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Geotechnical Assessment Report

Delta Small Communities Flood Risk Reduction Program – Community of Hood

Sacramento County, California

Submitted to:
Sacramento County
827 7th Street, Room 301
Sacramento, CA 95814

Submitted by:
GEI Consultants, Inc.
2868 Prospect Park Drive, Suite 400
Rancho Cordova, CA 95670

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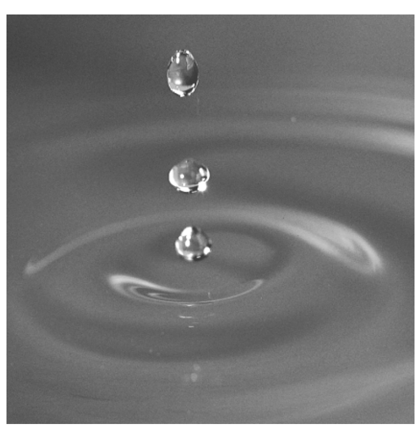

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Abbreviations and Acronyms

AWSE	Assessment Water Surface Elevation
CPT	Cone Penetrometer Test
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
DWR	Department of Water Resources
FSRP	Flood System Repair Project
GIS	geographic information system
HASP	Health and Safety Plan
HDERR	Hood East Railroad
HDSRR	Hood South Railroad
HNCL	Hood North Cross Levee
LiDAR	light detection and ranging
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NULE	Non-Urban Levee Evaluation
RD	Reclamation District
SCFRRP	Small Communities Flood Risk Reduction Program
SPFC	State Plan of Flood Control
ULDC	Urban Levee Design Criteria
ULE	Urban Levee Evaluation
USA	Underground Service Alert
USACE	United States Army Corps of Engineers

1 Introduction

1.1 Purpose and Scope

The California Department of Water Resources (DWR) Small Communities Flood Risk Reduction Program (SCFRRP) was created following adoption of the 2012 Central Valley Flood Protection Plan (CVFPP) by the Central Valley Flood Protection Board (CVFPB). Under the SCFRRP, Sacramento County, as the local land-use planning entity, was awarded a DWR grant in 2017 on behalf of the community of Hood, to prepare a Feasibility Study to identify and prioritize flood risk reduction management actions. This Geotechnical Assessment Report (Report) will be an appendix to and has been prepared to support the Feasibility Study.

The purpose of this Report is to summarize the available geotechnical information and geotechnical assessment completed for the levees protecting the community of Hood as shown on Figure 1. The geotechnical assessment completed for this Report included additional field exploration and screening level evaluation of existing levee conditions for the levees that surround the community of Hood. This Report will be used to support the Feasibility Study's evaluation of the structural alternatives for the community of Hood. The identification of conceptual remedial alternatives is essential to facilitate comparative costs assessment for the array of structural alternatives considered in the Feasibility Study.

1.2 Project Description

The levees protecting this community are constructed along the left bank of the Sacramento River (DWR Non-Urban Levee Evaluation [NULE] Segments 106), the RD 744 Cross Levee, the East Railroad Embankment, and the South Railroad Embankment as shown on Figure 1 and discussed in more detailed below. The levee segments surrounding the community of Hood include State Plan of Flood Control (SPFC), Non-SPFC levees, and railroad embankments. SPFC levees are a shared State-federal flood protection system that ensures the maintenance and management obligations are met. Non-SPFC levees and railroad embankments are not maintained by State-federal flood protection system. These levees encompass the community of Hood.

Along the Hood levees there are homes and other structures against the landside levee toe and within 15 feet of the toe, railroad embankments, and highway embankments that are adjacent to and cross over the levee at various locations.

1.2.1 Sacramento River (NULE Segment 106)

The Sacramento River left bank levee near Hood (NULE Segment 106) is an SPFC levee that extends approximately 9 miles along Sacramento River from near Freeport Avenue southward to just north of Courtland. The portion of this Sacramento River segment that protects the Community of Hood is approximately 2.5 miles long from the RD 744 cross levee to the former railroad embankment immediately south of Hood. Along this Sacramento River extent, flow is from north to south.

1.2.2 RD 744 Cross Levee (Segment HNCL)

The cross levee that is north of the Hood is approximately 0.25 miles long and extends from the MA 9 left bank Sacramento River levee east to the former railroad embankment. The cross levee is a non-SPFC levee and is a part of RD 744. This RD 744 cross levee was not a part of the NULE project or the SAFCA Evaluation.

1.2.3 South and East Railroad Embankments (Segments HDSRR and HDERR)

There are railroad embankments surrounding the community of Hood to the east and south. The railroad embankments are non-SPFC but are pertinent to the flood protection of the community of Hood, acting as levees to protect the community from flood waters from the south and east. The portions of the embankments protecting the community of Hood include approximately 2.4 miles of the embankment to the east of Hood and about 0.6 miles of embankment along the south end of the community. These former railroad embankments were not a part of the NULE project's assessment or the SAFCA Evaluation.

1.3 Background Information and Existing Data

The left bank Sacramento River levee protecting Hood was originally constructed by local interests in the mid-1800's to early 1900's and was brought up to federal standards by the United Sates Army Corps of Engineers (USACE) in between 1947 and 1955. Construction records for the levee are not available; however, it is assumed that a clam shell and/or suction dredger approach, commonly used during the time period, was likely used to construct the levees. The USACE improvements included bank protection along portions of the levee. Construction records for the cross levee to the north and former railroad embankment levees to the east and south of Hood are unavailable.

Based on historic past performance documentation, the Sacramento River levee protecting the community of Hood has experienced wide-spread seepage, boils, and waterside erosion. Past performance data was not available for the Cross Levee or Railroad Embankments.

An Existing Geotechnical Data Technical Memorandum (Appendix A) was prepared for Hood as an earlier task preceding the geotechnical assessment. The Existing Geotechnical

Data Technical Memorandum covers more details on the levee construction history, past levee performance, and the existing geotechnical information available prior to this study. Past performance records and existing exploration locations are included in Figure 2.

1.4 Project Stationing and Topography

The levee stationing used in this assessment along the Sacramento River has been adopted from the stationing developed by DWR for the Non-Urban Levee Evaluation (NULE) project. The stationing along the RD 744 cross levee and railroad embankments were created for this project. Stationing is shown in Figure 2.

Topographic mapping used for levee geometry for the Report assessment was developed using a light detection and ranging (LiDAR) data from DWR's Central Valley Floodplain Evaluation and Delineation (CVFED) LiDAR collected between October 2008 and February 2009. Metadata available with the CVFED LiDAR indicates the data meets the 3.5 feet horizontal accuracy standard at the 95 percent confidence level and post processed LiDAR elevations have been tested to 4-inch vertical accuracy at 95 percent confidence level.

The vertical datum used for elevations in this Report is the 1988 North American Vertical Datum (NAVD88). The horizontal datum is the North American Datum of 1983 (NAD83).

2 Field Exploration and Laboratory Testing

2.1 Purpose

The purpose of the subsurface exploration completed for this study was to gather information where there is currently no data and/or confirm the subsurface stratigraphy on the landside of the levee where data is limited. This additional information was intended to help fill data gaps for the geotechnical assessment.

2.2 Exploration Program Description

The selection of subsurface exploration locations and exploration depths was developed based on a review of available existing exploration data, reports, maps, geomorphologic data, topographic data, and other historical information available (summarized in Appendix A). Based on this review, subsurface exploration locations were chosen to:

- Assess embankment and foundation blanket conditions in areas where data gaps were identified based on existing explorations
- Collect samples of a range of embankment and foundation soils for testing and evaluation

The exploration program was developed to gather data for both the foundation materials and the levee embankment materials where possible. For SPFC levees, permits from United State Army Corps of Engineers (USACE) are required for drilling through the levee embankment and typically takes 6 months or longer to obtain. Therefore, only toe explorations were completed on the SPFC levees within the scope of this study. The field exploration program included advancing Cone Penetration Test (CPT) soundings and sampling at selected depths at each CPT location. CPT is a direct-push technology where an instrumented cone is pushed into the ground at a constant rate. Sensors in the cone provide essentially continuous measurements of tip resistance, sleeve friction, and dynamic pore pressure. This data can aid in the interpretation of materials encountered and can be used in future studies to help estimate engineering parameters using correlations, including friction angle, undrained shear strength, equivalent blow counts, and soil behavior type (a proxy to textural identification) for analyses.

Prior to the start of field explorations, the goals and challenges of the exploration program were identified through discussion and site reconnaissance with staff and the exploration subcontractor, ConeTec. Because this project involved exploration activities in a number of parcels owned by private landowners, site access agreements in these areas were coordinated during the exploration program planning by MBK Engineers (MBK). Other significant considerations of the exploration program included:

- Project goals and objectives;
- Project Health and Safety Plan (HASP)
- The scope of field explorations;
- Sampling procedures and sample requirements;
- Specific sampling targets and strategies to optimize sampling methods;
- Exploration depth targets;
- Site access and contact information;
- Utility clearance and permits;
- Site security and noise;
- Backfill requirements;
- Site restoration requirements

CPTs were advanced by ConeTec using a truck or track mounted CPT rig (depending on location) and a cone penetrometer with a cross-sectional area of 15 cm^2 and a resulting hole diameter of approximately 2 inches. The CPTs were performed in accordance with ASTM D5778, “Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.”

For this study, 11 CPTs were completed by GEI between August and November 2019. The 11 completed CPTs are summarized in Table 1 and shown in Figure 2. The CPTs located near the landside toe were approximately 15 feet or more from the landside toe, which is outside of the USACE levee easement. The depth of the CPTs ranged between 40 and 110 feet, approximately four times the levee height. A complete report on the CPT soundings, which includes plots of the CPT data is included as Appendix B.

Soil sampling consisted of advancing a second CPT probe adjacent to the first CPT and sampling at depths selected by the field engineer. Samples were collected in tubes and were bagged, labeled, and retained for visual inspection and potential laboratory testing. Upon completion the CPT probe holes were backfilled with a cement-bentonite grout mix in accordance with Sacramento County permit requirements and consistent with the standard of practice for levee evaluations in the area. The grout mix used for backfill contained approximately 5 percent bentonite to provide the grout some elasticity to help with shrinkage and cracking. The grout was placed in the hole by the tremie method, with the tremie pipe extending to the bottom of the hole. The tremie was removed as grout was being pumped; the bottom of the tremie was submerged in grout at all times. At the end of each day/next day, the holes were revisited and topped off with additional grout mix if needed.

In addition to soil sampling, pore pressure dissipation tests were conducted typically within granular materials below the water table. The test results were used to estimate the depth to groundwater. In a dissipation test, the CPT sounding is advanced to the estimated test depth, or as directed by the field representative, and then paused. The changes in the "dynamic" pressure is then monitored. Pore pressure data during the test are digitally recorded for subsequent analyses. After the dissipation test data are recorded, cone advancement is resumed. Dissipation test results are included in the CPT report (Appendix B). The interpreted depth to groundwater from the pore pressure dissipation tests are included in Table 1. Detailed methods and equipment used to advance the CPT soundings, is also included in Appendix B.

2.2.1 Health and Safety

A project-specific HASP (included in Appendix C) was developed for the subsurface field exploration. Field personnel were given a health and safety briefing by the Field Exploration Manager and also held daily health and safety tailgate meetings with subcontractors during the field exploration. Field personnel were also provided with specific guidelines and information about emergency action protocols, including the location of the closest emergency medical facility. Field personnel had no reportable incidents during field explorations.

2.2.2 Drilling Permit

GEI obtained a county well permit from the Sacramento County Environmental Management Department before starting the field exploration. A copy of the well permit is located in the Work Plan in Appendix C.

2.2.3 Utility Clearance

Each exploration location was visually observed for the presence of overhead and underground utilities and then outlined in white paint as required by Underground Service Alert (USA). USA was then contacted a minimum of two business days before subsurface exploration of the site. A USA ticket number as well as the clearance date, expiration date and extension date were obtained for the work area and documented in the project file.

2.2.4 Documentation of Exploration Locations

Field personnel and ConeTec used a handheld GPS unit to record CPT locations in the field. GPS coordinates and spatial references in the field were used to position the exploration locations in a geographic information system (GIS). The CVFED LiDAR topographic survey data was then used to estimate the ground surface elevations of each boring. Coordinates and estimated ground surface elevations are provided in Table 1. The locations are reported in feet, with reference to the NAVD88 vertical datum and NAD83 horizontal datum.

2.3 Geotechnical Laboratory Testing

Geotechnical laboratory tests were performed on selected samples obtained from the CPT sampling to assist with characterization of the embankment and foundation materials. The geotechnical laboratory testing for the explorations covered by this Report was performed by Blackburn Consulting, in West Sacramento, CA. Soil sample laboratory testing included:

- Sieve analysis with hydrometer, ASTM D6913 and D7928
- Fines content (percent passing #200), ASTM D1140
- Atterberg Limits, ASTM D4318

Laboratory test results are presented in Appendix D.

2.4 Quality Assurance and Quality Control

2.4.1 Cone Penetration Test and Data Quality Control

To confirm consistency and repeatability of collected CPT data, the measuring and test equipment used for ConeTec’s cone penetration testing was calibrated, adjusted, and maintained at intervals prescribed in the most current ASTM D5778 standard. The additional non-measuring parts of the cone (wear ring and cone body) were changed out whenever excessive wear was observed.

Checks of field equipment were performed before, during and after the execution of related field activities to ensure compliance with technical and quality requirements and specifications. A log of zero load baseline readings for every CPT sounding is maintained in a field log book. These recordings are maintained and reviewed by the field operator prior to performing a CPT sounding.

Field records (i.e. equipment serial numbers, load cell capacities, baselines and calibrations) having direct bearing on the quality of the work were maintained as the work progressed and were checked and verified for consistency and completeness by ConeTec. Any unusual or nonconforming equipment conditions were recorded and reported as required by ASTM and ConeTec’s standard operating procedures.

The documents resulting from the CPT work were controlled in the field and subsequently in a completed final report (Appendix B). The final report submitted to the client was prepared by either the ConeTec project manager, field manager, or regional manager, and reviewed by ConeTec's technical oversight (technical manager, regional manager, and/or field manager, who was not responsible for the original data processing).

2.4.2 Laboratory Testing and Test Results

While the tests were in progress, project team engineers/geologists reviewed test results as they became available, maintained regular coordination with the laboratory representatives, addressed questions posed by laboratory representatives and provided additional instructions as necessary.

Laboratory index test results were reviewed by project team engineers/geologists to gauge conformance with CPT interpretations. If laboratory results were in conflict with the field data, the matter was typically resolved through a visual check and classification of a sample of the soil in question.

3 Site Conditions

3.1 Regional Geology

The study area is located in the Sacramento San Joaquin River Delta. The Delta is formed at the western edge of the Central Valley by the confluence of the Sacramento and San Joaquin Rivers and lies just east of where the rivers enter the Suisun Bay.

The Delta was formed by the raising of sea level, leading to the accumulation of Sacramento and San Joaquin River sediments. The Delta was a large freshwater marsh consisting of many shallow channels and sloughs surrounding low islands of peat and Tule.

3.2 Geomorphology

Geomorphic classification maps prepared for the DWR NULE project were reviewed to aid in the assessment of foundation conditions that could affect the vulnerability of the levees. The purposes of the review were to identify depositional conditions that could be linked to past performance issues and provide context for the limited existing subsurface exploration data.

The geomorphic analyses performed for the NULE project consisted of Level 2-I analyses and Level 2-II analyses. NULE Level 2-I mapping was based primarily on the compilation and analysis of existing regional geologic and geomorphic information (e.g., soil survey maps, geologic maps). Level 2-I analyses provided geologic and geomorphic maps at a regional scale, preliminary assessments of the hazard of levee underseepage, and information on soft soil areas and subsidence. The North NULE Level 2-I Geomorphic Assessment was completed in April 2010 (DWR, 2011) and included the entire community of Hood levee system.

NULE Level 2-II studies yielded detailed geologic and geomorphic information and involved the integration and analysis of aerial photography, topographic maps, geologic maps, soil maps, and historical documents. Synthesis of these data helped construct a detailed surficial geologic map, develop an assessment of the primary geomorphic processes responsible for distributing or modifying surficial deposits in the study area, and develop levee underseepage susceptibility hazard maps. The Level 2-II Geomorphic Assessment and Surficial Mapping was completed in December 2010 (DWR, 2011) and included the Sacramento River and a portion of The Meadows Slough within the community of Hood.

DWR' report (DWR, 2011) covering the community of Hood basin, geologic, and underseepage susceptibility maps are included in Appendix C of the Existing Geotechnical Data Technical Memorandum which is Appendix A to this report.

Sacramento River (NULE Segment 106), NULE Level 2-II mapping indicates Segments 106 levees overlay Historic and Holocene overbank deposits consisting of interbedded silt, sand and clay that likely interfingers with adjacent flood plain silt and clay sediments and are likely to vary laterally in extent and character. The Level 2-II mapping also indicates that the levee overlies recent channel (well sorted sand and trace fine gravel) (DWR, 2011).

RD 744 cross levee (Segment HNCL) is covered by Level 2-II NULE geomorphic mapping. Based on the Level 2-II mapping, the cross levee overlies Historic and Holocene overbank deposits consisting of interbedded silt, sand and clay that likely interfingers with adjacent flood plain silt and clay sediments.

The east railroad embankments (Segment HDERR) is covered by Level 2-II NULE geomorphic mapping. Based on the Level 2-II mapping, the northern half of the segment overlies Historic and Holocene overbank deposits consisting of interbedded silt, sand and clay that likely interfingers with adjacent flood plain silt and clay sediments. Whereas the southern half overlies marsh deposits (silt and clay with organic-rich soils) and riverbank formation (consolidated gravel, sand, silt, and clay).

The southern railroad embankments (Segment HDSRR) is covered by Level 2-II NULE geomorphic mapping. Based on the Level 2-II mapping, the embankment overlies basin deposits (fine sand, silt, and clay) and marsh deposits (silt and clay with organic-rich soils). The level 2-II mapping also indicates the embankment overlies a Holocene channel deposit that consists of well sorted sand and trace fine gravel.

3.3 Sacramento River (NULE Segment 106)

In addition to geomorphology, historical explorations compiled from available references and CPTs performed for this study area, were used to assess the embankment and subsurface conditions along the Sacramento River levee protecting the community of Hood (NULE Segment 106).

3.3.1 Embankment Conditions

No CPTs performed for this study area were collected through the levee prism of the Sacramento River due to permitting requirements for performing explorations through federal “project” levees, as in Section 2.2 above. As such, embankment composition was assessed based on the conditions identified in historic data. One historic exploration was available. This exploration indicates that the embankment consists of sand and sandy silt. The historic exploration log is contained in Appendix A.

3.3.2 Foundation Conditions

Available explorations for the interpretation of foundation conditions were generally limited to explorations through the levee crown and landside toe. Only one exploration was available on the waterside, and it was an overwater boring.

Available explorations along Segment 106 included six historical explorations and two CPTs completed for this study area. Four of these explorations indicate a fine-grained blanket ranging in thickness from 7 to 33 feet thick with three explorations showing a shallow unit of coarse/sandy material is present along the segment.

Where a thin blanket condition was indicated, it is underlain by a pervious aquifer layer extending to depths of at least 20 feet. No fine-grained aquitard layer was encountered as the explorations were terminated within the aquifer. The deepest exploration that encountered a thin blanket condition was terminated at a depth of approximately 20 feet.

Three of the available explorations along Segment 106 indicate a shallow unit of coarse/sandy material is present along the reach. The coarse/sandy material is underlain by a fine-grained shallow aquitard.

The historic exploration logs/sticks are in included in Appendix A and the CPT plots for this study area are in Appendix B.

3.4 RD 744 Cross Levee (Segment HNCL)

No historical explorations were available for Segment HNCL. Two CPTs were completed along this levee segment for the community of Hood and were used to estimate the levee segment's subsurface conditions along with geomorphology.

3.4.1 Embankment Conditions

The two CPTs completed for the RD 744 Cross Levee in the community of Hood were performed from the levee crest and used to assess the embankment conditions. These CPTs indicate the embankment consists of sand and silt. The CPT plots are in Appendix B.

3.4.2 Foundation Conditions

The two explorations available for the RD744 Cross Levee in the community of Hood indicate a fine-grained layer ranging in thickness from at least 20 to at least 49 feet thick. In both explorations they were terminated in the fine-grained layer. The CPT plots are in Appendix B.

3.5 East Railroad Embankment (Segment HDERR)

No historical explorations were available for Segment HDERR. Four CPTs were completed along this levee segment for the community of Hood and were used to estimate the levee segment's subsurface conditions along with geomorphology.

3.5.1 Embankment Conditions

The four CPTs completed for the East Railroad Embankment in the community of Hood were performed from the levee crest and used to assess the embankment conditions. These CPTs indicate the embankment consists of silt and clay. The CPT plots are in Appendix B.

3.5.2 Foundation Conditions

The four explorations available for the East Railroad Embankment in the community of Hood indicate a fine-grained layer ranging in thickness from at 21 to at least 65 feet thick. The only exploration that was not terminated in the fine-grained layer indicated that the blanket was underlain by approximately 21 feet of sandy aquifer. That exploration indicates that the aquifer is underlain by fine-grained aquitard. The CPT plots are in Appendix B.

3.6 South Railroad Embankment (Segment HDSRR)

No historical explorations were available for Segment HDSRR. Two CPTs were completed along this levee segment for the community of Hood and were used to estimate the levee segment's subsurface conditions along with geomorphology.

3.6.1 Embankment Conditions

The two CPTs completed for the South Railroad Embankment in the community of Hood were performed from the levee crest and used to assess the embankment conditions. These CPTs indicate the embankment consists of silt, sand, and clay. The CPT plots are in Appendix B.

3.6.2 Foundation Conditions

The two explorations available for the South Railroad Embankment in the community of Hood indicate a fine-grained layer up to 32 feet thick. The only exploration that fully penetrated the blanket layer indicated that it was underlain by approximately 18 feet of sandy aquifer. That exploration indicates that the aquifer is underlain by fine-grained aquitard. The CPT plots are in Appendix B.

4 Assessment Approach and Criteria

The assessment of existing condition and conceptual remediation requirements of various segments of the levees within the study area was based on available existing information (Appendix A) and data collected during the field exploration summarized in Section 2. The geotechnical assessment presented in this Report was performed to assess existing conditions vulnerability of the levees under 100-year flood conditions. The assessment performed for this study area consisted of a paper study and modeled analysis was not performed. The levee was evaluated at the assessment water surface elevation (AWSE) based on the hydraulic profile from hydraulic analysis performed by GEI (GEI, 2020). The AWSE incorporates proposed future projects, sea level rise, and climate change. Additional detail on the AWSE profile can be found in the hydrology and hydraulics technical memorandum prepared for this Project (GEI, 2020). The AWSE for the cross levee was determined based on a breach analysis that assumed a breach had flooded RD 744. The purpose of this screening level assessment was to identify stretches of levee that are potentially vulnerable to underseepage, through seepage, slope instability, erosion, and freeboard and develop dimensions for conceptual level levee remediations. The identification of conceptual remedial alternatives will support the comparative costs assessment for the array of structural alternatives considered in the Feasibility Study.

Each levee segment was divided into reaches of similar conditions by evaluating cross-sections at 500-foot spacing along the levee alignment and comparing factors including levee geometry, head pressure, blanket thickness/presence, embankment materials, foundation materials, and reported past performance. As a result of this assessment the levees surrounding the community of Hood were subdivided into six reaches as summarized in Table 2 and shown on Figure 3.

Assessment also considered the understanding of geotechnical conditions from two prior studies, the NULE Phase 1 Geotechnical Assessment and DWR's Flood System Repair Project (FSRP). The NULE Phase 1 geotechnical assessments were utilized on non-intrusive studies and readily available data to evaluate hazard indicators and levee performance history as the basis for categorizing each levee segment for four potential failure mechanisms: underseepage, slope stability, through seepage, and erosion. The FSRP program evaluated past performance records project for non-urban SPFC levees through existing documentation and field reconnaissance and identified critical and serious sites for repair. Further description and results identified by these studies are included in Existing Geotechnical Data Technical Memorandum prepared for Hood (Appendix A). For the community of Hood, the FRSP identified one serious seepage site and two critical seepage sites.

4.1 Geotechnical Evaluation of Underseepage

Underseepage issues along levees generally occur when there is a pervious foundation layer, or aquifer, that is overlain by a relatively continuous top stratum of semi-pervious or impervious soil, or where the levee is built directly on a pervious stratum. The impervious or semi-pervious top stratum, or blanket, tends to confine seepage from the river through the aquifer to the landside area beyond the levee, thus allowing seepage pressures to build up in the aquifer beneath the blanket. If the pressures are high enough and the blanket is thin enough, the pressures may crack and uplift the blanket (often referred to as “heave”) allowing concentrated flows to occur and the formation of sand boils. If an erosion pipe forms (which would require overlying materials that are able to support the development of a “roof”) that extends continuously under the levee to the river, seepage flows could increase causing further erosion, eventually leading to collapse of the pipe, settlement/deformation of the levee and subsequent breaching of the levee. For blanket layers consisting of semi-pervious, low plasticity soils (i.e. plasticity index less than 7) subjected to excessive hydraulic gradients, the hydraulic conductivity may be high enough to allow flow through the top stratum at sufficient velocity to initiate internal erosion and piping without heaving or cracking the blanket layer.

The assessment for underseepage vulnerability was completed by comparing the head at the base of the fine-grained blanket layer to the fine-grained blanket thickness (where present) using a unitless parameter known as an exit gradient and evaluating it against an average vertical exit gradient criterion of 0.5 (United States Army Corps of Engineers [USACE] EM 1110-1-1913). Where ditches/depressions occurred at a distance from the landside toe, the exit gradient criterion was increased to 0.8 at 150 feet or greater beyond the toe with linear interpolation between the landside toe and 150 feet from the toe.

The exit gradient is calculated as the head at the base of the blanket (net head minus an assumed 2 feet of head loss) divided by the blanket thickness. For this study, the head at the base of the blanket was estimated from the AWSE, subtracting 2 feet for head loss in the aquifer and then subtracting the landside toe elevation. An average vertical exit gradient of 0.5 (criterion per USACE EM 1110-1-1913) corresponds to a factor of safety of 1.6 for an assumed saturated unit weight of soil equal to 112.5 pounds per cubic foot. Based on this relationship and an exit gradient criterion of 0.5 the estimated required blanket thickness is computed as shown below:

Estimated required blanket thickness = (Net Head – 2 ft) / 0.5

If available information indicates that the blanket thickness is less than the estimated required blanket thickness, it assumed for this study that the levee is vulnerable to underseepage.

Additionally, if no fine-grained blanket material was present beneath the levee, referred to in this report as a “leaker” condition, a Creep Ratio calculation was performed where sandy soil layers exist in the upper foundation. Creep Ratio is a metric for evaluating the risk of backward erosion of a sandy layer below a hypothetical impermeable roof, which is considered not erodible. Creep Ratios were originally based on observations of piping occurring from foundations supporting masonry dams, but the use of Creep Ratios for evaluation of levees provides an indication of conditions that may lead to piping and backward erosion of the foundation. Backward erosion is a mechanical process that initiates and continues if the hydraulic shear forces are of a sufficient magnitude to detach soil particles and no compatible filter is in place to arrest the erosion process. Use of creep ratio for evaluation of this potential condition in levees in consistent with the *Guidance Document for Geotechnical Analysis* (ULE Guidance Document) prepared for the DWR Urban Levee Evaluation (ULE) project (DWR, 2015) and the International Levee Handbook (CIRIA, 2013). The calculation compares the seepage flow distance, or the levee base width (W), to the Net Head (h_{cr}).

Specific critical Creep Ratios, or creep factors, have been identified for different soil types, with more erodible soils (i.e. fine sands or silt) requiring a greater base width for a given hydraulic head. For purposes of this screening level study, where a “leaker” condition was indicated, a conservative assumption was made to treat the material as very fine sand for purposes of creep ratio evaluation. Bligh (1927) provides a creep factor of 18 for very fine sand, indicating that if a site’s base width/net head ratio is less than the 18, it would be susceptible to backward erosion and piping (assuming no flow through the overlying structure) (CIRIA, 2013). The use of Creep Ratios for this evaluation provides a relative indication of conditions that may be more vulnerable to “leaker” seepage and/piping.

Where available geotechnical data indicated the presence of silt in the shallow foundation, engineering judgement was used to determine the characteristics of the underlying material would act as a blanket condition or a leaker condition. For example, if a high fines content silt was present underlain by a sand, the silt would likely act as confining layer creating a blanket condition. Alternatively, a sandy silt underlain by a clay layer would create a leaker condition.

4.2 Geotechnical Evaluation of Through Seepage

Through levee seepage is a concern principally in cohesionless soils within the levee embankment where a high phreatic line can develop during the relatively short duration of a flood event, and when the phreatic surface intersects and exits on the landside slope. In such a case, there is a concern for both slope stability and for removal of soil particles by the exit flows, commonly known as backward erosion. As described above, backward erosion is a mechanical process that initiates and continues if the hydraulic shear forces are of a sufficient magnitude to detach soil particles and no compatible filter is in place to arrest the erosion process. Therefore, the composition and potential erodibility of the levee embankment must be assessed. It is commonly accepted that if the embankment materials are cohesive and not susceptible to backward erosion (i.e. plasticity index greater than 7), remedial measures are not generally required (FEMA, 2011). Further, such soils may not develop a high phreatic line during the short duration of a flood event due to their low hydraulic conductivity. If the embankment materials are susceptible to backward erosion (i.e. fine-grained soils with a plasticity index less than 7 or uniformly graded granular soils), remedial measures may be required.

Through seepage was assessed using phreatic surface breakout (i.e. at least 1 foot above the landside levee toe) and composition and erodibility of the embankment (i.e. sand or silt). This approach is generally consistent with past levee feasibility assessments such as DWR’s ULE and NULE projects.

Based on review of available embankment data, it appears a majority of the study area levees are constructed of erodible material. Therefore, for this assessment, screening for through seepage vulnerability relied on the estimated phreatic breakout height, which was related to the AWSE height above the waterside toe through a series of sensitivity seepage analyses performed varying the embankment geometry and soil type of the shallow foundation material (Figure 4 and Figure 5). The sensitivity analyses involved a theoretical homogeneous levee modeled in Geostudio SEEP/W software to estimate the amount of head on the waterside of the levee above the landside toe elevation, also referred to as “head differential”, that would result in a phreatic breakout of 1 foot. The head values were then used as the screening criteria for through seepage vulnerability based on geometry and shallow subsurface conditions.

The embankment was assumed to be an erodible silty sand material during the sensitivity analyses which was conservative, resulting in a more limited head drop across the levee prism (i.e. higher breakout for a given AWSE). The ranges of embankment geometry and shallow foundation soil types were based on data collected throughout the study area. The shallow foundation conditions varied from a blanket condition/confining layer condition (i.e. lower hydraulic conductivity lean clay) to a no-blanket condition/non-confining layer condition (i.e. higher hydraulic conductivity silty sand). The hydraulic conductivity parameters were selected based on the recommended values published in the ULE Guidance Document (DWR, 2015). Based on the data summarized in Section 4 of the ULE Guidance Document (DWR, 2015) the following parameters were used in the seepage models:

- Erodible Embankment (silty sand) with a vertical hydraulic conductivity of $6x10^{-4}$ cm/sec

- Blanket/Confining Foundation (lean clay) with a vertical hydraulic conductivity of $5x10^{-6}$ cm/sec
- No-blanket/Non-confining Foundation (silty sand) with a vertical hydraulic conductivity of $6x10^{-4}$ cm/sec

For these models, an anisotropy ratio (k_v/k_h) of 0.25 was assumed for each material. For evaluating the effect of levee geometry on through seepage vulnerability, a crest width of 20 feet was assumed and the landside and waterside slopes were varied to create a range of embankment base widths. Analyses were performed with 95-, 120-, 145-, 170-, 195-, 220-, and 245-foot base widths. The 95-foot base width case is presented as an example (Figure 4) and the results for all base widths are summarized and plotted in Figure 5. For screening, the results established the criteria for levees up to the next analysis base width (i.e. the 95-foot base width case was used for levees with base widths ranging from 95 to 119 feet). This was considered a reasonable, but still conservative approach for this screening level study. Where no data on the embankment composition was available the material was conservatively assumed to be erodible.

4.3 Geotechnical Evaluation of Slope Stability

To assess the stability of the levees for this study, the slopes were compared to typical design slopes as described in the DWR Urban Levee Design Criteria (ULDC) guidance (DWR, 2012) and EM 1110-1-1913. The geometry guidance for existing levee slopes are generally 2 horizontal(H) : 1 vertical(V) for the landslide slope and 3H:1V for the waterside slope. At locations where the slopes were steeper than these typical slopes, the overall levee geometry was assessed to establish if the levee section in those locations appear to be overbuilt (i.e. wide crest width/base width). If the levee appears to be overbuilt, the levee was not identified as vulnerable to slope instability, since slope instability would be less likely to encroach on the central portion of the levee associated with the typical design prism for the project. If the levee was not overbuilt, and the slopes were steeper than those discussed above, then the levee was identified as vulnerable to slope instability.

4.4 Evaluation of Erosion

For the purposes of evaluating the vulnerability of the Hood study area levees to erosion, considerations included a qualitative assessment of the overall levee geometry, oversteepening of the waterside slopes, past erosion performance, documented mitigation, and potential erodibility of the embankment material.

The vulnerability assessment focused on erosion that could threaten the integrity of the levee (referred to as erosion-driven failure) indicated by oversteepened slopes that encroach on the standard levee prism as described above. This is in contrast to minor erosion/sloughing that can be addressed by regular observation and maintenance of the levee slope. If not properly maintained, this type of minor erosion can progress and begin to threaten the levee integrity.

4.5 Evaluation of Freeboard

To limit overtopping risk, FEMA requires riverine levees must provide a minimum freeboard of three feet above the 100-year water-surface level. For this study, freeboard was assessed at each 500-foot cross-section by comparing the existing levees crest elevations (taken from LiDAR data at the stationing alignment location on the crown) to a threshold set three feet above the AWSE. In areas that have an adequate amount of freeboard, there was approximately 3 to 7 feet.

5 Discussion of Site Specific Assessment

5.1 Sacramento River (NULE Segment 106)

The Sacramento River levee segment in the Hood study area constitutes of one reach based on the assessment approach described in Section 4. The reach and location of available explorations are shown in Figure 2. Segment 106 is located at the western portion of the Hood study area along the Sacramento River between Segment North CL and South RR. The assessments performed for this study are described below for this reach. Appendix E provides the Hood Assessment Table that includes the assessment details for cross-sections every 500-feet along the levee.

5.1.1 Reach 106-A

Reach 106-A is 13,053 feet long and is located between Station 3107+39 and Station 3237+92. Six explorations are located along the levee toe within the reach and one exploration is located along the levee crest. This reach was identified as vulnerable to underseepage due to a blanket condition shown in one exploration that is thinner at the landside toe than the estimated required blanket thicknesses in the reach, calculated as described in Section 4.1. Additionally, three explorations indicate a leaker condition with a creep ratio that does not meet criteria as described in Section 4.2. This is consistent with reports of past performance including seepage and boils throughout the reach. Approximately a quarter of the reach is identified as FSRP sites. The FSRP table and map of these sites are included in the Existing Geotechnical Data Technical Memorandum (Appendix A). This reach was also identified as vulnerable to through seepage because of erodible embankment material and the AWSE is higher than the criteria described in Section 4.2.

The reach was not identified as vulnerable to landside slope instability since the landside slopes along the majority of the reach are flatter than 2H:1V with an average of 2.4H:1V. In the isolated locations where landside slopes are steeper than 2H:1V, the levee crest is larger than 20 feet, indicating that the levee is overbuilt at these locations. Additionally, documented history of landside slope instability is documented at only one location and the levee is overbuilt in that area.

The reach was not identified as vulnerable to erosion-driven failure despite the erodible embankment material and waterside slopes along the majority of the reach being steeper than 3H:1V with an average of 2.2H:1V. In the locations where waterside slopes are steeper than 3H:1V, the levee crest is larger than 20 feet, indicating that the levee is overbuilt at these locations. Erosion could be addressed as a maintenance issue, however if left unmaintained, the levee could become vulnerable over time.

The assessment found that approximately 90% of Reach 106-A has sufficient freeboard of 3 feet or more for the AWSE. The deficient 10%, or approximately 1250 feet of levee, is located at the southern end of the reach near Segment South RR and has an average freeboard of 2.8 feet.

5.2 RD 744 Cross Levee (Segment HNCL)

The RD 744 Cross Levee segment in the Hood study area constitutes of one reach based on the assessment approach described in Section 4. The reach and location of available explorations are shown in Figure 2. Segment HNCL is located at the northern portion of the Hood study area along the RD 744 Cross Levee between Segment 106 and East RR. The assessments performed for this study are described below for this reach. Appendix E provides the Hood Assessment Table that includes the assessment details for cross-sections every 500-feet along the levee.

5.2.1 Reach HNCL

Reach HNCL is 1,300 feet long and is located between Station 0+00 and Station 13+00. Two explorations are located along the levee crown within the reach. This reach was identified as vulnerable to underseepage due to a blanket condition shown in the explorations at the landside toe that is less than the estimated required blanket thicknesses in the reach as described in Section 4.2. This reach was also identified as vulnerable to through seepage because of erodible embankment material and the AWSE is higher than the criteria described in Section 4.2.

The reach was not identified as vulnerable to landside slope instability despite the landside slopes along the majority of the reach being steeper than 2H:1V with an average of 1.4H:1V. In the locations where landside slopes are steeper than 2H:1V, the levee crest is larger than 20 feet, indicating that the levee is overbuilt at these locations. Additionally, no history of landside slope instability has been documented.

The reach was not identified as vulnerable to erosion-driven failure despite the erodible embankment material and waterside slopes along the reach being steeper than 3H:1V with an average of 4.8H:1V. In the locations where waterside slopes are steeper than 3H:1V, the levee crest is larger than 20 feet, indicating that the levee is overbuilt at these locations. Erosion could be addressed as a maintenance issue, however if left unmaintained, the levee could become vulnerable over time.

The assessment found that all of Reach HNCL does not have a sufficient freeboard of 3 feet or more for the AWSE.

5.3 East Railroad Embankment (Segment HDERR)

The East Railroad Embankment segment in the Hood study area constitutes of three reaches based on the assessment approach described in Section 4. The reaches and location of available explorations are shown in Figure 2. Segment HDERR is located at the eastern portion of the Hood study area along the East Railroad Embankment between Segment HNCL and HDSRR. The assessment indicates that none of the HDERR reaches have insufficient freeboard. The other assessments are described below individually for each reach. Appendix E provides the Hood Assessment Table that includes the assessment details for cross-sections every 500-feet along the levee.

5.3.1 Reach HDERR-A

Reach HDERR-A is 4,500 feet long and is located between Station 0+00 and Station 45+00. Two explorations are located along the levee crown within the reach. This reach was not identified as vulnerable to underseepage due to a blanket condition shown in the explorations that is greater at the landside toe than the estimated required blanket thicknesses in the reach, calculated as described in Section 4.1. This reach was identified as vulnerable to through seepage because of erodible embankment material and the AWSE is higher than the criteria described in Section 4.2.

The reach was not identified as vulnerable to landside slope instability since the landside slopes along the majority of the reach are flatter than 2H:1V with an average of 2.5H:1V. In the isolated location where the landside slope is steeper than 2H:1V, the levee crest is larger than 20 feet, indicating that the levee is overbuilt at this location. Additionally, no history of landside slope instability has been documented.

The reach was identified as vulnerable to erosion-driven failure due to the erodible embankment material, narrow crest width at some locations, and waterside slopes along the reach being steeper than 3H:1V with an average of 1.9H:1V.

5.3.2 Reach HDERR-B

Reach HDERR-B is 4,500 feet long and is located between Station 45+00 and Station 90+00. One exploration is located along the levee toe within the reach. This reach was identified as vulnerable to underseepage due to a blanket condition shown in the exploration that is thinner at the landside toe than the estimated required blanket thicknesses in the reach, calculated as described in Section 4.1. This reach was also identified as vulnerable to through seepage because of erodible embankment material and the AWSE is higher than the criteria described in Section 4.2.

The reach was identified as vulnerable to landside slope instability due to the narrow crest width at some locations and the landside slopes along the majority of the reach being steeper than 2H:1V with an average of 1.7H:1V.

The reach was identified as vulnerable to erosion-driven failure due to the erodible embankment material, narrow crest width at some locations, and waterside slopes along the reach being steeper than 3H:1V with an average of 1.6H:1V.

5.3.3 Reach HDERR-C

Reach HDERR-C is 4,125 feet long and is located between Station 90+00 and Station 131+25. One exploration is located along the levee crown within the reach. This reach was not identified as vulnerable to underseepage due to a blanket condition shown in the exploration that is greater at the landside toe than the estimated required blanket thicknesses in the reach, calculated as described in Section 4.1. This reach was not identified as vulnerable to through seepage because of non-erodible embankment material. These assessments were based on a single exploration and further explorations are necessary for design level considerations.

The reach was not identified as vulnerable to landside slope instability despite the landside slopes along the majority of the reach being steeper than 2H:1V with an average of 1.9H:1V. In the locations where landside slopes are steeper than 2H:1V, the levee crest is larger than 20 feet, indicating that the levee is overbuilt at these locations. Additionally, no history of landside slope instability has been documented.

The reach was not identified as vulnerable to erosion-driven failure despite the erodible embankment material and waterside slopes along the reach being steeper than 3H:1V with an average of 1.9H:1V. In the locations where waterside slopes are steeper than 3H:1V, the levee crest is larger than 20 feet, indicating that the levee is overbuilt at these locations. Erosion could be addressed as a maintenance issue, however if left unmaintained, the levee could become vulnerable over time.

5.4 South Railroad Embankment (Segment HDSRR)

The South Railroad Embankment segment in the Hood study area constitutes of one reach based on the assessment approach described in Section 4. The reach and location of available explorations are shown in Figure 2. Segment HDSRR is located at the southern portion of the Hood study area along the South Railroad Embankment between Segment 106 and HDERR. The assessments performed for this study are described below for this reach. Appendix E provides the Hood Assessment Table that includes the assessment details for cross-sections every 500-feet along the levee.

5.4.1 Reach HDSRR-A

Reach HDSRR-A is 3,421 feet long and is located between Station 0+00 and Station 34+21. Two explorations are located along the levee crown within the reach, however, one exploration encountered refusal 5 feet below the landsite toe elevation. This reach was not identified as vulnerable to underseepage due to a blanket condition shown in one exploration that is greater at the landside toe than the estimated required blanket thicknesses in the reach, calculated as described in Section 4.1. This reach was identified as vulnerable to through seepage because of erodible embankment material and the AWSE is higher than the criteria described in Section 4.2. These assessments were based on a single exploration and further explorations are necessary for design level considerations.

The reach was identified as vulnerable to landside slope instability due to the landside slopes along the majority of the reach being steeper than 2H:1V with an average of 1.9H:1V.

The reach was identified as vulnerable to erosion-driven failure due to the erodible embankment material and waterside slopes along the reach being steeper than 3H:1V with an average of 2.2H:1V.

The assessment found that all of Reach HDSRR-A does have a sufficient freeboard of 3 feet or more for the AWSE.

6 Existing Geotechnical Condition Summary

The Hood levees were assessed using the exiting information as well as the data gathered for this project and assessed based on the approaches described in Section 4. A total of approximately 6 miles were assessed along a total of 4 segments. Each segment was divided into reaches and assessed for underseepage, through seepage, slope stability, erosion, and freeboard as described in Section 4.

The geotechnical vulnerabilities for the existing conditions were assessed considering available geotechnical data, levee geometry, and documented past performance observations. This screening level assessment was appropriate for the support of the Feasibility Study, facilitating evaluation of conceptual structural alternatives and comparative costs assessment. If levee mitigation needs for this study area progress to subsequent study or design, additional subsurface exploration and analysis will be necessary to refine the understanding of the levee and foundation conditions and repair requirements.

6.1 Sacramento River (NULE Segment 106)

The geotechnical evaluation along the Sacramento River indicates that the levee along Sacramento River in the Hood study area was identified as vulnerable to through seepage and underseepage. The evaluation also indicates that approximately 10% of the levee has less than 3 feet of freeboard at the AWSE. See the Evaluation table included in Appendix E for more details.

6.2 RD 744 Cross Levee (Segment HNCL)

The geotechnical evaluation along the RD 744 Cross Levee indicates that the levee was identified as vulnerable to through seepage and underseepage. The evaluation also indicates 100% of the levee has less than 3 feet of freeboard at the AWSE. See the Evaluation table included in Appendix E for more details.

6.3 East Railroad Embankment (Segment HDERR)

The geotechnical evaluation along the East Railroad Embankment indicates that Reaches HDERR-A and HDERR-B were identified as vulnerable to through seepage and erosion driven failure. Reach HDERR-B was also identified as vulnerable to underseepage and slope instability. Reach HDERR-C was not identified as vulnerable to underseepage, through seepage, slope instability, or erosion-driven failure. Additionally, none of the reaches along the East Railroad Embankment have less than 3 feet of freeboard a the AWSE. See the Evaluation table included in Appendix E for more details.

6.4 South Railroad Embankment (Segment HDSRR)

The geotechnical evaluation along South Railroad Embankment indicates that the levee was identified as vulnerable to through seepage, underseepage, and slope instability. The evaluation also indicated none of the levee has less than 3 feet of freeboard at the AWSE. See the Evaluation table included in Appendix E for more details.

7 Fix-in-Place Levee Improvement Alternatives

Standardized conceptual remedial alternatives were considered for this screen level assessment. They were identified generally consistent with the DWR ULE and NULE project's limited and standardized conceptual remedial alternatives considered.

For the purpose of the Feasibility Study's comparative costs assessment, where feasible, two remedial alternatives were considered for each reach to address underseepage, through seepage, and/or landside levee stability. Restrictions on the landside of the levee, such as developed property and/or land use activity, may limit practical solutions to a single alternative in some locations.

The following standardized conceptual remedial alternatives were considered for the vulnerability indicated:

	Existing Condition Levee Vulnerabilities Addressed				
Remedial Alternative	**Underseepage**	**Through Seepage**	**Landside Levee Stability**	**Freeboard**	**Erosion**
Cutoff Wall	X	X	X		
Seepage Berm	X				
Drained Stability Berm		X	X		
Combination Seepage-Stability Berm	X	X	X		
Freeboard Repair				X	
Rock Slope Protection					X

The standardized conceptual remedial alternatives considered in this study, included standardize dimensions or approaches to dimensions. This was in line with the goal of the assessment, facilitation of cost estimating, and necessary based on limited information available for the levees. Assumptions for remedial alternative dimensions included:

- Cutoff Walls:
    - Cutoff walls were considered to address underseepage, through seepage, and stability as follows:
        - A shallow wall was considered for scenarios where through seepage vulnerabilities were identified or where a leaker condition was

present beneath the levee and a shallow wall would serve to cutoff the leaker and extending into a shallow aquitard layer.

- A full-depth wall was considered for scenarios where an aquifer is present underlying a thin blanket condition, or a leaker condition with a thick pervious layer beneath the embankment and the deep wall would cutoff the aquifer by extending through the pervious aquifer and ending in a deep aquitard layer.

- Where slope instability is driven by the seepage conditions a cutoff wall to mitigate the seepage was considered to indirectly improve the stability of the slope. None of the reaches in the Hood study area were identified as vulnerable to slope instability.

  - For full-depth cutoff walls:

    - When subsurface exploration data is available to depths deep enough to identify a fine-grained layer (aquitard), the cutoff wall depth is identified to provide a tip elevation embedment 5 feet into the fine-grained layer (aquitard).

    - When exploration data is not available or a fine-grained layer (aquitard) layer depth is not identified within the depth of available data, an 80-foot deep wall was assumed (deepest wall achievable with a conventional long-reach excavator).

  - Depths assume construction from a half-levee height degrade working surface.

  - The cutoff wall thickness of 36 inches is identified for the standardized conceptual remedial wall alternative.

- Seepage berm dimensions assume a berm thickness of 5 feet at the levee toe sloping to 3 feet thick at the berm toe.

This information is intended for feasibility study level cost estimates to compare repair alternatives. Cost estimates will be prepared separately and are not a part of this Geotechnical Assessment Report.

Remediation Alternatives for seepage and stability improvements, including lengths and Reach specific dimensions, are included in the Table 3.

8 Geotechnical Considerations for Additional Structural Alternatives

The Feasibility study this Report is supporting will be considering other structural alternatives such as new cross-levees, ring levees, etc. Geotechnical considerations for new levees are generally the same as existing levees; freeboard, stability, through seepage, and underseepage need to meet FEMA and other relevant design criteria. Freeboard, stability, and through seepage considerations will be addressed by the design requirements for the new levee embankment. Underseepage vulnerability is largely based on existing foundation conditions at the cross-levee location. Very limited data is available for the foundation materials in the Hood study area, therefore underseepage mitigation requirements for new cross-levees could not be fully evaluated. Structural alternatives that include cross-levees will need to conservatively assume underseepage mitigation is necessary. Further site exploration and subsequent evaluation and/or design might be able to eliminate the need for the underseepage mitigation.

Any new levee construction will also need to consider settlement. The levees within the community of Hood are located in the Sacramento Delta. Settlement in the Delta is common based on the presence of Marsh and peat deposits (compressible soils), which have been mapped within the study area. Additional explorations will need to be performed along the proposed levee alignment to determine the subsurface conditions and thickness of peat and other compressible soils. The thickness of the compressible soils can have a major effect on the design and construction of the new levee.

Other possible structural alternatives that were not included in this report could include half to full levee rebuild to address through seepage and stability vulnerability and relief wells to address underseepage vulnerability. Rebuilding a levee is extremely costly compared to other remedial alternatives to mitigate for through seepage and/or stability concerns. Relief wells can be used to mitigate underseepage issues but were not considered as one of the remedial alternatives due to the high potential for maintenance issues. If relief wells are not maintained properly, the screens could plug and render the relief well ineffective.

9 Limitations

This assessment report, associated data, and preparation have been performed in accordance with the standard of care commonly used as the state-of-practice in the engineering profession for levee evaluation projects. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this area performing the same services under similar circumstances during the same period.

Discussions of subsurface conditions summarized in this report are based on subsurface soil and groundwater conditions at limited exploration locations. Variations in subsurface conditions may exist between exploration locations, and the Project team may not be able identify all adverse conditions in the levee and/or its foundation.

No warranty, either expressed or implied, is made in the furnishing of this report. The Project team makes no warranty that actual encountered site and subsurface conditions will exactly conform to the conditions described herein, nor that this report's interpretations and recommendations will be sufficient for all construction planning aspects of the work. The design engineer and/or contractor should perform a sufficient number of independent explorations and tests as they believe necessary to verify subsurface conditions rather than relying solely on the information presented in this report.

The Project team does not attest to the accuracy, completeness, or reliability of geotechnical borings and other subsurface data collected by other consultants or agencies as part of prior studies that are included in this report. The Project team has not performed independent validation or verification of data by others.

Data presented in this report are time-sensitive in that they apply only to locations and conditions existing at the time of the exploration and preparation of this report. Data should not be applied to any other projects in or near the area of this study nor should they be applied at a future time without appropriate verification.

This report is for the use and benefit of the County of Sacramento. Use by any other party is at their own discretion and risk.

This report is one of multiple documents describing work completed. It supplements other reports presenting the geotechnical data collected for this study.

10 References

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Tables

Table 1: Summary of Subsurface Explorations
Small Communities Flood Risk Reduction Plan
Community of Hood

Exploration ID	Exploration Area	Segment Number	Exploration Location	Approximate NULE Levee Station (ft)	Approximate Coordinates[1] Latitude	Approximate Coordinates[1] Longitude	Approx. Levee Crown Elev[2] (ft)	Approx. LS Toe Elev[2] (ft)	Approx. Levee Height	Approximate Depth to Groundwater[3] (ft)	Exploration Depth (ft)
GEI_Hood_001C	Sacramento River	106	Landside Toe	3165+00	38.381742	-121.519626	30.5	16.1	14.4	7.7	60.2
GEI_Hood_002C	Sacramento River	106	Landside Toe	3205+00	38.390539	-121.512376	30.6	13.4	17.2	6.4	96.3
GEI_Hood_003C	North Cross Levee	NA	Crown	1+65	38.399733	-121.511592	29.0	3.7	25.3	7.0	40.0
GEI_Hood_004C	North Cross Levee	NA	Crown	11+05	38.399644	-121.508157	20.4	4.4	16.0	7.0	65.0
GEI_Hood_005C	East Railroad	NA	Crown	26+05	38.395595	-121.508385	26.5	11.0	15.5	22.0	65.5
GEI_Hood_006C	East Railroad	NA	Crown	41+50	38.389753	-121.508794	26.3	10.1	16.2	22.1	81.5
GEI_Hood_007C	East Railroad	NA	Landside Toe	69+00	38.380751	-121.509259	26.8	-0.3	27.1	2.9	109.5
GEI_Hood_008C	East Railroad	NA	Crown	103+00	38.372903	-121.509669	26.1	7.6	18.5	20.0	60.5
GEI_Hood_009C	South Railroad	NA	Crown	7+40	38.365632	-121.513503	25.7	7.9	17.8	20.0	23.5
GEI_Hood_010C	South Railroad	NA	Crown	26+65	38.366448	-121.51699	26.4	8.3	18.1	19.6	75.5
GEI_Hood_011C	Field	NA	Field	NA	38.372493	-121.515008	NA	NA	NA	1.8	55.5

[1] Locations are approximate - based on field GPS and GIS tools. Horizontal datum is NAD 83.
[2] Elevations are approximate - based on GIS tools and/or GPS. Vertical datum is NAVD 88
[3] Depth to groundwater was based on the results of the shallowest pore pressure dissipation tests performed within the sounding.

Table 2. Summary of Hood Levee Vulnerability

NULE Alignment ID	NULE Segment	Reach	Start Station	End Station	Vulnerability				Freeboard (% Deficient)	Notes
					Underseepage	Through Seepage	Slope Stability	Erosion		
SACR-L	106	106-A	3107+39	3237+92	X	X	-	-	-	Reach Characteristics: - Predominantly underlain by historical overbank deposits with some Holocene overbank deposits on the landside - Average 9 feet of head above landside toe - History of seepage, boils, and waterside erosion throughout the reach - Seven explorations along reach – four indicate that there is a blanket condition ranging from 7 to 33-feet thick and three indicated a leaker condition with an average creep ratio of approximately 12 Levee Geometry: - Average Height: 16 feet - Average LS Slope: 2.4H:1V - Average WS Slope: 2.2H:1V - Average Crest Width: 33 feet Conclusions: - Underseepage: Identified as vulnerable due to the high head condition with a blanket condition in some portions and a leaker condition in others with creep ratios that do not meet criteria - Through Seepage: Identified as vulnerable due to an erodible embankment material and head that does not meet criteria - Slope Stability: Not identified as vulnerable due to wide levee crest indicating an overbuilt levee - Erosion: Not identified as vulnerable despite waterside slopes steeper than 3H:1V throughout the reach and the erodible embankment material because levee is overbuilt. Erosion could be addressed as a maintenance issue; however, left unmaintained could become vulnerable. - Freeboard: More than 3 feet freeboard present along the reach
HNCL	North CL	North CL	0+00	13+00	X	X	-	-	100%	Reach Characteristics: - Predominantly underlain by historical culturally deposited borrow pits with some historical overbank deposits on the landside; waterside is underlain by historical overbank deposits - Average 18 feet of head above landside toe - No documented past performance - Two explorations along reach – one indicated that there is a blanket condition at least 49 feet thick and one indicated a leaker condition with a average creep ratio of approximately 7 Levee Geometry: - Average Height: 17 feet - Average LS Slope: 1.4H:1V - Average WS Slope: 4.8H:1V - Average Crest Width: 39 feet Conclusions: - Underseepage: Identified as vulnerable due to the high head and a leaker condition that does not meet creep ratio criteria - Through Seepage: Identified as vulnerable due to an erodible embankment material and high head that does not meet criteria - Slope Stability: Not identified as vulnerable due to wide levee crest indicating an overbuilt levee - Erosion: Not identified as vulnerable despite waterside slopes steeper than 3H:1V throughout the reach and the erodible embankment material because levee is overbuilt. Erosion could be addressed as a maintenance issue; however, left unmaintained could become vulnerable. - Freeboard: Less than 3 feet freeboard present along the reach
HDERR	East RR	East RR-A	0+00	45+00	-	X	-	X	-	Reach Characteristics: - Predominantly underlain by Holocene overbank deposits with some historical overbank deposits on both landside and waterside. - Average 10 feet of head above landside toe - No documented past performance - Two explorations along reach indicated a blanket condition ranging from at least 49 feet to at least 65 feet thick Levee Geometry: - Average Height: 17 feet - Average LS Slope: 2.5H:1V - Average WS Slope: 1.9H:1V - Average Crest Width: 23 feet Conclusions: - Underseepage: Not identified as vulnerable due to the presence of a thick blanket condition meets criteria - Through Seepage: Identified as vulnerable due to an erodible embankment material and high head that does not meet criteria - Slope Stability: Not identified as vulnerable due to landside slopes that were predominantly flatter than 2H:1V and where steeper slope were noted, the crest width was wide indicating an overbuilt levee - Erosion: Identified as vulnerable due to waterside slopes steeper than 3H:1V, narrow crest width in some locations, and erodible embankment material - Freeboard: More than 3 feet freeboard present along the reach

Table 2. Summary of Hood Levee Vulnerability

NULE Alignment ID	NULE Segment	Reach	Start Station	End Station	Vulnerability				Freeboard (% Deficient)	Notes
					Underseepage	Through Seepage	Slope Stability	Erosion		
HDERR	East RR	East RR-B	45+00	90+00	X	X	X	X	-	Reach Characteristics: - Predominantly underlain by Quaternary riverbank and historical marsh deposits with one location of Historical crevasse splay deposits - Average 16 feet of head above landside toe - No documented past performance - One exploration along reach indicated a blanket condition of approximately 21 feet thick Levee Geometry: - Average Height: 23 feet - Average LS Slope: 1.7H:1V - Average WS Slope: 1.6H:1V - Average Crest Width: 20 feet Conclusions: - Underseepage: Identified as vulnerable due to the presence of high head and blanket condition that does not meet criteria - Through Seepage: Identified as vulnerable due to an erodible embankment material and high head that does not meet criteria - Slope Stability: Identified as vulnerable due to landside slopes steeper than 2H:1V along the reach - Erosion: Identified as vulnerable due to waterside slopes steeper than 3H:1V and possible erodible embankment material - Freeboard: More than 3 feet freeboard present along the reach
HDERR	East RR	East RR-C	90+00	131+25	-	-	-	-	-	Reach Characteristics: - Predominantly underlain by Quaternary riverbank deposits with one location of historical eolian deposits - Average 10 feet of head above landside toe - No documented past performance - One exploration along reach indicated a blanket condition of at least 42 feet thick Levee Geometry: - Average Height: 16.5 feet - Average LS Slope: 1.9H:1V - Average WS Slope: 1.9H:1V - Average Crest Width: 33 feet Conclusions: - Underseepage: Not identified as vulnerable due to the presence of a blanket condition that meets criteria; however, this is based on a single exploration and further explorations are necessary for design level considerations - Through Seepage: Not identified as vulnerable due to a non-erodible embankment material; however, this is based on a single exploration and further explorations are necessary for design level considerations - Slope Stability: Not identified as vulnerable due to wide levee crest indicating an overbuilt levee - Erosion: Not identified as vulnerable despite waterside slopes steeper than 3H:1V throughout the reach and the erodible embankment material because levee is overbuilt. Erosion could be addressed as a maintenance issue; however, left unmaintained could become vulnerable. - Freeboard: More than 3 feet freeboard along the reach
HDSRR	South RR	South RR-A	0+00	34+21	-	X	X	X	-	Reach Characteristics: - Predominantly underlain by historical culturally deposited borrow pits with some Pleistocene Eolian and historical overbank deposits on the landside; waterside is underlain by Holocene basin deposits and Pleistocene riverbank formation - Average 13 feet of head above landside toe - No documented past performance - One exploration along reach indicated a blanket condition of at 32 feet thick Levee Geometry: - Average Height: 17.5 feet - Average LS Slope: 1.9H:1V - Average WS Slope: 2.2H:1V - Average Crest Width: 31 feet Conclusions: - Underseepage: Not identified as vulnerable due to the presence of a blanket condition that meets criteria; however, this is based on a single exploration and further explorations are necessary for design level considerations - Through Seepage: Identified as vulnerable due to an erodible embankment material and high head that does not meet criteria - Slope Stability: Identified as vulnerable due to landside slopes steeper than 2H:1V along the reach - Erosion: Identified as vulnerable due to waterside slopes steeper than 3H:1V and erodible embankment material - Freeboard: More than 3 feet freeboard along the reach

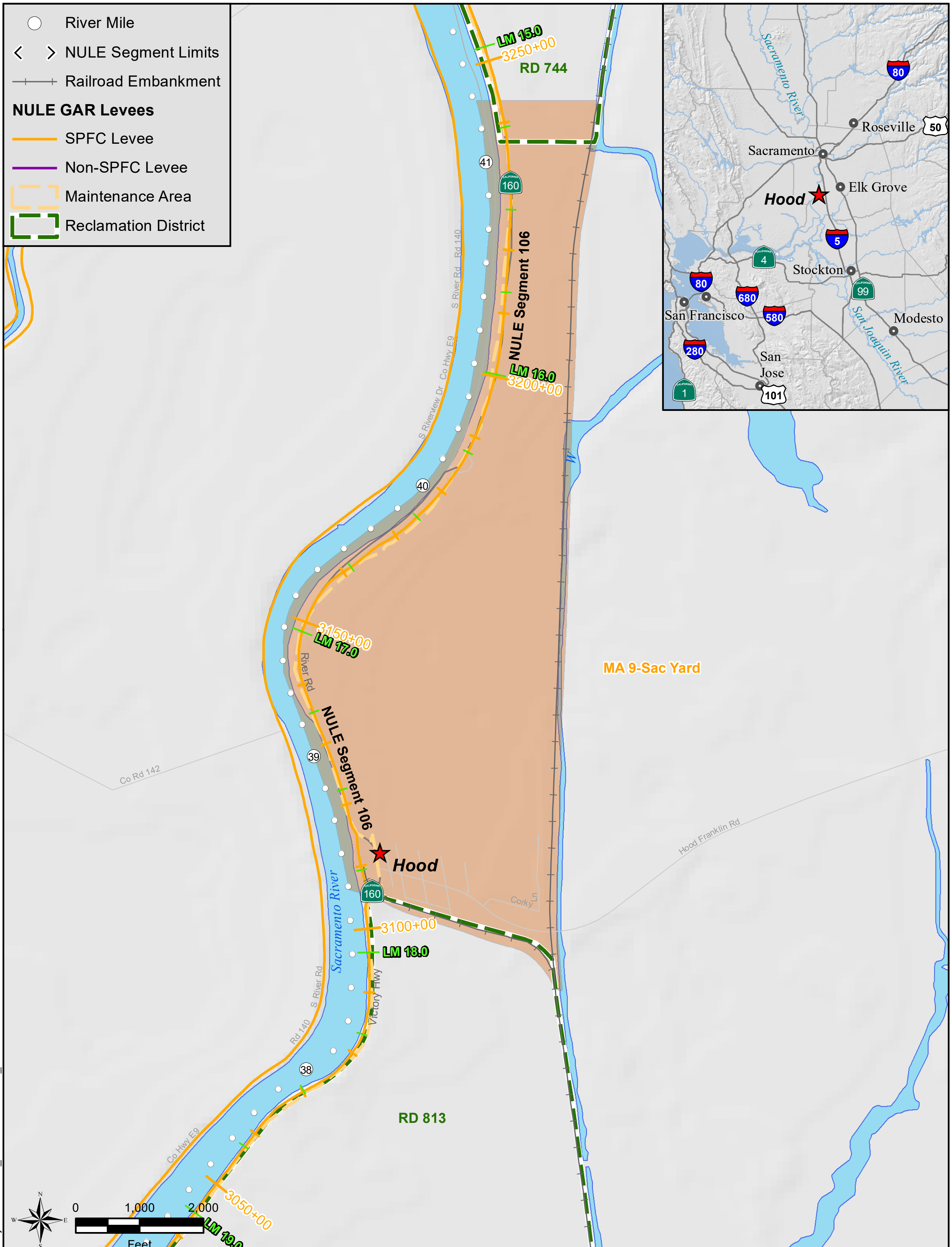
Table 3. Summary of Hood Remedial Alternatives

NULE Alignment ID	Segment Name	NULE Segment	Reach	Start Station	End Station	Reach Length (feet)	Remediation Alternative 1 Dimensions	Remediation Alternative 2 Dimensions[1]	Vulnerability				Freeboard (% Deficient)
									Underseepage	Through Seepage	Slope Stability	Erosion	
SACR-L	Sacramento River Left Bank	106	106-A	3107+39	3237+92	13,053	80-foot deep cutoff wall	80-foot wide 9-foot tall combo berm	X	X	-	-	-
HNCL	Hood North Cross Levee	North CL	HNCL	0+00	13+00	1,300	50-foot deep cutoff wall	85-foot wide 16-foot tall combo berm	X	X	-	-	100%
HDERR	Hood East Railroad Embankment	East RR	HDERR-A	0+00	45+00	4,500	15-foot deep cutoff wall 105-foot wide RSP (4,500 feet)	12-foot tall drained stability berm 105-foot wide RSP (4,500 feet)	-	X	-	X	-
HDERR	Hood East Railroad Embankment	East RR	HDERR-B	45+00	90+00	4,500	60-foot deep cutoff wall 140-foot wide RSP (3,500 feet)	140-foot wide 19-foot tall combo berm 140-foot wide RSP (3,500 feet)	X	X	X	X	-
HDERR	Hood East Railroad Embankment	East RR	HDERR-C	90+00	131+25	4,125	-	-	-	-	-	-	-
HDSRR	Hood South Railroad Embankment	South RR	HDSRR-A	0+00	34+21	3,421	15-foot deep cutoff wall 105-foot wide RSP (3,000 feet)	13-foot tall drained stability berm 105-foot wide RSP (3,000 feet)	-	X	X	X	-

*Only affects a portion of the reach

Note: Wall depths and berm widths rounded up to the nearest 5-foot dimension and stability berm heights rounded to the nearest 1-foot dimension.

Figures

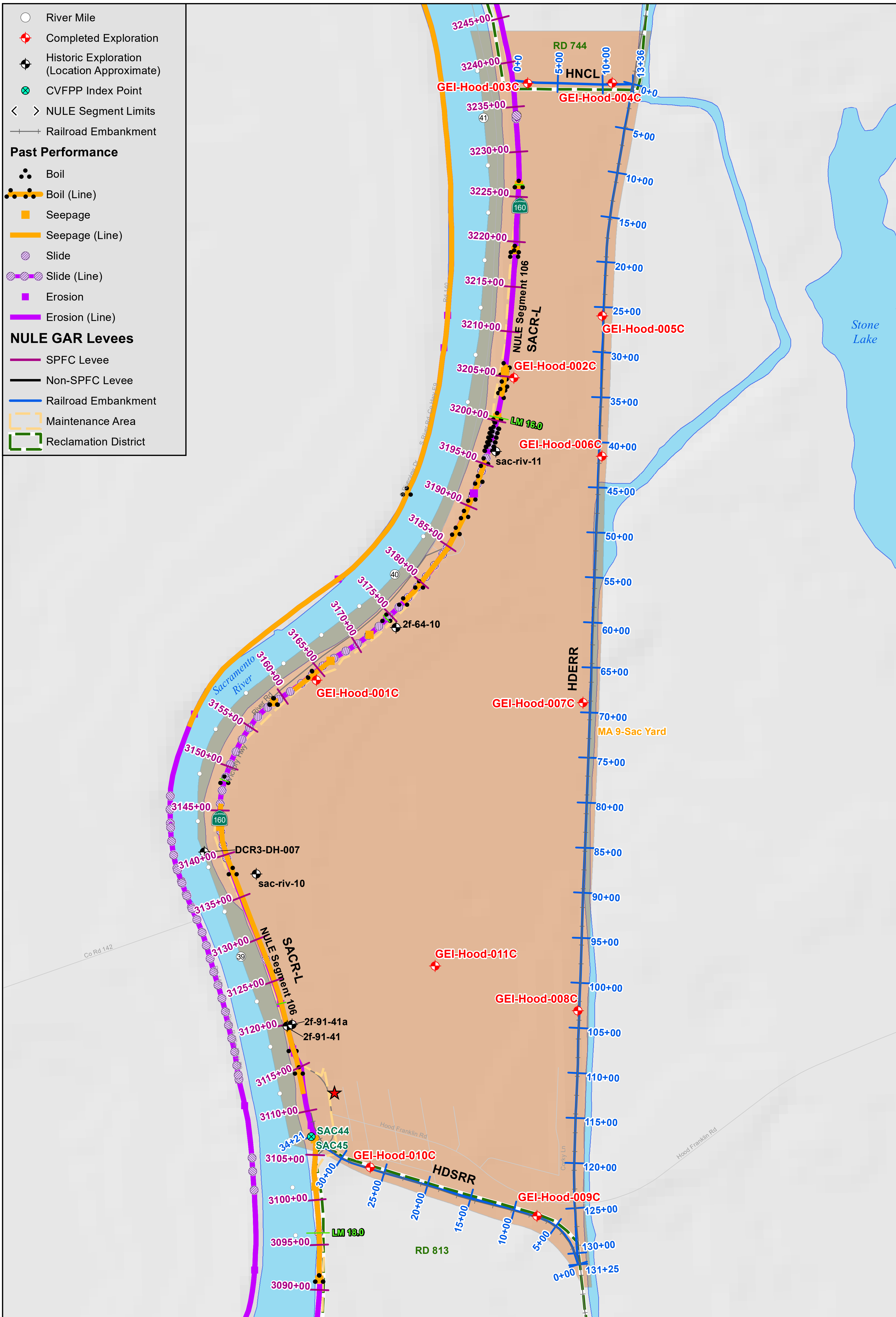


Small Communities
Flood Risk Reduction Program

County of Sacramento

COMMUNITY OF HOOD

OCTOBER 2020 DRAFT FIGURE 1



1,000 500 0 1,000 Feet	Small Communities Flood Risk Reduction Program	GEI Consultants	EXPLORATIONS AND PAST PERFORMANCE COMMUNITY OF HOOD
	County of Sacramento		OCTOBER 2020 DRAFT FIGURE 2

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1,000 500 0 1,000
Feet

Small Communities
Flood Risk Reduction Program

County of Sacramento

GEI Consultants

HOOD
OVERVIEW OF
GEOTECHNICAL VULNERABILITIES

OCTOBER 2020 DRAFT FIGURE 3

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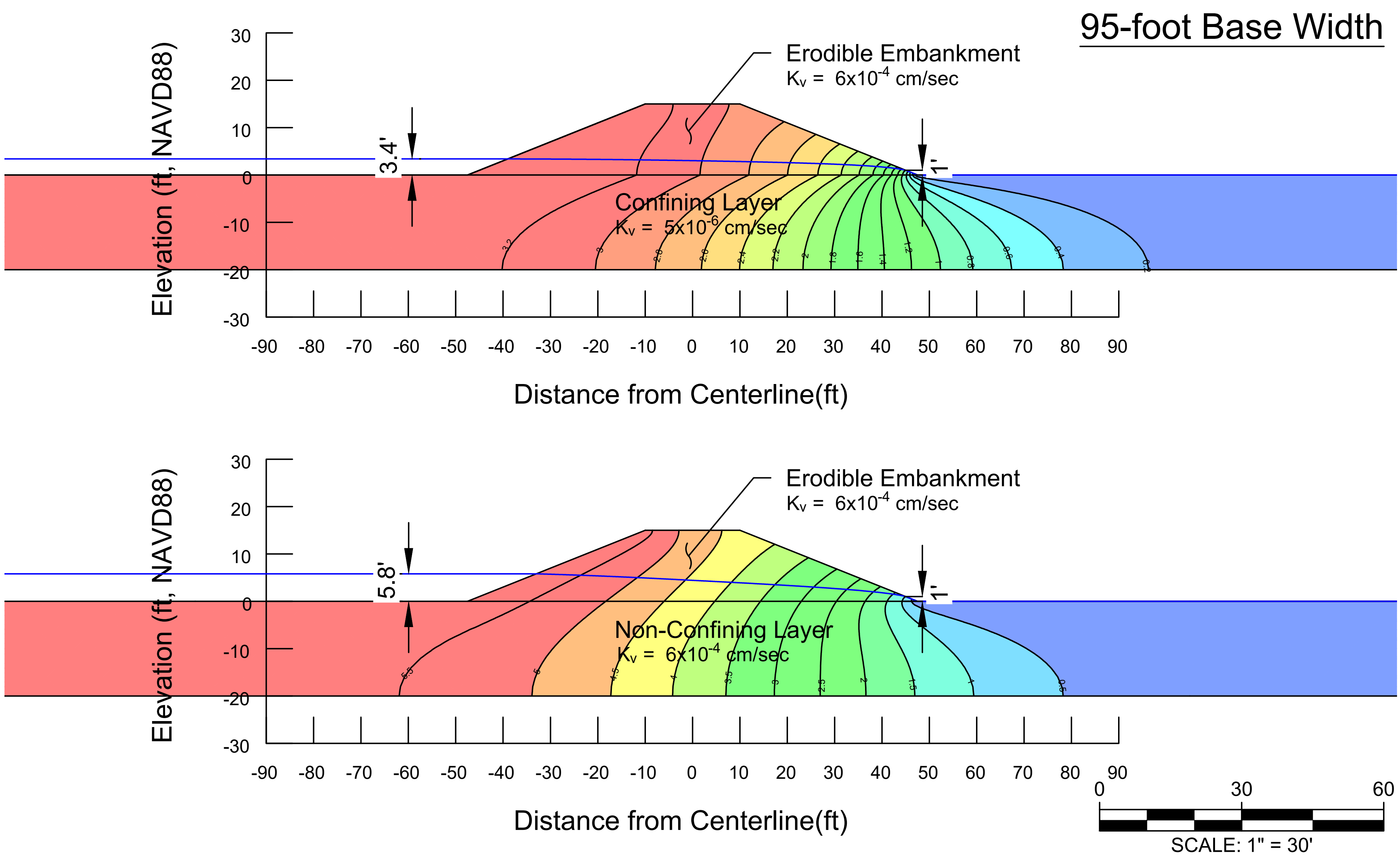

Delta Small Communities Flood Risk Reduction Program Community of Hood	GEI Consultants	Through Seepage Criteria Analysis Cases
Sacramento County, CA	Project 1800776	OCTOBER 2020 Figure 4

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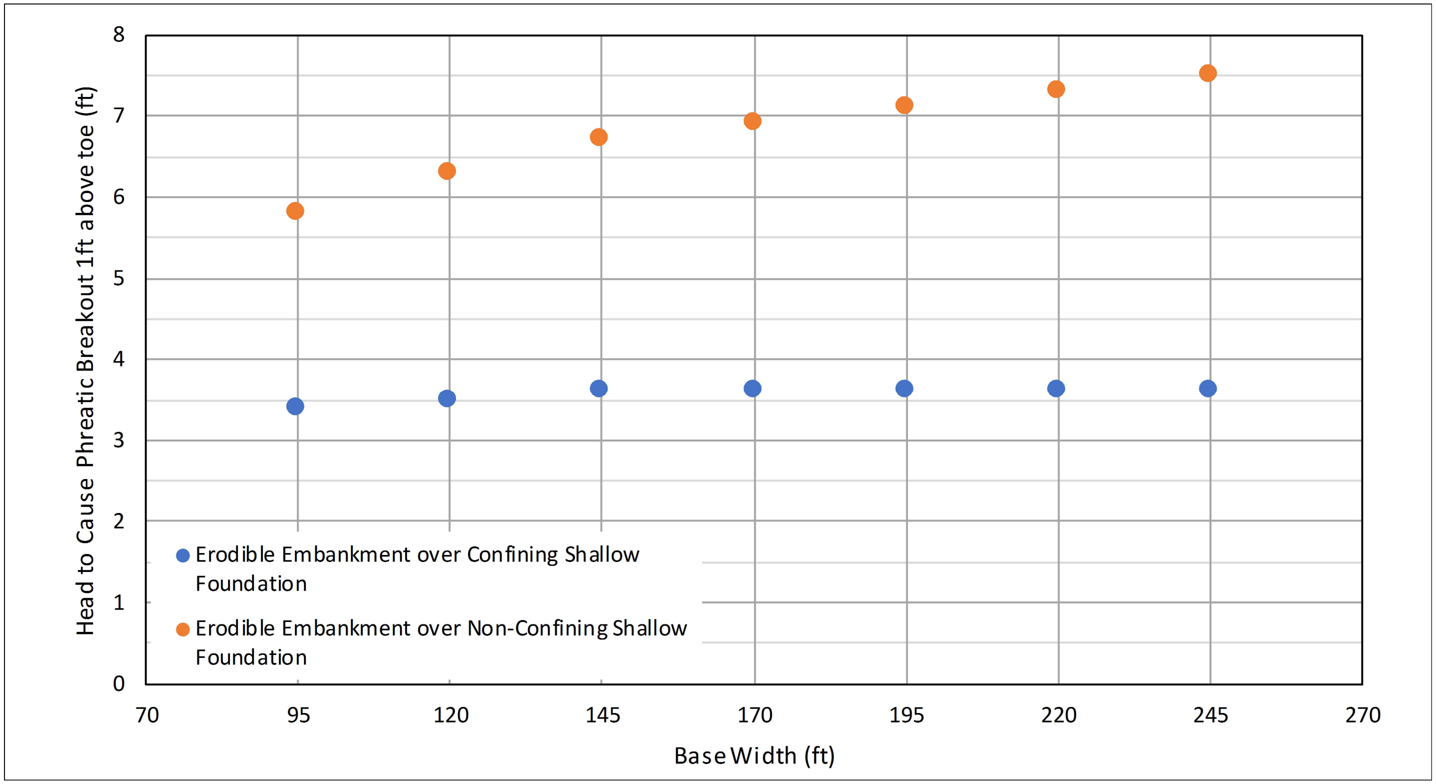

CRITERIA SUMMARY		Levee Base Width (feet)						
Analysis Case	Emb./Found.	95	120	145	170	195	220	245
		Head to Cause Through Seepage						
1	Erodible Embankment over Confining Shallow Foundation	3.4	3.5	3.6	3.6	3.6	3.6	3.6
2	Erodible Embankment over Non-Confining Shallow Foundation	5.8	6.3	6.7	6.9	7.1	7.3	7.5

NOTES:

1. Model assumes 20-foot crest width
2. Erodible Embankment: $k_v = 6x10^{-4}$ cm/sec
3. Confining Foundation: $k_v = 5x10^{-6}$ cm/sec
4. Non-confining Foundation: $k_v = 6x10^{-4}$ cm/sec

Delta Small Communities Flood Risk Reduction Plan - Community of Hood

Sacramento County, CA

GEI Consultants

Project 1800776

Head to Cause Phreatic Breakout 1ft above toe

OCTOBER 2020

Figure 5

\\sac1v-fs01\ J:\Sacramento County Small SPFC Communities\ThroughSeepage_Criteria\Figure\TSCriteriaAnalyses_Hood.dwg - 10/12/2020

Appendix A

Technical Memorandum

To: George Booth and Shayan Rehman, Sacramento County - Department of Water Resources

From: Graham Bradner and Jeff Twitchell, GEI Consultants, Inc.

