure is complex and it is our view that except in special circumstances, prudent practice should assume that if undrained loading can occur, it will occur at some point in the life of the facility. 7-11b

Given the presence of a significant saturated zone of fill and the contractive nature during shear, the conditions for undrained failure exist. 7-12

Screening Analyses

Undrained shear strength properties are required for stability analyses. Both of the references cited above and theoretical considerations suggest undrained strength ratios over the range of 0.25 to 0.3. 7-13

We have performed screening-level analyses based on the cross-sections presented on Figure 5.2(c) and 5.2(d) of the Stability Assessment Report. Figure 5.2(c) is re-presented on Figure 1 along with a plan view showing the location of the study section evaluated. Our screening-level analyses are not presented as design calculations, but are intended to illustrate the sensitivity of the design to undrained stability calculations. The calculations are made for static conditions alone for the proposed geometry and should be compared with those presented for static conditions. For Case 1, the calculated factors of safety range from 0.89 to 1.03 compared with 1.7 to 2.0 given in Table 5.2 of the Stability Assessment Report. A factor of safety of less than 1.0 would indicate failure. Figure 2 presents slope stability analysis results for Case 1. For Case 2 the undrained strength ratio for the degraded rockfill is modeled with an anisotropic strength ranging from 0.25 for horizontal portions of the shear surface and 0.30 for the steeper portions of the failure surface. For the tailings and the saturated historic rockfill portions of the model, the two undrained strength ratios of 0.25 and 0.3 were used again. For Case 2, the calculated factors of safety range from 0.95 to 0.96, which also indicate failure. These results are presented on Figure 3.

7-15

7-15a

7-15b

7-15c

We believe similar factors of safety may exist for the existing embankment and strongly encourage the Engineer of Record to perform those calculations for an undrained condition for existing conditions and geometry. Opinions in this report are based solely on information provided to us. We have not presented slope stability analysis results for existing conditions.

7-16

With respect to declared requirements, the Montana Code Annotated 2015 regulations (82-4-376 Tailings storage facility – design document) for new facilities are as follows:

- 1.5 for static loading under normal operating conditions, with appropriate use of undrained shear strength analysis for saturated, contractive materials;
- 1.3 for static loading under construction conditions if the independent review panel created pursuant to MCA 82-4-376 agrees that site-specific conditions justify the reduced factor of safety and that the extent and duration of the reduced factor of safety are acceptable; and
- 1.2 for postearthquake, static loading conditions with appropriate use of undrained analysis and selection of shear strength parameters. Under these conditions, a postearthquake factor of safety less than 1.2 but greater than 1.0 may be accepted if the amount of estimated deformation does not result in loss of containment.

Moreover the Guidance Document for the Health, Safety, and Reclamation Code for Mines in British Columbia, which is becoming a leading reference for tailings dam designs, presents in their Table 3-2 a minimum static factor of safety of 1.5 for tailings dam design (2016a). We believe this reflects the most current applicable technology or techniques for safe dam design. This guidance, and Montana legal requirements to use the most current technologies and techniques under MCA 82-4-376(e), require a factor of safety of 1.5 for operating conditions at the YDTI.

7-17

The revisions to the Health, Safety, and Reclamation Code for Mines in British Columbia (2016b) state "for a tailing storage facility design that has a calculated static factor of safety of less than 1.5, the manager shall submit justification by the engineer of record for the selected factor of safety and receive authorization by the chief inspector prior to construction." At other facilities, we have adopted a factor of safety of 1.3 for special conditions when geotechnical properties are known to a high degree and performance is monitored in detail. It is our opinion this facility does not meet the conditions for applying a 1.3 factor of safety.

It is our view that the implications of undrained failure should be assessed for both current and future proposed sections under both static and dynamic loading conditions. 7-18

It is our view that the undrained strength, the degree of strain weakening associated with both static and dynamic loading, and the extent of saturated conditions are not known to us with sufficient precision to support a reduction in required factor of safety from 1.5 as a basis for design. We await additional input from MR and their consultant as to their assessment of conditions.

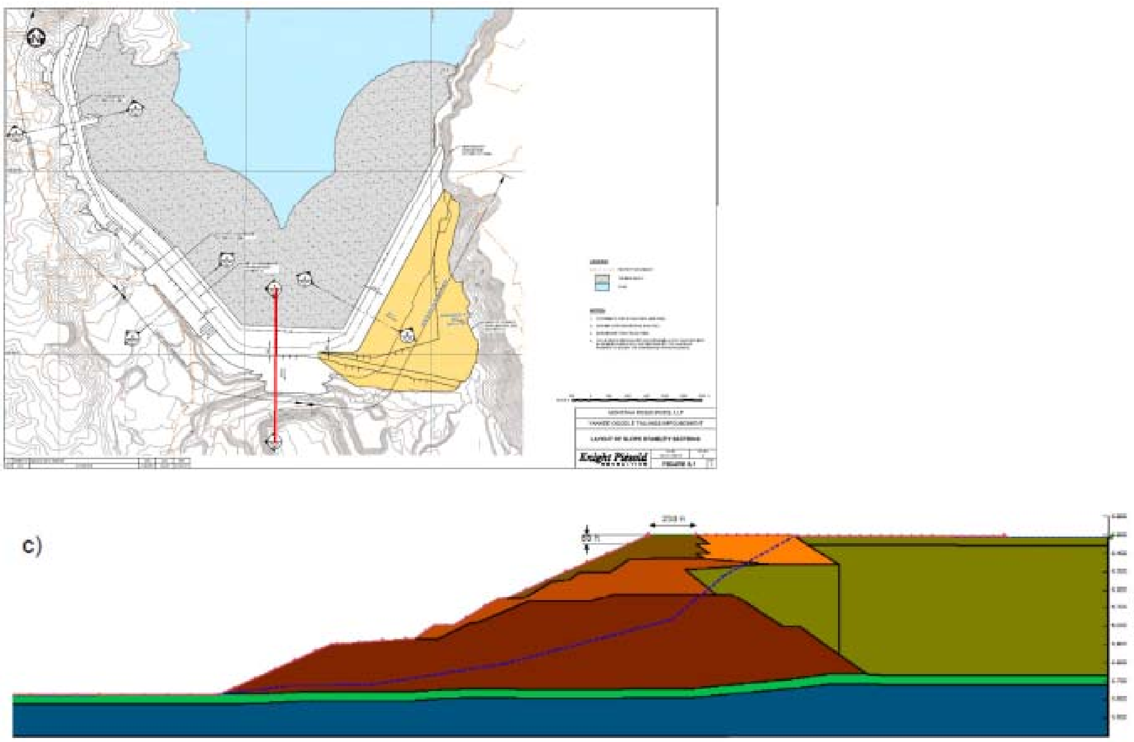
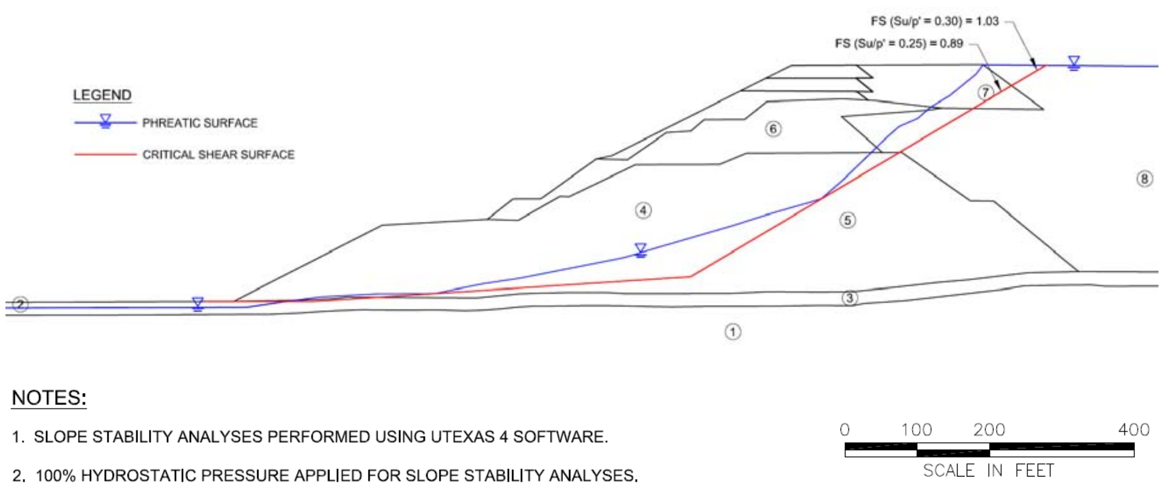


Figure 1. Study Section 8+00W originally from Knight Piésold for proposed, raised conditions and used for our analyses.

MATERIAL PROPERTIES					
SOIL TYPE NO.	MATERIAL DESCRIPTION	TOTAL UNIT WEIGHT (PCF)	UNDRAINED EFFECTIVE STRESS SHEAR STRENGTH		
			EFFECTIVE COHESION (PSF)	EFFECTIVE FRICTION ANGLE (DEGREES)	UNDRAINED STRENGTH RATIO
1	BEDROCK	165	10,000	45	NA
2	OVERBURDEN	135	0	33	NA
3	SATURATED OVERBURDEN	135	0	27	NA
4	DEGRADED HISTORIC ROCKFILL	140	0	LEPS ANGULAR SAND	NA
5	SATURATED DEGRADED HISTORIC ROCKFILL	140	0	NA	0.25/0.30
6	HISTORIC ROCKFILL	140	0	LEPS ANGULAR SAND	NA
7	SATURATED HISTORIC ROCKFILL	140	0	NA	0.25/0.30
8	TAILINGS SAND	120	0	NA	0.25/0.30



NOTES:

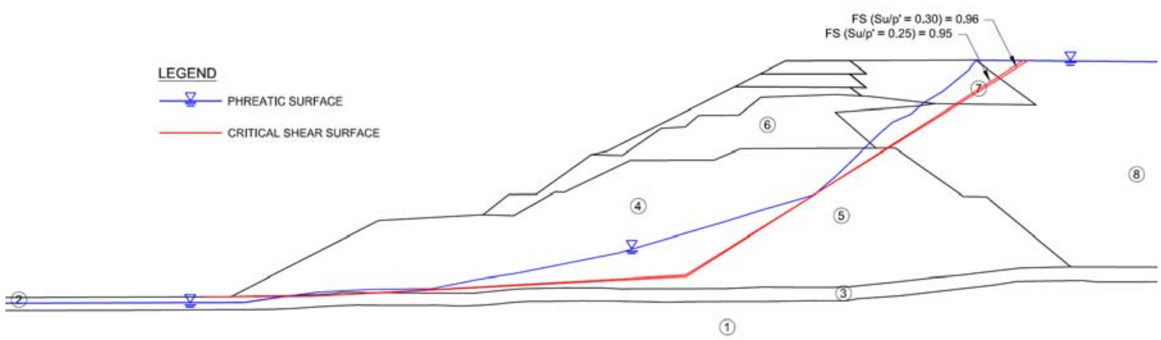
1. SLOPE STABILITY ANALYSES PERFORMED USING UTEXAS 4 SOFTWARE.

2. 100% HYDROSTATIC PRESSURE APPLIED FOR SLOPE STABILITY ANALYSES.

3. PHREATIC SURFACE BASED ON KNIGHT PIÉSOLD'S FIGURE 5.2c AND A MINIMUM FREEBOARD REQUIREMENT OF 5 FEET.

Figure 2. Undrained slope stability analysis results for Case 1 (Su/p' = 0.25 and 0.30).

MATERIAL PROPERTIES					
SOIL TYPE NO.	MATERIAL DESCRIPTION	TOTAL UNIT WEIGHT (PCF)	UNDRAINED EFFECTIVE STRESS SHEAR STRENGTH		
			EFFECTIVE COHESION (PSF)	EFFECTIVE FRICTION ANGLE (DEGREES)	UNDRAINED STRENGTH RATIO
1	BEDROCK	165	10,000	45	NA
2	OVERBURDEN	135	0	33	NA
3	SATURATED OVERBURDEN	135	0	27	NA
4	DEGRADED HISTORIC ROCKFILL	140	0	LEPS ANGULAR SAND	NA
5	SATURATED DEGRADED HISTORIC ROCKFILL	140	0	NA	ANISOTROPIC 0.25/0.30
6	HISTORIC ROCKFILL	140	0	LEPS ANGULAR SAND	NA
7	SATURATED HISTORIC ROCKFILL	140	0	NA	0.25/0.30
8	TAILINGS SAND	120	0	NA	0.25/0.30



NOTES:

1. SLOPE STABILITY ANALYSES PERFORMED USING UTEXAS 4 SOFTWARE.
2. 100% HYDROSTATIC PRESSURE APPLIED FOR SLOPE STABILITY ANALYSES.
3. PHREATIC SURFACE BASED ON KNIGHT PIÉSOLD'S FIGURE 5.2c AND A MINIMUM FREEBOARD REQUIREMENT OF 5 FEET.

0 100 200 400

SCALE IN FEET

Figure 3. Undrained slope stability analysis results for Case 2 (anisotropic rockfill).

7.2 Commentary on Earthquake-Induced Embankment Deformation

These comments are based on the analytical models adopted in the Report for computing earthquake-induced embankment deformations. The criteria that we adopt for tolerable deformations are:

- There must be no loss of containment; and
- There must be no secondary failure modes arising from the deformations that could lead to loss of containment.

There are several aspects of these calculations that we would like to understand better:

- The plan layout of the YDTI is not favorable for potential multiple directions of horizontal ground motions. If the ground motions include components that are somewhat oblique to the East-West Embankment they could tear the embankment apart. At this point it would not be able to contain the liquefied tailings. 7-19
- It appears that calculated yield accelerations will depend upon the loading of liquefied tailings on the factor of safety. It is not clear to us whether this is adequately considered in the analyses.
- The implication of the adopted undrained failure mechanism will also have to be evaluated with respect to earthquake induced embankment deformation. 7-20

8 EOR 2015 ANNUAL INSPECTION REPORT

This is the first YDTI Annual Inspection Report (AIR) prepared by KP and it provides an overview of the status of the facilities at the time of inspection performed on 9 July 2015, 17 September 2015, and 10 February 2016. It also includes a review of 2015 monitoring data. We found the AIR to be comprehensive and of considerable value.

8.1 Seepage

Of particular interest to us is the information on seepage control and leakage incidents. Evidently the alluvium separation zone has not been considered an integral part of the design of the embankment, but more as a mitigation measure when waste and tailings were observed to flow into the structure. Since 2013, the spigot deposition in this corner was used to promote saturation of the tailings beach. While clearly valuable for dust control, this practice also facilitates seepage and tailings entering the embankment. 8-1

A particularly serious leakage event occurred on 16 November 2015 when new leakage was detected from the downstream face of the North-South Embankment, at about midway up its face. Seepage was observed from Station 13+00 to 20+00. Ponding developed on the 6300 Lift. 8-2

Elsewhere, considerable seepage is collected about 250 ft. above the toe and at the Horse Shoe Bend (HSB) collection system at the toe of the embankment. 8-3
Measurements from piezometers in the East-West Embankment indicate levels as high as 6300 ft. 8-4

All of the above supports our view that significant zones of saturation exist within the embankment. 8-5

8.2 Cracking

Photos 5 and 6 in the 2015 AIR display longitudinal cracking on the surface of the North-South Embankment, which have been interpreted to be the result of differential settlement and hence of limited consequence. We agree that this may well be the case. However, the pattern of cracking, particularly in Photo 6, looks like a system of Riedel shears, that would be symptomatic of differential lateral deformation. This photo is duplicated below in Photo 3. Additional surface cracking along the North-South Embankment is shown in Photo 8 of the 2016 AIR and duplicated below in Photo 4. 8-6


Photo 3. Cracking typical of a Riedel shear system.


Photo 4. Cracking reported in the 2016 AIR report on the North-South Embankment.

We recommend that the cracking pattern be presented in plan and assessed as to whether any lateral displacements are likely, and if so, if they are of consequence. 8-7

9 DAM BREACH RISK ASSESSMENT

This assessment presents an examination of foundation and embankment instability, overtopping, and internal erosion and piping. As stated in the Dam Breach Risk Assessment, the assessment considers loading during maximum normal operating conditions, loading from seismic and flood events, and malfunction of the reclaim water and tailings distribution systems. The Dam Breach Consequence Report, that has not yet been provided to us, would clarify the potential consequences to the downstream receptors. If a dam breach consequence report is not going to be prepared, information regarding the potential consequences of a breach is still needed to evaluate potential actions to mitigate the risk. 9-1

As presented in the application documents the risks associated with potential instability and normal operating conditions are deemed to be very low by MR and KP. Some uncertainty with respect to the potential for internal erosion piping initiated by flooding has been identified and measures to minimize the risk have been identified. However, the residual risk associated with closure based on a wet cover remains, and under the current closure design it will have to be managed in perpetuity.

If the concerns that we have raised regarding the potential for undrained failure are incorporated into the risk assessment, it will require major revision. In this context, we wish to caution that recent industrial experience highlights the merit of prudent judgement in the face of low likelihood / extreme consequence events. We draw attention to the merit of some of the alternatives for creation of a suitable dry closure landform. In the short-term other risk mitigation measures may be warranted including reduction of water in the tailings impoundment, development of alternative disposal locations, buttressing, and/or alternative disposal technologies. 9-2

10 RECLAMATION OVERVIEW

This reclamation report declares that the proposed Amendment design identifies the following four reclamation components for the YDTI:

- Additional embankment acreage;
- Additional impoundment acreage;
- Closure spillway; and
- West embankment drain.

The reclamation plan builds on the 2015 Plan where appropriate. Modifications are proposed to result in a partial wet closure for the northern portion of the tailings impoundment, consisting of a pond and adjacent wetland area.

10.1 Concerns

One of the concerns highlighted by the Mt. Polley failure investigation is the long term vulnerability associated with tailings facilities that have extensive wet closure ponds (Morgenstern et al. 2015). As discussed under Section 4, Alternatives Assessment, a focus on feasibility of dry closure would clarify the options available, particularly for the long term. 10-1

The final closure spillway is a critical element of the proposed plan. We found no discussion of the proposed plan, nor any discussion of the options to satisfy that the plan is optimal, particularly related to long term opportunities with periodic flooding of the basin that generates its own potential risks.

We recommend that the closure strategy be re-visited after the other technical issues raised in this report have been addressed, to further evaluate dry closure alternatives. 10-2

11 POTENTIAL MITIGATIONS

As previously mentioned, we recommend MR re-evaluate slope stability for the existing and proposed future conditions. If the factor of safety for slope stability is below the accepted minimum value for new facilities, or will reduce the existing factors of safety for the existing facility, then it would appear that MR would need to adjust the design to meet Montana safety requirements in MCA 82-4-376. MR should consider mitigating this concern by evaluating some high-level conceptual designs such as:

- Add a buttress at the toe and along the downstream face as necessary. 11-1a
- Develop an "improving stability approach" by storing tailings in the Berkeley Pit or elsewhere while building the buttress. Long-term draindown and saturation would also be enhanced. 11-1b
- Develop a "no harm" approach to expansion, such as constructing a buttress, or recognizing that as the impoundment is expanded the calculated factor of safety increases with time, or incorporating three-dimensional effects into the slope and seepage models. It is recognized that the buttress construction would need to be a priority and proceed as soon as practicable, but incrementally, based on availability of material from the mine plan; and 11-1c
- Construct leadoff berms to allow for deposition further from the crest. 11-1d

12 RECENT DISCUSSIONS

An additional topic requiring attention:

- Future monitoring of the performance of piezometers and observation wells is essential to confirming adequate slope stability under various types of loading. Compared to other tailings facilities of this magnitude the instrumentation program is relatively limited. The actual phreatic surface within most of the North-South and East-West Embankments is unknown. More instrumentation sections are warranted. 12-1

On March 27, 2017 we received a number of detailed presentations on the construction history, seepage patterns, and undrained stability analyses. These are summarized in a presentation from KP (2007c) titled "YDTI East-West Embankment Conditions, ARCO Presentation." From this presentation we concluded the following:

- There appears to be agreement that undrained failure is a potential failure mechanism.
- The saturated zone adopted for past stability studies is likely more complex than portrayed in the permit documents. KP have suggested an alternate distribution of saturation that is significantly more favorable but we have not yet received 12-2a

information to demonstrate that this is an appropriate portrayal. Additional studies should be performed. 12-2b

- Undrained strength ratios that we have previously suggested appear to be reasonable but experimental data in KP records possibly indicate higher values. Operational strengths to be used in stability calculations should be presented. Note, we remind KP to emphasize direct simple shear (DSS) stress paths in this evaluation. 12-3
- KP have suggested that a factor of safety of 1.2 for the undrained condition analysis postearthquake may be acceptable but as summarized above this is inconsistent with the regulatory requirements. Additional studies by KP should be performed. 12-4

It is our understanding that KP will undertake the following:

- Drilling and sampling to further characterize the field material and its saturation 12-5a
- Possible use of geophysical techniques to evaluate the distribution of saturation. 12-5b
- Fast Lagrangian Analysis of Continua (FLAC) analyses to determine seismically induced deformations. It should be noted that the outcome of these analyses will be very sensitive to the proposed undrained shear strength and strain weakening characteristics due to high stresses and large deformations. 12-5c

We note the following data gaps that also merit attention:

- Foundation and seepage characteristics along the North-South embankment related to the leaching history or presence of buried leach dumps covered by the embankment. 12-6a
- Synthesize construction records based on all available information to portray the inclination of dump faces with time. 12-6b
- Empirical information to assess the degree of mobility that might develop in the design earthquake and any potential breaching mechanism. 12-6c

Arising from discussion on April 21, 2017 it is our understanding that these additional items are being evaluated and a supplemental undrained failure design analysis report will be prepared by MR/KP.

13 REPORT CLOSURE

We stand ready to meet with Stakeholders as required to explain our views and receive relevant additional information that address our concerns.

Attachments:
A – Summary of Information Received
B – Glossary of Selected Terms and References
C – CPT Information and Interpretation

References:

Al Atik, L. and Gregor, N. (2015). Seismic Hazard Assessment for the Yankee Doodle Tailings Impoundment Site, Butte, Montana. Prepared for Knight Piésold, Ltd. February 19.

Dawson, R.F., Morgenstern, N.R. and Stokes, A.W. (1998). Liquefaction flowslides in Rocky Mountain coal mine waste dumps, Canadian Geotechnical Journal, Vol. 35, p. 328 – 343.

Ministry of Energy and Mines (2016a). Guidance Document, Part 10 of the Health, Safety, and Reclamation Code for Mines in British Columbia. Version 1.0. July 20.

Ministry of Energy and Mines (2016b). Revisions, Part 10 of the Health, Safety, and Reclamation Code for Mines in British Columbia. July 20.

Morgenstern, N. R.; Vick, S.G.; Van Zyl, D. (2015). Report on Mount Polley Tailings Storage Facility Breach, Independent Expert Engineering Investigation and Review Panel. Province of British Colombia. January 30.

Knight Piésold (2016a). Design Basis Report. Prepared for Montana Resources, LLP. November 21.

Knight Piésold (2016b). Stability Assessment Report. Prepared for Montana Resources, LLP. November 21.

Knight Piésold (2017a). Site Characterization Report. Prepared for Montana Resources, LLP. January 10.

Knight Piésold (2017b). Alternatives Assessment. Prepared for Montana Resources, LLP. January 9.

Knight Piésold (2017c). YDTI East-West Embankment Conditions, ARCO Presentation. Prepared for Montana Resources, LLP. March 27.

Valenzuela, L., Band, E. and Campana, J. (2011) Seismic considerations in the design of high waste dumps, Proc. 5th International Conference on Earthquake Geotechnical Engineering, Santiago Chile.

Attachment A – Summary of Information Received

SUMMARY OF INFORMATION RECEIVED

The following information was provided to AECOM.