Date: October 2018

Re: Existing Geotechnical Data Technical Memorandum
SCFRR - Community of Hood in Sacramento County

Introduction

The purpose of this memorandum is to summarize existing geotechnical information and past performance for the levees protecting the community of Hood in Sacramento County and identify recommendations for further subsurface investigation. The community of Hood is protected by a portion of the Maintenance Area (MA) 9 levee constructed along the left bank of Sacramento River (California Department of Water Resources [DWR] Non-Urban Levee Evaluation [NULE] Segment 106), as shown on Figure 1 and discussed in more detail below. Additionally, former railroad embankments are present along the southern extent of Hood and to the east of the community. To the north of Hood, along the Reclamation District (RD) 744 boundary, a cross-levee embankment runs between the MA 9 levee (NULE Segment 106) and the former railroad embankment.

Existing levee conditions information for these levees is available from the Sacramento Area Flood Control Agency (SAFCA) Evaluation of Sacramento River Non-Urban Levees memorandum (SAFCA Evaluation) performed by GEI and the DWR Division of Flood Management's NULE project. The NULE project addressed State Plan of Flood Control (SPFC) levees protecting populations of fewer than 10,000 people and Non-SPFC levees that were considered appurtenant and may impact the performance of SPFC levees.

Sacramento River Levee

The NULE Segment 106 levee is a SPFC levee along the Sacramento River left bank that extends approximately 9 miles along Sacramento River from near Freeport Avenue southward to just north of Courtland. The portion of this Sacramento River segment that protects the Community of Hood is approximately 2.5 miles long from the RD 744 cross levee to the former railroad embankment immediately south of Hood. Along this Sacramento River extent, flow is from north to south. The approximate upstream water surface elevation (WSE) near river mile (RM) 40.9 for the 100-year WSE is 24.9 feet and the downstream 100-year WSE near RM 38.4 is approximately 23.6 feet (GEI, 2016). The United States Army Corps of Engineers (USACE) 1955/57 design profile WSE as provided by DWR (1955/57 design profile) is 24.4 feet at the upstream end near the RD 744 cross levee and 22.9 feet at the downstream end near the former railroad embankment to the south of Hood. These WSEs are in reference to the North American Vertical Datum of 1988 (NAVD88).

2868 Prospect Park Drive, Suite 310
Rancho Cordova, CA 95670
916.631.4500 fax 916.631.4501

RD 744 Cross Levee

The cross levee that is north of the Hood is approximately 0.25 miles long and extends from the MA 9 left bank Sacramento River levee east to the former railroad embankment. The cross levee is a non-SPFC levee and is a part of RD 744. A 100-year and 1955/57 design profile WSEs are not available for this cross levee. This RD 744 cross levee was not a part of the NULE project or the SAFCA Evaluation.

Railroad Embankments

There are railroad embankments surrounding the community of Hood to the east and south. The railroad embankments are non-SPFC but are pertinent to the flood protection of the community of Hood, acting as levees to protect the community from flood waters from the south and east. The portions of the embankments protecting the community of Hood include approximately 2.4 miles of the embankment to the east of Hood and about 0.6 miles of embankment along the south end of the community. Since the embankments are non-SPFC, 100-year and 1955/57 design profile WSEs are not available. These former railroad embankments were not a part of the NULE project's assessment or the SAFCA Evaluation.

Levee Construction History and Improvements

The left bank Sacramento River levee protecting Hood was originally constructed by local interests in the mid-1800's to early 1900's and was brought up to federal standards by the United Sates Army Corps of Engineers (USACE) in between 1947 and 1955. Construction records for the levee are not available; however, it is assumed that a clam shell and/or suction dredger approach, commonly used during the time period, was likely used to construct the levees. The USACE improvements included bank protection along portions of the levee.

Construction records for the cross levee to the north and former railroad embankment levees to the east and south of Hood are unavailable.

Levee Past Performance

Past performance is based on the DWR NULE project and the SAFCA Evaluation information which were gathered through review of available documents and interviews with levee maintenance personnel. Past performance information was available for the Sacramento River levee, but data was not collected or reviewed for the RD 744 cross levee or former railroad embankments as they were not a part of the NULE project or SAFCA Evaluation.

In general, the Sacramento River levee protecting the community of Hood has experienced widespread seepage, boils, and erosion including slips, bank caving, and revetment failure during past high-water events. Past performance is summarized in Table 1 and shown on Figure 2.

In 2012, DWR's Flood System Repair Project (FSRP) evaluated past performance records for non-urban SPFC levees through existing documentation and field reconnaissance and identified *critical* and *serious* sites for repair. The FSRP was designed to be consistent with the state system-wide investment approach of the Central Valley Flood Protection Plan (CVFPP), and the SPFC. The FSRP goal was to help prioritize funded system repair projects to focus on repair of damage or deficiencies that are critical, that have a potential to become critical, or that may impede flood fight capabilities. For the FSRP *critical* and *serious* past performance problems were generally defined as follows:

- *Critical* Past Performance Problem: If not repaired, the site presents a significant risk of failure or would impede flood control function or flood fight activities during the next highwater event.
- *Serious* Past Performance Problem: If not repaired in a timely manner, the site has the potential to become critical during the next high-water event.

The (FSRP identified two *critical* sites and one *serious* site along the levee protecting the community of Hood on NULE Segment 106. All are seepage sites at the location of past, reoccurring boils. A map and table of the *critical* and *serious* sites from the FSRP Levee Performance Problems Evaluation Report (URS, 2013) are included in Appendix A.

Most recently, a July 2018 DWR report titled “2017 Storm Damage – DWR Emergency Rehabilitation” (IFC, 2018) summarized DWR rehabilitation sites and USACE PL 84-99 sites resulting from 2017 storm damage. For DWR’s review of the 2017 damage sites, they followed FSRP guidelines to identify sites as *critical* or *serious*. No *critical* or *serious* 2017 storm damage sites were identified along the portion of the Sacramento River levee that protects the Community of Hood. The report also notes identification of “area of concern” sites that did not rise to the level of *critical* or *serious*. Location information for these sites was not available from DWR at the time of this Memorandum. No USACE PL 84-99 sites from the 2017 storm damage were identified along the Hood levees.

Levee Freeboard and Geometry

The NULE project and the SAFCA Evaluation both reviewed freeboard and geometry for the Sacramento River levee protecting Hood. Both assessments utilized levee geometry data based on Light Detection and Ranging (LiDAR) topography collected for DWR’s Central Valley Floodplain Evaluation and Delineation (CVFED) between October 2008 and February 2009.

The DWR NULE project freeboard review measured available freeboard against the 1955/57 design water surface profile for SPFC levees. For the Sacramento River levee protecting the community of Hood (NULE Segments 106) the NULE review found that a minimum of 3 feet of freeboard above the 1955/57 design profile was available throughout the full segment except for an approximately 600-foot portion of the levee adjacent to Hood (approximately LM 17.65 to 17.8) where the levee crest appears to be approximately 1.1 feet below the 1955/57 design freeboard.

The SAFCA Evaluation freeboard review measured available freeboard against the 200-year WSE (provided by MBK). For the Sacramento River levee protecting the community of Hood, the minimum of 3 feet of freeboard above the 200-year WSE was available for the majority of the segment. The minimum of 3 feet of freeboard was not available for the portion of levee adjacent to Hood where available freeboard ranged from about 1.3 to 1.7 feet above the 200-year WSE.

The NULE project geometry review was at the segment level (summarizing all 9 miles of NULE Segment 106 together), while the SAFCA Evaluation summarized conditions every 500-feet. Geometry information presented in the SAFCA Evaluation for the Sacramento River levee protecting the community of Hood is summarized in Table 2. For the Sacramento River left bank levee protecting the community of Hood the levee height typically ranged from 15 to 17 feet above the landside toe, but is only about 8 to 10 feet high at the southern extent, nearest Hood. The crest widths are generally about 30 to 40 feet, but widen to up to about 100 feet at the southern extent, nearest Hood. Landside slopes are typically ranged from 1.5H:1V to 2.5H:1V and waterside slopes typically ranged from 1.3H:1V to 2.5H:1V.

2868 Prospect Park Drive, Suite 310
Rancho Cordova, CA 95670
916.631.4500 fax 916.631.4501

The RD 744 cross levee and railroad embankments surrounding the community of Hood are non-SPFC embankments, so freeboard and geometry reviews are not available in existing data as they were not assessed as part of the NULE project or SAFCA Evaluation.

Available Geotechnical Information

The DWR NULE project included an assessment (Phase 1 only) of the Sacramento River levee extent protecting the community of Hood. The NULE Phase 1 study was based on non-intrusive studies and readily available data. No subsurface explorations were completed as a part of the NULE Phase 1 study. Assessment data such as historical reports, interviews with personnel, construction records, levee performance records, existing explorations records, and other data provided by relevant agencies was collected and reviewed for the study. Geomorphic studies and topographical surveys were also completed. This collection of information was used to characterize the existing condition of the Non-Urban levees in the NULE Geotechnical Assessment Report (GAR). The NULE GAR segment specific write-up for NULE Segment 106 protecting the community of Hood is attached in Appendix B. The SAFCA Evaluation used the data collected by NULE and completely additional document review and evaluation but no additional geomorphic mapping or subsurface data was collected.

More recently than the NULE data collection and review, DWR has conducted geotechnical borings in the Delta to obtain information for the proposed alignment of the water conveyance facilities associated with the Bay Delta Conservation Plan (BDCP), also referred to as California WaterFix. Data available for review is limited at this time and subsurface information (log or profile data) from this effort was only found for one boring along the Sacramento River levee that protects the Community of Hood between the RD 744 cross-levee and the railroad embankment to the south of the community. It is an overwater boring along Segment 106 about 0.5 miles upstream of Hood, the approximate location is shown on Figure 2. All available exploration data is described further below.

Geomorphic Setting

Geomorphology mapping developed for the DWR NULE project indicates the levee along the Sacramento River left bank that protect the community of Hood primarily overlies historical and Holocene overbank deposits (Rob and Hob) likely consisting of interbedded sand, silt, and clay deposited during high-stage flow, overtopping channel banks. A localized area of a Holocene distributary channel deposits (Hdc) is mapped near LM 16.7. The distributary channel deposits likely contain sand, silt, and clay from channelized flow conducting sediment to the floodplain. A borrow pit (present in 1937) is mapped on the landside of the levee approximately 0.4-miles downstream from the RD 744 cross levee.

While the RD 744 cross levee and former railroad embankments surrounding the community of Hood were not a part of the NULE project assessment, the geomorphologic mapping does cover their extents. The RD 744 cross levee is mapped overlying historical overbank deposits (Rob) with borrow pits (present in 1937) in Holocene basin deposits (Hn) mapped along the south side of the cross-levee. The basin deposits are likely to contain fine sand, silt, and clay.

The railroad embankment to the east overlies historical and Holocene overbank deposits (Rob and Hob) along the northern half, with a localized area near the middle of the segment overlying Holocene Marsh deposits (Hs), and the southern half overlying lower member Pleistocene Riverbank Formation (Qrl). The Marsh deposits likely consist of silt and clay and are organic-rich. The lower member Riverbank Formation is likely composed of consolidated dense to very dense alluvium consisting of gravel, sand silt, and minor clay. Along the northern portion of the embankment, there is a waterside bench and a borrow pit (present in 1937) is mapped adjacent to the embankment.

The railroad embankment to the south of Hood is mapped to overly lower member Pleistocene Riverbank Formation (Qrl) along the eastern half and Holocene Basin deposits (Hn) to the west with small extents of historical and Holocene overbank deposits closest to the Sacramento River levee. A localized area of a Holocene channel deposit (Hch) likely containing well sorted sand and trace fine gravel is also mapped through the basin deposits. A borrow pit (present in 1937) is also mapped on the south side of the embankment for most of the extent. For mapping and additional information, the technical memorandum for the geomorphology effort that covers this area is included in Appendix C.

Existing Subsurface Explorations

Based on review of existing subsurface data, there are total of six explorations along approximately 2.5 miles of the Sacramento River levee protecting the community of Hood, as shown on Figure 2. The borings are derived from DWR's 1958 Salinity Control Barrier Investigations (2 borings), 1964 and 1993 USACE investigations (3 boring), and the more recent DWR drilling for the BDCP (1 boring record available as discussed above). Available log information for the six borings is limited to profiles without detailed material descriptions. Some index test laboratory results are indicated on the profiles, but detailed results are not available. Based on the available information, borings along, or near, the levee north of the community of Hood show a blanket layer that varies in thickness from about 12 feet to more than 25 feet below the natural ground surface. The blanket layer is underlain by a pervious aquifer, but the borings were generally shallow or not deep enough to confirm the depth to a deeper aquiclude layer. Only one of the borings was drilled through the levee and shows a levee embankment of sand and silty sand to sandy silt. Available profile information for these existing investigations are included in Appendix D.

No existing subsurface explorations have been identified along the former railroad embankments or the RD 744 cross levee.

Understanding of Existing Geotechnical Conditions

Two existing conditions assessments are available for the Sacramento River levee protecting Hood, the NULE GAR assessment for NULE Segment 106 and the SAFCA Evaluation. The railroad embankments and RD 744 cross levee have not been assessed.

The NULE GAR assessments were based on non-intrusive studies and readily available data as discussed above. More specifically, hazard indicators and levee performance history identified during the data review process were used as the basis for categorizing each levee segment. For each levee segment, hazard indicators were assessed for four potential failure mechanisms: underseepage, slope stability, through seepage, and erosion. Assessments were made based on information about levee and foundation composition, levee geometry, hydraulic head at the assessment WSE, and the presence of penetrations, ditches, and burrowing animal activity. These hazard indicators were then compared to a levee's performance history to categorize each geotechnical potential failure mode. The NULE GAR assessments were performed at a single WSE (assessment WSE). The assessment WSE was the 1955/57 design profile, where available. Otherwise assessments were performed for a water surface at 1.5 to 6 feet below the levee crest, depending on the levee location. For Delta levees where a 1955/57 design profile was not available, the assessment WSE was set at 1.5 feet below the levee crest. Hazard categories were assigned for each of the four potential failure mechanisms (underseepage, slope stability, through seepage, and erosion) and then were evaluated collectively to assign an overall hazard level category to each NULE segment. The NULE GAR found NULE Segment 106 along Sacramento River, to have a *high* likelihood of levee failure at the 1955/57 design WSE based on potential vulnerability to underseepage, slope stability, through seepage, and erosion. Individual results for the four potential failure mechanisms are summarized in Table 3. More discussion of these results can be found in the GAR segment write-up included in Appendix B.

The vulnerability assessment performed for the SAFCA Evaluation for the Sacramento River were evaluated for relative vulnerability using existing information and comparing it with vulnerability criteria developed for the project that considered the following:

- Levee geometry
- Geomorphology and subsurface conditions
- Past performance – Seepage, boils, landside stability, and waterside erosion
- DWR monitoring categorization

The relative vulnerability was rated to be very low, low, moderate, or high for each evaluated stretch of levee. Based on this assessment, the northern 1-mile and southern 0.4-miles of the left bank Sacramento River levee extent protecting the community of Hood were given a high vulnerability rating due to a combination of history of significant boils and DWR critical sites, not meeting the minimum requirement of 3 feet of freeboard, likely sand levee, and/or steep slopes. The middle approximately 1.1 miles of the Sacramento River extent protecting the community of Hood was given a low to moderate vulnerability rating. This was based on adequate freeboard, flatter slopes, less past performance issues, but with likely sand levees. For more details, summary of the vulnerability evaluation for the extent of levee protecting the community of Hood is provided in Table 4.

Conclusions and Recommendations

Geotechnical understanding of the embankment and foundation will be critical to the evaluation of structural alternatives for the community of Hood. As discussed above, limited existing geotechnical information is available for the cross levee and former railroad embankments protecting Hood. Further understanding of the subsurface conditions including the depth of the aquiclude layer will be critical in determining cutoff wall construction depths and requirements during evaluation of potential structural improvements. Therefore, additional data is recommended to complete the feasibility study. Site-specific geotechnical explorations will be outlined in a separate geotechnical investigation plan. The investigation program will include collection of soil samples and in-situ data, detailed descriptions of embankment and foundation conditions, and laboratory testing to support geotechnical evaluation and development of feasibility-level repair recommendations.

References

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2868 Prospect Park Drive, Suite 310
Rancho Cordova, CA 95670
916.631.4500 fax 916.631.4501

Tables

Figures

Appendices

Acronyms

BDCP	Bay Delta Conservation Plan
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPP	Central Valley Flood Protection Plan
DWR	California Department of Water Resources
FSRP	DWR's Flood System Repair Project
GAR	Geotechnical Assessment Report
LiDAR	Light Detection and Ranging
MA	Maintenance Area
NAVD88	North American Vertical Datum of 1988
NULE	Non-Urban Levee Evaluation
RD	Reclamation District
RM	River Mile
SAFCA	Sacramento Area Flood Control Agency
SPFC	State Plan of Flood Control
USACE	United States Army Corps of Engineers
WSE	Water Surface Elevation

Tables

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916.631.4500 fax 916.631.4501

Table 1. Summary of Reported Past Performance - Sacramento River Levee Protecting the Community of Hood

NULE Segment and Location	Flood Season	Reported Performance Description	Approximate Location (Levee Mile when available)	Mitigation
Portion of NULE Segment 106 Left Bank Sacramento River MA 9 (SPFC Levee)	1936	Bank caving	RM 39.5, 39.6, 39.85, 40.8	None documented
	1957	Caved slopes, 8-10' above water surface (20' above at LM 18.58-18.59)	LM 15.26 - 15.40 LM 15.47 - 15.57 LM 15.78 - 15.80 LM 15.88 - 15.92 LM 15.98 - 16.03 LM 16.25 - 16.31 LM 17.0 - 17.12 LM 17.18 - 17.29 LM 17.40 - 17.41 LM 17.48 - 17.49 LM 17.53 - 17.54 LM 17.58 - 17.59 LM 17.61 - 17.62	None documented
	1964 & 1974	Four small boils (1964) and seepage (1974) observed within a few feet of the levee toe	LM 16.8	Monitor
	1970	Seepage 25 to 35 feet from the landside toe	LM 15.5 and LM 17.1	None documented
	1973	Boils observed at the landside toe	LM 17.6	Monitor
	1980	4-inch boil carrying material was observed 75' from the landside toe.	LM 15.65	Sack ring was constructed around the boil.
	1981	200 feet long seepage was observed along the landside toe.	LM 16.65	None documented
	1986 & 1998	Erosion and wavewash on the levee slope with a 5 to 6-foot vertical face.	LM 15.56 - 15.91 LM 17.5 - 17.55	None documented
	1986	Boils were observed. Some described as sand boils, generally occurring within a few feet of levee toe.	LM 16.1- 16.3, LM 16.4, LM 16.7, LM 17.0, LM 17.2, and LM 17.65	Sand boils were sacked with sandbag chimneys

Table 1. Summary of Reported Past Performance - Sacramento River Levee Protecting the Community of Hood

NULE Segment and Location	Flood Season	Reported Performance Description	Approximate Location (Levee Mile when available)	Mitigation
Portion of NULE Segment 106 Left Bank Sacramento River MA 9 (SPFC Levee)	1986	Seepage was observed. No additional details available	LM 15.9 LM 16.20 - 16.45 LM 16.55 LM 16.65-16.75 LM 17.05-17.7	None documented
	1995, 1996, and 1998	Erosion	LM 17.4	None documented
	1995	Erosion on the landside shoulder down slope	LM 15.5	None documented
	1995	Erosion	LM 16.8	Covered with visquine and sand bags to prevent further damage
	1995	Erosion on waterside slope at the property owners concrete walkway near the boat dock.	LM 17.61	None documented
	1995	Landside sluffing 100 long, 15 feet wide, and 8 feet deep - middle of slope to toe	LM 16.8	Covered with visquine and sand bags to prevent further damage
	1995	Seepage at the landside toe around irrigation valves	LM 17.8 - 17.9	None documented
	1996	Sluff and wavewash erosion	LM 16.3, LM 16.5, and LM 17.6	None documented
	1996	450 feet of seepage at the landside toe near irrigation valves	17.8-18.1	None documented
	1997	Seepage and 1-inch to 3-inch boils 0-20 feet from the landside toe. A couple locations had boils carrying material.	LM 15.5 LM 16.0 - 16.07 LM 16.8	At LM 16.0 & 16.05, boils were carrying material. Sack ring was constructed around these boils.
	1997	Revetment damage on the waterside slope 33 feet high, 50 feet long, and 1 to 3 feet deep.	LM 16.17	None documented
	1997	12 to 40 feet of sluffing was observed on the waterside. The slough at LM 17.4 was observed to be 12 feet high, about 12 feet long and 2.5 feet deep.	LM 17.4 LM 17.77 LM 17.8	Erosion at LM 17.77 was covered with visquine and held down with sandbags.

Table 1. Summary of Reported Past Performance - Sacramento River Levee Protecting the Community of Hood

NULE Segment and Location	Flood Season	Reported Performance Description	Approximate Location (Levee Mile when available)	Mitigation
Portion of NULE Segment 106 Left Bank Sacramento River MA 9 (SPFC Levee)	1998	Slips were observed 5 to 6 feet up the levee slope	LM 15.35 - 15.36 LM 16.01-16.18	None documented
	1998	Levee slips were observed as well as rock revetment toe failures	LM 16.3 - 17.17	None documented
	1998	Erosion	LM 17.5	None documented
	2017	Small boils with minor sediment transport.	LM 16.45 LM 16.5 LM 16.7	Sack rings were constructed to stop flow
	1997 and Reoccurring in High Water	Boils and seepage reported to occur at every highwater period.	LM 15.64 LM 15.89 - 15.95	None documented

Table 2. Summary of Levee Geometry[1] - Sacramento River Levee Protecting the Community of Hood

NULE Segment and Location	NULE Stationing[2]	Approximate Base Width (ft)	Approximate Crest Width (ft)	Approximate Landside Levee Height (ft)	Approximate Landside Toe Elevation (NAVD88)	Approximate Landside Slope (XH:1V)	Approximate Waterside Slopes (XH:1V)
Portion of NULE Segment 106 Left Bank Sacramento River MA 9 (SPFC Levee)	3105+00	158	101	8	18.6	5.0	2.1
	3110+00	143	107	10	14.5	1.8	1.8
	3115+00	87	36	11	14.3	2.7	1.9
	3120+00	102	33	17	13.0	2.1	1.8
	3125+00	98	33	16	14.3	1.8	2.2
	3130+00	119	48	16	13.8	2.1	2.2
	3135+00	102	33	16	13.5	1.7	2.5
	3140+00	113	28	15	14.9	3.0	2.6
	3145+00	101	39	15	13.9	1.8	2.3
	3150+00	100	36	16	14.0	1.8	2.1
	3155+00	88	36	15	13.9	1.6	1.8
	3160+00	95	30	16	13.2	1.6	2.3
	3165+00	88	37	15	14.5	1.7	1.6
	3170+00	94	30	16	12.9	2.0	2
	3175+00	101	34	17	12.3	2.1	1.7
	3180+00	97	37	16	13.2	2.0	1.7
	3185+00	92	41	12	17.1	2.9	1.3
	3190+00	100	37	15	13.9	1.6	2.5
	3195+00	94	38	16	13.5	1.7	1.7
	3200+00	97	37	16	13.6	2.0	1.6
	3205+00	109	34	17	13.3	2.2	2.1
	3210+00	96	37	16	14.0	2.0	1.6
	3215+00	108	38	17	13.0	1.5	2.5
	3220+00	107	30	17	13.8	2.2	2.2
	3225+00	100	37	16	14.0	2.1	1.7
	3230+00	104	32	17	14.1	2.0	2.1
	3235+00	95	35	17	14.1	1.8	1.7

[1] Adapted from Table A-1 of SAFCA Evaluation of Sacramento River Non-Urban Levees Memorandum.

[2] DWR NULE Stationing for Sacramento River left bank, see Figure 1

Table 3. Summary of NULE GAR Assessment Results - Levee Protecting the Community of Hood

NULE Segment	Segment Location	Assessment WSE	Overall Segment Categorization[1]	Results by Individual Failure Mechanism			
				Underseepage[2]	Slope Stability[2]	Through Seepage[2]	Erosion[2]
106[3]	Left Bank Sacramento River - MA 9 (SPFC levee)	1957 Design WSE	High	High	Moderate	High	Moderate

[1] As part of the NULE GAR, hazard categories for each of the four potential failure mechanisms were evaluated collectively to assign an overall hazard level category to each segment.

[2] Likelihood of either levee failure or the need to flood-fight to prevent levee failure when the water reaches the assessment WSE.

[3] NULE segment extends beyond Community of Hood, NULE assessment for segment as a whole

Table 4. Summary of SAFCA Vulnerability Evaluation - Levee Protecting the Community of Hood

		SAFCA Evaluation Results[1]		
NULE Segment and Location	**Approximate Levee Miles**	**NULE Stationing[2]**	**SAFCA Evaluation Vulnerability Rating**	**Evaluation Notes**
Portion of NULE Segment 106 Left Bank Sacramento River MA 9 (SPFC Levee)	LM 15.3 to LM 16.3	3235+00 to 3185+00	High	• 4.6 to 6.4 feet of freeboard; w/s slope 6 of 11 locations < 2H:1V and 1 of 11 locations ≤ 1.5H:1V, l/s slope 4 of 11 locations < 2H:1V and 1 of 11 locations ≤ 1.5H:1V. • Likely sand levee, overbank deposits with crevasse splay and historical borrow pit, outside bank of meander. • History of significant boils, minor seepage and w/s slips. • DWR Seepage Category: critical (for isolated areas within the reach).
	LM 16.4 to LM 16.9	3180+00 to 3155+00	Moderate	• 4.4 to 5.8 feet of freeboard, w/s slope 4 of 6 locations < 2H:1V, l/s slope 3 of 6 locations < 2H:1V. • Likely sand levee, overbank deposits with distributary channel, outside bank of meander. • History of boils, seepage, l/s slip, and w/s erosion and slips in isolated areas. • DWR Seepage Category: serious (for isolated areas within the reach).
	LM 16.95 to LM 17.35	3150+00 to 3130+00	Low	• 5.6 to 6.8 feet of freeboard, w/s slope all locations > 2H:1V, l/s slope 3 of 5 locations < 2H:1V. • Likely sand levee, overbank deposits. • History of minor boils and seepage, and w/s isolated slips.
	LM 17.45 to LM 17.85	3125+00 to 3105+00	High	• 1.3 to 6.5 feet of freeboard, w/s slope 3 of 5 locations < 2H:1V, l/s slope 2 of 5 locations < 2H:1V. • Likely sand levee, overbank deposits, outside bank of meander. • History of minor boils, significant seepage, and w/s isolated erosion and slips. • DWR Seepage Category: critical.

[1] Extracted from Table 5 of SAFCA Evaluation of Sacramento River Non-Urban Levees Memorandum.

[2] DWR NULE Stationing for Sacramento River left bank, see Figure 1

Figures

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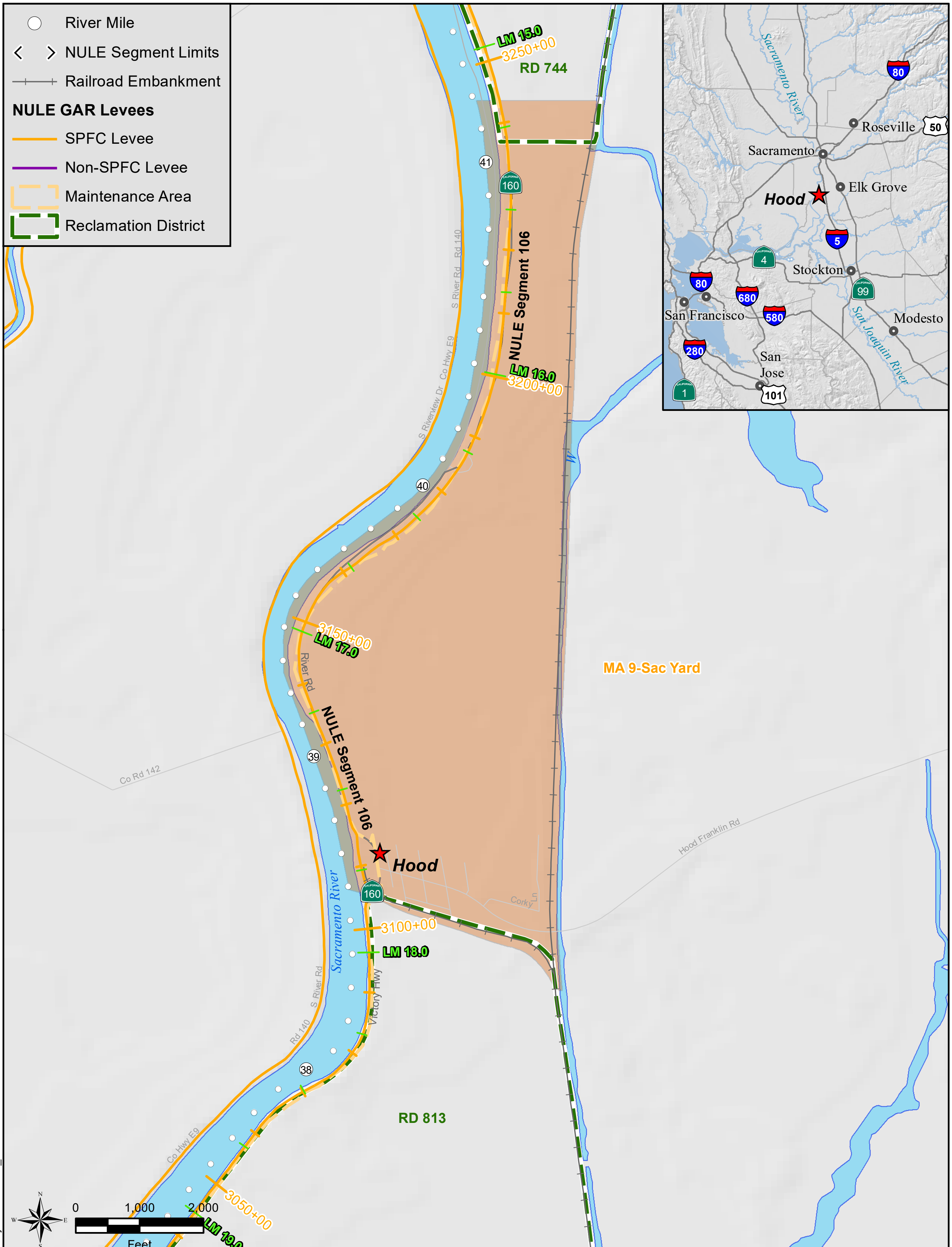

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Small Communities
Flood Risk Reduction Program

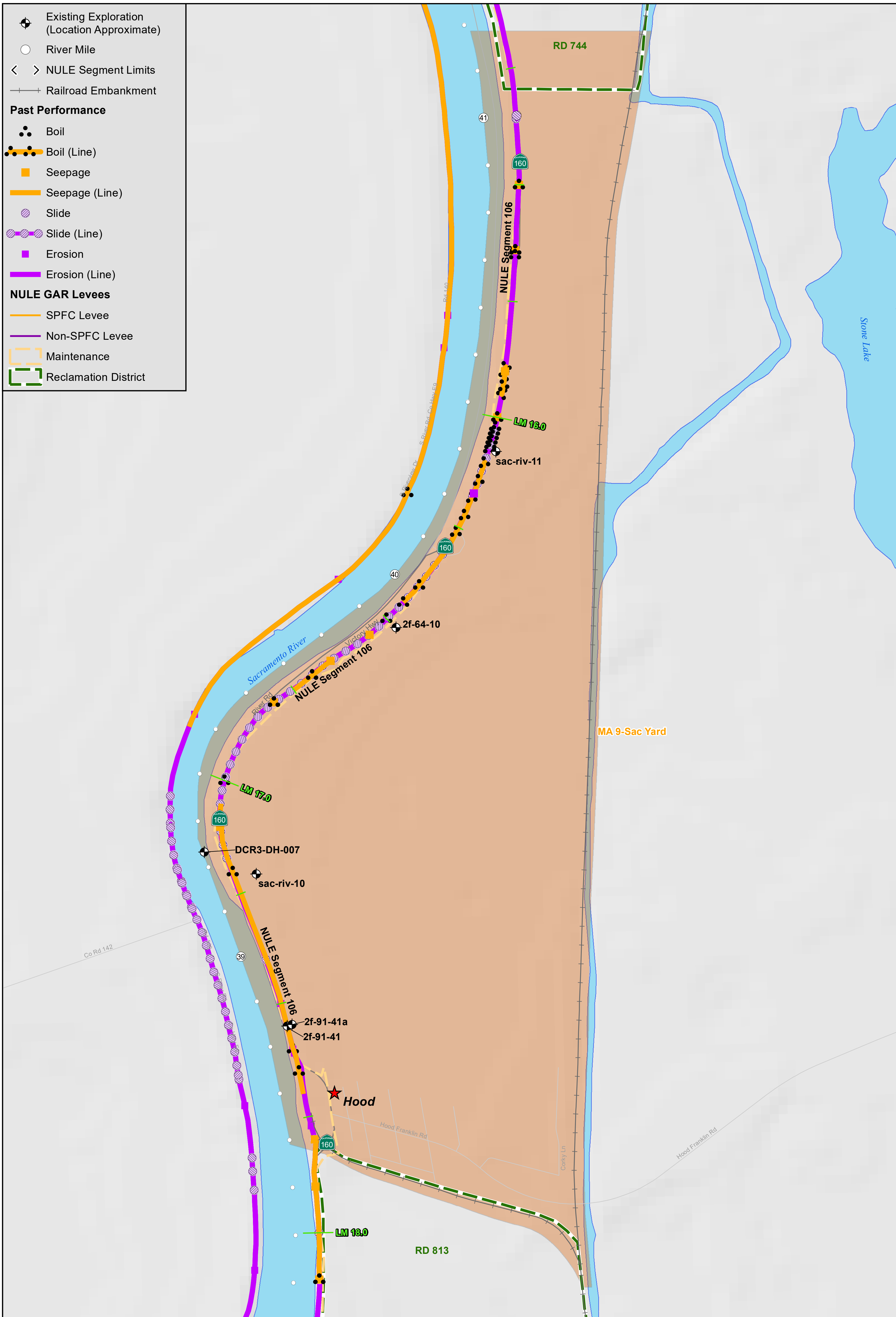
County of Sacramento

GEI Consultants

COMMUNITY OF HOOD

OCTOBER 2018

FIGURE 1



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Flood Risk Reduction Program

County of Sacramento

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EXISTING EXPLORATIONS AND
PAST PERFORMANCE
COMMUNITY OF HOOD

OCTOBER 2018

FIGURE 2

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Appendix A

FSRP *Critical* and *Serious* Site Map and Table

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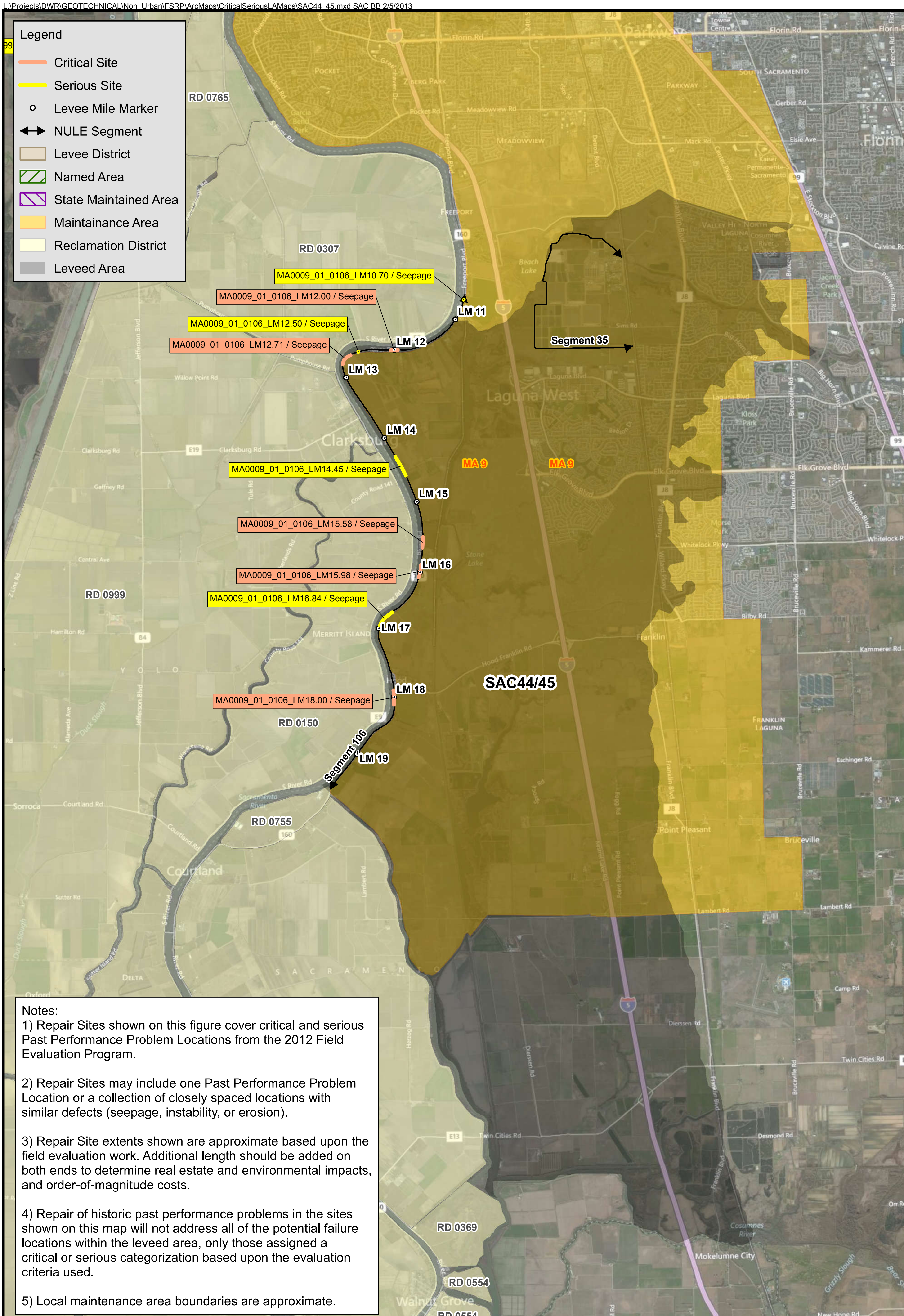

Notes:
1) Repair Sites shown on this figure cover critical and serious Past Performance Problem Locations from the 2012 Field Evaluation Program.

2) Repair Sites may include one Past Performance Problem Location or a collection of closely spaced locations with similar defects (seepage, instability, or erosion).

3) Repair Site extents shown are approximate based upon the field evaluation work. Additional length should be added on both ends to determine real estate and environmental impacts, and order-of-magnitude costs.

4) Repair of historic past performance problems in the sites shown on this map will not address all of the potential failure locations within the leveed area, only those assigned a critical or serious categorization based upon the evaluation criteria used.

5) Local maintenance area boundaries are approximate.

N

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Miles

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Division of Flood Management
Levee Evaluations Branch

URS

Critical and Serious Sites SAC44/45

Flood System Repair Project

Figure SAC44/45-1

TABLE SAC44/45-2
CRITICAL AND SERIOUS SITES

SAC44/45 (Pilot Study Area)
Area Name: Stone Lake & Hood
Includes Segments: 35, 106

Reconnaissance Dates: May 23 to May 31, 2012

This table includes sites along all of Segment 106. Those within the approximately 2.5 mile extent protecting the community of Hood are within red box below.

Critical and Serious Site Name	Past Performance Problem or Observation	Segment	Unit	Waterway	LMA	Failure Mode	Site Status	Approximate Levee Mile Location	Past Performance Problem Length	Supporting Evidence for Rating	Senior Review Date
MA0009_01_0106_LM10.70	106-230 (Point added to POI list after Pilot Study was completed, visited on 9/20/2012 by Team 3)	106	Unit No. 1	Sacramento River	MA9	Seepage	Serious	10.7	150 ft	Seepage and boils were observed during the 1981 and 1997 floods. The boils were located near the landside toe, did not carry material, and did not have a flood fight. No signs of active seepage or evidence of past seepage damage observed during the FSRP reconnaissance. Site is "serious" due to recurrent sand boils that did not carry material.	September 12, 2012
MA0009_01_0106_LM12.00	106-83, 106-314, 106-129, 106-146, 106-215, 106-243, 106-50, 106-121	106	Unit No. 1	Sacramento River	MA9	Seepage	Critical	11.95 - 12.05	500 ft	Past flood fights: 1986 likely; 1997 landside. sack rings. 1993 USACE report calls for repair of this reach (REF1044, MA9-5, 7200 ft.). This location was noted in 2008 MA9 interview as boil spot (REF8314, Way Point 53).	July 24, 2012
MA0009_01_0106_LM12.50	106-63, 106-315	106	Unit No. 1	Sacramento River	MA9	Seepage	Serious	12.5	100 ft	Boils noted in 1981, slope sloughing/slumping noted in 1996.	July 24, 2012
MA0009_01_0106_LM12.71	106-247 106-164, 106-59, 106-248, 106-295, 106-32, 106-60	106	Unit No. 1	Sacramento River	MA9	Seepage	Critical	12.62 - 12.80	1,000 ft	Poor levee material, pervasive hydrophilic vegetation, slope sloughing. Past boils 1981, 1988; flood fight 1998 (sand bags); slope sloughing/slumping 1998. At river bend, a relatively long reach. May extend south to LM 12.87	July 24, 2012
MA0009_01_0106_LM14.45	106-203, 106-219 106-52, 106-166, 106-78, 106-15 106-223, 106-301	106	Unit No. 1	Sacramento River	MA9	Seepage	Serious	14.3 - 14.6	1,500 ft	Poor levee material, pervasive hydrophilic vegetation, some rodent activities. 1993 USACE report calls for repair of this reach (REF1044, MA9-4A, 2000 ft.). Past boils 1986, 1997; flood fight 1986 (sand bags)	July 24, 2012
MA0009_01_0106_LM15.58	106-100, 106-133 106-254, 106-42, 106-255	106	Unit No. 1	Sacramento River	MA9	Seepage	Critical	15.50 - 15.65	800 ft	Poor levee material, pervasive hydrophilic vegetation, rodent burrow holes, minor toe cut. Reference #765 show sack rings at LM 15.64. Past boils 1980, 1997; flood fight 1997 (sand bags).	July 24, 2012
MA0009_01_0106_LM15.98	106-43 106-134, 106-39, 106-135, 106-136, 106-137, 106-138, 106-139, 106-140	106	Unit No. 1	Sacramento River	MA9	Seepage	Critical	15.89 - 16.07	1,000 ft	Poor levee material, pervasive hydrophilic vegetation, rodent activity, slope slough and slump, pipe penetration. 1993 USACE report calls for repair of this reach from approx. LM 16 to 18.2 (REF1044, MA9 2A-4E, 2.2 miles, RM 37.8 to 40.0). Past boils 19971, 1988; flood fight 1986 likely, 1997 sack ring; slope sloughing/slumping 1998 (and current).	July 24, 2012
MA0009_01_0106_LM16.84	106-54 106-141, 106-222	106	Unit No. 1	Sacramento River	MA9	Seepage	Serious	16.70 - 16.97	1,500 ft	1993 USACE report calls for repair of this reach from approx. LM 16 to 18.2 (REF1044, MA9 2A-4E, 2.2 miles, RM 37.8 to 40.0). Past boils 1964, 1986, 1997, 2006?; flood fight 1986 likely, 1997 sack ring; slope sloughing/slumping 1995.	July 24, 2012

TABLE SAC44/45-2
CRITICAL AND SERIOUS SITES

Critical and Serious Site Name	Past Performance Problem or Observation	Segment	Unit	Waterway	LMA	Failure Mode	Site Status	Approximate Levee Mile Location	Past Performance Problem Length	Supporting Evidence for Rating	Senior Review Date
MA0009_01_0106_LM18.00	106-165, 106-152 106-220, 106-88, 106-221 106-339	106	Unit No. 1	Sacramento River	MA9	Seepage	Critical	17.90 - 18.10	1,600 ft	Poor levee material, Landside slope slump and shallow slough, rodent burrow holes. 1993 USACE report calls for repair of this reach from approx. LM 16 to 18.2 (REF1044, MA9 2A-4E, 2.2 miles, RM 37.8 to 40.0). This location was noted in 2008 MA9 interview as seepage spot (REF8314, Way Point 57). Past boils 1986, 1997; flood fight 1986 likely, 1997 sack ring; slope sloughing/slumping currently.	July 24, 2012

Note: POI same as Past Performance Problem

Appendix B

NULE GAR Segment Write-Up

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Rancho Cordova, CA 95670
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MA-9, UNIT 1, SEGMENT 106 SUMMARY

This segment summary presents collected information and the assessment results for Segment 106. The summary is based on data that were readily available data at the time the segment was assessed. The amount of detail that was available varied. Known pertinent details are included. For details on the data collection and assessment procedures, see Volume 1, Section 2 of this report.

This summary is organized into the following seven sections:

- Segment Description and Assessment Summary
- Levee Segment History
- General Levee Conditions
- Levee Composition and Foundation Conditions
- Geotechnical Assessment Results
- Other Levee Assessments
- Hazard Mitigation

Segment 106: Segment Description and Assessment Summary

Segment 106 is an urban and non-urban Project levee located on the left (east) bank of the Sacramento River in Sacramento County, California (see attached map).The NULE portion of the segment extends from about Freeport Avenue southward to the confluence of the Sacramento River and Snodgrass Slough, then southward to just north of Courtland. The following table summarizes segment information.

Segment 106 Information

Maintenance Authority	Unit	Levee Miles*	NULE Stationing*
MA-9	1	10.6 to 19.61	Sacramento River Left Bank 3012+10 to 3479+00

* The levee mile and stationing alignments differ.

As directed by DWR, the segment was assessed for each potential failure mode at the 1955/1957 design water surface elevation provided by DWR. The following table presents the Segment 106 categorizations for each potential failure mode.

Segment 106 Potential Failure Mode Assessment Summary

Potential Failure Mode	Categorization
Underseepage	Hazard Level C
Stability	Hazard Level B
Through Seepage	Hazard Level C
Erosion	Hazard Level B

Based on these NULE Phase 1 levee assessments, the overall categorization for Segment 106 is Hazard Level C.

Segment 106: Levee Segment History

The levee segment history described in the following sections is based on reviews of documents that are available in the NULE document database, and on interviews with personnel familiar with the levee and its history. The descriptions include construction history, performance, improvements, and planned improvements. The amount and quality of information varies from segment to segment. This segment summary contains pertinent information gathered during data collection. Some details may not be known.

Construction History

Based on historical topographic maps (Courtland 1:62,500) (Doc-8590), the Segment 106 levee was initially constructed prior to 1906 by local interests. Information about the methods used for initial construction of the levee was not available. However, levees along the Sacramento River were generally built using materials dredged from the river channel and placed without compaction (Doc-5249). Portions of the levee that did not meet Project standards were improved by the USACE to Project standards between 1947 and 1955 (Doc-2116). The improvements included bank protection work at RM 41.0 in 1947, emergency banks repairs at RM 43.25 and RM 43.75 in 1953, and bank protection at unlisted locations from 1954 to 1955. The following table presents the 1953 MOU geometric criteria for Segment 106.

Segment 106 Geometric Criteria

Levee Type	Crown Width (feet)	Waterside Slope	Landside Slope
Project Levee	20	3H:1V	2H:1V

Performance

Levee performance information was obtained from reviewed documents and interviews with MA-9 maintenance personnel. Based on the available information, performance events in Segment 106 include erosion, underseepage, through seepage, and slope instability that occurred during multiple flood seasons. The following table summarizes reported performance events.

Segment 106 Reported Levee Performance Events

Flood Season	Reported Performance Event	Approximate Location (Levee Mile)	Mitigation
1961 1986 1995 to 1998 2000 2005 to 2006	Multiple erosion sites (Doc-1540, Doc-765, Doc-936, Doc-3941, Doc-3762, Doc-469, Doc-4519, Doc-8314, and the CLD)	Multiple locations	Some locations mitigated using rip-rap revetment; mitigation not documented at other locations.
1981 to 1999	Several landside sloughs during flood fighting. The most significant is a 400-foot slough with seepage (Doc-1540 and Doc-3941).	Multiple with significant slough at LM 12	Not indicated.
1981 to 1999	Seepage and boils at multiple locations (Doc-3941).	10.6 – 18.7	Some sandbags, many not indicated.
1986	Seepage and boils that generally occurred within a few feet of the levee toe (Doc-1044).	10.8 – 12.2 14.25 – 14.35 16.05 – 16.25 16.55 – 16.65 16.95 – 17.5 18 – 18.2	Sacked with sandbag chimneys during the flood (Doc-1044) .Other mitigation not found.
2006	Boil; details not provided (Doc-8314).	16.97	Mitigation not found.

Underseepage

Numerous occurrences of seepage and boils are identified in the CLD and the documents reviewed. The occurrences are most pervasive between LM 11.2 to LM 13.8 and between LM 14.5 to LM 18.7. The documented location of the seepage and boils is generally at or near the levee toe. Most of the boils that occurred during the 1986 flood season were reported to have transported small volumes of fine to medium sand (Doc-1044). Boils at LM 15.6 and from LM 15.89 to LM 15.95 were reported after the 1997-1998 flood season to occur during every high-water period, and were not growing in size. The documentation and the 2008 interview with MA-9 personnel (Doc-8314) indicate that boils are mitigated using sandbags.

In addition to the underseepage documented in the table of Segment 106 Reported Levee Performance Events, the CLD lists a relief well at LM 17.8. Relief wells are typically installed in areas of underseepage. Details of the relief well were not found.

Stability

A number of landside sloughs were documented by MA-9 from 1981 to 1999. The most significant of these is at LM 12. This occurrence is reported as a 400-foot-long slough associated with through seepage (Doc-3941). Some of the sloughs are documented as associated with seepage, and others are not.

Through Seepage

Through seepage is documented as associated with landside sloughs, as described in the section above on stability. In addition, much of the documented seepage occurs near the levee toe. Seepage at the levee toe may result from through seepage rather than underseepage.

Erosion

Segment 106 has had erosion problems since 1955. Erosion has been frequent and pervasive along this segment because the levee materials are highly erodible sand and silt materials (Doc-607). Multiple erosion sites along the segment were identified during inspections following the 1961, 1986, 1995 to 1998, 2000, and 2005 to 2006 flood seasons (Doc-1540, Doc-765, Doc-936, Doc-3941, Doc-3762, Doc-469, Doc-4519, Doc-8314, and the CLD). MA9 maintenance logs indicate that several erosion occurrences were repaired with revetment in the years following the flood events (Doc-3941). Erosion repair after the 1997 flood includes the placement of rock revetment at six PL 84-99 sites (Doc-765). Four more recent erosion sites (LM 11.0, LM 11.1, LM 11.99, and LM 12.0) were repaired in 2000 based on a CDFG Streambed Alteration Permit application (Doc-469). Photographs of repaired erosion sites resulting from a storm in 2005-2006 were obtained during the 2008 interview with MA-9 personnel (Doc-8314).

Improvements

Improvements include riverbank protection work performed under the Sacramento River Bank Protection Project (SRBPP) during Phase 1 from 1963 to 1967 and from 1969 to 1973, and during Phase 2 in 1976 and 1981 (Doc-8587). The completed riverbank protection work included the placement of revetment at multiple locations along the segment.

Planned Improvements

Based on the team’s review, no improvements to Segment 106 are currently planned.

Segment 106: General Levee Conditions

This section describes levee conditions based on document reviews, interviews, site reconnaissance, the LiDAR survey, and other collected data. These conditions include the levee geometry, penetrations, and animal activity.

Levee Geometry

Segment 106 levee heights range from approximately 14 to 20 feet above the landside toe. Including the rounded shoulders, crest width ranges from approximately 20 to 35 feet. LiDAR survey data indicate the landside slopes are approximately 1.5H:1V to 2.5H:1V. The waterside slopes are approximately 1.3H:1V to 3H:1V. A ditch is present along the landside toe of Segment 106 from about Station 3326+00 to Station 3338+00.

Penetrations

According to the DWR Pipe Inventory, 55 pipes penetrate the levee segment. Pipe diameters range from 2 to 48 inches. The pipes are approximately 1 to 20.5 feet below the levee crown. Several penetrations appear to coincide with past seepage performance problems. Seepage associated with pipe penetrations was documented in 1995 and 1996 at LM 17.8, LM 17.9 and LM 18.7 (Doc-3941).

Animal Activity

Animal activity was not reported in the reviewed documents. However, occasional animal activity was noted during the 2008 interview with MA-9 personnel (Doc-8314). Animal persistence based on data from DWR is “Low” in Segment 106.

Maintenance

Based on the DWR assessments performed in the fall of 2008, DWR rates the levee maintenance as “Minimally Acceptable” for this segment.

Other Features

The Southern Pacific Railroad embankment intersects the levee at the north end of the NULE portion of Segment 106, and continues northward on the crest of the ULE portion of Segment 106. A building facility at NULE Station 3109+50 to Station 3110+50 includes access to a dock-loading facility on the levee crest. Segment 106 has one ditch near NULE station 3237+00 that does not run parallel to the levee. A borrow pit is indicated on the Level 2-II mapping between NULE Station 3223+00 to Station 3235+00.

Segment 106: Levee Composition and Foundation Conditions

The NULE team established an understanding of levee and levee foundation geotechnical conditions based on work performed by the geomorphology team, reviews of other available geologic and soil maps, data contained in reports that were reviewed, and general knowledge of levee conditions in the area. This section summarizes the team’s understanding of geotechnical conditions in Segment 106.

In Segment 106, the levee foundation consists mainly of interbedded layers of silt, clay, and sand underlain by a sand layer, and the levee consists primarily of loose sand and some silt.

Geomorphic Setting

Segment 106 is in the Sacramento Valley flood basin. The Level 2-II mapping indicates that the northern 6.2 miles of the segment between LM 10.6 to LM 19.6 overlies recent and Holocene overbank deposits consisting of interbedded silt, sand, and clay. These deposits likely interfinger with adjacent flood plain silt and clay sediments, and are likely to vary laterally in extent and character. The Level 2-II mapping also includes occurrences of Holocene crevasse splays between LM 10.6 to LM 11.3, recent and Holocene crevasse splays between LM 13.9 to LM 15.1, and a recent crevasse splay at LM 16.1. The recent and Holocene crevasse splays are described as likely to consist of fine sand with silt and clay. The mapping also shows that the southern 2.8 miles of the segment, from LM 16.8 to LM 19.6, overlies recent overbank deposits of interbedded silt, sand, and clay.

Geotechnical Investigations

Geotechnical investigations for Segment 106 performed by others include six borings in the DWR Salinity Control Barrier Study (1958) (Doc-8306), three borings from the Peripheral Canal Study (1966) (Doc-8306), five borings by Wahler Associates (1986) (Doc-3762), three borings for the Sacramento River Flood Control System Evaluation (USACE 1993) (Doc-1044) and two borings by the USACE in 2006 (Doc-8592) just north of the segment in the ULE portion of Segment 106. Three of these borings were drilled through the crest of the levee, while the other 16 borings were drilled near the landside levee toe. These borings range in depth from 15 to 50 feet. Stick logs indicate that the soil in the levee prism consists primarily of loose sand and some silt, and that the soil in the foundation consists mainly of interbedded layers of silt, clay, and sand underlain by a sand layer.

Other Subsurface Information

The USCS soil map indicates that the existing levee overlies fine-grained soils (CL and CL-ML) from LM 10.6 to LM 14.75, coarse-grained soils (SM) from LM 14.75 to LM 15.2, and fine-grained soils (CL-ML) from LM 15.2 to LM 19.6. The USCS map does not show the soil type variations that are indicated in the Level 2-II mapping or that were found in the borings.

Levee Composition

The available boring data indicate that the levee consists of loose sand and some silt.

Segment 106: Geotechnical Assessment Results

The overall Segment 106 categorization is Hazard Level C. As discussed in Volume 1, Section 2 of this report, the overall assessment is based on the individual potential failure mode categorizations. A summary of the LAT results and the matrix plots are attached. For this segment, the potential failure mode categorization for both underseepage and through seepage is Hazard Level C, resulting in an overall categorization of Hazard Level C.

A Weighted Hazard Indicator Score was calculated for each potential failure mode at the assessment water surface elevation, the 1955/1957 water surface elevation provided by DWR. The assessment is based on identified geologic, geometric, and other hazards. A rating for past performance based on documented performance events was assigned. The categorizations for each potential failure mode are discussed in the sections that follow.

Underseepage

Segment 106 Underseepage Assessment Results

WHIS			Performance Summary			Categorization
Best Estimate	Minimum Credible	Maximum Credible	Best Estimate	Minimum Credible	Maximum Credible	
79	68	79	Multiple recurring boils	Multiple recurring boils	Multiple recurring boils	Hazard Level C

The WHIS results from levee foundation materials that have high to very high underseepage susceptibility, as indicated by the geomorphic mapping, the available boring information, and a levee section that is relatively narrow for the differential head between the assessment water surface elevation and the levee toe. The WHIS is consistent with the past performance data of documented multiple, recurring boils in the segment. Segment 106 is categorized as Hazard Level C for the underseepage potential failure mode based on the WHIS and the past performance history of multiple, recurring boils.

Stability

Segment 106 Stability Assessment Results

WHIS			Performance Summary			Categorization
Best Estimate	Minimum Credible	Maximum Credible	Best Estimate	Minimum Credible	Maximum Credible	
53	43	53	Minor	Minor	Moderate	Hazard Level B

The WHIS results from the levee composition of loose sand, the levee height of up to 20 feet above the levee toe, a moderate differential head between the assessment water surface elevation and the levee toe, and levee slopes steeper than 2H:1V. Segment 106 is categorized as Hazard Level B for the stability potential failure mode based on the WHIS and the past performance history of minor instability in the segment.

Through Seepage

Segment 106 Through Seepage Assessment Results

WHIS			Performance Summary			Categorization
Best Estimate	Minimum Credible	Maximum Credible	Best Estimate	Minimum Credible	Maximum Credible	
70	55	75	Free seepage	Wet area	Free seepage	Hazard Level C

The WHIS results from the levee composition of loose sand, low animal persistence, multiple penetrations and a levee section that is relatively narrow for the differential head between the assessment water surface elevation and the levee toe. The WHIS is consistent with the documented past performance history of free seepage in the segment. Segment 106 is categorized as Hazard Level C for the through seepage potential failure mode based on the WHIS and the past performance history of free seepage.

Erosion

Segment 106 is categorized as Hazard Level B for erosion. The segment has a history of erosion events; the most recent was reported in the 2005-2006 flood season, as noted in the 2008 interview with MA-9 personnel. Documented mitigation of several of the past erosion sites was not found. The reported erosion sites were not documented as impacting the levee crown. Based on the LiDAR data, erosion of the waterside slope may be occurring along about 40 percent of the segment.

Anomalies

Seepage associated with pipe penetrations was documented in 1995 and 1996 at LM 17.8, LM 17.9, and LM 18.7 (Doc-3941). Documented mitigation for the seepage at the penetrations was not found.

Segment 106: Other Levee Assessments

Freeboard

Data from the LiDAR survey indicate that the levee crest for Segment 106 is above the 1955/1957 WSE. However, a minimum freeboard of 3 feet is not present from approximately Station 3107+50 to Station 3113+50 where the crest appears to be up to approximately 1.1 feet below the design freeboard.

Overtopping

Overtopping was considered based only on past performance. Evaluation of flood flows, flood elevations, channel capacities, and other factors influencing overtopping risk is beyond the scope of the NULE project. These factors should be studied by others to evaluate the overtopping risk to the NULE levees. Documents do not indicate this levee segment has been overtopped.

Geometry

Using the LiDAR data, the levee geometry was compared with a standard levee prism defined by the Segment 106 1953 MOU geometric criteria. This check was performed by assessing whether the levee indicated by topography developed from the LiDAR data was larger than or equal to the standard levee prism at any given cross section. Wide levees could meet this requirement even where levee slopes are steeper than those described in the 1953 MOU. For Segment 106, approximately 25 percent of the levee is smaller than the standard levee prism.

Segment 106: Hazard Mitigation

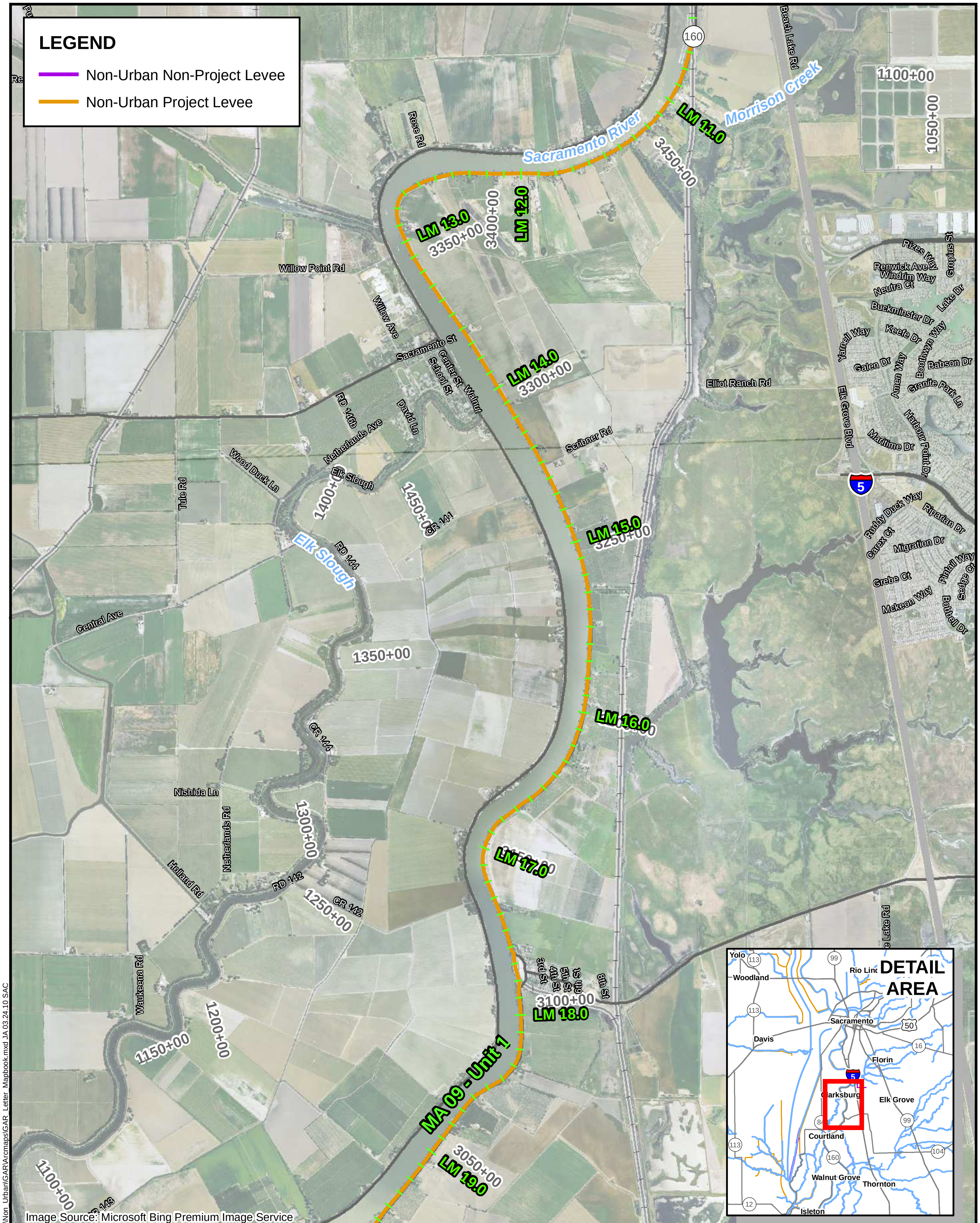
The following table presents identified hazards for Segment 106, and the estimated extent of the hazard. Comments are provided to assist with identifying potential remedial requirements.

Segment 106 Hazards

Hazard	Extent (percent)	Comments
Underseepage	80	Sand layers underlying the levee may extend up to 75 feet below the levee toe elevation. Extent is based on portions of segment that have a relatively narrow base width, as indicated by LiDAR data.
Stability	40	Extent is based on portions of the levee where LiDAR data indicate landside slopes steeper than 2H:1V. However, mitigation for through seepage will likely also address levee instability.
Through Seepage	80	Clean sand levee. Extent is based on portions of the segment that have a relatively narrow levee section, as indicated by LiDAR data.
Erosion	40	Estimated based on areas of oversteepened slopes, as interpreted from LiDAR data.

Segment 106: Anomalous Hazards

Seepage associated with pipe penetrations was documented in 1995 and 1996 at LM 17.8, LM 17.9, and LM 18.7 (Doc-3941). A borrow pit is mapped adjacent to the levee on the Level 2-II geomorphic mapping between NULE Station 3223+00 and Station 3235+00.



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Feet

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Department of Water Resources
Division of Flood Management
Levee Evaluations Branch

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Segment 106

Maintenance Area No. 09

Geotechnical Assessment Report

NORTH NON-URBAN LEVEE EVALUATIONS

Non Urban Levee Evaluation Program (NULE) Levee Assessment Tool, Version 1.2 (revised: 1/7/2010)

				Begin	End
Levee Segment Name:	Maintenance Area No. 9		NULE Station (ft):	3012+10	3479+00
Levee Segment Number:	106		Levee Mile:	19.6	10.64
Brief Description of Segment/Reach:	City of Sacramento - south of American River along left bank of Sacramento River		Segment/Reach Length:	8.8 (miles)	46690 (feet)
			Crest Width Design Criterion (ft):	20	
Local Maintenance Authority:	Maintenance Area No. 9		Design Guidance Document:	1953 MOU	
Freeboard Evaluation Criterion (ft):	3				
Water Side Slope Design Criterion:	3H : 1V	Enter Other Criterion	Project or Non-Project Levee?	Project	
Land Side Slope Design Criterion:	2H : 1V	Enter Other Criterion			
North or South NULE?	North				

LEVEE CONSTRUCTION

Describe what is known about construction of this levee segment:	The Segment 106 levee was initially constructed by local interests. Based on an early topographic map (Courtland, 1:62,500), initial construction occurred prior to 1906. Specific documentation of the construction methods for the levee were not found. Levees along the Sacramento River were generally built using materials dredged from the river channel placed without compaction (Doc-5249). Portions of the levee were improved by USACE to project standards between 1947 and 1955 (Doc-2116). The improvements included bank protection work at RM 41.0 in 1947, emergency banks repairs at RM 43.25 and 43.75 in 1953, and bank protection at unlisted locations in 1954 to 1955.

Analysts should populate all yellow cells, and not populate grey cells; green cells store calculated values. Use the suite of available data in making ratings. See User Guide and tables for further information.

PAST PERFORMANCE

	Value (where applicable)	Best Estimate Rating	Minimum Credible Rating	Maximum Credible Rating	Explanation & Comments (include event date and flood elevation, if available)
Underseepage		*Multiple, recurring sand boils*	*Multiple, recurring sand boils*	*Multiple, recurring sand boils*	Doc 3941 - Multiple locations whenever high water in channel
Landside slope stability		*Minor*	*Minor*	*Moderate*	Doc 3941 - 1997 - 400' landside slough at LM 12; 1995 - slough at LM 16.8
Through seepage		*Free seepage*	*Wet area*	*Free seepage*	Doc 3941 - Multiple seepage locations (data not clear if on slope or beyond toe)

In addition to Ayres 2008/DWR 2009 studies, are there erosion occurrences identified in this study?	Yes	**If yes, please describe:**	The segment has experienced ongoing erosion problems since 1955. Erosion has been frequent and pervasive along this segment due to levee materials being highly erodible sand and silt materials (Doc-607). Multiple erosion sites along the segment were identified during inspections following the 1961, 1986, 1995-1998, 2000 and 2005-2006 flood seasons (Doc-1540, Doc-765, Doc-936, Doc-3941, Doc-3762, Doc-469, Doc-4519, DWR MA 9 2008 Interview, CLD).				
North NULE	**Erosion sites from the Ayres 2008 study**	**Ayres Methodology 2**			**Ayres Methodology 4**		
		Rating (1 to 72)	**Ranking (out of 117)**		**Rating (1 to 47)**	**Ranking (out of 117)**	
Are there erosion occurrences compiled in the Ayres study?	No	N/A	N/A		N/A	N/A	
	Comments:	N/A			**Comments:**	N/A	
South NULE	Erosion sites from the DWR 2008 study	DWR Prioritization 2008					
		Rating (1 to 100)	Ranking (out of 67)				
Are there erosion occurrences compiled in the DWR study?							
	Comments:						

Past overtopping or near overtopping?:	Never overtopped	**Comments:**	N/A
Past breach in area?	None Identified	**Comments:**	N/A

HAZARD INDICATORS

	Value (where applicable)	Best Estimate Rating	Minimum Credible Rating	Maximum Credible Rating	Explanation & Comments

I- LEVEE COMPOSITION - *at selected cross section* - Interpreted from Borings, Test Pits, field reconnaissance, NRCS maps, and analyst's interpretation of this assemblage of information

	Value	Best Estimate Rating	Minimum Credible Rating	Maximum Credible Rating	Explanation & Comments
Composition of levee material *for through seepage assessment*		*5 - Loose: SP, SP-SM, SM, NP ML; documented loose high permeability fill; loose sand, sand with silt, silty sand, non-plastic silt*	*3 - SM, ML, Moderately dispersive soils; soils are silty sands or sandy silts with higher permeability than category 1 soil; soils are suspected of being moderately dispersive based on SAR or other factors*	*5 - Loose: SP, SP-SM, SM, NP ML; documented loose high permeability fill; loose sand, sand with silt, silty sand, non-plastic silt*	Borings SAC-RIV-9 and SAC-RIV-10 from DWR Salinity Control Barrier Investigation 1958.
Composition of levee material *for stability assessment*		*4 - CH, MH; moderately dispersive soils; loose sand, sand with silt, or non-plastic silt*	*2 - SM, ML, clean gravels; soils are silty sands or sandy silts*	*4 - CH, MH; moderately dispersive soils; loose sand, sand with silt, or non-plastic silt*	Borings SAC-RIV-9 and SAC-RIV-10 from DWR Salinity Control Barrier Investigation 1958.

II- GEOLOGY - *at selected cross section*

	(Scale of mapping)	Best Estimate Rating	Minimum Credible Rating	Maximum Credible Rating	Explanation & Comments
Underseepage susceptibility *for underseepage assessment*	1:24,000	*5 - Very high*	*4 - High*	*5 - Very high*	Mapped as recent overbank deposits with very high underseepage susceptibility.
Dispersive soils *for stability assessment*	1:24,000	*1 - Not dispersive*	*1 - Not dispersive*	*1 - Not dispersive*	SAR map shows soils are not like dispersive.
Piping potential *for underseepage assessment*	1:24,000	*5 - Very high*	*4 - High*	*5 - Very high*	The piping potential layer indicates very high piping potential.
Piping potential *for through seepage assessment*	1:24,000	*2 - Low*	*2 - Low*	*4 - High*	Based on available boring data, levee consists of sand and silt.
Soft soils *for stability assessment*	1:24,000	*1 - Not present*	*1 - Not present*	*1 - Not present*	Soft soils are not mapped in this segment.