Alternatives Assessment Review

a. *Alternatives Assessment,* Knight Piésold Ltd. – January 9, 2017

Site Characterization Review

a. *Site Characterization Report*, Knight Piésold Ltd. – January 10, 2017
b. *Site Characterization Report*, Knight Piésold Ltd. – Rev. 1. March 3, 2017
c. *VA15-03370 Yankee Doodle Tailings Impoundment 2015 Site Investigation Program – Phase 1A West Embankment Test Pit Program Summary,* Knight Piésold Ltd. – December 24, 2015
d. *VA15-03524 Yankee Doodle Tailings Impoundment 2015 Site Investigation Program – Phase 1B West Embankment Trench Program Summary,* Knight Piésold Ltd. – January 21, 2016
e. *VA15-03317 Yankee Doodle Tailings Impoundment 2015 Site Investigation Program – Phase 2A West Embankment Geotechnical Drilling Program Summary,* Knight Piésold Ltd. – February 19, 2016
f. *VA15-03525 Yankee Doodle Tailings Impoundment 2015 Site Investigation Program – Phase 2B West Embankment Geotechnical Drilling Program Summary,* Knight Piésold Ltd. – February 29, 2016
g. *VA16-00012 Yankee Doodle Tailings Impoundment 2015 Site Investigation Program – Phase 2C West Embankment Hydrogeological Drilling Program Summary,* Knight Piésold Ltd. – March 21, 2016
h. *VA16-00013 Yankee Doodle Tailings Impoundment 2015 Site Investigation Program – Phase 3 East-West Embankment Sonic Drilling Program Summary,* Knight Piésold Ltd. – May 4, 2016
i. *VA16-00014 Yankee Doodle Tailings Impoundment 2015 Site Investigation Program – Phase 4 Tailings Impoundment SCPT Program Summary,* Knight Piésold Ltd. – March 18, 2016
j. *VA16-00856 Yankee Doodle Tailings Impoundment 2016 Site Investigation Program – Phase 5 West Embankment Hydrogeological Drilling Program Summary,* Knight Piésold Ltd. – November 14, 2016
k. *Hydrologic Evaluation of the Yankee Doodle Tailings Impoundment West Ridge Area Silver Bow County, Montana*, Hydrometrics, Inc. – January 2017

Seismic Hazard Assessment Review

a. *Seismic Hazard Assessment for the Yankee Doodle Tailings Impoundment Site,* Linda Al Atik and Nick Gregor – February 19, 2016
b. Appendices

Stability Assessment Review

a. *Stability Assessment Report*, Knight Piésold Ltd. – November 21, 2016
b. *Stability Assessment Report*, Knight Piésold Ltd. – Rev. 1. March 10, 2017

Annual Inspection Review

a. *2015 Annual Engineer of Record Inspection Report for Yankee Doodle Tailings Impoundment and Corrective Action Plan for Recommendations,* Montana Resources – June 14, 2016
b. *2016 Annual Inspection Report,* Montana Resources – February 2, 2017
c. *Yankee Doodle Tailings Impoundment Design and Construction,* Montana Resources – March 1999
d. *Summary Comments from Meeting No. 1*, L. Smith; J. Swaisgood.; D. van Zyl – August 31, 2015
e. *Meeting No. 2 Report,* L. Smith; J. Swaisgood.; D. van Zyl – February 21, 2016
f. *YDTI West Embankment Drain – Buried Drain Pipe*, Knight Piésold Ltd. – December 21, 2015
g. *Meeting No. 3 Report,* L. Smith; J. Swaisgood.; D. van Zyl – June 30, 2016
h. *Design Basis Report*, Knight Piésold Ltd. – November 21, 2016
i. *Design Basis Report*, Knight Piésold Ltd. – Rev. 1. March 7, 2017
j. *Amendment 10 Expansion: Reclamation Overview*, Knight Piésold Ltd. – January 17, 2017

Dam Failure Mode Analysis Review

a. *Yankee Doodle Tailings Dam Failure Mode Analysis,* Kirk Engineering & Natural Resources, Inc. – February 21, 2013

Emergency Action Plan Review

a. *Emergency Action Plan*, Montana Resources – December 2015
b. *Dam Breach Risk Assessment Rev 0,* Knight Piésold Ltd. – January 27, 2017
c. *Dam Breach Risk Assessment Rev 0,* Knight Piésold Ltd. – Rev. 1. February 27, 2017

Water Management Review

a. *Site Water Balance,* Knight Piésold Ltd. – October 20, 2005
b. *Reclaimed Yankee Doodle Tailings Impoundment Pond Area,* Knight Piésold Ltd. – January 8, 2008
c. *Bathymetric Survey – 2016*, Montana Resources – September 23, 2016
d. *Water Management Report,* Knight Piésold Ltd. – January 11, 2017
e. *Water Management Report,* Knight Piésold Ltd. – Rev. 1. March 13, 2017

Construction Management Review

a. *Draft Construction Management Plan,* Knight Piésold Ltd. – March 24, 2016
b. *Construction Management Plan,* Knight Piésold Ltd. – Rev. 1. February 27, 2017
c. *Tailings, Operations, Maintenance and Surveillance Manual,* Montana Resources LLP and Knight Piésold – April 20, 2016
d. *Constructions from Cross-Sections in 1997 Design Report (1963-2013).* Yankee Doodle Tailings Impoundment. PowerPoint Presentation.

Additional Data

a. *Cone Tec, Cone Penetration Test Data, October 1, 2012*

b. *Cone Tec, Cone Penetration Test Data, November 6, 2013*
c. Cone Tec, Presentation of Site Investigation Results, Yankee Doodle TSF, December 4, 2015

Miscellaneous Documents

a. Health, Safety and Reclamation Code for Mines in British Columbia
b. Part 10 Guidance Document
c. Part 10 Revisions
d. Montana Code Annotated
e. Montana Extreme Storm
f. *The State of Mining Geotechnics* (Davidson)
g. *Liquefaction Flow slides in Rocky Mountain Coal Mine Waste Dumps* (Dawson, Morgenstern, Stokes)
h. *Geotechnical Characterisation of Waste Material in Very High Dumps with Large Scale Triaxial Testing* (Liner, Palma, Apablaza)
i. "Seismic Considerations in the Design of High Waste Rock Dumps" (Valenzuela et al.)
j. Mount Polley ConeTec Site Investigation Report
k. Finger Dump Preliminaries Promise Improved Copper Leaching at Butte
l. 1973 Robinson Anaconda's Test and Production Finger Dump
m. KP PowerPoint presentation slide deck from March 27, 2017 meeting in Denver

Attachment B – Glossary of Selected Terms and References

Glossary of Selected Terms

Cone Penetration Test (CPT) – CPTs are conducted to evaluate geotechnical properties of soils including soil stratigraphy, relative density, strength, and equilibrium pore pressures. An electric piezocone is hydraulically advanced through the soil and built-in pressure transducers within the piezocone measure tip resistance, sleeve friction, and pore pressure (ConeTec 2017).

Contractive behavior – Contractive behavior of a material is typically observed in loose, granular materials when sheared as the particles move into a denser configuration generating positive excess pore pressures and are more susceptible to liquefaction (Winckler et al. 2014).

Deterministic Seismic Hazard Analysis (DSHA) – The DSHA determines a particular earthquake magnitude for a particular seismic source and estimates a level of ground shaking based on the minimum distance from the site (USBR 2015).

Dilative behavior – Materials exhibiting dilative behavior are either too dense to move closer together or may be partially saturated, thereby reducing pore pressures, and are less likely to liquefy than contractive material (Winckler et al. 2014).

Dry Cover – Permanent dry soil placed over the tailings to provide isolation and control of radiological, oxidation, and/or leaching effects (Wels, et al. 2000)

Factor of Safety – A ratio of the shear strength of the soil divided by the shear stress required for equilibrium (Duncan et al. 2014).

Peak Ground Acceleration (PGA) – The largest increase in velocity recorded by a particular station during an earthquake (USGS 2016).

Phreatic Surface – The line of zero pore pressure (atmospheric pressure) (Duncan et al. 2014).

Probable Maximum Precipitation (PMP) – Theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year (NOAA 1978)

Probable Maximum Flood (PMF) – The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area (ASDSO 2017).

Probabilistic Seismic Hazard Analysis (PSHA) – The PSHA collectively considers the contributions from the known potential sources of earthquake shaking and most importantly the likelihood of various earthquakes from multiple potential seismic sources, each having a range of uncertainty in source characteristics (USBR 2015).

Riedel Shear – The Riedel shears (also called R shears) are a network of shear bands, commonly developed in zones of simple shear during the early stages of faulting (Katz et al. 2003). http://geos.gsi.gov.il/rami/PUBLICATIONS/Riedel.pdf

Tailings Slimes – Fine-grained (silt and clay) portion of tailings that settle near the pond (Vick 1990).

Sonic Drilling – Sonic drilling is a rapid, primarily dry, drilling method that provides continuous sampling of subsurface materials (ASTM 2016).

Wet Cover – Water coverage over the tailings to provide isolation and control of radiological, oxidation, and/or leaching effects (Wels et al. 2000).

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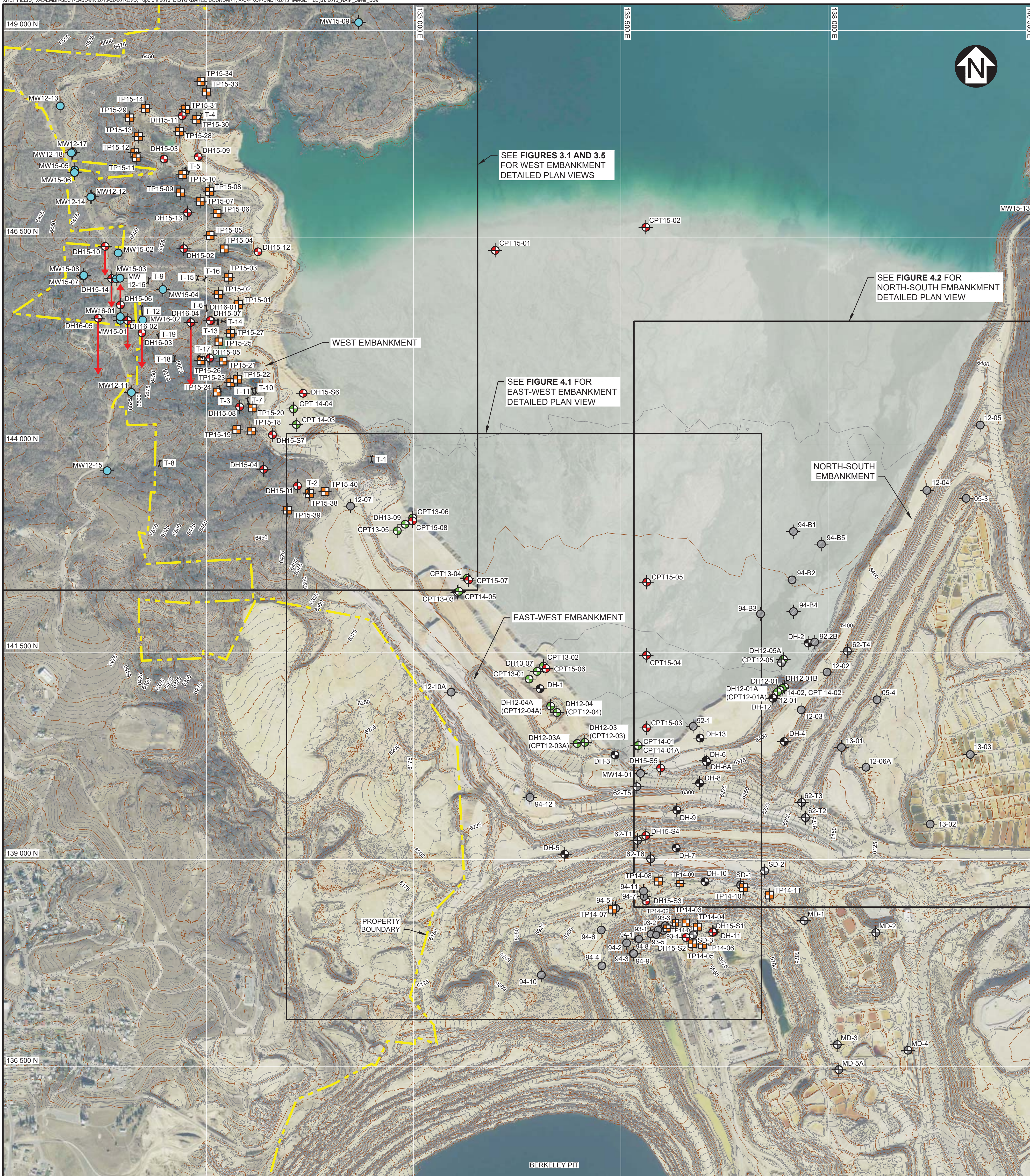
Attachment C – CPT Information and Interpretation



LEGEND:

- DRILLHOLES AND CPTS - KNIGHT PIESOLD 2015-2016
- TEST PIT - KNIGHT PIESOLD 2014-2015
- MONITORING WELLS - HYDROMETRICS 2012-2015
- DRILLHOLES AND CPTS - KNIGHT PIESOLD 2012-2014
- MONITORING WELLS - MR ENGINEERING DEPT.
- DRILLHOLES - IECO 1981
- DRILLHOLES - DAMES & MOORE 1962, BOTZ 1969
- TRENCH - KNIGHT PIESOLD 2015
- PROPERTY BOUNDARY

NOTES:

1. COORDINATE GRID IS ANACONDA MINE GRID.
2. CONTOUR INTERVAL IS 5 FEET.
3. DIMENSIONS AND ELEVATIONS ARE IN FEET, UNLESS NOTED OTHERWISE.

SCALE A: 500 0 500 1000 1500 2000 2500 3000 ft

MONTANA RESOURCES, LLP

YANKEE DOODLE TAILINGS IMPOUNDMENT

HISTORIC DRILLHOLE AND TEST PIT LOCATIONS

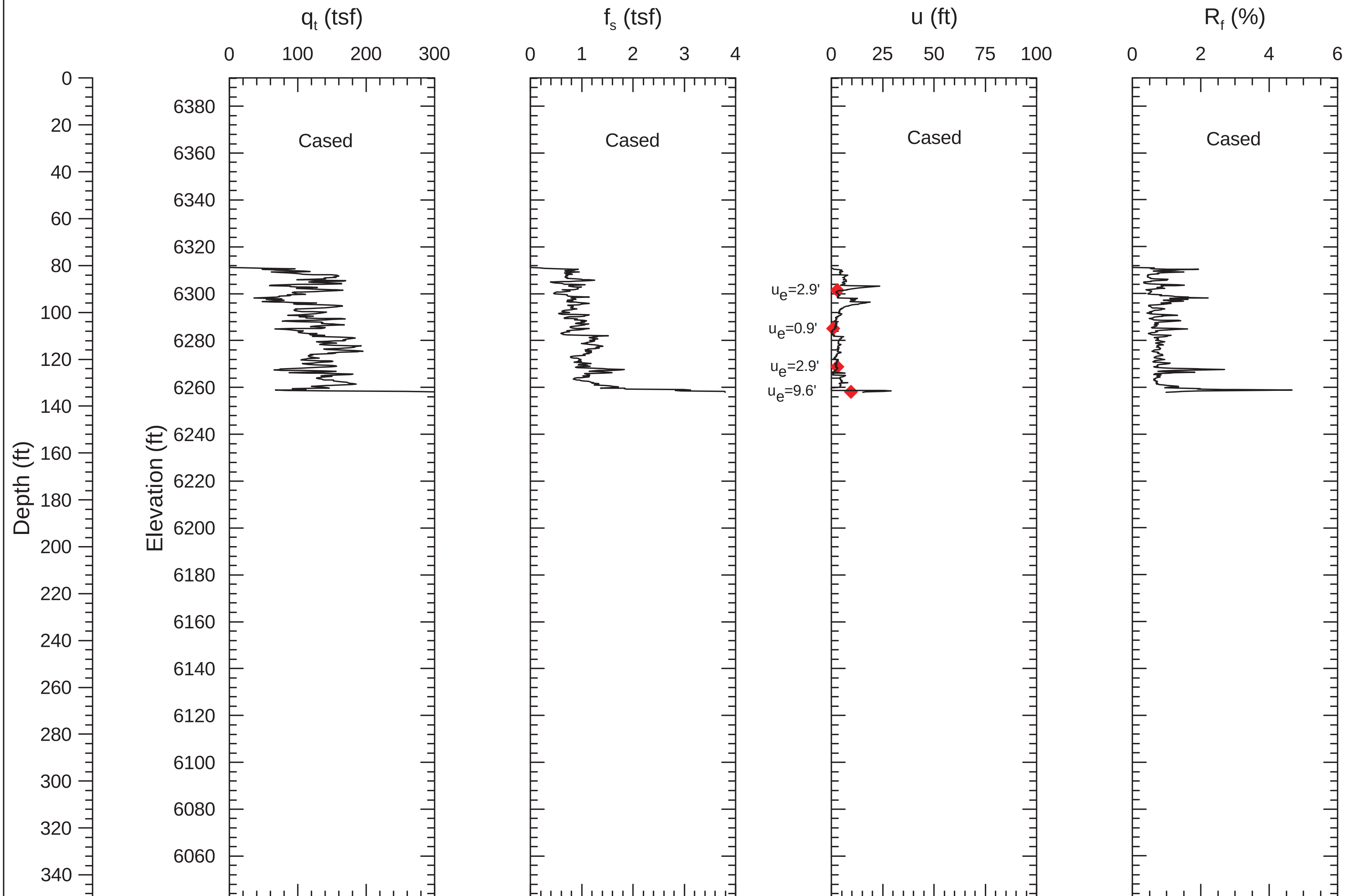
Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-126/14	2

FIGURE 2.1 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	10JAN'17	ISSUED WITH REPORT	JAS	WAL	DDF

Fig. C-1



Pore Pressure Dissipation Tests

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT12-01A
Prepared By: MEK	
Date: 02/14/2017	

Fig. C-2

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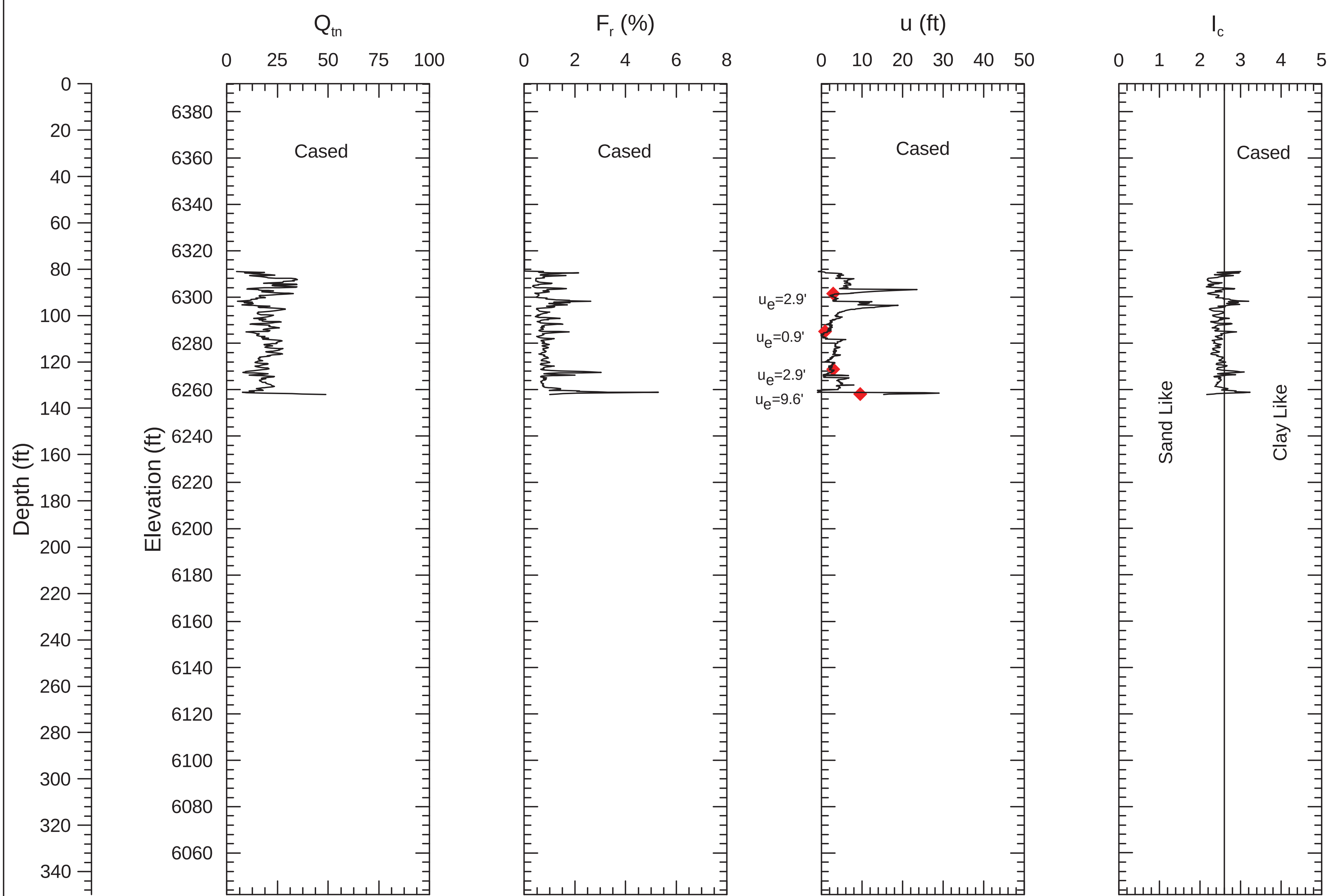

◆ Pore Pressure Dissipation Tests

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT12-01A
Prepared By: MEK	
Date: 02/21/2017	

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Fig. C-3

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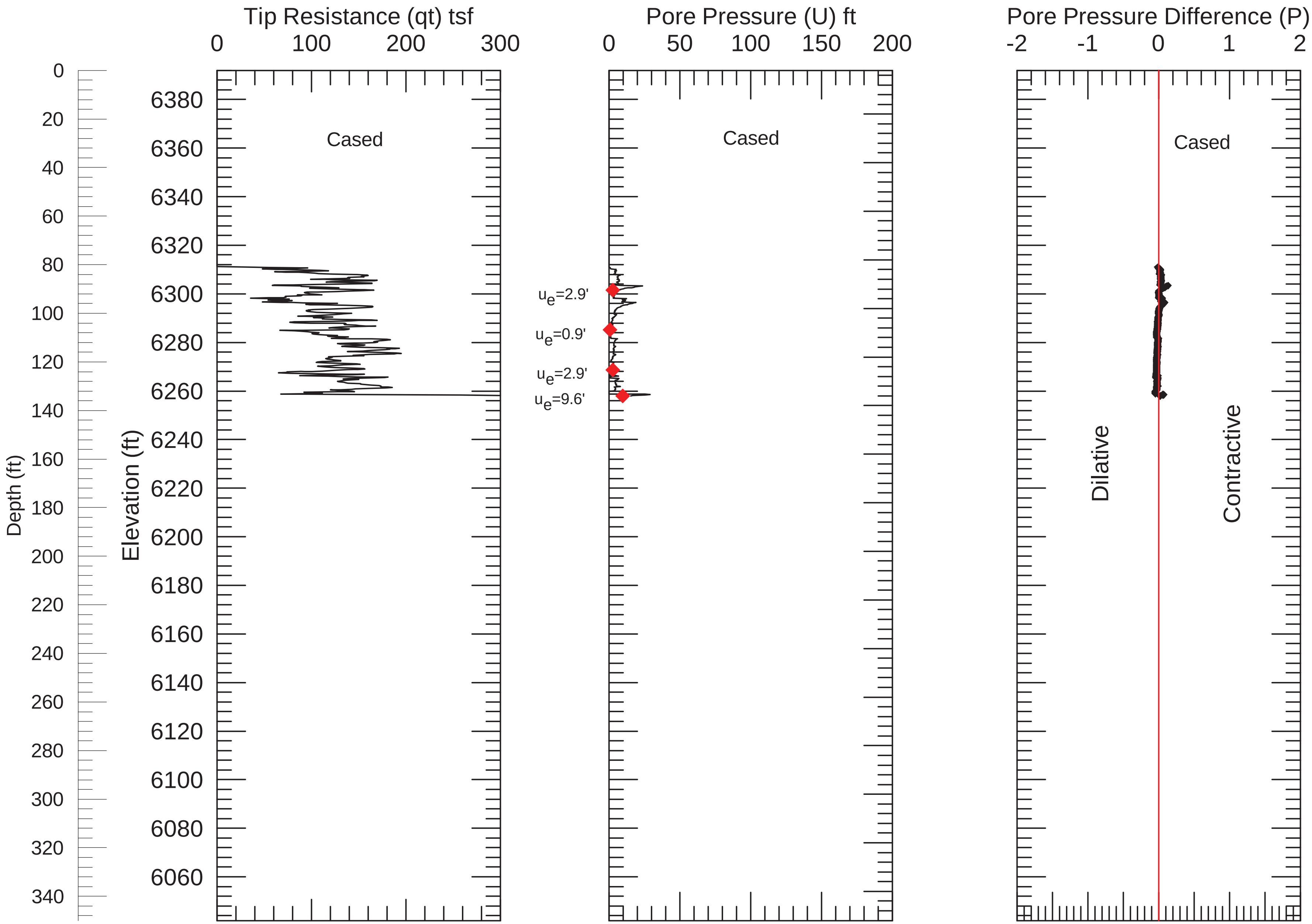