III- OTHER INDICATORS - *at selected cross section*

Animal persistence/burrows? *for through seepage assessment*		*2 -Low*	*2 -Low*	*2 -Low*	Low animal persistence based on data from DWR.
Is a landside ditch or borrow pit present within 200 ft of toe? *for underseepage assessment*	No ditch	1			0
Is a landside ditch or borrow pit present within 200 ft of toe? *for stability assessment*	No ditch	1			0
Is waterside blanket present? *for underseepage assessment*	No				0
Are there locations where penetrations and historical underseepage are coincident?	Yes	**If yes, please describe:**	There are multiple locations where penetrations are coincident with boil locations.		
Are there locations where penetrations and historical through seepage are coincident?	Yes	**If yes, please describe:**	There are multiple locations where penetrations are coincident with probable through seepage locations.		
Have encroachments that may potentially affect levee integrity been identified?	No	**If yes, please describe:**	N/A		
Provide the number of levee penetrations below the evaluation water surface elevation:	5 - More than 20	**Notes:**	55 pipes ranging in size from 2.5 to 48 inches in diameter and between 1 and 20.5 feet below the levee crest. 42 of the pipes are below the evaluation water surface elevation (about 5 feet below the levee crown). Three locations with 2 clustered pipes each at RM 36.88, 37.6 and 37.74 based on DWR inventory.		
DWR's LMA maintenance rating from Maintenance Deficiency Summary Report:	Minimally acceptable	**Notes:**	Fall 2008.		

IV- TOPOGRAPHIC & ELEVATION INFORMATION - *at selected cross section(s)*

	Default cross section (used for Underseepage assessment)		Would you like to evaluate a different cross-section for **Stability**?	No	Would you like to evaluate a different cross-section for **Through Seepage**?	No
	Cross-section Station	3035+00	**Cross-section Station**		**Cross-section Station**	
	Underseepage		**Stability**		**Through Seepage**	
Report elevations in NAVD 88	**Value** (where applicable)	**Rating** [1 (good) to 5 (bad)]	**Value** (where applicable)	**Rating** [1 (good) to 5 (bad)]	**Value** (where applicable)	**Rating** [1 (good) to 5 (bad)]
Levee crest elevation (ft)	29					
Levee toe elevation (landside) (ft)	13					
Levee crest width (ft)	20	1				
Evaluation water elevation (ft)	23					
Levee slope - landside (xH : 1V); **Enter x**	1.5	5				
Levee slope - waterside (xH : 1V); **Enter x**	1.7					
Freeboard above evaluation flood elevation (ft) (= levee crest elevation - evaluation water elevation)	6.0					
Levee height (ft) (= levee crest elevation - landside toe elevation)	16.0	4				
Levee prism base width (ft)	71.2					
Head (ft) (= evaluation water level - landside toe elevation)	10.0	3				
Head-to-base-width ratio (= head / base width)	0.140	4				
Base-width to head ratio (= base width / head)	7					

V- ANOMALIES

	Anomalies?	**Description**	**Effect on Performance**
Underseepage	Yes	Segment 106 has one ditch that does not run parallel to the levee. The ditch is located near NULE station 3237+00. A borrow pit is indicated on the Level 2-II mapping at LM 15.7.	Potential location of free seepage or boils.
Stability	No	N/A	N/A
Through Seepage	No	N/A	N/A
Erosion	No	N/A	N/A

MITIGATION AND PAST BREACHES

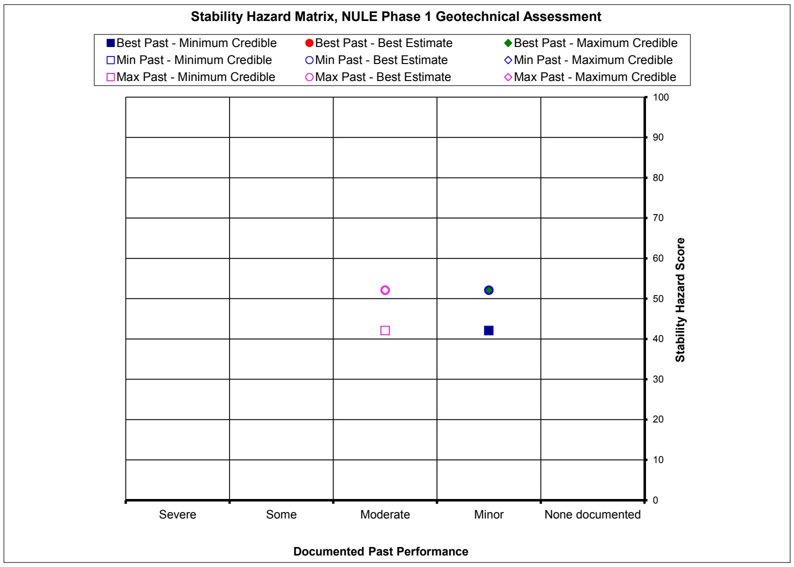
Existing constructed mitigation (List all)	Improvements include riverbank protection work performed under the Sacramento River Bank Protection Project (SRBPP) during Phase 1 in 1963-1967 and 1969-1973, and during Phase 2 in 1976 and 1981. The completed riverbank protection work included placement of revetment at multiple locations along the segment.
Has there been a past breach?	None Identified
If yes, describe nature of the breach and how it has been mitigated?	

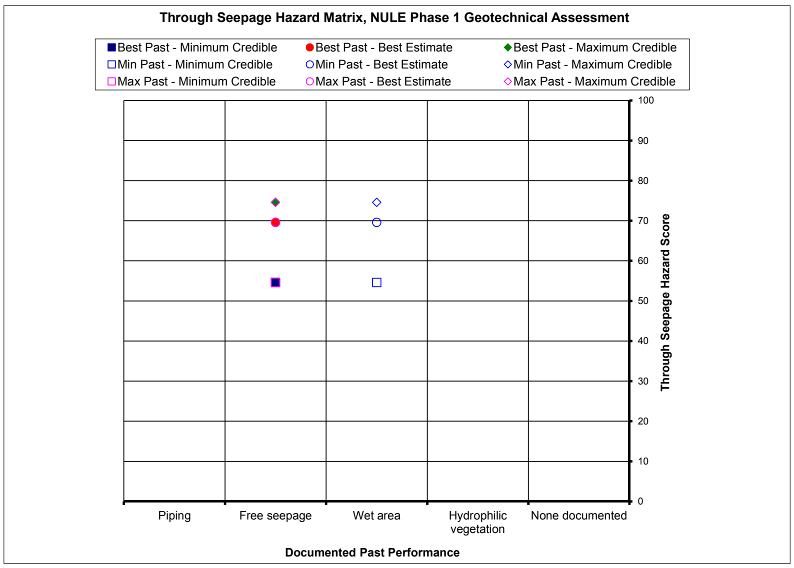
SUMMARY

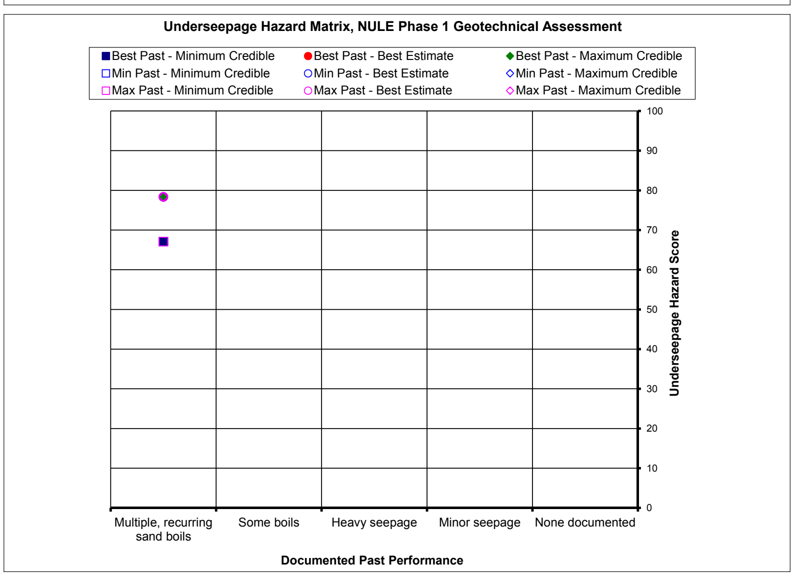
Failure Mode	**Weighted Hazard Indicator Score (Best)**	**Weighted Hazard Indicator Score (Minimum Credible)**	**Weighted Hazard Indicator Score (Maximum Credible)**	**Past performance issues?**	**Are past performance and Weighted Hazard Indicator Score consistent?**	**Levee categorization**
Underseepage	**79**	68	79	Multiple, recurring sand boils	Yes	***Hazard Level C***
Justification:	The high WHIS is consistent with past performance data of documented multiple, recurring boils within the segment.					
Suggested additional data:	N/A					
Stability	**53**	43	53	Minor	Yes	***Hazard Level B***
Justification:	The moderate WHIS are consistent with documented landside sloughs, however, the sloughs may be more likely related to through seepage.					
Suggested additional data:	Confirm associated with through seepage; if so consider Hazard Level A.					
Through Seepage	**70**	55	75	Free seepage	Yes	***Hazard Level C***
Justification:	The high WHIS is consistent with past performance data of documented free seepage within the segment.					
Suggested additional data:	N/A					
Erosion				Yes		***Hazard Level B***
Justification:	The segment has a history of erosion events with the most recent reported in 2005-2006 flood season as reported in the 2008 interview with MA 09 personnel. Documented mitigation of several of the past erosion sites was not found. The reported erosion sites were not documented as impacting the levee crown. Based on the LIDAR data, erosion of the waterside slope may be occurring along about 40 percent of the segment.					
Suggested additional data:	N/A					

Freeboard Check	Does levee pass freeboard check?	**No**	
Provide details about where along segment (and by how much) levee does not pass freeboard check:	Freeboard requirements are met at all locations except one 600-foot-long location between NULE Station 3107+50 to 3113+50.		
Are there anomalies along the segment with respect to freeboard?	No	Describe anomalies:	0
Levee Geometry Check	Does levee pass geometry check?	**No**	
Provide details about where along segment (and by how much) levee does not pass geometry check:	25% did not pass geometry check (Stations 3072+50 to 3102+50, 3112+50 to 3117+50, 3152+50 to 3162+50, 3167+50 to 3172+50, 3247+50 to 3552+50, 3262+50 to 3267+50, 3332+50 to 3337+50, 3347+50 to 3352+50, 3387+50 to 3392+50, 3402+50 to 3422+50, 3427+50 to 3432+50, 3447+50 to 3452+50, 3222+50 to 3227+50, 3332+50 to 3337+50, 3387+50 to 3392+50, 3452+50 to 3457+50).		
Are there anomalies along the segment with respect to geometry?	No	Describe anomalies:	0
Summary Characterization of Levee Segment	Hazard Level C	**Comment / Justification:**	The potential failure mode categorizations for underseepage and through seepage are Hazard Level C resulting in an overall categorization of Hazard Level C.

Evaluator:	JWR	Evaluation Date:	3/9/2010
Checked By:	TK	Check Date:	3/9/2020
Senior Reviewer:	KLK, SP, RSA	Review Date:	3/10/2010







Department of Water Resources
Division of Flood Management
Levee Evaluations Branch

URS

Segment 106 LAT Results
Geotechnical Assessment Report

NORTH NON-URBAN LEVEE EVALUATIONS

Appendix C

Geomorphology Technical Memorandum

2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833
Tel: 916.679.2000 Fax: 916.679.2900

In association with
William Lettis & Associates, Inc.

Prepared For	Department of Water Resources Division of Flood Management
Project	Non-Urban Levee Evaluations Project Task Order UT05-03
Date	December 20, 2010
Subject	Level 2-II Geomorphic Assessment and Surficial Mapping of South of Sacramento Study Area
Prepared By	Cooper Brossy, Fugro William Lettis & Associates (FWLA), October 2009
Reviewed By	Justin Pearce, FWLA, October 2009; Keith Knudsen, Jackie Bott, Lisa Dougherty, URS; Lewis Hunter, U.S. Army Corps of Engineers

INTRODUCTION

This technical memorandum presents the results of surficial geologic mapping and geomorphic assessment in the South of Sacramento Study Area. The Study Area includes approximately 53 miles of non-urban Project levees along the Sacramento River, Elk Slough, and appurtenant structures directly south of Sacramento and West Sacramento, California (Figure 1).

The primary goal of thisl assessment is to develop and analyze map data about the type and distribution of surface and shallow subsurface deposits underlying NULE Project levees to develop an assessment of levee underseepage susceptibility hazard, and secondarily, to develop an initial conceptual model allowing reasonable stratigraphic interpretations between widely-spaced subsurface explorations. Plate 1 presents the surficial geologic map of the South of Sacramento Study Area.

TECHNICAL APPROACH

This assessment involved the integration and analysis of aerial photography, topographic maps, geologic maps, soil maps, and historical documents. Synthesis of these data helped construct a detailed surficial geologic map, develop an assessment of the primary geomorphic processes responsible for distributing surficial deposits in the Study Area, and develop levee underseepage susceptibility hazard maps.

The project team analyzed the following data:

- Vintage 1937 aerial photography[1] (Table 1a)

[1] All photographs are black and white, stereo-pairs, ~1:20,000 scale, flown August, 18, 1937.

Table 1a. Aerial Photography.

County Code	Roll Number	Frame Numbers
ABC	49	48 and 49
ABB	49	50 through 59
ABC	49	60 and 61
ABB	50	26 through 29
ABC	50	15
ABB	50	16 and 17
ABC	49	8 through 16
ABB	49	17 through 19
ABC	49	20 and 21

- Early and modern USGS topographic maps (Table 1b)
- Published surficial geologic maps (Helley and Harwood, 1985; Atwater, 1982)
- Early and modern soil survey maps (Cole et al., 1954; Tugel, et al., 1992)
- Other maps and documents (e.g., California Debris Commission, 1908)

Knowledge of fluvial processes and the ability to recognize depositional environments in the geologic record are key to identifying locations along levees where underseepage is most likely to occur (Llopis et al., 2007). Through surficial geologic mapping, primary geomorphic features and associated surficial geologic deposits like crevasse splay and overbank deposits, meander scroll deposits and other features commonly associated with large active river systems and distributary channels are identified (e.g., Saucier, 1994).

The South of Sacramento Study Area's surficial geologic map (Plate 1) was developed at the nominal scale of 1937 aerial photography (approximately 1:20,000) and is presented at 1:24,000 scale. The map should not be used or displayed at scales greater than 1:24,000. Solid map unit boundaries shown on the surficial geologic map should be considered approximate, and are accurate to within about 100 feet on either side of the line shown on the map; dashed contacts should be considered accurate to within about 200 feet on either side of the line.

Map units shown on Plate 1 primarily are based on analysis of 1937 aerial photography and soil surveys in conjunction with early topographic maps. The map is a compilation of the latest Holocene and historical geologic conditions up until 1937. These 1937 aerial photographs are the primary data set for interpreting surficial geologic deposits because they are the oldest high-quality images pre-dating much of the urbanization and landscape alteration in present-day Sacramento and Solano Counties. These data also represent a close approximation to surficial deposits that were likely present at ground surface prior to levee construction. The 1937 photographs in this Study Area were taken in the month of August. Integration of data from the 1937 photography, older and more recent topographic maps, geologic maps, soil surveys and historical documents provide sufficient information to delineate many of the pre-historical and historical surficial deposits in detail. Taken together, these data provide key insights to the characteristics of deposits beneath the levees, and serves as a technical framework for assessing underseepage susceptibility in the South of Sacramento Study Area. **Error! Reference source not found.** Table 1b lists the topographic maps used during map development for this project.

Table 1b. USGS Topographic Maps.

Quadrangle Name	Publication Date	Photo Revision Date	Series	Scale	Survey Date
Clarksburg (formerly Babel Slough)	1916	N/A	7.5-Minute	1:31,680	1906
Clarksburg	1967	1980	7.5-Minute	1:24,000	N/A
Courtland	1908	N/A	15-Minute	1:62,500	1906
Courtland	1978	1983	7.5-Minute	1:24,000	N/A
Davisville	1907	N/A	15-Minute	1:62,500	1905
Florin	1909	N/A	7.5-Minute	1:31,680	1907
Florin	1968	1980	7.5-Minute	1:24,000	N/A
Sacramento West	1948	1992	7.5-Minute	1:24,000	N/A

For underseepage hazard assessment, levee foundations were assigned a susceptibility class based on their underlying surficial geologic deposits. Map data were imported into a geographic information system (GIS) and spatially intersected with NULE Project levee lines; susceptibility categories were then assigned to levee segments as shown in **Error! Reference source not found.**. Underseepage susceptibility category assignments were made based on geologic age and depositional environment, as well as relative hydraulic conductivity. The validity of these hazard assignments were tested during the Level 2-I work phase by analyzing levee past performance data as an indicator for underseepage susceptibility.

GEOLOGIC SETTING

The South of Sacramento Study Area lies in the south-central Sacramento Valley (Figure 1), and occupies a topographically low position at about 0 to 10 feet elevation above mean sea level. The Study Area is directly south of the confluence of the Sacramento and American Rivers, two large waterways that drain a substantial portion of northern California. Farther south is the Sacramento-San Joaquin Delta (Delta), a formerly extensive area of tule marshes whose sediments are characterized by organic-rich peat and peaty mud deposits (Atwater, 1982). Downstream of its confluence with the American River, the Sacramento River has irregular sinuosity with both large and small radius-of-curvature meander bends. It also has both narrow and wide distributary channels, including Elk Slough, Sutter Slough, and Snodgrass Slough. The river has, in places, laterally migrated over the past hundreds of thousands of years and deposited a sediment load rich in sand and gravel (Shlemon, 1967). As a result, geologically older and erosion-resistant Pleistocene Riverbank Formation is present at the ground surface south and east of the City of Sacramento, and younger alluvium is inset into this formation. Over the past several hundreds of years, erosion along the Sacramento River occurred on the outsides of bends, depositing younger sand-rich sediment (e.g., point bar) that occurs on the insides of the river bends. Because of the low topographic position and its location between the confluence of these two large rivers and the Delta, the South of Sacramento Study Area has been subjected to repeated inundation by floodwaters over the past several thousand years via distributary channels and floodplain overflow. Floodwaters deposit fine sand and silt-rich alluvium along the flanks of the river bank and finer-grained clay and silt are carried in suspension onto the distal floodplain and low lying flood basins. This hydraulic sorting process created a natural levee (or channel ridge) landform with a topographic gradient that slopes away from the river (Atwater, 1982).

Historical accounts document two large flood events along the Sacramento and American Rivers known to have been destructive to early settlers. One occurred in water-year 1850, and another larger flood occurred in January 1862, inundating and substantially damaging the recently founded City of Sacramento. These flood events quickly spurred construction of flood protection levees along many of the banks of the Sacramento River, as well as a cultural re-alignment of the American River in 1868. Furthermore, hydraulic mining activity in the Sierra Nevada Range began in 1850 and supplied a substantial amount of sediment to many creeks and rivers draining those watersheds (James, 1999). Primary geomorphic responses to this activity were aggradation (i.e., backfilling) of channels, exacerbated flooding related to decreases in channel cross section area, and deposition of mining-related sediment on the adjacent floodplain. Additional large historical flood events occurred subsequently in the area, such as 1904, 1907, and 1955, among others (Ellis, 1939).

SURFICIAL GEOLOGIC MAPPING

Previous geologic mapping in the South of Sacramento Study Area was performed by Atwater (1982) and Helley and Harwood (1985). Both maps recognize two primary depositional environments: one proximal to the modern river channel (floodplain) and the other in low lying areas distal to the modern river channel (flood basin). Surficial deposits in these two environments are generally latest Holocene to historical in age, receiving sedimentation prior to construction of the flood protection levees. The alluvial deposits consist chiefly of silt, clay, and fine sand flanking the modern river channels. Floodbasin deposits principally consist of silt and clay, commonly elastic, representing deposition in low-energy environments (e.g., slack water). This analysis uses this previously developed geologic framework as a basis for more detailed mapping of late Quaternary deposits and geomorphic features (Plate 1).

Surficial geologic mapping in the South of Sacramento Study Area delineates individual alluvial deposits based on relative age and depositional process or environment, using the regional mapping as an initial framework (Plate 1). Three ages of deposits are recognized at the ground surface within the map area: mid-to-late Pleistocene (about 450,000 to 11,000 years), Holocene (less than 11,000 years), and historical (post-1849). The section below briefly describes the primary geologic deposits within the map area from oldest to youngest, giving a framework for understanding the Study Area's geomorphology and related surficial and shallow surficial deposits.

The oldest unit exposed in the South of Sacramento Study Area (Figure 1, Plate 1) is the lower member of the Riverbank Formation (map unit Qrl). The lower Riverbank Formation is mid- to late-Pleistocene age (no older than 450,000 years old; Helley and Harwood, 1985). This unit is composed of weathered reddish gravel, sand, and silt, and underlies old river terraces and alluvial fans. It is exposed in the southeastern part of the map area as a preserved alluvial fan surface topographically higher than the modern floodplain (Plate 1).

Late Holocene deposits underlying the modern floodplain along the Sacramento River are categorized as channel, floodplain, and flood basin deposits (Plate 1). Channel deposits (map unit Hch), and meander scrolls (map unit Hms) consist of fine- to coarse-grained sand, silty sand, and clayey sand. Holocene overflow channels (Hofc) are present adjacent to the main channel, usually on the inside of a bend, and are active during high-stage flow events when they collect water overtopping channel banks. These overflow channels then direct water downstream where it re-enters the main channel. Abandoned channels may contain fine-grained material in the upper several feet of the deposit, from post-abandonment infilling (Saucier, 1994; Tugel et al. 1992). Holocene floodplain deposits include crevasse splays (map unit Hcs) and overbank deposits (map unit Hob). Crevasse splay deposits are formed from the breaching of river banks or natural levees during high flood stages and deposition on the floodplain via small distributary channels. Overbank deposits are formed from the localized overtopping of river banks or natural levees, and deposition from shallow sheet flow. Holocene flood basin deposits (map unit Hn) consist of soft silt and clay laid down by slow-moving floodwater in a relatively low-energy depositional environment. Marsh deposits (map unit Hs) are identified on early topographic maps depicting the extent of fresh water marshes and tule fields with a bush-like symbol. Peat and mud deposits (map unit Qpm) are locally present in the Study Area, and consist of fine-grained sediments with various amounts of organic matter (Atwater, 1982).

Historical deposits mapped in the South of Sacramento Study Area include stream channel and floodplain deposits, as well as cultural artificial fill deposits (Plate 1). The term “historical” denotes deposits laid down since 1849, and indicate these with an “R” as a map unit symbol. Historical channel deposits (map unit Rch), bars (map unit Rb), or meander scrolls (map unit Rms) are adjacent to the present-day Sacramento River and are generally, but not exclusively, present on the waterside of the modern-day levees. These deposits likely consist of stratified, intermixed and interbedded silt, sand and trace gravel. They were probably derived from re-working, transport, and deposition of hydraulic mining detritus (James, 1999). Historical crevasse splay and overbank deposits are differentiated based on cross-cutting and their superposition relationships with existing cultural deposits present on the 1937 aerial photographs. In general, younger deposits overlie or onlap older deposits. Historical deposits typically have stronger topographic expression than older deposits, as well as brighter tonal contrasts in the 1937 aerial photos, indicating younger or sandier deposits. Artificial fills (map units AF, L, RR) are culturally-emplaced levee, canal berm, or railroad embankment deposits. These deposits include undivided fill, levee structures, road, and railroad fills; they are included on the surficial geologic map where prominent in the 1937 aerial photographs.

Soils developed on Holocene and historical natural levee features (overbank and crevasse splay deposits) adjacent to the river include the Columbia silty loam of Cole et al (1954) and the Valpac loam of Tugel et al. (1992). Cole et al. (1954) indicate that debris from hydraulic mining probably contributed material to these deposits. In Solano County (west of the river), the soils associated with floodplain deposits include Tyndall very fine sandy loam, Sycamore silt loam, and distally the Merritt silty clay loam (Andrews, 1972). Farther from the Sacramento River, the flood basin environment hosts the Scribner clay loam (Tugel et al., 1992), Omni silty clay, and Sacramento clay (Andrews, 1972). Presence of the Gazwell mucky clay indicates that mucky clay and mucky peat from fresh water marshes exists in the near-surface (Tugel et al., 1992); this soil is associated with map unit Hpm. The Dierssen sandy clay loam is associated with the Riverbank Formation based on Tugel et al.'s (1992) description of the Dierssen being developed in dominantly granitic material and also exhibiting a silica-cemented hardpan. Limited areas of sandier deposits indicated by the presence of the Tinnin soil series are also found along the eastern margin of the Study Area, and are associated with Eolian (wind blown) sands from old dune fields along the distal margins of the Pleistocene alluvial fans (Atwater, 1982).

Other soils that are very young (Andrews et al., 1972) include areas of Tyndall very fine sandy loam and Maria silt loam that make up much of the material forming natural levees along the Babel Slough distributary channel and the large splay deposits that emanate from the Babel Slough channel. Along Elk Slough, extensive areas of Lang silt loam, Tyndall very fine silt loam, and Valdez silt loam soil are present proximal to the channel and are associated with historical crevasse splay and overbank deposits. The Tyndall very fine sandy loam and the Lang silt loam also occur locally along the Sacramento River and sometimes have distinct tongue-like or meandering shapes that suggest they formed on deposits that prograded out over the pre-existing natural levee hosting the Sycamore series soils.

CONCEPTUAL GEOMORPHIC MODEL

Based on synthesis of surficial geologic mapping, early topographic maps, soil surveys, geologic maps, and review of readily available subsurface borehole information, a preliminary conceptual model was developed to describe general relationships among surface and subsurface geologic deposits in the South of Sacramento Study Area (Figure 1). This conceptual model provides a consistent basis for understanding both the types and distribution of surficial geologic deposits, primary geomorphic processes, and the shallow subsurface stratigraphy in the Study Area.

Subsurface Stratigraphy

In general, the deposits beneath the floodplain of the Sacramento River and distributary channels consist of fluvial and alluvial fan stratigraphic layers. Available subsurface data suggest lateral variability in the extent and character of the deposits below the present-day floodplain, as well as upward-fining of sediment textures (Figure 2).

Sediments directly beneath the Elk Slough and Sacramento River NULE Project levees are Holocene overbank and crevasse splay deposits consisting of sandy silt and silty beds 16 to 20 feet thick (Figure 2). This layer is relatively thicker beneath the Sacramento River than Elk Slough; however, both layers likely laterally interfinger with adjacent sediments because of the dynamic depositional processes. Between these two channels is a flood basin environment consisting of laterally extensive silt and clay up to 25 feet thick.

Underlying the Holocene sediments of the Sacramento River natural levee are relatively clean sands (Figure 2) that were probably deposited by a Pleistocene course of the river that carried a coarser-grained sediment load as compared to present (Shlemon, 1967). Based on available data, the thick package of sand does not appear to be present beneath the Elk Slough distributary channel, suggesting that the sandy stratigraphic layer is not laterally continuous in the westerly direction. Instead, available subsurface data at Elk Slough show a hard (N-value of 70) clay layer present near Elevation −18 feet. The hard clay layer is interpreted as buried Pleistocene fan surface that dips easterly (Figure 2). Subsurface data east of the Sacramento River is not available, and interpretations of stratigraphy are speculative in this area.

Randall Island

Randall Island is somewhat different from other islands in the Delta region. Chiefly, other islands (e.g., Merritt Island) are laterally bound by large sloughs or rivers, whereas Randall Island is only bound on one side by the river, the island being nearly attached to the eastern alluvial landmass (Plate 1, Figure 3). Moreover, inspection of topographic contours indicates a natural levee landform flanking the eastern margin of Randall Island along a narrow channel, as well as a natural levee landform along the Sacramento River, each separated by a small flood basin (Plate 1). As of 1937, Randall Island was bound on the eastern side by a narrow channel; the channel was flanked on its eastern side by a short artificial levee (Figure 3). The presence of developed natural levee landforms along the narrow channel raises the question of the natural levee's origin along the narrow channel, as well as the geomorphic origin of the narrow channel itself. The topographic gradients of the natural levee landforms along the Sacramento River are slightly, but not wholly, different from those along the narrow channel (Figure 3). For example, the basin-ward gradient of the Randall Island natural levees is slightly steeper than those along the Sacramento River (Figure 3). Landform differences suggest that depositional history influenced natural levee development.

Speculatively, the process responsible for the development of Randall island and its natural levee morphology include:

- A paleo-Sacramento River along the course of the narrow eastern channel.
- Avulsion of the Sacramento River toward the west but incomplete abandonment of the original course.
- Sedimentation and partial infilling of the former river course to form the narrow channel.
- Activation of the narrow channel and consequent overbank sedimentation during pre-artificial levee flood discharge events.

Whatever the genesis of Randall Island, geomorphic observations suggest that coarse-grained deposits of a former Sacramento River channel may be in the subsurface of the present–day NULE Project levee at the head and mouth of the narrow channel. Observations also suggest that, if present, these deposits may form a conduit underlying the levee at an oblique angle near the head of the narrow channel, and a sub-orthogonal angle at the confluence (Plate 1; Figure 3).

Secondly, map data indicate that the narrow channel along eastern margin of Randall Island historically contributed sediment to the natural levee and adjacent floodplain based on the following observations:

- The large levee fill prism at the head of the Snodgrass Slough and Randall Island channels visible in the 1937 aerial photographs (Figure 3) suggest these channels historically contributed extensive overbank deposition downstream.
- These aerial photographs show a very short artificial levee continuing downstream along the southeast bank of the Randall Island channel. A road runs along the crest of the levee (Figure 3).
- The presence of this artificial levee further suggests this channel was active historically, delivering and depositing sediment to the floodplain to the southeast (Plate 1).

In general, the conceptual model illustrates that natural levee landforms are expressed adjacent to the river and slough as relatively fine-grained with a silty top stratum, and locally overlie coarser-grained strata of the former Sacramento River. This stratigraphic arrangement likely represents a geotechnical blanket layer along the Sacramento River, but not necessarily Elk Slough (Figure 2). A thick layer of fine-grained sediment is present in between the Sacramento River and Elk Slough channel because of Holocene floodwater deposition. Buried Sacramento River channel deposits may underlie the present-day levee where the narrow channel joins the river. Additional subsurface data are needed to clarify the lateral relationships of the deposits away from the present-day levees.

APPLICATION TO STUDY AREA LEVEES

The preceding sections briefly summarize the major map units comprising levee foundations and shallow stratigraphic relationships in the South of Sacramento Study Area. These factors (sediment type, permeability and shallow stratigraphic relationships) exert controls on underseepage processes when incorporated into underseepage susceptibility analysis.

Underseepage susceptibility analysis considers geologic deposits underlying present-day levees, the characteristics of soils developed on those deposits, and the surficial landscape features that may influence or control underseepage. The underseepage susceptibility classes in Table 2 were assigned based on geologic age, depositional environment, stratigraphic relationships and inferred relative soil permeability. Table 2 lists the units present beneath Study Area levees; underseepage assignments are not shown for deposits present elsewhere in the NULE Project area. Analysis results are described below.

Underseepage Susceptibility of Mapped Geologic Units

Based on the susceptibility assignments shown in Table 2 and surficial geologic deposits (Plate 1), the underseepage susceptibility of much of the levee foundation in the South of Sacramento Study Area is high to very high (Table 2).

Table 2. Underseepage Susceptibility Summary.

Unit Symbol	Unit Name	Susceptibility Rating	Mileage	Percent
Rob	Historical overbank deposits	Very High	24.7	46.0
Rcs	Historical crevasse splay deposits	Very High	4.8	8.9
Rch	Historical channel deposits	Very High	0.1	0.2
Rdf	Historical distributary fan deposits	Very High	0.1	0.2
Rdc	Historical distributary channel deposits	Very High	0.1	0.1
Hob	Holocene overbank deposit	High	19.4	36.1
Hms	Holocene meander scroll deposits	High	1.2	2.1
Hcs	Holocene crevasse splay deposits	High	1.1	2.1
Hs 1906	Holocene marsh deposits	High	1.6	3.0
Hofc	Holocene overflow channel deposits	Moderate	0.2	0.4
Hdc	Holocene distributary channel deposits	Moderate	<0.1	<0.1
Pf	Pleistocene alluvial fan deposits	Low	0.4	0.8
Rb	Holocence channel bar deposits	Very High	0.0	0.0
Rsl	Holocence slough channel deposits	Very High	0.0	0.0
Hpm	Holocene peat and mud	Very High	0.0	0.0
Hch	Holocence channel deposits	High	0.0	0.0
Hsl	Holocene slough channel deposits	High	0.0	0.0
Ha	Holocene alluvium undifferentiated	High	0.0	0.0
Qe	Quaternary eolian deposits	Moderate	0.0	0.0
Hn	Holocene basin deposits	Low	0.0	0.0
Qru	Pleistocene Riverbank Formation (upper member)	Low	0.0	0.0
Qrl	Pleistocene Riverbank Formation (lower member)	Low	0.0	0.0

Of the 53.7 total non-urban levee miles in the Study Area, about 30 miles of levee (55 percent of total) overlie very high susceptibility foundations. The primary very high susceptibility geologic unit is historical overbank deposits (map unit Rob; about 25 miles). Secondarily, historical crevasse splay deposits (map unit Rcs) contribute just less than 5 miles of levee to the very high susceptibility category (Table 2). The historical deposits likely consist of sediment derived from upstream hydraulic mining debris. In the Study Area, the very high susceptibility class is associated with adverse past levee underseepage performance including seepage and sand boils.

About 23 miles of non-urban levees in the South of Sacramento Study Area (43 percent of total) overlie high susceptibility foundations; they are composed primarily of map unit Hob (about 19 miles; Table 2). Other high susceptibility units include Holocene crevasse splays, meander scroll deposits, and marsh deposits.

Analysis results show 0.24 miles of moderate susceptibility foundations (Table3), and 0.44 miles of low susceptibility foundations (map unit Pf). In sum, moderate and low susceptibilities total no more than 2 percent of the levee miles in the South of Sacramento Study Area.

SUMMARY

Initial surficial geologic mapping and geomorphic analysis demonstrates a complex relationship of fluvial deposits at the surface and beneath the floodplain of the Sacramento River and Elk Slough. The surface and subsurface distributions of sandy and clayey deposits are a function of former river positions on the landscape, characteristics of former fluvial systems, and historical geomorphic processes adjacent to the river channel (i.e., flooding and deposition). Overall, the non-urban levee in the South of Sacramento Study Area is chiefly underlain by geologically young, unconsolidated, silty and sandy-silty fluvial deposits. Thick clean sands underlie this top stratum along the Sacramento River levees; less so along Elk Slough. As such, surficial geology along the length of the alignment indicates a relatively high potential for shallow subsurface seepage given certain hydraulic conditions, and suggests geotechnical blanket layer conditions along the Sacramento River.

LIMITATIONS

This geomorphic assessment has been performed in accordance with the standard of care commonly used as the state-of-practice in the engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this geographic area performing the same services under similar circumstances during the same time period.

Discussions of shallow subsurface conditions in this technical memorandum are based on interpretation of geomorphic data supplemented with very limited subsurface exploration information. Variations in subsurface conditions may exist between those shown on maps and actual conditions. Due to the scale of mapping, the project team may not be able to identify all adverse conditions in levee foundation materials.

No warranty, either express or implied, is made in the furnishing of this technical memorandum that is the result of geotechnical evaluation services. The project team makes no warranty that actual encountered site and subsurface conditions will exactly conform to the conditions described herein, nor that this technical memorandum’s interpretations and recommendations will be sufficient for construction planning aspects of the work. The design engineer or contractor should perform a sufficient number of independent explorations and tests as they believe necessary to verify subsurface conditions rather than relying solely on the information presented in this report.

The project team does not attest to the accuracy, completeness, or reliability of maps, data sources, geotechnical borings and other subsurface data produced by others that are included in this technical memorandum. The project team has not performed independent validation or verification of data reported by others.

2870 Gateway Oaks Drive, Suite 150
Sacramento, CA 95833
Tel: 916.679.2000 Fax: 916.679.2900

Data presented in this technical memorandum are time-sensitive in that they apply only to locations and conditions that were identified at the time of preparation of this report. The maps produced generally present conditions as they occurred in the early 1900s, as primary data interpreted for this report are from this period. Data should not be applied to any other projects in or near the area of this study nor should they be applied at a future time without appropriate verification, at which point the one verifying the data takes on the responsibility for it and any liability for its use.

This technical memorandum is for the use and benefit of DWR. Use by any other party is at their own discretion and risk.

This technical memorandum should not to be used as a basis for design, construction, remedial action or major capital spending decisions.

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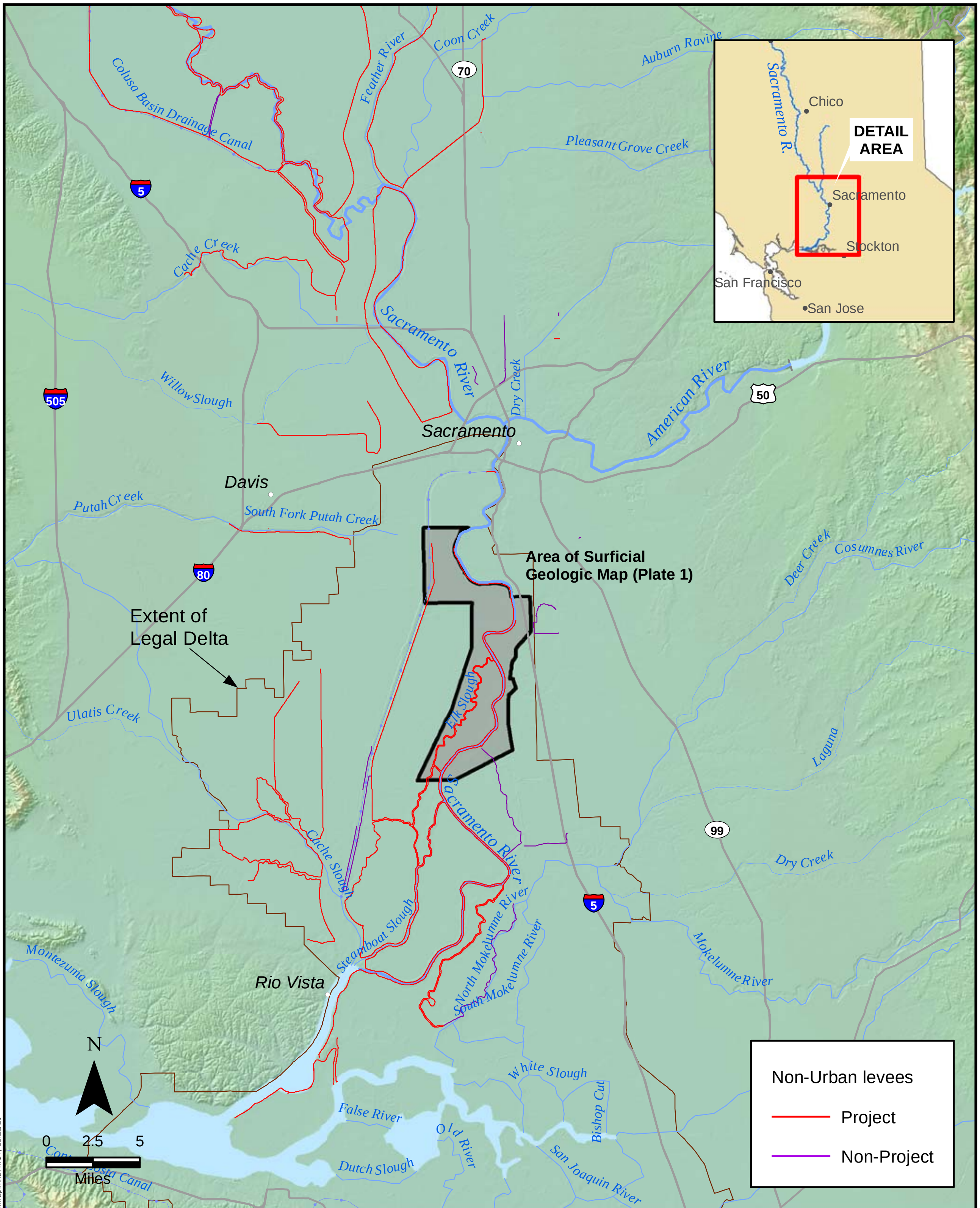

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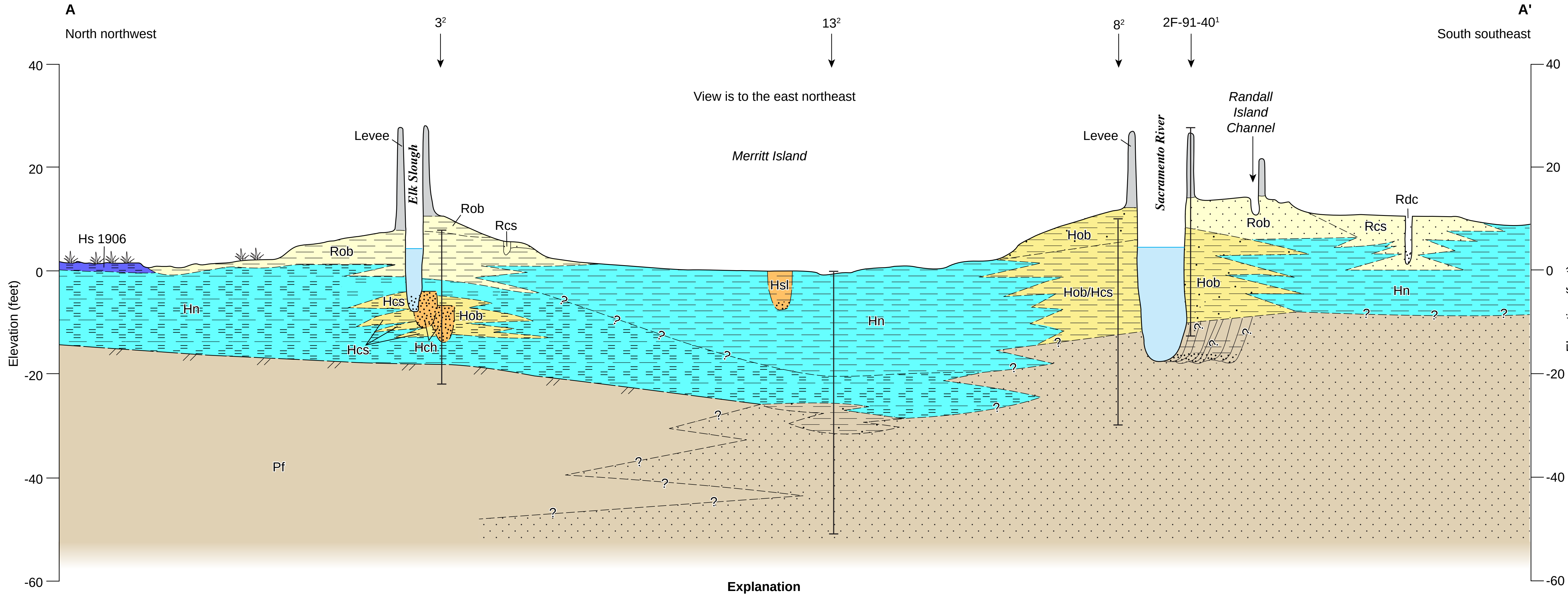
Location Map

NORTH NON-URBAN LEVEE EVALUATIONS

Figure 1

1965_2_NULE_SouthSac_LocationMap.mxd, MGT, 12/21/10



Explanation

Symbols

- Borehole
- Probable calcareous clay hardpan
- Contact, approximately located
- Contact, location uncertain

General Textures

- Clay
- Silt
- Sand

Geologic Units

Af	Artificial fill
Rdc	Recent distributary channel
Rob	Historical overbank
Rcs	Historical crevasse splay
Hob	Holocene overbank
Hch	Holocene channel (buried)
Hcs	Holocene crevasse splay
Hsl	Holocene slough
Hn	Flood basin
Hs	Marsh deposits
Pf	Pleistocene alluvial fan

20 feet
0
0 1200 feet
Vertical exaggeration = 60x

Notes: 1. Borehole from 1993 ACOE Sacramento River flood control system evaluation, lower Sacramento River area, Phase IV.
2. Borehole from DWR salinity control barrier investigation, Merritt Island explorations.
3. Topographic data from ftp://gforge.casil.ucdavis.edu/pub/delta-vision/LiDAR/
4. See Plate 1 for cross section location.

Graphics, Projects, 1965 North Urban Levees, 2_ South Sacramento, modified 10.20.10

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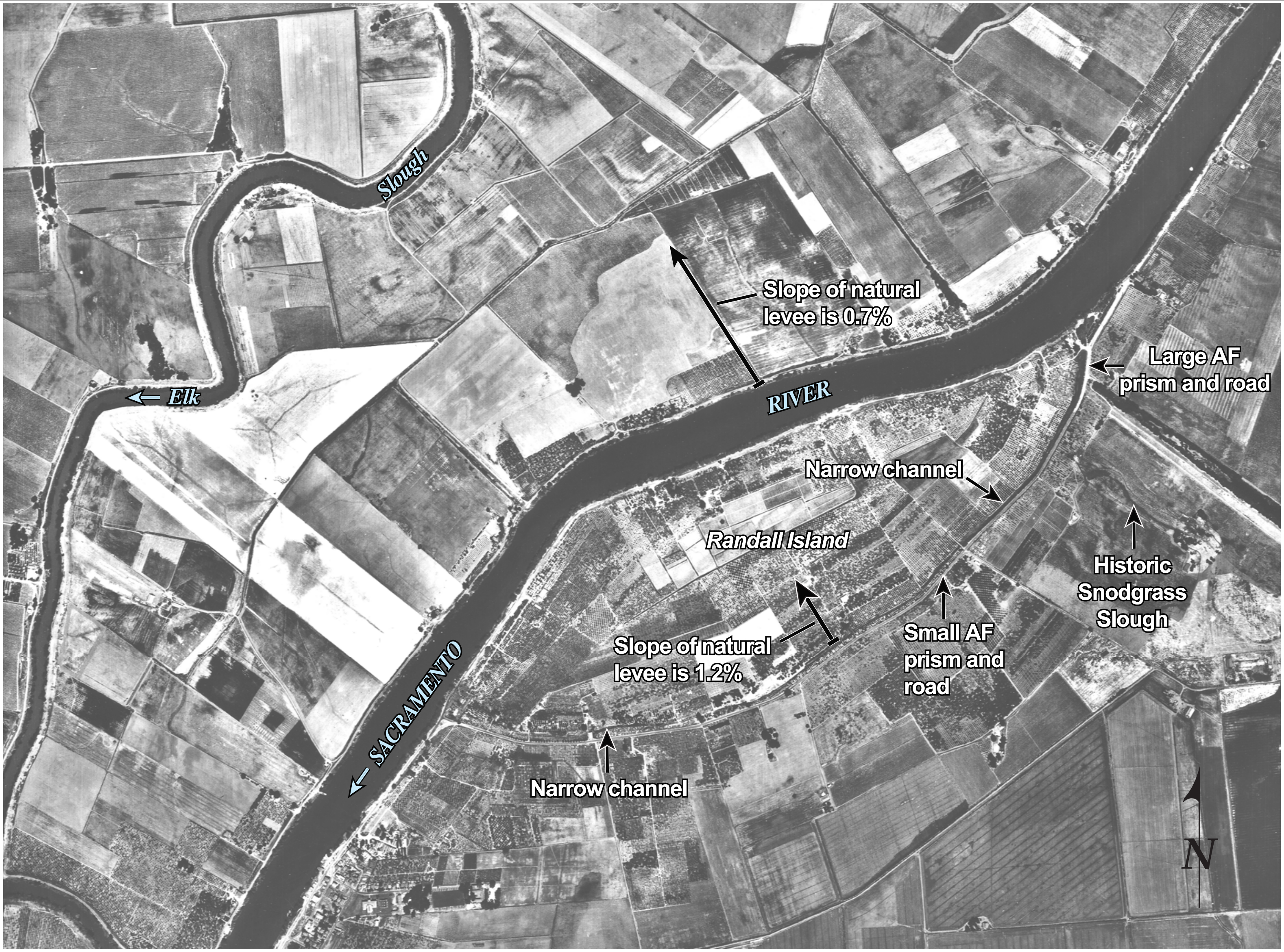
Conceptual Cross Section across Elk Slough, Merritt Island, and Lower Sacramento River, South Sacramento Study Area

NORTH NON-URBAN LEVEE EVALUATIONS

Figure 2



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1937 aerial photograph ABC-49-49. Based on 10 measurements, the slope of the natural levees confining the Randall Island channel is generally 0.5–1.5%, whereas the slope of the Sacramento River natural levees is generally 0.3–1%.

NORTH NON-URBAN LEVEE EVALUATIONS

Figure 3

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below). See accompanying technical memorandum for complete descriptions of map units, process descriptions and methodology. Adjacent polygons that have identical map unit symbols are employed to delineate sequences of sedimentation and landscape evolution.

Explanation

Underseepage Susceptibility Along Non-Urban Levee Alignment

Very High — High — Moderate — Low

Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; solid contacts accurate to within about 100' on either side of line shown on map. Dashed contacts are accurate to within about 250', and are generally gradational.

Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.

Canal

Levee; artificial fill prism, generally <60 ft in width.

A — A' Cross Section

- W 1937 — Water; date indicates year of historical dataset.
- C — Canal, circa 1937.
- BP/Hs — Borrow pit present in 1937; unit after slash indicates the deposit in which the borrow pit is located.

Geologic Units

- AF — Artificial fill, circa 1937.
- L — Levee (made of artificial fill), circa 1937.
- RR — Railroad embankment (made of artificial fill), circa 1937.

HISTORICAL

- Rla — Lacustrine deposits; fine sand, silt and clay. Date indicates year of historical dataset.
- Rob — Overbank deposits; silt, clay, and lesser sand; deposited during high-stage water flow, overtopping channel banks.
- Rcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
- Rdf — Distributary fan deposits; sand, silt and clay.
- Rch — Channel deposits; well sorted sand and trace fine gravel.
  - Rb — Channel bar deposits; fine gravel, sand, and silt deposited in or along channel lateral margins.
- Rdc — Distributary channel deposits, sand, silt, and clay; channelized flow conducting sediment to floodplain.
- Rsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.

HOLOCENE

- Hob — Overbank deposits; silt, clay, and lesser sand; deposited during high-stage water flow, overtopping channel banks.
- Hcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
- Hofc — Overflow channel deposits; vertically stratified sand, silt and clay in channels occupied when high-stage water overtops channel banks.
- Hpm — Peat and mud; peat and organic-rich silt and clay.
- Hch — Channel deposits; well sorted sand and trace fine gravel.
  - Hms — Channel meander scroll deposits; interbedded sand, silt and clay from lateral channel migration.
- Hdc — Distributary channel deposits, sand, silt, and clay; channelized flow conducting sediment to floodplain.
- Hsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ha — Alluvial deposits, undifferentiated; sand, silt, and minor lenses of gravel.
- Hl 1906 — Lacustrine deposits; silt and clay. Date indicates year of historical dataset.
- Hn — Basin deposits; fine sand, silt and clay.
- Hs 1937 — Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.

PLEISTOCENE

- Qe — Eolian deposits; poorly consolidated sandy windblown material.
- Pf — Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.
- Qru — Riverbank Formation; upper member, semi-consolidated to consolidated gravel, sand, silt and minor clay.
- Qrl — Riverbank Formation; lower member; consolidated gravel, sand, silt, and clay, generally capped by a paleo-soil with strong duripan horizon.

Stratigraphic Correlation Chart

Time: Epoch	Depositional Environment: Channel deposits	Floodplain and alluvial-fan deposits	Flood basin deposits	Cultural deposits
Historical	Rch; Rb; Rdc; Rsl	Ra; Rob; Rcs; Rdf	Hn; Hs; Rla; Hl 1906	L; AF; RR
Holocene	Hch; Hms; Hdc; Hsl	Ha; Hob; Hcs; Hofc	Hn; Hs; Hpm; Hl 1906	
Pleistocene		Pf; Qe; Qru; Qrl		

Map projection: UTM NAD83 Zone 10N

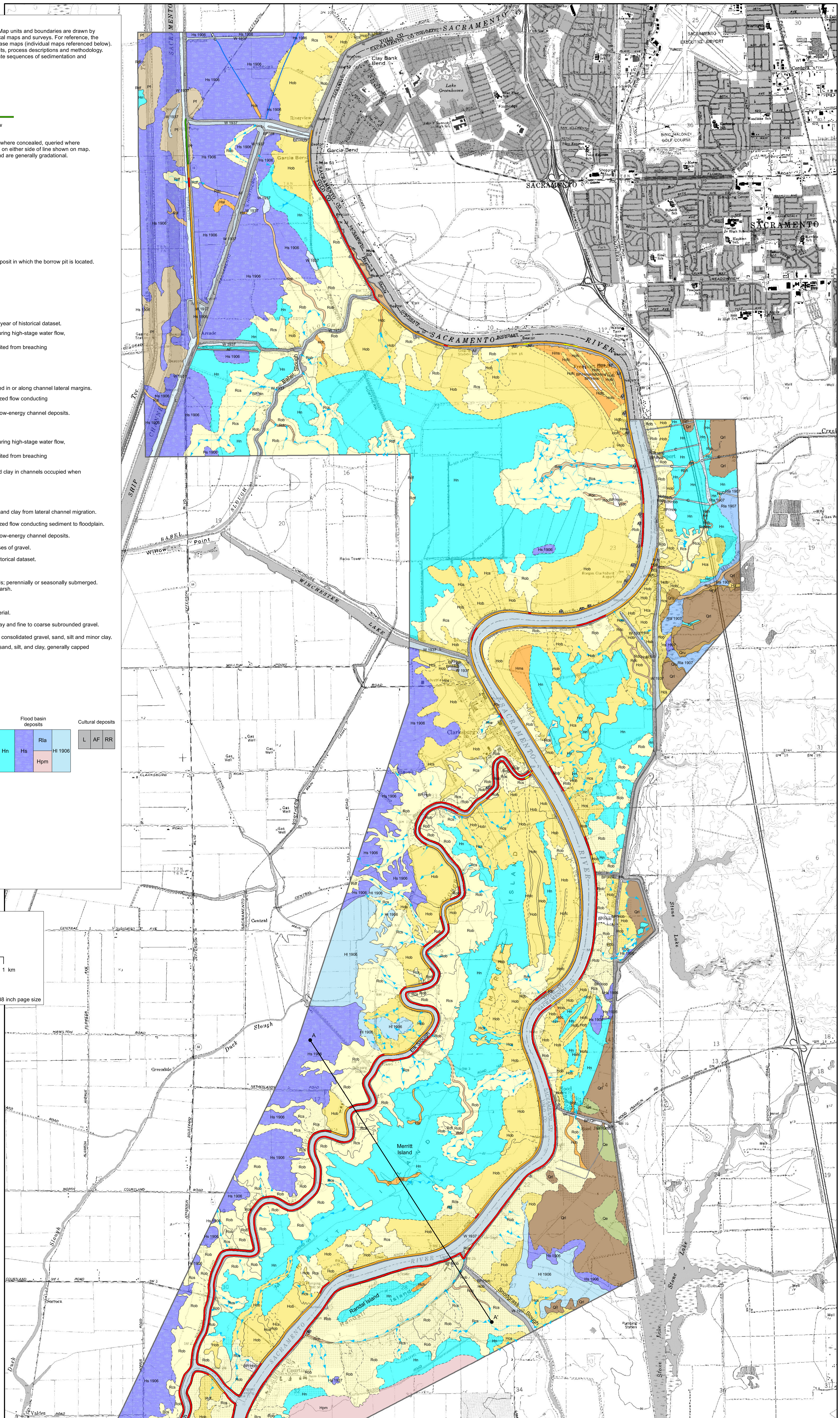
Topographic base USGS 7.5' quadrangles:
Clarksburg, published 1967, revised 1980; map scale 1:24,000, five foot contour interval.
Courtland, published 1978, revised 1993; map scale 1:24,000, five foot contour interval.
Florin, published 1968, revised 1980; map scale 1:24,000, five foot contour interval.
Sacramento West, published 1948, revised 1992; map scale 1:24,000, five foot contour interval.

Geologic Mapping by C. Brossy, J. Pearce, A. Streig
Digital Cartography by M. Ticci

N

0 — 2,000 ft
0 — 1 km
1:24,000

Scale is 1 in = 2,000 ft when printed at 28 inch by 38 inch page size



Department of Water Resources
Division of Flood Management
Levee Evaluations Branch

URS
in association with:
Fugro William Lettis & Associates, Inc.

Surficial Geologic Map of the South Sacramento Study Area

NORTH NON-URBAN LEVEE EVALUATIONS

Plate 1

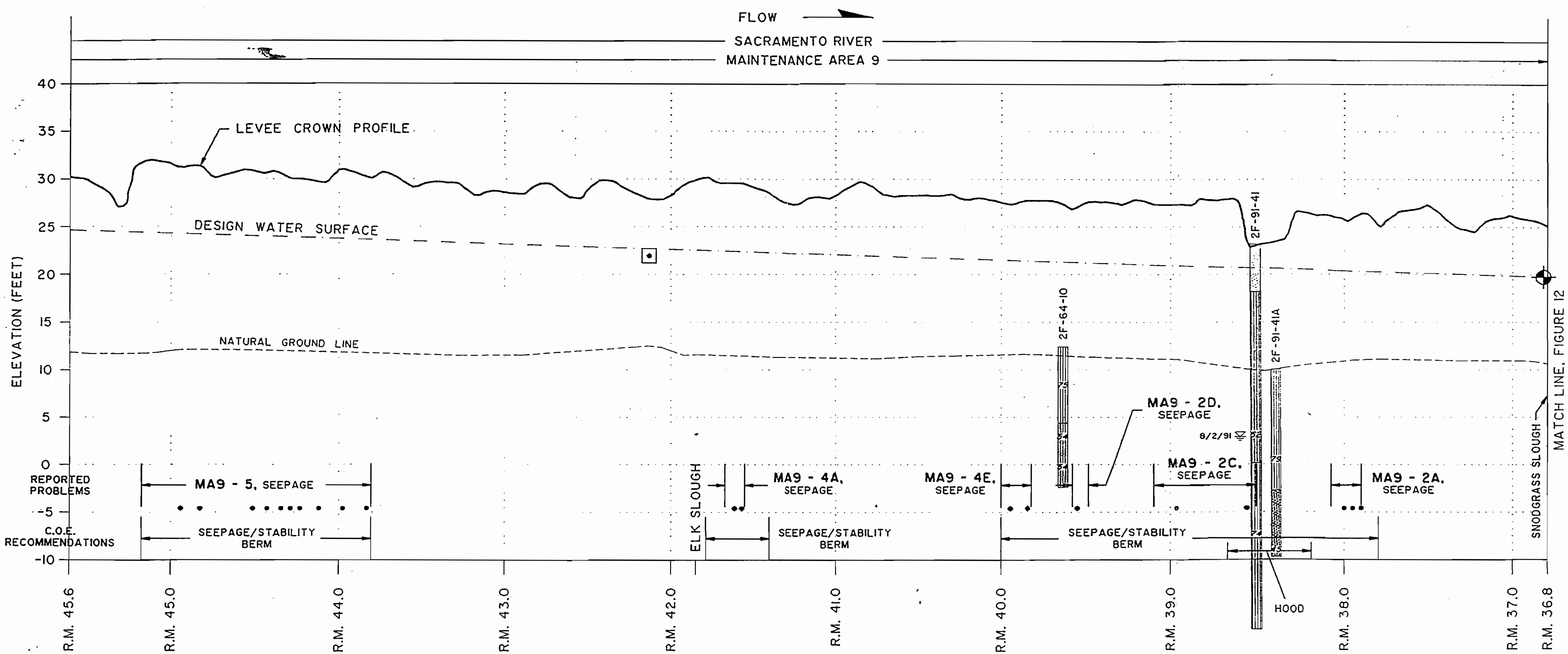
NULE Level 2-II: South of Sacramento Geomorphic Assessment

1065_2_NULE_SouthSac_Plate.mxd MGT 12/21/2010

Appendix D

Existing Exploration Logs

2868 Prospect Park Drive, Suite 310
Rancho Cordova, CA 95670
916.631.4500 fax 916.631.4501



SCALE: 1" = 3000'

NOTES:

1. REFER TO FIGURE 6 FOR NOTES.

LEGEND

- SILT (>70% FINES)
- SILTY SAND OR SANDY SILT (12%-70% FINES)
- CLAY (>70% FINES)
- CLAYEY SAND OR SANDY CLAY (12%-70% FINES)
- SAND (<12% FINES)
- OH
- 1986 BOIL LOCATIONS
- CLAY (HIGH PLASTICITY, CH)
- PEAT
- PERCENTAGE OF FINES (MINUS 200 SIEVE SIZE) PER LABORATORY TESTING
- FEBRUARY 1986 HIGH WATER MARKS
- SURVEYED
- STAGE RECORDERS

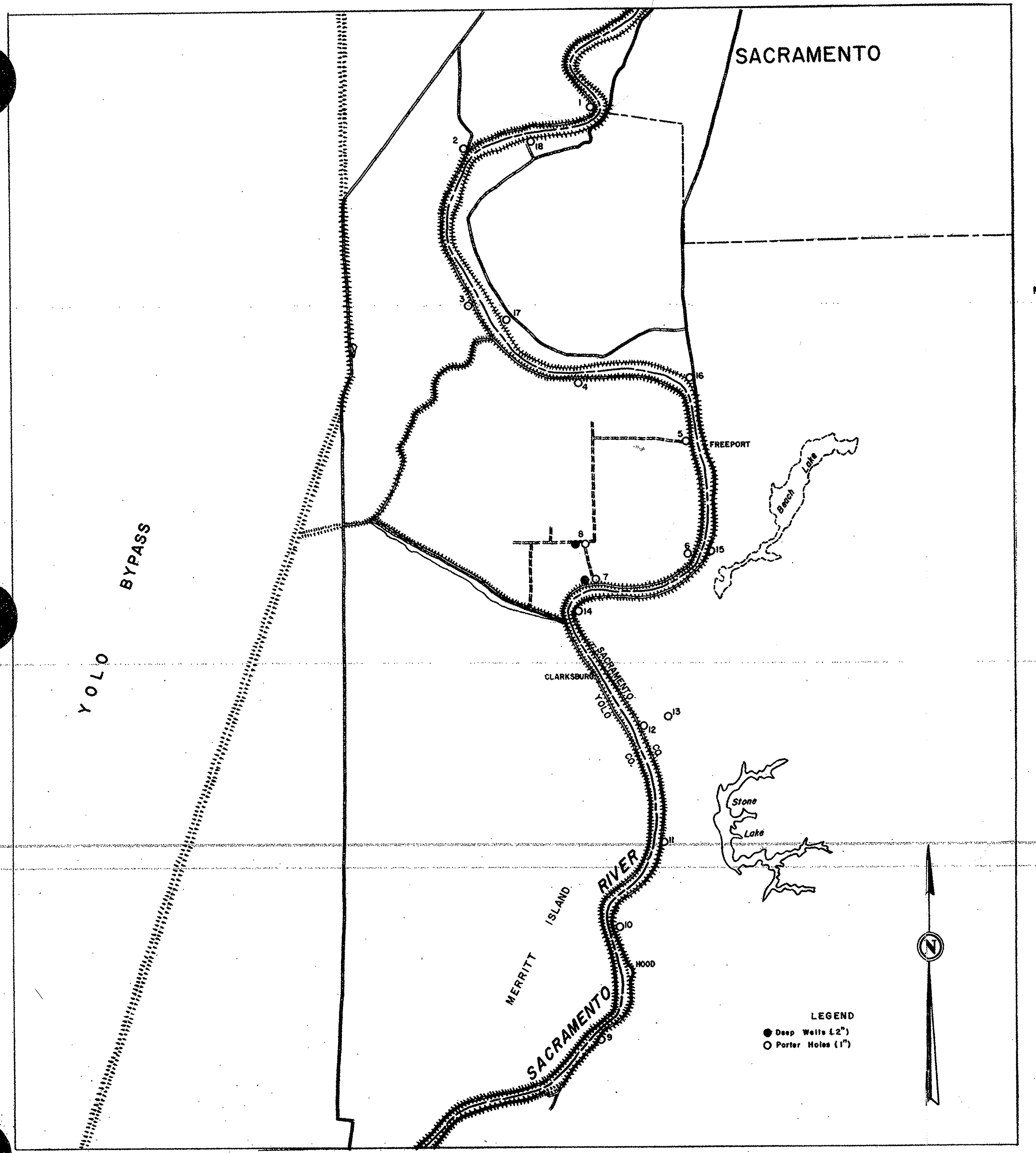
SACRAMENTO RIVER
FLOOD CONTROL SYSTEM EVALUATION
LOWER SACRAMENTO AREA, PHASE IV

LEVEE PROFILES
SACRAMENTO RIVER
LEFT BANK - R.M. 36.8 TO 45.6

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PREPARED BY: D. RICKETTS
DRAWN BY: R. IWASA
FEBRUARY 1993

FIGURE 11



PLAN

SCALE IN FEET

4,000 0 4000 8000 12000

PROFILE

SCALE AS SHOWN

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION.
ALL BORINGS ARE ONE INCH DIAMETER, EXCEPT WHERE NOTED
HAMMER WEIGHT – 1" HOLES 100 & 116 lbs. 2" HOLES 175 lbs.

DRILLING DATES:
1" HOLES – MAR. 7, 1958 TO MAY 22, 1958
2" HOLES – APRIL 10, 1958

LEGEND

BLOWS PER FOOT (P INDICATES PUSH) (W INDICATES WASH)

DRY WET DENSITY IN POUNDS PER CUBIC FOOT

UNCONFINED COMPRESSIVE STRENGTH, Kc Kg/cm^2

UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2

LOSS ON IGNITION IN PERCENT

MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}

SPECIFIC GRAVITY

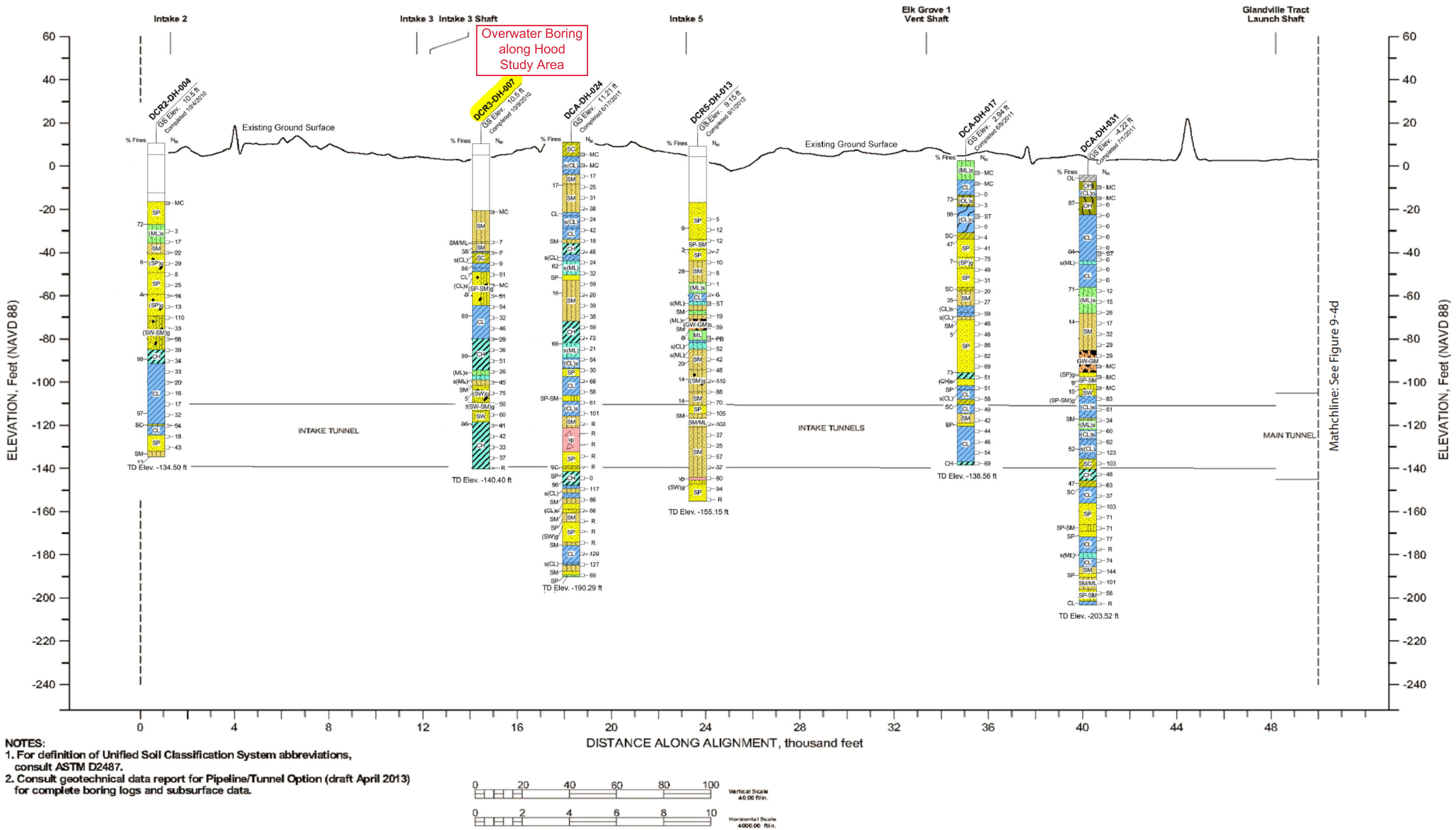
SILT
PEAT
CLAY
SAND
ORGANIC SILT
ORGANIC CLAY
SILTY PEAT
SILTY CLAY
SILTY SAND
SAND, WITH SILT LENSES

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
SALINITY CONTROL BARRIER INVESTIGATION

SUBSURFACE EXPLORATION SACRAMENTO RIVER HOOD TO SACRAMENTO

PLAN AND PROFILE OF BORINGS

SCALE AS SHOWN



NOTES:
1. For definition of Unified Soil Classification System abbreviations, consult ASTM D2487.
2. Consult geotechnical data report for Pipeline/Tunnel Option (draft April 2013) for complete boring logs and subsurface data.

Sources: DWR 2009-2012 Geotechnical Data Reports; California Department of Water Resources 2015.

Figure 9-4c
Geologic Borehole Logs in the Vicinity of Proposed Tunnels

Appendix B

PRESENTATION OF SITE INVESTIGATION RESULTS

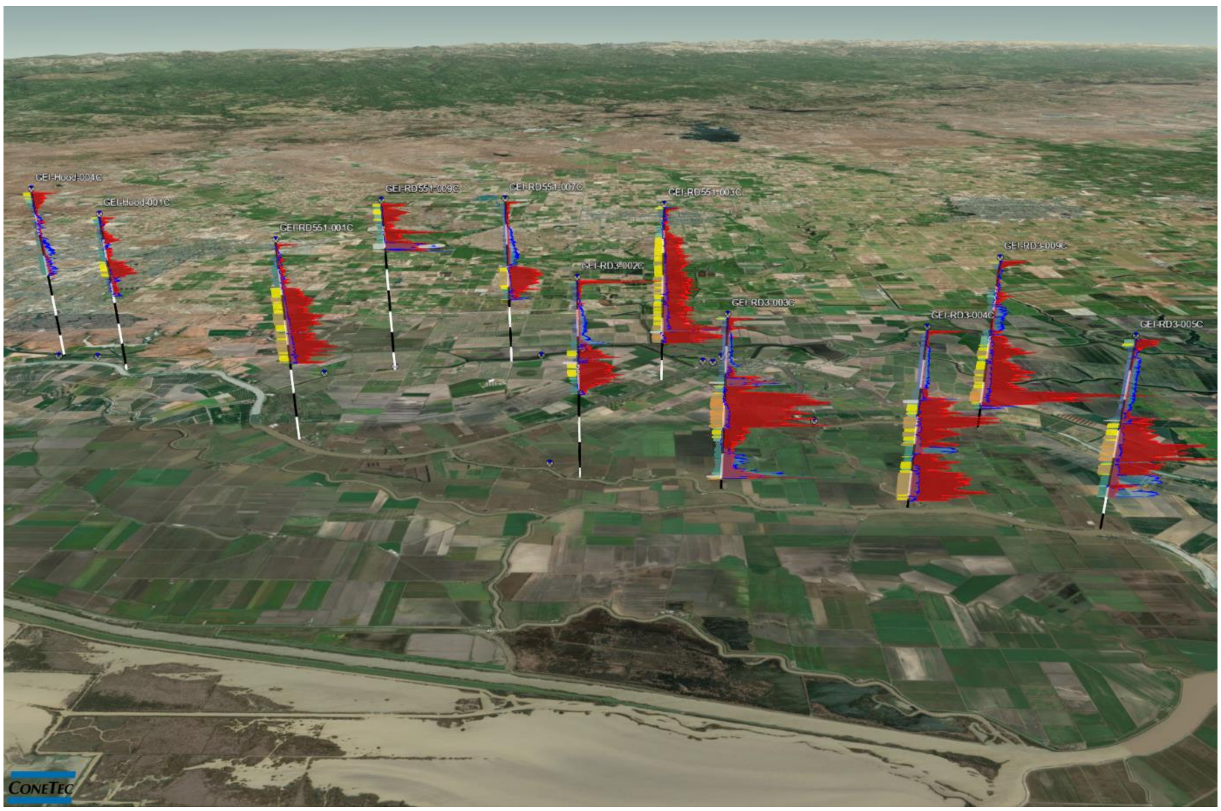
Small Communities

Prepared for:

GEI Consultants

ConeTec Job No: 19-56124

Project Start Date: 19-Aug-2019
Project End Date: 28-Aug-2019
Report Date: 05-Sep-2019



Prepared by:

ConeTec Inc.
820 Aladdin Avenue
San Leandro, CA 94577

Tel: (510) 357-3677

ConeTecCA@conetec.com
www.conetec.com
www.conetecdataservices.com

CONETEC

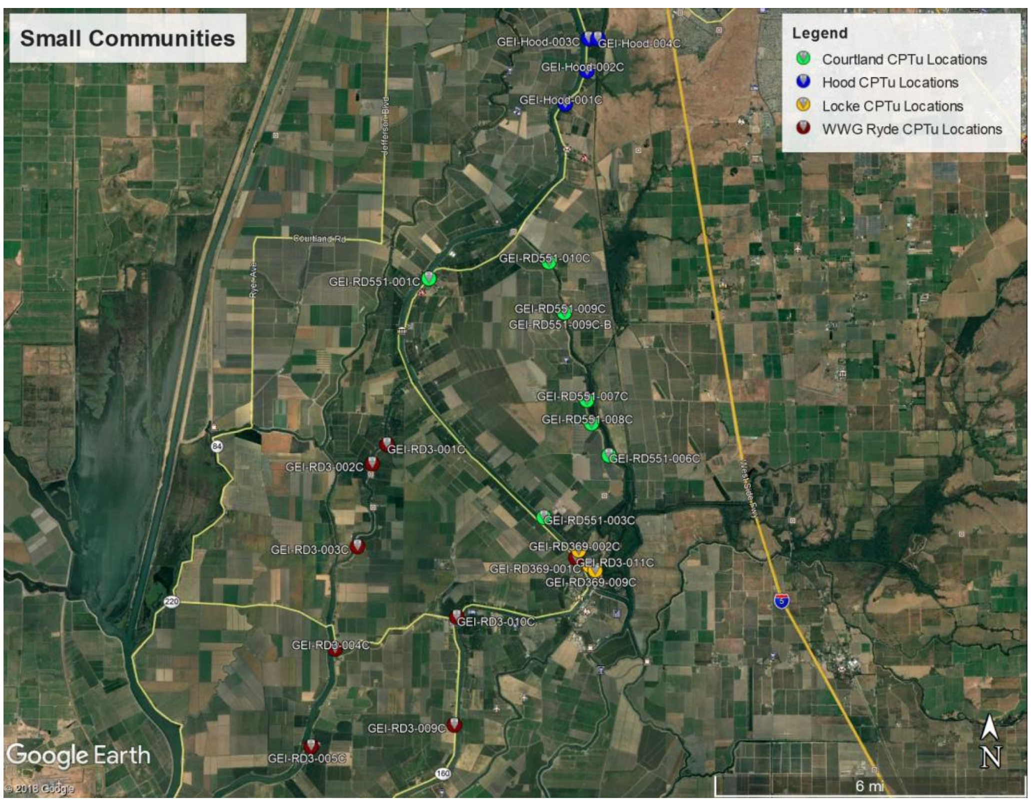
Introduction

The enclosed report presents the results of the site investigation program conducted by ConeTec Inc. for GEI Consultants of Oakland, CA. The program consisted of cone penetration testing (CPTu) at twenty-two (22) locations, with one (1) re-push. Soil samples were collected at all locations with the CPT piston sampler.

Project Information

Project	
Client	GEI Consultants
Project	Small Communities
ConeTec Project #	19-56124

An aerial overview from Google Earth including the CPT test locations is presented below.



Rig Description	Deployment System	Test Type
CPT truck rig	30-ton truck mounted cylinder	CPTu

Coordinates		
Test Type	Collection Method	EPSG Number
CPTu	Consumer grade GPS	32610

Cone Penetrometers Used for this Project						
Cone Description	Cone Number	Cross Sectional Area (cm^2)	Sleeve Area (cm^2)	Tip Capacity (bar)	Sleeve Capacity (bar)	Pore Pressure Capacity (psi)
391:T1500F15U500	391	15	225	1500	15	500
499:T1500F15U500	499	15	225	1500	15	1000
The CPT Summary shows which cone was used on each sounding.						

Cone Penetration Test	
Depth reference	Depths are referenced to the existing ground surface at the time of test.
Tip and sleeve data offset	0.1 Meter This has been accounted for in the CPT data files.
Additional Comments	Standard plots with expanded scales, Advanced plots with Ic, Phi, Su(Nkt), and N1(60)Ic, as well as Soil Behavior Type (SBT) Scatter plots have been included in the data release package.

Calculated Geotechnical Parameter Tables	
Additional information	The Normalized Soil Behaviour Type Chart based on Q_{tn} (SBT Q_{tn}) (Robertson, 2009) was used to classify the soil for this project. A detailed set of calculated CPTu parameters have been generated and are provided in Excel format files in the release folder. The CPTu parameter calculations are based on values of corrected tip resistance (q_t) sleeve friction (f_s) and pore pressure (u_2). Effective stresses are calculated based on unit weights that have been assigned to the individual soil behaviour type zones and the assumed equilibrium pore pressure profile. Soils were classified as either drained or undrained based on the Q_{tn} Normalized Soil Behaviour Type Chart (Robertson, 2009). Calculations for both drained and undrained parameters were included for materials that classified as silt mixtures (zone 4).

Limitations

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

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

Cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd., a subsidiary of ConeTec.

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

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in 5 cm^2, 10 cm^2 and 15 cm^2 tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table presented in the first appendix. The 15 cm^2 penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm^2 piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross-sectional area (typically forty-four millimeter diameter over a length of thirty-two millimeter with tapered leading and trailing edges) located at a distance of 585 millimeters above the cone tip.

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

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

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

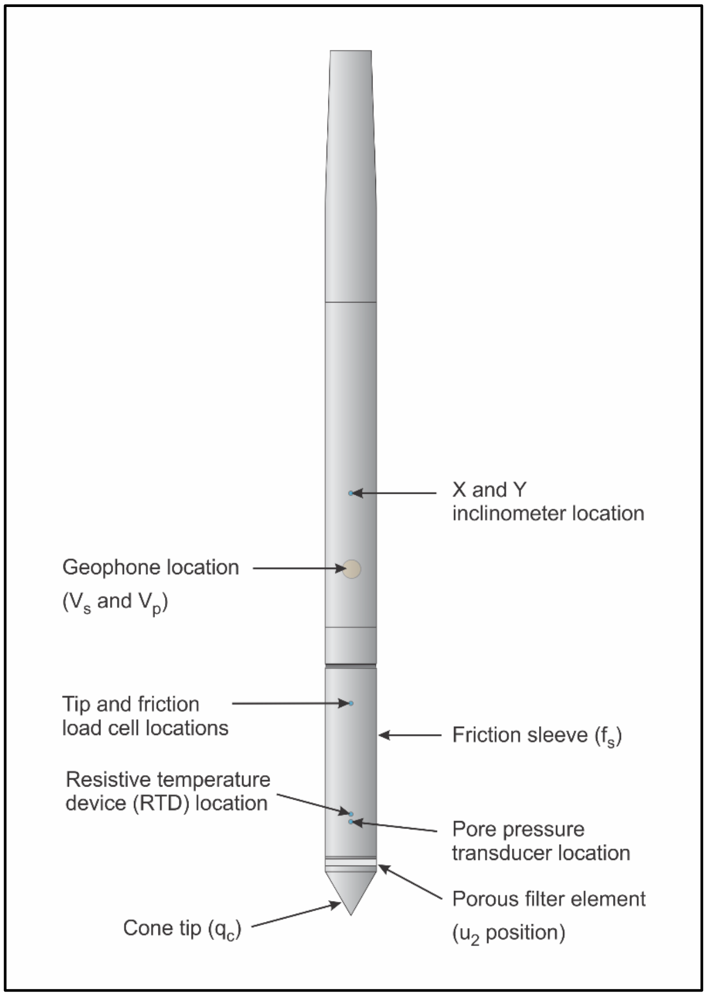


Figure CPTu. Piezocone Penetrometer (15 cm^2)

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

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

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

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

The CPTu is conducted at a steady rate of two centimeters per second, within acceptable tolerances. Typically, one-meter length rods with an outer diameter of 38.1 millimeters are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

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

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

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson et al. (1986) and Robertson (1990, 2009). It should be noted that it is not always possible to accurately identify a soil behaviour type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behaviour type.

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

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

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

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

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

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

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

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

References

ASTM D5778-12, 2012, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM International, West Conshohocken, PA. DOI: 10.1520/D5778-12.

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

Mayne, P.W., 2013, “Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests”, Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420. DOI: 10.1061/9780784412770.027.

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

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

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

Robertson, P.K., 1990, “Soil Classification Using the Cone Penetration Test”, Canadian Geotechnical Journal, Volume 27: 151-158. DOI: 10.1139/T90-014.

Robertson, P.K., 2009, “Interpretation of cone penetration tests – a unified approach”, Canadian Geotechnical Journal, Volume 46: 1337-1355. DOI: 10.1139/T09-065.

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

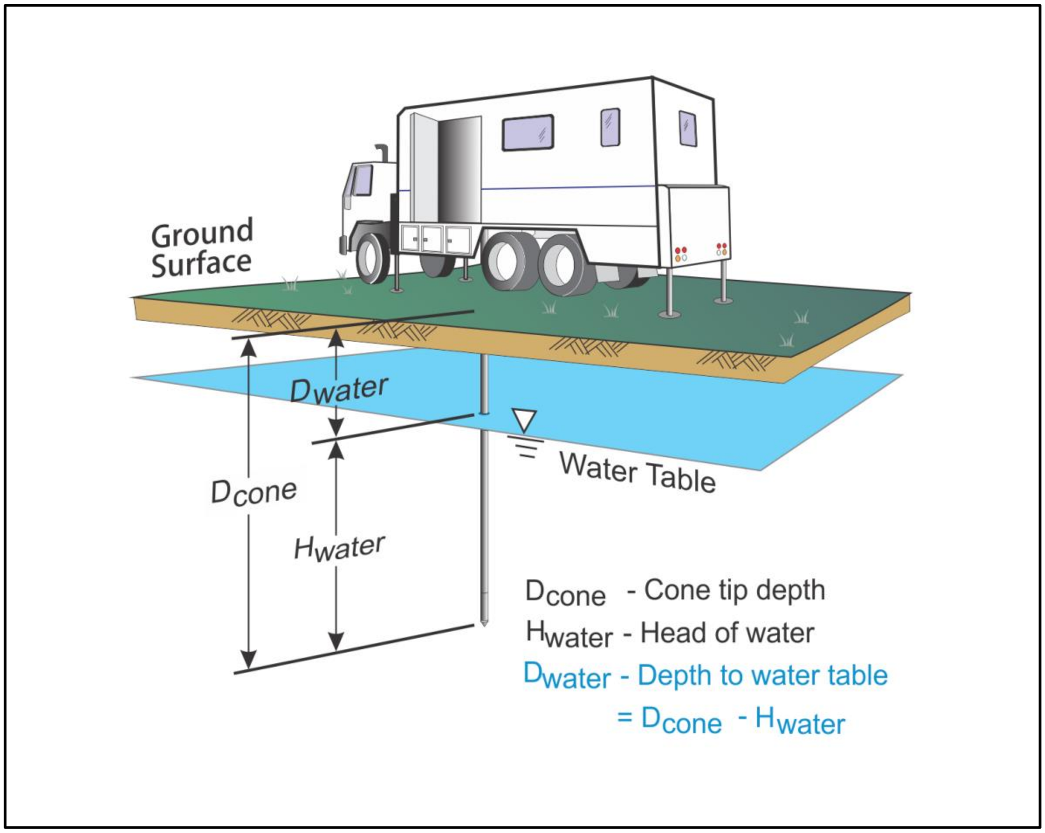


Figure PPD-1. Pore pressure dissipation test setup

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

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

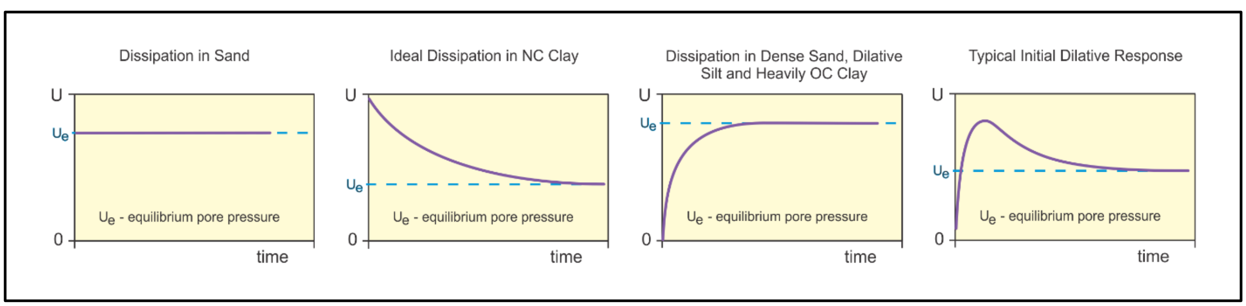


Figure PPD-2. Pore pressure dissipation curve examples

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

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

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

Where:

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

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

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

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

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

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

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

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

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

References

Burns, S.E. and Mayne, P.W., 1998, “Monotonic and dilatory pore pressure decay during piezocone tests”, Canadian Geotechnical Journal 26 (4): 1063-1073. DOI: 1063-1073/T98-062.

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

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

Robertson, P.K., Sully, J.P., Woeller, D.J., Lunne, T., Powell, J.J.M. and Gillespie, D.G., 1992, “Estimating coefficient of consolidation from piezocone tests”, Canadian Geotechnical Journal, 29(4): 539-550. DOI: 10.1139/T92-061.

Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J., 1999, “An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils”, Canadian Geotechnical Journal, 36(2): 369-381. DOI: 10.1139/T98-105.

Teh, C.I., and Houlsby, G.T., 1991, “An analytical study of the cone penetration test in clay”, Geotechnique, 41(1): 17-34. DOI: 10.1680/geot.1991.41.1.17.

The appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Standard Cone Penetration Test Plots with Expanded Range
- Advanced Cone Penetration Test Plots with Ic, Phi, Su(Nkt), and N1(60)Ic
- Soil Behavior Type (SBT) Zone Scatter Plots
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots
- Soil Sample Summary

Cone Penetration Test Summary and Standard Cone Penetration Test Plots

CONETEC

Job No: 19-56124
Client: GEI Consultants
Project: Small Communities
Start Date: 19-Aug-2019
End Date: 28-Aug-2019

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (ft)	Final Depth (ft)	Northing[2] (m)	Easting[2] (m)	Elevation[3] (ft)	Refer to Notation Number
GEI-Hood-001C	19-56124_CP-Hood-001C	28-Aug-2019	391:T1500F15U500	7.7	60.20	4249187	629280	14	
GEI-Hood-002C	19-56124_CP-Hood-002C	28-Aug-2019	391:T1500F15U500	6.4	96.29	4250216	629936	13	
GEI-Hood-003C	19-56124_CP-Hood-003CC	27-Aug-2019	391:T1500F15U500	7.0	40.03	4251212	629972	29	4
GEI-Hood-004C	19-56124_CP-Hood-004C	27-Aug-2019	391:T1500F15U500	7.0	65.04	4251216	630257	27	4

1. The assumed phreatic surface was based on the results of the shallowest pore pressure dissipation test performed within the sounding. Hydrostatic conditions were assumed for the calculated parameters.
2. The coordinates were acquired using consumer grade GPS equipment, datum: WGS 1984 / UTM Zone 10 North.
3. Elevations are refrenced to the ground surface and are derived from Google Earth Elevation for the recorded coordinates.
4. The assumed phreatic surface was based on the pore pressure dissipation test at GEI-Hood-002C.
5. The assumed phreatic surface was based on the pore pressure dissipation test at GEI-RD3-009C.
6. The assumed phreatic surface was based on the pore pressure dissipation test at GEI-RD551-010C.
7. Maxed out the pore pressure sensor on the cone. Switched to high pore pressure cone offset and re-pushed location.

Job No: 19-56124
Client: GEI Consultants
Project: Small Communities
Start Date: 21-Oct-2019
End Date: 01-Nov-2019

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (ft)	Final Depth (ft)	Northing[2] (m)	Easting[2] (m)	Elevation[3] (ft)	Refer to Notation Number
GEI-Hood-005C	19-56124_CP-Hood-005C	22-Oct-2019	494:T1500F15U500	22.0	65.53	4250428	630232	28	4
GEI-Hood-006C	19-56124_CP-Hood-006C	22-Oct-2019	494:T1500F15U500	22.1	81.53	4249954	630236	34	
GEI-Hood-007C	19-56124_CP-Hood-007C	21-Oct-2019	494:T1500F15U500	2.9	109.50	4249120	630181	5	
GEI-Hood-008C	19-56124_CP-Hood-008C	21-Oct-2019	494:T1500F15U500	20.0	60.53	4248079	630175	25	4
GEI-Hood-009C	19-56124_CP-Hood-009C	30-Oct-2019	448:T1500F15U500	20.0	23.54	4247384	630045	17	4
GEI-Hood-009C-B	19-56124_CP-Hood-009C-B	30-Oct-2019	448:T1500F15U500	20.0	22.23	4247379	630051	17	4
GEI-Hood-010C	19-56124_CP-Hood-010C	21-Oct-2019	494:T1500F15U500	19.6	75.54	4247542	629479	26	
GEI-Hood-011C	19-56124_CP-Hood-011C	25-Oct-2019	499:T1500F15U1K	1.8	55.53	4248225	629691	5	

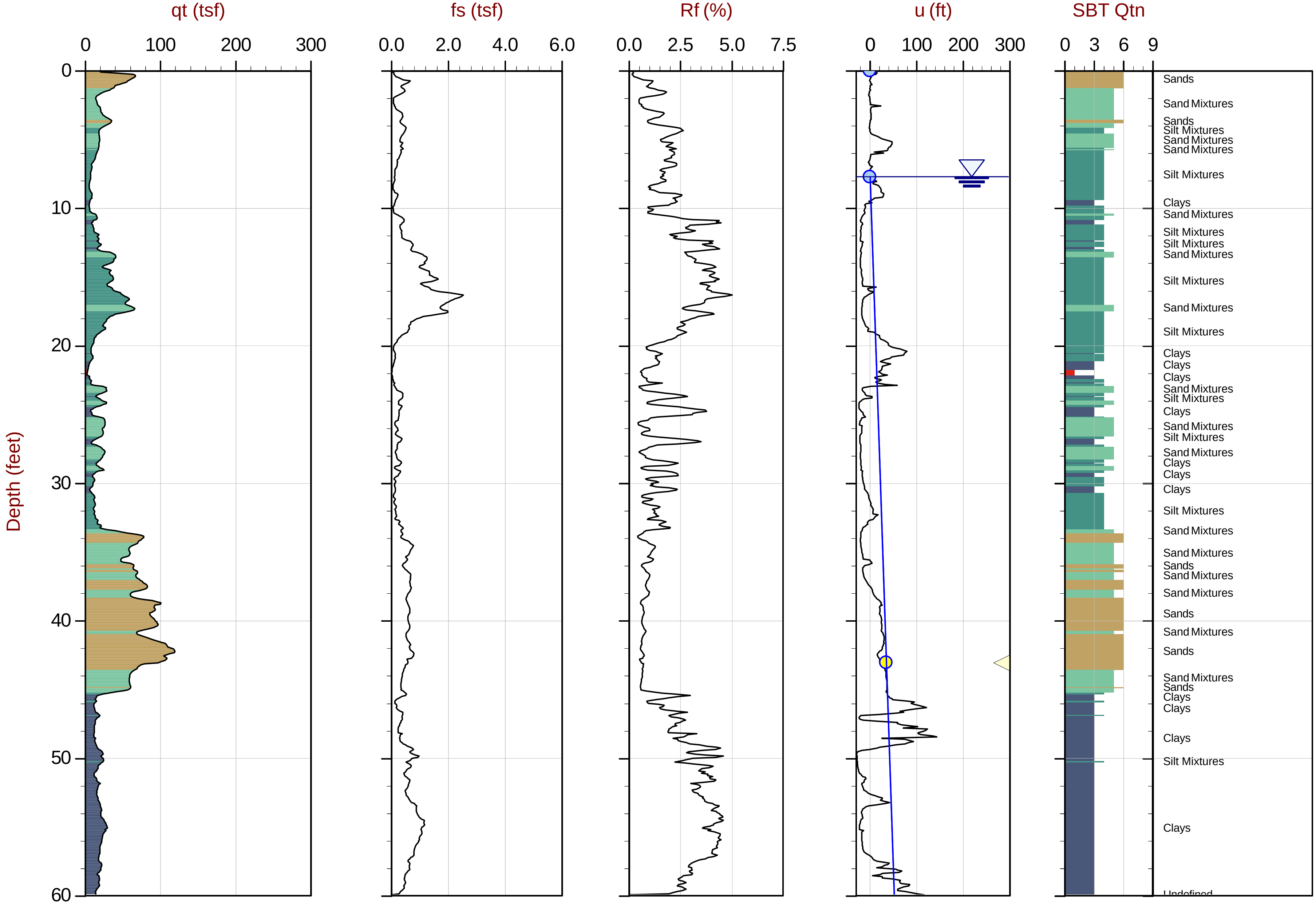
1. The assumed phreatic surface was based on the results of the shallowest pore pressure dissipation test performed within the sounding. Hydrostatic conditions were assumed for the calculated parameters.
2. The coordinates were acquired using consumer grade GPS equipment, datum: WGS 1984 / UTM Zone 10 North.
3. Elevations are refrenced to the ground surface and are derived from Google Earth Elevation for the recorded coordinates.
4. The assumed phreatic surface was based on dynamic pore pressure and the pore pressure dissipation tests at nearby soundings.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-28 07:52
Site: Hood

Sounding: GEI-Hood-001C
Cone: 391:T1500F15U500



Max Depth: 18.350 m / 60.20 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-001C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249187m E: 629280m

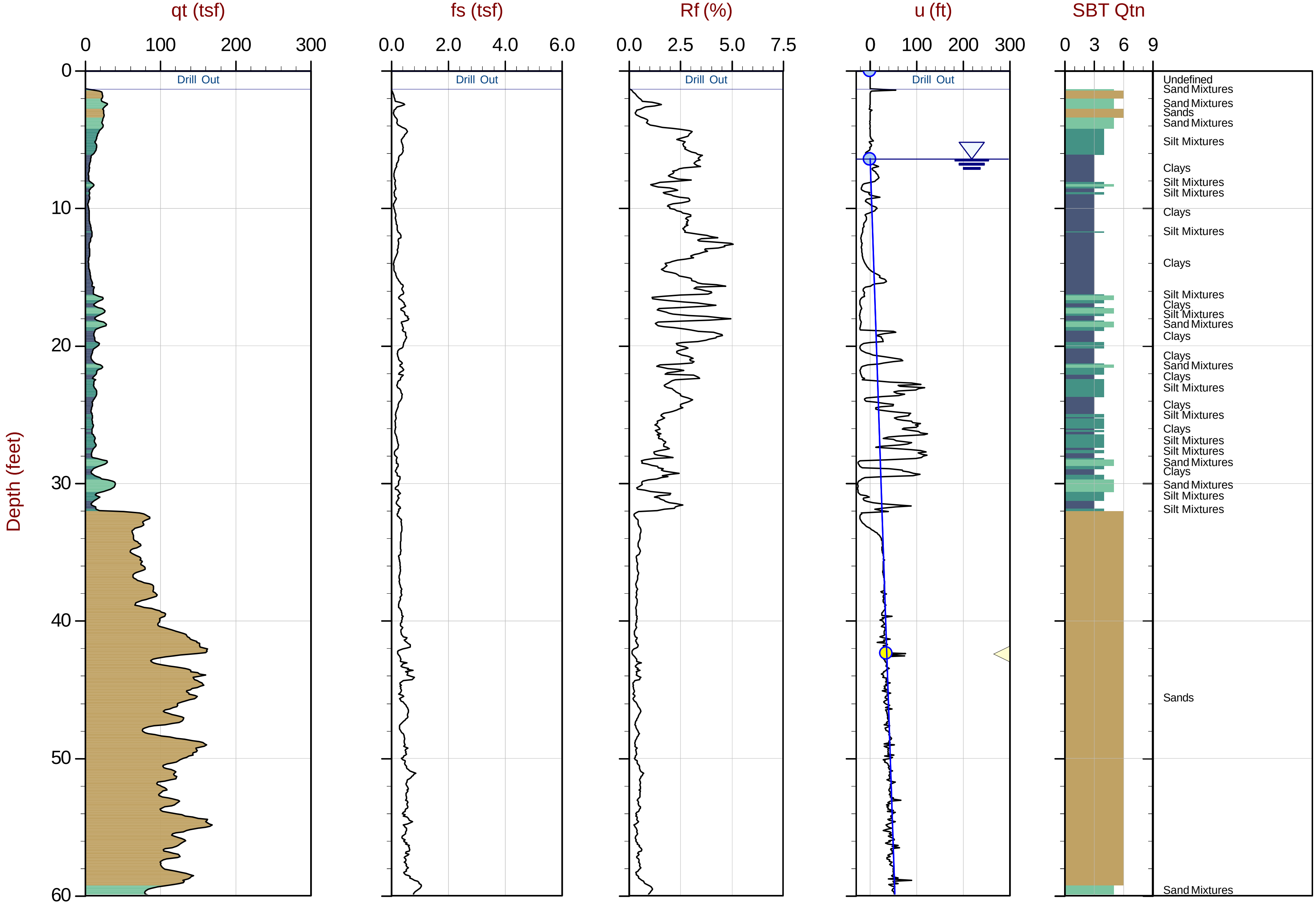
Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

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

GEI

Job No: 19-56124
Date: 2019-08-28 10:01
Site: Hood

Sounding: GEI-Hood-002C
Cone: 391:T1500F15U500



Max Depth: 29.350 m / 96.29 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-002C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250216m E: 629936m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

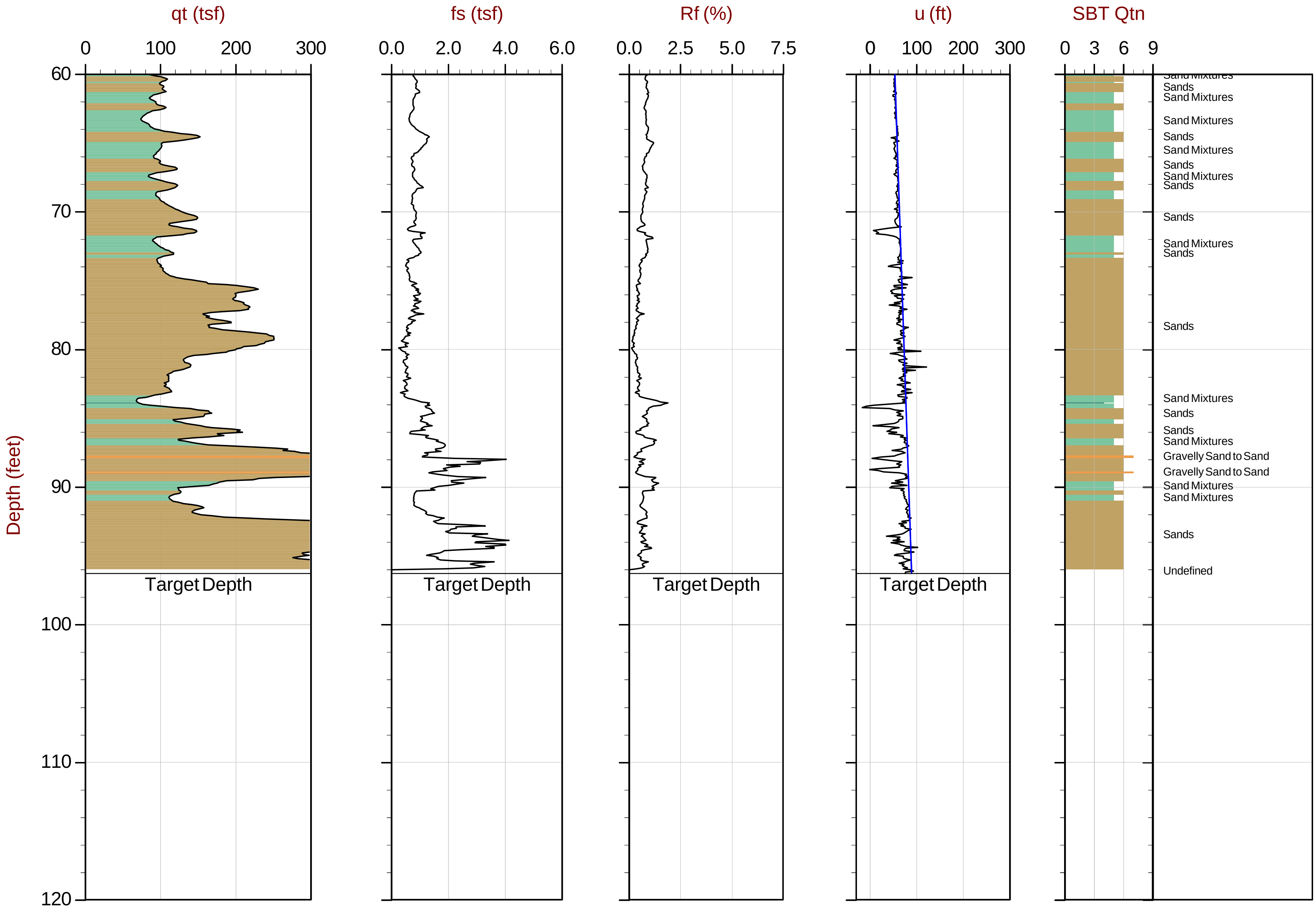
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

GEI

Job No: 19-56124
Date: 2019-08-28 10:01
Site: Hood

Sounding: GEI-Hood-002C
Cone: 391:T1500F15U500



Max Depth: 29.350 m / 96.29 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-002C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250216m E: 629936m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

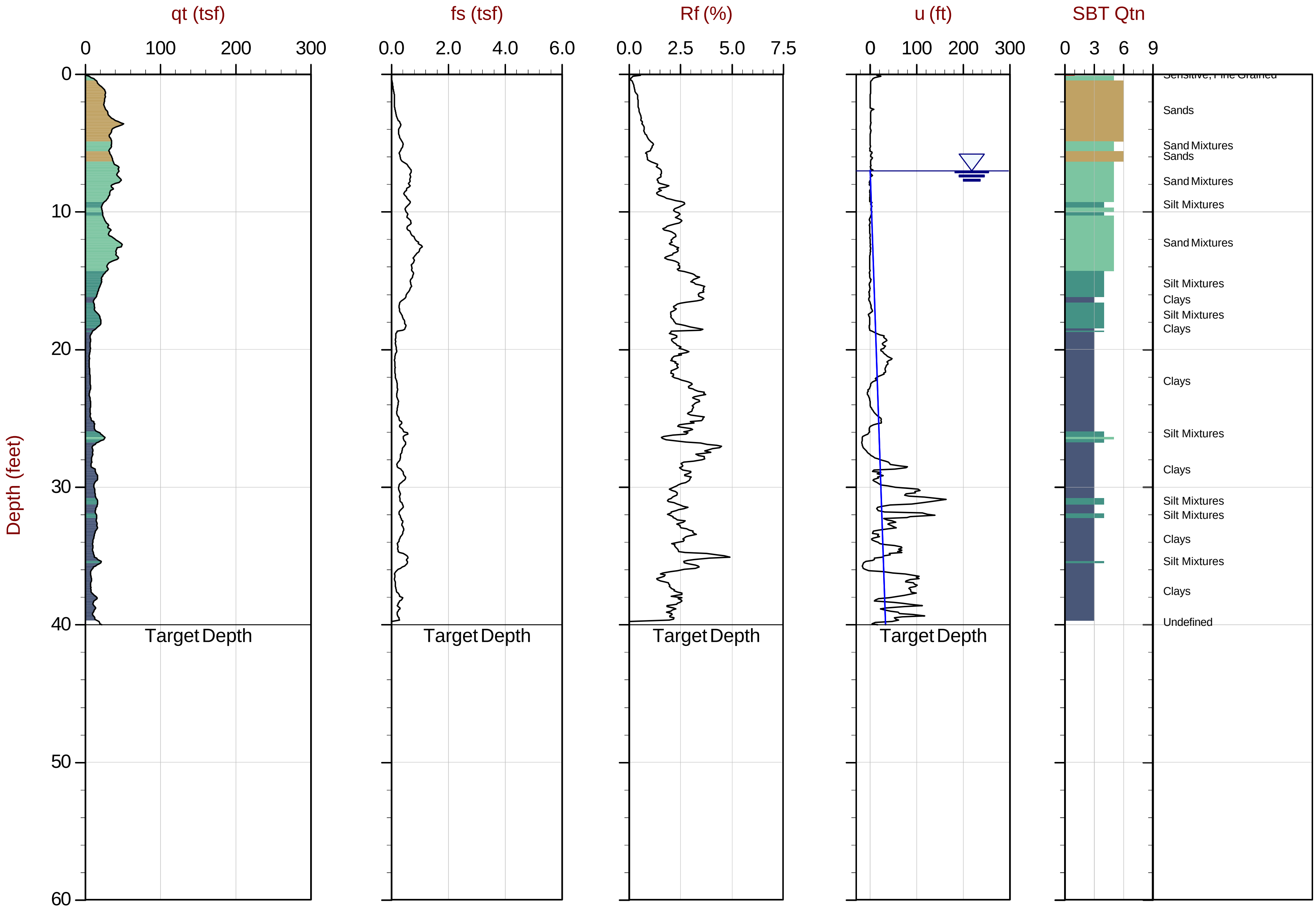
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-27 11:42
Site: Hood

Sounding: GEI-Hood-003C
Cone: 391:T1500F15U500



Max Depth: 12.200 m / 40.03 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-003C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4251212m E: 629972m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

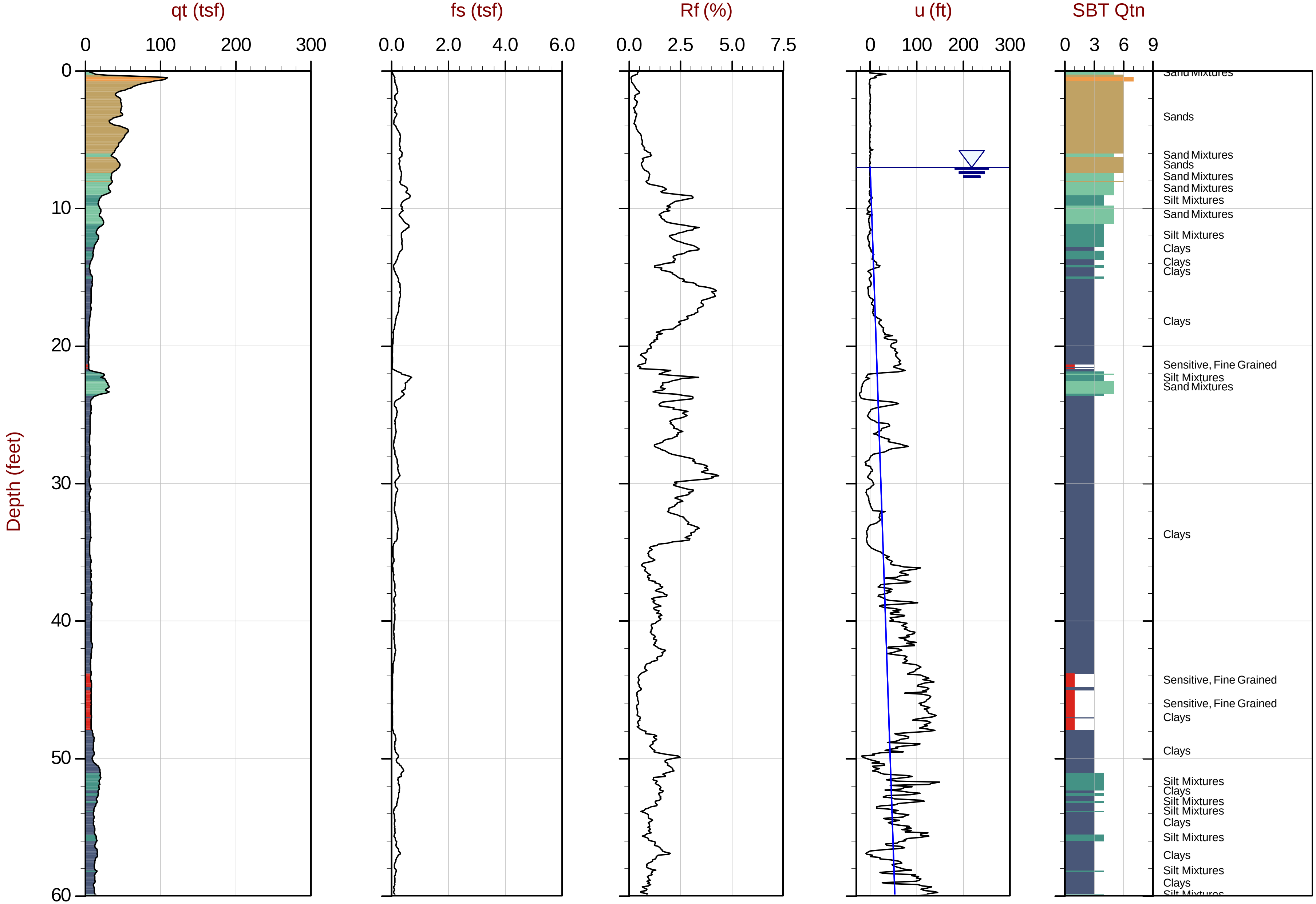
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-27 13:25
Site: Hood

Sounding: GEI-Hood-004C
Cone: 391:T1500F15U500



Max Depth: 19.825 m / 65.04 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-004C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4251216m E: 630257m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

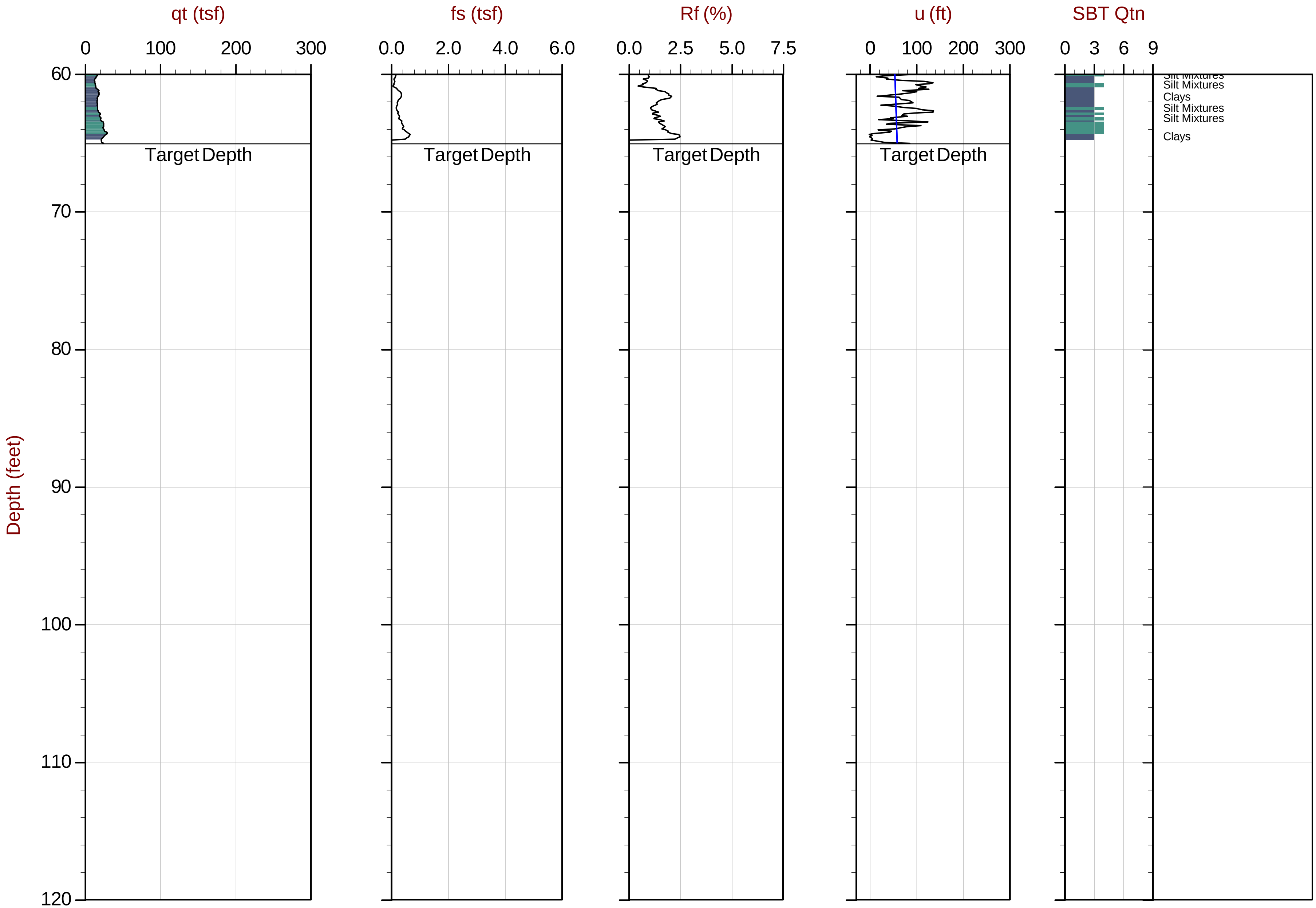
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-27 13:25
Site: Hood

Sounding: GEI-Hood-004C
Cone: 391:T1500F15U500



Max Depth: 19.825 m / 65.04 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-004C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4251216m E: 630257m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

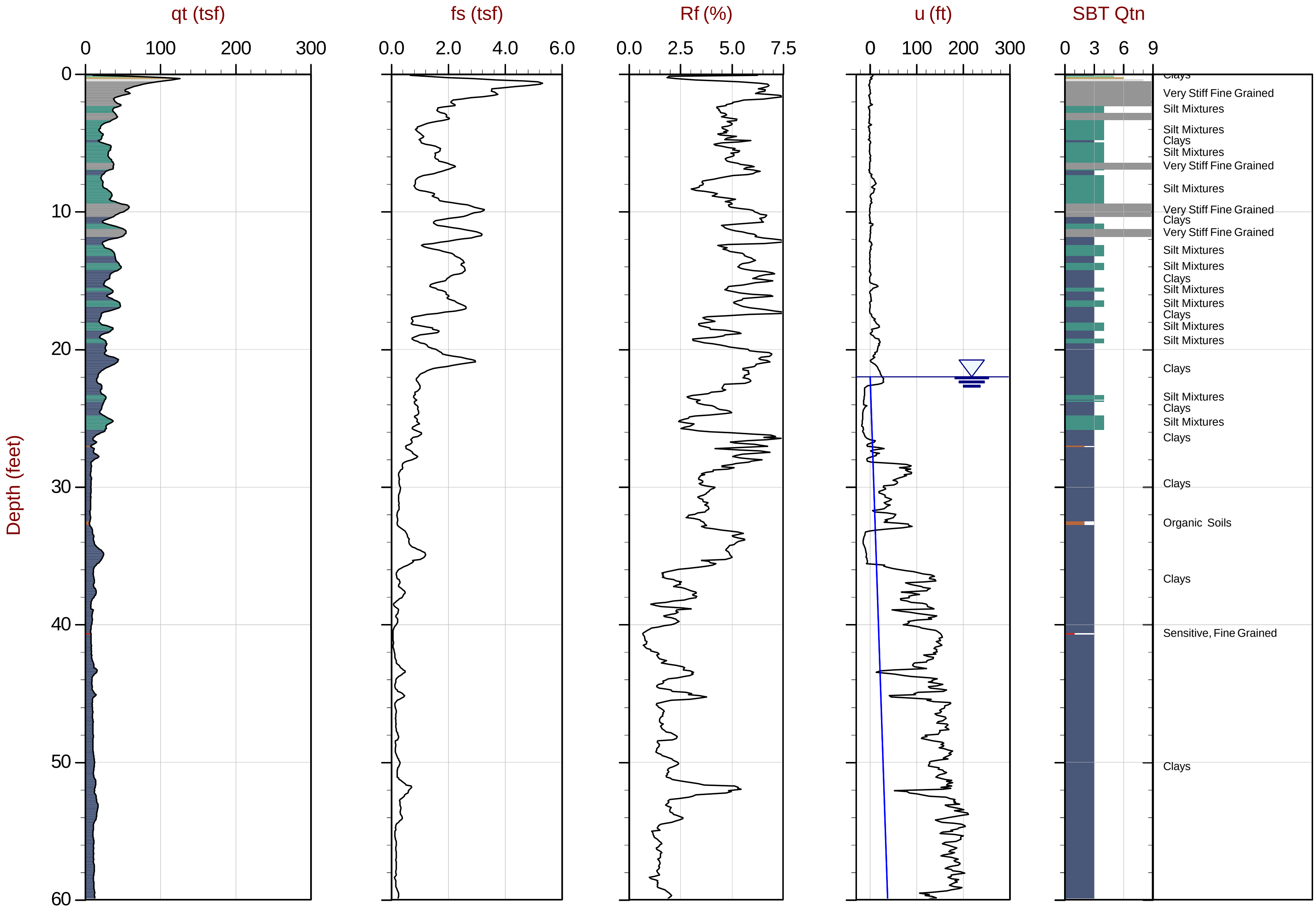
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-22 14:03
Site: Hood

Sounding: GEI-Hood-005C
Cone: 494:T1500F15U500



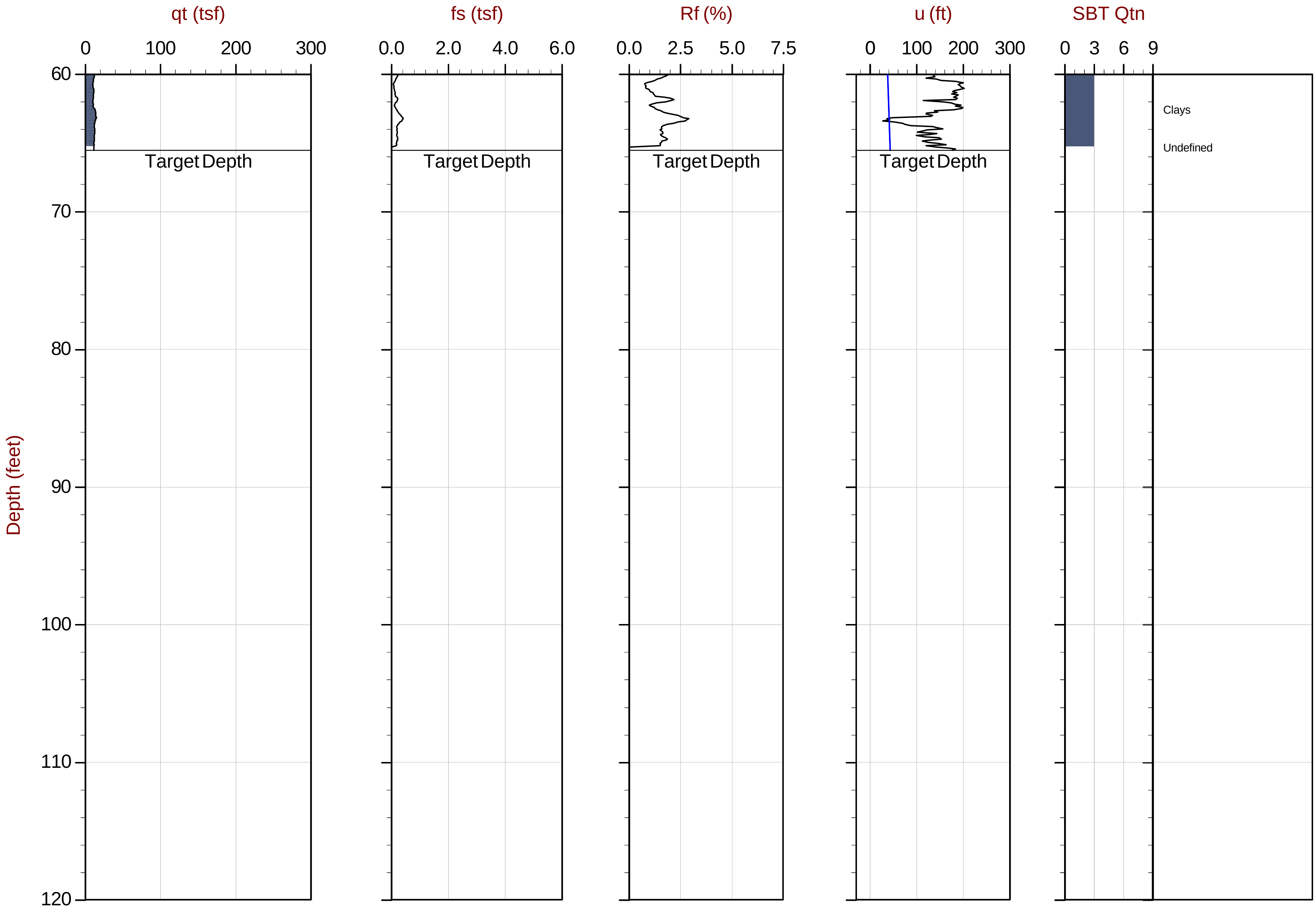
Max Depth: 19.975 m / 65.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-005C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250428m E: 630232m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

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



Max Depth: 19.975 m / 65.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-005C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250428m E: 630232m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

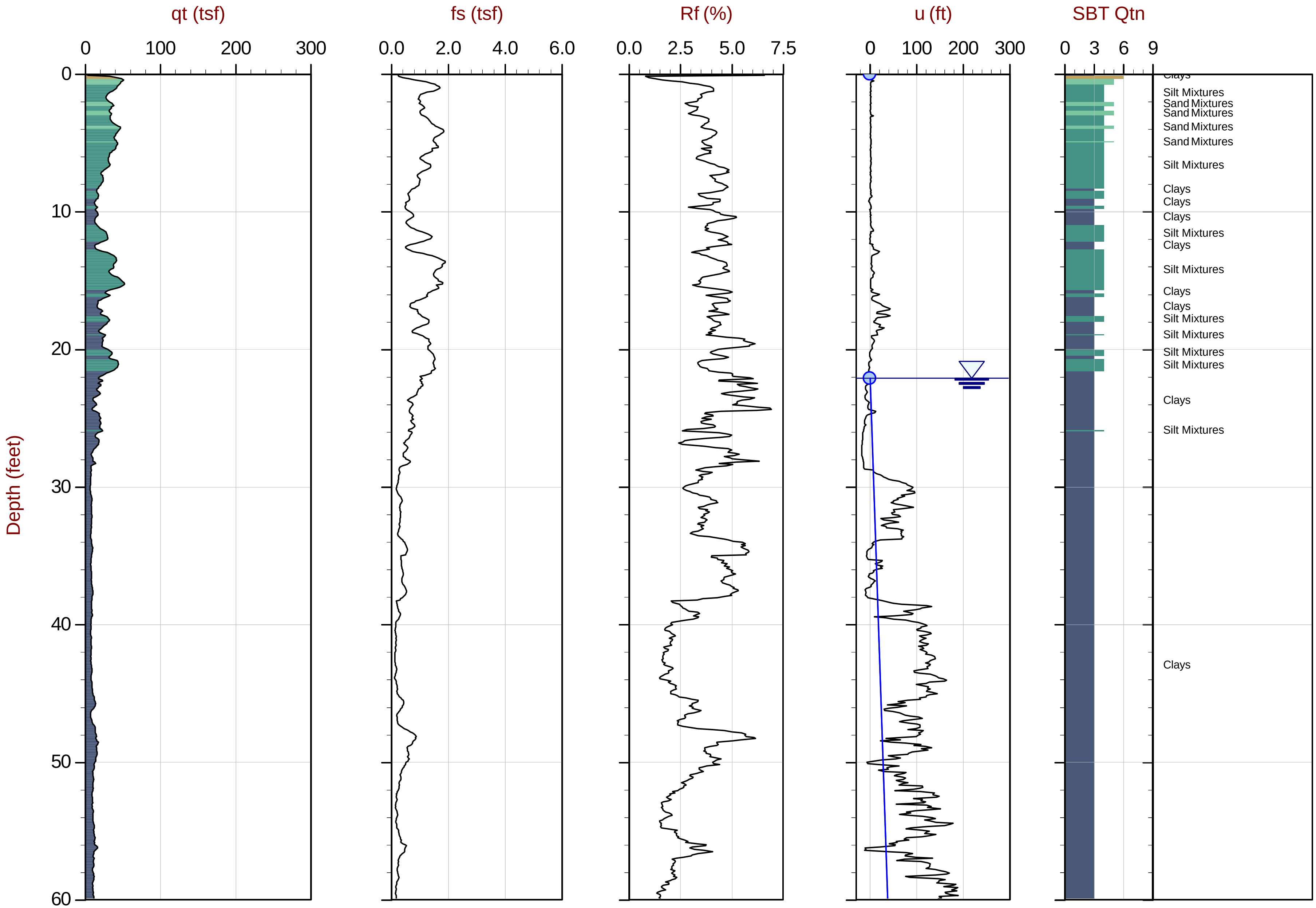
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-22 09:06
Site: Hood

Sounding: GEI-Hood-006C
Cone: 494:T1500F15U500



Max Depth: 24.850 m / 81.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-006C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249954m E: 630236m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

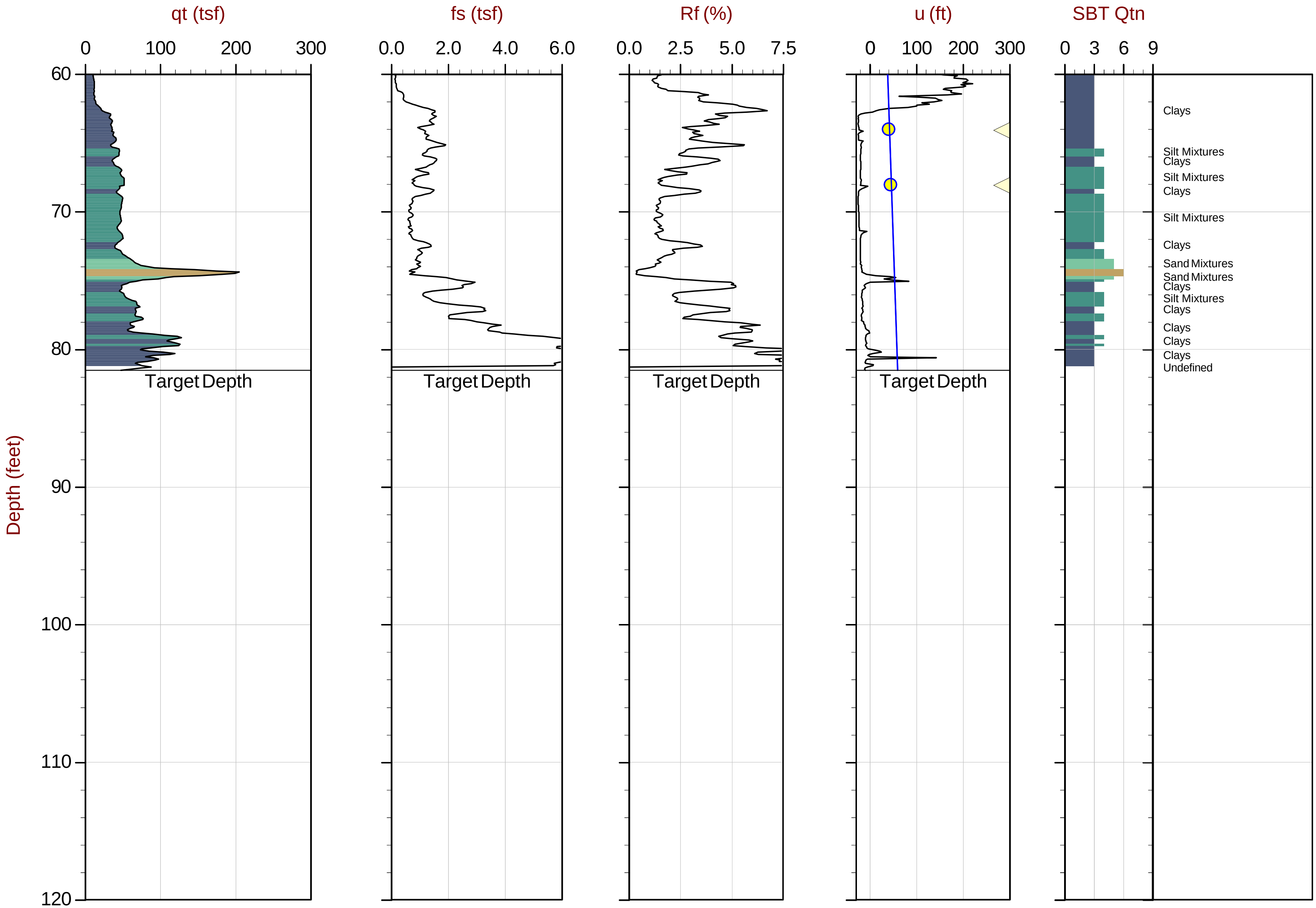
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-22 09:06
Site: Hood

Sounding: GEI-Hood-006C
Cone: 494:T1500F15U500



Max Depth: 24.850 m / 81.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-006C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249954m E: 630236m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

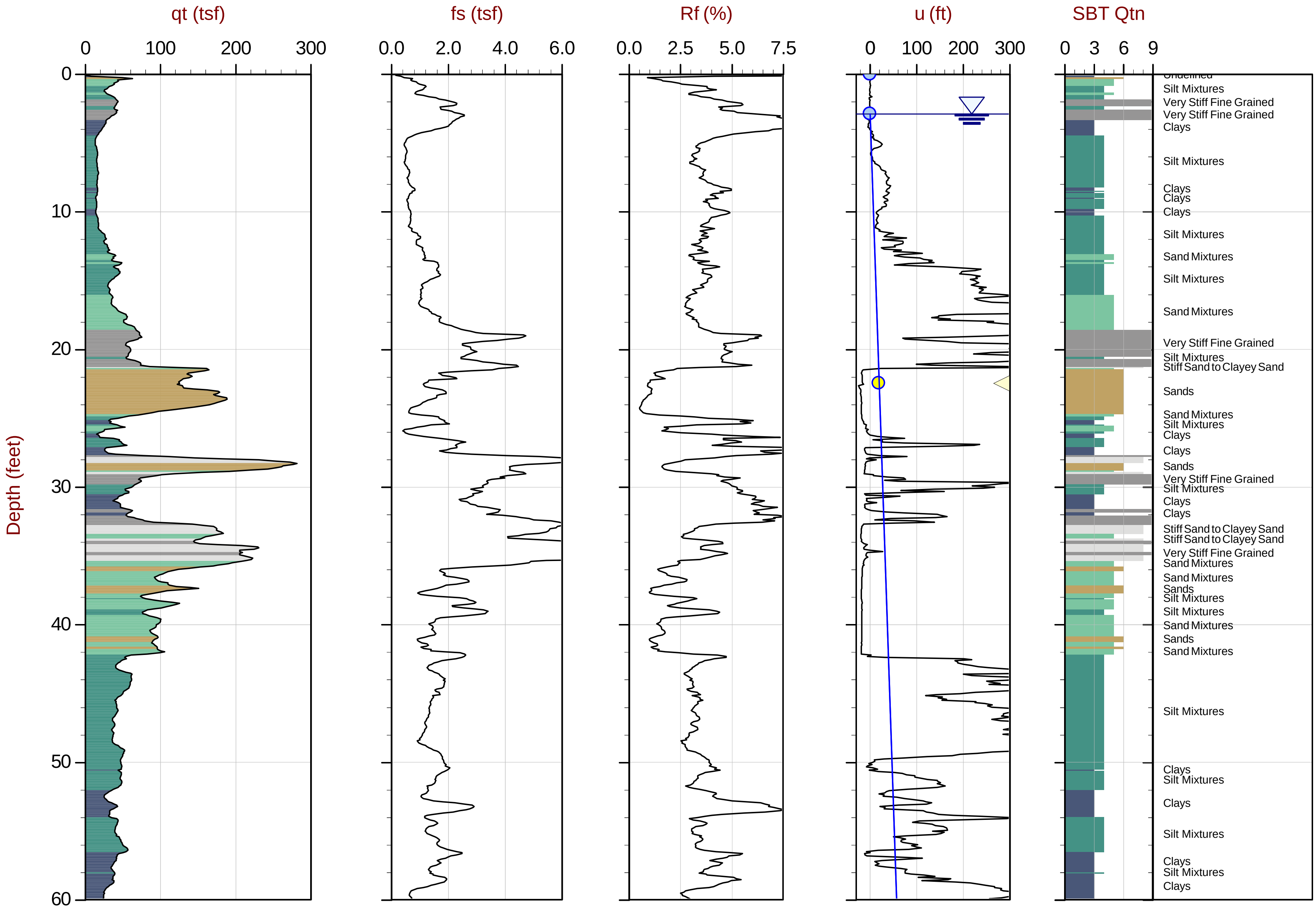
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 16:24
Site: Hood

Sounding: GEI-Hood-007C
Cone: 494:T1500F15U500



Max Depth: 33.375 m / 109.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-007C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249120m E: 630181m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

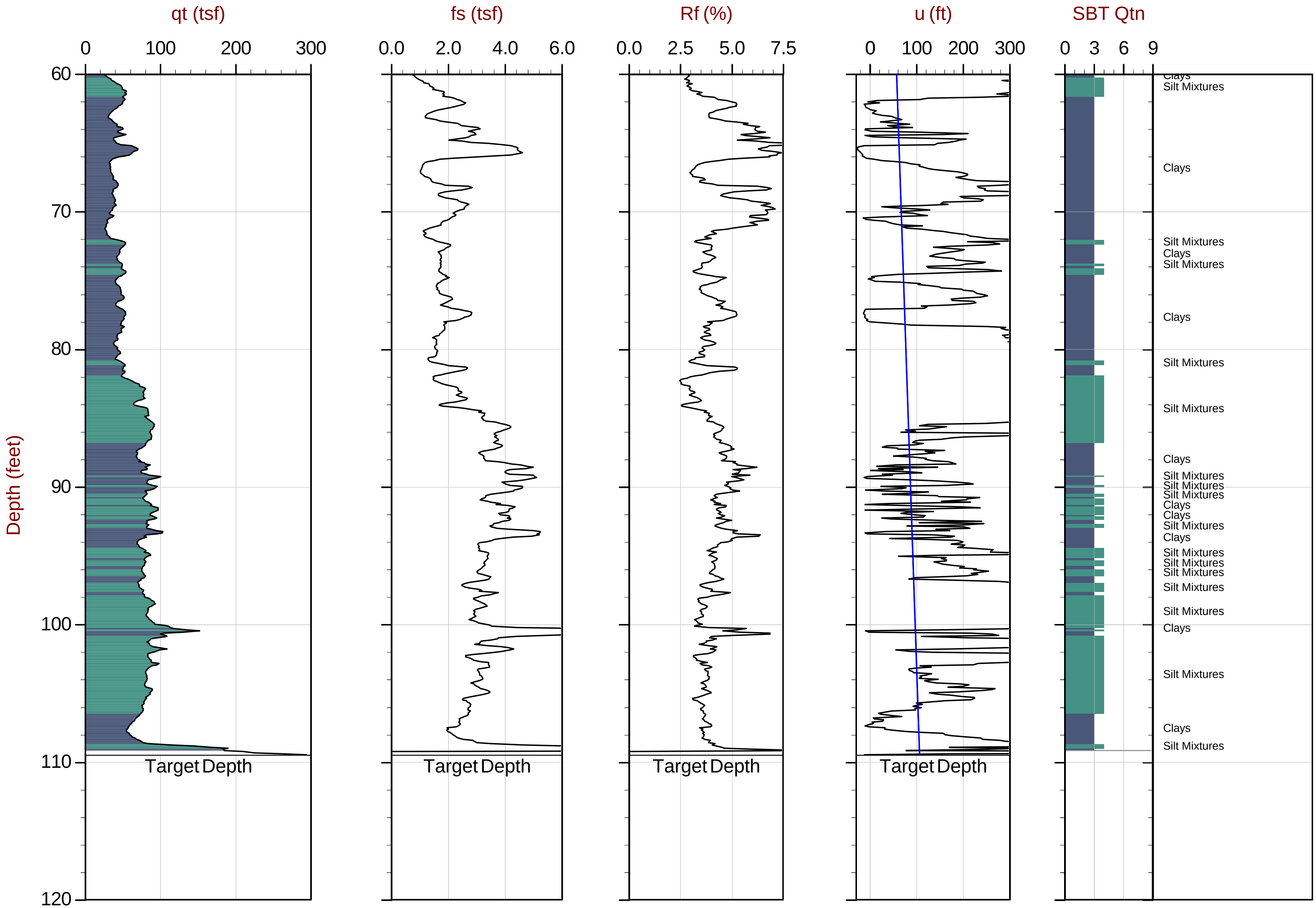
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 16:24
Site: Hood

Sounding: GEI-Hood-007C
Cone: 494:T1500F15U500



Max Depth: 33.375 m / 109.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-007C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249120m E: 630181m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

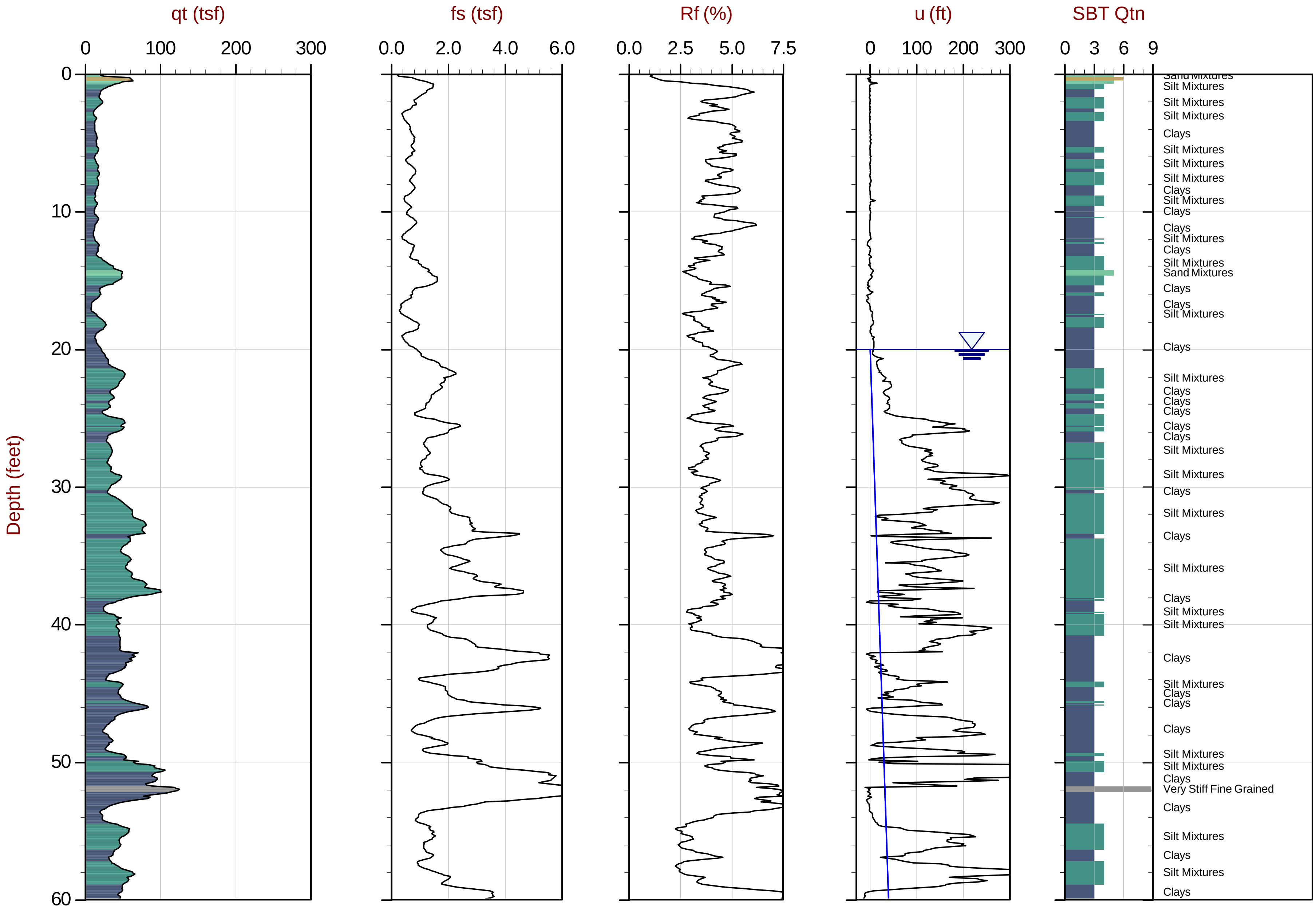
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 10:06
Site: Hood

Sounding: GEI-Hood-008C
Cone: 494:T1500F15U500



Max Depth: 18.450 m / 60.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-008C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4248079m E: 630175m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

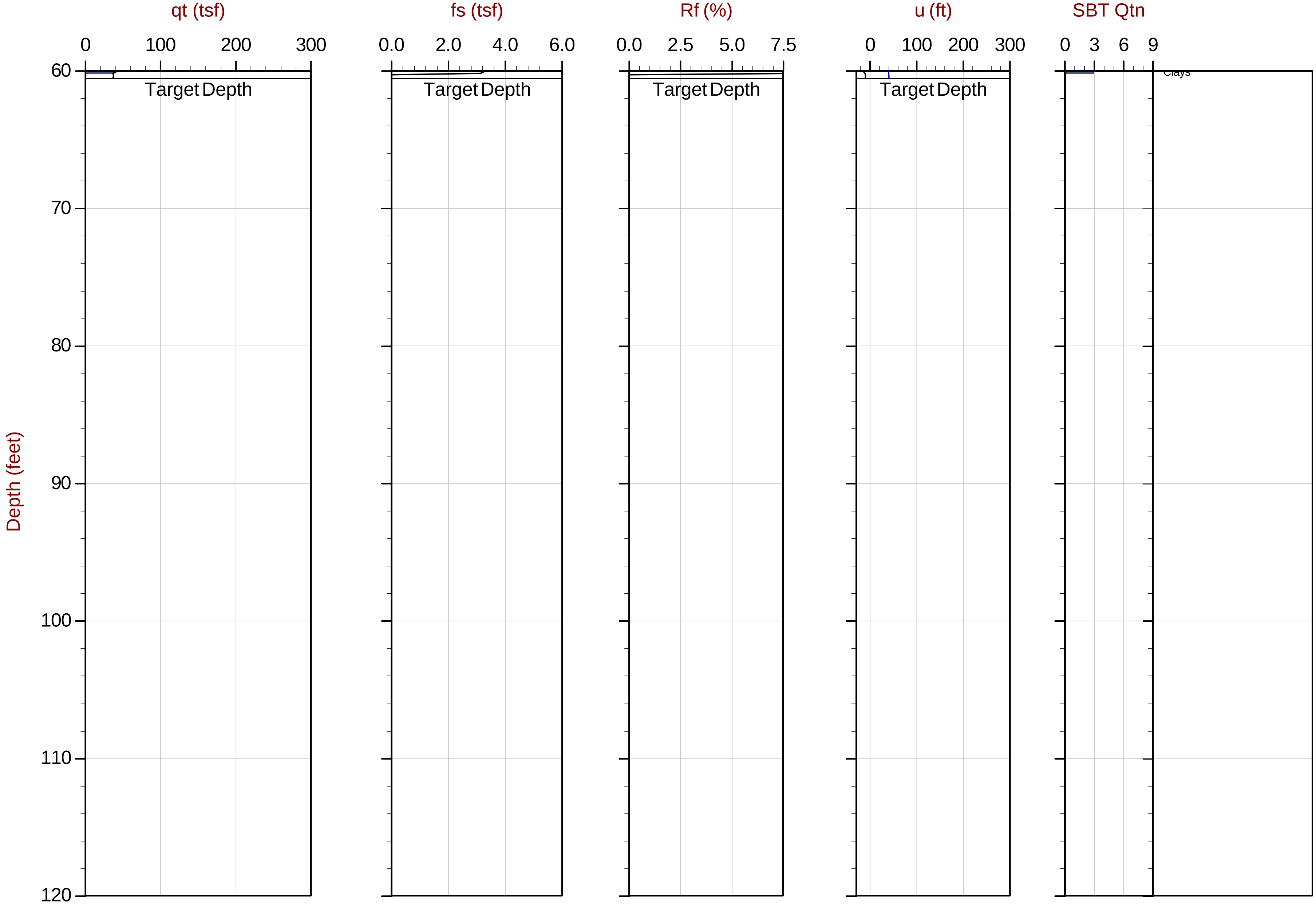
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

GEI

Job No: 19-56124
Date: 2019-10-21 10:06
Site: Hood

Sounding: GEI-Hood-008C
Cone: 494:T1500F15U500



Max Depth: 18.450 m / 60.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-008C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4248079m E: 630175m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

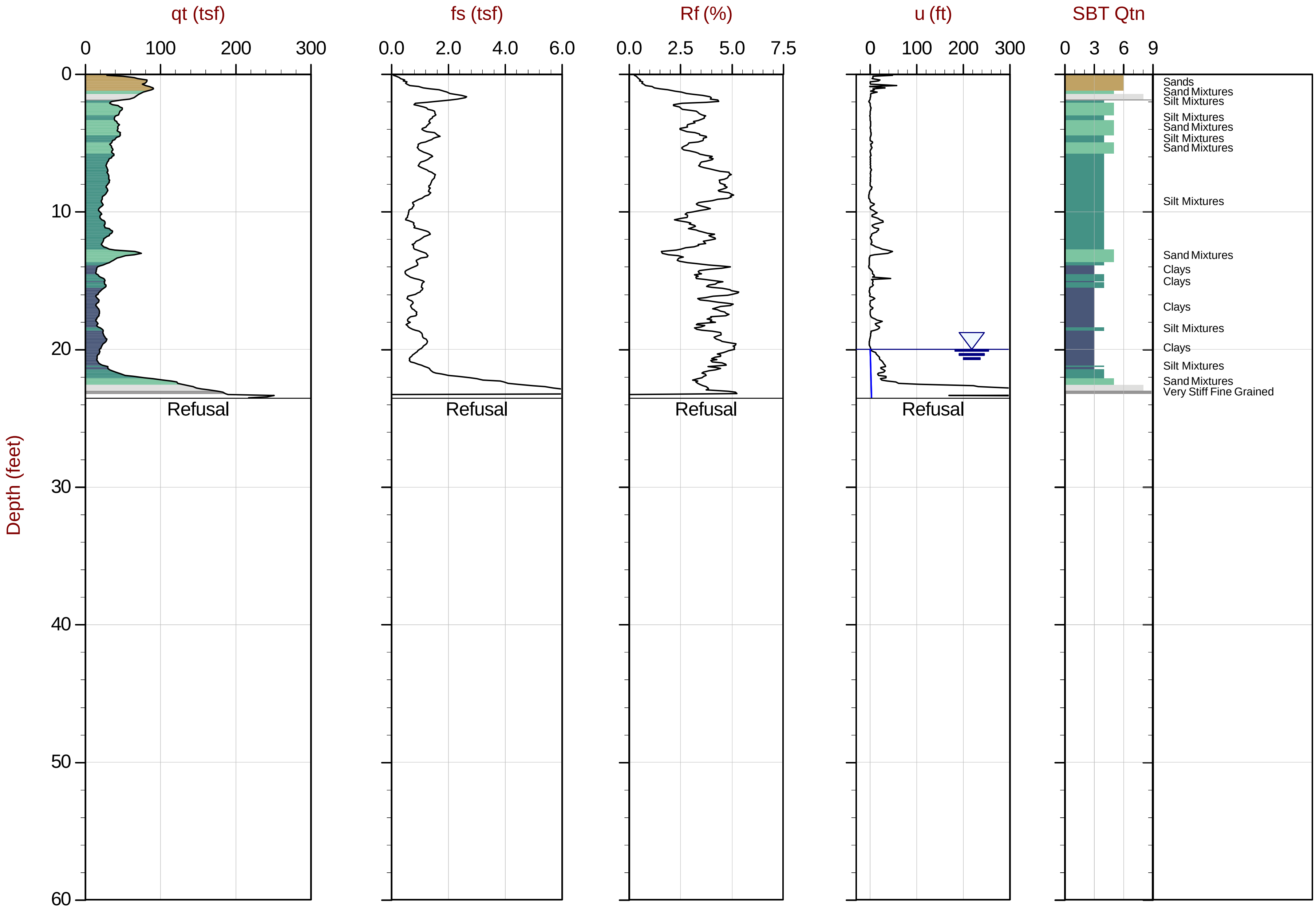
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-30 10:11
Site: Hood

Sounding: GEI-Hood-009C
Cone: 448:T1500F15U500



Max Depth: 7.175 m / 23.54 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-009C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247384m E: 630045m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