Pore Pressure Dissipation Tests

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Project No. 60531387	CPT12-01A Normalized Pore Pressure Difference
Prepared By: MEK	
Date: 02/21/2017	

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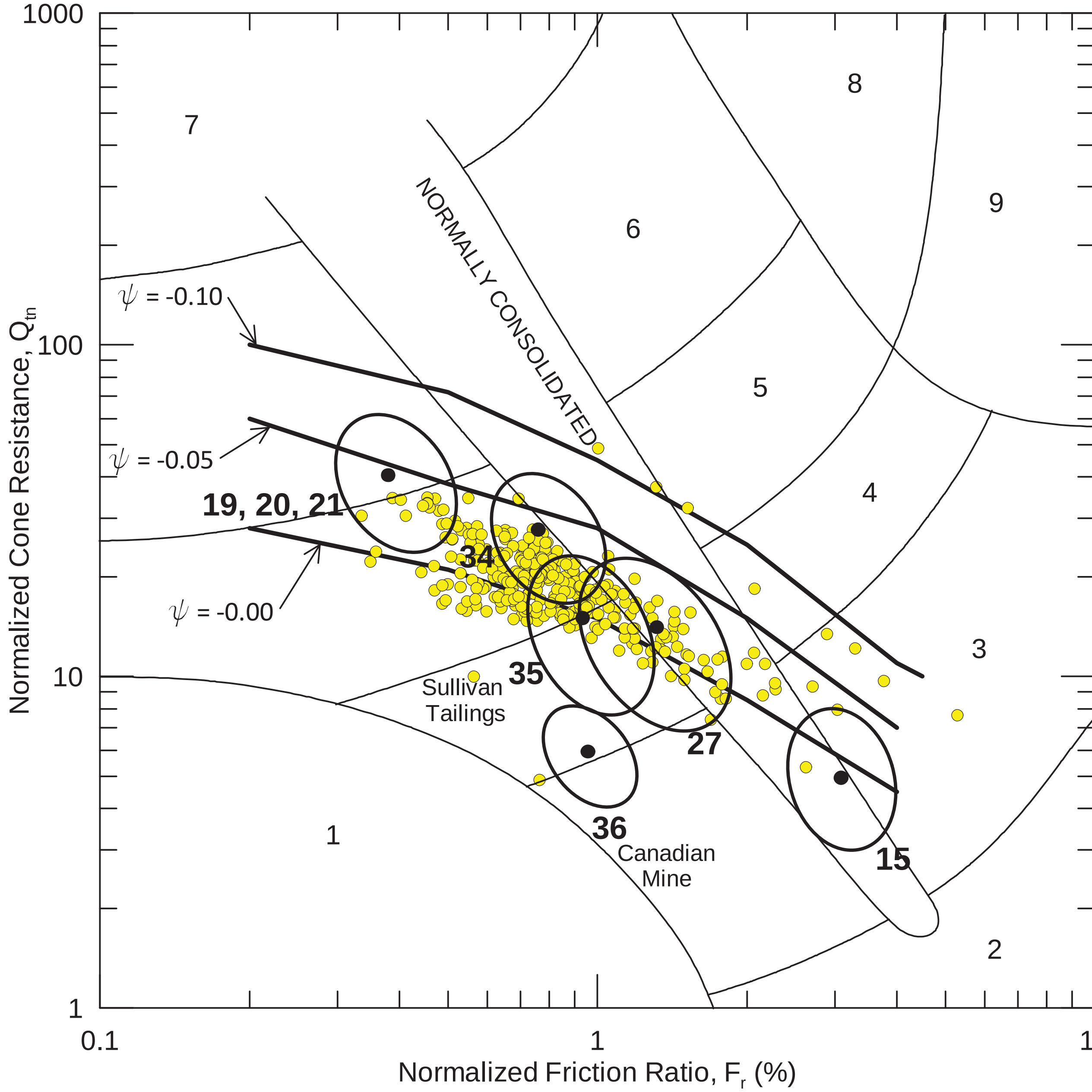
Fig. C-4



LEGEND

● Unsaturated Tailings

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*

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters CPT12-01A
Prepared By: MEK	
Date: 02/14/2017	

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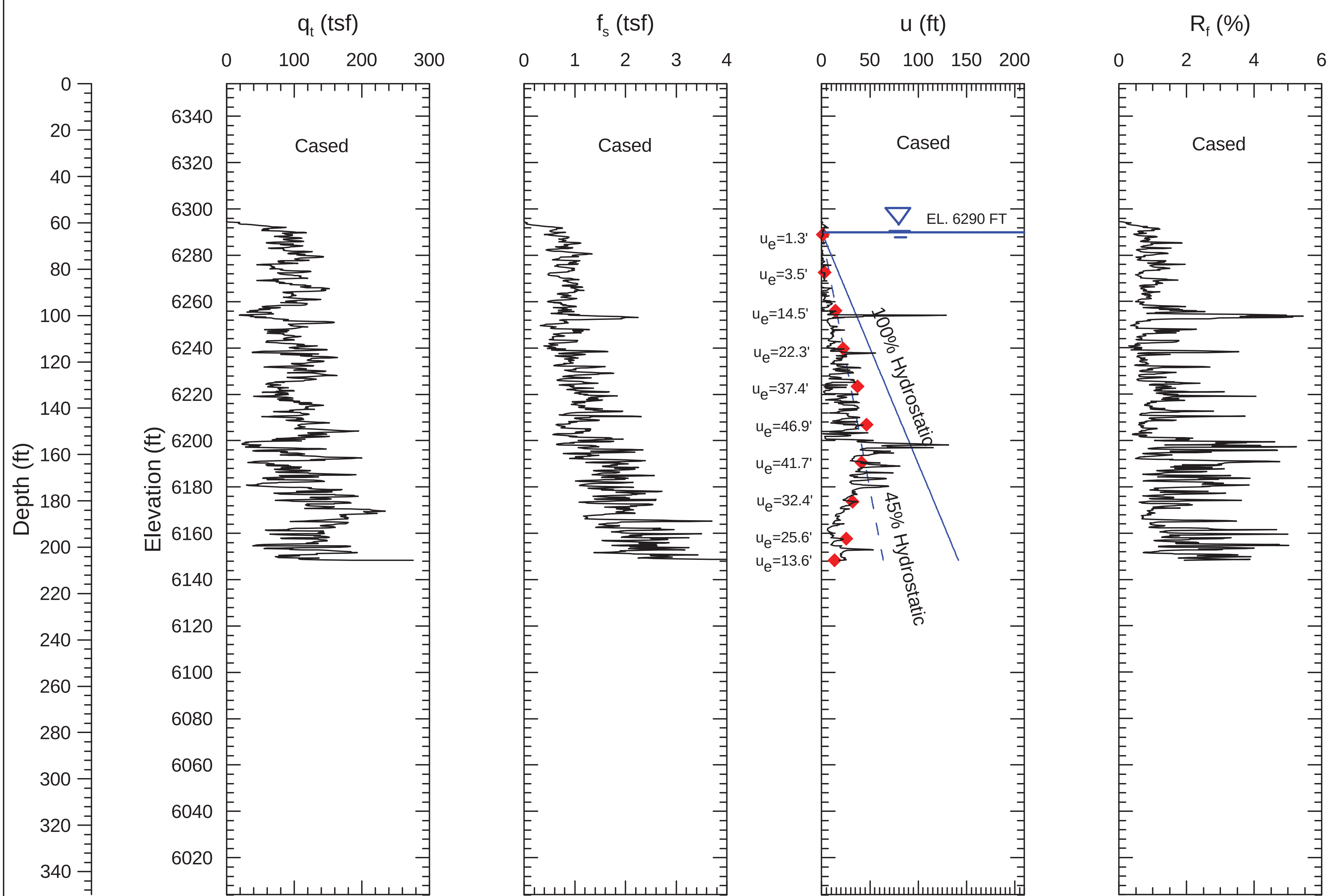
Fig. C-5



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
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Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT12-03A
Prepared By: MEK	
Date: 02/14/2017	

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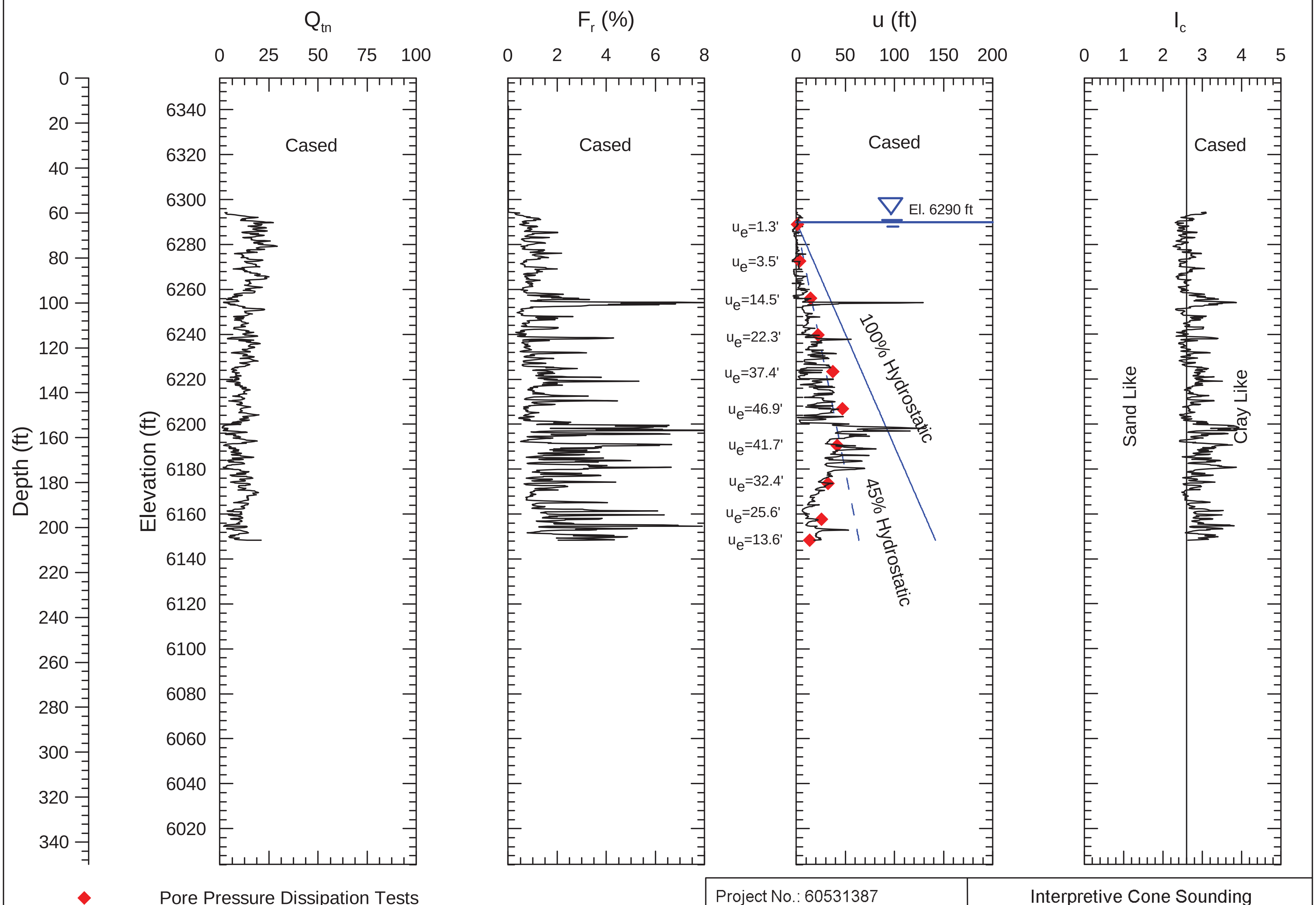
Fig. C-6



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Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT12-03A
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-7

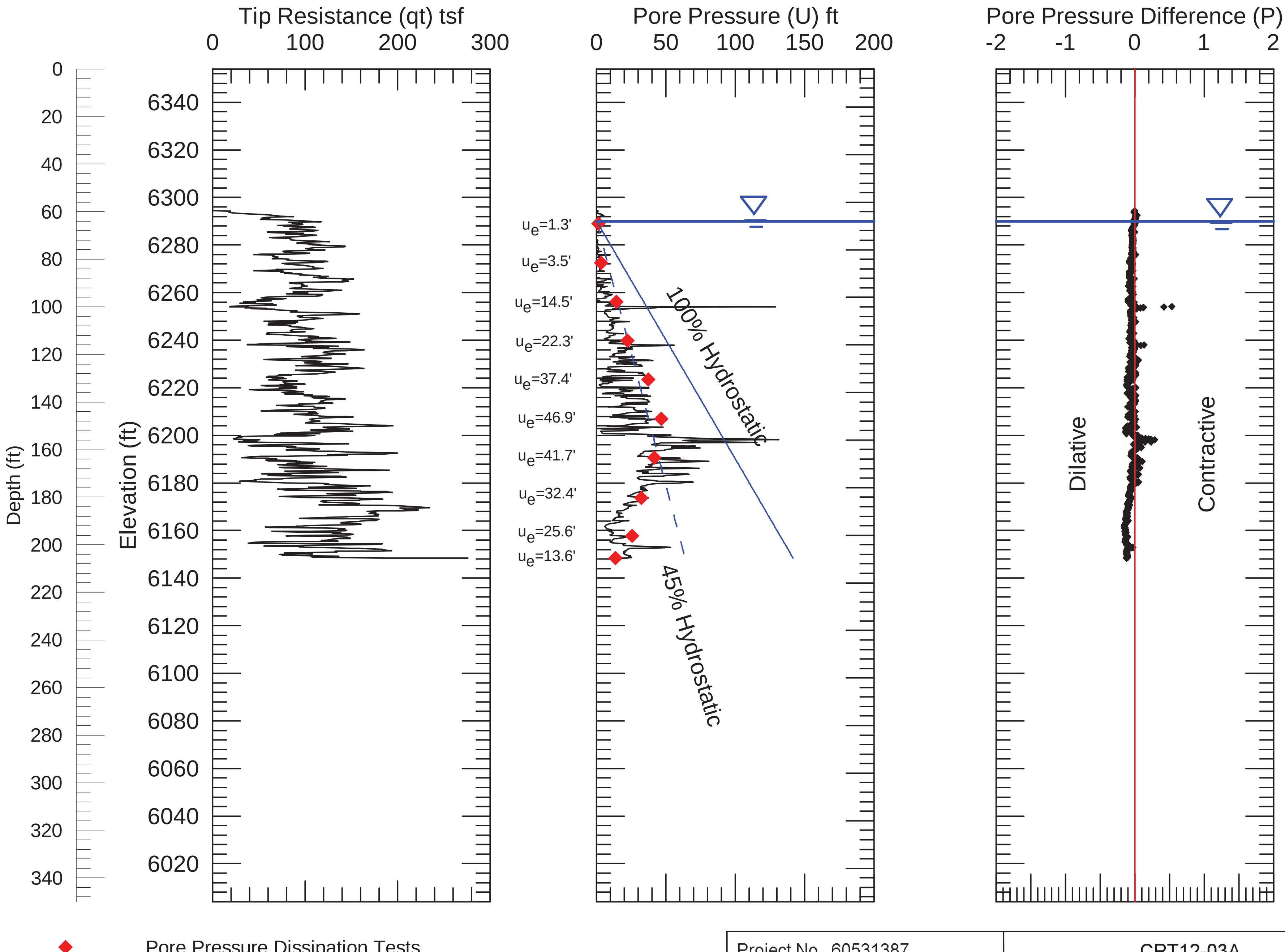

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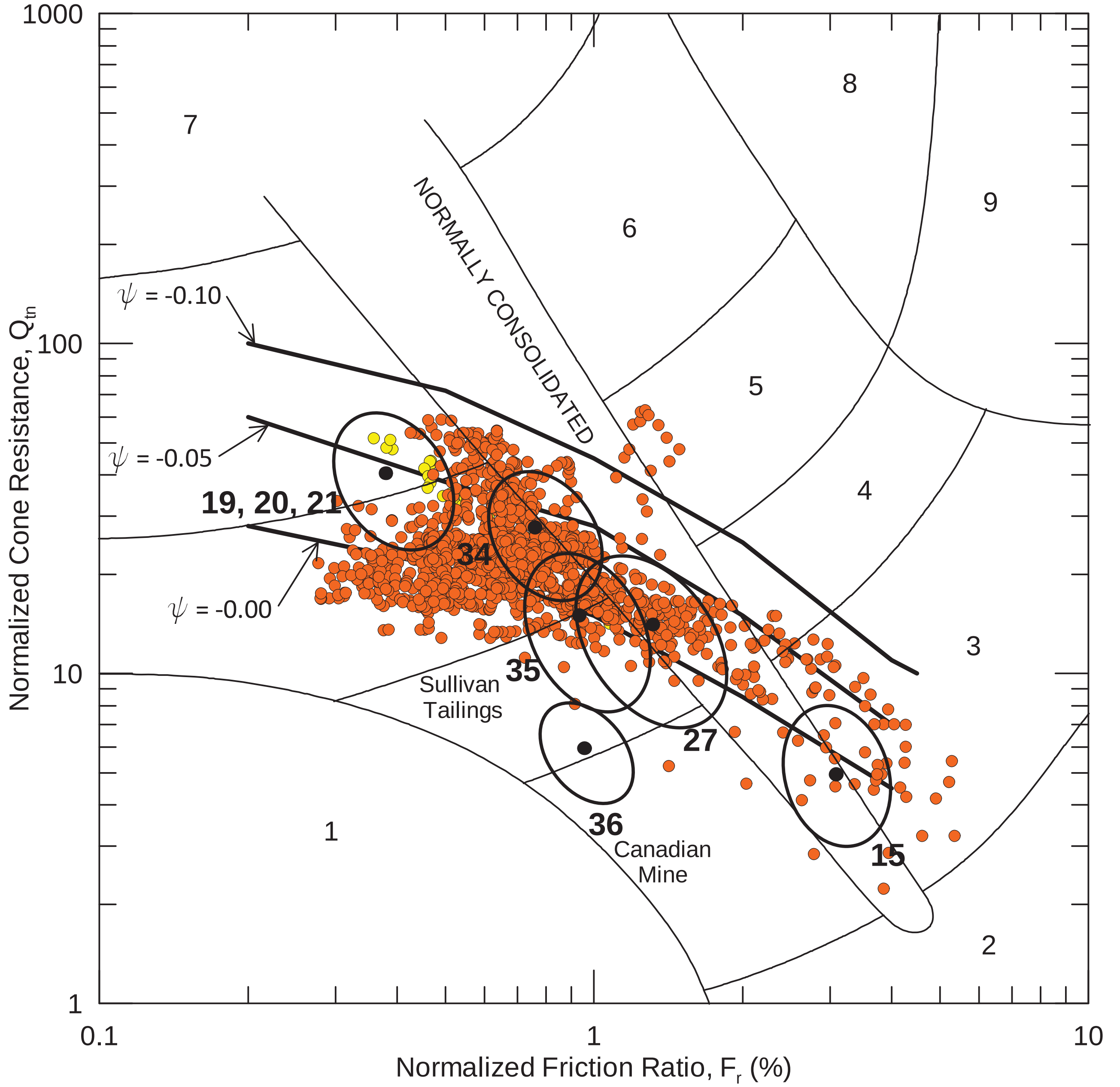
Fig. C-8



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*

LEGEND

- Unsaturated Rockfill
- Saturated Rockfill

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
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Prepared By: MEK	
Date: 02/14/2017	

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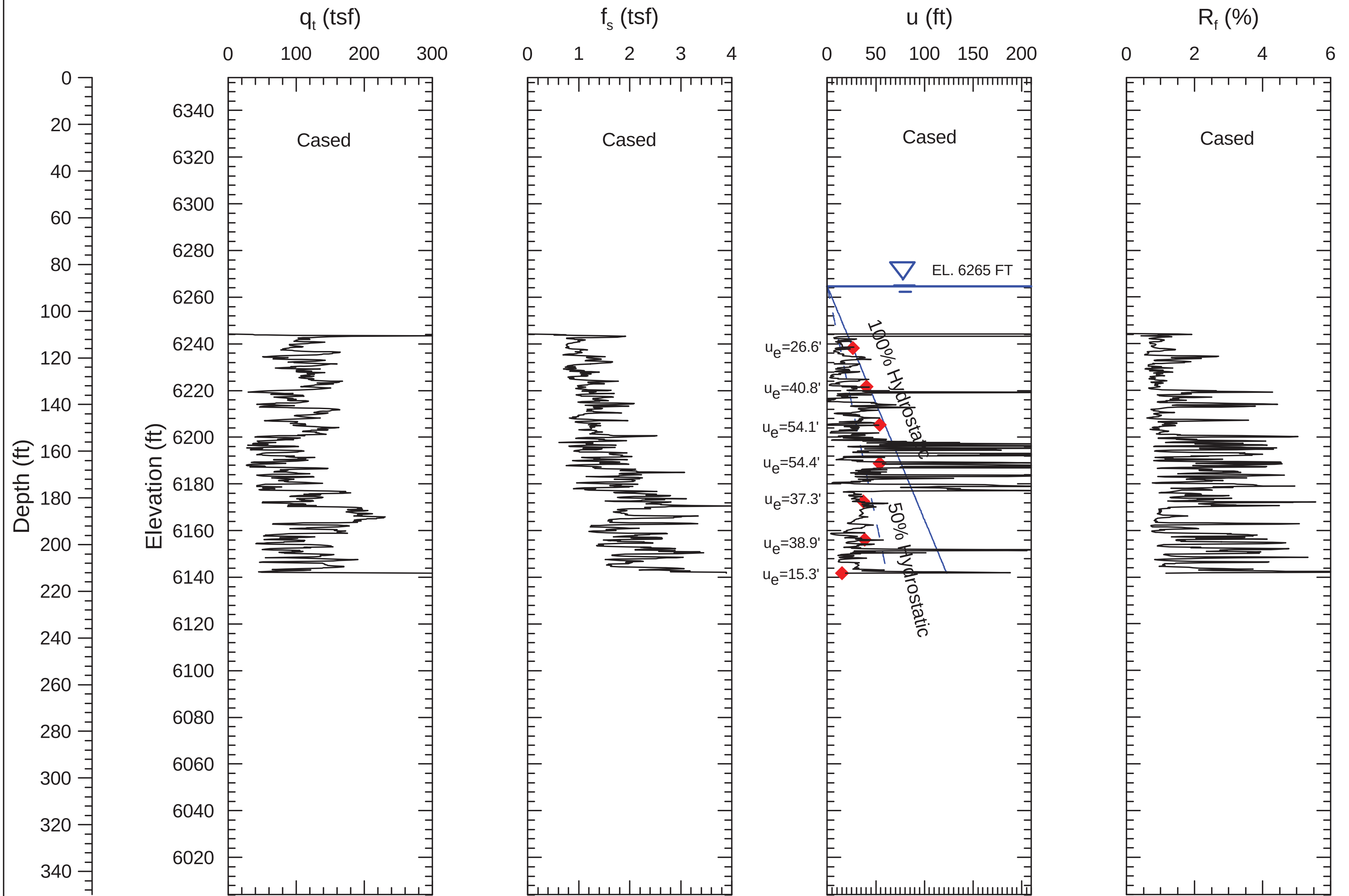
Fig. C-9