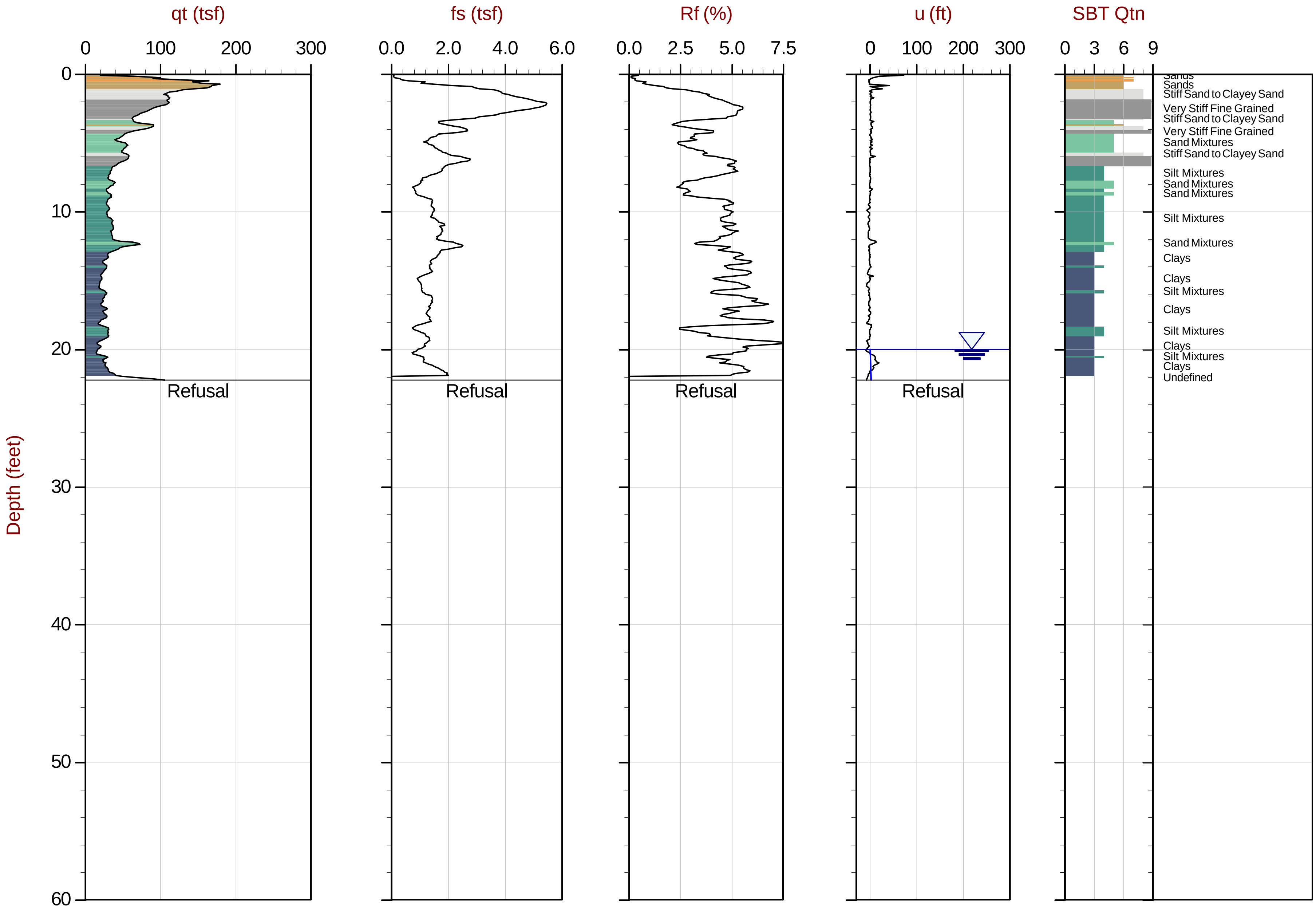
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-30 11:14
Site: Hood

Sounding: GEI-Hood-009C-B
Cone: 448:T1500F15U500



Max Depth: 6.775 m / 22.23 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-009C-B.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247379m E: 630051m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

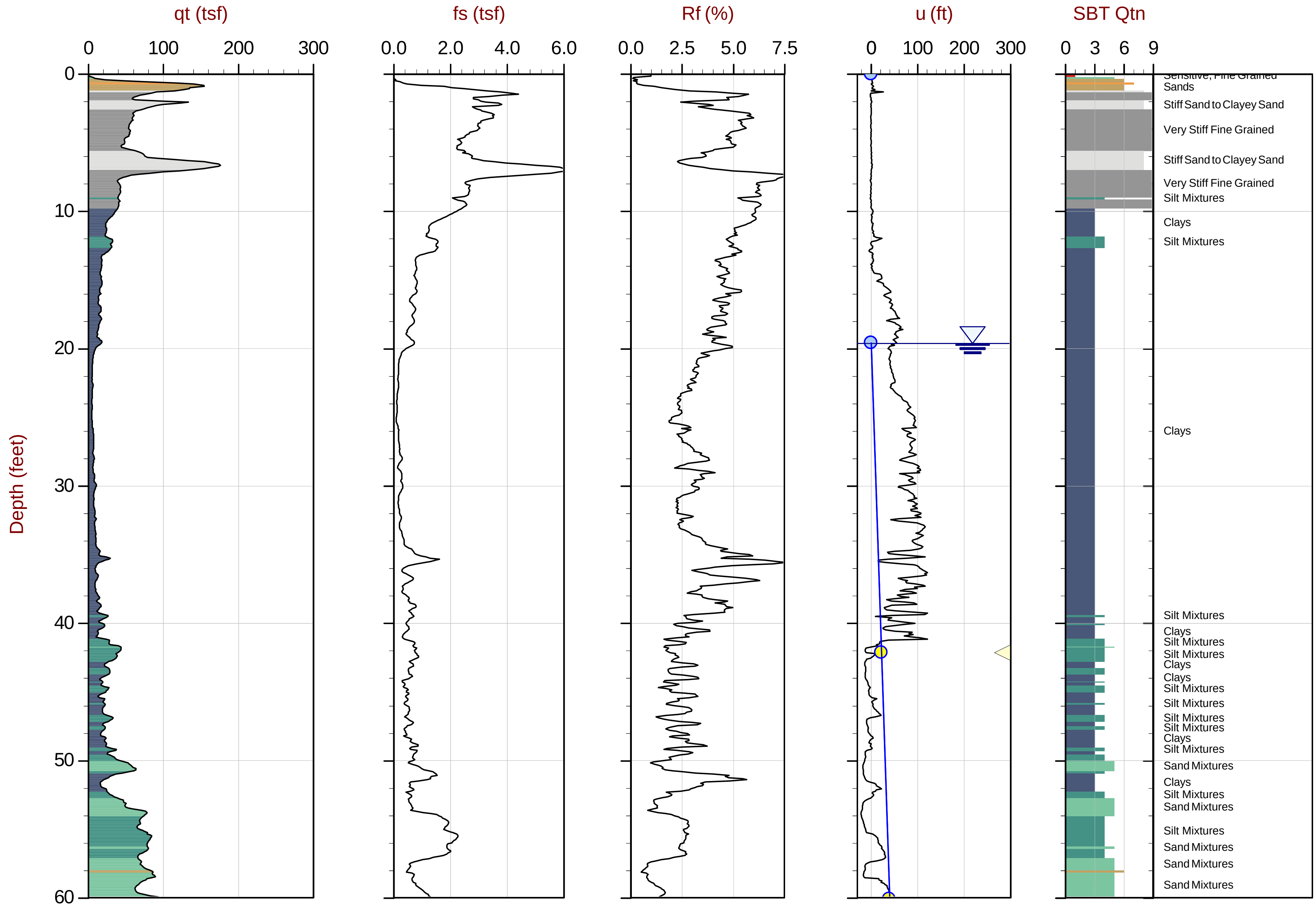
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

GEI

Job No: 19-56124
Date: 2019-10-21 12:53
Site: Hood

Sounding: GEI-Hood-010C
Cone: 494:T1500F15U500



Max Depth: 23.025 m / 75.54 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-010C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247542m E: 629479m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

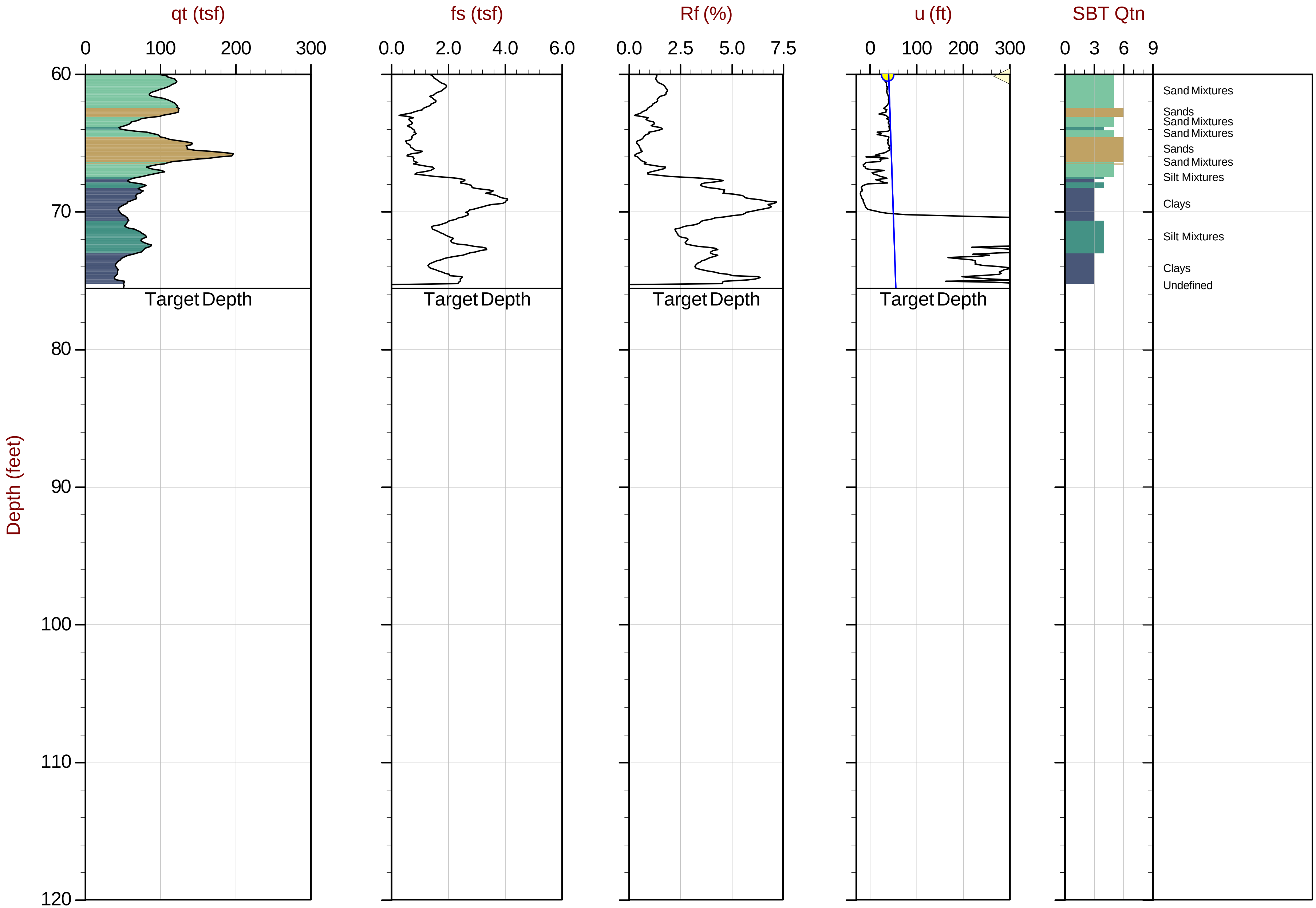
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 12:53
Site: Hood

Sounding: GEI-Hood-010C
Cone: 494:T1500F15U500



Max Depth: 23.025 m / 75.54 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-010C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247542m E: 629479m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

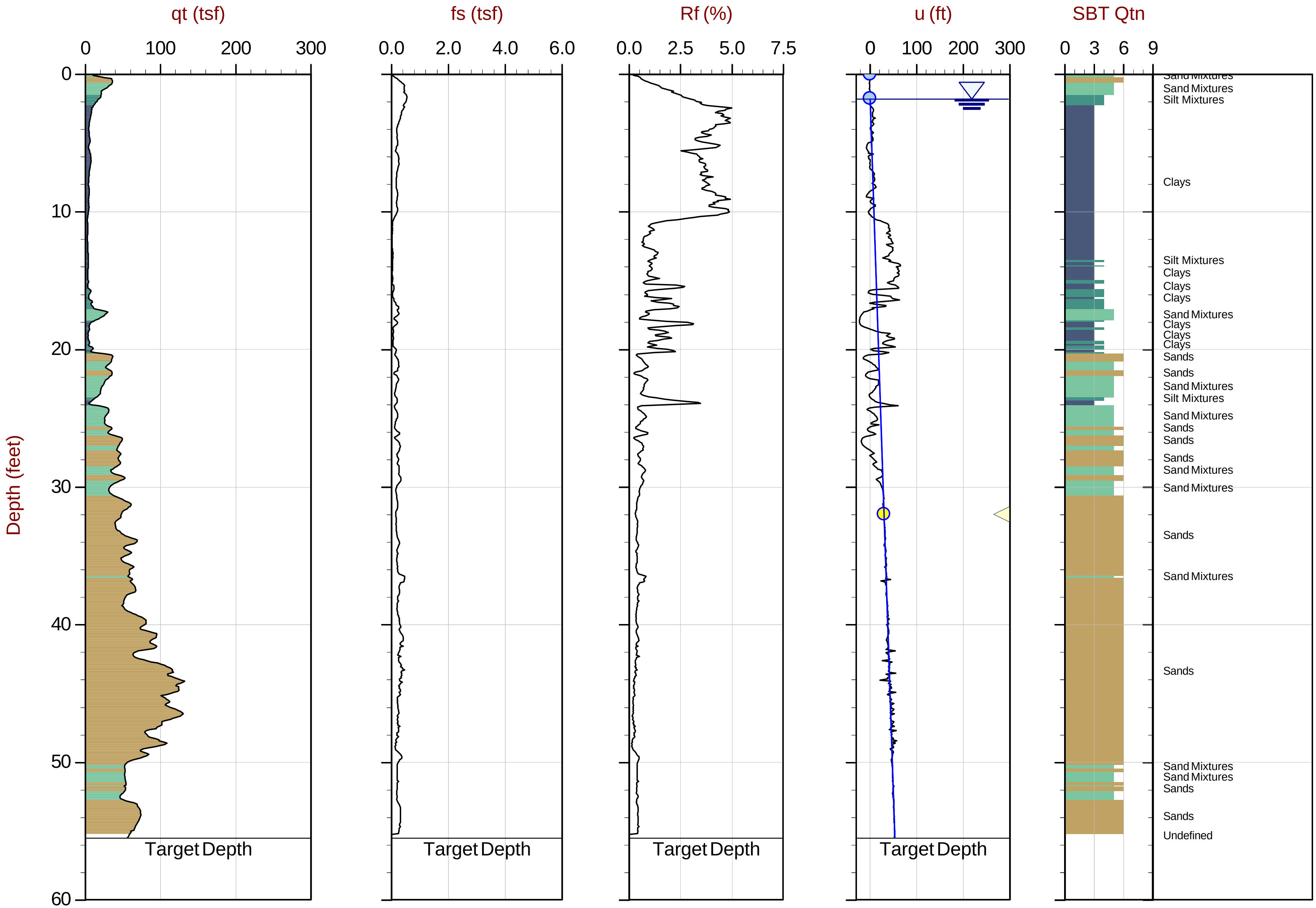
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-25 08:44
Site: Hood

Sounding: GEI-Hood-011C
Cone: 499:T1500F15U1K



Max Depth: 16.925 m / 55.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-011C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4248225m E: 629691m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

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

Standard Cone Penetration Test Plots with Expanded Range

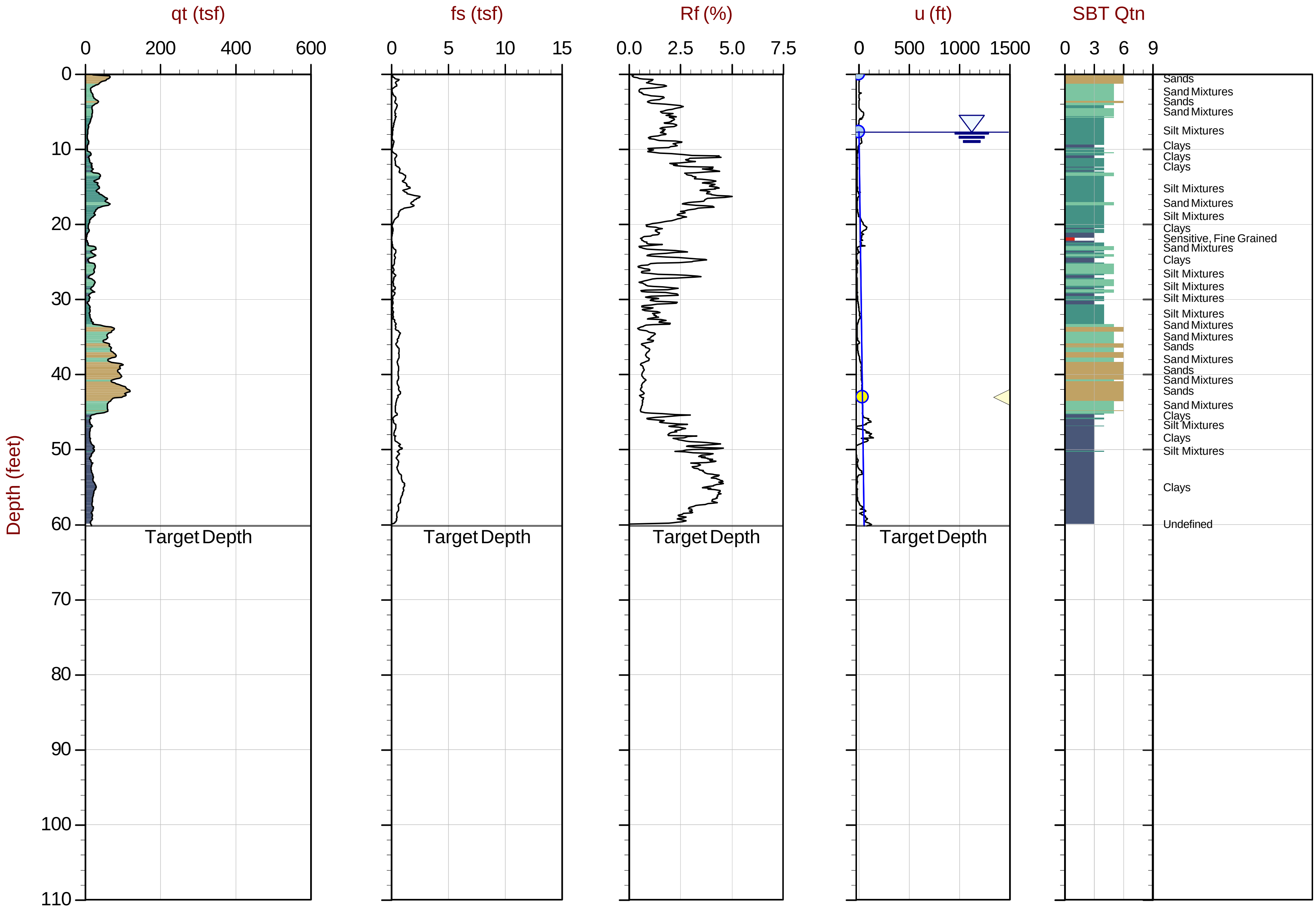
ConeTec

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-28 07:52
Site: Hood

Sounding: GEI-Hood-001C
Cone: 391:T1500F15U500



Max Depth: 18.350 m / 60.20 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-001C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249187m E: 629280m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

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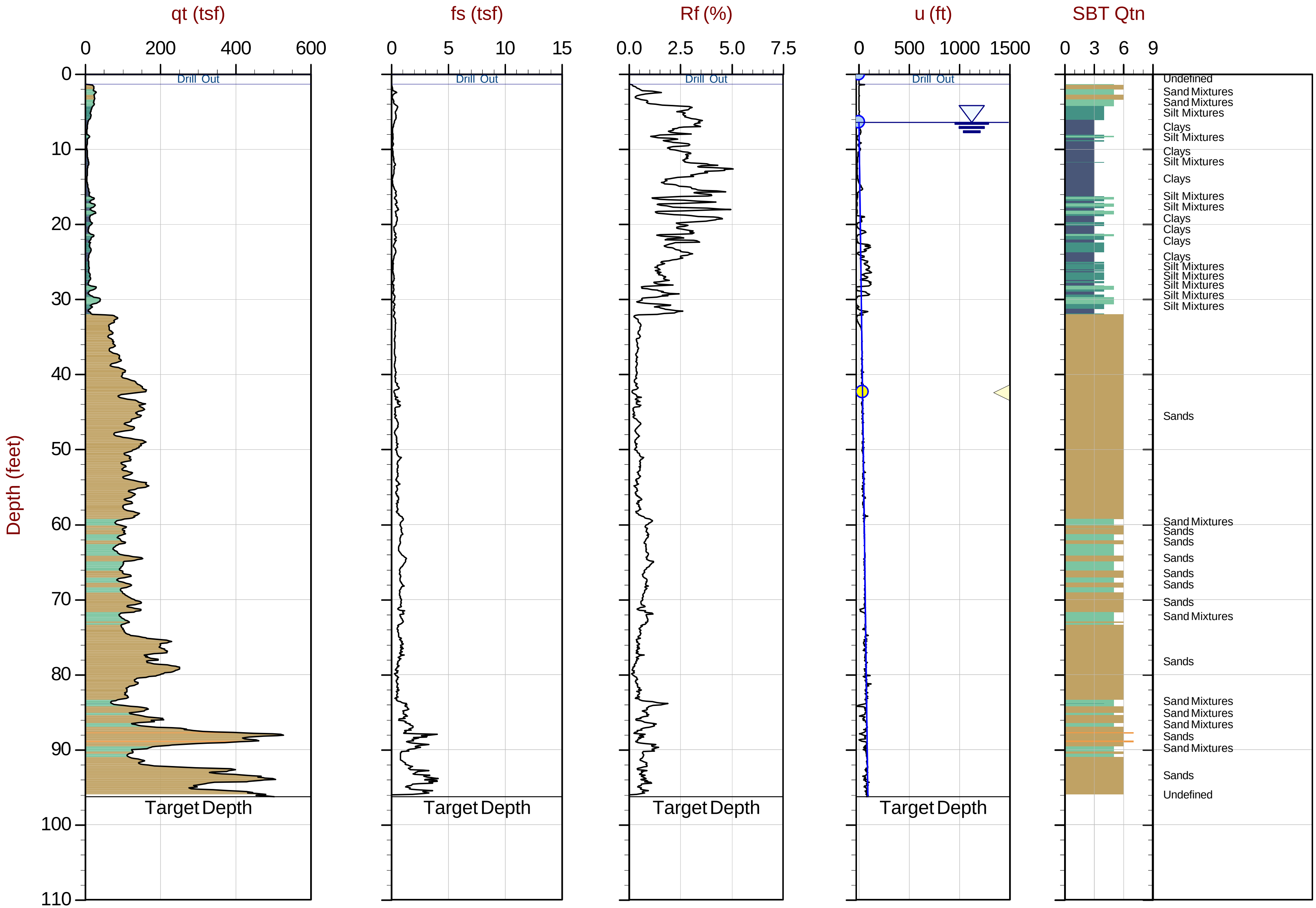
CONETEC

GEI

Job No: 19-56124
Date: 2019-08-28 10:01
Site: Hood

Sounding: GEI-Hood-002C
Cone: 391:T1500F15U500



Max Depth: 29.350 m / 96.29 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-002C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250216m E: 629936m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

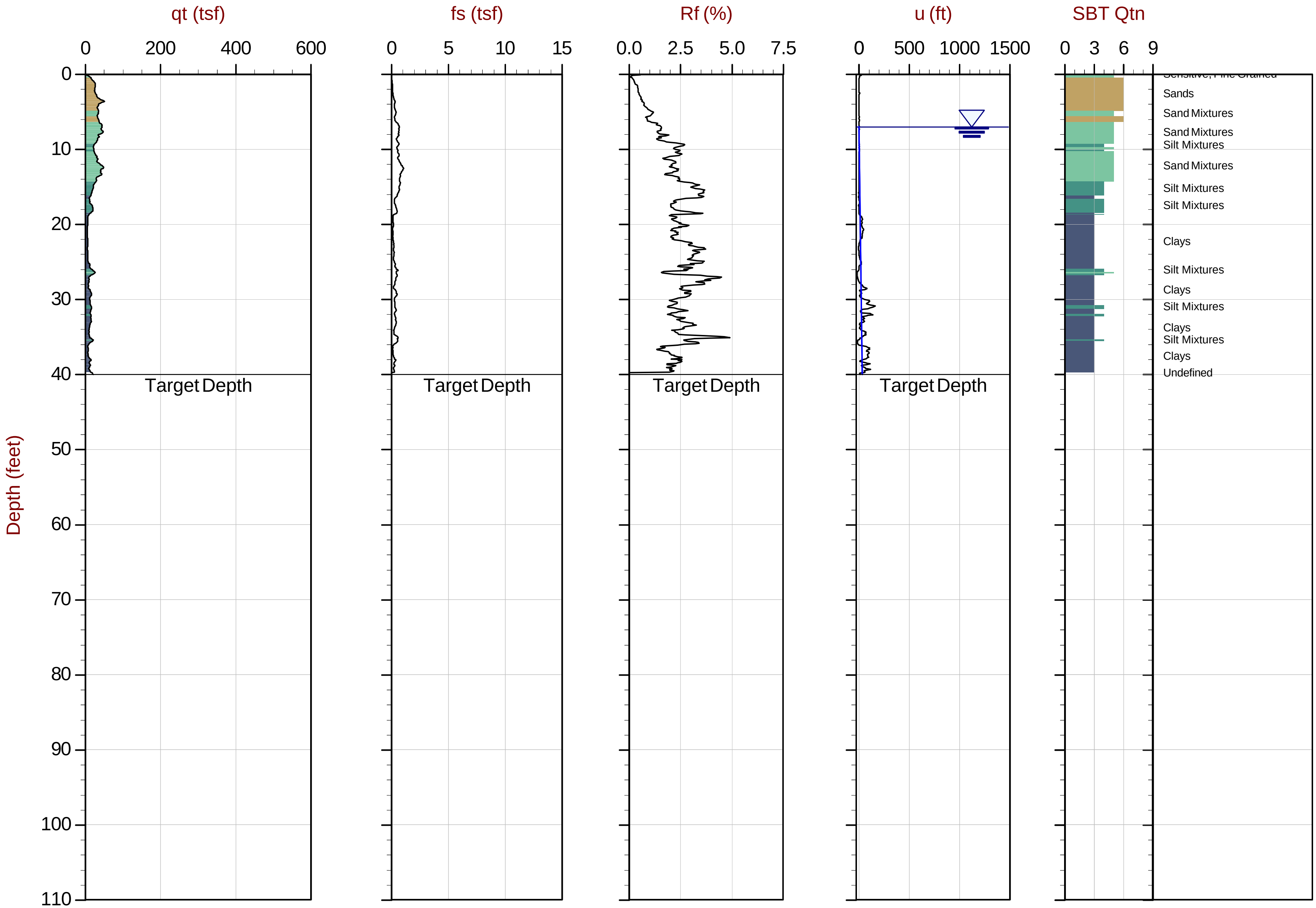
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-27 11:42
Site: Hood

Sounding: GEI-Hood-003C
Cone: 391:T1500F15U500



Max Depth: 12.200 m / 40.03 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-003C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4251212m E: 629972m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

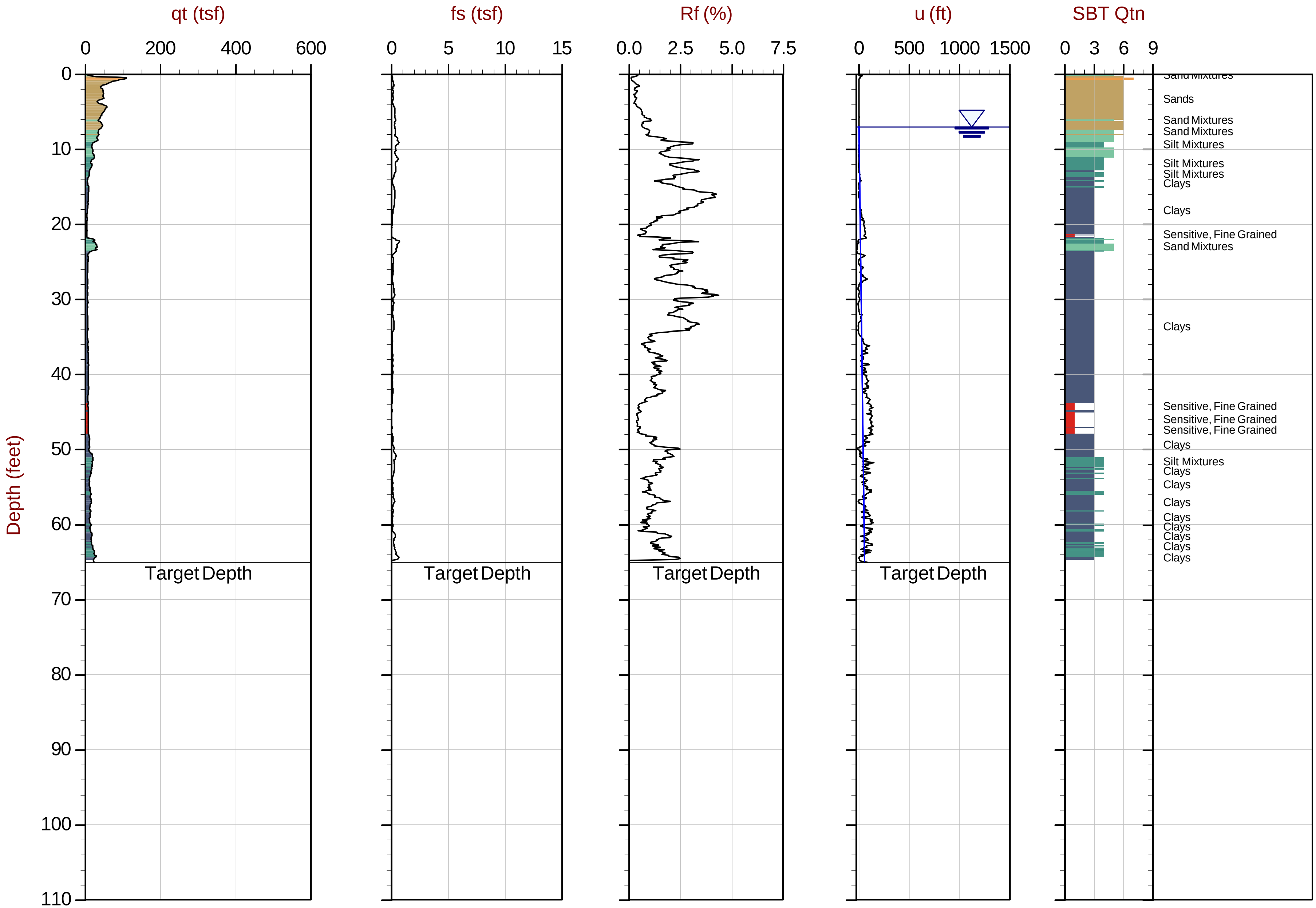
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-27 13:25
Site: Hood

Sounding: GEI-Hood-004C
Cone: 391:T1500F15U500



Max Depth: 19.825 m / 65.04 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-004C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4251216m E: 630257m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

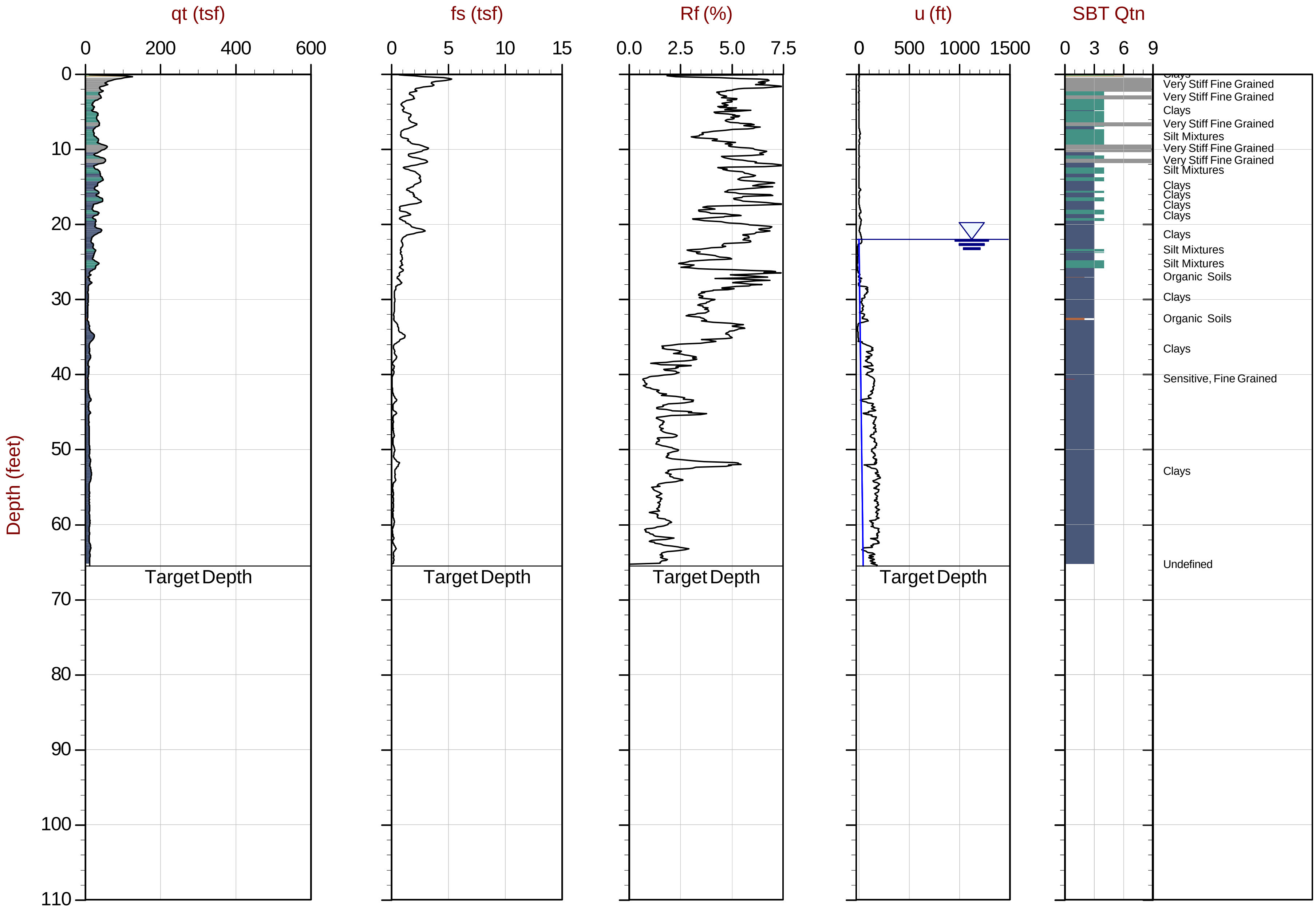
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-22 14:03
Site: Hood

Sounding: GEI-Hood-005C
Cone: 494:T1500F15U500



Max Depth: 19.975 m / 65.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-005C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250428m E: 630232m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

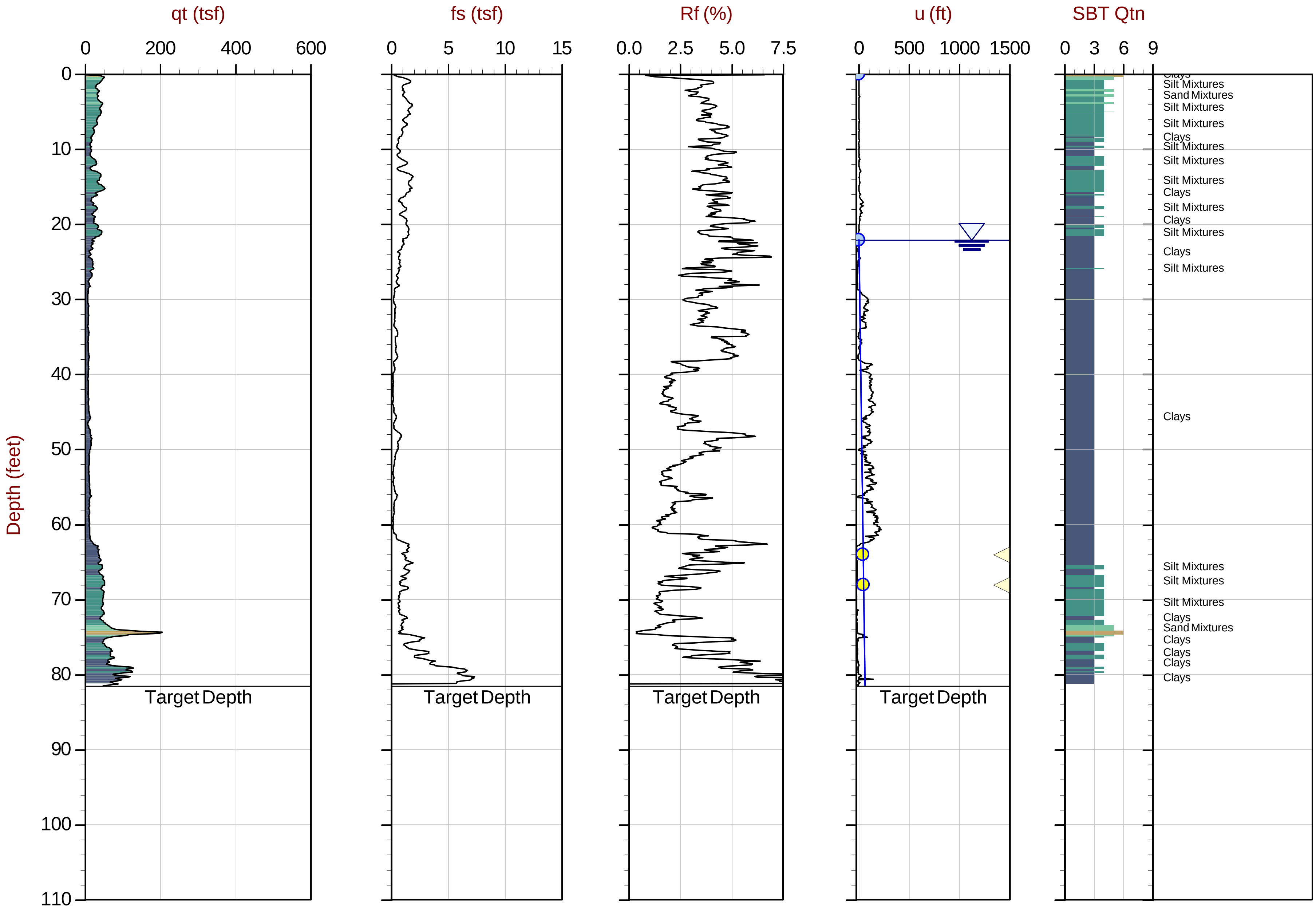
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-22 09:06
Site: Hood

Sounding: GEI-Hood-006C
Cone: 494:T1500F15U500



Max Depth: 24.850 m / 81.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-006C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249954m E: 630236m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

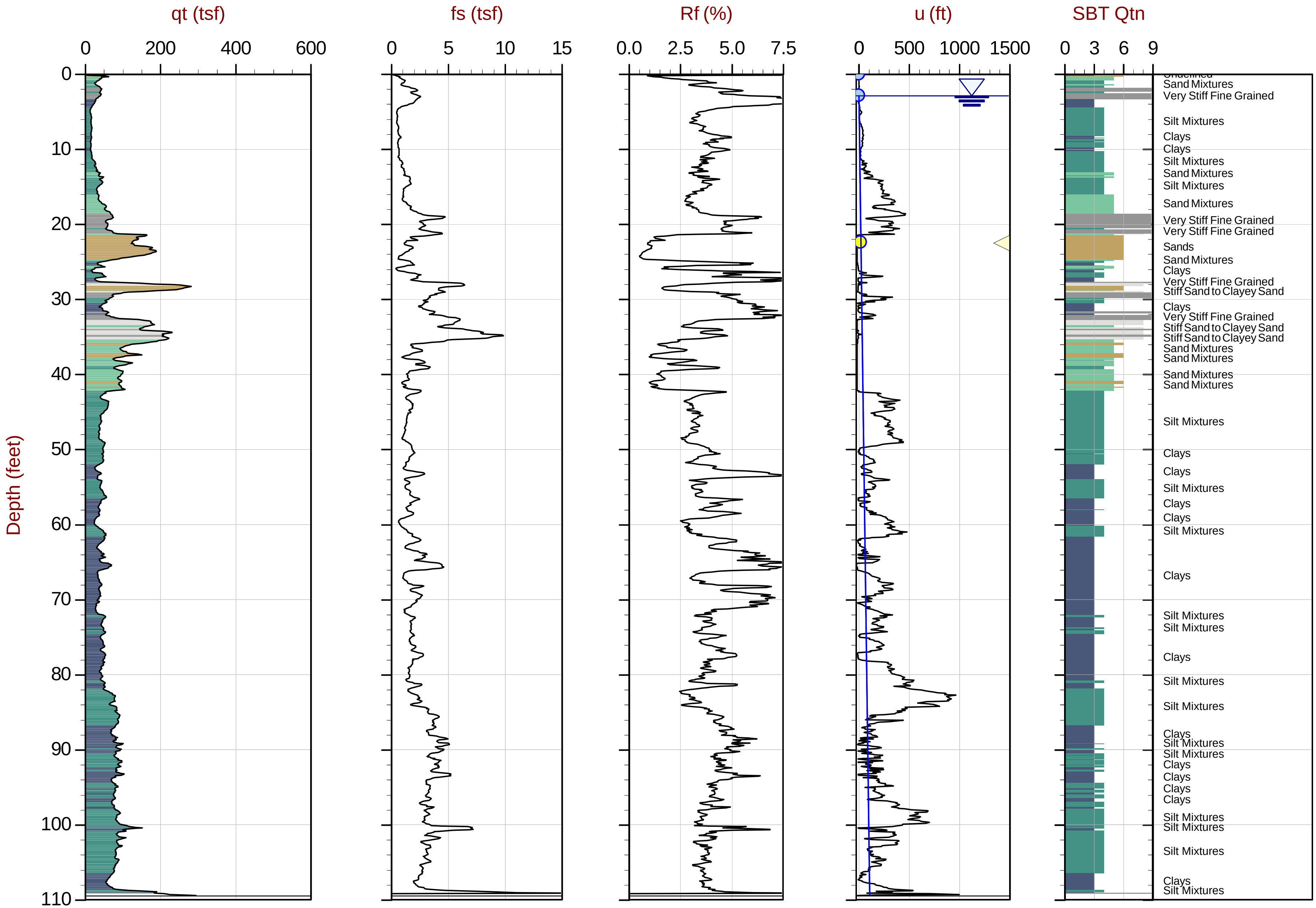
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 16:24
Site: Hood

Sounding: GEI-Hood-007C
Cone: 494:T1500F15U500



Max Depth: 33.375 m / 109.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-007C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249120m E: 630181m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

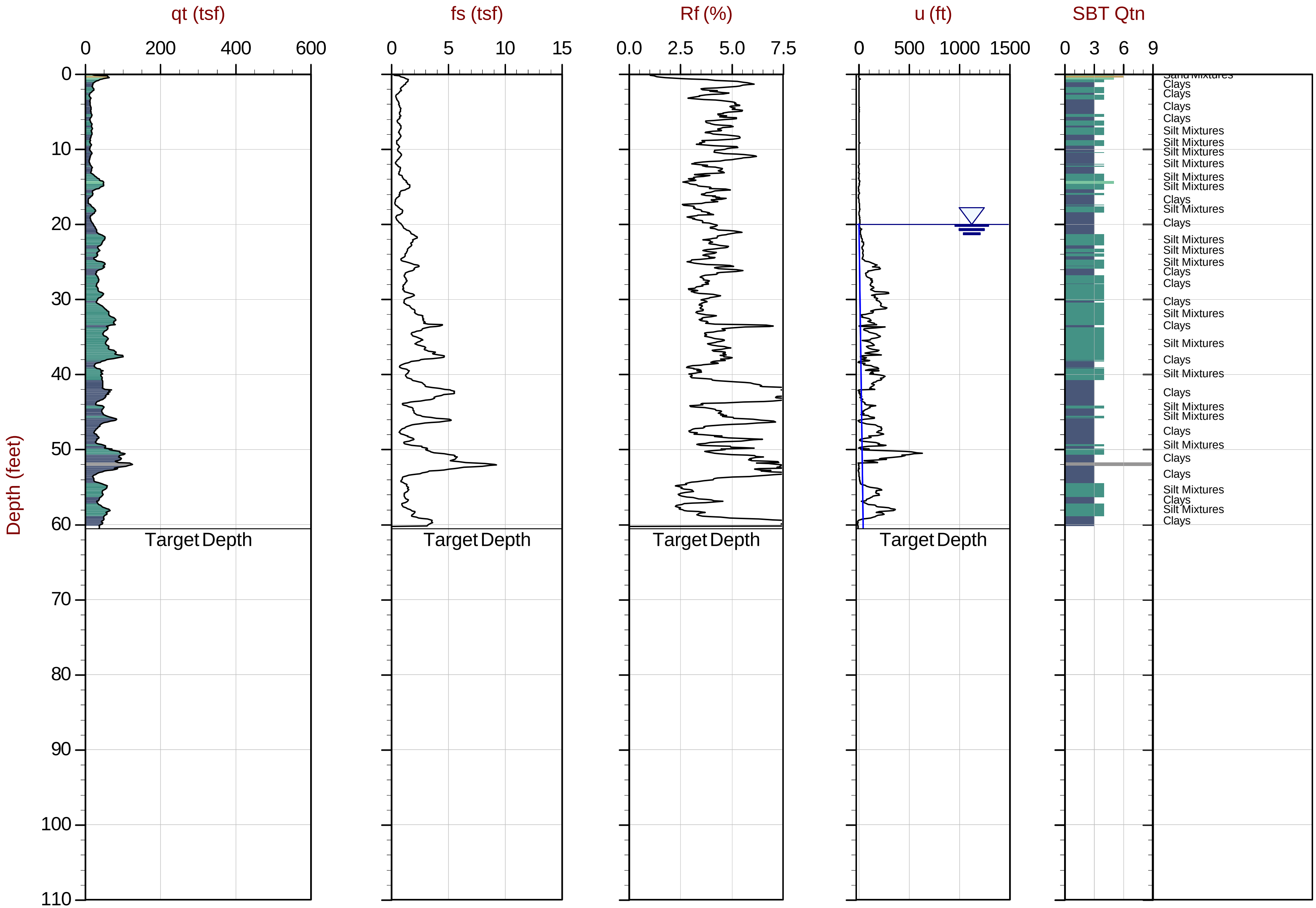
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 10:06
Site: Hood

Sounding: GEI-Hood-008C
Cone: 494:T1500F15U500



Max Depth: 18.450 m / 60.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-008C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4248079m E: 630175m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

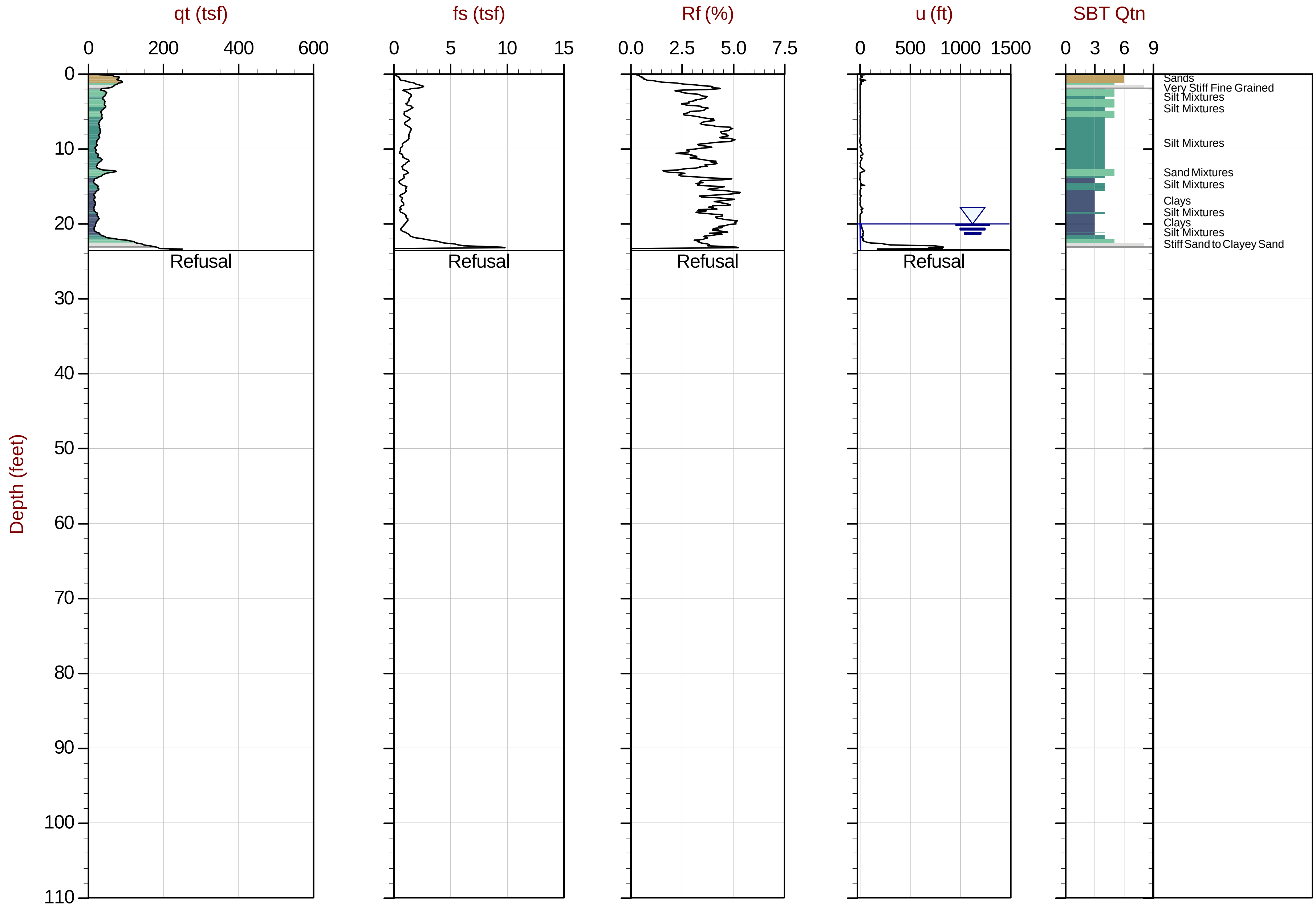
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-30 10:11
Site: Hood

Sounding: GEI-Hood-009C
Cone: 448:T1500F15U500



Max Depth: 7.175 m / 23.54 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-009C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247384m E: 630045m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

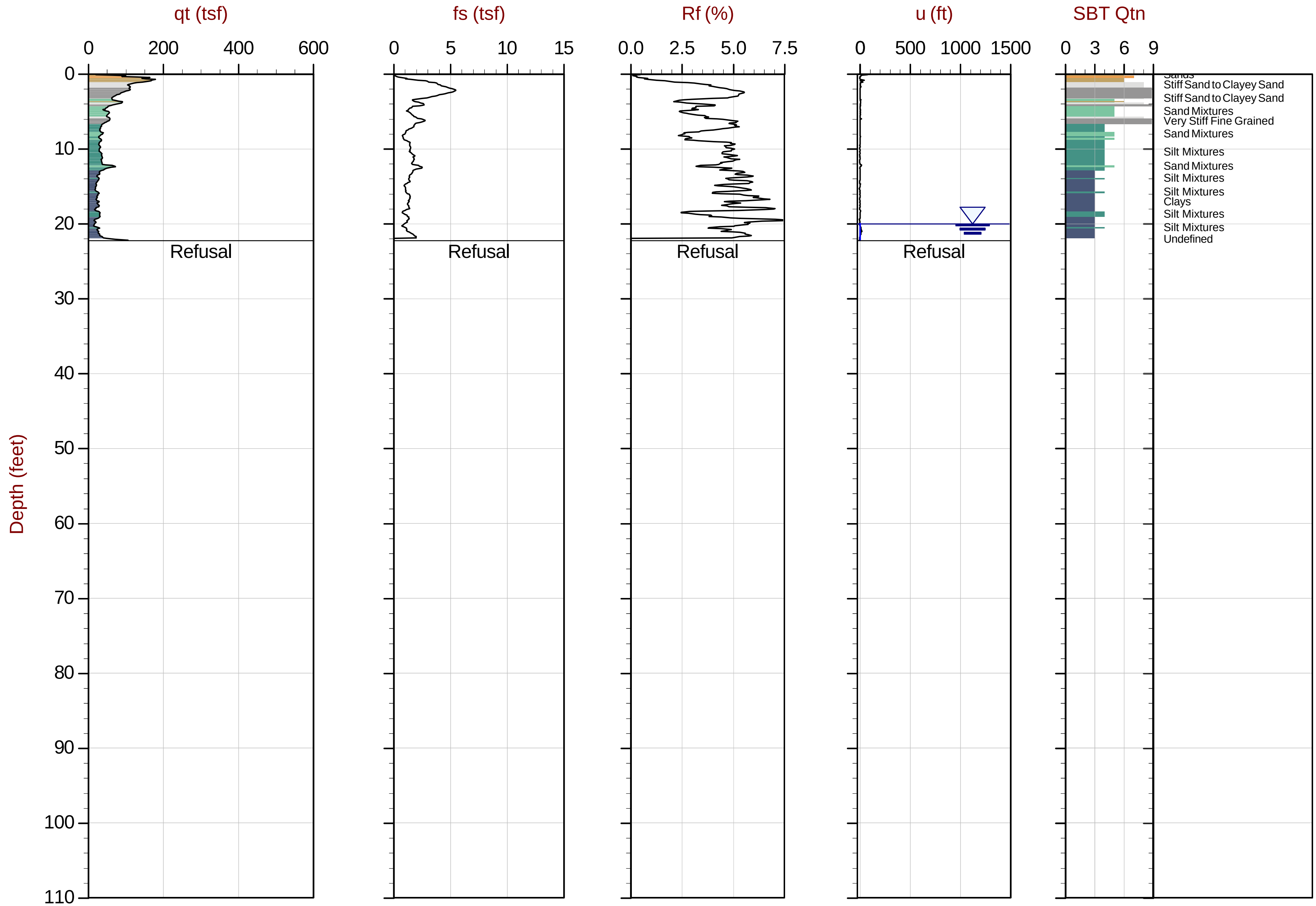
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

GEI

Job No: 19-56124
Date: 2019-10-30 11:14
Site: Hood

Sounding: GEI-Hood-009C-B
Cone: 448:T1500F15U500



Max Depth: 6.775 m / 22.23 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-009C-B.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247379m E: 630051m

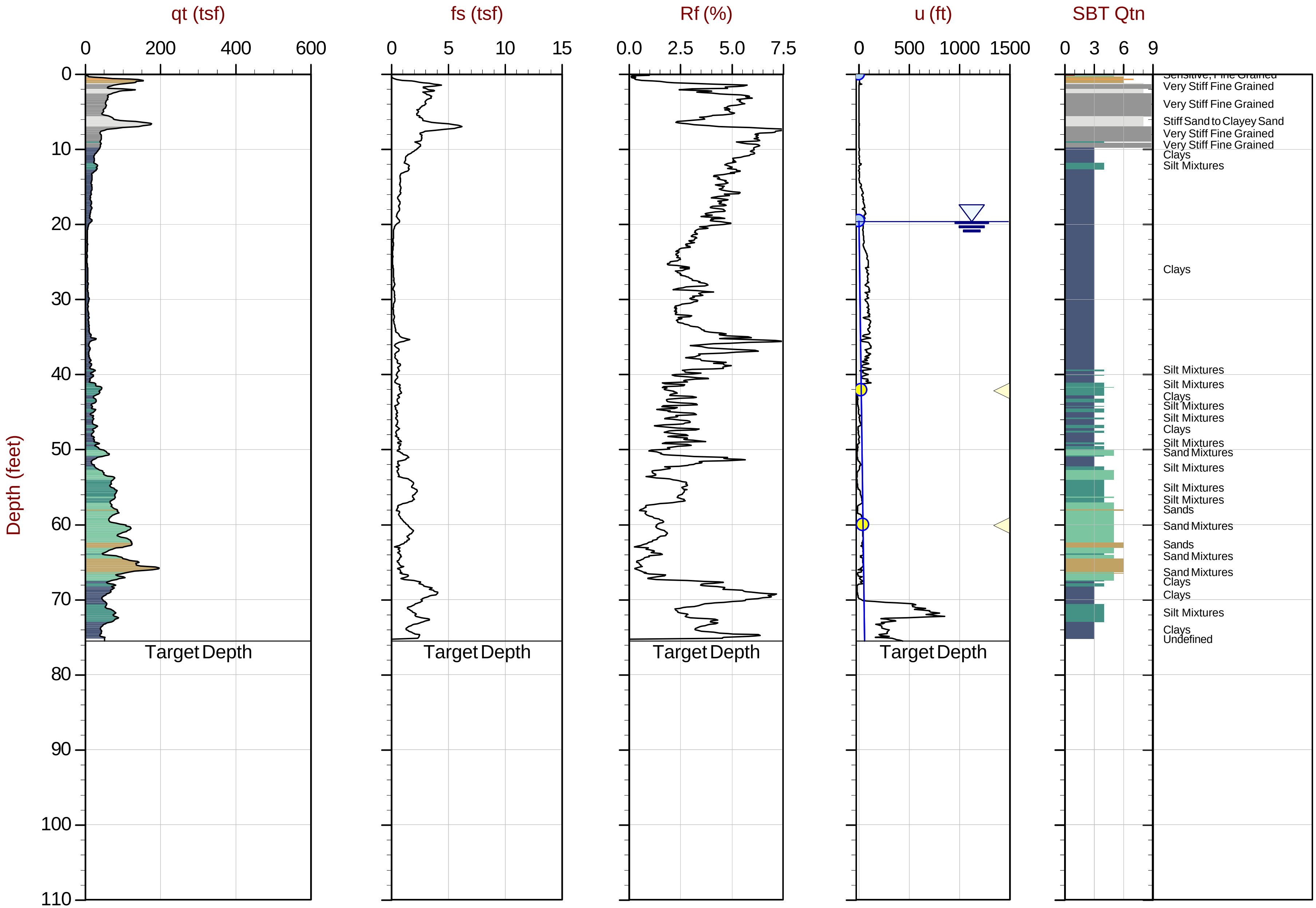
Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

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

GEI

Job No: 19-56124
Date: 2019-10-21 12:53
Site: Hood

Sounding: GEI-Hood-010C
Cone: 494:T1500F15U500



Max Depth: 23.025 m / 75.54 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-010C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247542m E: 629479m

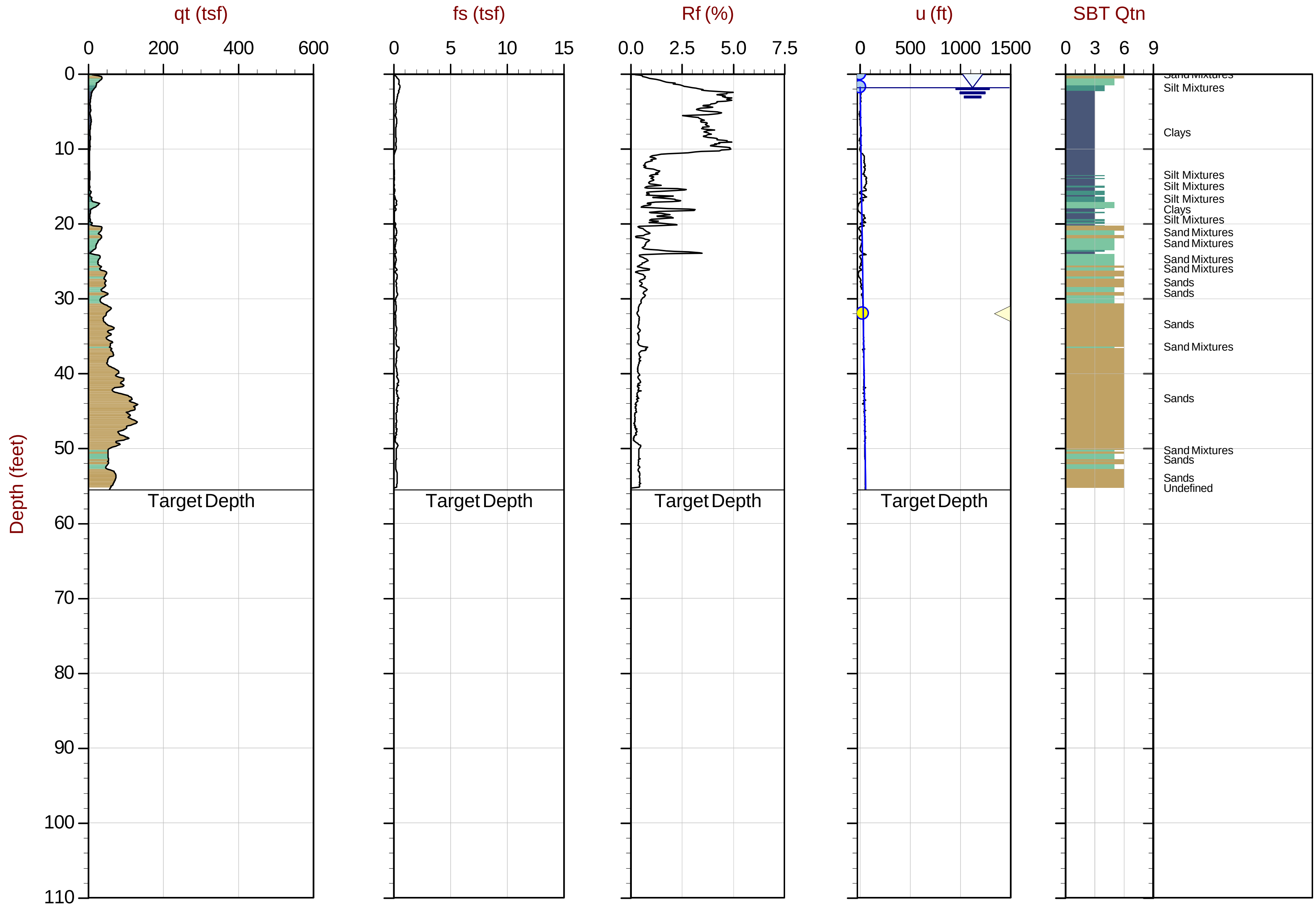
Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

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

GEI

Job No: 19-56124
Date: 2019-10-25 08:44
Site: Hood

Sounding: GEI-Hood-011C
Cone: 499:T1500F15U1K



Max Depth: 16.925 m / 55.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-011C.COR
Unit Wt: SBTQtn (PKR2009)

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4248225m E: 629691m

Equilibrium Pore Pressure (Ueq) — Assumed Ueq — Dissipation, Ueq achieved — Dissipation, Ueq not achieved — Hydrostatic Line

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

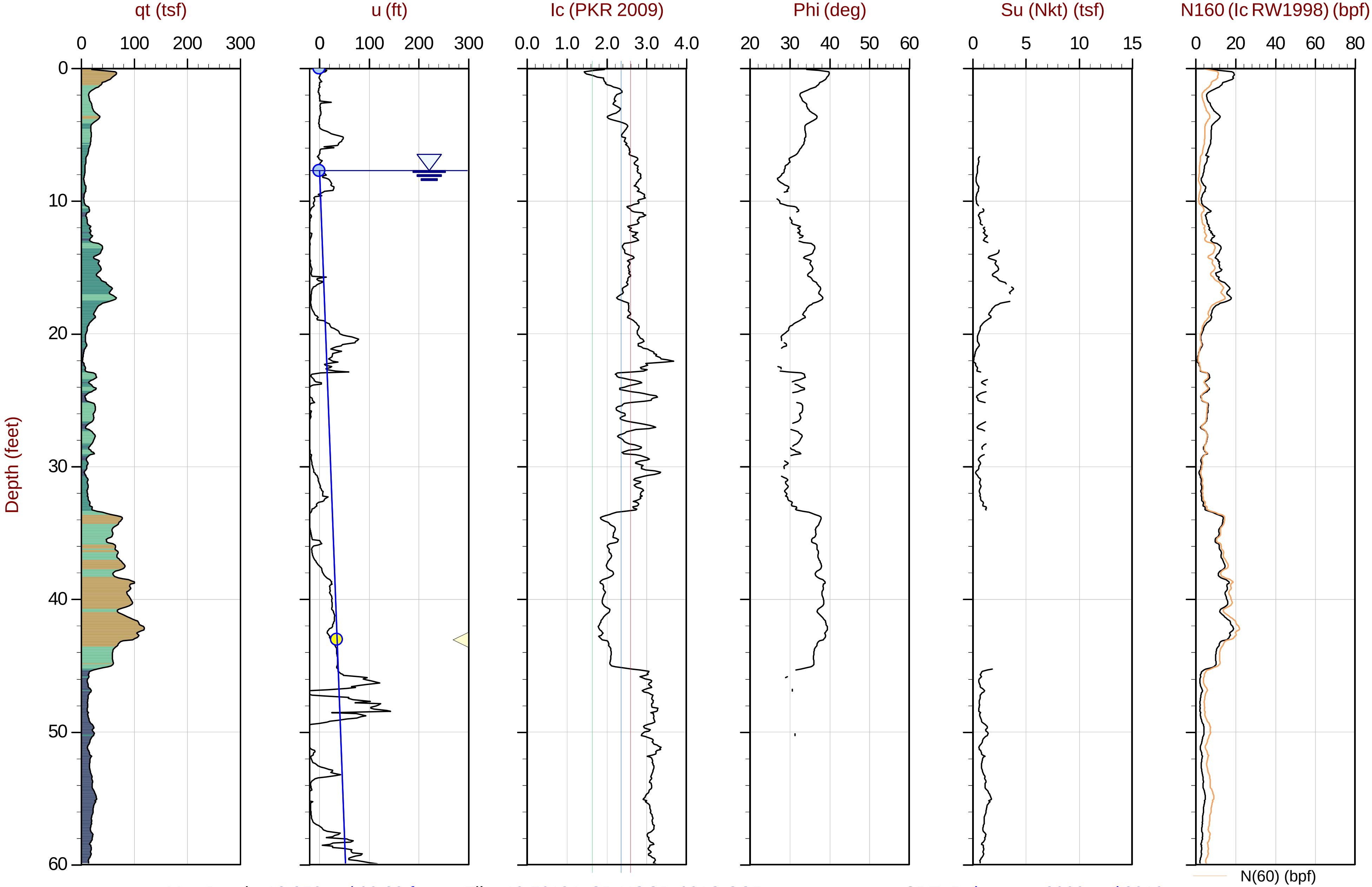
Advanced Cone Penetration Test Plots with Ic, Phi, Su(Nkt), and N1(60)Ic

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-28 07:52
Site: Hood

Sounding: GEI-Hood-001C
Cone: 391:T1500F15U500



Max Depth: 18.350 m / 60.20 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-001C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249187m E: 629280m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

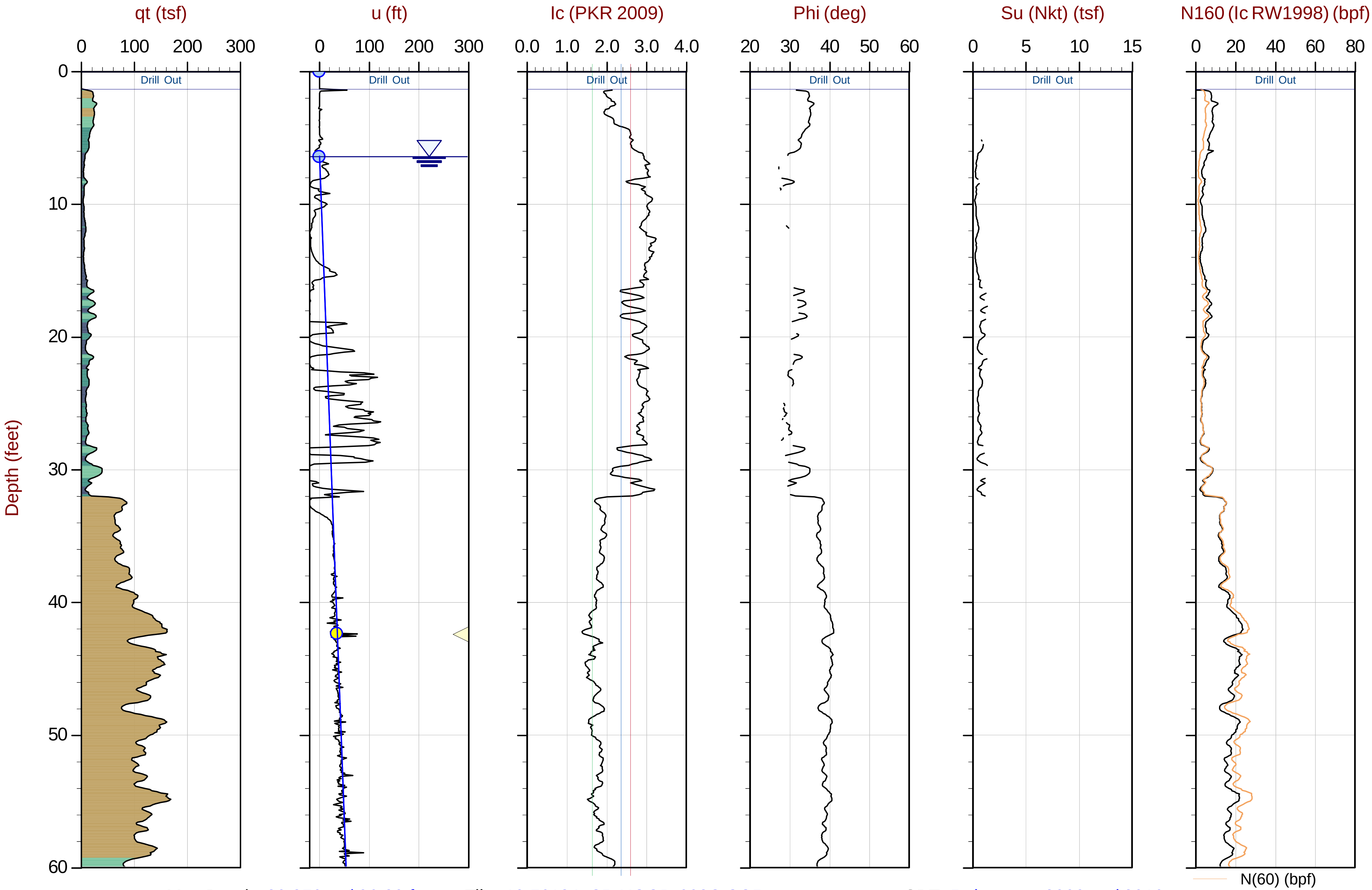
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-28 10:01
Site: Hood

Sounding: GEI-Hood-002C
Cone: 391:T1500F15U500



Max Depth: 29.350 m / 96.29 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-002C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250216m E: 629936m

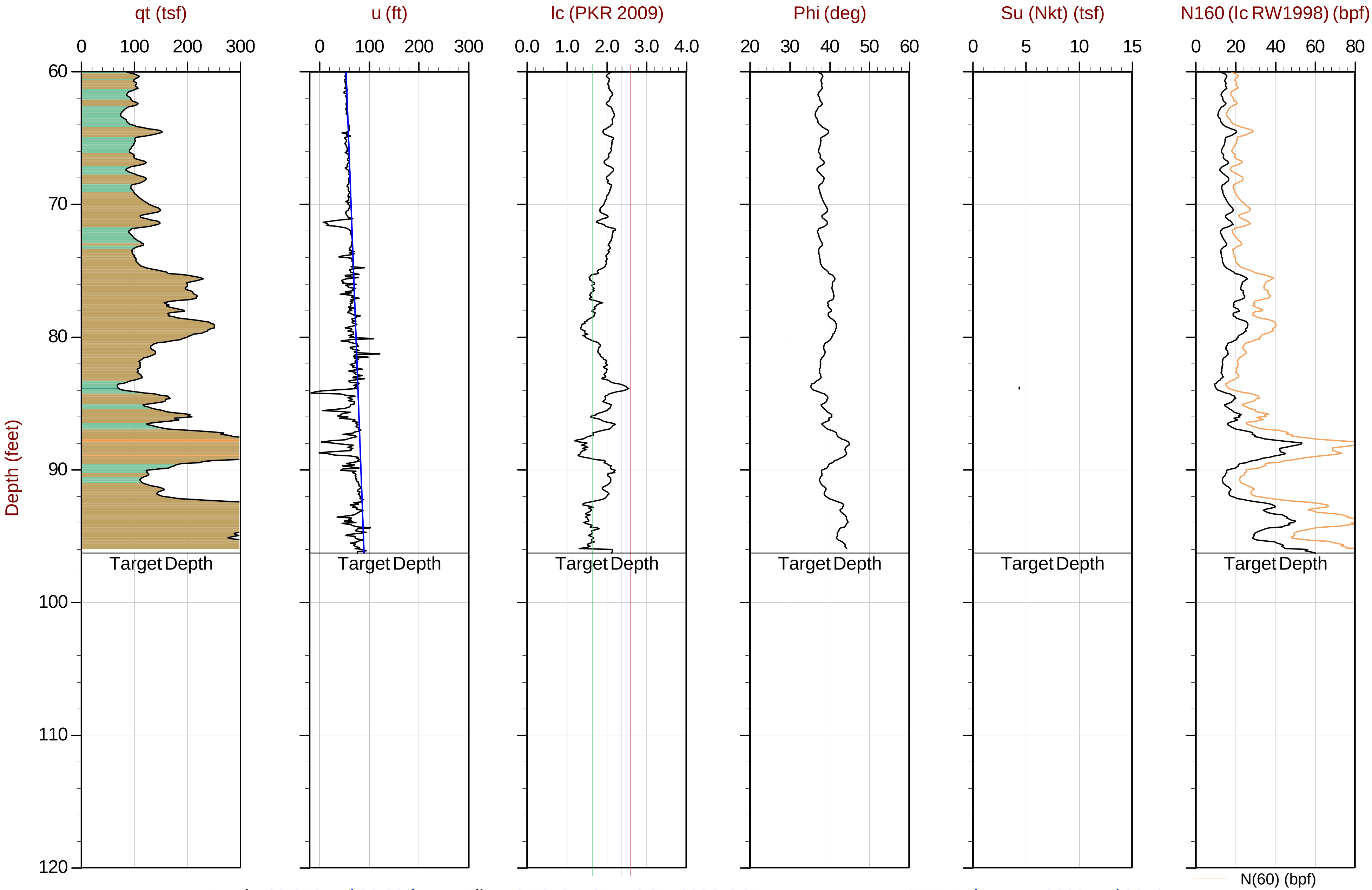
Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

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

GEI

Job No: 19-56124
Date: 2019-08-28 10:01
Site: Hood

Sounding: GEI-Hood-002C
Cone: 391:T1500F15U500



Max Depth: 29.350 m / 96.29 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

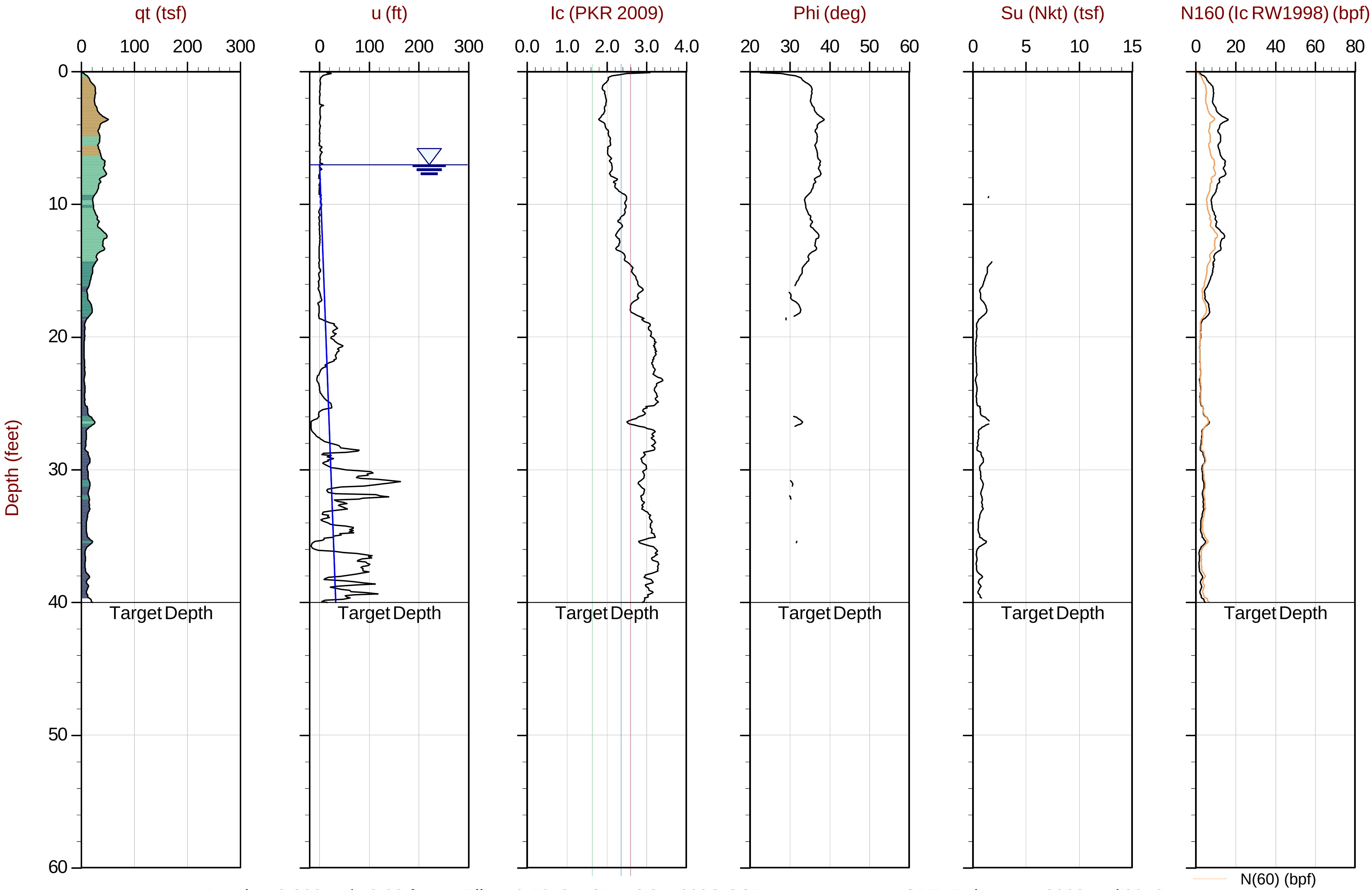
File: 19-56124_CP-HOOD-002C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250216m E: 629936m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

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

GEI	Job No: 19-56124 Date: 2019-08-27 11:42 Site: Hood	Sounding: GEI-Hood-003C Cone: 391:T1500F15U500



Max Depth: 12.200 m / 40.03 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-003C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4251212m E: 629972m

Equilibrium Pore Pressure (Ueq) — Assumed Ueq — Dissipation, Ueq achieved — Dissipation, Ueq not achieved — Hydrostatic Line

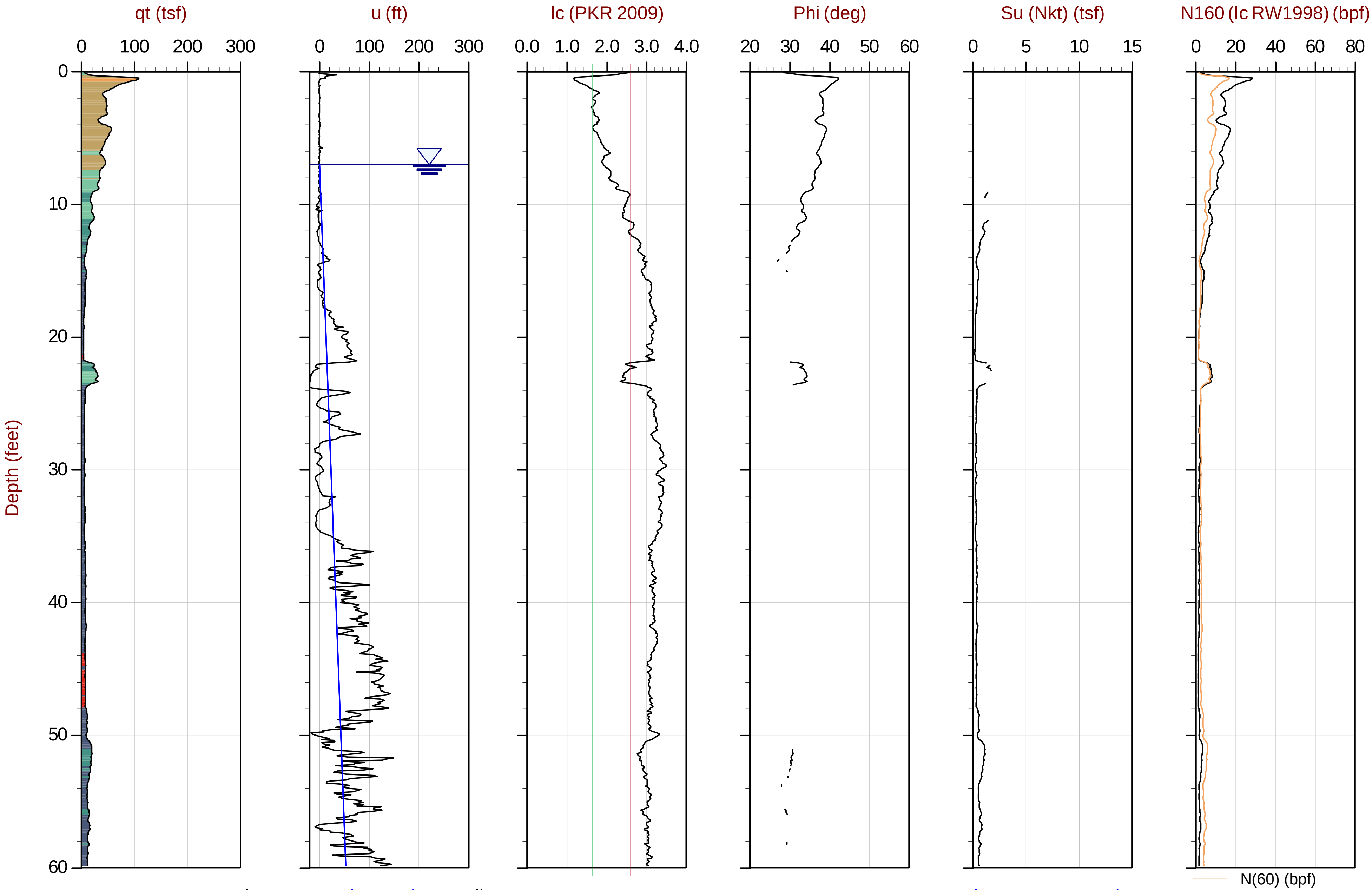
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-27 13:25
Site: Hood

Sounding: GEI-Hood-004C
Cone: 391:T1500F15U500



Max Depth: 19.825 m / 65.04 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-004C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4251216m E: 630257m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

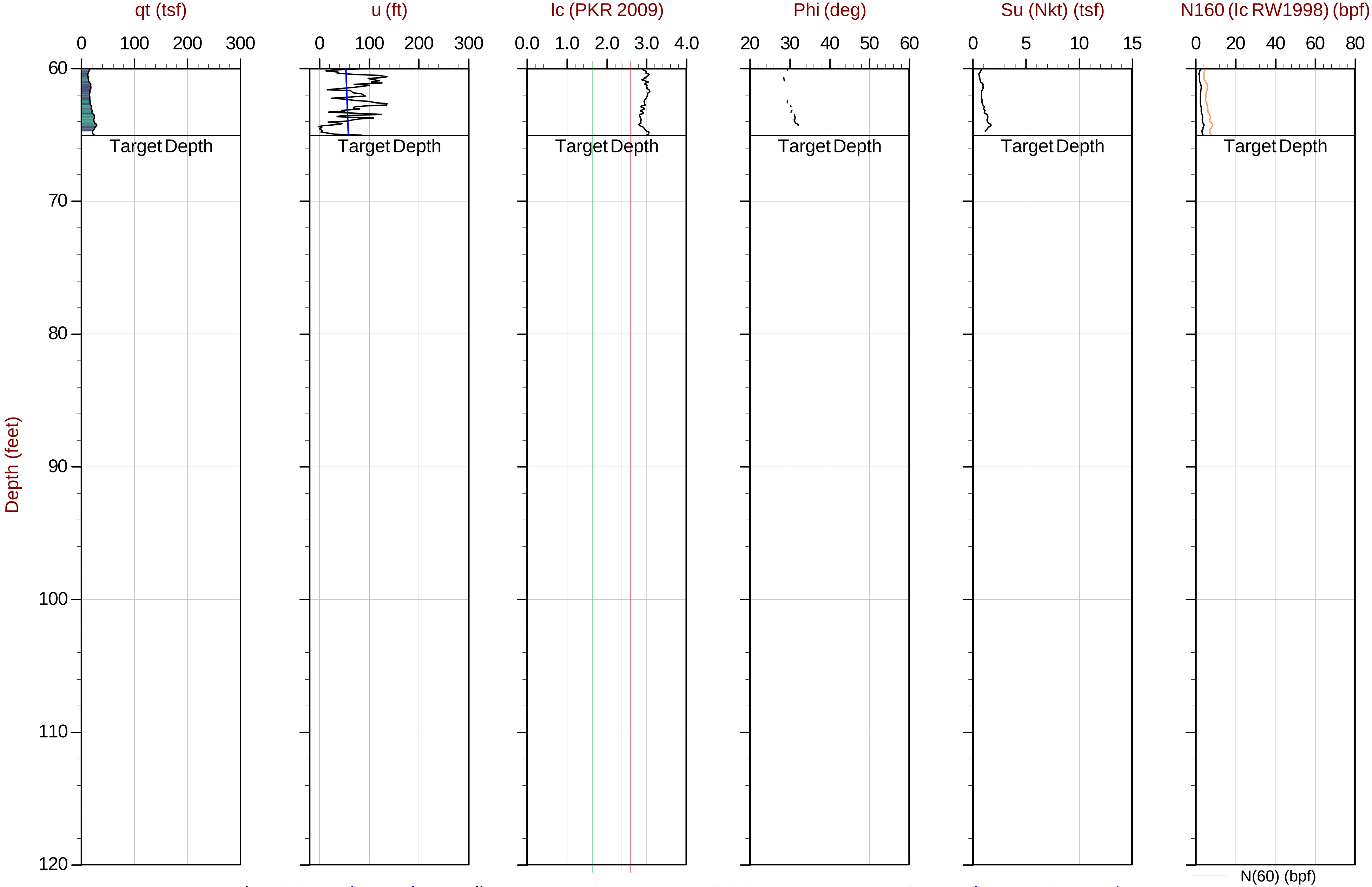
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-08-27 13:25
Site: Hood

Sounding: GEI-Hood-004C
Cone: 391:T1500F15U500



Max Depth: 19.825 m / 65.04 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-004C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

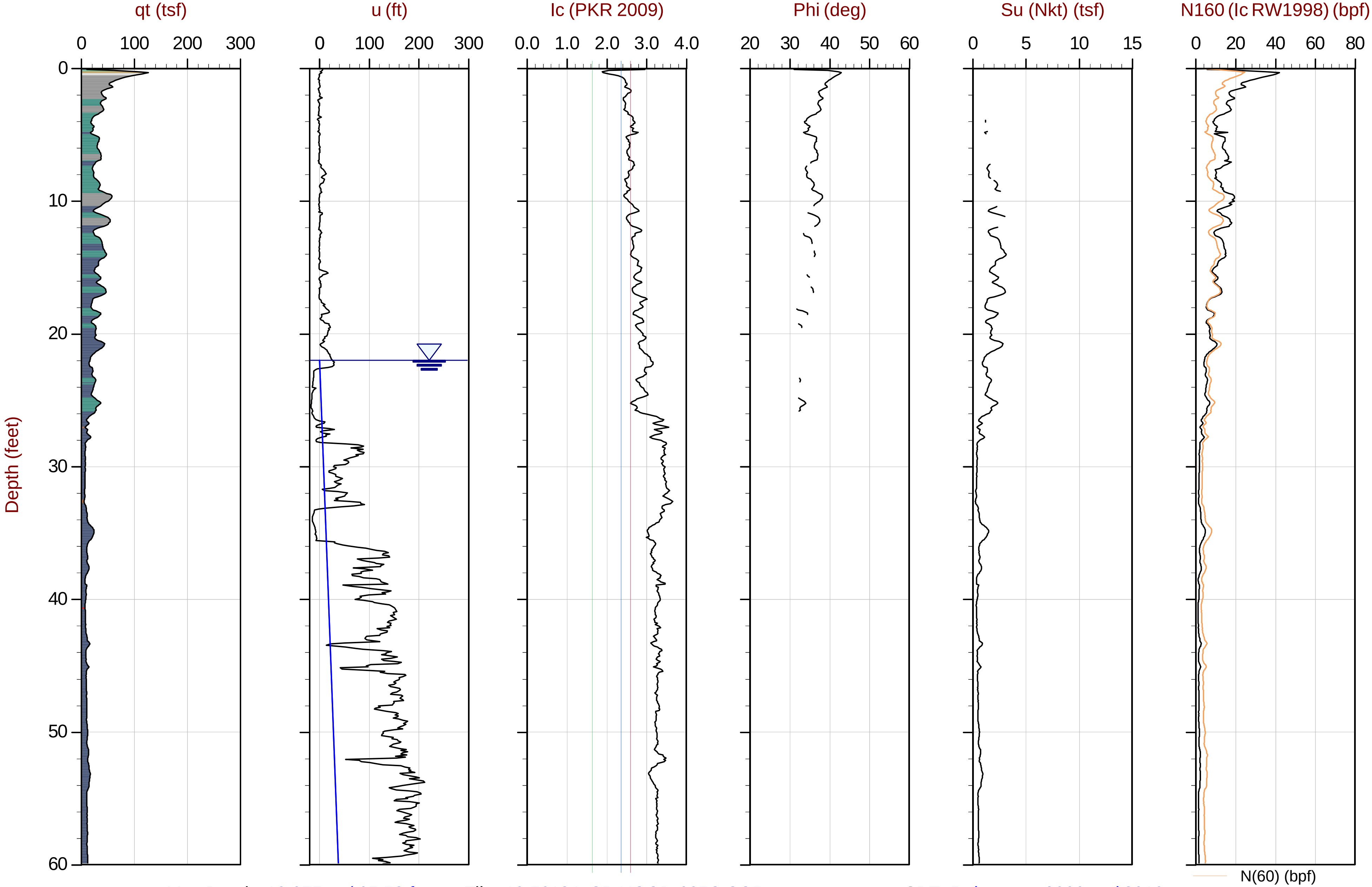
SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4251216m E: 630257m

Equilibrium Pore Pressure (Ueq) · Assumed Ueq · Dissipation, Ueq achieved · Dissipation, Ueq not achieved · Hydrostatic Line

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

Job No: 19-56124	Sounding: GEI-Hood-005C
Date: 2019-10-22 14:03	Cone: 494:T1500F15U500
Site: Hood	

GEI



Max Depth: 19.975 m / 65.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-005C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250428m E: 630232m

Equilibrium Pore Pressure (Ueq) · Assumed Ueq · Dissipation, Ueq achieved · Dissipation, Ueq not achieved · Hydrostatic Line

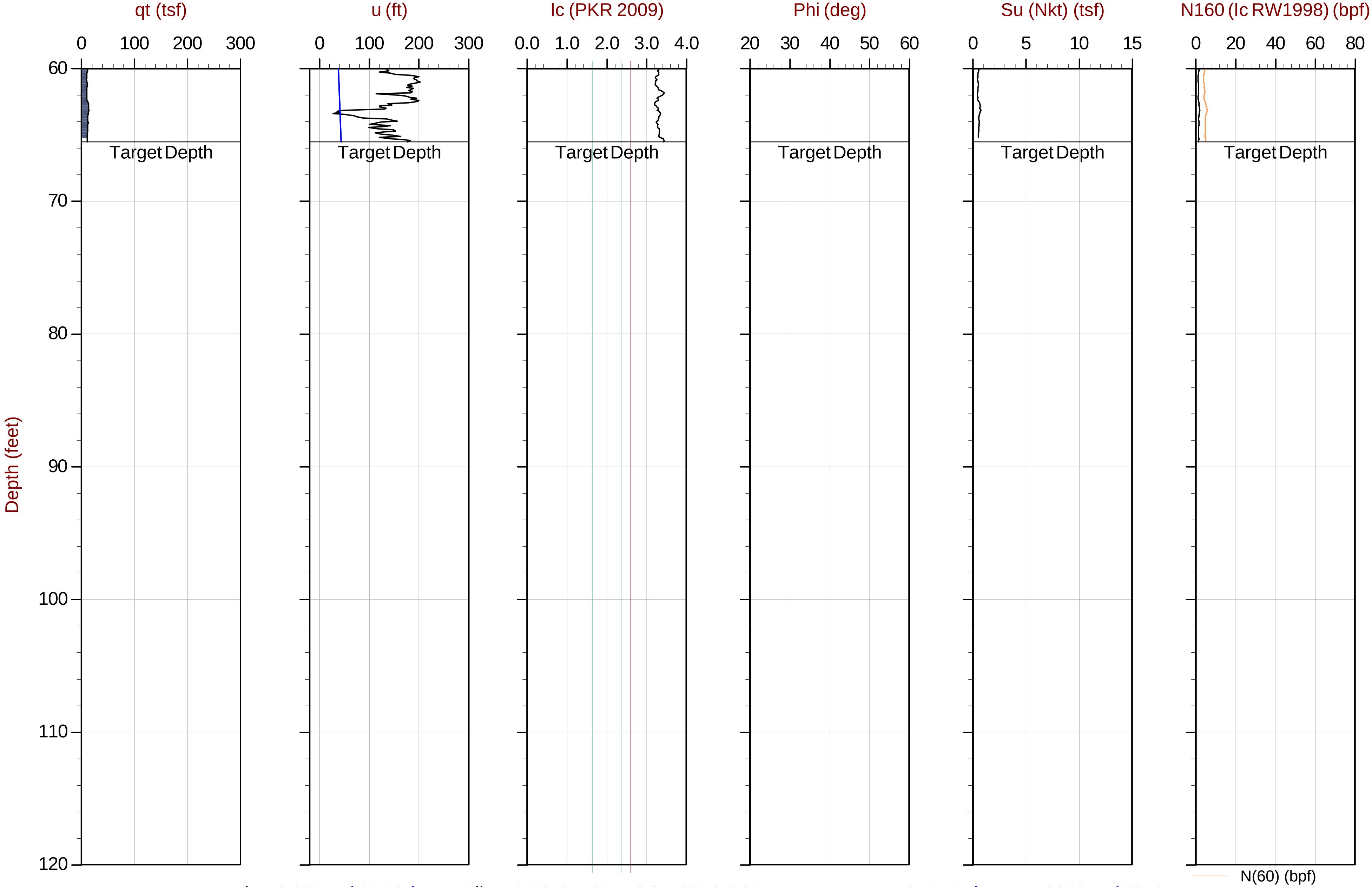
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-22 14:03
Site: Hood

Sounding: GEI-Hood-005C
Cone: 494:T1500F15U500



Max Depth: 19.975 m / 65.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-005C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4250428m E: 630232m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

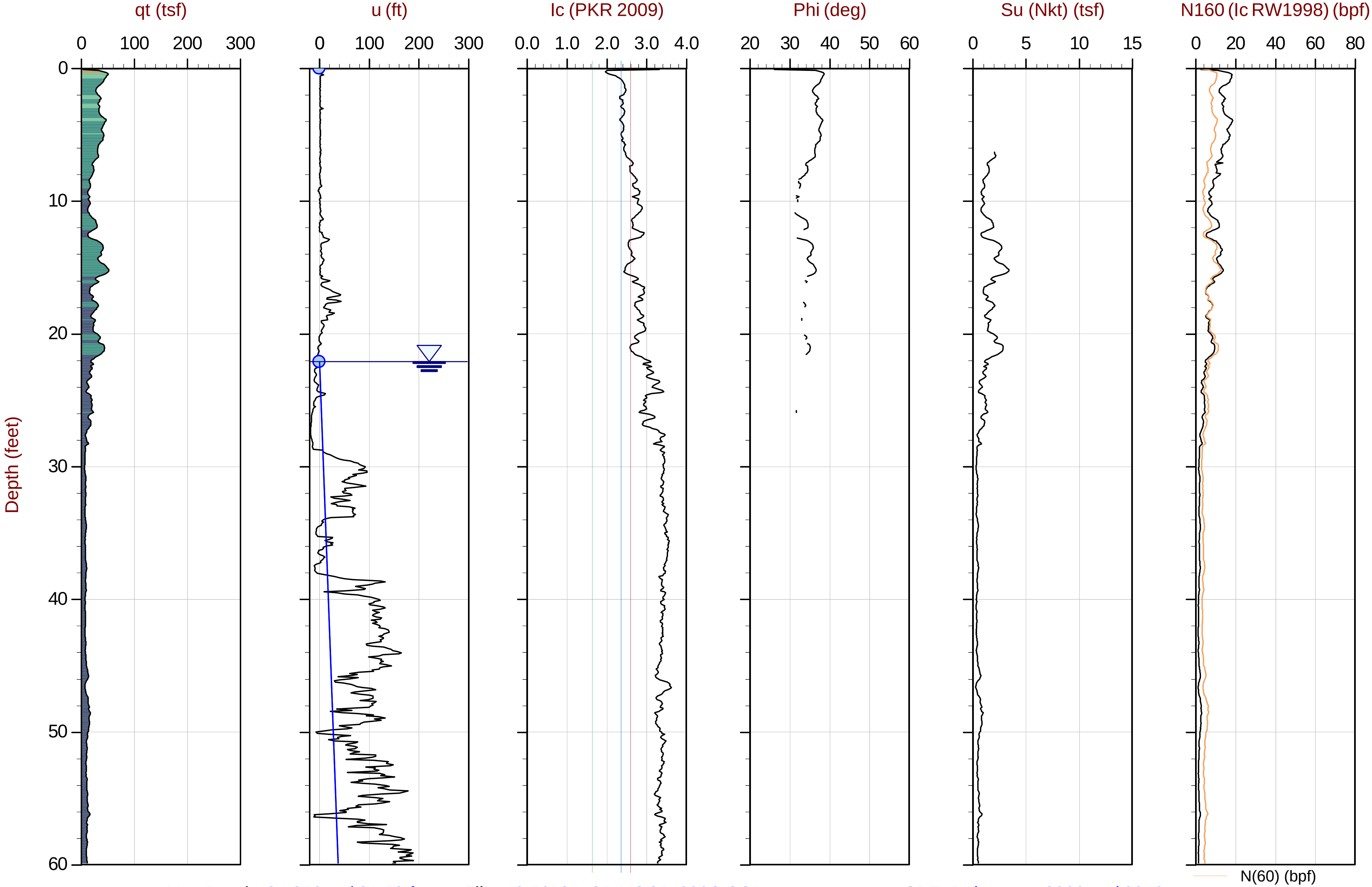
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-22 09:06
Site: Hood

Sounding: GEI-Hood-006C
Cone: 494:T1500F15U500



Max Depth: 24.850 m / 81.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-006C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249954m E: 630236m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

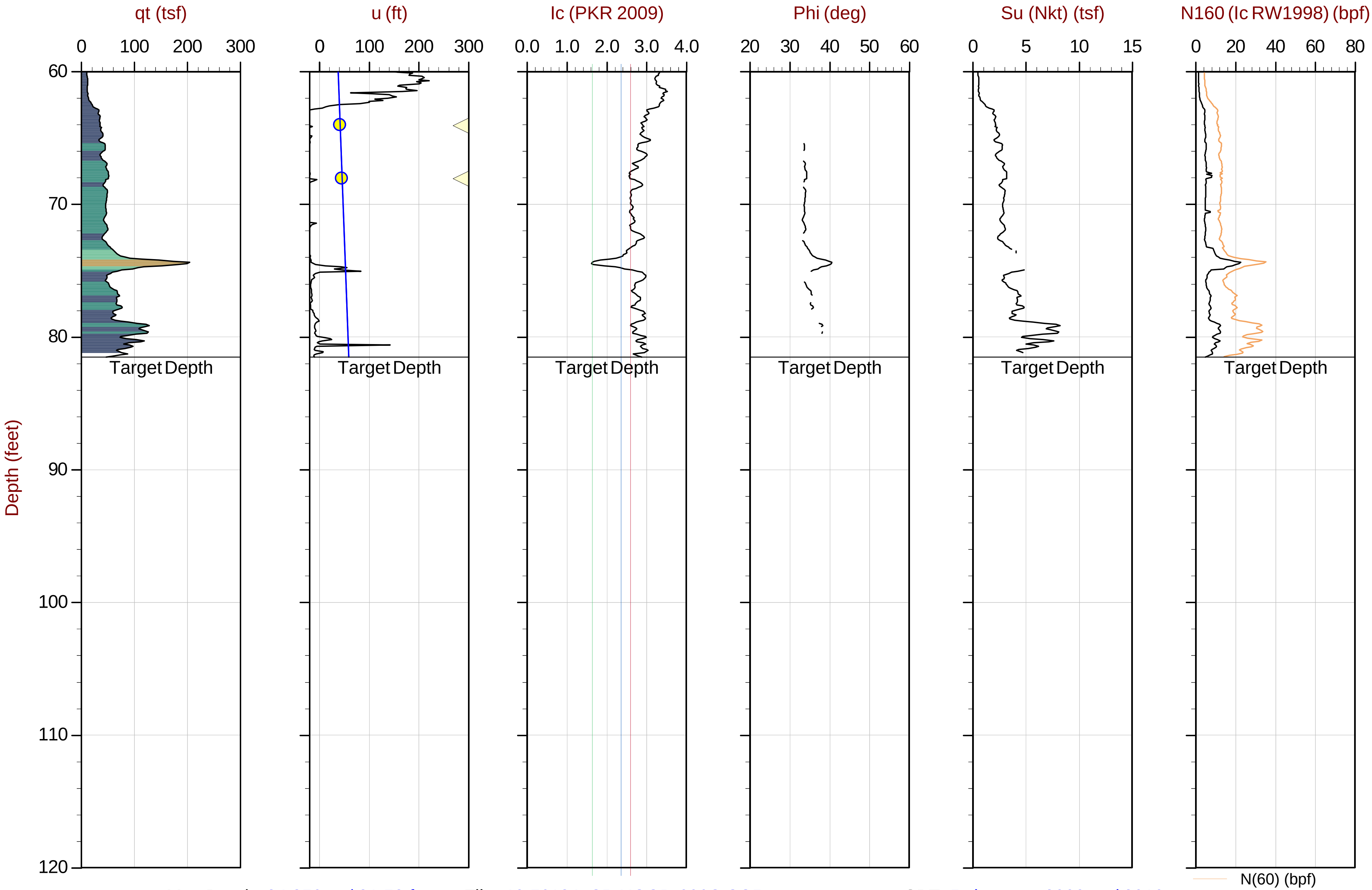
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-22 09:06
Site: Hood

Sounding: GEI-Hood-006C
Cone: 494:T1500F15U500



Max Depth: 24.850 m / 81.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-006C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249954m E: 630236m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

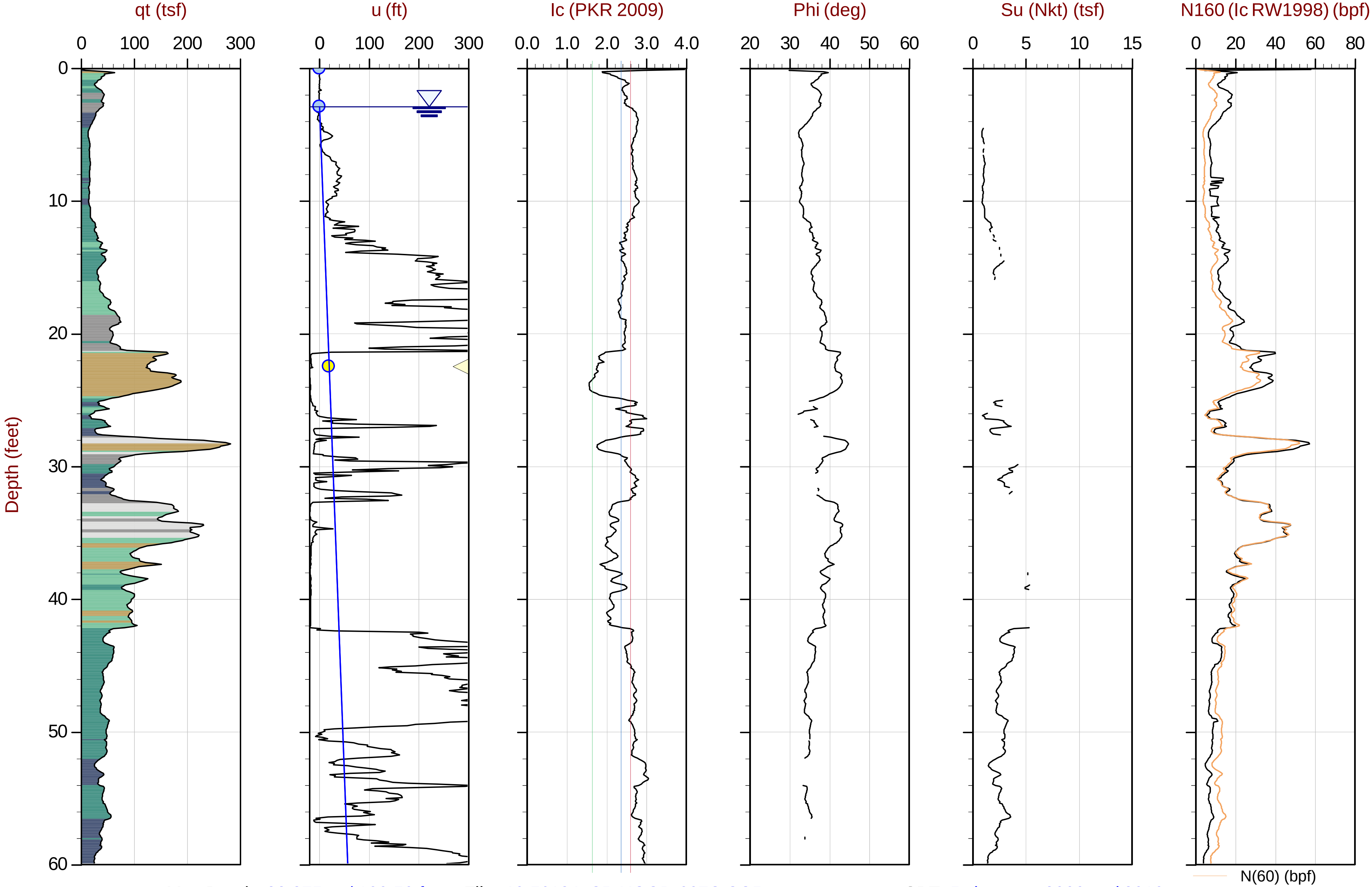
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 16:24
Site: Hood

Sounding: GEI-Hood-007C
Cone: 494:T1500F15U500



Max Depth: 33.375 m / 109.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-007C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249120m E: 630181m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

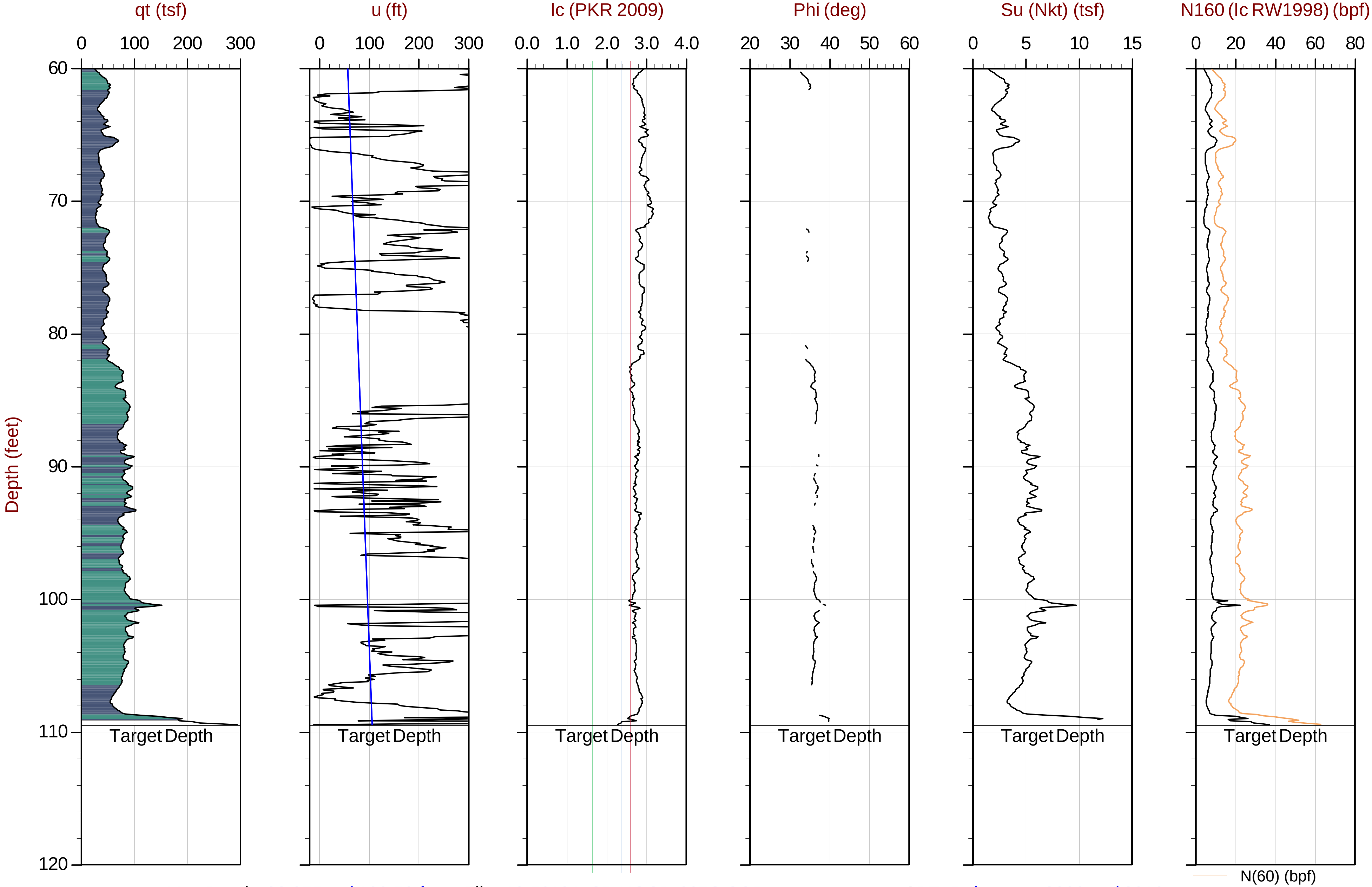
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 16:24
Site: Hood

Sounding: GEI-Hood-007C
Cone: 494:T1500F15U500



Max Depth: 33.375 m / 109.50 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-007C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4249120m E: 630181m

Equilibrium Pore Pressure (Ueq) — Assumed Ueq — Dissipation, Ueq achieved — Dissipation, Ueq not achieved — Hydrostatic Line

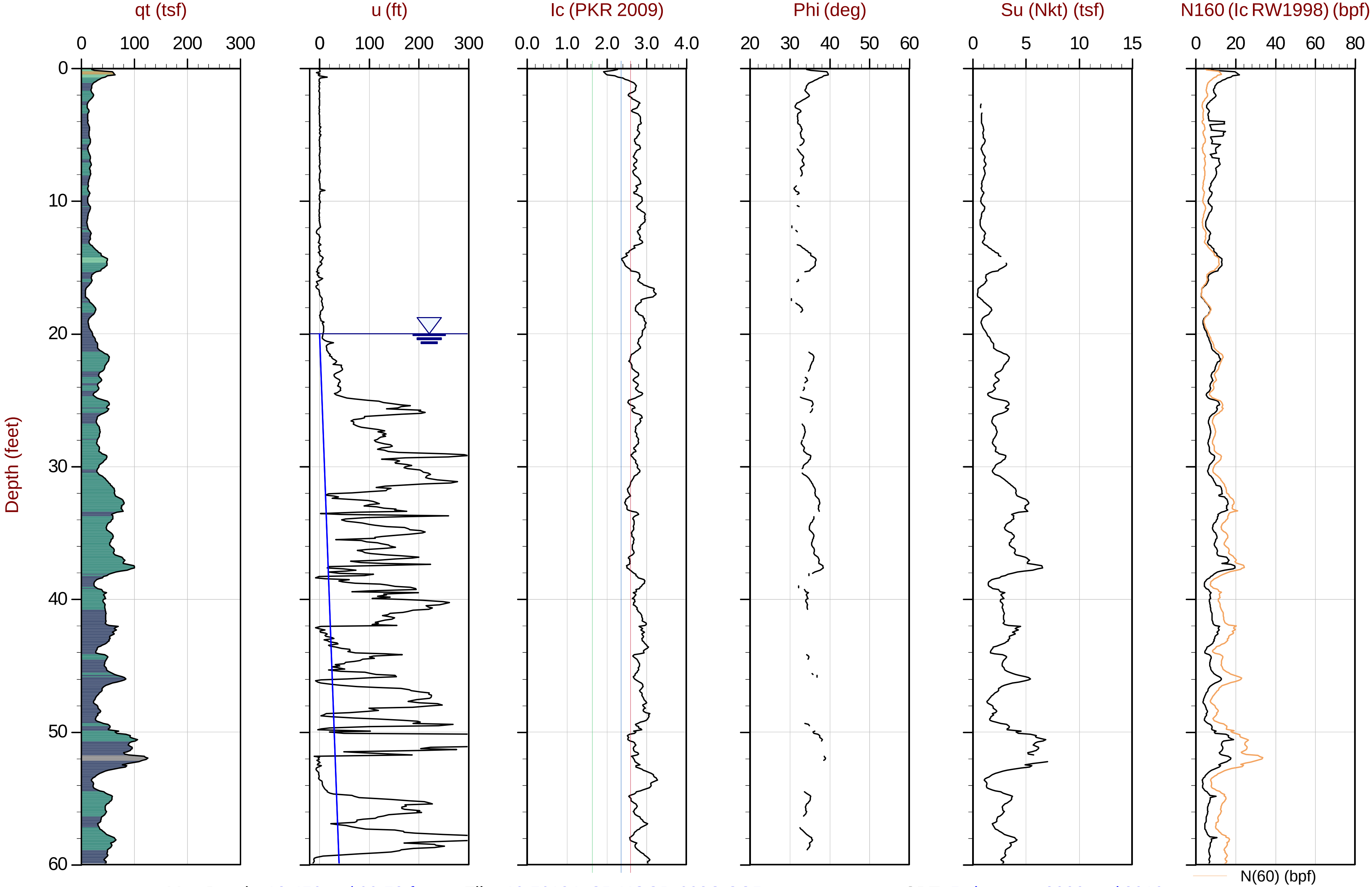
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-21 10:06
Site: Hood

Sounding: GEI-Hood-008C
Cone: 494:T1500F15U500



Max Depth: 18.450 m / 60.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

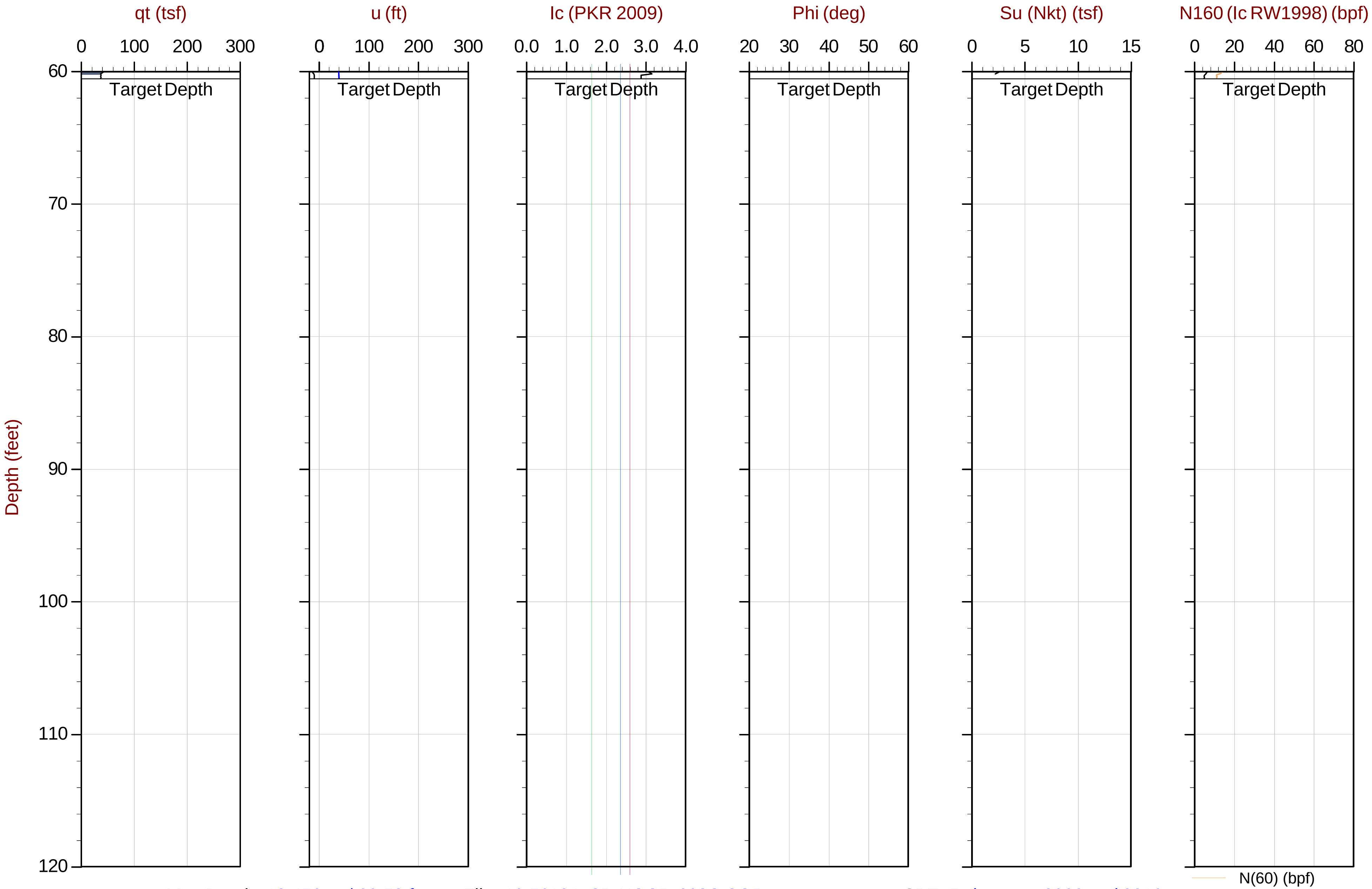
File: 19-56124_CP-HOOD-008C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4248079m E: 630175m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

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

Job No: 19-56124
Date: 2019-10-21 10:06
Site: Hood
Sounding: GEI-Hood-008C
Cone: 494:T1500F15U500



Max Depth: 18.450 m / 60.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-008C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4248079m E: 630175m

Equilibrium Pore Pressure (Ueq) | Assumed Ueq | Dissipation, Ueq achieved | Dissipation, Ueq not achieved | Hydrostatic Line

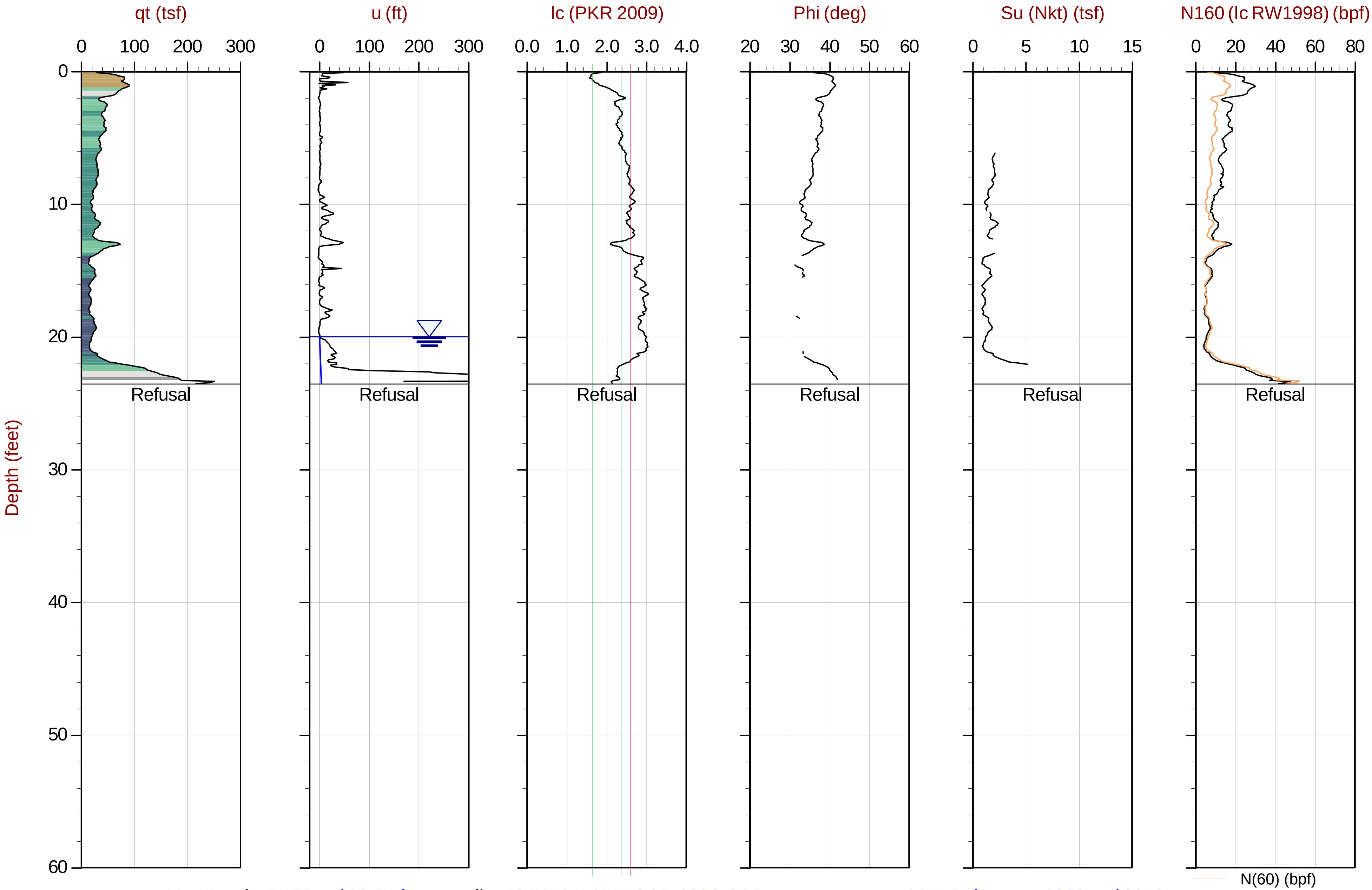
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-30 10:11
Site: Hood

Sounding: GEI-Hood-009C
Cone: 448:T1500F15U500



Max Depth: 7.175 m / 23.54 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-009C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247384m E: 630045m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

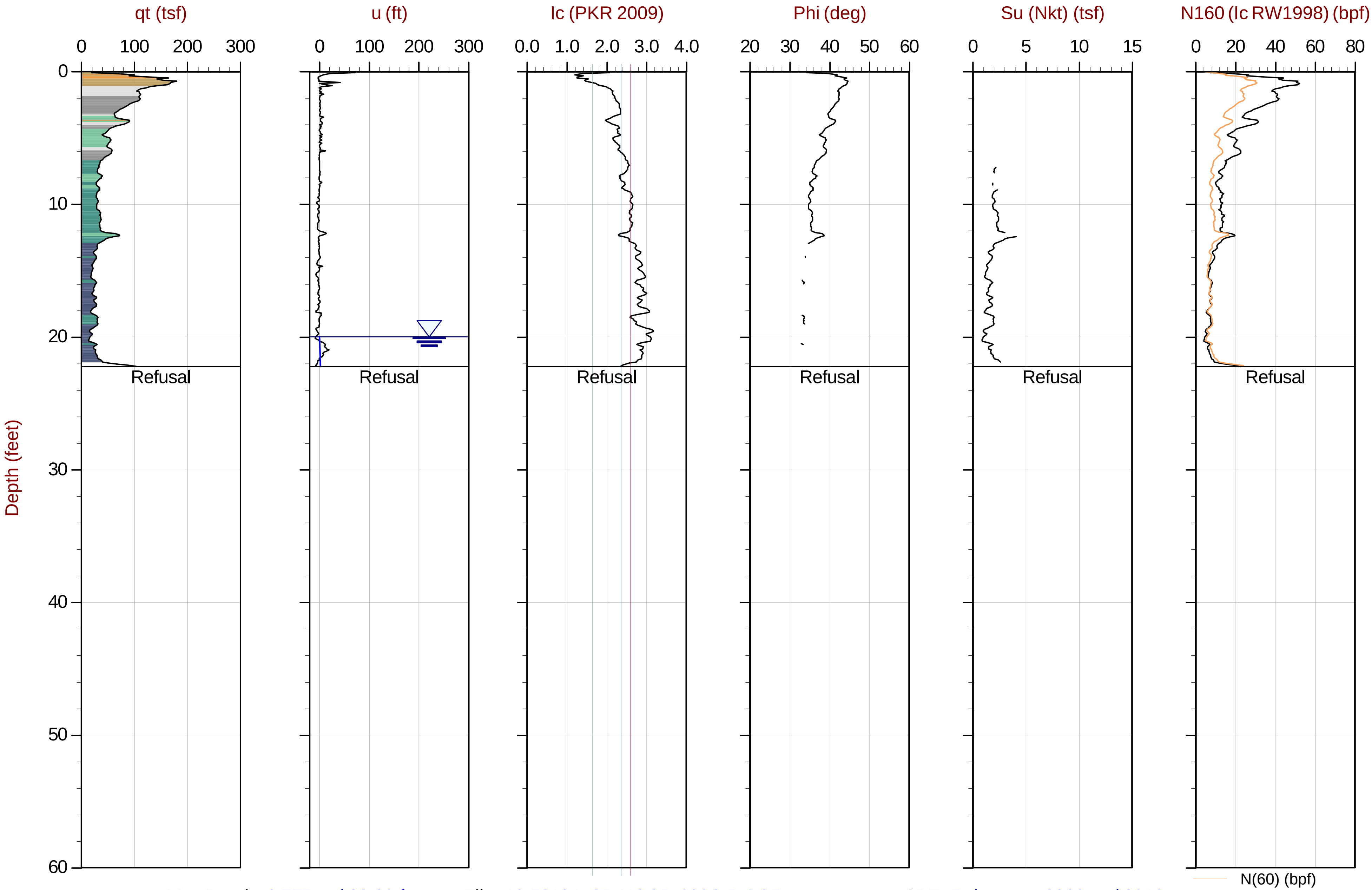
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-30 11:14
Site: Hood

Sounding: GEI-Hood-009C-B
Cone: 448:T1500F15U500



Max Depth: 6.775 m / 22.23 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-009C-B.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247379m E: 630051m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

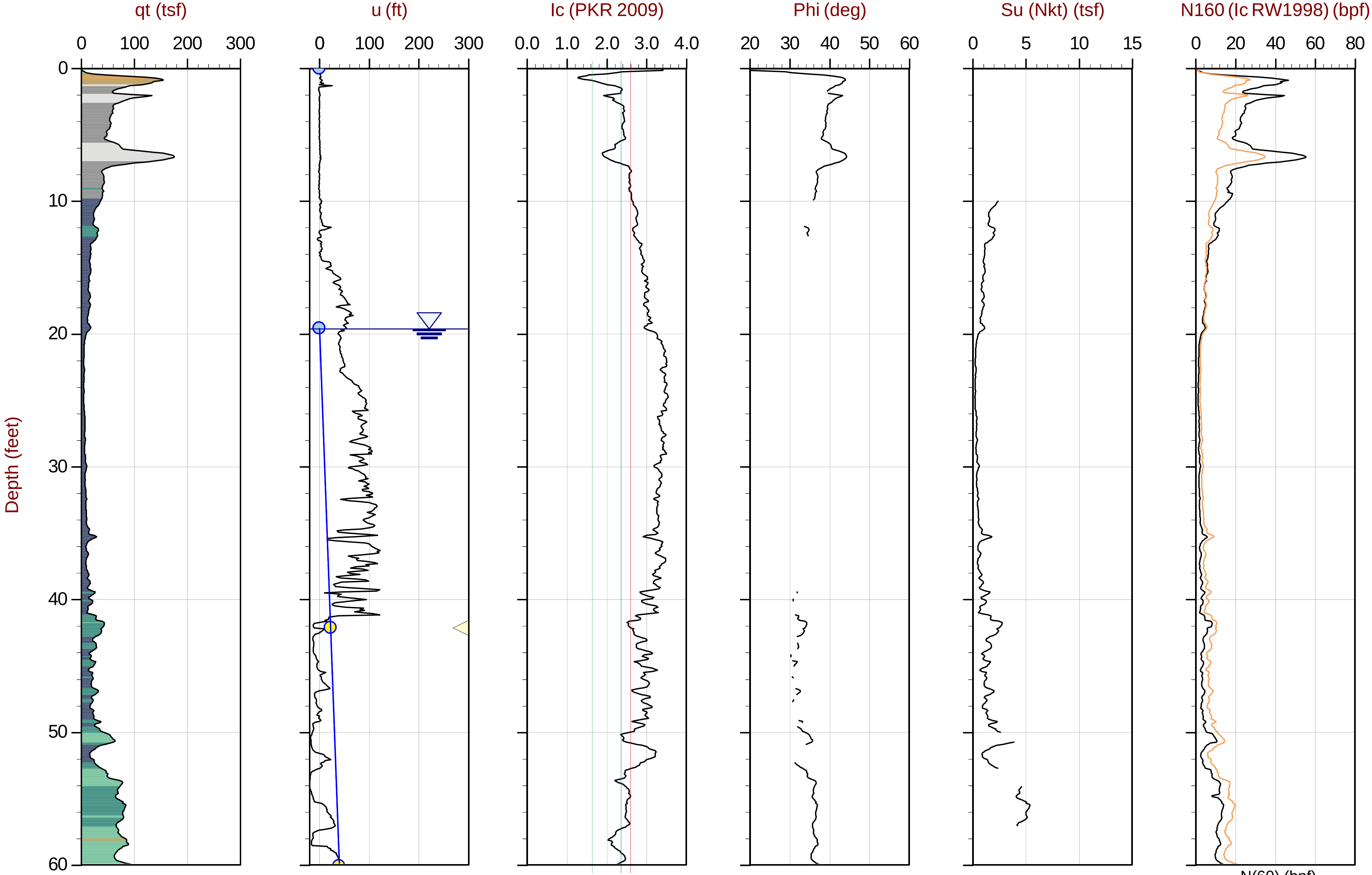
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

GEI

Job No: 19-56124
Date: 2019-10-21 12:53
Site: Hood

Sounding: GEI-Hood-010C
Cone: 494:T1500F15U500



Max Depth: 23.025 m / 75.54 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-010C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247542m E: 629479m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

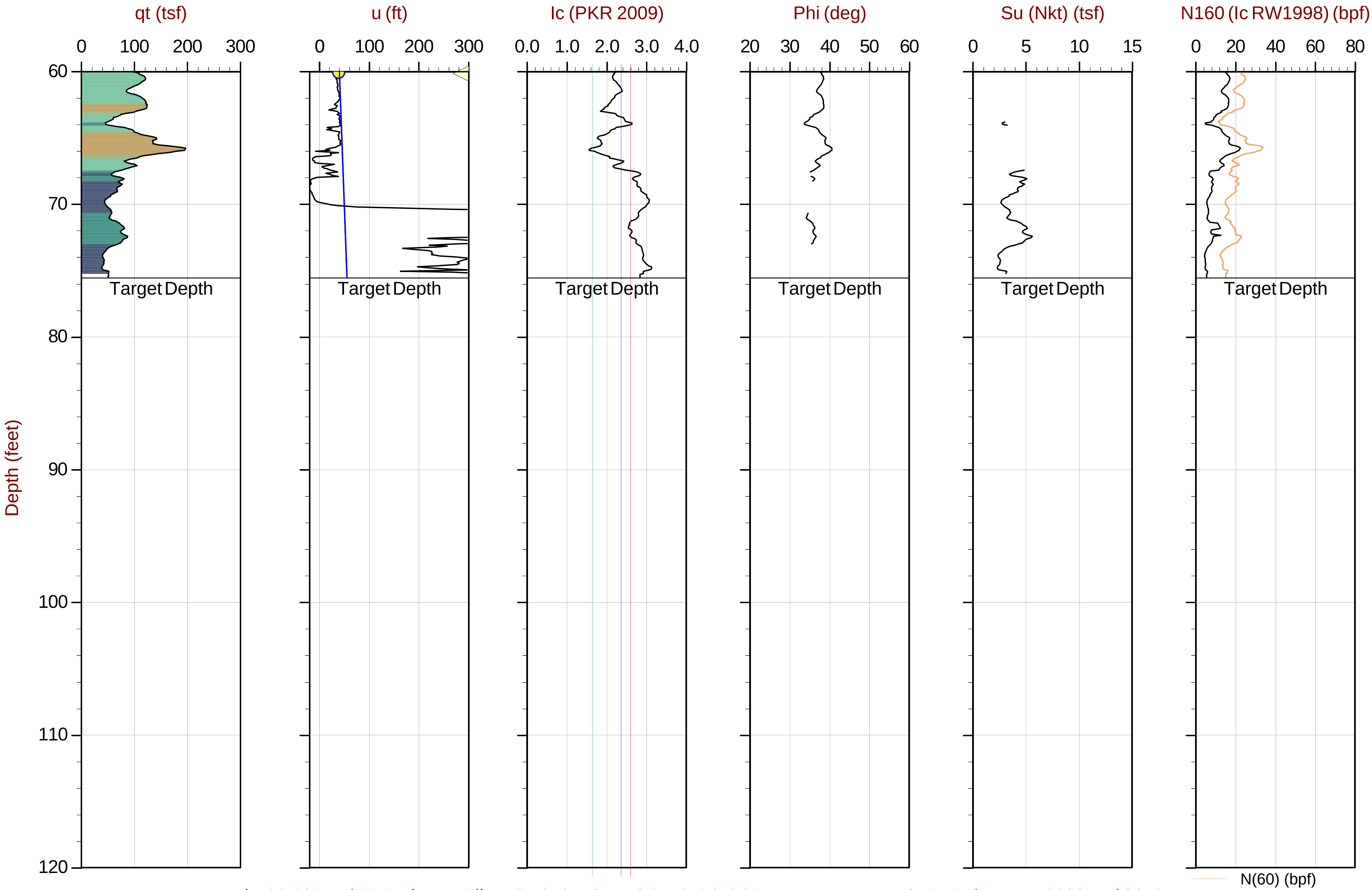
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

GEI

Job No: 19-56124
Date: 2019-10-21 12:53
Site: Hood

Sounding: GEI-Hood-010C
Cone: 494:T1500F15U500



Max Depth: 23.025 m / 75.54 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-010C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4247542m E: 629479m

Equilibrium Pore Pressure (Ueq) Assumed Ueq Dissipation, Ueq achieved Dissipation, Ueq not achieved Hydrostatic Line

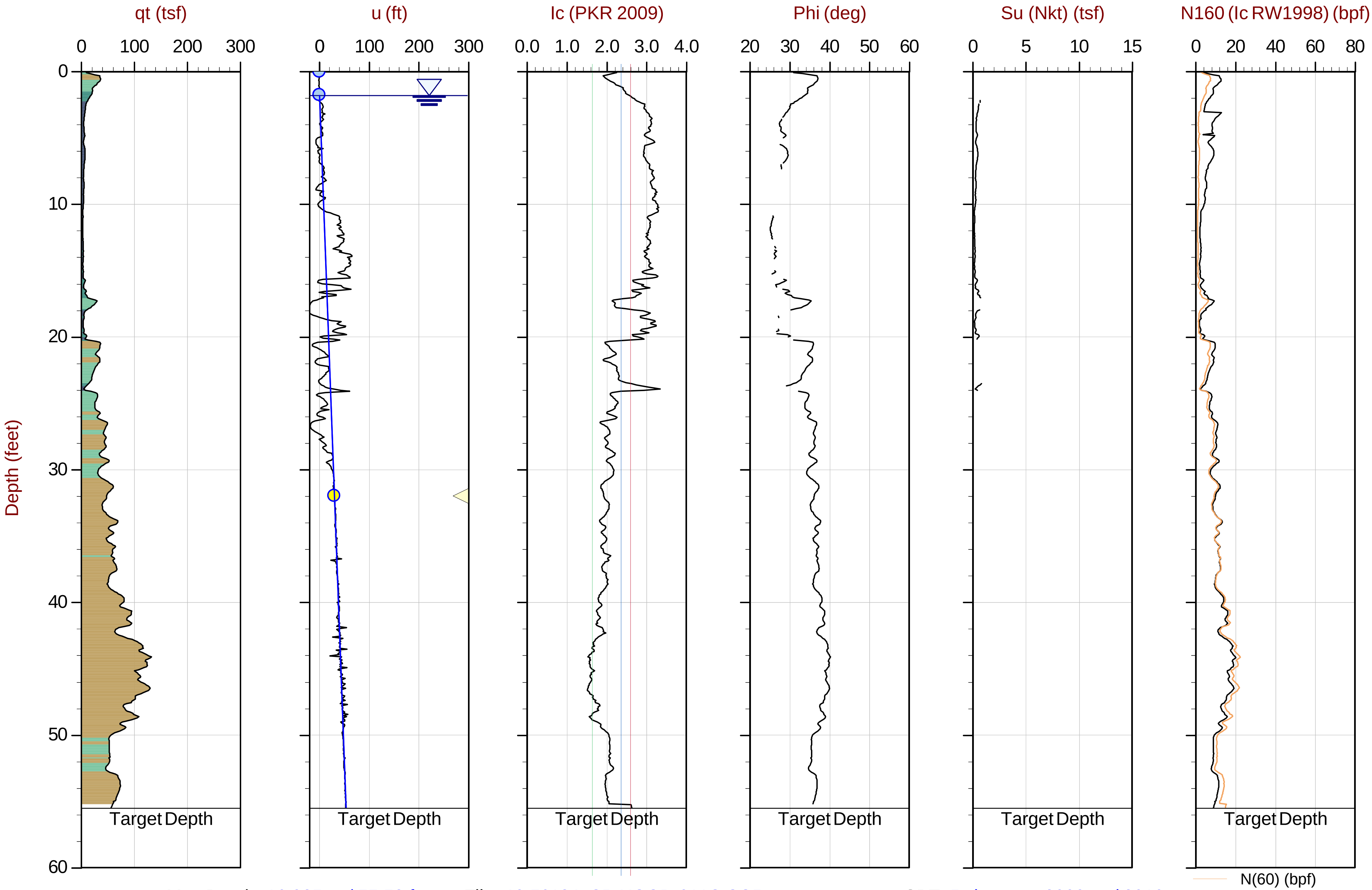
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

GEI

Job No: 19-56124
Date: 2019-10-25 08:44
Site: Hood

Sounding: GEI-Hood-011C
Cone: 499:T1500F15U1K



Max Depth: 16.925 m / 55.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 19-56124_CP-HOOD-011C.COR
Unit Wt: SBTQtn (PKR2009)
Su Nkt: 15.0

SBT: Robertson, 2009 and 2010
Coords: UTM 10N N: 4248225m E: 629691m

Equilibrium Pore Pressure (Ueq) · Assumed Ueq · Dissipation, Ueq achieved · Dissipation, Ueq not achieved · Hydrostatic Line

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

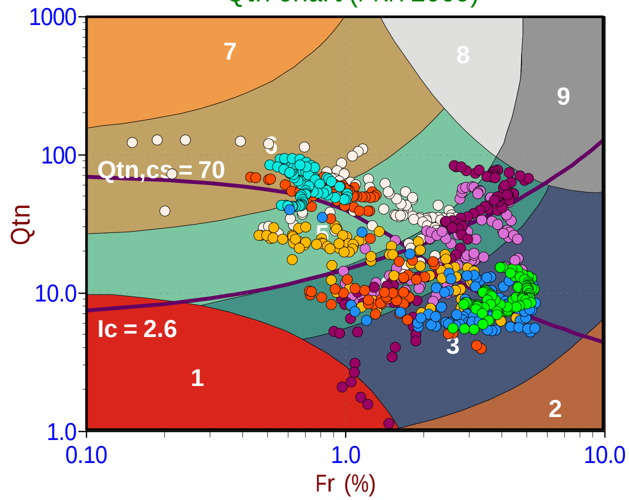
Soil Behavior Type (SBT) Scatter Plots

GEI

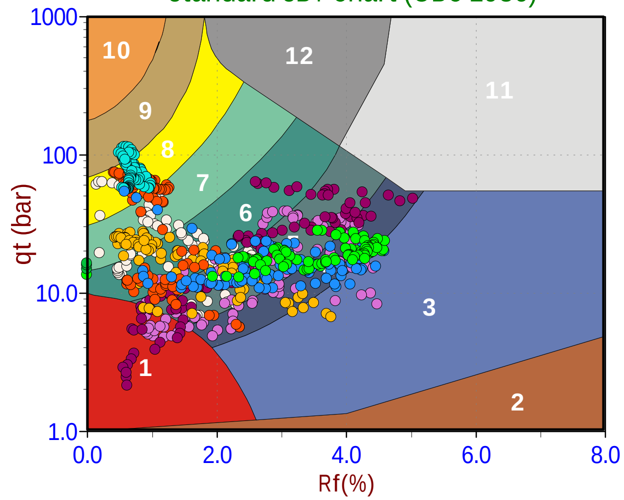
Job No: 19-56124
Date: 2019-08-28 07:52
Site: Hood

Sounding: GEI-Hood-001C
Cone: 391:T1500F15U500

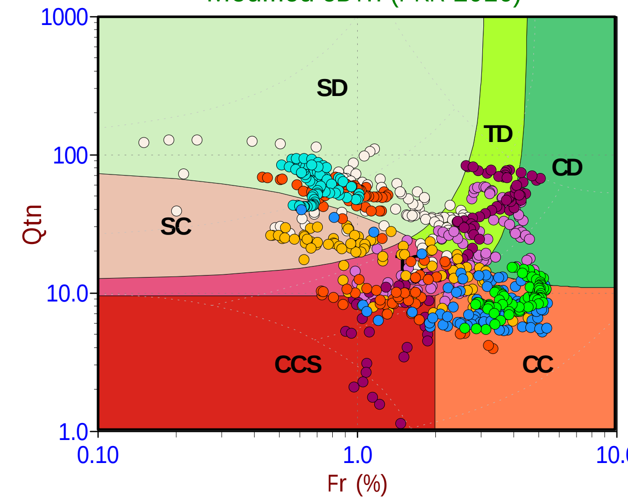
Qtn Chart (PKR 2009)



Standard SBT Chart (UBC 1986)



Modified SBTn (PKR 2016)



Depth Ranges

- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

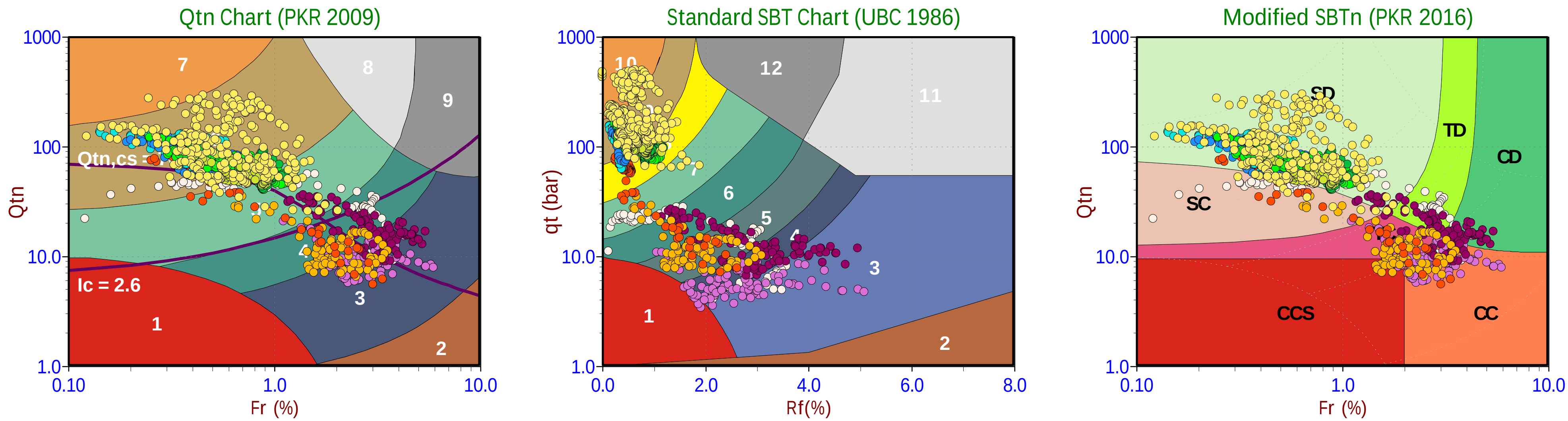
Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

GEI

Job No: 19-56124
Date: 2019-08-28 10:01
Site: Hood

Sounding: GEI-Hood-002C
Cone: 391:T1500F15U500



Depth Ranges
- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend
- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend
- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

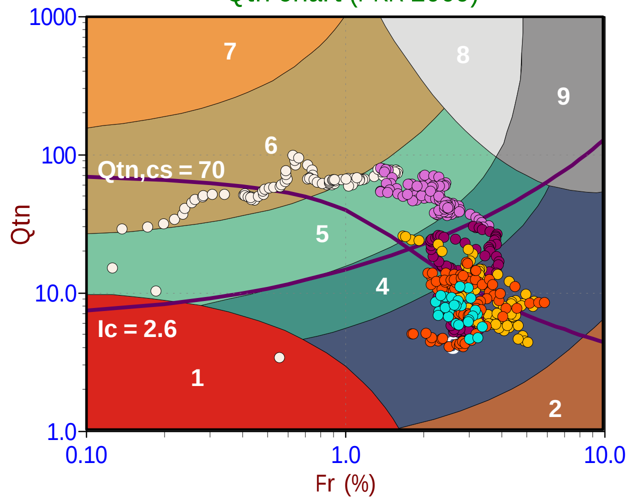
CONETEC

GEI

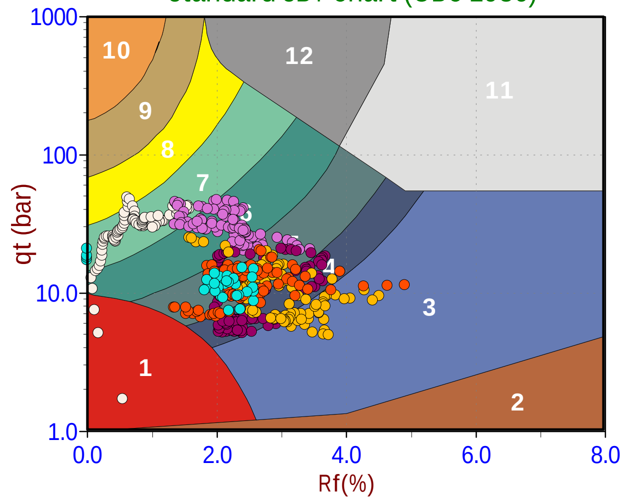
Job No: 19-56124
Date: 2019-08-27 11:42
Site: Hood

Sounding: GEI-Hood-003C
Cone: 391:T1500F15U500

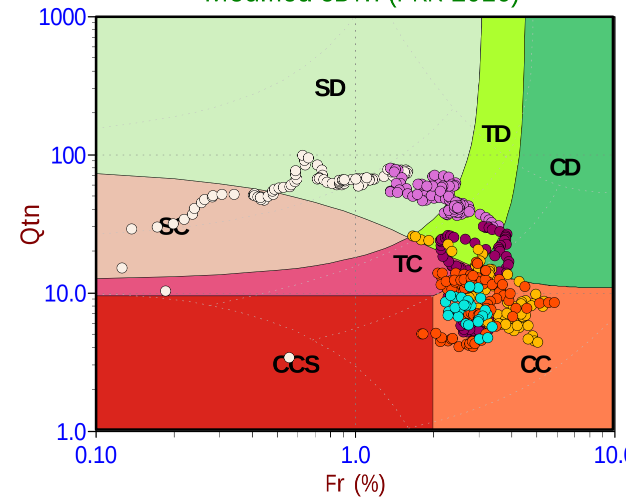
Qtn Chart (PKR 2009)



Standard SBT Chart (UBC 1986)



Modified SBTn (PKR 2016)



Depth Ranges
- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend
- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend
- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

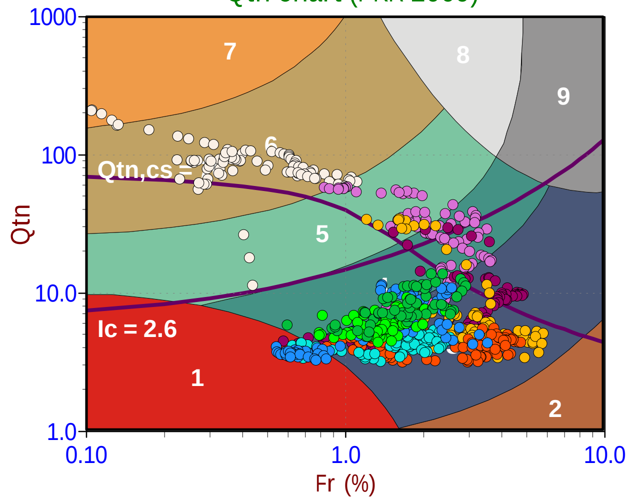
CONETEC

GEI

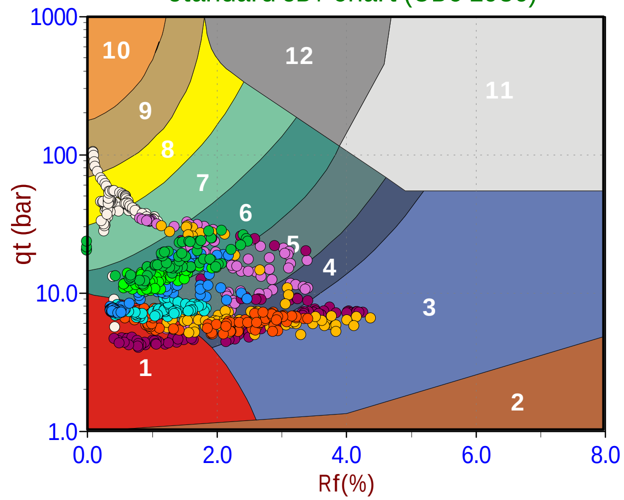
Job No: 19-56124
Date: 2019-08-27 13:25
Site: Hood

Sounding: GEI-Hood-004C
Cone: 391:T1500F15U500

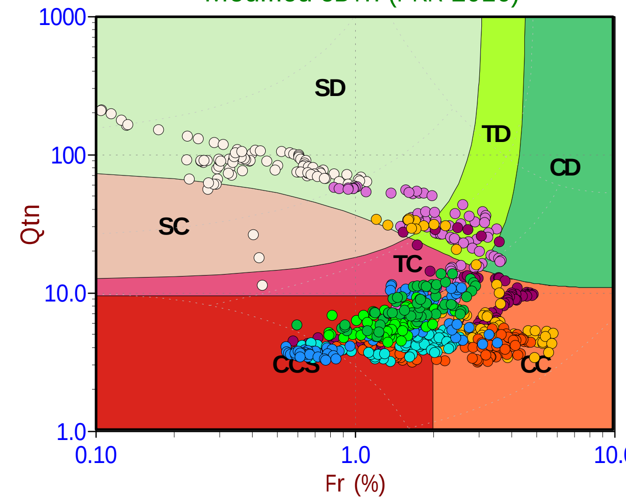
Qtn Chart (PKR 2009)