Pore Pressure Dissipation Tests

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Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT12-04
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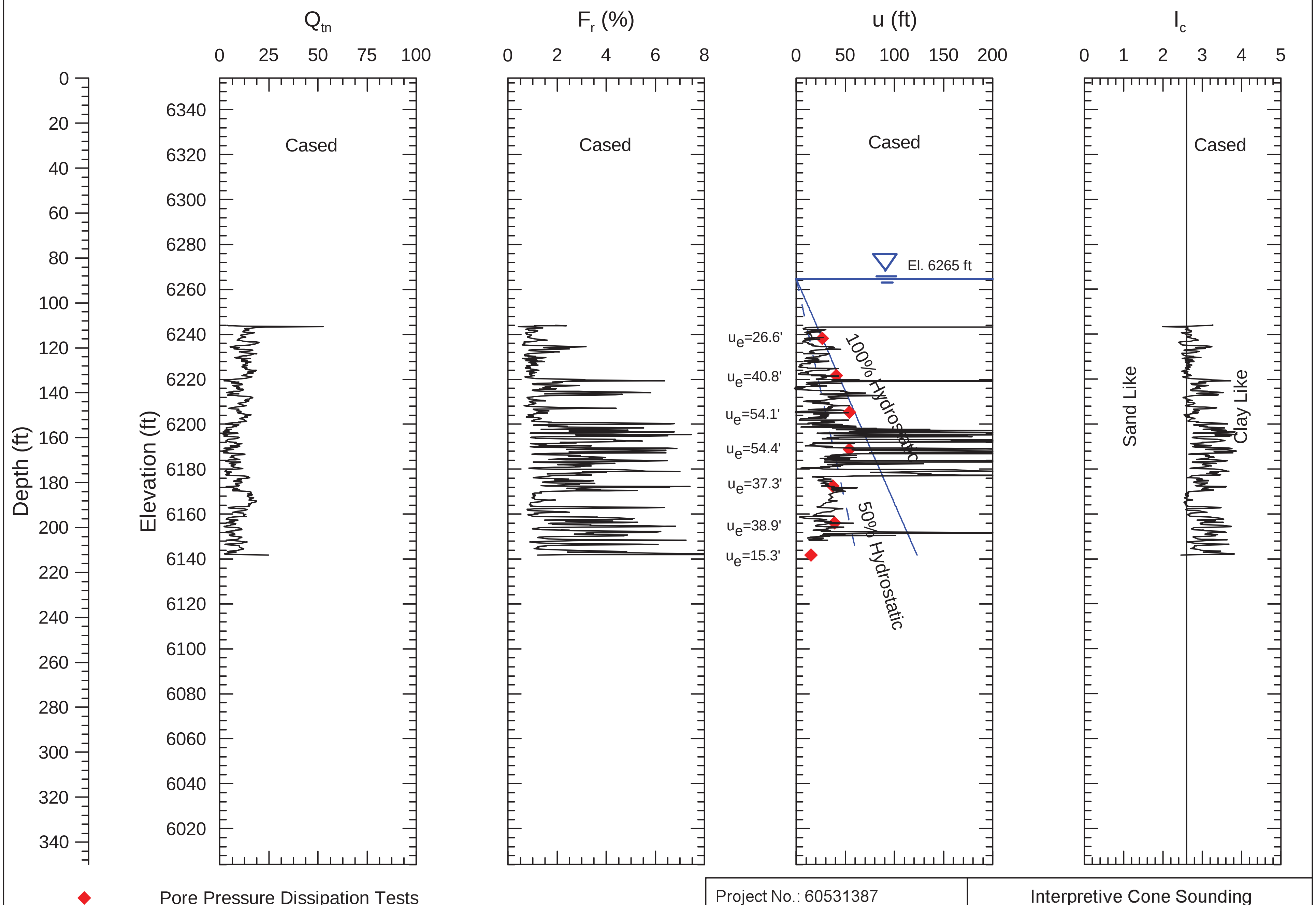
Date: 02/14/2017	

Fig. C-10



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Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT12-04
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Fig. C-11

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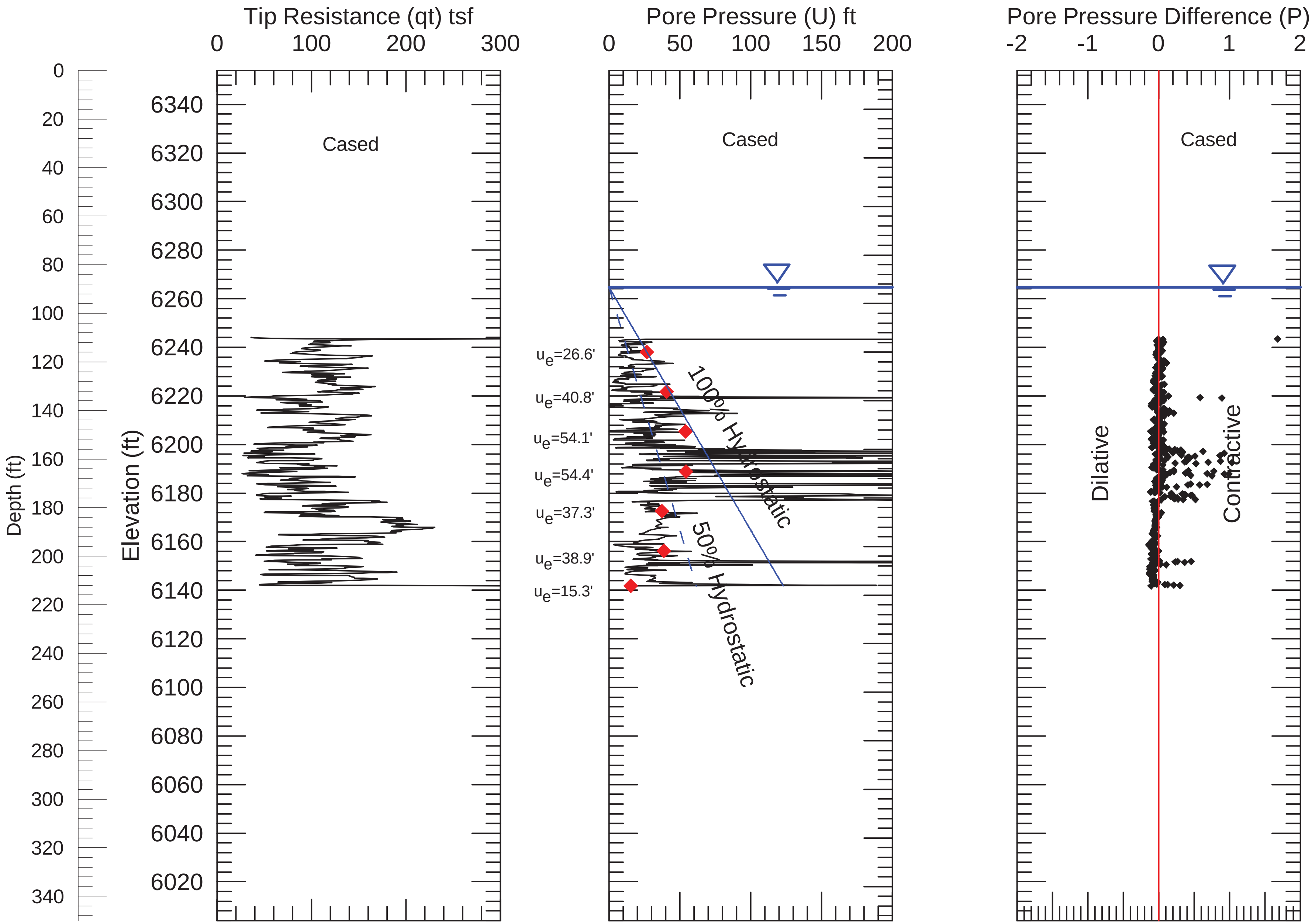

Pore Pressure Dissipation Tests

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Fig. C-12

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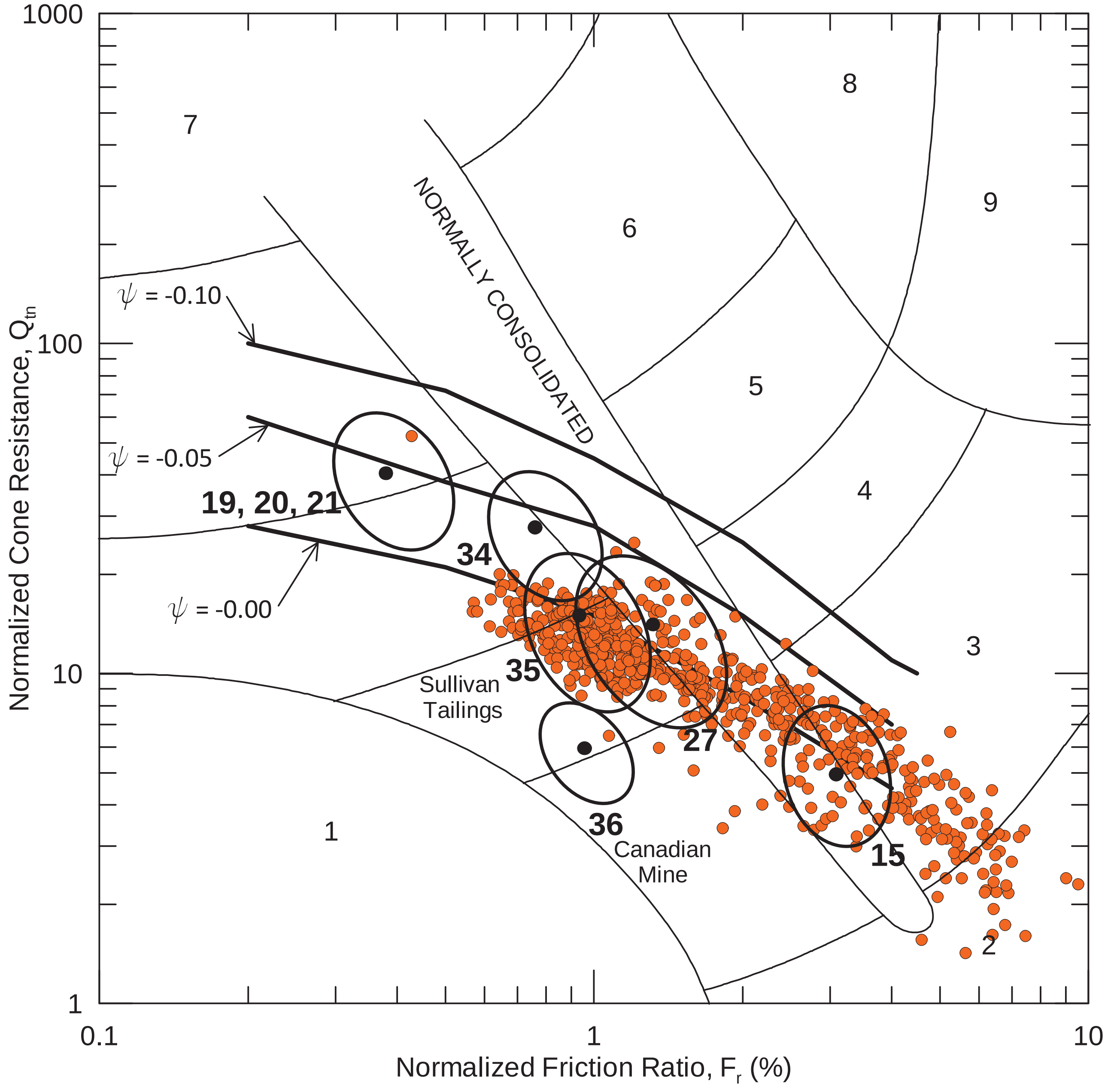

Zone	Soil Behavior Type	Ic
1	*Sensitive, fine grained*	N/A
2	*Organic soils-peats*	>3.6
3	*Clays-silty clay to clay*	2.95-3.6
4	*Silt mixtures-clayey silt to silty clay*	2.6-2.95
5	*Sand mixtures-silty sand to sandy silt*	2.05-2.6
6	*Sands-clean sand to silty sand*	1.31-2.05
7	*Gravelly sand to dense sand*	<1.31
8	*Very stiff sand to clayey sand**	N/A
9	*Very stiff, fine grained**	N/A

**Heavily overconsolidated or cemented*

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Fig. C-13

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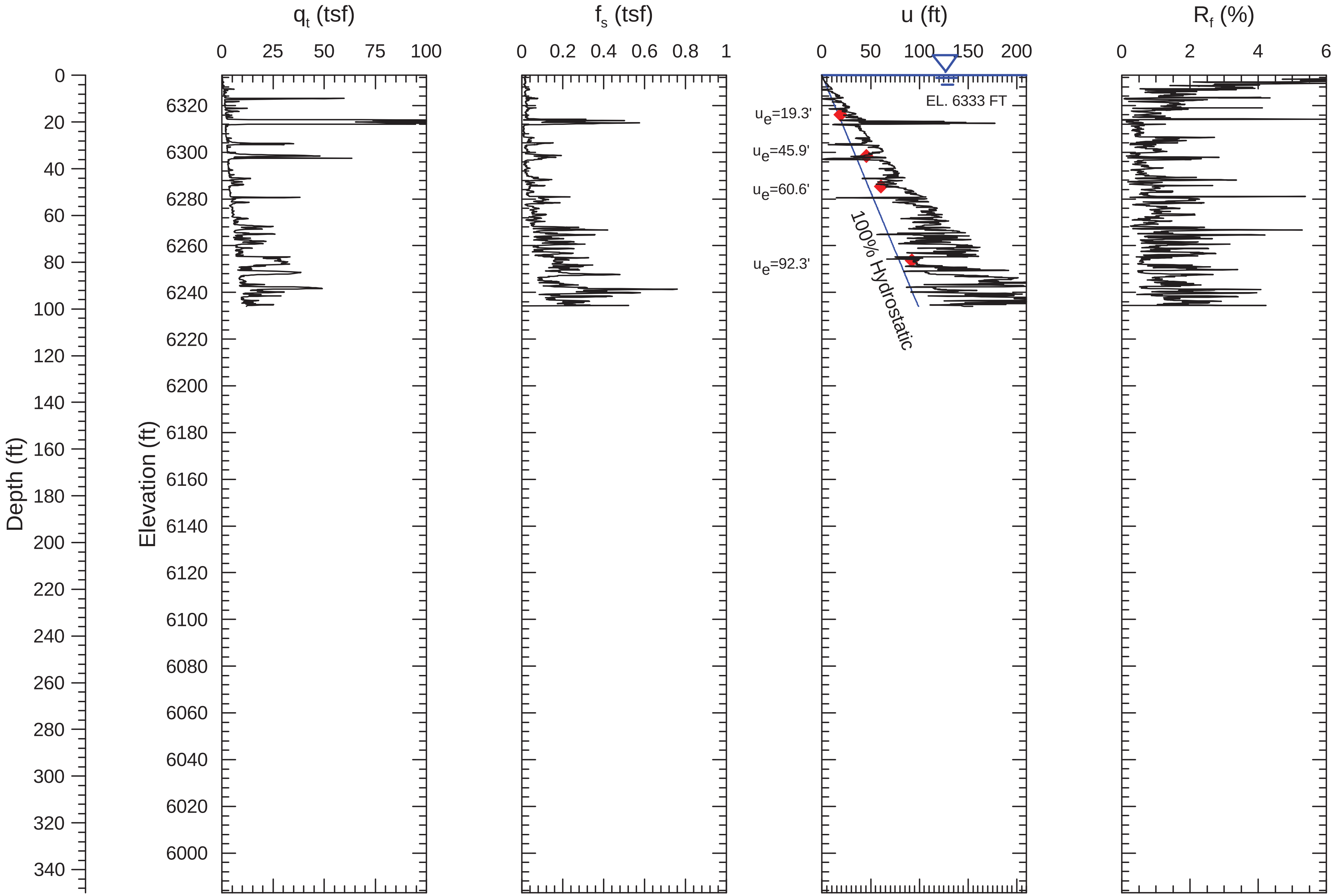

Pore Pressure Dissipation Tests

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Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT15-01
Prepared By: MEK	
Date: 02/21/2017	

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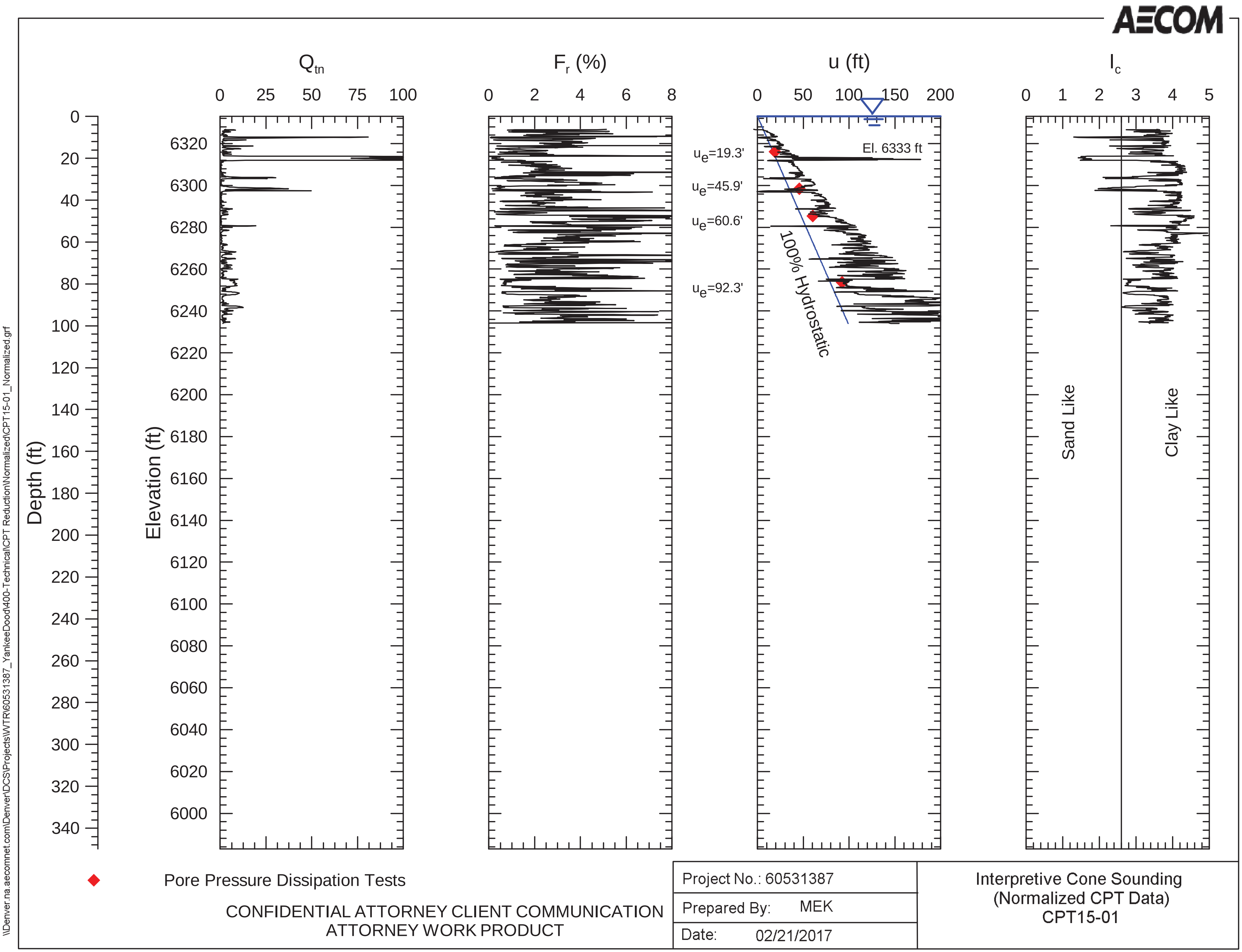
Fig. C-14



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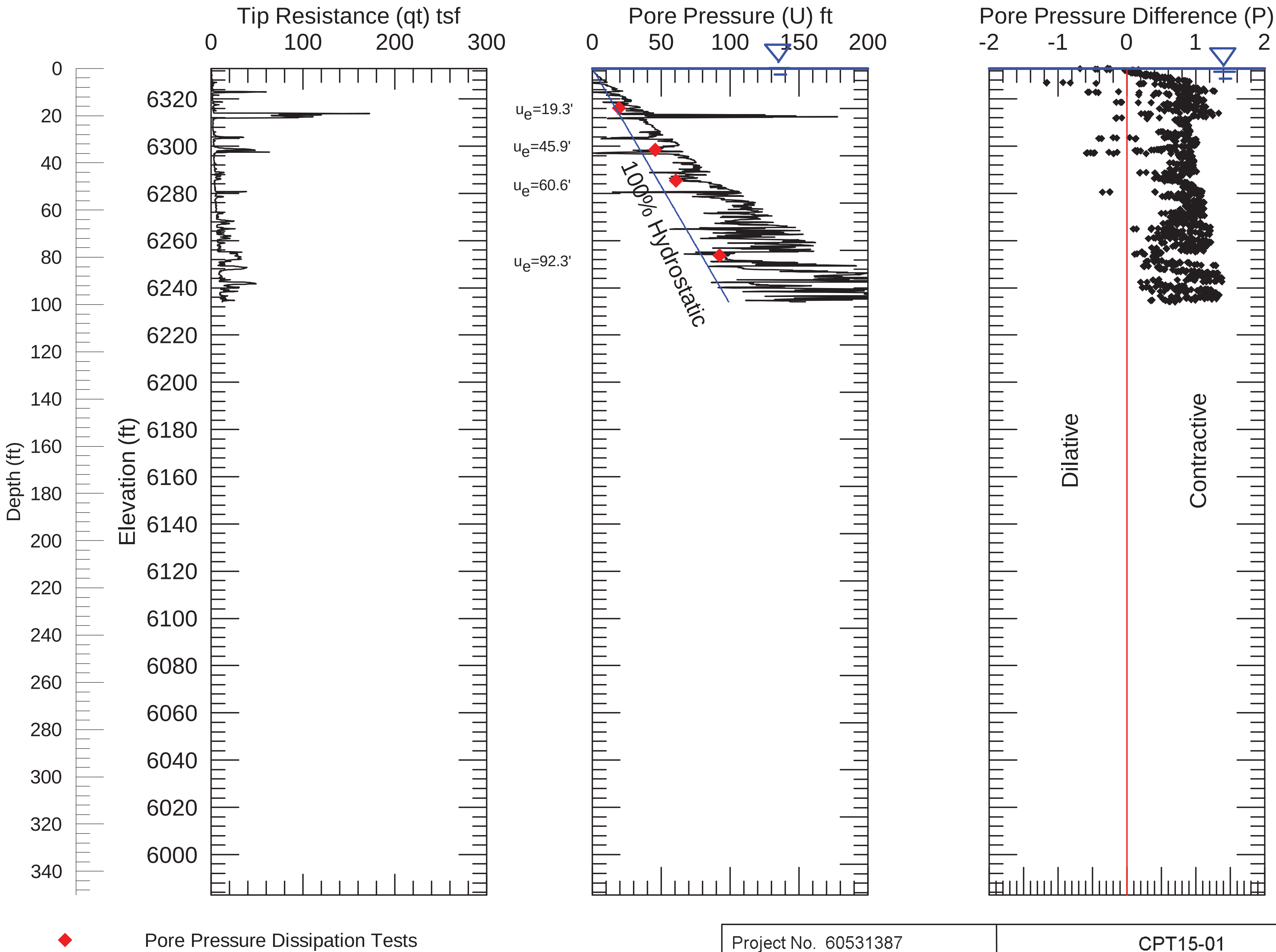
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-15



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Project No. 60531387	CPT15-01 Normalized Pore Pressure Difference
Prepared By: MEK	
Date: 02/21/2017	

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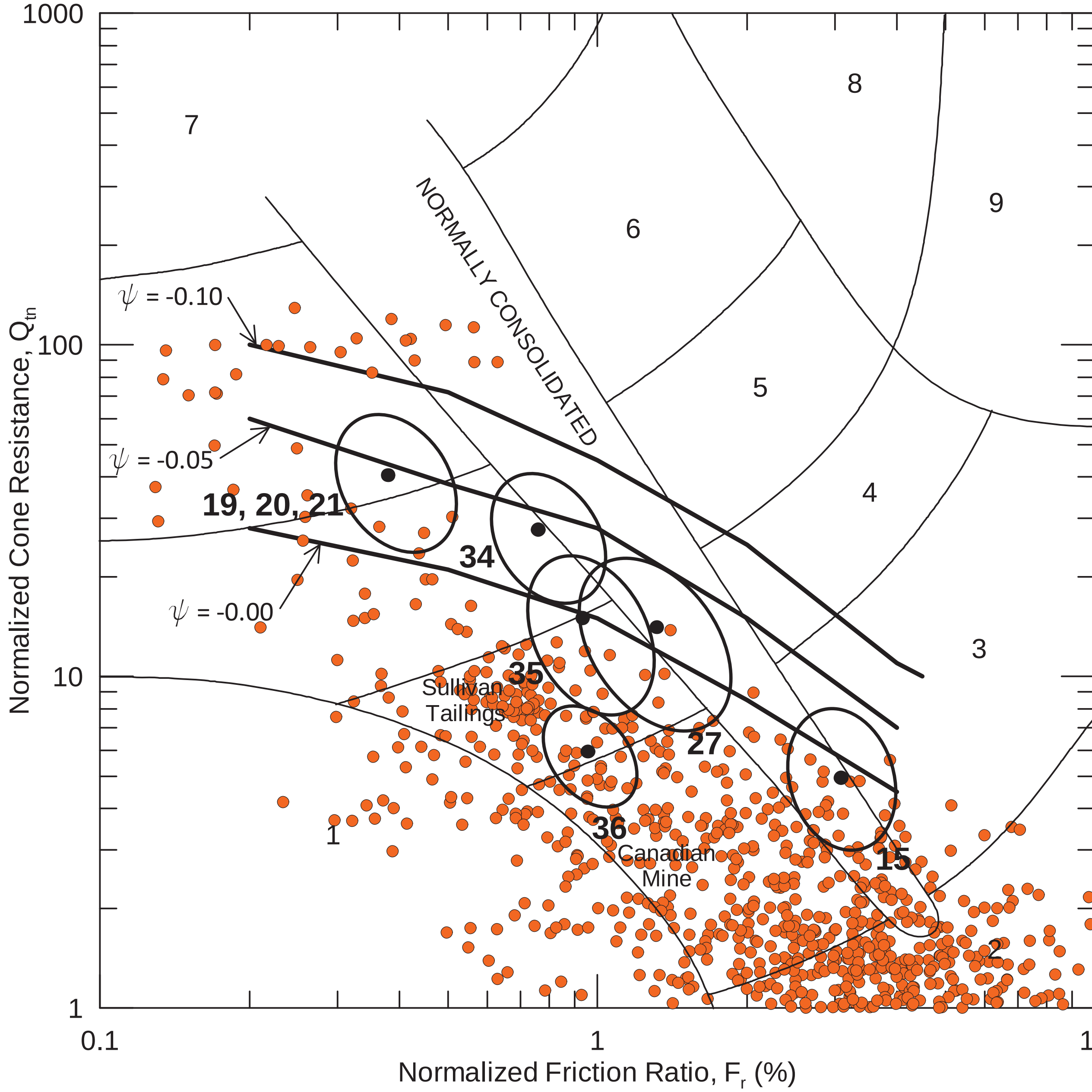
Fig. C-16



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*

LEGEND

● Saturated Tailings

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters CPT15-01
Prepared By: MEK	
Date: 02/21/2017	

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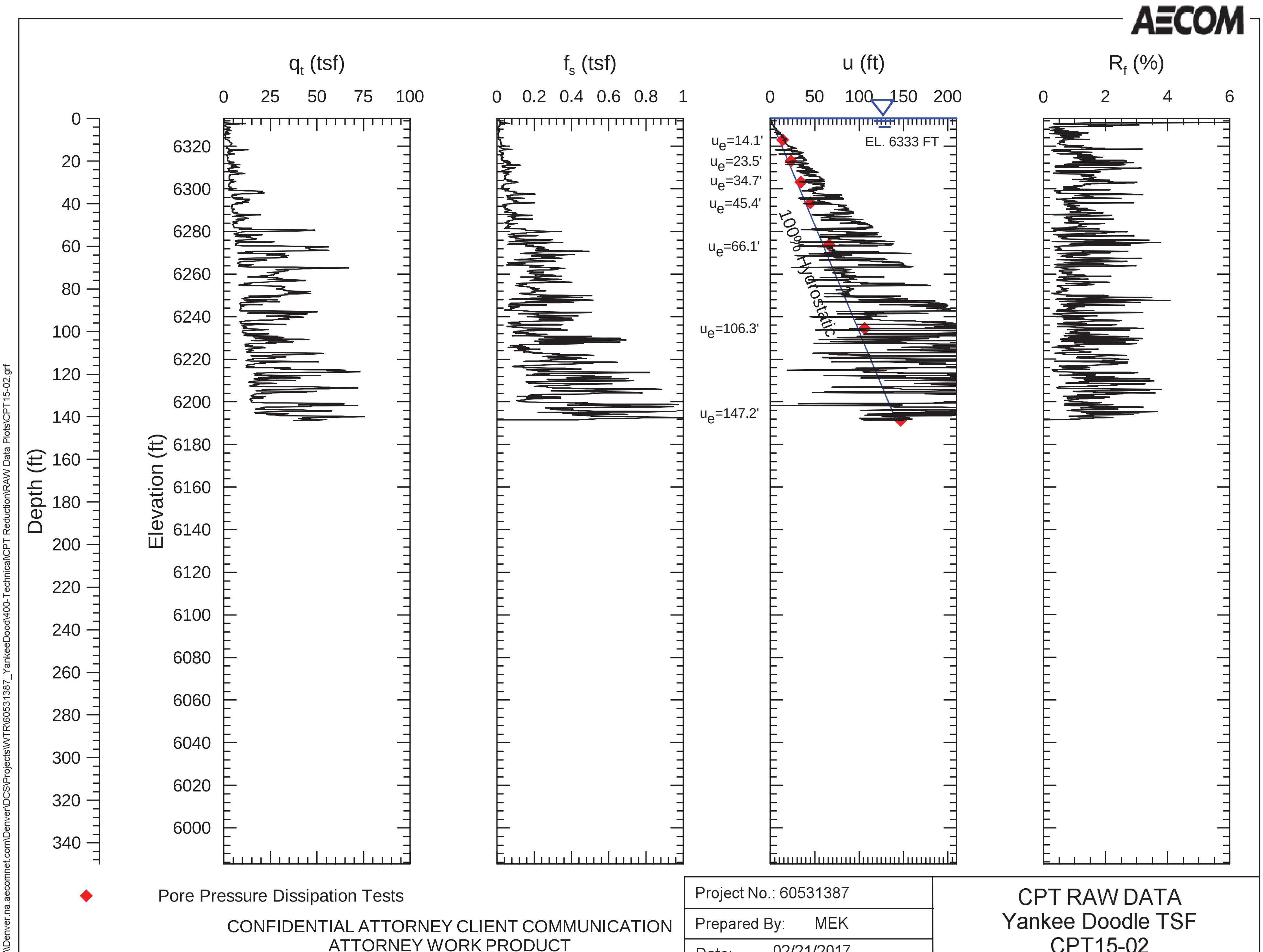
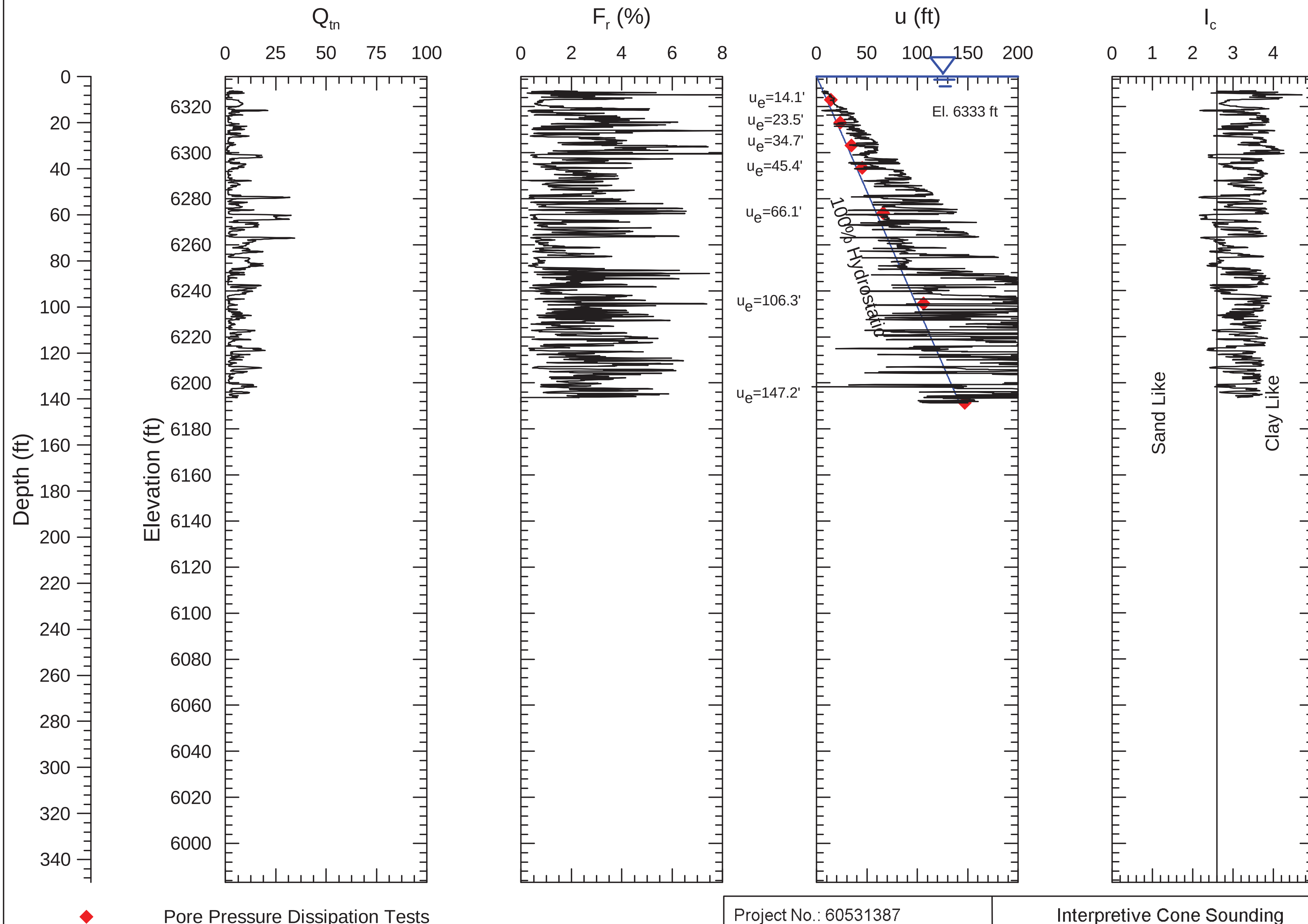
Fig. C-17



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT15-02
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-18



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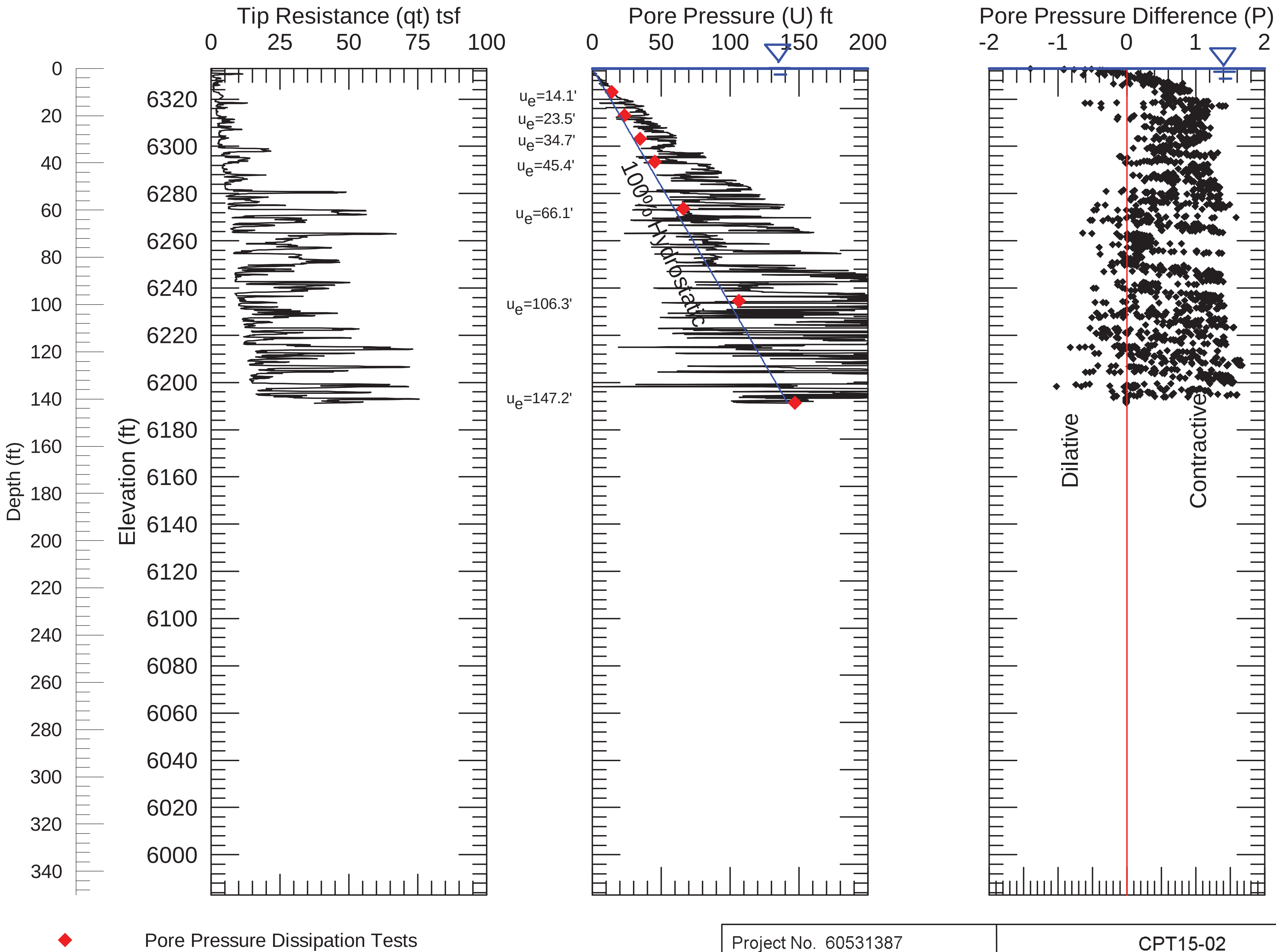
ATTORNEY WORK PRODUCT

Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT15-02
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-19



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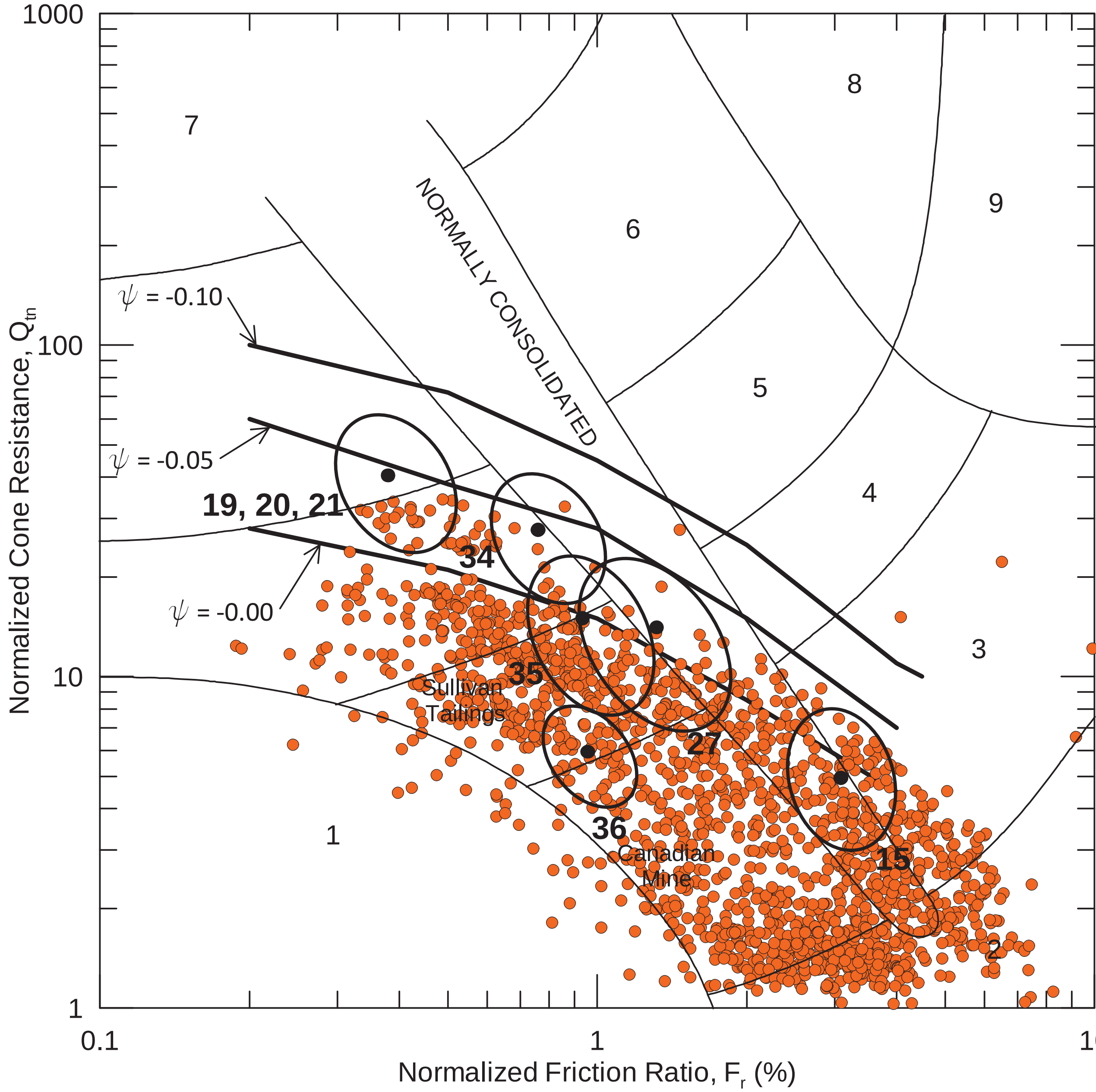
CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No. 60531387	CPT15-02 Normalized Pore Pressure Difference
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-20

AECOM



LEGEND

● Saturated Tailings

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*

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters CPT15-02
Prepared By: MEK	
Date: 02/21/2017	

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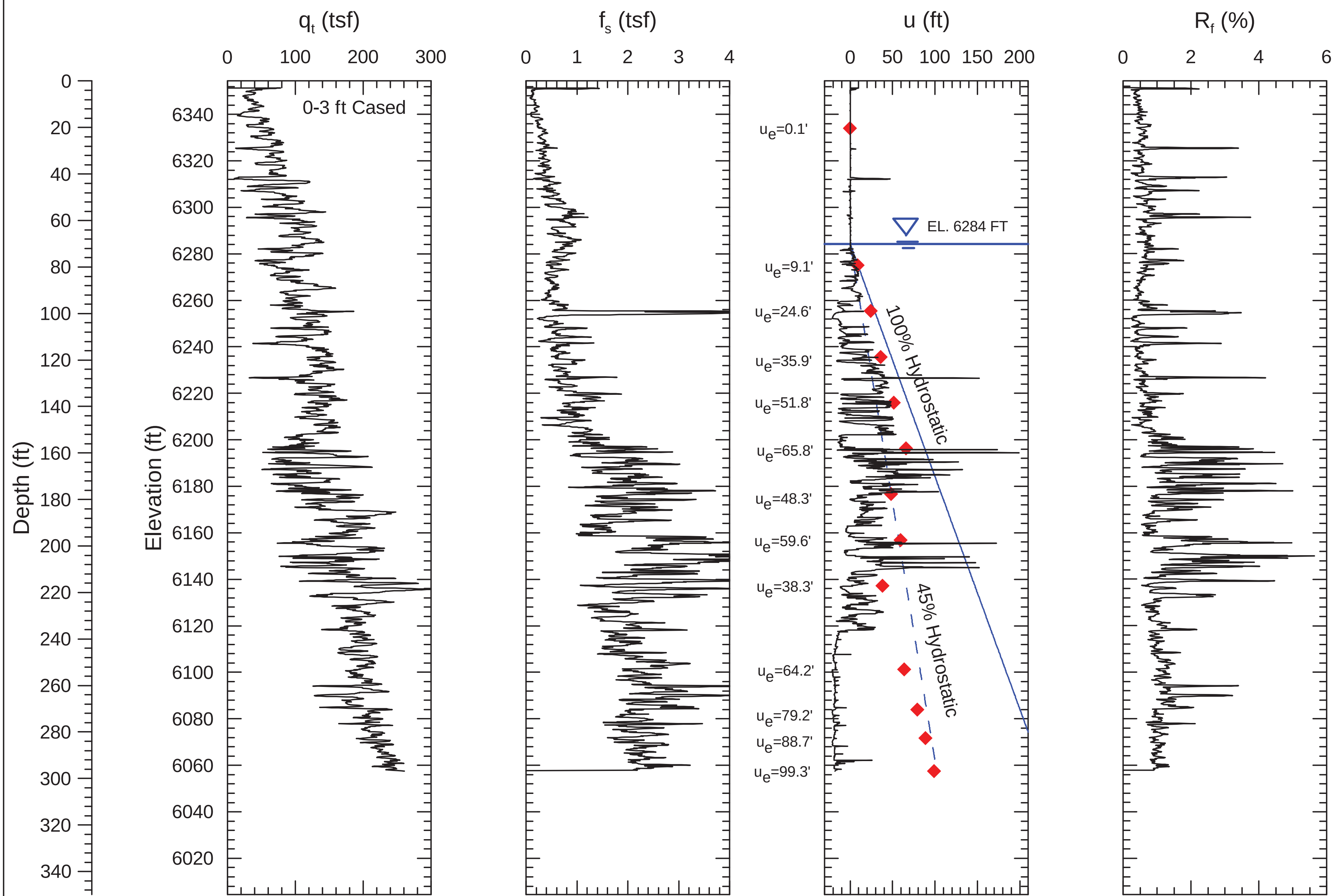
Fig. C-21