Standard SBT Chart (UBC 1986)



Modified SBTn (PKR 2016)



Depth Ranges

- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend

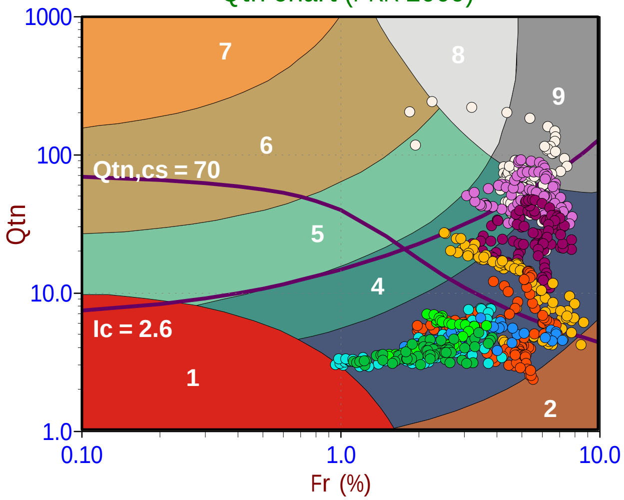
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

ConeTec

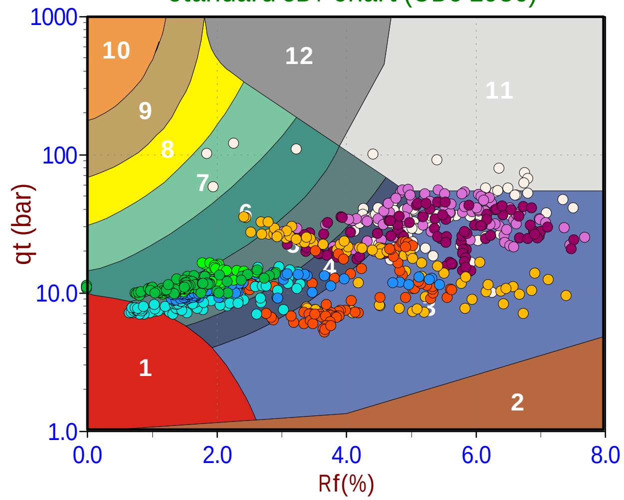
GEI

Job No: 19-56124
Date: 2019-10-22 14:03
Site: Hood
Sounding: GEI-Hood-005C
Cone: 494:T1500F15U500

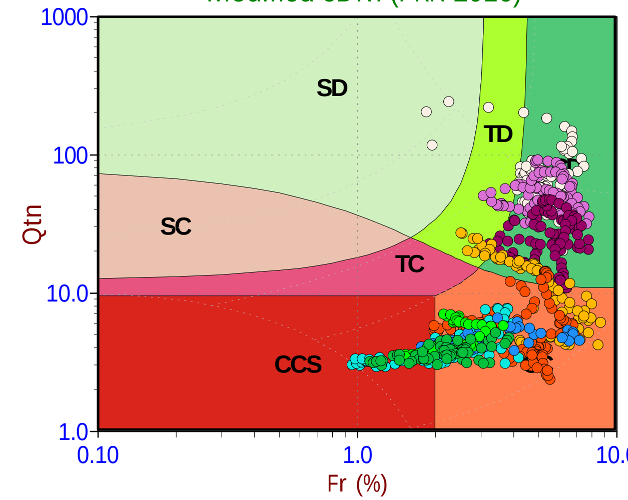
Qtn Chart (PKR 2009)



Standard SBT Chart (UBC 1986)



Modified SBTn (PKR 2016)



Depth Ranges
- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend
- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

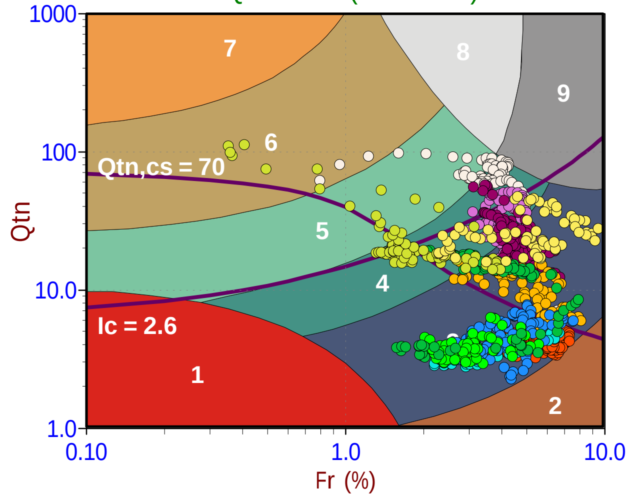
Legend
- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

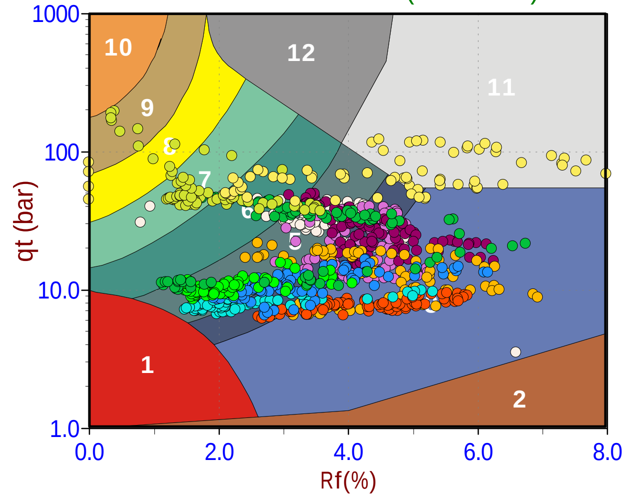
CONETEC

GEI	Job No: 19-56124	Sounding: GEI-Hood-006C
	Date: 2019-10-22 09:06	Cone: 494:T1500F15U500
	Site: Hood	

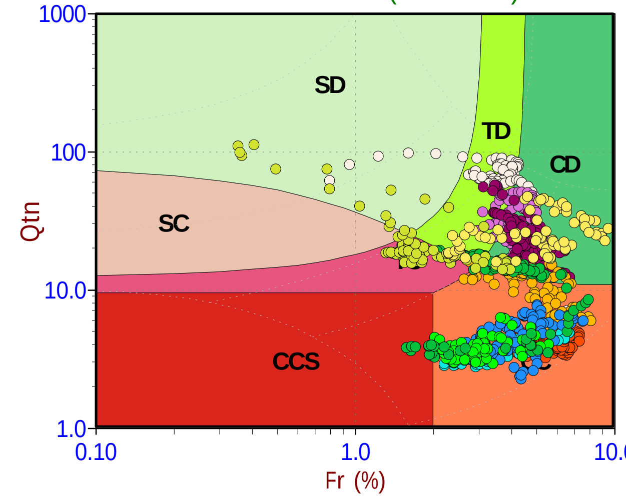
Qtn Chart (PKR 2009)



Standard SBT Chart (UBC 1986)



Modified SBTn (PKR 2016)



Depth Ranges

- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

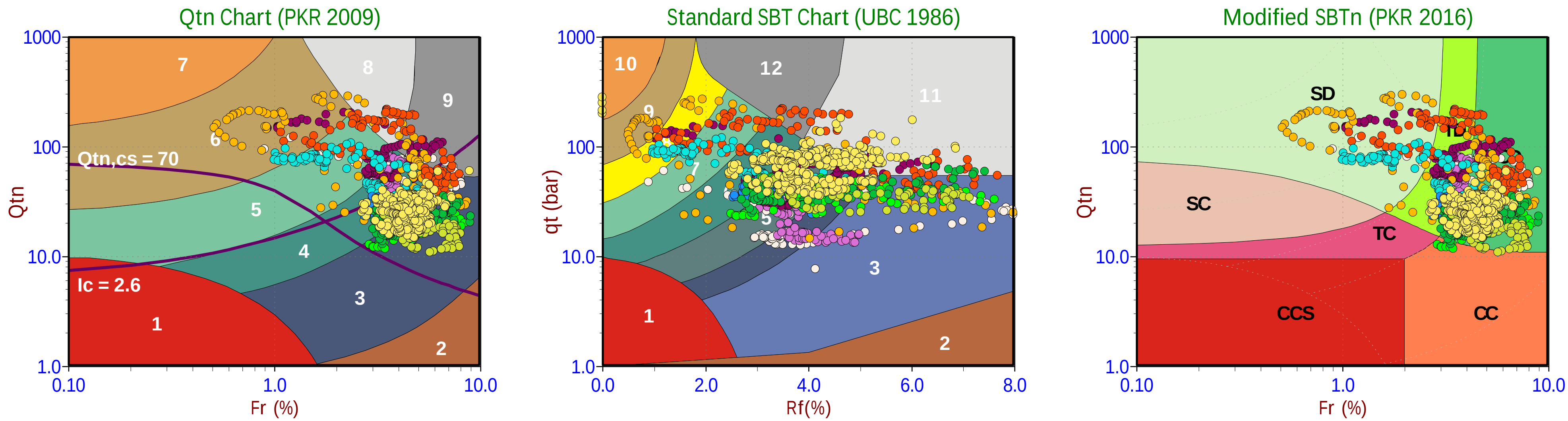
Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

GEI	Job No: 19-56124	Sounding: GEI-Hood-007C
	Date: 2019-10-21 16:24	Cone: 494:T1500F15U500
	Site: Hood	



Depth Ranges

- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

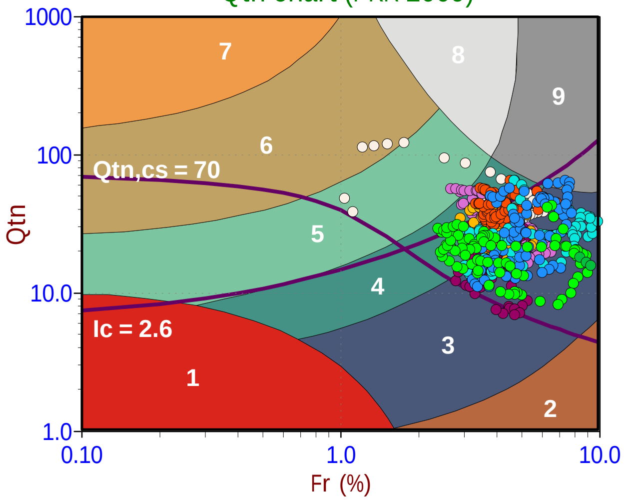
CONETEC

GEI

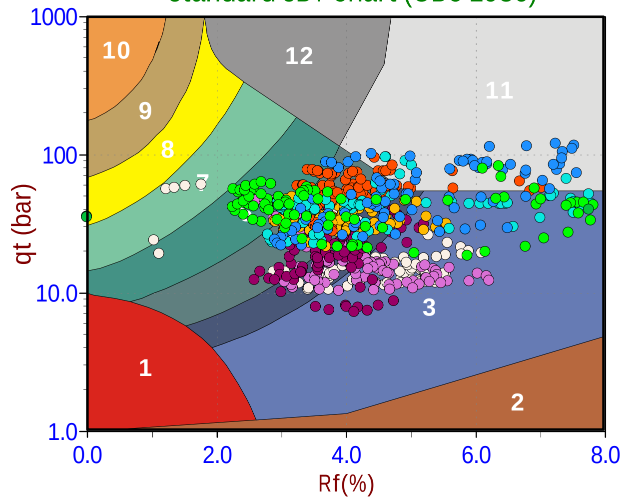
Job No: 19-56124
Date: 2019-10-21 10:06
Site: Hood

Sounding: GEI-Hood-008C
Cone: 494:T1500F15U500

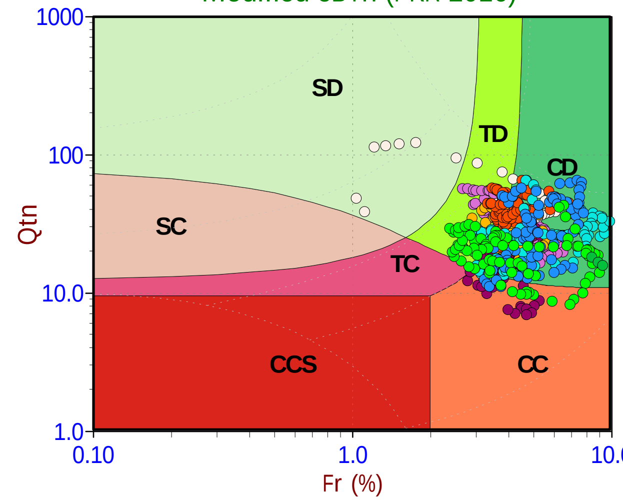
Qtn Chart (PKR 2009)



Standard SBT Chart (UBC 1986)



Modified SBTn (PKR 2016)



Depth Ranges
- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend
- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend
- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

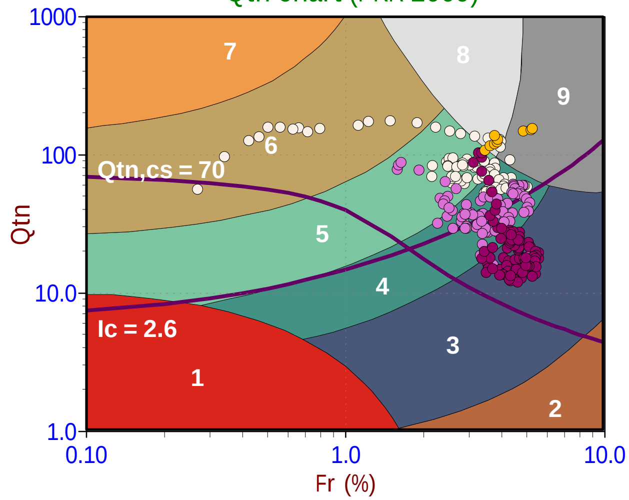
Legend
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

GEI

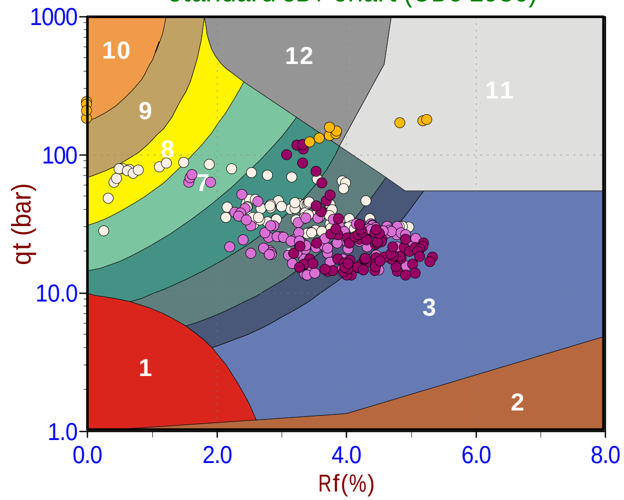
Job No: 19-56124
Date: 2019-10-30 10:11
Site: Hood

Sounding: GEI-Hood-009C
Cone: 448:T1500F15U500

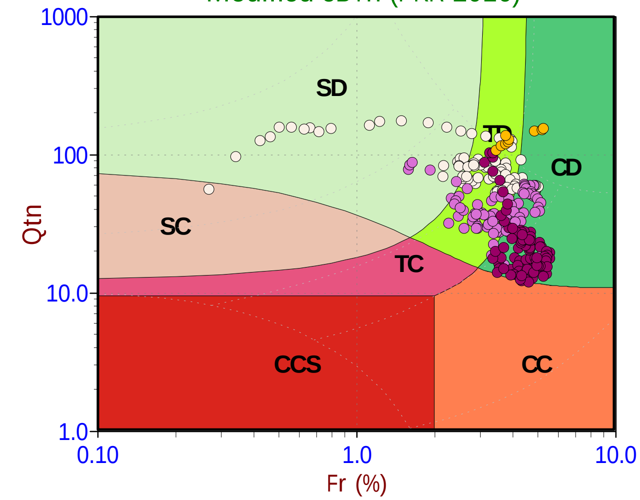
Qtn Chart (PKR 2009)



Standard SBT Chart (UBC 1986)



Modified SBTn (PKR 2016)



Depth Ranges

- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

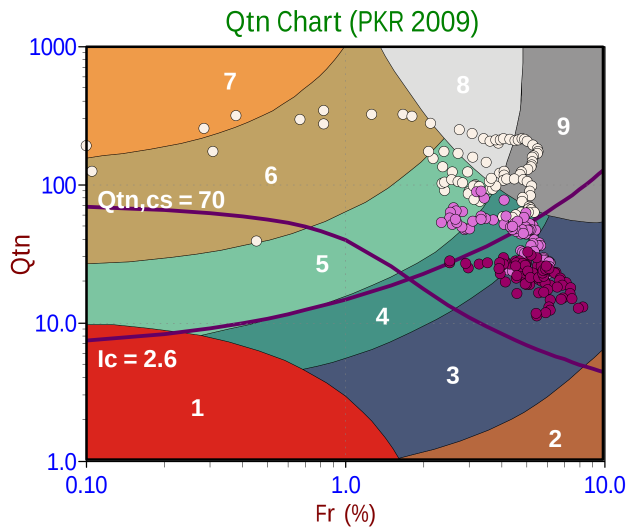
Legend

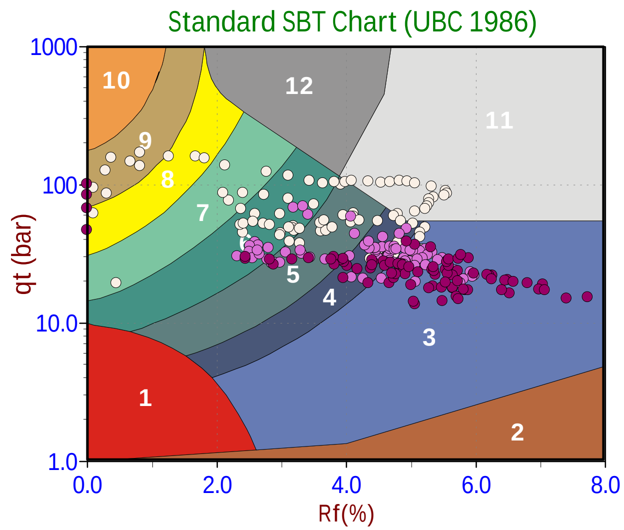
- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

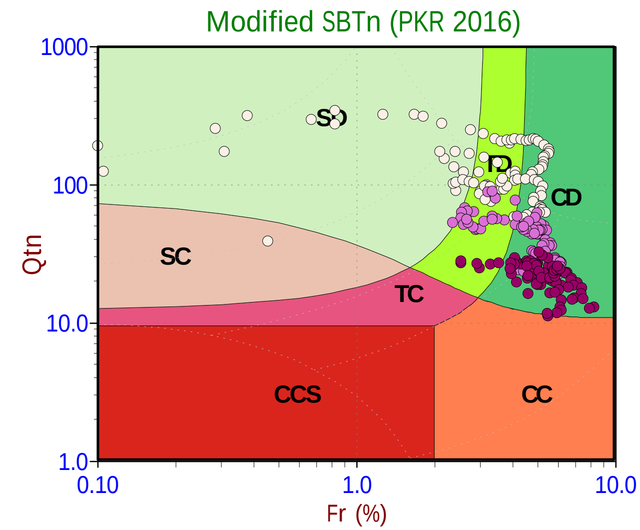
Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

GEI	Job No: 19-56124 Date: 2019-10-30 11:14 Site: Hood	Sounding: GEI-Hood-009C-B Cone: 448:T1500F15U500







Depth Ranges

- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend

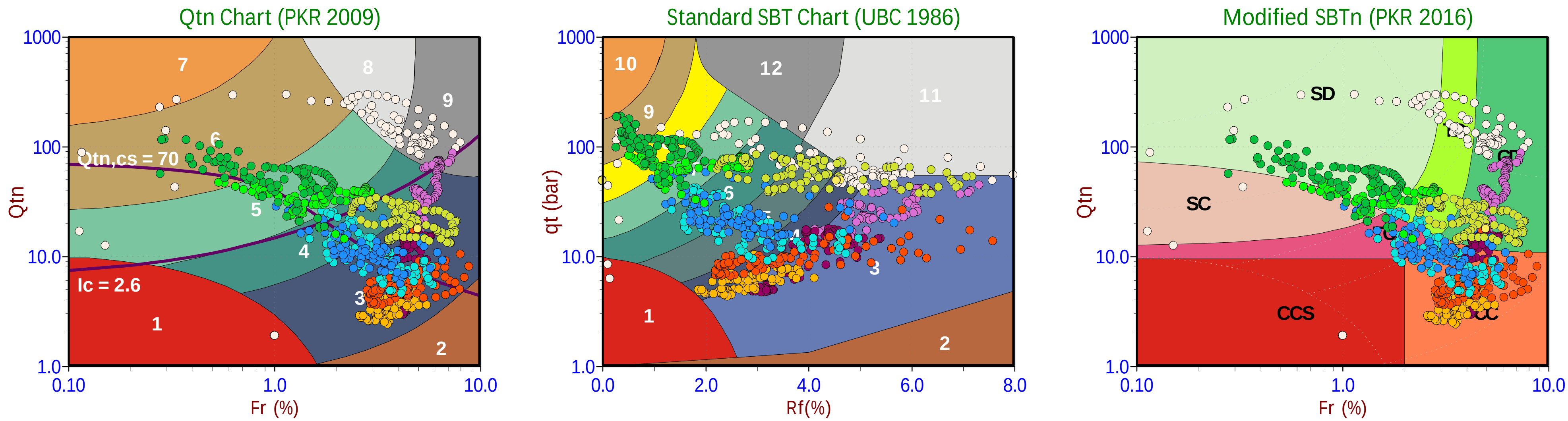
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

ConeTec

GEI

Job No: 19-56124
Date: 2019-10-21 12:53
Site: Hood

Sounding: GEI-Hood-010C
Cone: 494:T1500F15U500



Depth Ranges

- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend

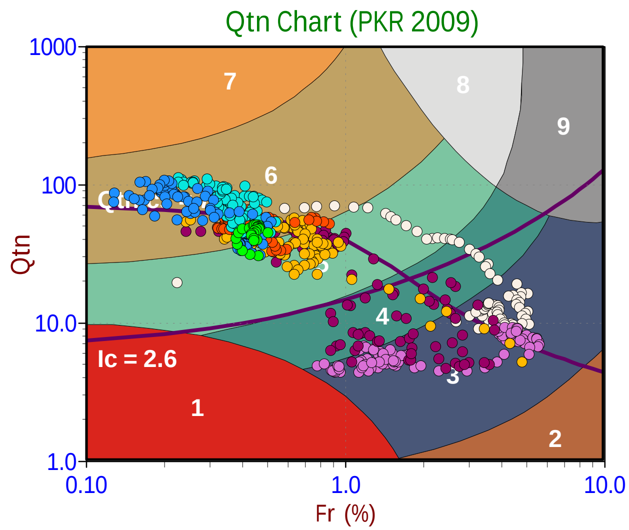
- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

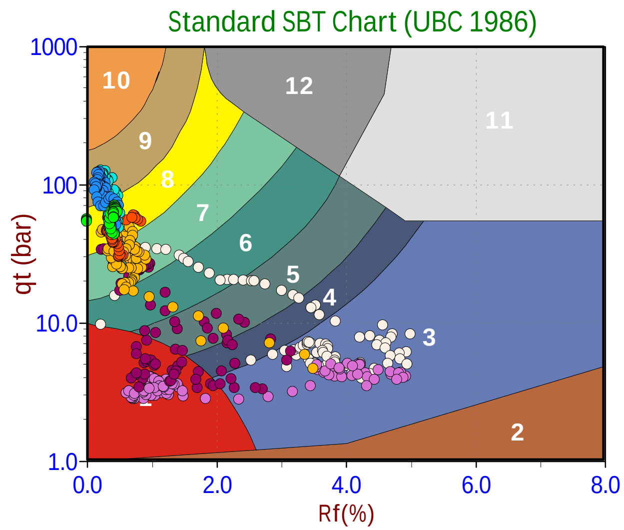
CONETEC

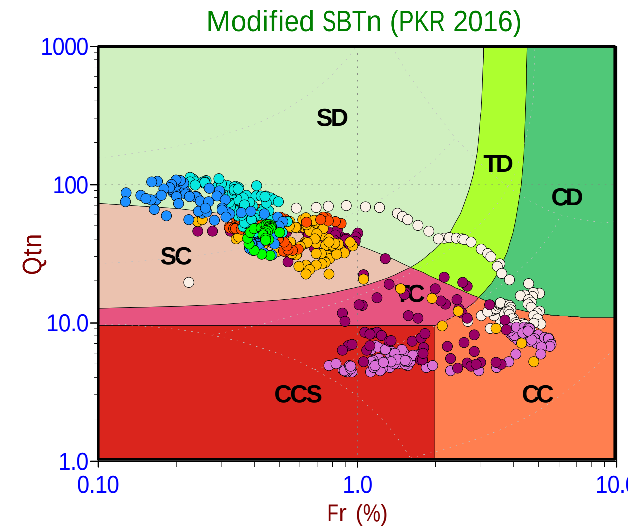
GEI

Job No: 19-56124
Date: 2019-10-25 08:44
Site: Hood

Sounding: GEI-Hood-011C
Cone: 499:T1500F15U1K







Depth Ranges

- >0.0 to 7.5 ft
- >7.5 to 15.0 ft
- >15.0 to 22.5 ft
- >22.5 to 30.0 ft
- >30.0 to 37.5 ft
- >37.5 to 45.0 ft
- >45.0 to 52.5 ft
- >52.5 to 60.0 ft
- >60.0 to 67.5 ft
- >67.5 to 75.0 ft
- >75.0 ft

Legend

- Sensitive, Fine Grained
- Organic Soils
- Clays
- Silt Mixtures
- Sand Mixtures
- Sands
- Gravelly Sand to Sand
- Stiff Sand to Clayey Sand
- Very Stiff Fine Grained

Legend

- Sensitive Fines
- Organic Soil
- Clay
- Silty Clay
- Clayey Silt
- Silt
- Sandy Silt
- Silty Sand/Sand
- Sand
- Gravelly Sand
- Stiff Fine Grained
- Cemented Sand

Legend

- CCS (Cont. sensitive clay like)
- CC (Cont. clay like)
- TC (Cont. transitional)
- SC (Cont. sand like)
- CD (Dil. clay like)
- TD (Dil. transitional)
- SD (Dil. sand like)

Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

ConeTec

Job No:	19-56124
Client:	GEI Consultants
Project:	Small Communities
Start Date:	19-Aug-2019
End Date:	28-Aug-2019

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U_{eq} (ft)	Calculated Phreatic Surface (ft)
GEI-Hood-001C	19-56124_CP-Hood-001C	15	335	43.06	35.3	7.7
GEI-Hood-002C	19-56124_CP-Hood-002C	15	305	42.40	36.0	6.4

Job No: 19-56124
Client: GEI Consultants
Project: Small Communities
Start Date: 21-Oct-2019
End Date: 01-Nov-2019

CPTu PORE PRESSURE DISSIPATION SUMMARY

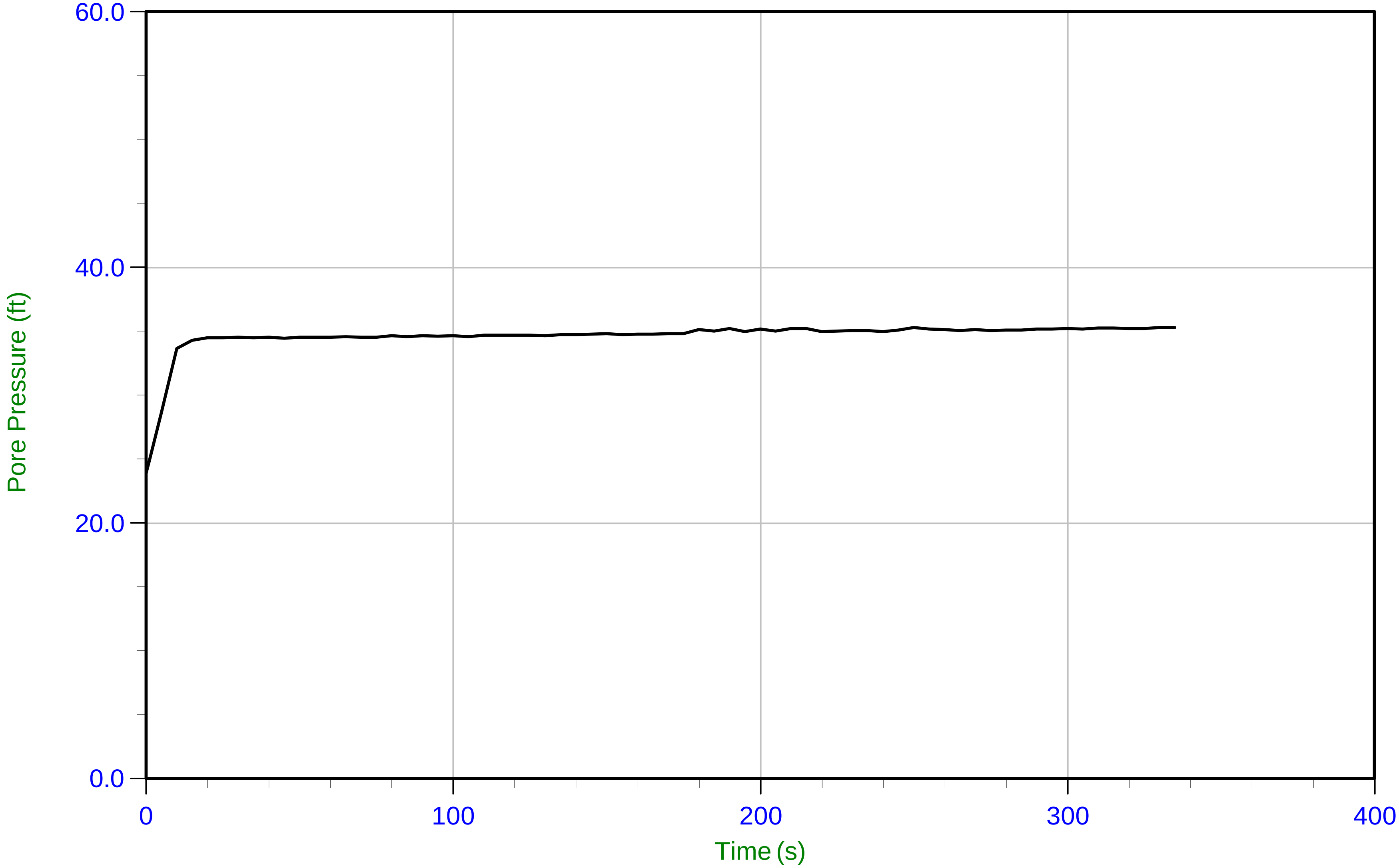
Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (ft)	Estimated Equilibrium Pore Pressure U_{eq} (ft)	Calculated Phreatic Surface (ft)
GEI-Hood-006C	19-56124_CP-Hood-006C	15	335	64.06	41.9	22.1
GEI-Hood-006C	19-56124_CP-Hood-006C	15	250	68.08	45.8	22.3
GEI-Hood-007C	19-56124_CP-Hood-007C	15	300	22.47	19.6	2.9
GEI-Hood-010C	19-56124_CP-Hood-010C	15	300	42.16	22.6	19.6
GEI-Hood-010C	19-56124_CP-Hood-010C	15	305	60.12	39.8	20.3
GEI-Hood-011C	19-56124_CP-Hood-011C	15	300	31.99	30.2	1.8

CONETEC

GEI

Job No: 19-56124
Date: 08/28/2019 07:52
Site: Hood

Sounding: GEI-Hood-001C
Cone: 391:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 19-56124_CP-Hood-001C.PPD
Depth: 13.125 m / 43.061 ft
Duration: 335.0 s

u Min: 23.9 ft
u Max: 35.3 ft
u Final: 35.3 ft

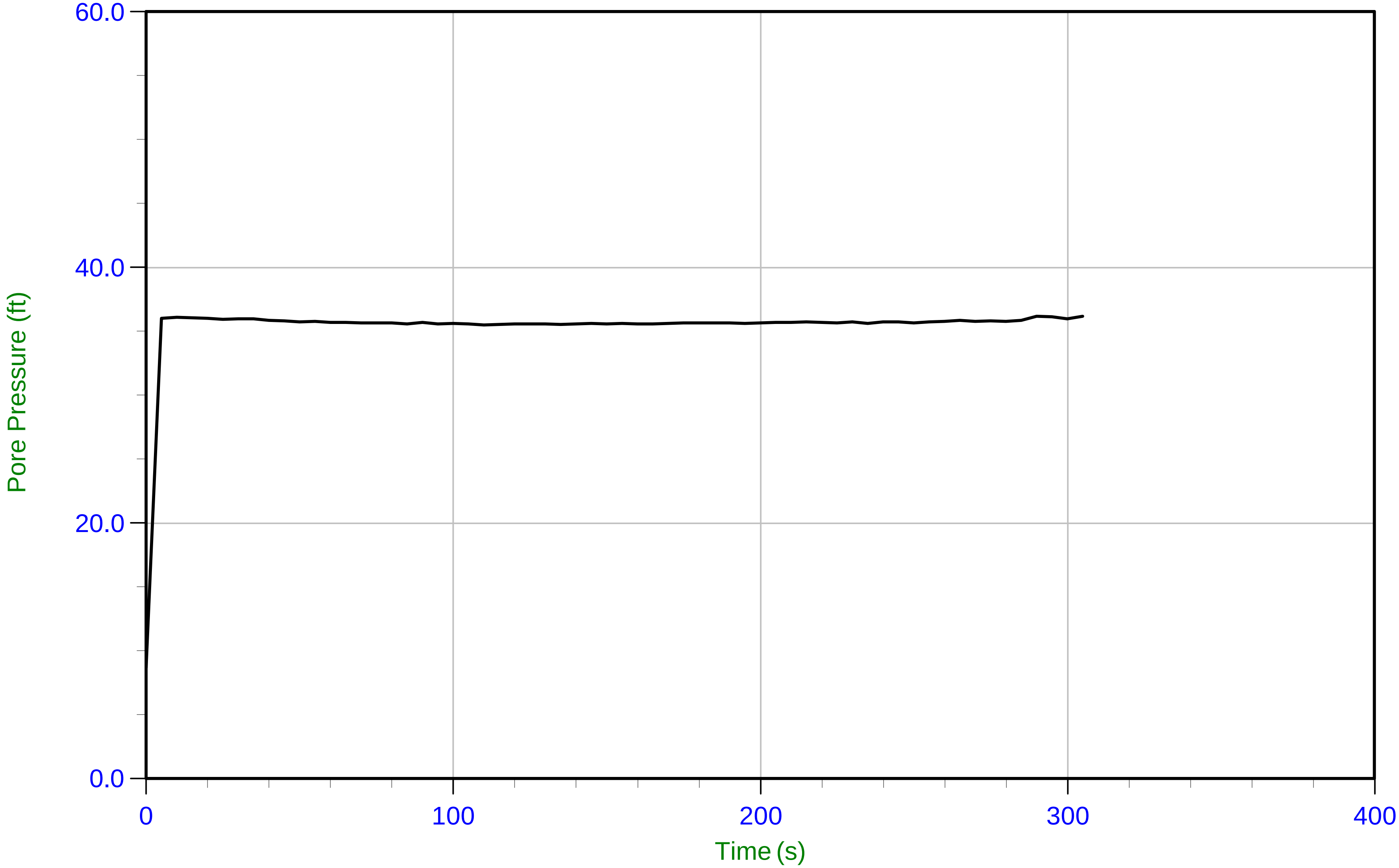
WT: 2.361 m / 7.746 ft
Ueq: 35.3 ft

CONETEC

GEI

Job No: 19-56124
Date: 08/28/2019 10:01
Site: Hood

Sounding: GEI-Hood-002C
Cone: 391:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 19-56124_CP-Hood-002C.PPD
Depth: 12.925 m / 42.404 ft
Duration: 305.0 s

u Min: 8.7 ft
u Max: 36.2 ft
u Final: 36.2 ft

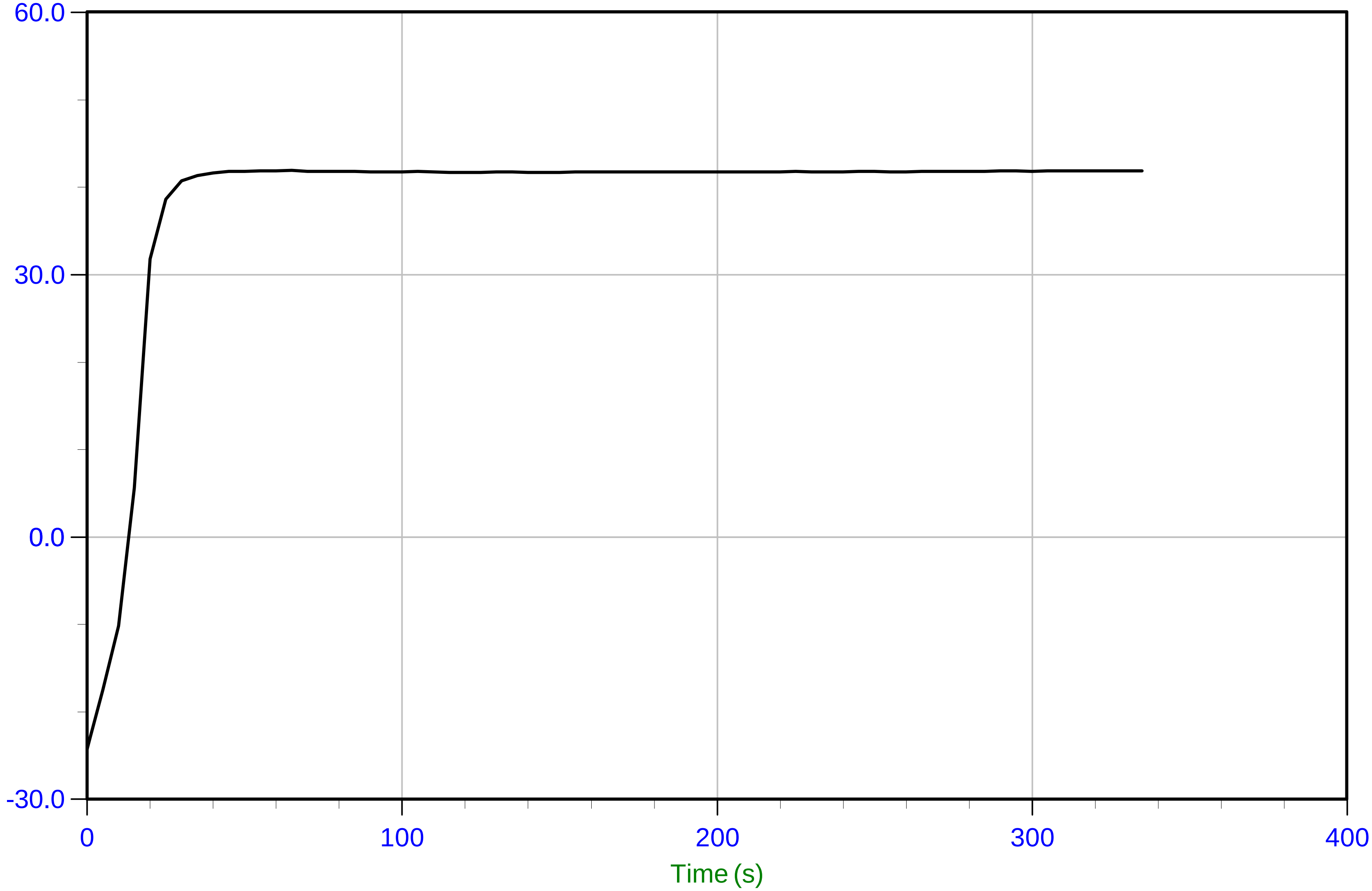
WT: 1.965 m / 6.447 ft
Ueq: 36.0 ft

ConeTec

GEI

Job No: 19-56124
Date: 10/22/2019 09:06
Site: Hood

Sounding: GEI-Hood-006C
Cone: 494:T1500F15U500 Area=15 cm²



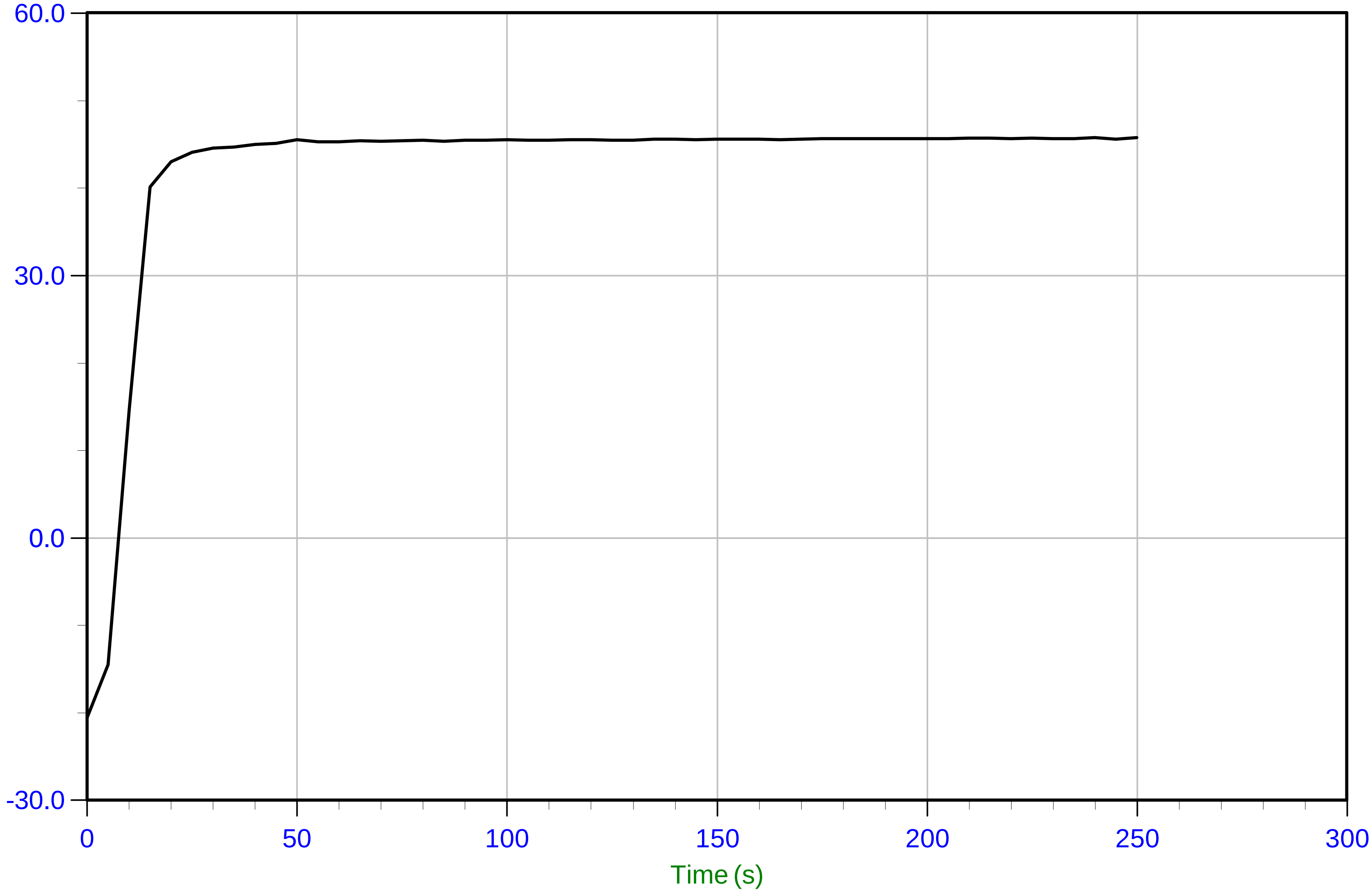
Trace Summary:

Filename: 19-56124_CP-Hood-006C.PPF
Depth: 19.525 m / 64.058 ft
Duration: 335.0 s

u Min: -24.3 ft
u Max: 41.9 ft
u Final: 41.9 ft

WT: 6.748 m / 22.139 ft
Ueq: 41.9 ft

GEI	Job No: 19-56124 Date: 10/22/2019 09:06 Site: Hood	Sounding: GEI-Hood-006C Cone: 494:T1500F15U500 Area=15 cm²



Trace Summary:

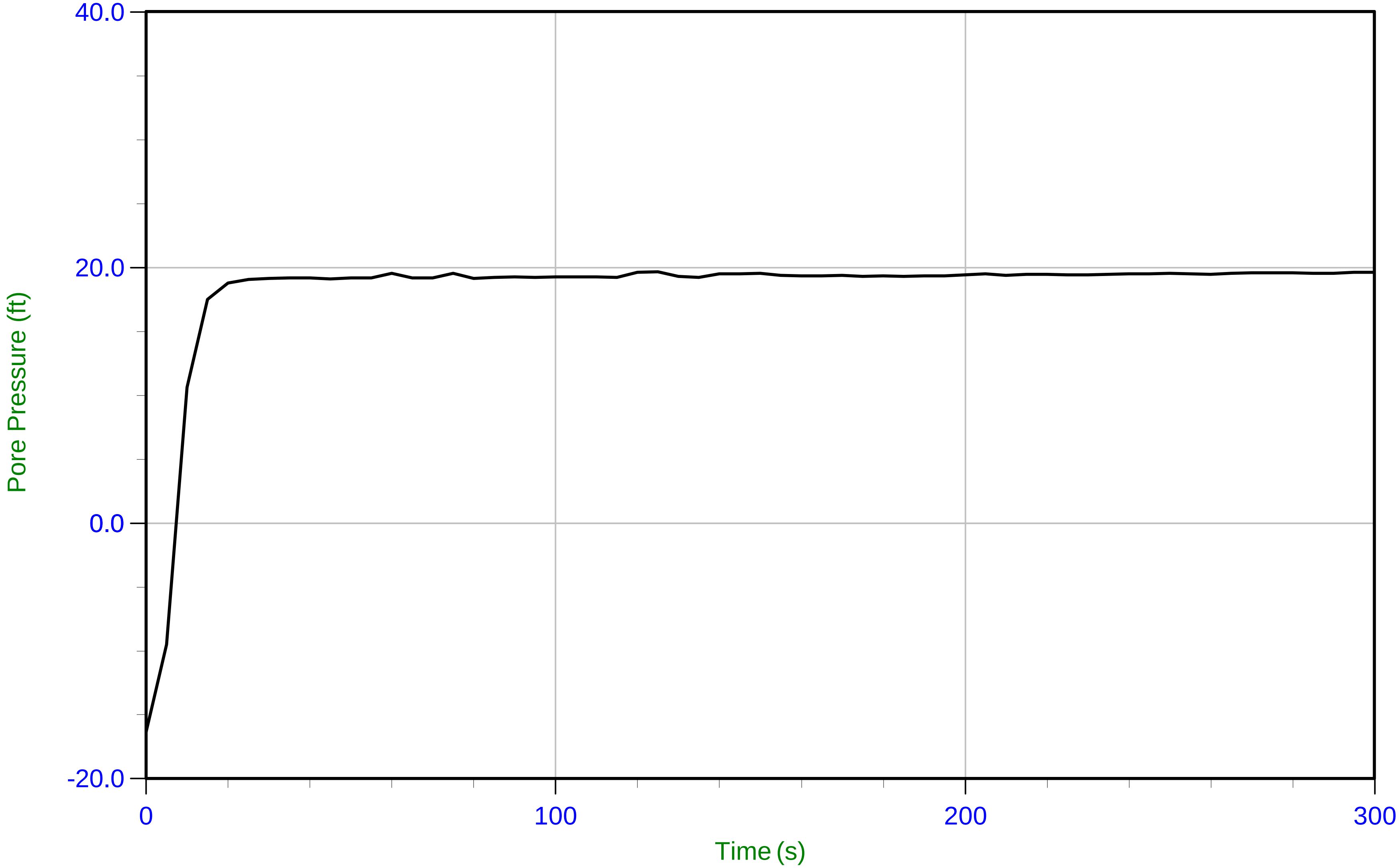
Filename: 19-56124_CP-Hood-006C.PPF
Depth: 20.750 m / 68.077 ft
Duration: 250.0 s

u Min: -20.5 ft
u Max: 45.8 ft
u Final: 45.7 ft

WT: 6.800 m / 22.308 ft
Ueq: 45.8 ft

CONETEC

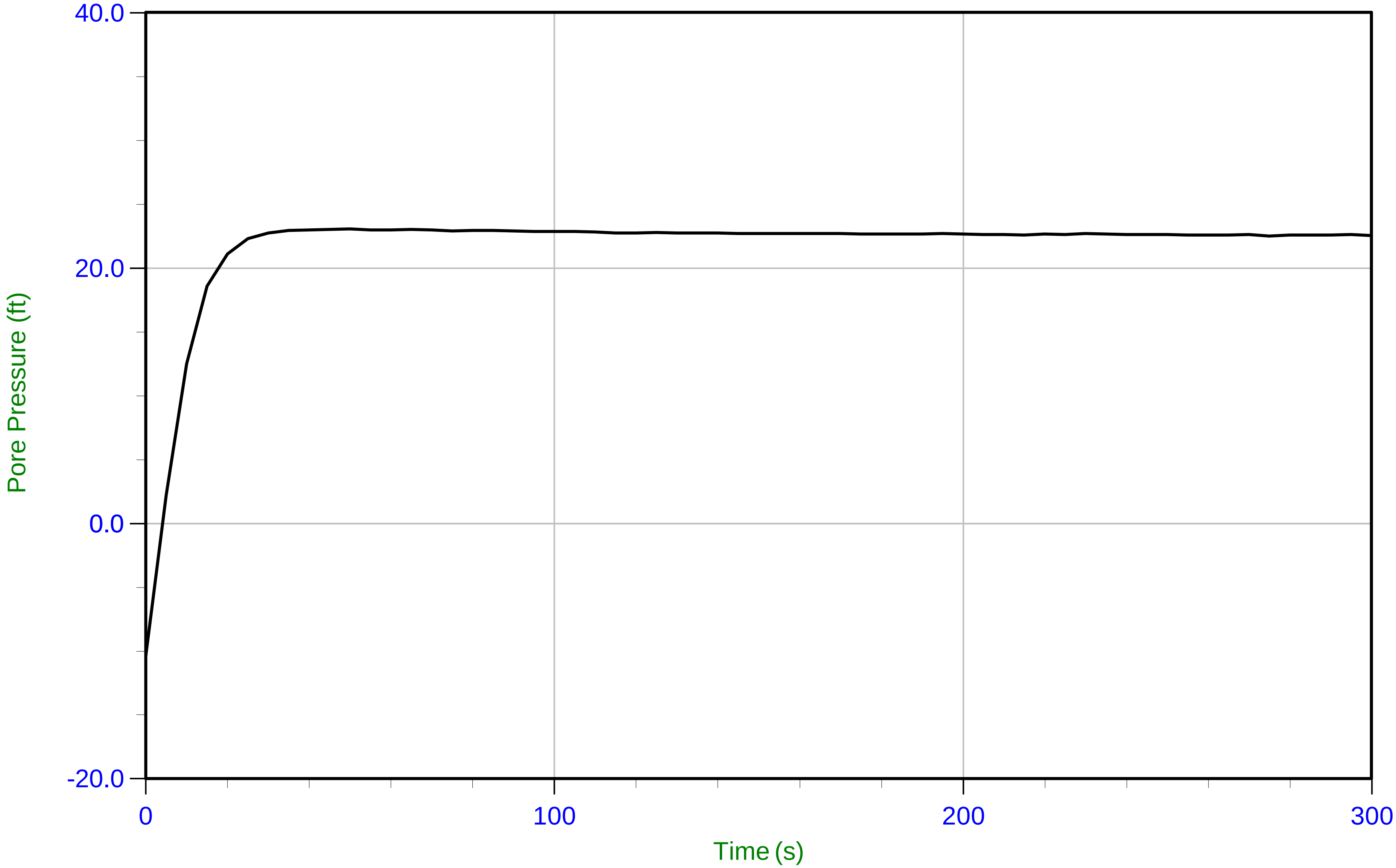
GEI	Job No: 19-56124 Date: 10/21/2019 16:24 Site: Hood	Sounding: GEI-Hood-007C Cone: 494:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 19-56124_CP-Hood-007C.PPF	u Min: -16.4 ft	WT: 0.879 m / 2.884 ft
Depth: 6.850 m / 22.473 ft	u Max: 19.6 ft	Ueq: 19.6 ft
Duration: 300.0 s	u Final: 19.6 ft	

GEI	Job No: 19-56124 Date: 10/21/2019 12:53 Site: Hood	Sounding: GEI-Hood-010C Cone: 494:T1500F15U500 Area=15 cm²



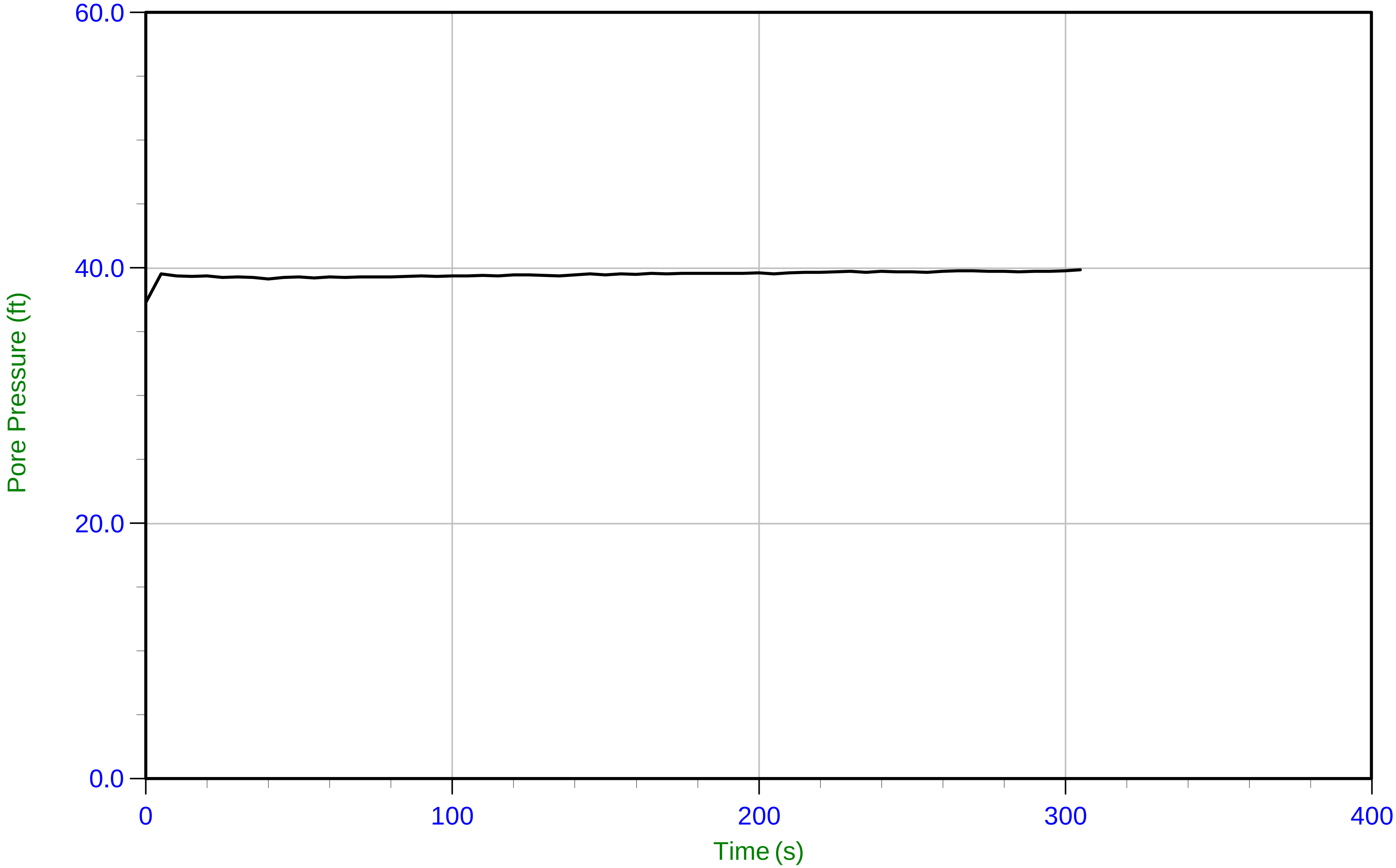
Trace Summary:

Filename: 19-56124_CP-Hood-010C.PPF
Depth: 12.850 m / 42.158 ft
Duration: 300.0 s

u Min: -10.4 ft
u Max: 23.0 ft
u Final: 22.6 ft

WT: 5.975 m / 19.604 ft
Ueq: 22.6 ft

CONETEC GEI	Job No: 19-56124 Date: 10/21/2019 12:53 Site: Hood	Sounding: GEI-Hood-010C Cone: 494:T1500F15U500 Area=15 cm²



Trace Summary:

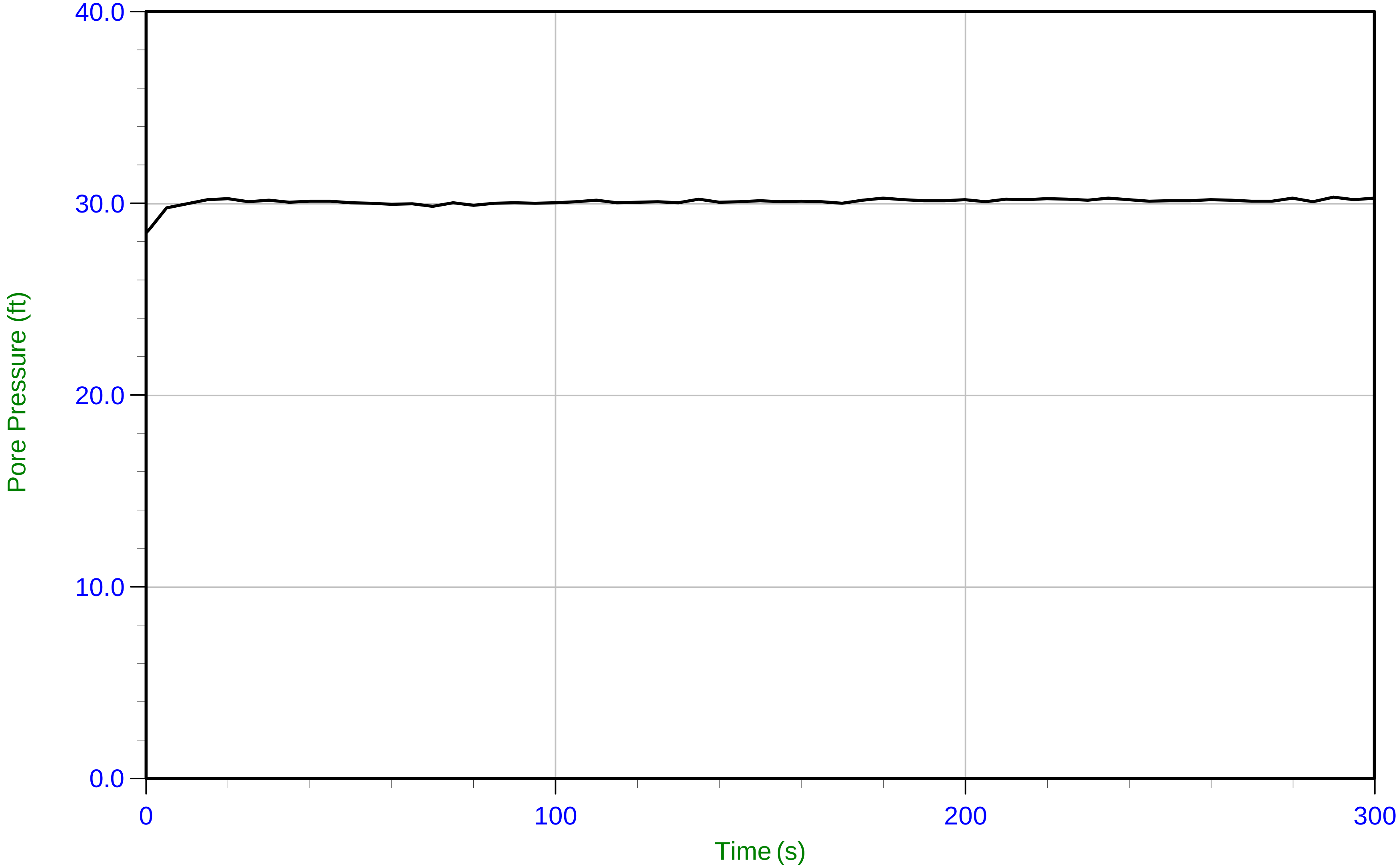
Filename: 19-56124_CP-Hood-010C.PPF	u Min: 37.3 ft	WT: 6.187 m / 20.297 ft
Depth: 18.325 m / 60.121 ft	u Max: 39.8 ft	Ueq: 39.8 ft
Duration: 305.0 s	u Final: 39.8 ft	

CONETEC

GEI

Job No: 19-56124
Date: 10/25/2019 08:44
Site: Hood

Sounding: GEI-Hood-011C
Cone: 499:T1500F15U1K Area=15 cm²



Trace Summary:

Filename: 19-56124_CP-Hood-011C.PPF
Depth: 9.750 m / 31.988 ft
Duration: 300.0 s

u Min: 28.5 ft
u Max: 30.3 ft
u Final: 30.3 ft

WT: 0.539 m / 1.769 ft
Ueq: 30.2 ft

Soil Sample Summary

CONETEC

Job No: 19-56124
Client: GEI Consultants
Project: Small Communities
Start Date: 19-Aug-2019
End Date: 28-Aug-2019

SOIL SAMPLE SUMMARY

Sounding ID	Sample Intervals (ft)	Sampling Date	Northing[1] (m)	Easting[1] (m)	Elevation[2] (ft.)	Samples Taken[3]	Refer to Notation Number
GEI-Hood-001C	1.0 - 3.0 5.0 - 7.0 8.0 - 10.0	28-Aug-2019	4249187	629280	14	6	
GEI-Hood-002C	2.0 - 5.0 6.0 - 8.0 10.0 - 14.0	28-Aug-2019	4250216	629936	13		4
GEI-Hood-003C	5.0 - 7.0 9.0 - 11.0 15.0 - 17.0	27-Aug-2019	4251212	629972	29	6	
GEI-Hood-004C	7.0 - 9.0 16.0 - 18.0 19.0 - 21.0	27-Aug-2019	4251216	630257	27	6	

1. The coordinates were acquired using consumer grade GPS equipment, datum: WGS 1984 / UTM Zone 10 North.
2. Elevations are refrenced to the ground surface and are derived from Google Earth Elevation for the recorded coordinates.
3. Refers to the number of 12 inch samples taken.
4. No recovery, hand augered to 3 feet to collect sample

Appendix C

GEI Consultants

Consulting
Engineers and
Scientists

Geotechnical Exploration Work Plan

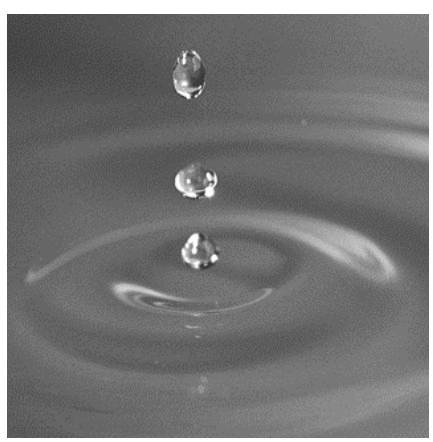
Sacramento County Small Community of Hood

Sacramento County, California

Submitted to:
Sacramento County Department of Water Resources
827 Seventh Street, Room 301
Sacramento CA 95814

Submitted by:
GEI Consultants, Inc.
2868 Prospect Park Drive, Suite 310
Rancho Cordova, CA 95670

Date: August 2019
Project No. 1800776



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Abbreviations and Acronyms

ASTM	American Society for Testing and Materials
CAL	Standard California Sampler
CPT	Cone Penetration Testing
DWR	California Department of Water Resources
FEMA	Federal Emergency Management Agency
GEI	GEI Consultants, Inc.
GPS	Global Positioning Satellite
HASP	Health and Safety Plan
District	Marin County Flood Control and Water Conservation District
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
QA/QC	Quality Assurance/Quality Control
SMART	Sonoma Marin Area Rail Transit
SPT	Standard Penetration Test
USA	Underground Service Alert
USACE	United States Army Corps of Engineers

1 Introduction and Background

1.1 Project Overview

1.1.1 Background

GEI Consultants, Inc. (GEI) is assisting Sacramento County (County) in DWR's Small Community Flood Risk Reduction Program (Project) for the community of Hood. Hood is located approximately 18 miles south of Sacramento (Figure 1). The community of Hood is protected by a portion of the Maintenance Area (MA) 9 levee constructed along the left bank of Sacramento River (California Department of Water Resources [DWR] Non-Urban Levee Evaluation [NULE] Segment 106. Additionally, former railroad embankments are present along the southern extent of Hood and to the east of the community. To the north of Hood, along the Reclamation District (RD) 744 boundary, a cross-levee embankment runs between the MA 9 levee (NULE Segment 106) and the former railroad embankment.

Exploratory borings were previously performed along Sacramento River levee left bank, but are sparse and were drilled between the 1950's and 1990's. Existing subsurface data is limited and previous assessments are based primarily on non-intrusive studies. Geotechnical exploration and evaluations are needed to further understand and characterize the levee and foundation composition and conditions, including the depth of the aquiclude layer.

This work plan describes the objectives of the geotechnical exploration and laboratory testing program and the methods and equipment that will be used. This project includes collection of soil samples and in-situ data, detailed descriptions of embankment and foundation conditions, and laboratory testing to support geotechnical evaluation and development of feasibility-level repair recommendations.

1.1.2 Purpose and Scope

The purpose of the geotechnical exploration and laboratory testing project is to collect additional site-specific subsurface information regarding soil properties and geotechnical conditions of the levee embankment and underlying foundation. The results of the exploration program will be used to help fill in the data gaps where no past explorations have been performed. GEI and its subcontractors have planned to complete 10 cone penetration tests (CPT's) approximately 15 feet or more from the landside toe for the

State Plan Flood Control (SPFC) levees and through the levee crown on Non-SPFC levees protecting the community of Locke (Figure 2).

The field explorations will be performed using ConeTec, Inc. from San Leandro, California. Explorations are expected to begin the week of August 19, 2019 and be completed by August 22, 2019.

This work plan describes the relevant information associated with the current exploration program and includes the proposed exploration locations (Figure 2), exploration methods, depths, types of samples, and a general plan for laboratory testing of collected samples. A site-specific Health and Safety Plan (HASP) has been prepared for this exploration program (Appendix E).

This Plan's scope is limited to:

- Reviewing existing data and planning/layout of proposed subsurface explorations;
- Performing the following geotechnical explorations:
    - 2 CPTs landward of the landside toe of the Sacramento River left bank;
    - 2 CPTs landward of the landside toe of the RD 744 Cross Levee;
    - 4 CPTs landward of the landside toe of the East railroad embankment;
    - 2 CPTs landward of the landside toe of the South railroad embankment;
- Documenting final CPT locations;
- Geotechnical laboratory testing;
- Providing final CPT logs and report.

Information collected during the subsurface exploration program will be documented in a Geotechnical Evaluation Report.

1.2 Site Description

The project area is in Sacramento County along 4 segments comprised of the levees and former railroad embankments surrounding the community of Hood as shown in Figure 1. Hood is protected to the west by an approximately 2.5-mile portion of the Maintenance Area (MA) 9 levee constructed along the Sacramento River right (eastern) bank extending from the Reclamation District (RD) 744 cross levee to the railroad embankment immediately south of Hood. Additionally, there is 2.4 miles of former railroad embankment to the east, a 0.25-mile cross levee to the north that extends from the MA 9 left bank to the eastern railroad embankment, and 0.6 miles of railroad embankment along the south end of Hood. This levee system protects an area of approximately 700 acres, which includes numerous farms and agricultural-related businesses.

1.3 Existing Data Summary

Based on review of existing subsurface data, there are total of five explorations along approximately 2.5 miles of the Sacramento River levee protecting the community of Hood, as shown on Figure 2. The borings are derived from DWR's 1958 Salinity Control Barrier Investigations (2 borings), and 1964 and 1993 USACE investigations (3 borings). Available log information for the 5 borings is limited to profiles without detailed material descriptions. Some index test laboratory results are indicated on the profiles, but detailed results are not available. Profiles of these historic explorations are in Appendix A.

The locations of the identified historic explorations by others are shown for reference in Figure 2, along with the proposed GEI explorations.

1.3.1 Foundation Conditions

Geomorphology mapping developed for the DWR NULE project (Figure 3) indicates the levee along the Sacramento River left bank that protect the community of Hood primarily overlies historical and Holocene overbank deposits (Rob and Hob) likely consisting of interbedded sand, silt, and clay deposited during high-stage flow, overtopping channel banks. A localized area of a Holocene distributary channel deposits (Hdc) is mapped near LM 16.7. The distributary channel deposits likely contain sand, silt, and clay from channelized flow conducting sediment to the floodplain. A borrow pit (present in 1937) is mapped on the landside of the levee approximately 0.4-miles downstream from the RD 744 cross levee.

While the RD 744 cross levee and former railroad embankments surrounding the community of Hood were not a part of the NULE project assessment, the geomorphologic mapping (Figure 3) does cover their extents. The RD 744 cross levee is mapped overlying historical overbank deposits (Rob) with borrow pits (present in 1937) in Holocene basin deposits (Hn) mapped along the south side of the cross-levee. The basin deposits are likely to contain fine sand, silt, and clay.

The railroad embankment to the east overlies historical and Holocene overbank deposits (Rob and Hob) along the northern half, with a localized area near the middle of the segment overlying Holocene Marsh deposits (Hs), and the southern half overlying lower member Pleistocene Riverbank Formation (Qrl). The Marsh deposits likely consist of silt and clay and are organic-rich. The lower member Riverbank Formation is likely composed of consolidated dense to very dense alluvium consisting of gravel, sand silt, and minor clay. Along the northern portion of the embankment, there is a waterside bench and a borrow pit (present in 1937) is mapped adjacent to the embankment.

The railroad embankment to the south of Hood is mapped to overly lower member Pleistocene Riverbank Formation (Qrl) along the eastern half and Holocene Basin deposits (Hn) to the west with small extents of historical and Holocene overbank deposits closest to the Sacramento River levee. A localized area of a Holocene channel deposit (Hch) likely containing well sorted sand and trace fine gravel is also mapped through the basin deposits. A borrow pit (present in 1937) is also mapped on the south side of the embankment for most of the extent.

Existing subsurface data from the borings along, or near, the levee north of the community of Hood show a fine-grained blanket layer that varies in thickness from about 12 feet to more than 25 feet below the natural ground surface. The blanket layer is underlain by a pervious aquifer, but the borings were generally shallow or not deep enough to confirm the depth to a deeper aquiclude layer. Only one of the borings was drilled through the levee and shows a levee embankment of sand and silty sand to sandy silt.

2 Health and Safety Plan, Permitting, and Clearances

2.1 Site Specific and Drilling Contractor Health and Safety Plans (HASPs)

A site-specific Health and Safety Plan (Site HASP), included in Appendix E, was prepared by GEI prior to commencing field work, to cover work performed by GEI field personnel. All work performed by GEI personnel will comply with the HASP. The drilling contractor will be required to prepare a Health and Safety Plan for their specific operations (Driller HASP) and the protection of their employees. Copies of the Driller HASPs must be provided to GEI prior to the initiation of any Project field exploration activities. If GEI personnel observe the drilling crew not following the Driller's health and safety policies, we will remind the crew of the need to comply. If they fail to do so, we will contact and inform Driller's management of the situation. If GEI personnel observe an obvious and serious failure to comply with the Driller's HASP requirements, and if the drilling crew continues to be non-compliant, operations will be shut down until the safety issue is resolved.

The drilling contractor has the sole Health and Safety responsibility for their operation. However, GEI will be vigilant in our assessment of conditions related to our work and the driller's work with respect to maintain a safe work environment. Safety tailgate meetings accompanied with sign-in sheets (Appendix D) will be conducted prior to beginning work each day and a copy of the Site HASP (Appendix E) will be kept on-site. GEI does not intend to complete an inspection checklist for ConeTec's equipment.

2.2 Permits

At the direction of the District, GEI obtained drilling permits, right of entry permits, county well permits, and an Environmental Health Services permit for the work included in this Plan.

Copies of these permits, included in Appendix B, required to perform field work will be kept on-site during the exploration.

2.3 Utility Clearance

Before exploration activities begin, Underground Service Alert (USA) requires a visual inspection at each exploration location. GEI has completed the visual inspection, and outlined each location with stakes and white paint. USA was contacted prior to any subsurface exploration with a minimum of 48 hours prior to the start of drilling. A USA ticket number, as well as clearance date, expiration date and call-back-to-extend date, was obtained for each work area and documented for the project file. Table 1 includes the USA ticket number for each exploration.

Exploration locations may be hand cleared (hand augered) for the upper five feet as directed by the field engineer/geologist. Hand auger borings will be monitored and logged by the GEI representative on site.

Proximity to overhead utilities will be evaluated at each exploration location. In general, a clearance of at least 15 feet will be maintained between a drill rig mast and any overhead utilities (i.e., power lines), including during mobilization when traversing the access roads leading to the exploration locations.

2.4 Organization and Communication

The key point of contact for all communication related to the exploration activities is the GEI Project Manager. The GEI Project Manager will be a licensed Professional Geologist and Certified Engineering Geologist in the State of California. The GEI Project Manager will communicate with the District regarding progress updates or any issues that warrant input. Contact information is provided in Table 2.

During field activities, the GEI Field Engineer/Geologist (point-of-contact on site) will prepare daily field reports summarizing work performed, footage drilled/explored, personnel and equipment on-site, and other related project information. Sample field forms are included in Appendix D. Daily field reports will be complied and provided to GEI's Project Manager.

Geotechnical data, including CPT logs and laboratory test results will be provided to the District in the Geotechnical Data Report.

Field exploration roles and responsibilities are as follows:

2.4.1 GEI Field Engineer/Geologist

- Reports daily to the GEI Project Manager
- Facilitates daily safety meetings
- Coordinates field logistics
- Supervises CPT activities
- Analyzes CPT report and identifies sampling depths

- Prepares field logs
- Labels and stores all recovered samples
- Communicates with the Project Manager, CPT subcontractor, utility locator, and site visitors

2.4.2 GEI Project Manager

- Coordinates program with personnel responsible for clearances (county and city)
- Monitors and supervises ongoing field activities
- Monitors exploration progress
- Coordinates and reviews daily reports compiled by field personnel
- Reviews and approves field logs
- Reviews field staff labor costs and driller invoices
- Communicates with field engineer(s)/geologist(s), Project Management team, and the District

3 Subsurface Exploration Plan

3.1 Overview

Prior to drilling, field personnel will review the field exploration program with the GEI Project Manager. Required permits and sub-consultants license are included in Appendix B and C, respectively.

This review provides the basis for field work completion and offers field personnel the opportunity to raise any questions regarding project scope, procedures, schedule, or any issue that may not be clearly understood. Items discussed during this pre-drilling meeting include:

- Health and safety
- Goals, objectives, and scope of the field explorations
- Project schedule
- Sampling procedures and sample requirements for laboratory testing
- Criteria for the final depth of explorations
- Site access and client contacts
- Utility clearance
- Permits and security
- Potential of encountering hazardous materials
- Backfill requirements
- Disposal of cuttings and drill fluids
- Erosion control requirements, if necessary
- Site restoration requirements
- Applicable standards (ASTM, etc.) to be implemented

All fieldwork will be summarized daily using a Daily Field Report (Appendix D).