◆ Pore Pressure Dissipation Tests

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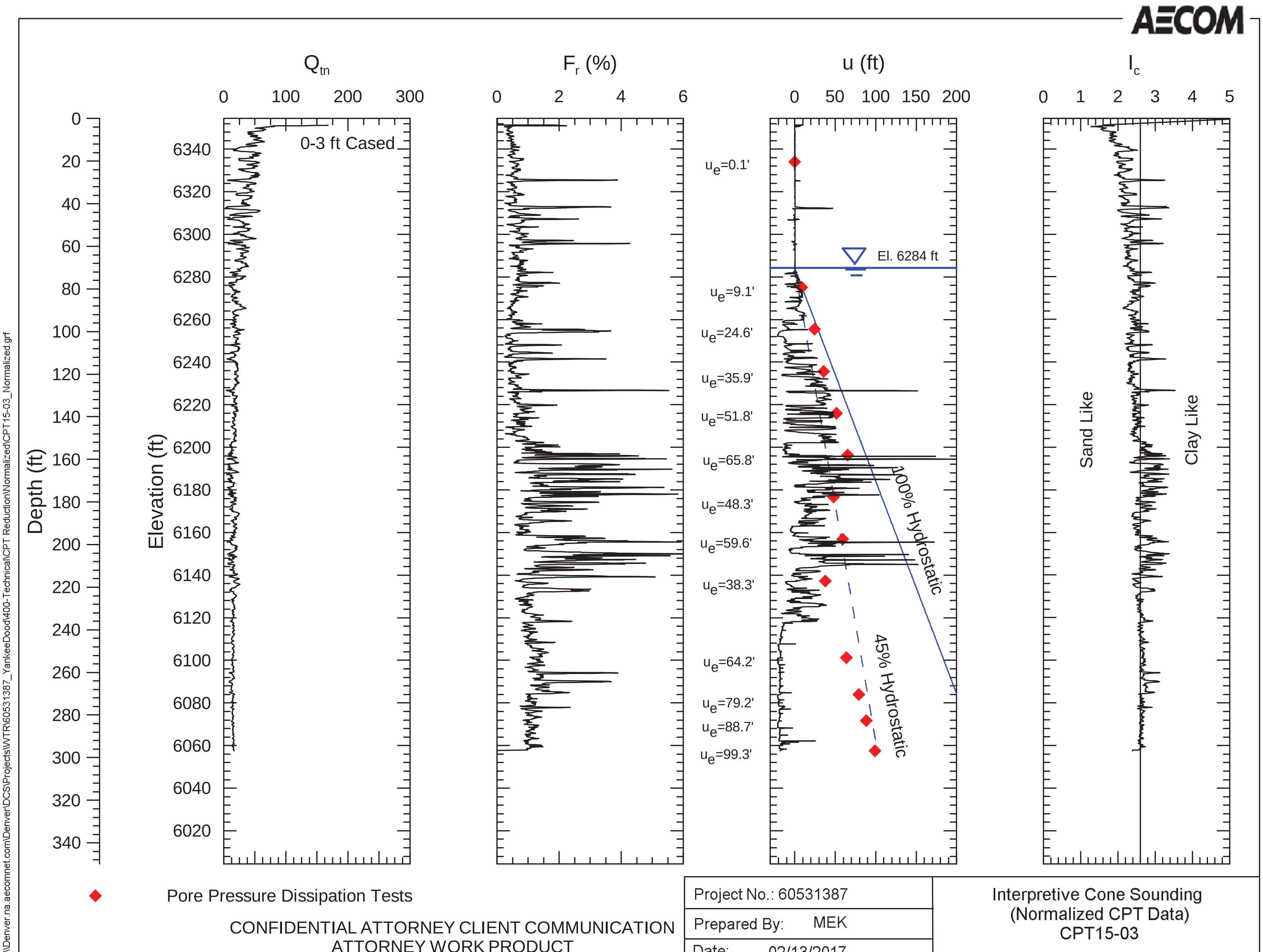
CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT15-03
Prepared By: MEK	
Date: 02/14/2017	

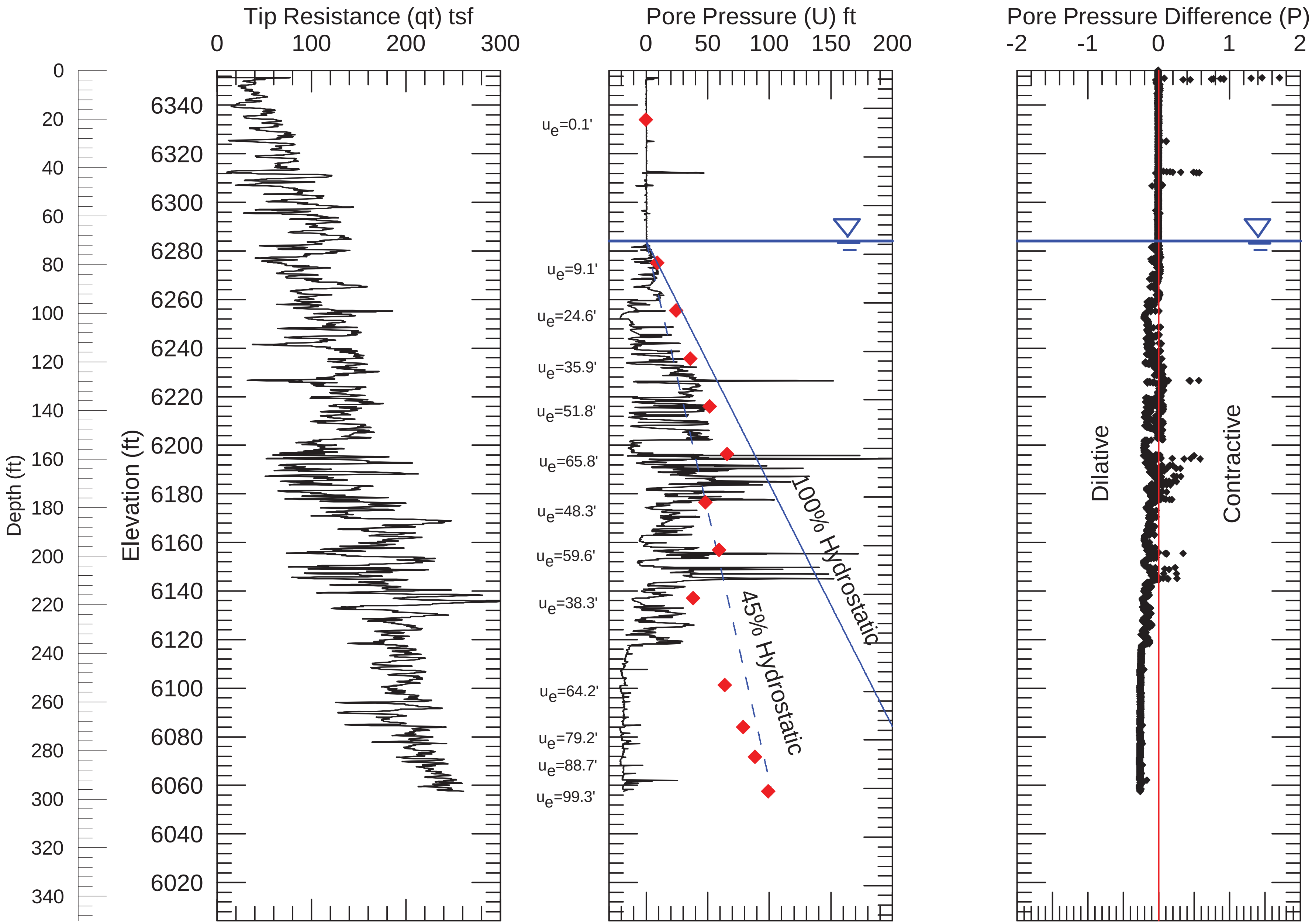
Fig. C-22



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT15-03
Prepared By: MEK	
Date: 02/13/2017	

Fig. C-23



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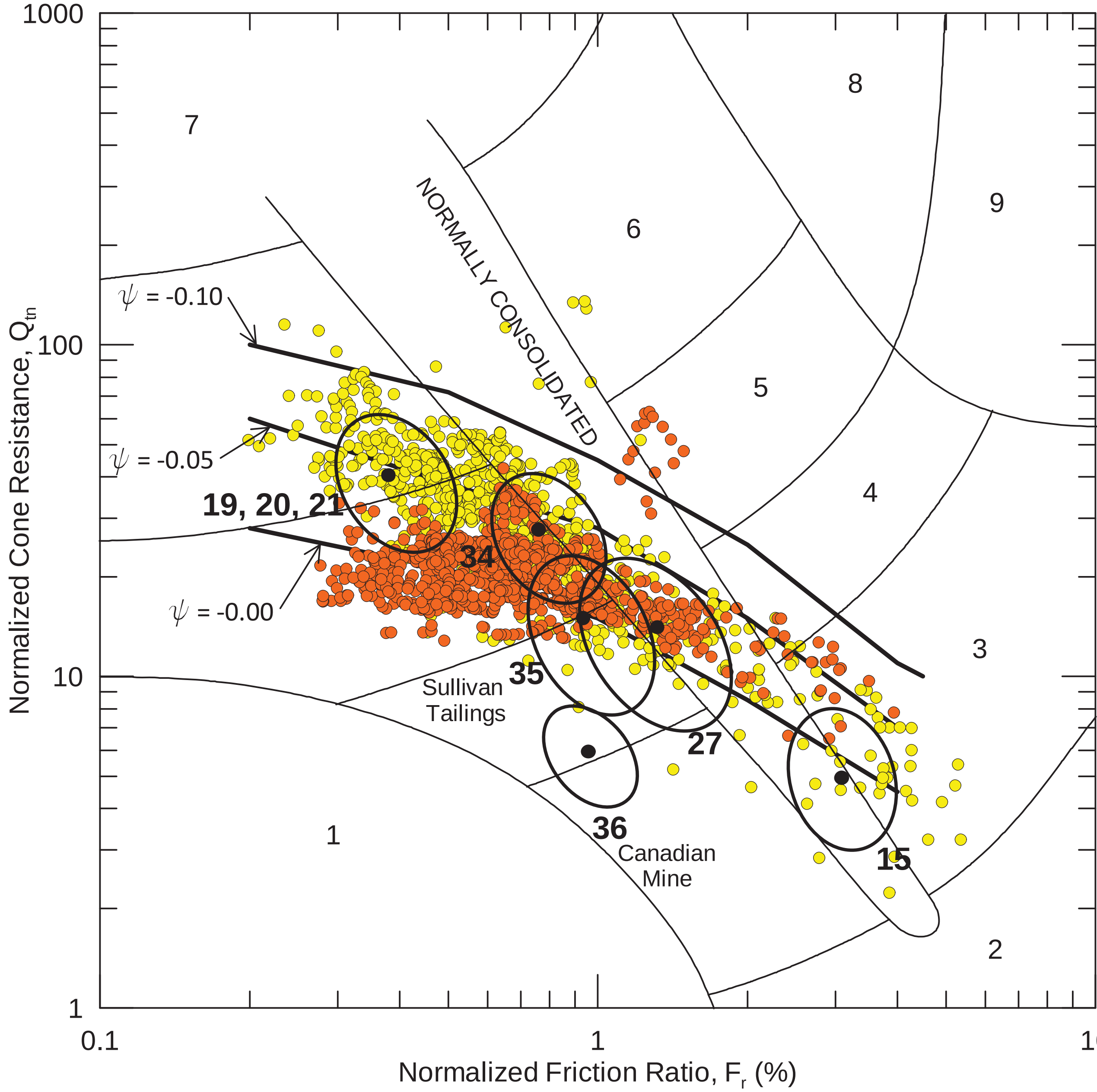
Pore Pressure Dissipation Tests

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No. 60531387	CPT15-03 Normalized Pore Pressure Difference
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-24



LEGEND

- Unsaturated Tailings
- Saturated Tailings

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*

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters CPT15-03
Prepared By: MEK	
Date: 02/14/2017	

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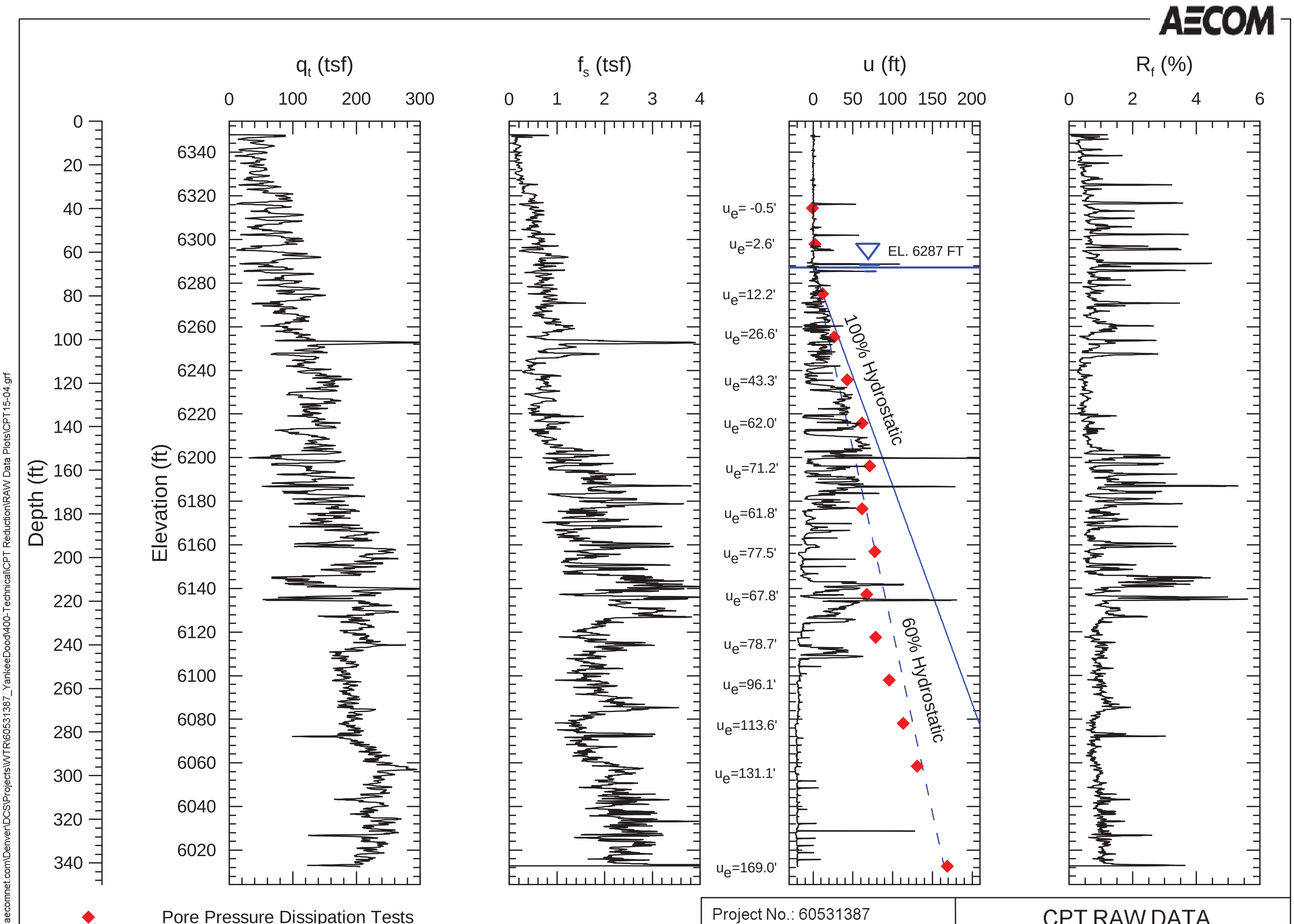
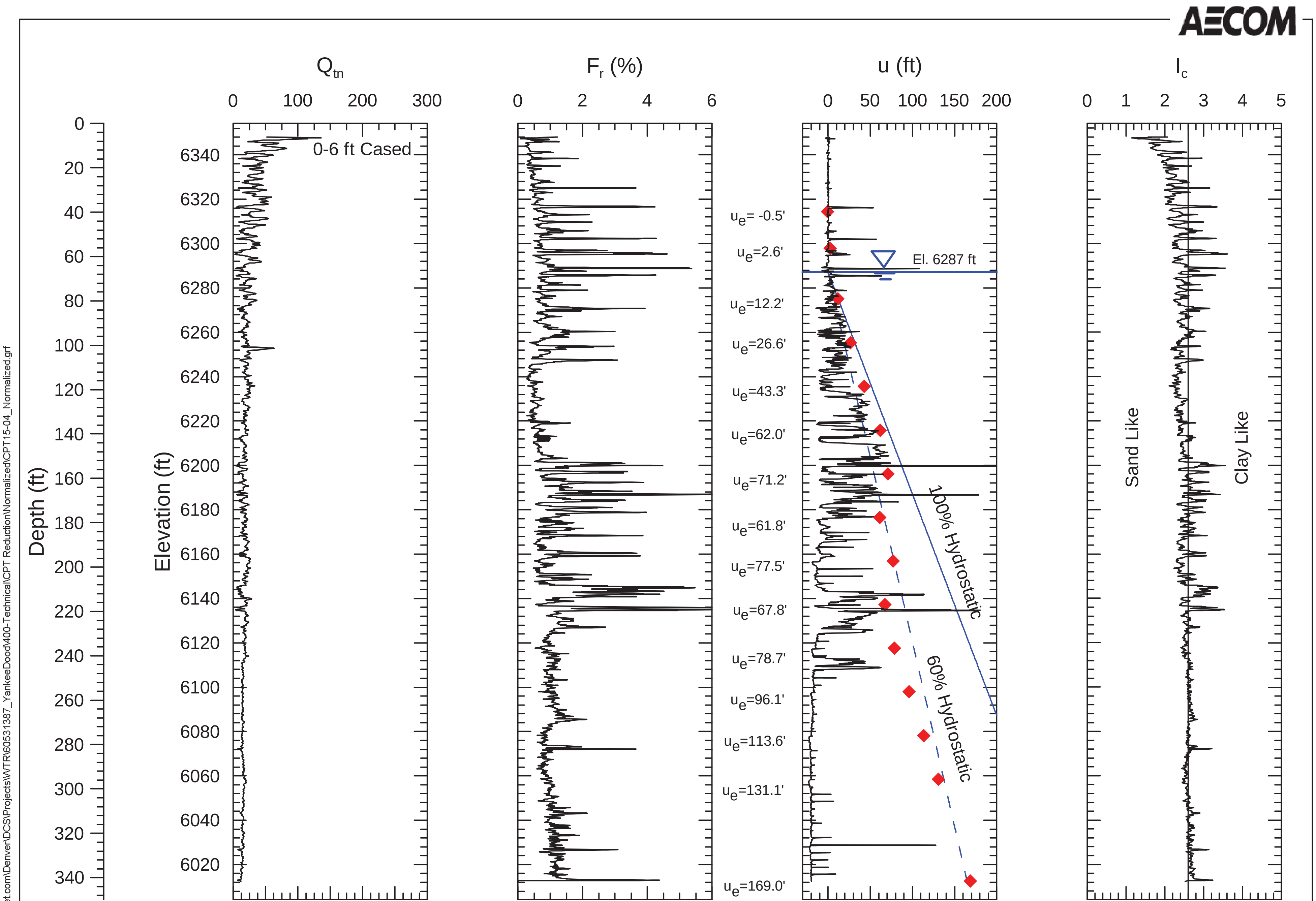
Fig. C-25



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT15-04
Prepared By: MEK	
Date: 02/14/2017	

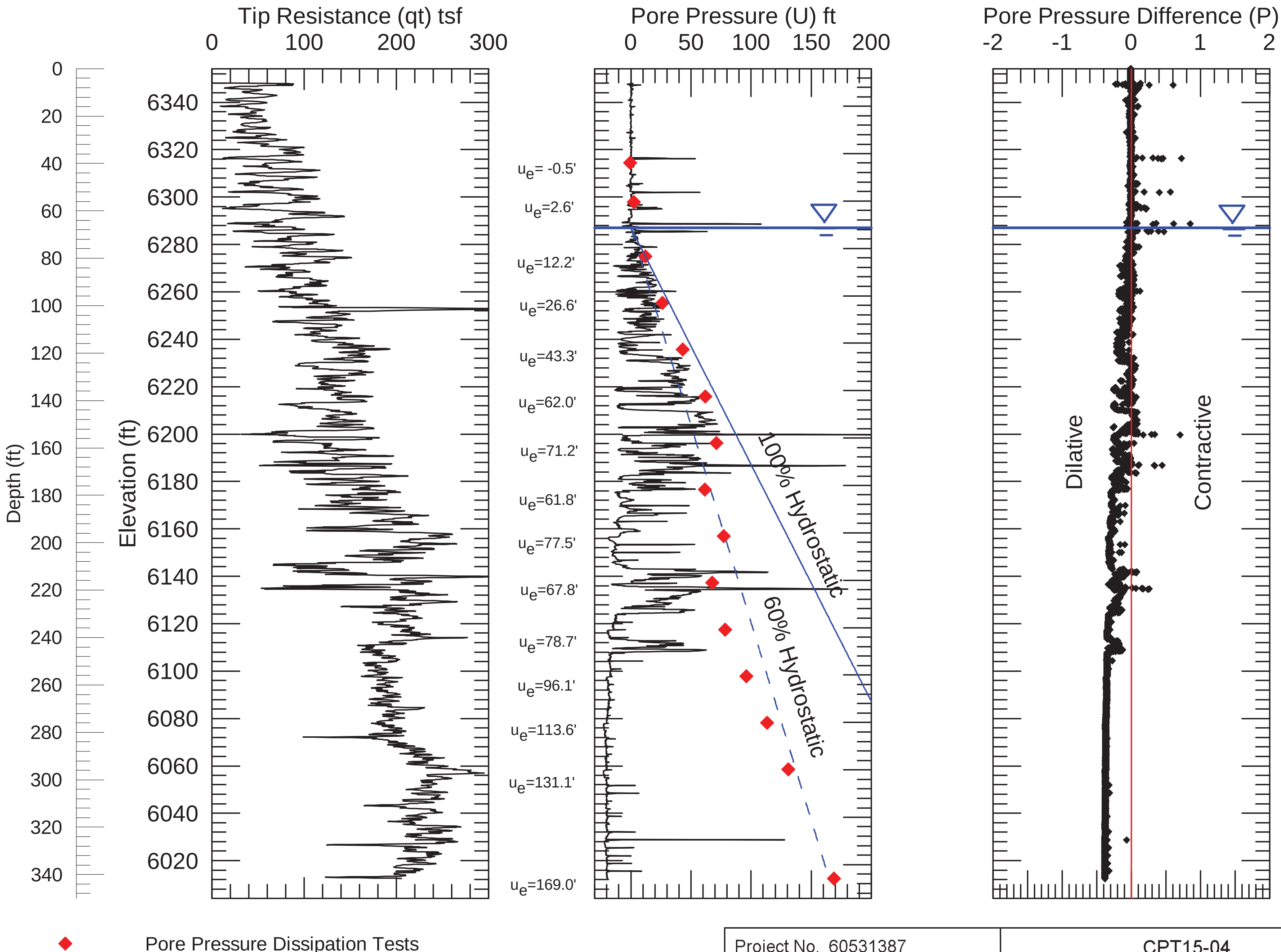
Fig. C-26



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT15-04
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-27

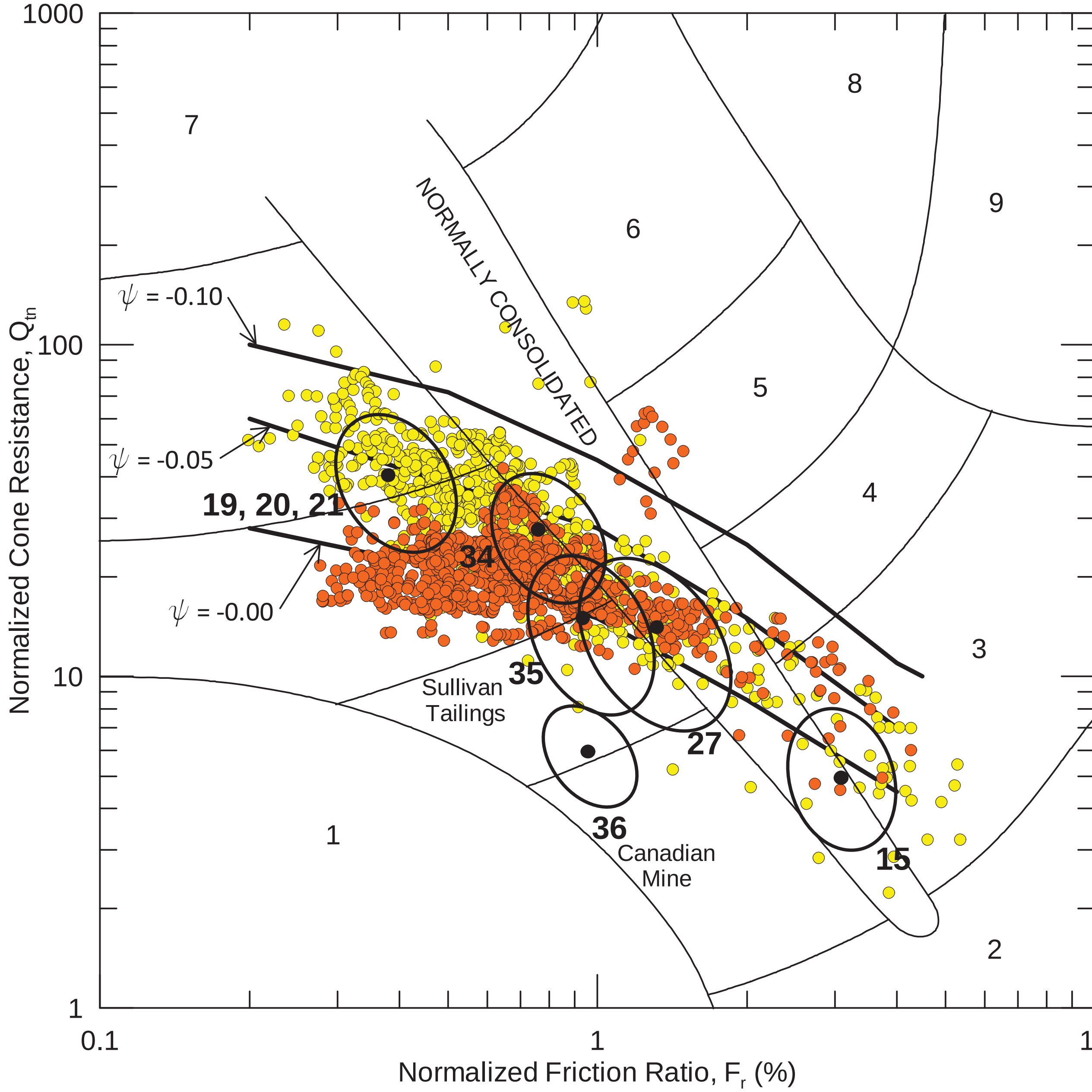


CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No. 60531387	CPT15-04 Normalized Pore Pressure Difference
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-28

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*

LEGEND

- Unsaturated Tailings
- Saturated Tailings

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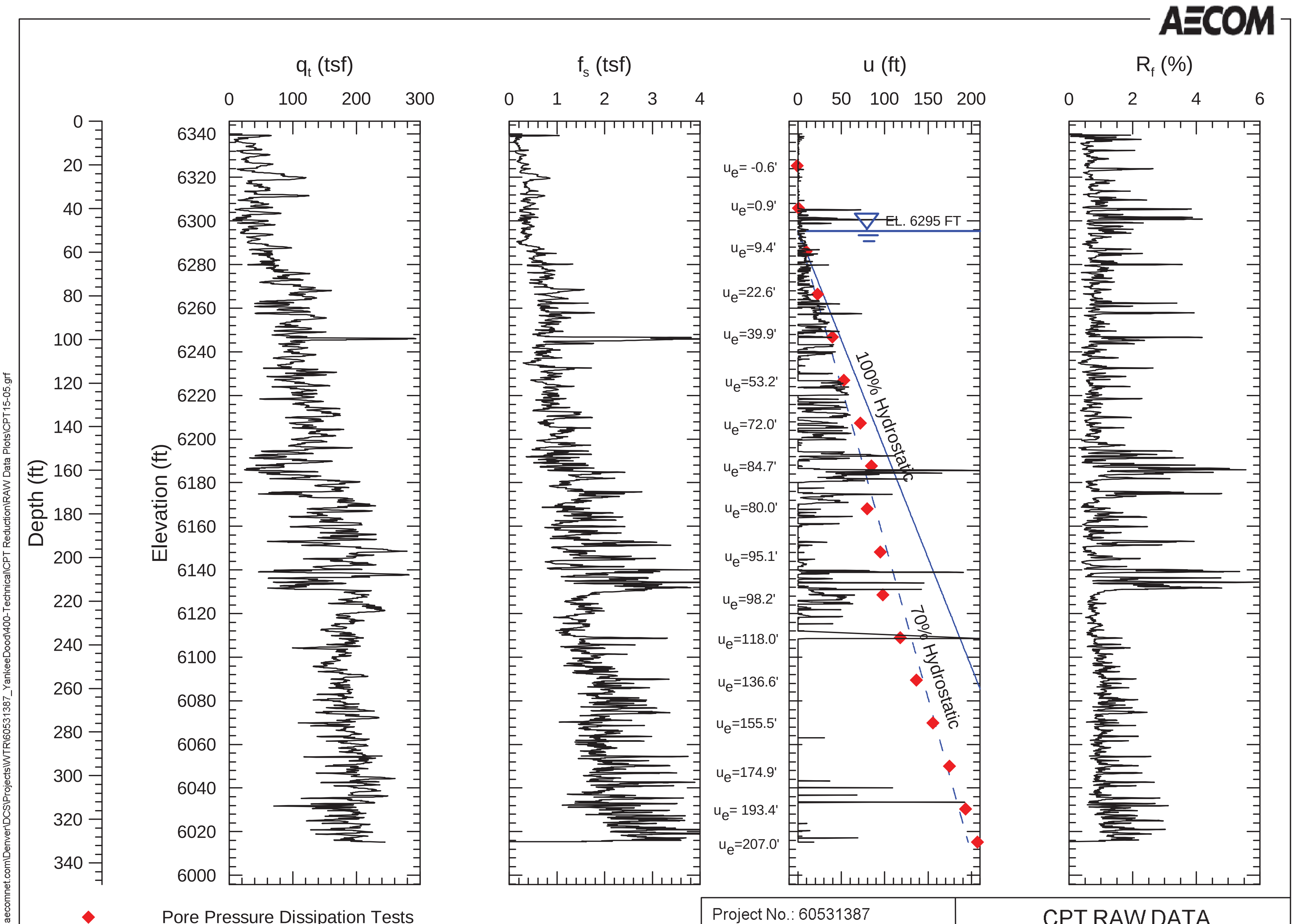
CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters CPT15-04
Prepared By: MEK	
Date: 02/14/2017	

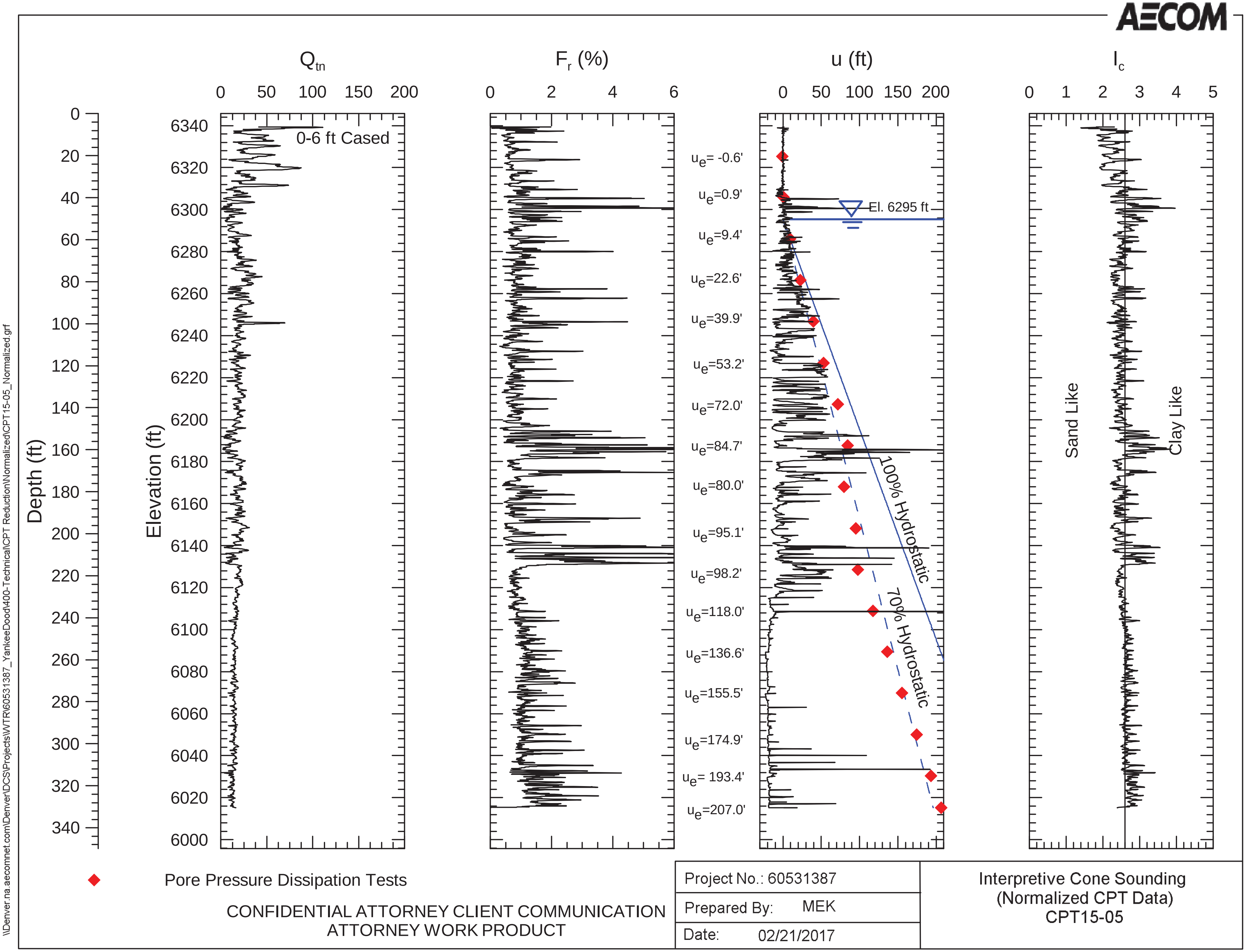
Fig. C-29



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT15-05
Prepared By: MEK	
Date: 02/14/2017	

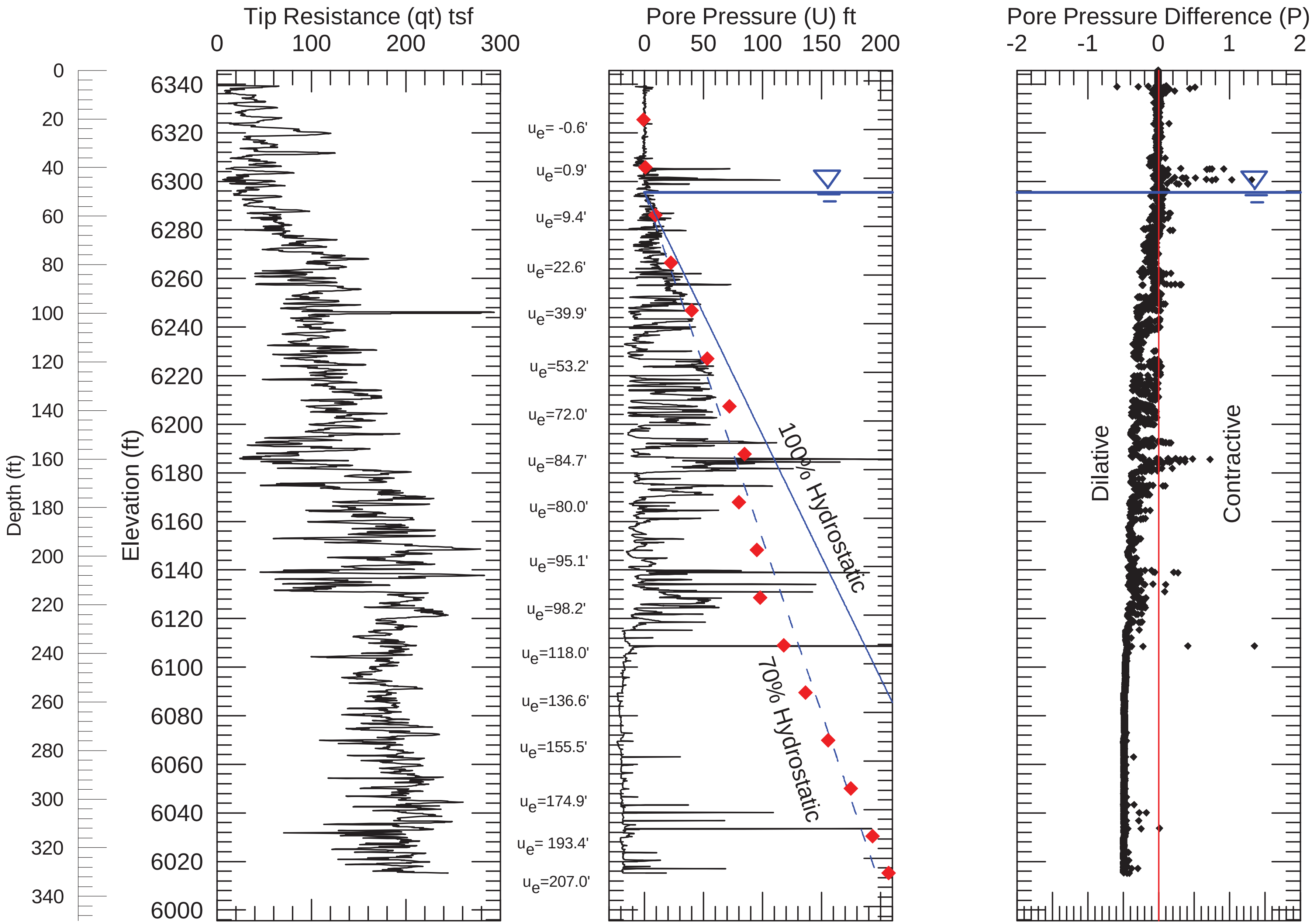
Fig. C-30



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT15-05
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-31



◆ Pore Pressure Dissipation Tests

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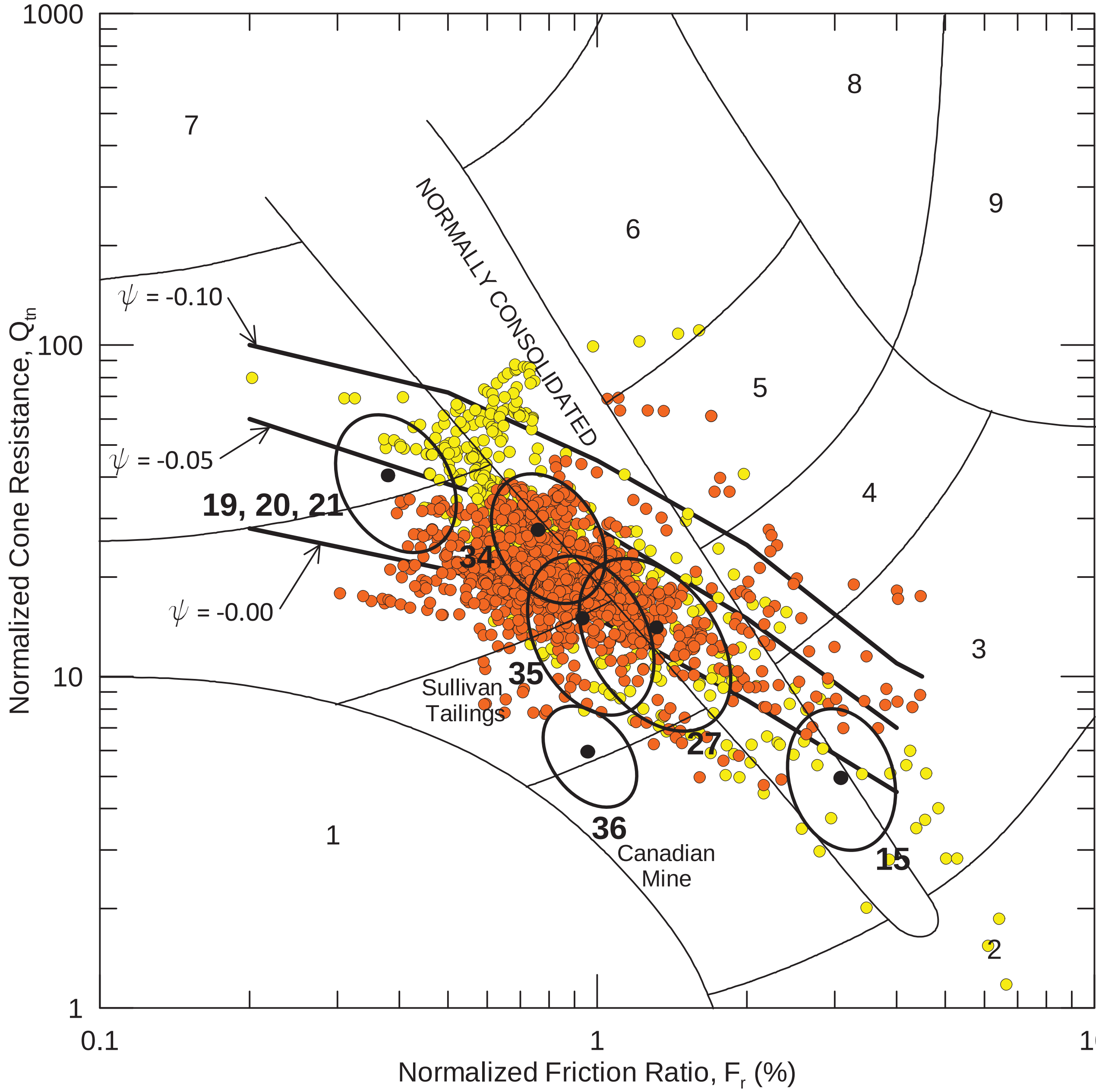
CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No. 60531387	CPT15-05 Normalized Pore Pressure Difference
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-32



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*

LEGEND

- Unsaturated Tailings
- Saturated Tailings

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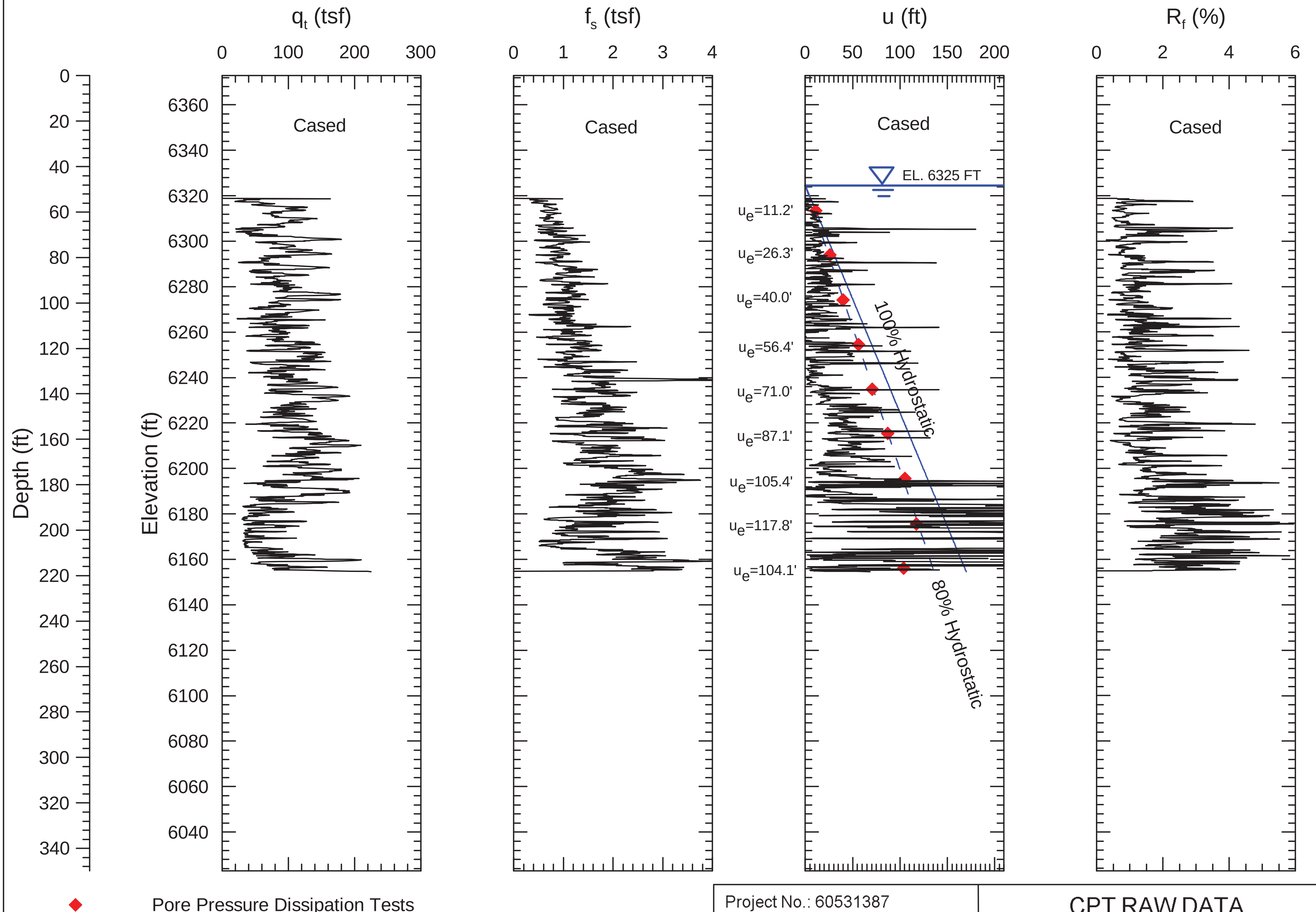
CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387
Prepared By: MEK
Date: 02/14/2017

Approximate Boundary Between
Dilative and Contractive Soil Response Using
Normalized CPT and Pore Pressure Parameters
CPT15-05

Fig. C-33



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	CPT RAW DATA Yankee Doodle TSF CPT15-07
Prepared By: MEK	
Date: 02/21/2017	

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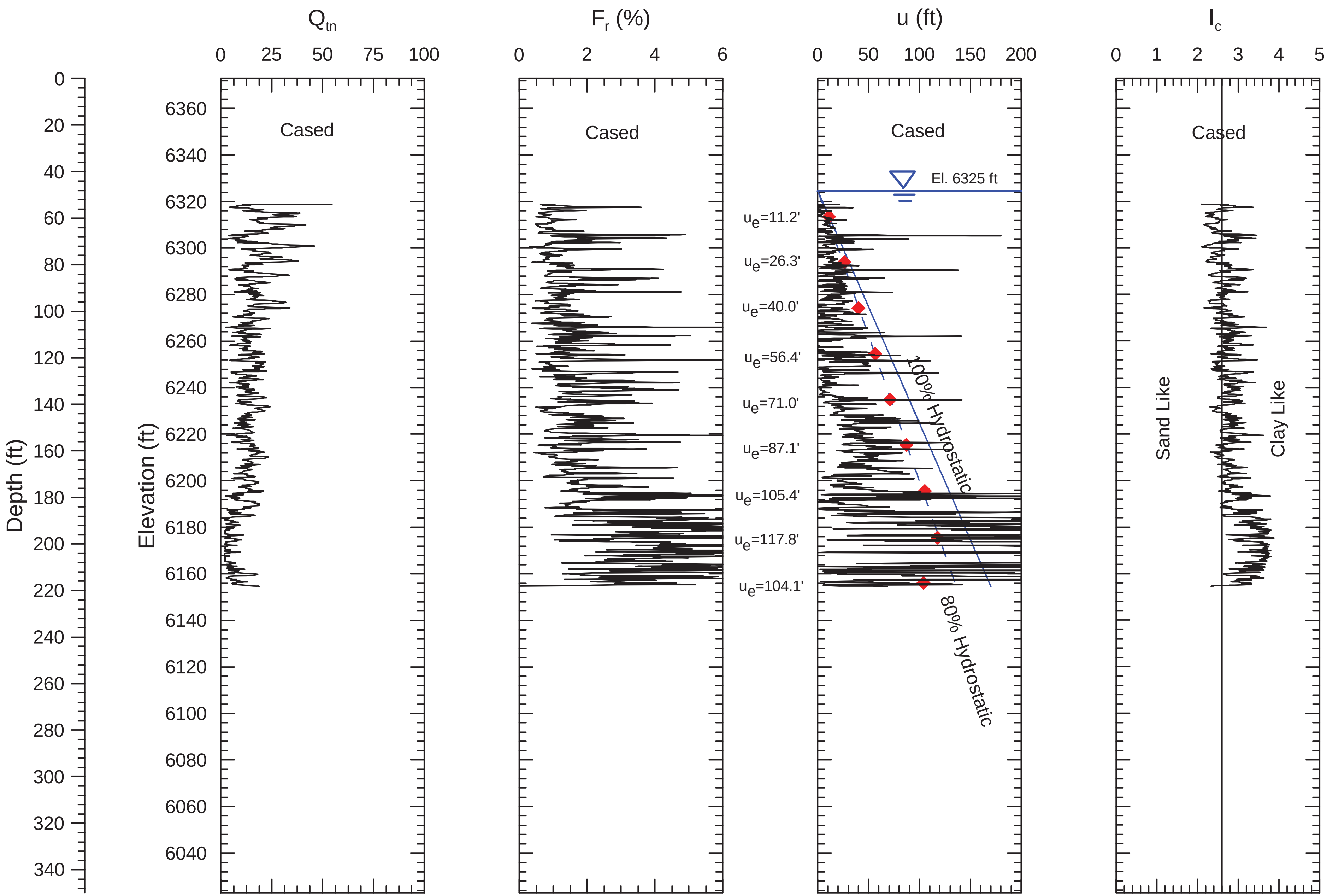
AECOM

Fig. C-34

AECOM



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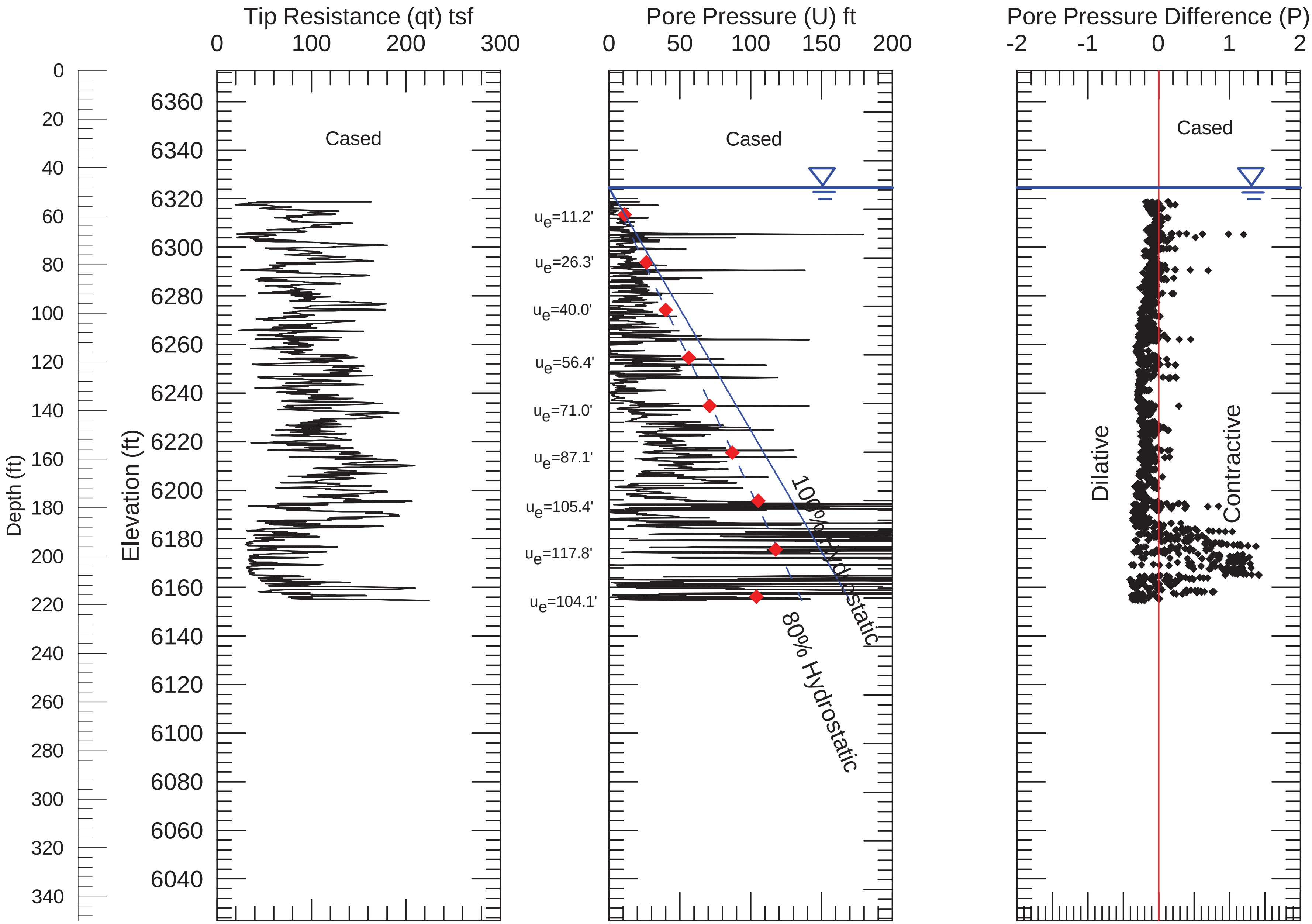
Pore Pressure Dissipation Tests

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT15-07
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-35

AECOM

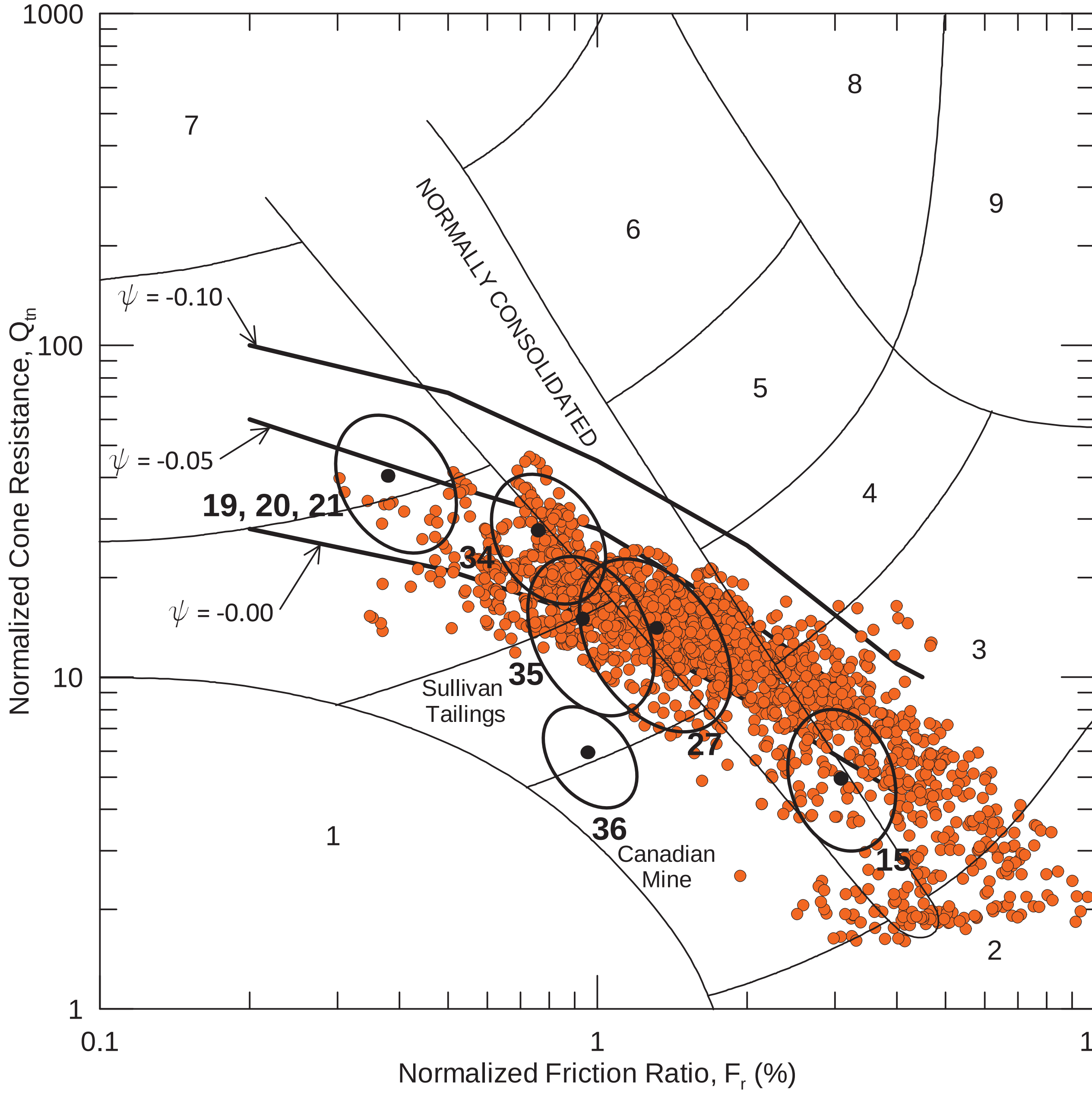


Pore Pressure Dissipation Tests

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No. 60531387	CPT15-07 Normalized Pore Pressure Difference
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-36



LEGEND

● Saturated Rockfill

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*

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters CPT15-07
Prepared By: MEK	
Date: 02/21/2017	

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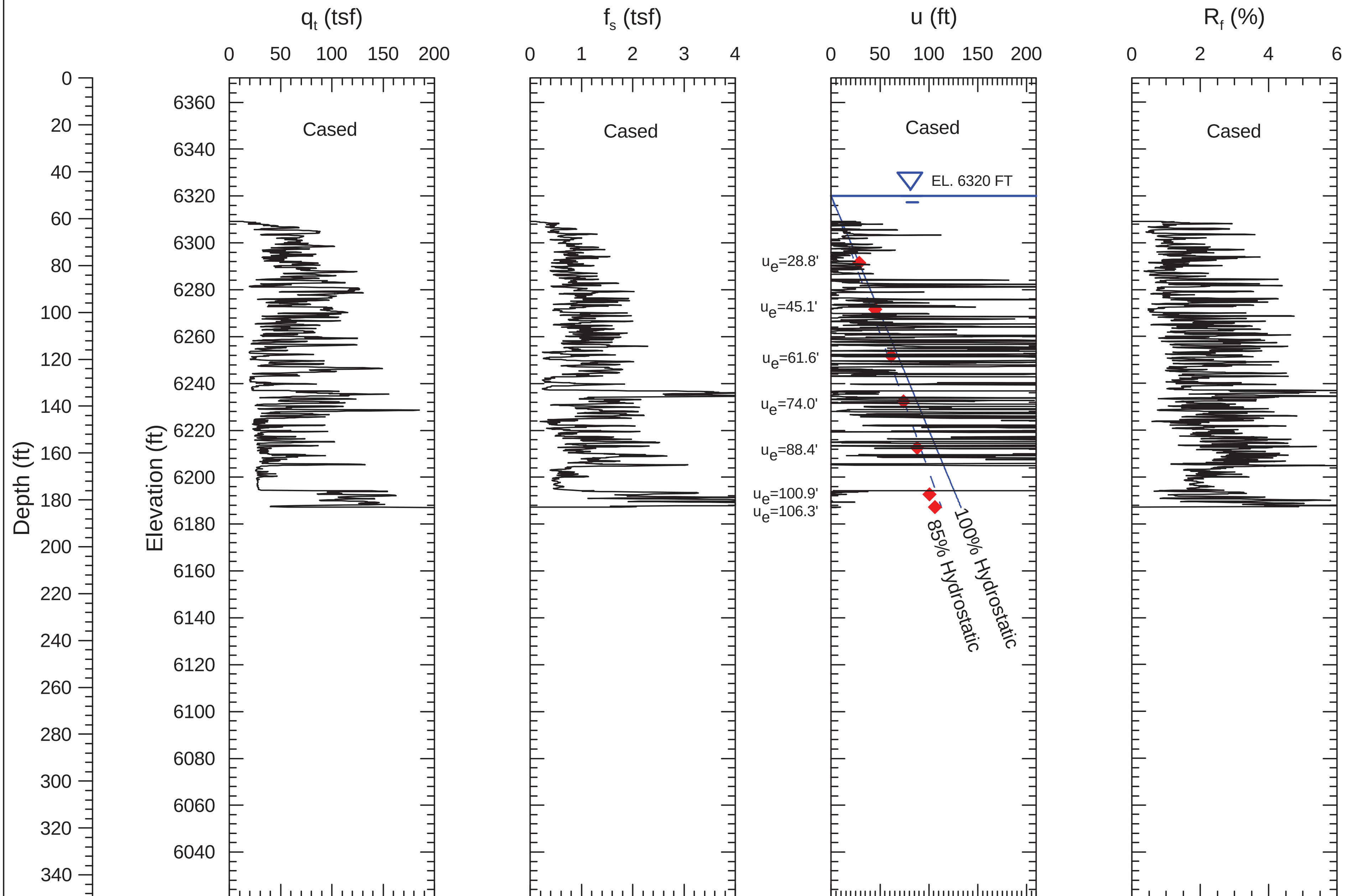
Fig. C-37



Pore Pressure Dissipation Tests

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	
Prepared By:	MEK
Date:	02/21/2017

CPT RAW DATA
Yankee Doodle TSF
CPT15-08

Fig. C-38

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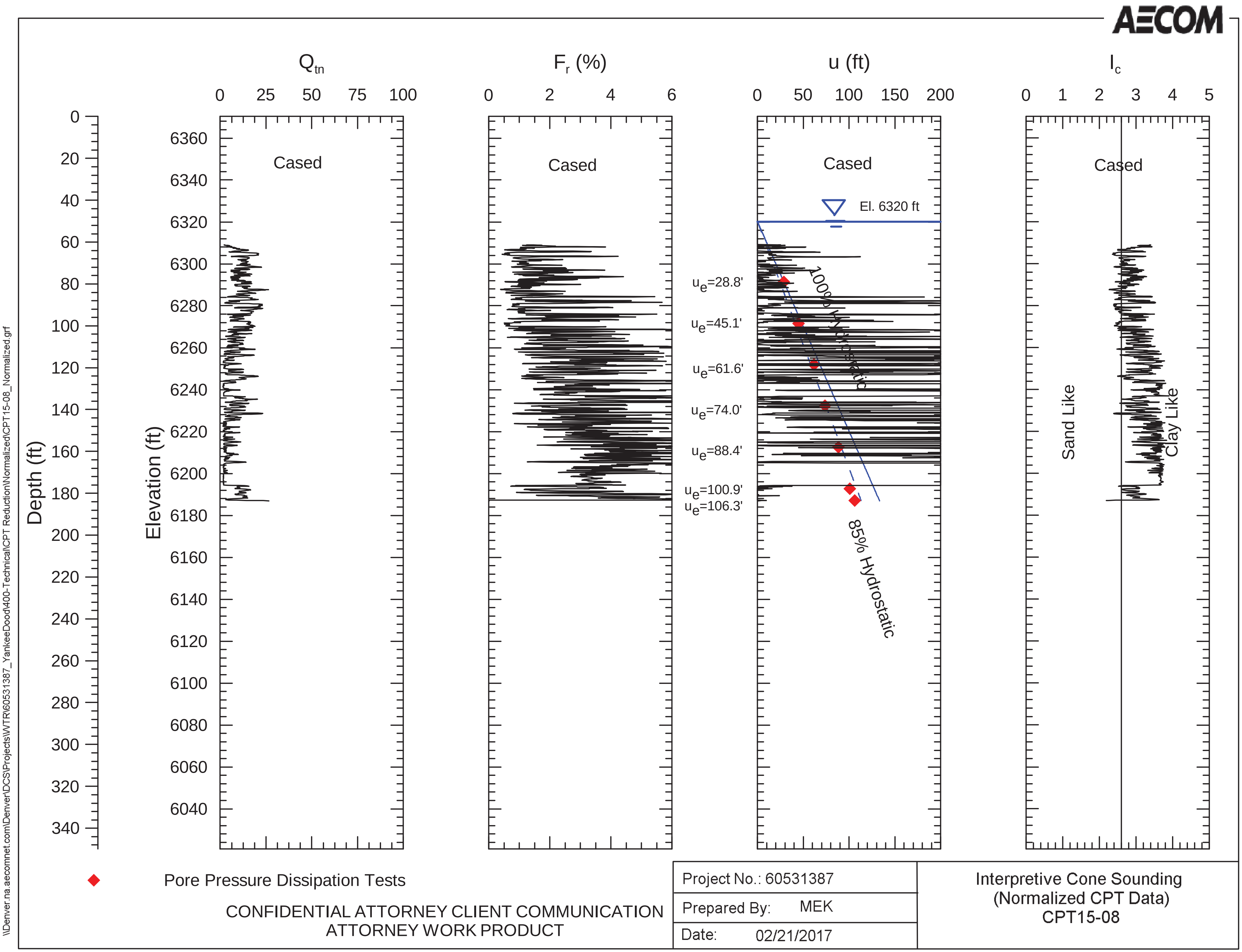
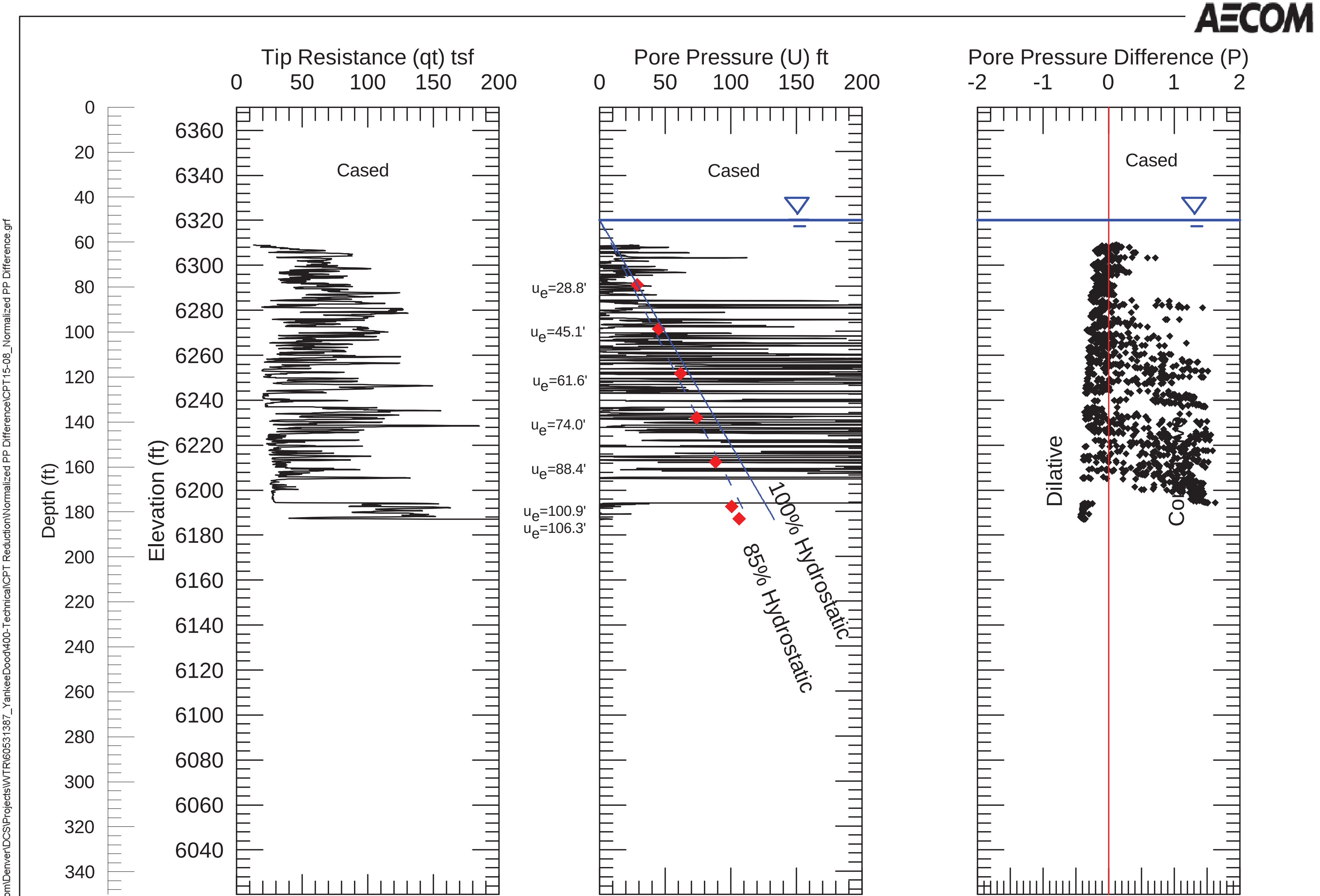


CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387	Interpretive Cone Sounding (Normalized CPT Data) CPT15-08
Prepared By: MEK	
Date: 02/21/2017	

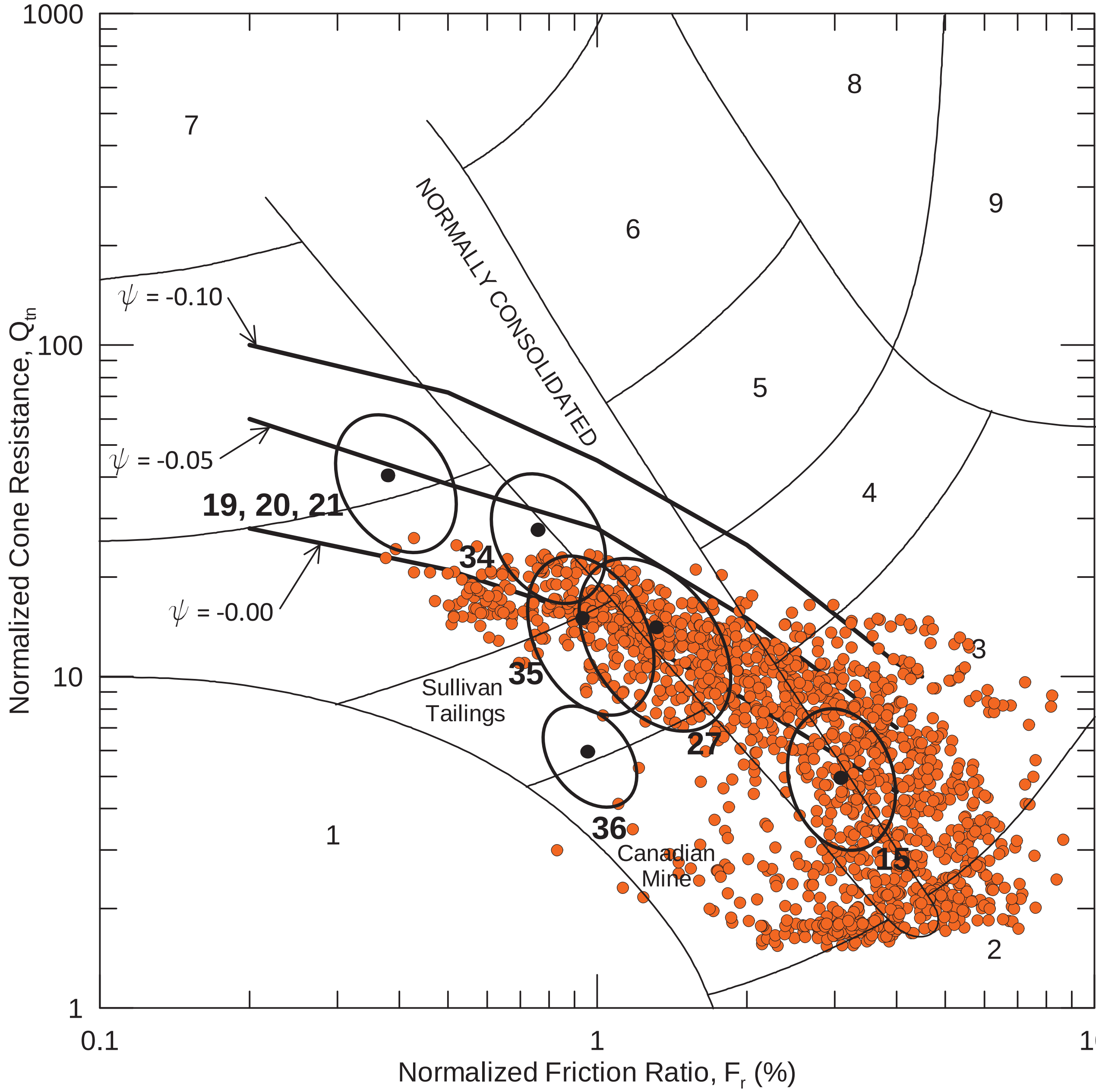
Fig. C-39



CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No. 60531387	CPT15-08 Normalized Pore Pressure Difference
Prepared By: MEK	
Date: 02/21/2017	

Fig. C-40



LEGEND

● Saturated Rockfill

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*

CONFIDENTIAL ATTORNEY CLIENT COMMUNICATION
ATTORNEY WORK PRODUCT

Project No.: 60531387
Prepared By: MEK
Date: 02/21/2017

Approximate Boundary Between Dilative and Contractive Soil Response Using Normalized CPT and Pore Pressure Parameters CPT15-08

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Fig. C-41