3.2 Objectives

The purpose of the exploration program is to define (or refine) site-specific information regarding soil properties and geotechnical conditions of the levee embankment and underlying foundational strata for engineering analyses required for the feasibility level analysis and evaluation. The focus of the geotechnical explorations will be on refining subsurface conditions of the study area, investigating the presence, thickness, extent(s), engineering properties, and depth of the fine-grained compressible layers. In addition, where appropriate, data will be obtained to either confirm or refine assumptions made in previous analyses.

3.3 Exploration Locations and Techniques

Geotechnical CPT explorations will be conducted at locations shown on Figure 2. A total of 10 CPTs are planned along the Sacramento River right (eastern) bank landside toe, Meadows Slough right (northern) bank crown, and Snodgrass Slough right (western) bank crown. A summary of the exploration locations and types is below:

Planned Explorations:

- Sacramento River left bank, NULE Segment 106 (SACR-L) - 2 CPTs
- RD 744 Cross Levee Embankment (HNCL) - 2 CPTs
- East Railroad Embankment (HDERR) - 4 CPTs
- South Railroad Embankment (HDSRR) – 2 CPTs

Exploration locations, types, and targeted depths are summarized on Table 1.

3.3.1 CPT Explorations

Continuous CPT soundings will be performed to log foundation sediments using a truck-mounted or track-mounted 20- to 30-ton capacity cone apparatus in general accordance with ASTM D5778. The typical track-mounted CPT operation includes the track-mounted CPT rig, a 2-axle supply/water support truck with trailer, and a personal vehicle for the field personnel. The conventional instrumented cone assembly includes a cone tip with a 60-degree apex and a cross-sectional area of 10 or 15 square centimeters (cm^2), a sleeve segment with a surface area of 200 cm^2, and a pore pressure transducer near the base (shoulder) of the cone tip. The CPT hole diameter is approximately 2 inches.

Prior to the start of testing, the rig is jacked up and leveled on four pads to provide a stable and level reaction for the cone thrust. During the test, the instrumented cone is hydraulically pushed into the ground at a rate of about 2 centimeters per second (cm/s), and readings of cone tip resistance, sleeve friction, and pore pressure are digitally recorded every second. As the cone tip advances, additional cone rods are added such that a "string" of rods continuously advances through the soil. As the test progresses, the CPT operator monitors the cone resistance and its deviation from vertical alignment.

Interpretation of the cone parameters are performed by on-board computers. Soils are classified based on the soil behavior type, which is an interpretation based on cone tip resistance and friction ratio. Cone resistance is typically high in sands and low in clays. Sampling and testing will help confirm the soil behavior type identified by the CPT. A continuous log of the soil is produced on a real-time basis.

Pore-pressure dissipation tests will be conducted in predominantly granular materials below the water table to determine approximate water levels and provide estimates of hydraulic conductivity. In a dissipation test, the CPT sounding is advanced to the test depth, or as directed by the field engineer/geologist, and then halted. In clays, pore pressure data is then recorded until approximately 50 to 75 percent of the induced excess pore pressure is dissipated, or to a maximum duration of approximately 30 minutes. In sands, pore pressure dissipation tests are generally conducted until 100 percent of the excess pore pressure is dissipated. All pore pressure data during the test are digitally recorded for subsequent analyses. After the dissipation test data are recorded, cone advancement is resumed. At the conclusion of each test, the electronic data are stored for further processing in the office. The direct push samples will be labeled in accordance with the naming convention described below.

3.3.1.1 Soil Sample Naming Convention

Soil samples will be clearly labeled with the following:

- GEI project number
- CPT exploration number
- sample identification number
- depth of sample
- date collected

The sample identification number consists of four primary identifiers. The first identifier will be the Sample Number and will be used to represent the sequence of sampling within the hole. The Sample Number will be numbered consecutively from the top of the hole to the bottom. For example, the sampling interval number for the first sample to be pushed in a given hole will be “1”, the sampling interval number for the second sample will be “2”, the sampling interval number for the third sample will be “3”, etc. Sample Numbers will be assigned for each sampling interval, even in situations where there is no sample recovery.

3.3.1.2 Soil Sampling and Frequency

Soil sampling will consist of advancing a second CPT probe adjacent to the first CPT and sampling at depths selected by the field engineer/ geologist on site. Samples will be bagged, and selected samples will be laboratory tested to confirm the soil behavior type shown on the CPT output.

3.4 Exploration Depths

The anticipated boring depths are included in Table 1. All proposed explorations are planned to reach a minimum of 40 feet or four times the levee height below ground surface to obtain a better understanding of the extents of the fine-grained layers encountered in previous explorations and determine the extents of these materials throughout the study area. The exploration depth typically range between 70 - 100 feet, with final termination depth determined by the field engineer/ geologist.

3.5 Hours of Operation

Normal exploration activities will be between about 7 AM and 5 PM. Drill rig maintenance activities will be performed during normal working hours.

3.6 CPT Reports

A field summary will be completed for every exploration. The field engineer/geologist should record the following information on the CPT field stratigraphy print out:

- Project name
- Project number
- Exploration number
- Start/ completion date
- CPT hole diameter
- Type of CPT rig
- Rig driller's name and helpers
- Exploration location (crown, landside toe, etc.)

As the exploration progresses and is completed, the field engineer/geologist should complete the following information on the log:

- The depth of encountered groundwater
- Method of backfilling

3.7 Access, Traffic Control, and Staging

Traffic control measures, including the placement of caution tape, cones, and signs around the drilling operation, will be used during drilling at some locations where pedestrian, bicycle, or vehicle traffic occurs, or limited property access exists. A staging area will be arranged for the overnight storage of equipment and supplies.

Levee toe areas are unpaved. Rainfall should not impact CPT operations unless the ground at a given boring location becomes too soft to mobilize a CPT truck or track rig, high water impounds against the levee, or lightning is present. Investigations will be terminated if lightning appears likely or if, in the opinion of the project team, water against the riverbank is too high. The GEI HASP states that work can resume 30-minutes after the last clap of thunder or flash of lightning. CPTs will be suspended if the river level is forecast to rise above the levee foundation.

3.8 Exploration Completion and Site Restoration

In accordance with county requirements, all CPTs will be backfilled with cement-bentonite grout (up to 5 percent bentonite) at the completion of drilling. The grout proportions and quantities will be recorded on the field CPT print out.

Grout will be placed into the hole by tremie method through a pipe placed at the bottom of the borehole. The end of the tremie pipe will be kept submerged in the grout as it fills the borehole and rises. The hole is to be grouted to 5 feet of the ground surface with the cement-bentonite grout mix. The remaining 5 feet will be backfilled with hydrated bentonite chips. Explorations will be backfilled the day that the hole is completed. At the end of the day, the holes are revisited and topped off with additional grout mix if needed.

Drill sites will be cleaned and restored as closely as practicable to pre-exploration conditions. At completion, all equipment, materials, tools, and unused materials will be removed, and trash will be disposed offsite.

3.9 Documentation of Exploration Locations

The locations of explorations will be documented using hand-held GPS unit. After completion of the exploration program, the exploration location will be confirmed or refined using physical features on the ground and aerial imagery. The elevations will be estimated from available topographic surveys using a horizontal datum of NAD83 and vertical datum in NAVD88.

4 Geotechnical Laboratory Testing

4.1 Material Sampling and Testing Protocols

Geotechnical laboratory tests will be performed on selected samples obtained from the borings to assist with characterization of the geotechnical engineering properties of the subsurface materials. The geotechnical laboratory testing will be performed by Geocon Consultants, Inc. (Geocon) in their Rancho Cordova, CA laboratory. This program is subject to modification based on actual conditions encountered, and on the judgments of the GEI Project Manager.

4.2 Geotechnical Laboratory Testing Program

Geotechnical laboratory testing will be performed on selected soil samples collected in the field to aid in soil classification and development of engineering parameters for geotechnical evaluations. Laboratory testing will be performed in general accordance with ASTM standards and will be focused on characterization of the composition of the levee embankment and foundation materials.

Soil sample laboratory testing may include Atterberg limits, grain-size distribution, in-situ moisture content and density (unit weight), shear/compressive strength, and consolidation tests, as appropriate. The number and type of geotechnical laboratory tests will be determined based on the subsurface conditions and stratigraphic units encountered in the CPTs and determined by the GEI Project Manager.

The list below summarizes possible laboratory testing, but is not limited to the following:

- Sieve Analysis, ASTM D422
- #200 Sieve Wash, ASTM D1140
- Moisture Content and Density of Soils, ASTM D2937
- Atterberg Limits, ASTM D4318
- Organic Content, ASTM D2974

5 Quality Assurance/ Quality Control (QA/QC)

5.1 Field Log and Data QC

Field quality control measures will be provided through senior engineering geologist oversight of the field activities throughout the duration of the geotechnical investigations.

GEI personnel are responsible for collecting and transporting soil samples to the soil testing laboratory, processing laboratory test results, and adjusting field logs based on laboratory test data.

Creating logs for this project includes:

- Field sampling and CPT reports.
- Quality check of field observations.
- Preparation of a draft gINT log.
- If laboratory tests are performed on samples recovered from explorations, soil classifications and descriptions will be refined as appropriate based on test results.
- CPT data will be compared with laboratory data and nearby explorations.
- Final draft CPT logs will be prepared based on adjustments for laboratory tests and subsequent quality checks.
- Final draft logs in gINT format will be reviewed by the Project Manager and any necessary final adjustments will be made prior to delivery to the County.

6 Public Awareness

All field personnel will be trained and informed to not provide opinions when approached by members of the general public or press who are seeking information regarding the Courtland Community Levee Evaluation Project. Rather, field personnel will explain that Sacramento County consultants are inspecting and documenting the subsurface conditions along the Sacramento River, Meadows Slough, and Snodgrass Slough levees. Field personnel will log the date and time of contact with members of the public, name of the person making the inquiry, and subject of the inquiry.

7 References and Documentation of Previous Explorations

AASHTO (1988). *Manual on Subsurface Investigations, Revision 1*. American Association of State Highway and Transportation Officials (AASHTO).

ASTM D422. *Standard Test Method for Particle-Size Analysis of Soils.*

ASTM D1140. *Standard Test Method for Amount of Material in Soils Finer than No. 200 (75µm) Sieve.*

ASTM D1587. *Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes*.

ASTM D2487. *Standard Practice for Classification of Soils for Engineering Purposes (United Soil Classification System)*.

ASTM D2488. *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).*

ASTM D2937. *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*.

ASTM D2974. *Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils*.

ASTM D4318. *Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.*

ASTM D4633. *Standard Test Method for Energy Measurement for Dynamic Penetrometers.*

ASTM D5778. *Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.*

Terzaghi and Peck (1967). *Soil Mechanics in Engineering Practice*. Karl Terzaghi and Ralph Peck, Wiley, 1967.

Tables

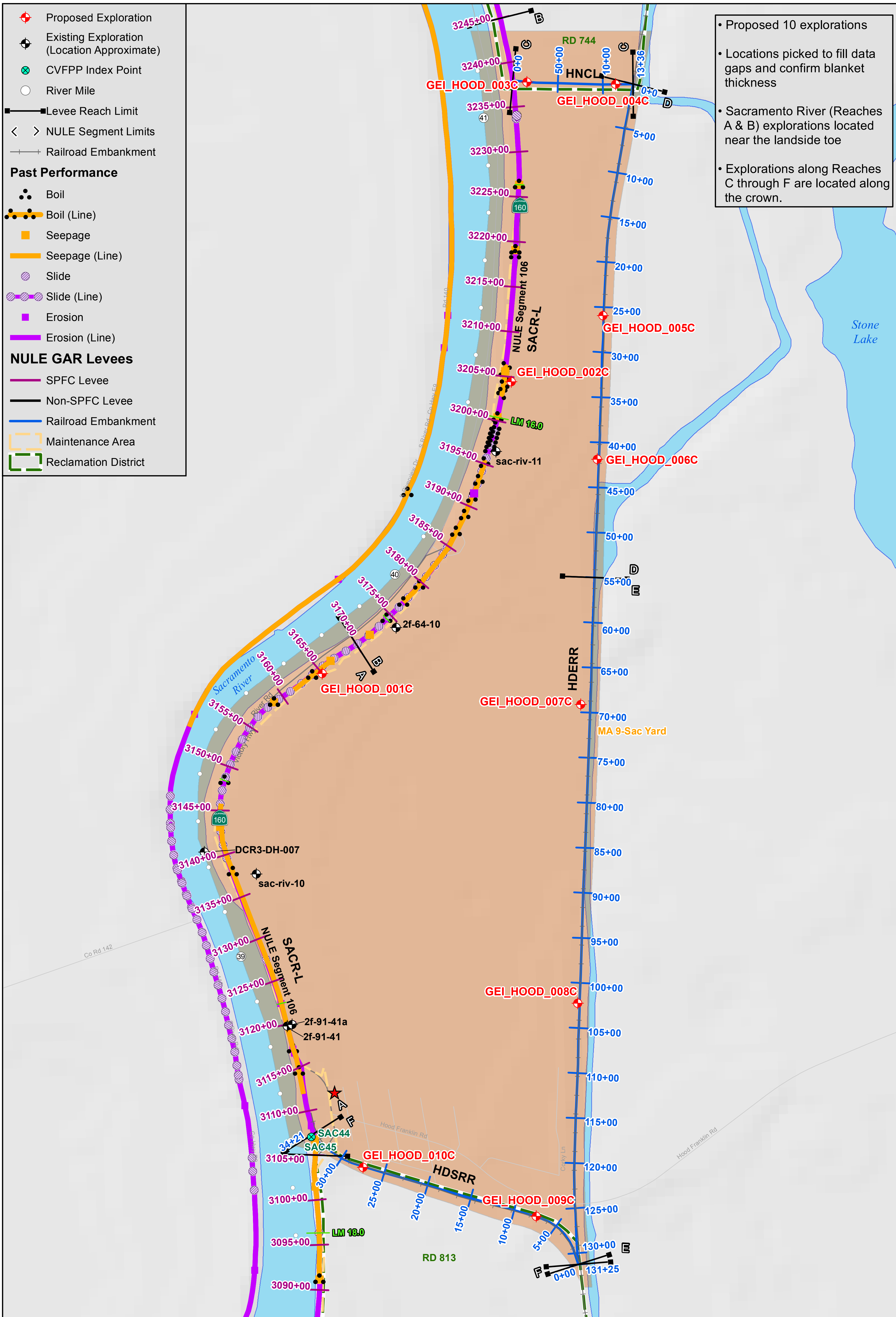
Table 1. Summary of Subsurface Explorations - Hood

Exploration ID	Latitude	Longitude	USA Ticket #	Parcel APN	Location of Exploration	Approximate Landside Levee Height	Proposed Exploration Depth (ft)
GEI_HOOD_001C	38.38174241	-121.5196263	X922002469	132-0120-001	Landside Toe	14	56
GEI_HOOD_002C	38.390597	-121.512248	X922003285	132-0010-016	Landside Toe	17	68
GEI_HOOD_003C	38.39972843	-121.5115791	X922003265	132-0010-005	Cross Levee Crown	9	36
GEI_HOOD_004C	38.39964418	-121.5081567	X922003275	132-0010-005	Cross Levee Crown	16	64
GEI_HOOD_005C	38.392599	-121.508693	X922500705	132-0010-010	Crown	15	60
GEI_HOOD_006C	38.388223	-121.508934	X922500667	132-0010-010	Crown	16	64
GEI_HOOD_007C	38.380763	-121.509628	X922101492	132-0010-042	Landside Toe	27	108
GEI_HOOD_008C	38.371657	-121.509813	X922500732	132-0120-090	Crown	15	60
GEI_HOOD_009C	38.36518	-121.51146	X922003234	132-0120-008	Crown	18	72
GEI_HOOD_010C	38.36670	-121.51814	X922003216	132-0120-008	Crown	18	72

Table 2. List of Contacts

Name	Role	Organization	Mailing Address	Email Address	Telephone	Cellular Telephone
Autumn Eberhardt	Regional Health & Safety Officer	GEI	2868 Prospect Park Drive, Suite 400, Rancho Cordova, 95670	AEberhardt@geiconsultants.com	(916) 631-4525	(631) 481-5094
Jeff Twitchell	Project Manager	GEI	180 Grand Avenue, Suite 1410 Oakland, CA 94612	jtwitchell@geiconsultants.com	(916) 631-4555	(916) 990-2569
Graham Bradner	Project Geologist	GEI	2868 Prospect Park Drive, Suite 310, Rancho Cordova, 95670	GBradner@geiconsultants.com	(916) 631-4577	(916) 709-3833
Nichole Tollefson	Project Engineer	GEI	2868 Prospect Park Drive, Suite 400, Rancho Cordova, 95670	ntollefson@geiconsultants.com	(916) 631-4590	(916) 580-7030
Emily Pappalardo	Project Engineer	MBK	455 University Ave #100, Sacramento, CA 95825	pappalardo@mbkengineers.com	(916) 456-4400	(916) 205-0770
Nicole Cholewinski	Field Geologist	GEI	2868 Prospect Park Drive, Suite 310, Rancho Cordova, 95670	ncholewinski@geiconsultants.com	(916) 631-4584	(803) 524-1060
John Rogie	CPT Manager	ConeTec	820 Aladdin Avenue, San Leandro, CA 94577	jrogie@conetec.com	(510) 357-3677	(650) 346-1490
Clayton Bartholomew	CPT Manager	ConeTec	820 Aladdin Avenue, San Leandro, CA 94577	cbartholomew@conetec.com	(510) 357-3677	(925) 849-2989
David VonAsper	Grout Inspector	County of Sacramento	10590 Armstrong Ave, Suite A, Mather, CA 95655	To Schedule: (916) 875-8524	(916) 875-8467	(916) 591-2679

Figures



Small Communities
Flood Risk Reduction Program

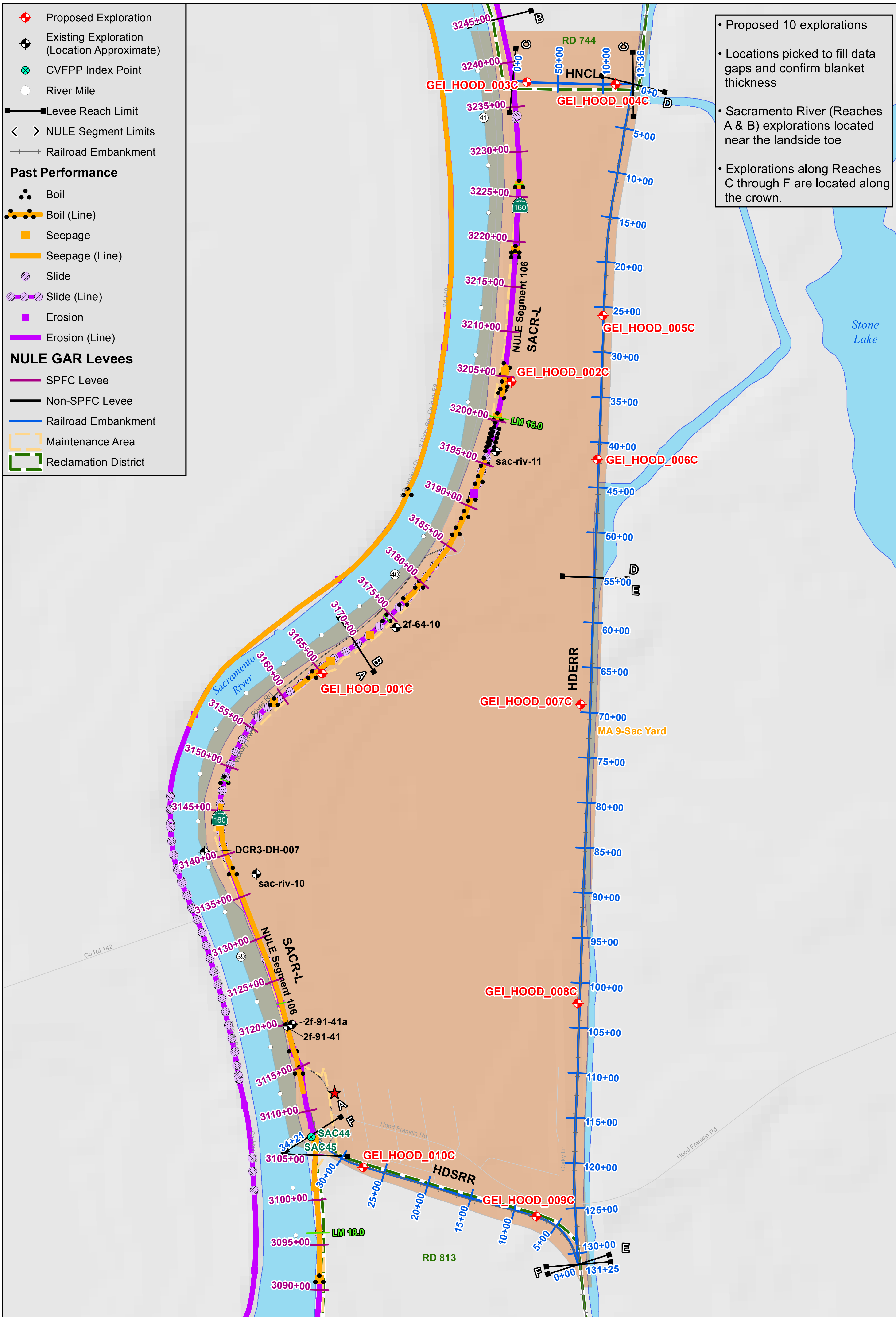
County of Sacramento

GEI Consultants

PROPOSED EXPLORATIONS AND PAST PERFORMANCE COMMUNITY OF HOOD

JULY 2019 | DRAFT | FIGURE

Z:\Projects\1800776_Hood\ProposedExplorations\ProposedExplorations_PastPerformance.mxd RS 12Jul2019



SOURCE:

1,000 500 0 1,000
Feet

Small Communities
Flood Risk Reduction Program

County of Sacramento

GEI Consultants

PROPOSED EXPLORATIONS AND PAST PERFORMANCE
COMMUNITY OF HOOD

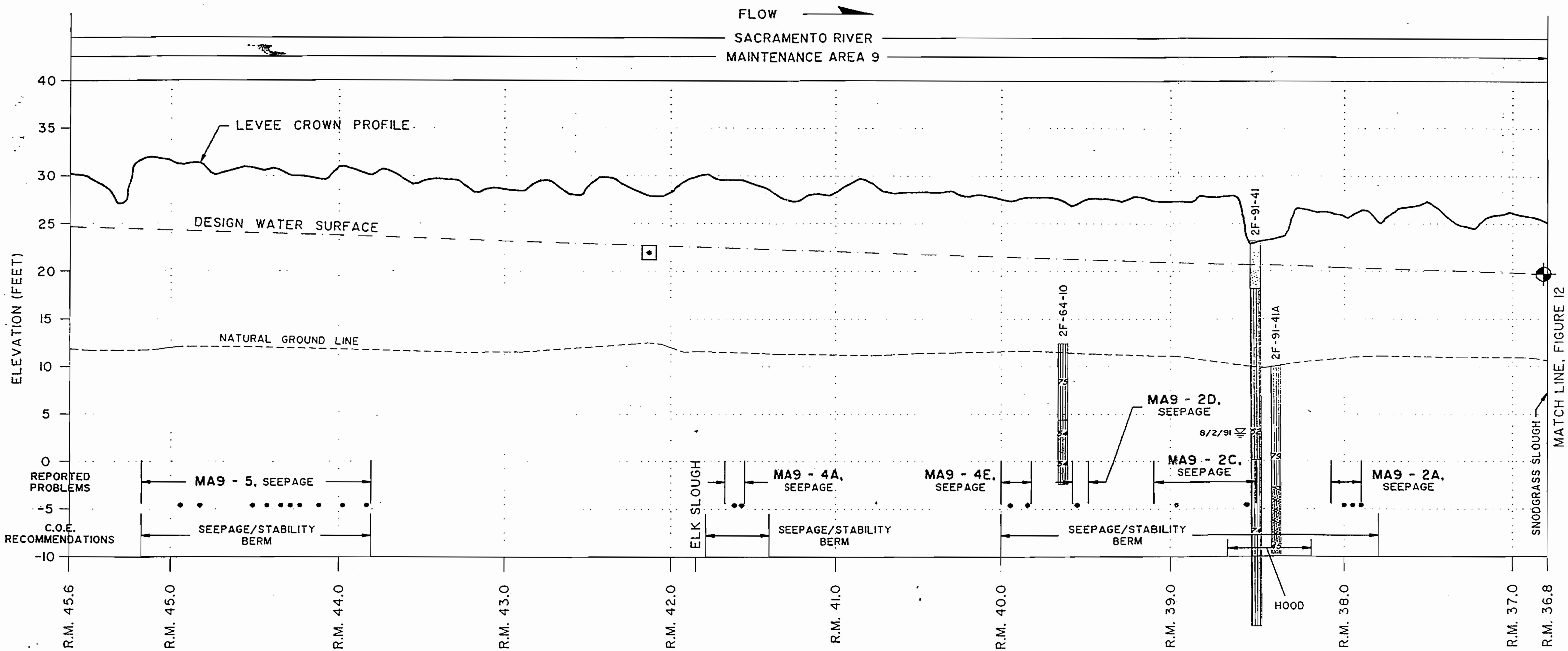
JULY 2019 DRAFT FIGURE

12Jul2019 Z:\Projects\1800776_Hood\ProposedExplorations\Hood_ProposedExplorations_PastPerformance.mxd RS

Appendix A

Historic Boring Logs

GEI Consultants



SCALE: 1" = 3000'

NOTES:

1. REFER TO FIGURE 6 FOR NOTES.

LEGEND

- SILT (>70% FINES)
- SILTY SAND OR SANDY SILT (12%-70% FINES)
- CLAY (>70% FINES)
- CLAYEY SAND OR SANDY CLAY (12%-70% FINES)
- SAND (<12% FINES)
- OH
- 1986 BOIL LOCATIONS
- CLAY (HIGH PLASTICITY, CH)
- PEAT
- PERCENTAGE OF FINES (MINUS 200 SIEVE SIZE) PER LABORATORY TESTING
- FEBRUARY 1986 HIGH WATER MARKS
- SURVEYED
- STAGE RECORDERS

SACRAMENTO RIVER
FLOOD CONTROL SYSTEM EVALUATION
LOWER SACRAMENTO AREA, PHASE IV

LEVEE PROFILES
SACRAMENTO RIVER
LEFT BANK - R.M. 36.8 TO 45.6

SACRAMENTO DISTRICT, CORPS OF ENGINEERS

PREPARED BY: D. RICKETTS
DRAWN BY: R. IWASA
FEBRUARY 1993

FIGURE 11

PCA-1 to 11

PCA-1

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF DESIGN AND CONSTRUCTION
PROJECT GEOLOGY BRANCH

DRILLING AND SAMPLING LOG

DELTA FACILITIES
PERIPHERAL CANAL

HOLE NO. PCA-1

ELEV. +11.6' (Surveyed)

FEATURE Hood to Mokelumne River DEPTH 47.0'

LOCATION California Coordinates (Est.), Zone III; N. 679,450; E 1,708,200 COUNTY Sacramento

LOGGED BY P. D. Juette DATE DRILLED 4/11-13/66 WATER LEVEL 9.2' 4-12-66

DRILLING CO. J. N. Pitcher DRILLER Leo Mesenbrink DRILL RIG Failing 750

Note: Hole #1 - Cored with Pitcher core barrel, 3.0" I.D.
Drove standard penetrometer using 140 lb. hammer with 30" drop.
Hole #2 - Pushed or drove DWR 2-1/2" I.D. sampler.
Drilled with 4-5/8" drag bit.

1/ - Sample number and field density (PCF)

ELEV. (DEPTH)	CLASS.	DESCRIPTION Field Identification	1/ SAMPLE NUMBER #1	#2	MODE #2	#1	REMARKS #1	#2
(0.0)	CL	0.0-4.0 SILT: Moist; quick to moderately quick dilatancy; nonplastic to slight plasticity; slightly compact; dusky yellowish-brown.	PB-1	L-1A 121.7#; L-1B 109.3#; L-1D 103.8#	RD; P	RD; P	Augered to 1.0'; Pushed Shelby tube 1.0-3.5'; 3.5-5.5'	Augered 0.0-1.7'; Pushed 1.7-4.0'; 300#/.5; 475#/.5; 475#/.5; 500#/.5; 500#/.3
(4.0)	SC	4.0-9.4 CLAYEY SAND: Moist to saturated; low plasticity; no dilatancy to slow dilatancy; low dry strength; organic staining; 80% fine-grained subangular sand; 20% clay; slightly compact; dark yellowish-brown.	PB-2	L-2A 130.0#; L-2B 130.3#; L-2C 132.6#; L-2D 134.1#	RD; P	P; P	Pushed 5.5-8.0'; 8.0-10.0'	Pushed 6.3-8.6'; 100#/.5; 125#/.5; 150#/.5; 175#/.5; 300#/.3
(8.0)	CL	9.4-16.2 SANDY CLAY: Wet; medium plasticity; medium to low dry strength; 30 to 40% fine- to medium-grained sand; 70 to 60% clay; scattered small organic fragments; old root holes; crumbles like a sand but works into a clay; light olive-brown.	PB-3		RD	P; DR; RD	W.L. 9.2' 4-12-66; Drove 10.0-11.5'; 24/.5; 50/.5; 50/.3	
(12.0)								

SHEET 1 OF 3

DRILLING AND SAMPLING LOG

FEATURE Hood to Mokelumne River HOLE NO. PCA-1

ELEV. (DEPTH)	CLASS.	DESCRIPTION Field Identification	1/ SAMPLE NUMBER #1	SAMPLE NUMBER #2	MODE #2	MODE #1	REMARKS #1	REMARKS #2
(12.0)	CL	9.4-16.2 SANDY CLAY: Contd.	PB-3	L-3C 130.6#; L-3D 127.1#	DR; RD	RD; RD	Cored 11.5-14.0'; 14.0-16.5'	Pushed 12.0-12.3' 600#/.3; Drove 12.3-14.0' 6/.2 25/.5 22/.5 30/.5 30/.3
(16.0)	ML	16.2-18.5 SANDY SILT: Saturated; quick dilatancy; nonplastic; 20% fine-grained micaceous subangular to subrounded sand; 80% silt; loose; dark yellowish-brown.	PB-4	L-4B 122.1#; L-4C 123.0#; L-4D 120.5#	DR	DR; RD	Drove 16.5-18.0' 15/.5 27/.5 34/.5; Cored 18.0-20.5'; 20.5-23.0'	Drove 17.0-19.3' 8/.5 15/.5 16/.5 15/.5 10/.3
(20.0)	SP	18.5-23.0 SAND: With thin clay and silt stringers; saturated; fine- to medium-grained sand; sand is in beds of predominantly one grain size; micaceous; stringers of fines at: 20.0-20.3'; 20.5-20.7'; 21.6-21.7'; 22.1-22.2'	PB-5		RD	RD		
(24.0)	SP	23.0-36.0 SAND: Saturated; fine- to coarse-grained, mostly medium-grained sand in beds of predominantly one grain size; subrounded to subangular; micaceous in the fine-grained sand, little mica in the medium and coarse sands; loose; moderate olive-brown from 23.0 to 29.5'; olive gray from 29.5-36.0'.	PB-6	L-5C 126.9#; L-5D 124.0#; L-6B 123.5#; L-6C 122.5#; L-6D 124.4#	P; RD; P	DR; RD	Drove 23.0-24.5' 12/.5 12/.5 12/.5; Mixed bentonite drilling mud.; Cored 24.5-27.0'; 27.0-29.5'	Pushed 23.0-25.3' 400#/.5 500#/.5 600#/.5 650#/.5 650#/.5; Pushed 25.5-26.5' 400#/.5 600#/.5
(28.0)					RD	RD	Drove 29.5-31.0' 11/.5 17/.5 21/.5	Drove 26.5-27.8' 18/.5 20/.5 9/.3
(30.0)					DR	DR		

DWR 888 (2)

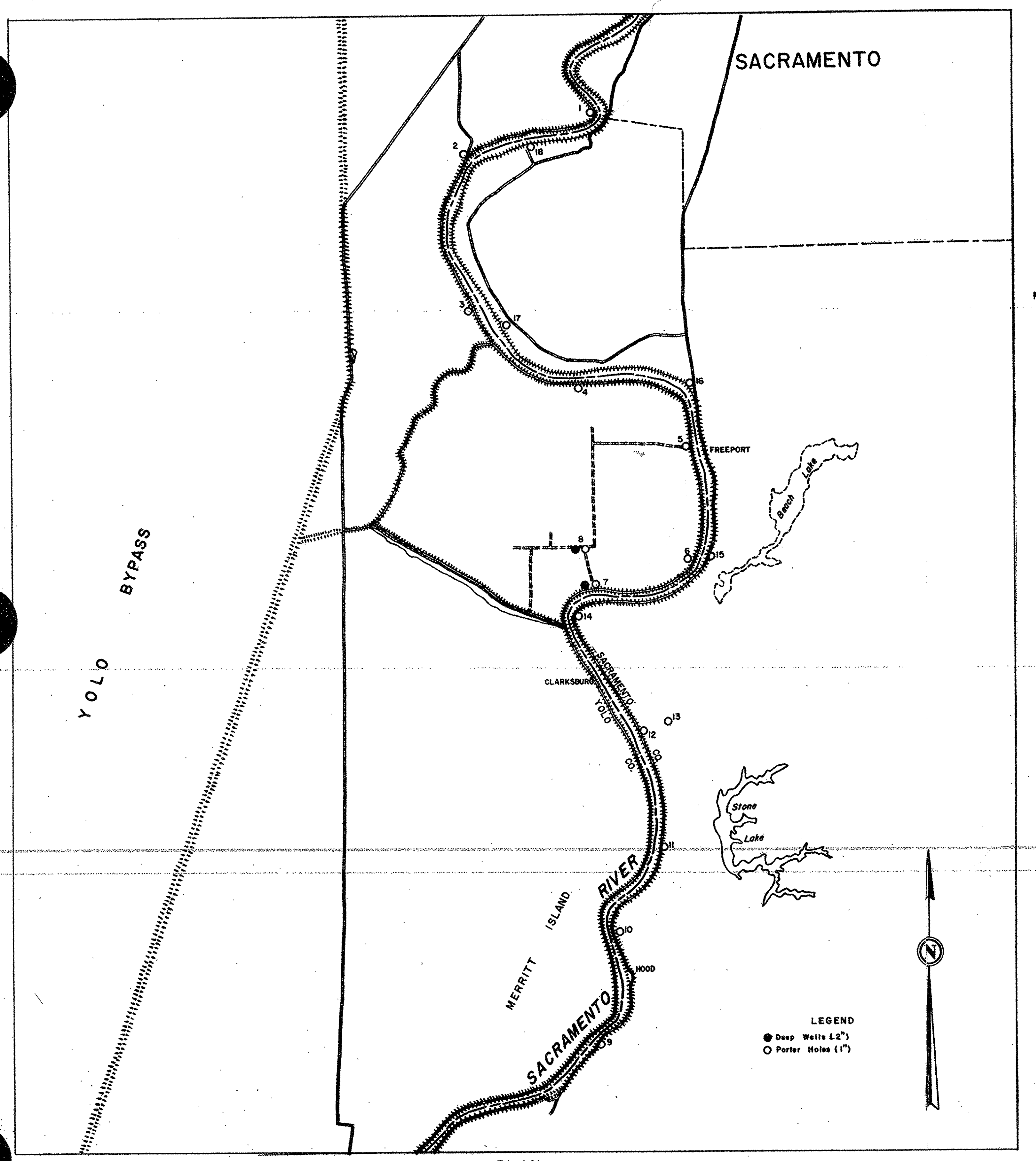
PCA-1

DRILLING AND SAMPLING LOG

FEATURE Hood to Mokelumne River HOLE NO. PCA-1

ELEV. (DEPTH)	CLASS.	DESCRIPTION Field Identification	1/ #1	SAMPLE NUMBER #2	MODE #2	MODE #1	REMARKS #1	REMARKS #2
(30.0)	SP	23.0-36.0 SAND: Contd.		L-7B 126.4#; L-7C 121.4#; L-7D 121.9#	DR; RD	DR; RD	Cored 31.0-33.5' 33.5-36.0'	Drove 29.5-31.8' 5/.5 10/.5 14/.5 17/.5 13/.3
(34.0)			PB-6	L-8B 129.4#; L-8C 124.9#; L-8D 132.1#	DR; RD	RD		Drove 32.5-34.8' 9/.5 13/.5 13/.5 17/.5 10/.3
(38.0)	CL	36.0-41.1 SANDY CLAY: Moist; medium plasticity; medium dry strength; stiff; "crumbles" but works into plastic clay with the addition of water; 35% fine-grained sand; 65% plastic fines; moderate yellowish-brown mottled with grayish-olive.	PB-7	L-9B 130.0#; L-9C 128.3#; L-9D 132.8#	DR; RD	DR; RD; RD	Drove 36.0-37.5' 10/.5 26/.5 37/.5; Cored 37.5-39.0' 39.0-41.0'	Drove 36.0-38.3' 9/.5 13/.5 15/.5 22/.5 21/.5
(42.0)	ML	41.1-47.0 SILT: Saturated; slow to quick dilatancy; slight plasticity to nonplastic; slightly compact; light olive-brown.	PB-8	L-10B 124.3#; L-10C 124.5#; L-10D 125.1#	DR	DR; RD; RD; RD	Drove 41.0-41.85' 25/.5 50/.35; Cored 42.0-44.5' 44.5-47.0'; Bottomed hole at 47.0' 4-12-66 Hole back-filled.	Drove 41.5-43.8' 21/.5 34/.5 46/.5 53/.5 35/.3; Bottomed hole at 43.8'; 43' of perforated downspout placed in hole, 1' stick-up. 4-13-66
(47.0)							Site marked with 4x 4" red and white post.	

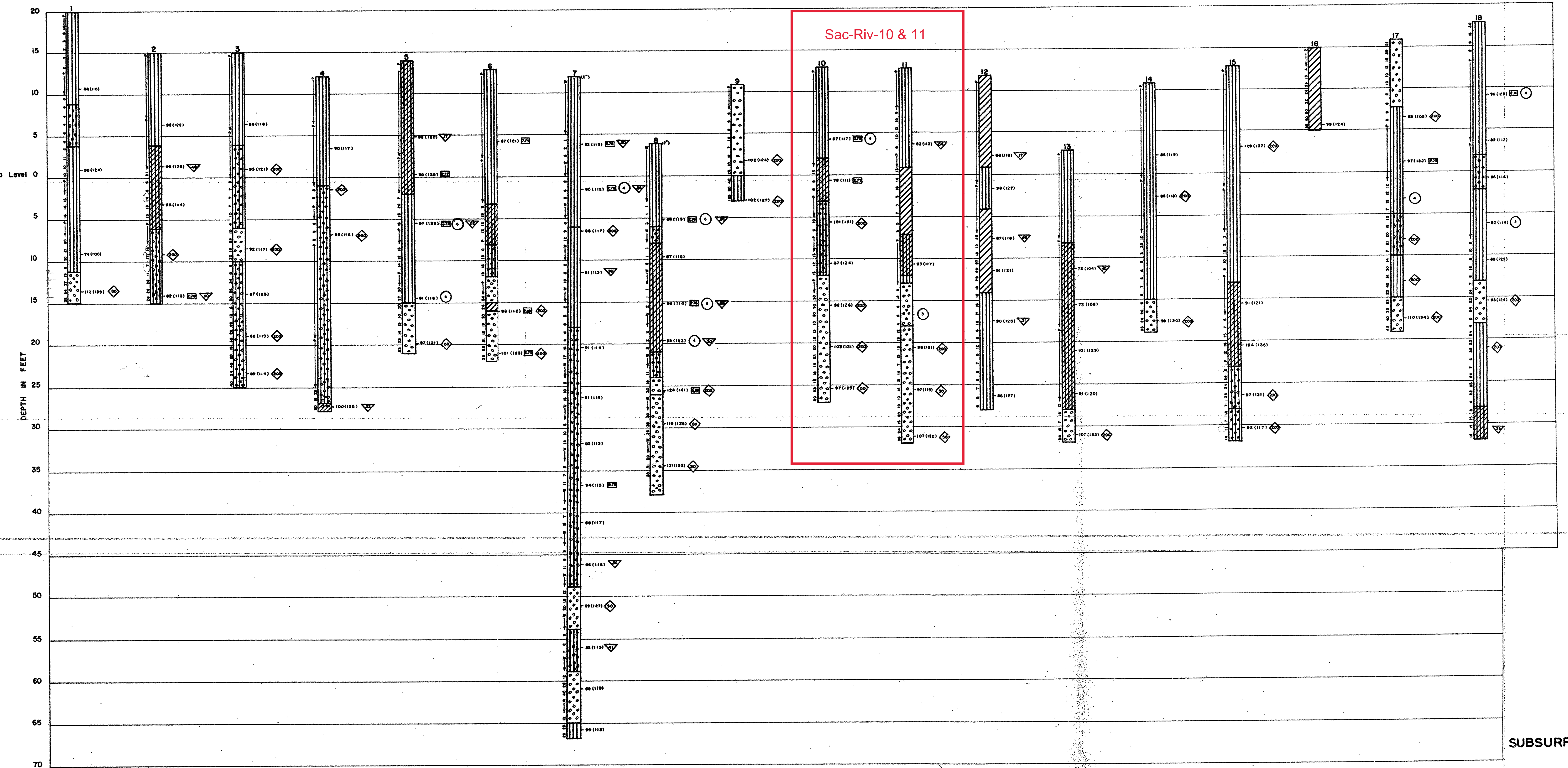
DWR 885 (2)



PLAN

SCALE IN FEET

4000 0 4000 8000 12000



PROFILE

SCALE AS SHOWN

NOTES:

GRAPHIC LOGS ARE BASED ON VISUAL CLASSIFICATION.
ALL BORINGS ARE ONE INCH DIAMETER, EXCEPT WHERE NOTED
HAMMER WEIGHT – 1" HOLES 100 & 116 lbs. 2" HOLES 175 lbs.

DRILLING DATES:
1" HOLES – MAR. 7, 1958 TO MAY 22, 1958
2" HOLES – APRIL 10, 1958

LEGEND

- W10P BLOWS PER FOOT (P INDICATES PUSH) (W INDICATES WASH)
- 9(70) DRY WET DENSITY IN POUNDS PER CUBIC FOOT
- UNCONFINED COMPRESSIVE STRENGTH, Kc Kg/cm^2
- UNCONFINED COMPRESSIVE STRESS AT 10% STRAIN, S_{10} Kg/cm^2
- LOSS ON IGNITION IN PERCENT
- MAXIMUM SIEVE SIZE RETAINING 50% OF SAMPLE BY WEIGHT, D_{50}
- SPECIFIC GRAVITY
- SILT
- PEAT
- CLAY
- SAND
- ORGANIC SILT
- ORGANIC CLAY
- SILTY PEAT
- SILTY CLAY
- SILTY SAND
- SAND, WITH SILT LENSES

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
SALINITY CONTROL BARRIER INVESTIGATION

SUBSURFACE EXPLORATION SACRAMENTO RIVER
HOOD TO SACRAMENTO
PLAN AND PROFILE OF BORINGS

SCALE AS SHOWN

Appendix B

Permits

GEI Consultants

WELL APPLICATION AND PERMIT FORM

ENVIRONMENTAL MANAGEMENT DEPARTMENT – ENVIRONMENTAL COMPLIANCE DIVISION
10590 ARMSTRONG AVENUE • SUITE A • MATHER, CA 95655
TELEPHONE (916) 875-8400 FAX: (916) 875-8513

AR 57769

WELL INSPECTION LINE: (916) 875-8524

IS THIS PERMIT FOR A HAZARDOUS SUBSTANCE INVESTIGATION? ☐ YES ☒ NO

FOR OFFICE USE ONLY | **EXPEDITED PROCESSING?** ☐ YES ☐ NO

☐ APPROVED ☒ APPROVED W/CONDITIONS (~~ATTACHED~~) Below — PERMIT NUMBER(S): 60993

BY: DVA DATE: 8·14·19 — DATE RECEIVED: 8-5-19 — TOTAL FEE: $426

INITIAL GROUT BY: ____ DATE: ____ — RECEIPT NO: 443814 — DEPTH TO WATER: ____

FINAL INSPECTION BY: ____ DATE: ____ — WELL DEPTH: ____ — GROUT DEPTH: ____

DESTRUCTION BY: ____ DATE: ____ — GPS: N: 38 — W: -121

COMMENTS: Backfill top 5' of each borehole with cleanfill (non-grout)

Delta Levee CPTS [RD concurs rec'd on 8·14·19]

SITE ADDRESS: See Attached Tables	
Job Address:	Nearest Major Cross Street:
Property Owner:	Parcel Number(s): Multiple - see table
Well Contractor: ConeTec	CA License No.: C57 1049248 Exp 1-31-21
Contractor's Address: 820 Aladdin Ave., San Leandro, CA 94577	510-357-3677
Well/Boring Identification Number(s): See Attached Tables	

TYPE OF WORK: (California C-57 License required unless noted otherwise)

☐ Well construction ☐ Vault box repair (General A or B) ☐ Well destruction **(SUPPLEMENT REQUIRED)**
☐ Pump replacement (or C-61) ☐ Well repair ☒ Exploratory boring (C-57 if water present)
☐ Well inactivation (Owner only) ☐ Pump repair (or C-61) ☒ Other: CPT (Cone Penetration Testing)

INTENDED USE:

☐ Domestic/private ☐ Dewatering ☒ Geotechnical ~~boring~~ exploration using CPT
☐ Irrigation/agricultural ☐ Cathodic protection ☐ Environmental boring
☐ Water/vapor monitoring/extraction ☐ Heat exchange ☐ Other: ____
☐ Public water system: ____
(NAME OF WATER PURVEYOR WITH CONTACT NAME AND TELEPHONE NUMBER)

DRILLING METHOD:

☐ Mud rotary ☐ Air Rotary ☐ Cable tool ☐ Auger ☐ Driven ☒ Other: CPT

SETBACKS: (Wells only)

Is the well located within 50 feet of a: ☐ sewer line, ☐ stream, ☐ ditch, ☐ drainage course, ☐ pond, or ☐ lake? ☐ No
Is the well located within 100 feet of a: ☐ septic tank, ☐ leach line, ☐ deep trench, or ☐ animal enclosure? ☐ No

SPECIFICATIONS:

BOREHOLE: Diameter: 2 in. Depth: 80 ft. — CASING: Diameter: ____ Depth: ____
Diameter: ____ Depth: ____ — CASING: Diameter: ____ Depth: ____
CONDUCTOR: Diameter: ____ Depth: ____ — IF STEEL: Gauge: ____ or Thickness: ____
ANNULAR SEAL: Depth: ____ Material: Neat cement — IF PLASTIC: Type: ____ (Must meet ASTM F-480)
TRANSITION SEAL: Material: ____ — MULTIPLE COMPLETION? ☐ Yes **(DIAGRAM REQUIRED)**
COMMENTS: grout with up to 5% bentonite by weight; addition of bentonite is optional. DVA

PUMP INSTALLATION/REPAIR:

Contractor: ____
License Number: ____ Type of Pump: ____ Horsepower: ____

I will comply with all Codes, Rules and Regulations of the State and County pertaining to or regulating wells and pumps, **call (916) 875-8524 for a grout inspection at least 24 hours prior to the requested appointment time**, submit a "Well Completion Report" (if required) within 60 days of the completion of my work so a final inspection can be made, and obtain WPD approval before placing a well in service.

SIGNATURE: [signature] ☐ Property Owner
PRINTED NAME: Eduardo Cerna Alvarez ☐ Well Contractor
COMPANY: GEI Consultants ☒ Agent **(REQUIRES AUTHORIZATION FORM)**
MAILING ADDRESS: 2868 Prospect Park Dr. Suite 310, Rancho Cordova, CA 95670
PHONE NUMBER: (916) 631-4526 FIELD PHONE: (831) 540-7620

A SITE PLAN MUST BE SUBMITTED WITH EACH APPLICATION.
PERMIT EXPIRES ONE (1) YEAR AFTER DATE APPROVED (UNLESS EXTENDED)

Appendix C

Sub-Consultants License

STATE OF CALIFORNIA

CONTRACTORS STATE LICENSE BOARD

Pursuant to Chapter 9 of Division 3 of the Business and Professions Code
and the Rules and Regulations of the Contractors State License Board,
the Registrar of Contractors does hereby issue this license to:

CONETEC INC

License Number 1049248

to engage in the business or act in the capacity of a contractor in the following classifications:

C57 - WELL DRILLING

Witness my hand and seal this day,

January 23, 2019

Issued January 22, 2019

Marlo Richardson, Board Chair

David R. Fogt, Registrar of Contractors

This license is the property of the Registrar of Contractors, is not transferable, and shall be returned to the Registrar upon demand when suspended, revoked, or invalidated for any reason. It becomes void if not renewed.

13L-24 (REV. 10/17)

OSP 17 143868

AUDIT NO: 666753

Appendix D

Field Forms

GEI Consultants

GEI Consultants

DAILY INSPECTION REPORT

CONTRACT: **DATE:** ____________________

GEI PROJECT # ______________
CONTRACTOR:_________________________ **SHIFT 1 2 3**
INSPECTOR: ___________________________ **TEMPERATURE:**_____**AM**_____**PM**
SUPERINTENDENT:______________________ **WEATHER:** **Clear Rain Showers Cloudy**

Crew	No.	Hrs	Crew	No.	Hrs
Foreman			Pipefitter(s)		
Operator(s)			Ironworker(s)		
Laborer(s)			Survey		
Teamster(s)					

(1) Detailed Contractor Activity/Progress: ____

Signature_________________________________

GEI Consultants

DAILY INSPECTION REPORT

CONTRACT: **DATE:** ________________

Signature______________________________

Daily Safety Briefing and Site Visitor Sign-In

Project Number:	**Project Name:**
[1]**Date:**	**Time:**
Briefing Conducted by:	**Signature:**

This sign-in log documents the tailgate briefing conducted in accordance with the site specific HASP. Personnel who perform work operations on site are required to attend each briefing and to acknowledge receipt of each briefing, daily.

TOPICS COVERED (check all those covered):

☐ Accident Reporting Procedures	☐ General PPE Usage	☐ Site Control	☐ Other:
☐ Cellular Phone Charged w/Service	☐ Heat Stress	☐ Site Emergency Procedures	☐ Other:
☐ Changes to the HASP	☐ Hearing Conservation	☐ Slips, Trips, Falls	☐ Other:
☐ Cold Stress	☐ Lockout/Tagout	☐ Traffic Safety	☐ Other:
☐ Confined Space	☐ Personal Hygiene	☐ Other:	☐ Other:
☐ Decon Procedures	☐ Respiratory Protection	☐ Other:	☐ Other:
☐ Exposure Guidelines	☐ Review of Hazards	☐ Other:	☐ Other:

Daily Safety Topic Description:

Personnel Sign-in List

Printed Name	Signature	Company Name	Time-In	Time-Out

[1] This form is applicable for *only* 1 day of site activity.

Project Safety Briefing Form

Project Number:	Project Name:
Date:	Time:
Briefing Conducted by:	Signature:

This sign-in log documents that a project specific-briefing was conducted in accordance with the site-specific HASP and GEI's H&S policy. GEI personnel who perform work on site are required to attend this project briefing. Applicable health and safety SOPs and any additional hazards are also required to be reviewed during this briefing. Prior to the start of the project or upon the start of a new on-site project team member, this form must be completed. Please email this completed form to:

SafetyTeam@geiconsultants.com

TOPICS COVERED (check all those covered):

SOP HS-001 Biological Hazards		SOP HS-025 Manual Lifting	
SOP HS-002 Bloodborne Pathogens		SOP HS -26 Hazard Identification	
SOP HS-003 Container Management		SOP HS-27 Confined Space Entry for Sanitary Sewers	
SOP HS-004 Driver Safety		SOP HS-28 Safe Trailer Use	
SOP HS-005a Electrical Safety		SOP HS-29 Overtime and Fatigue Management	
SOP HS-005b Lockout/Tagout		Accident Reporting Procedures	
SOP HS-006 Excavation/Trenching		Changes to the HASP	
SOP HS-008a Hand Tools (Non-Powered)		Cold Stress	
SOP HS-008b Powered Hand Tools		Confined Space	
SOP HS-009 Hazardous Substances Management		Decon Procedures	
SOP HS-010 Inclement Weather		Exposure Guidelines	
SOP HS-011 Ladders		General PPE Usage	
SOP HS-012 Noise Exposure		Heat Stress	
SOP HS-013 Nuclear Density Gauge		Hearing Conservation	
SOP HS-014 Utility Markout		Lockout/Tagout	
SOP HS-015 Respirator Fit Test		Personal Hygiene	
SOP HS-016 Traffic Hazards		Respiratory Protection	
SOP HS-017 Water Safety		Review of Hazard Evaluation	
SOP HS-018 Working Around Heavy Equipment		Site Control	
SOP HS-019 Rail Safety		Site Emergency Procedures	
SOP HS-020 Aerial Lift		Slips, Trips, Falls	
SOP HS-021 Mobile Equipment		Other (Specify):	
SOP HS-022 Aquatic Ecological Survey/Electrofishing		Other (Specify):	
SOP HS-023 Scaffolding		Other (Specify):	
SOP HS-024 Wilderness Safety		Other (Specify):	

Personnel Sign-in List

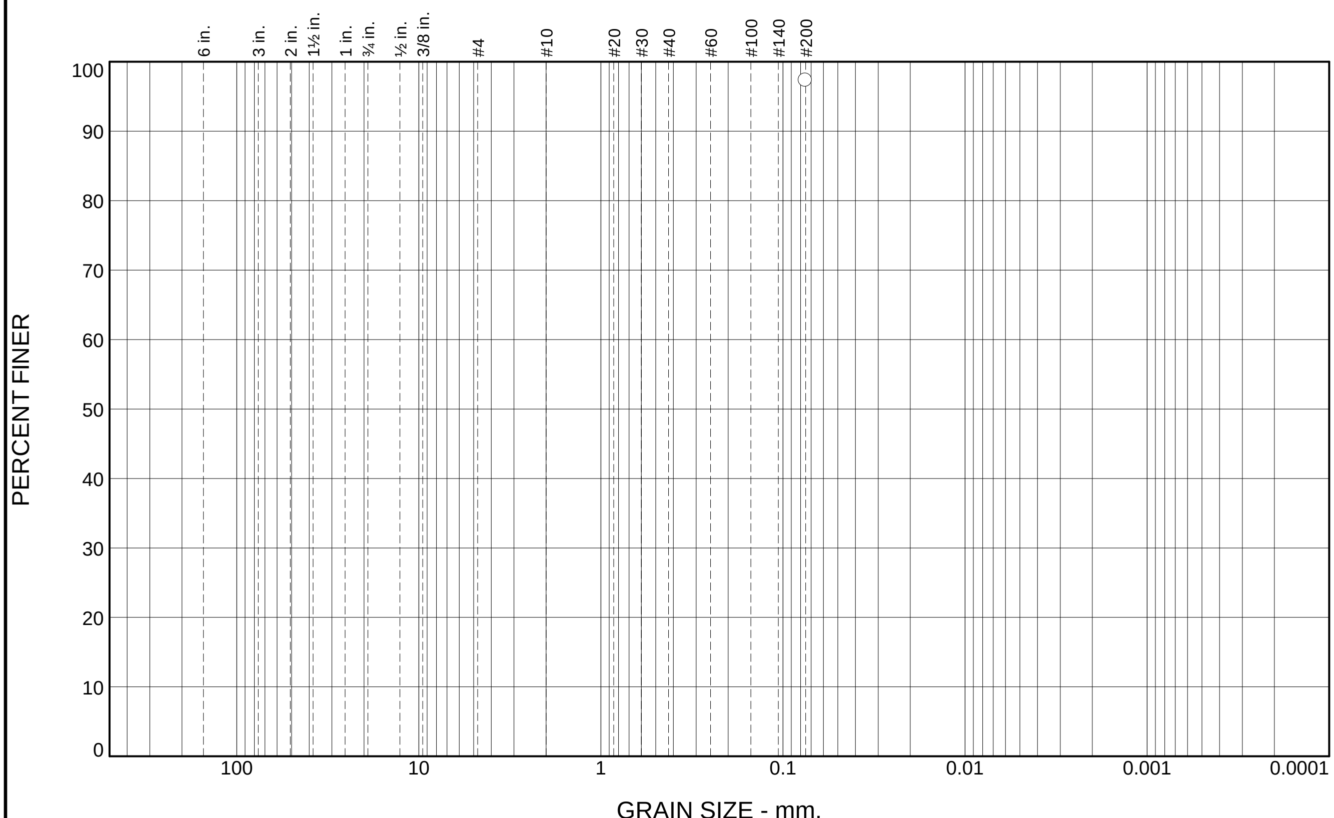
Printed Name	Signature

Appendix D

Small Communities - Hood Lab Request Summary
GEI Project Number: 1800776

Community	Sounding	Exploration Location	Sample No.	Depth (ft)	CPT Classification	Retained Sample (in)	Moisture ASTM D2216	Atterberg Limits LL/PI ASTM D4318	Wet Sieve Analysis (GS) ASTM D422	Sieve and Hydrometer %Silt/%Clay ASTM D422	#200 Wash % Fines ASTM D1140	Comments
Hood	GEI_HOOD_001C	Levee Toe	S03A/B	5-6'	SM/SP/ML	10/12"					97.3	
			S04A/B	6-7'	ML	8/12"		39/13			89.6	General Note: Samples combined to provide enough material for testing.
			S05A/B	8-9'	ML	11/12"						
			S06A/B	9-10'	ML/CL	11/12"						
	GEI_HOOD_002C	Levee Toe	S01A/B	2-3'	SM/SP	10/12"						
			S02A/B	3-4'	ML/CL	11/12"					73.3	
			S06A	10-11'	CL	5/12"	36.5	40/17			88.7	
			S07A	11-12'	ML/CL	4/12"						
			S08A/B	12-13'	CL	12/12"						
	GEI_HOOD_003C	Levee Crown H≈9'	S01A/B	5-6'	SM/SP/SW	11/12"					58.2	
			S02A/B	6-7'	SM/SP/SW	10/12"						
			S03A/B	9-10'	ML/SM/SP	11/12"					73.6	
			S04A/B	10-11'	SM/SP	10/12"						
			S05A/B	15-16'	ML	11/12"	19.2	43/22		42.4/38.9		
			S06A/B	16-17'	CL/ML	11/12"						
	GEI_HOOD_004C	Levee Crown H≈16'	S01A/B	7-8'	SP/SM/SW	10/12"					48.9	
			S02A/B	8-9'	SP/SM/SW	8/12"						
			S03A/B	16-17'	CL	7/12"						
			S04A/B	17-18'	CL	12/12"						
			S05A/B	19-20'	CL	11/12"	34.5	41/21			81.5	
			S06A/B	20-21'	CL	11/12"						
	GEI_HOOD_005C	Levee Crown H≈15.5'	S01A/B	10.1-11'	CL							
			S02A	11.3-11.5'	ML/CL	2/12'						
			S02B	11.5'-12'	ML/CL	2/12'						
			S03A/B	22-23'	CL							
			S04A/B	23-24'	CL							
	GEI_HOOD_006C	Levee Crown H≈16'	S01A/B	10.3-11'	CL/ML			40/19			68.5	
			S02A/B	17-18'	CL/ML							
			S03A/B	30-31'	CL/ML							
	GEI_HOOD_007C	Levee Toe	S01	2-6'	CL/ML	37/48"		48/31			79.4	Sample depth: 3'-5'
			S02	6-10'	CL/ML	48/48"						
			S03	10-14'	CL/ML	48/48"						
			S04	14-18'	CL/ML	48/48"		39/17			75.1	Sample depth: 15'-17'
			S05	22-23.5'	SM/SP/SW	19/48"					3.2	
	GEI_HOOD_009C	Levee Crown H≈18'	S01	2-6'	CL/ML	32/48"		36/14			53.7	Sample depth: 4'-6'
			S02	6-10'	ML/CL	34/48"		31/14			53	Sample depth: 8'-10'
			S03	10-14'	CL/ML	36/48"						
			S04	14-18'	ML/CL	38/48"						
			S05	18-22'	ML/CL	36/48"						
	GEI_HOOD_010C	Levee Crown H≈18'	S01	2-6'	ML/CL	33/48"		NP			34.8	Sample depth: 4'-6'
			S02	6-10'	ML/CL/UND	35/48"						
			S03	10-14'	CL/ML	35/48"						
			S04	14-18'	ML/CL	29/48"						
			S05	18-22'	ML/CL	36/48"						
	GEI_HOOD_011C	Proposed Cross Levee Location	S01A	1-3'	CL/ML/SP/SM		31.4	64/31		25.8/70.9		
			S02A/B	12-13'	CL/ML		39.8	38/15			97.7	
			S03A/B	13-14'	CL/ML							

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						97.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	97.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Source of Sample: GEI_Hood_001C **Depth:** 5-6'
Sample Number: S03 A/B **Date:**

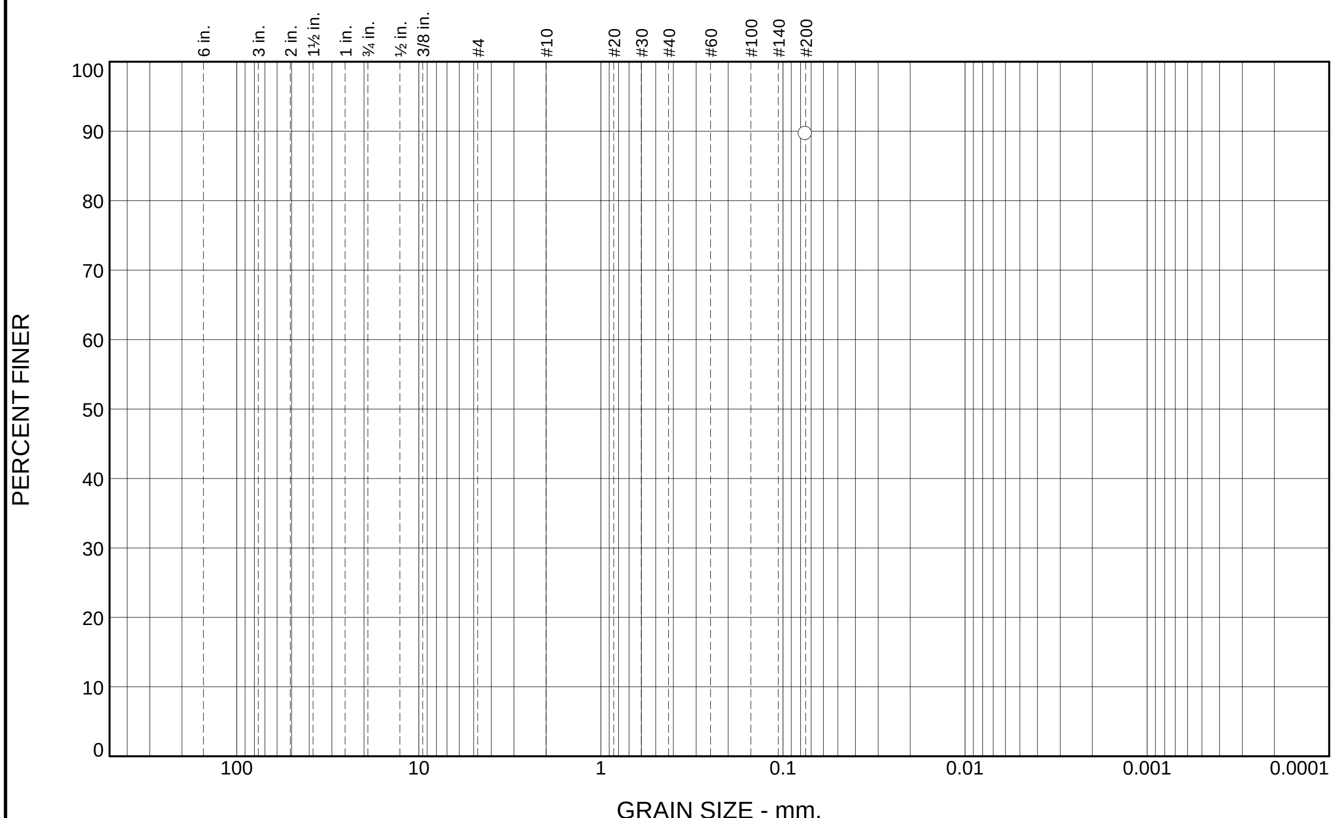
Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)

Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						89.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	89.6		

* (no specification provided)

Material Description

SILT, dark grayish brown

Atterberg Limits

PL= 26 LL= 39 PI= 13

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO=

Remarks

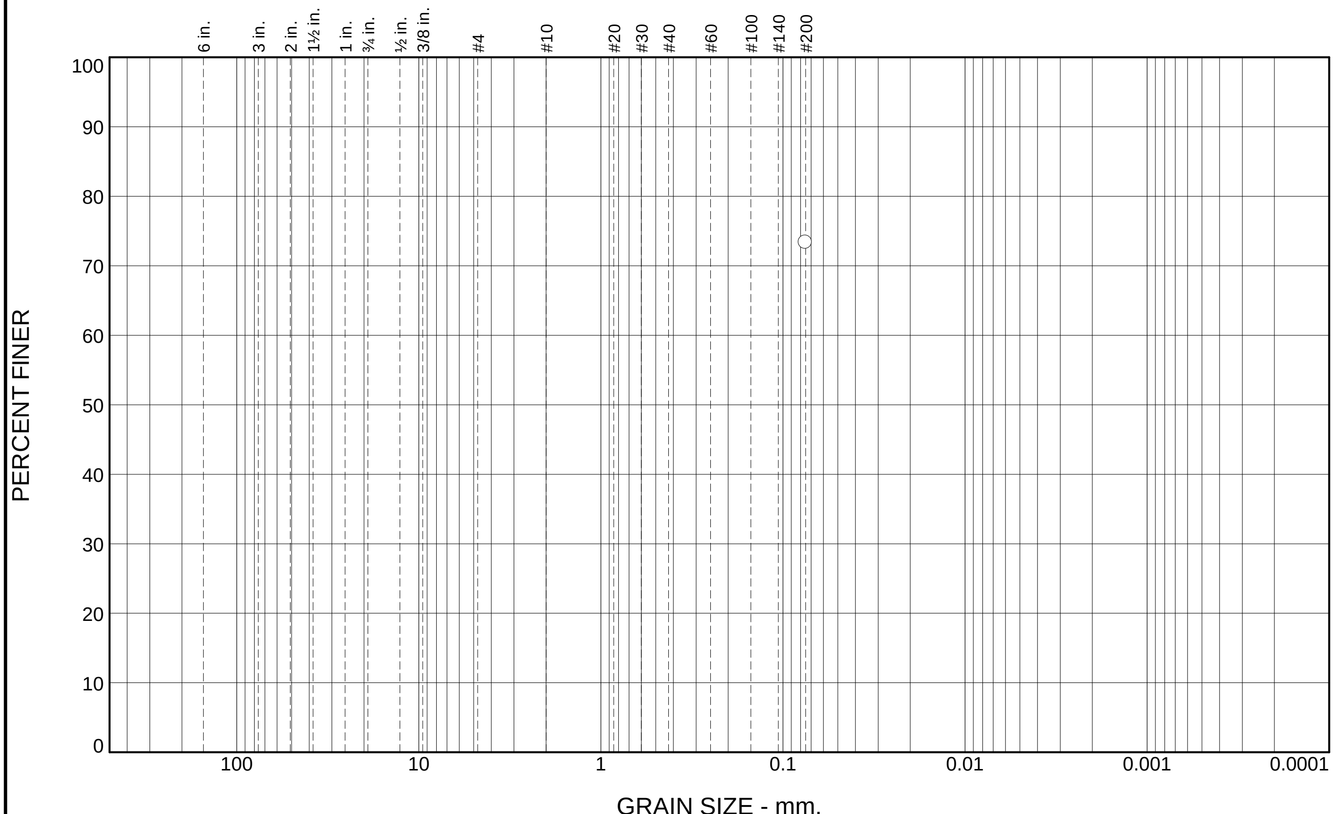
Source of Sample: GEI_Hood_001C **Depth:** 6-9'
Sample Number: S04,S05 A/B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						73.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	73.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

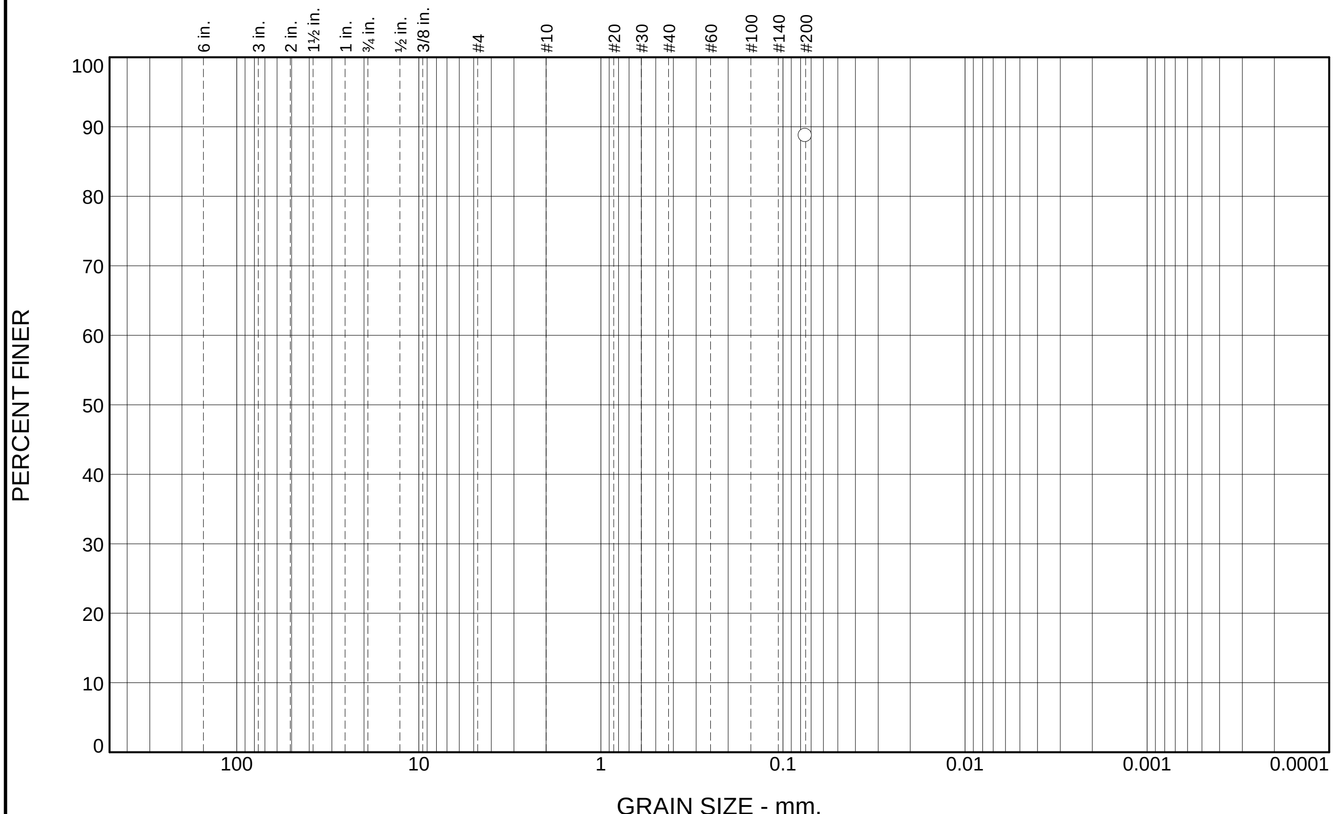
Source of Sample: GEI_Hood_002C **Depth:** 3-4'
Sample Number: S02 A/B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						88.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	88.7		

* (no specification provided)

Material Description

Lean CLAY, grayish brown

Atterberg Limits

PL= 23 LL= 40 PI= 17

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

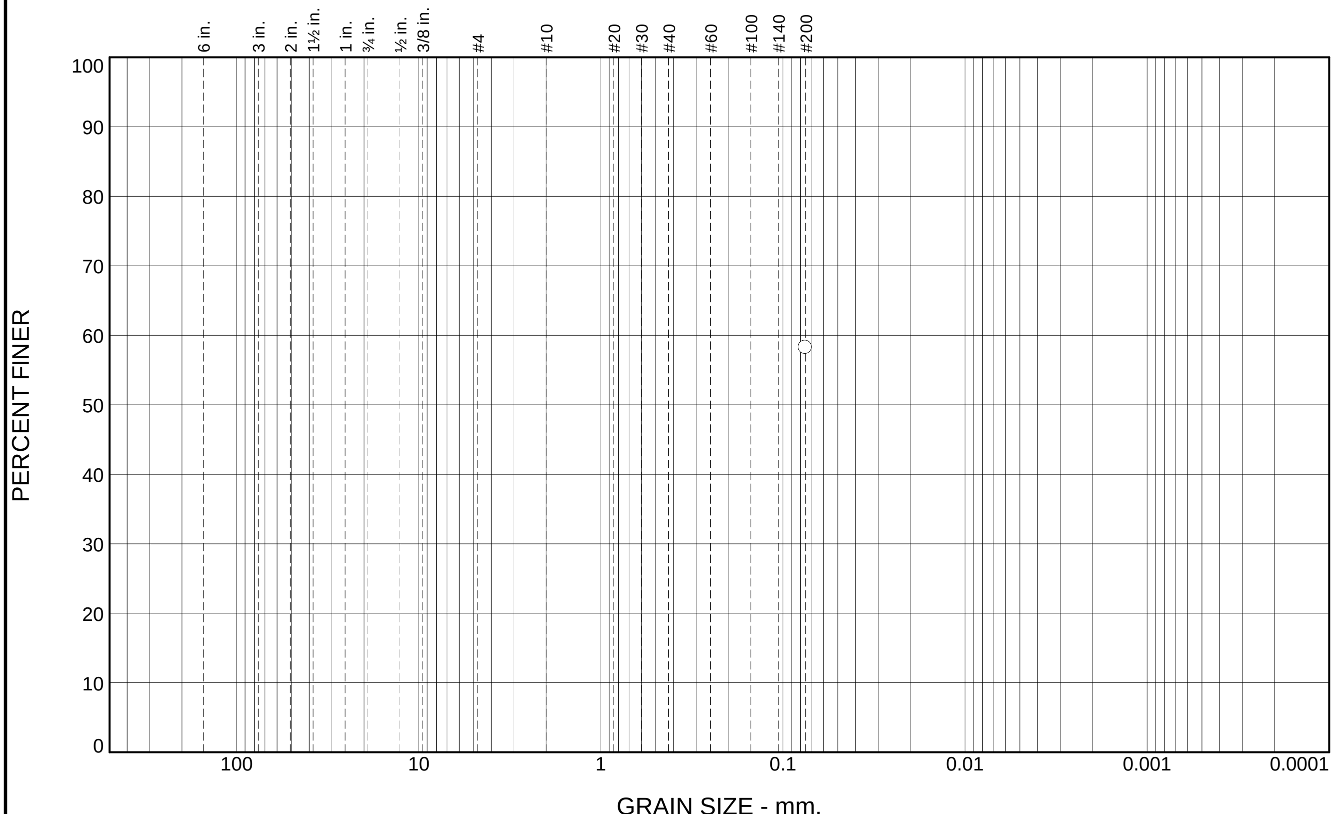
Source of Sample: GEI_Hood_002C **Depth:** 10-13'
Sample Number: S06A,S07A,S08A/B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						58.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	58.2		

* (no specification provided)

Material Description

brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

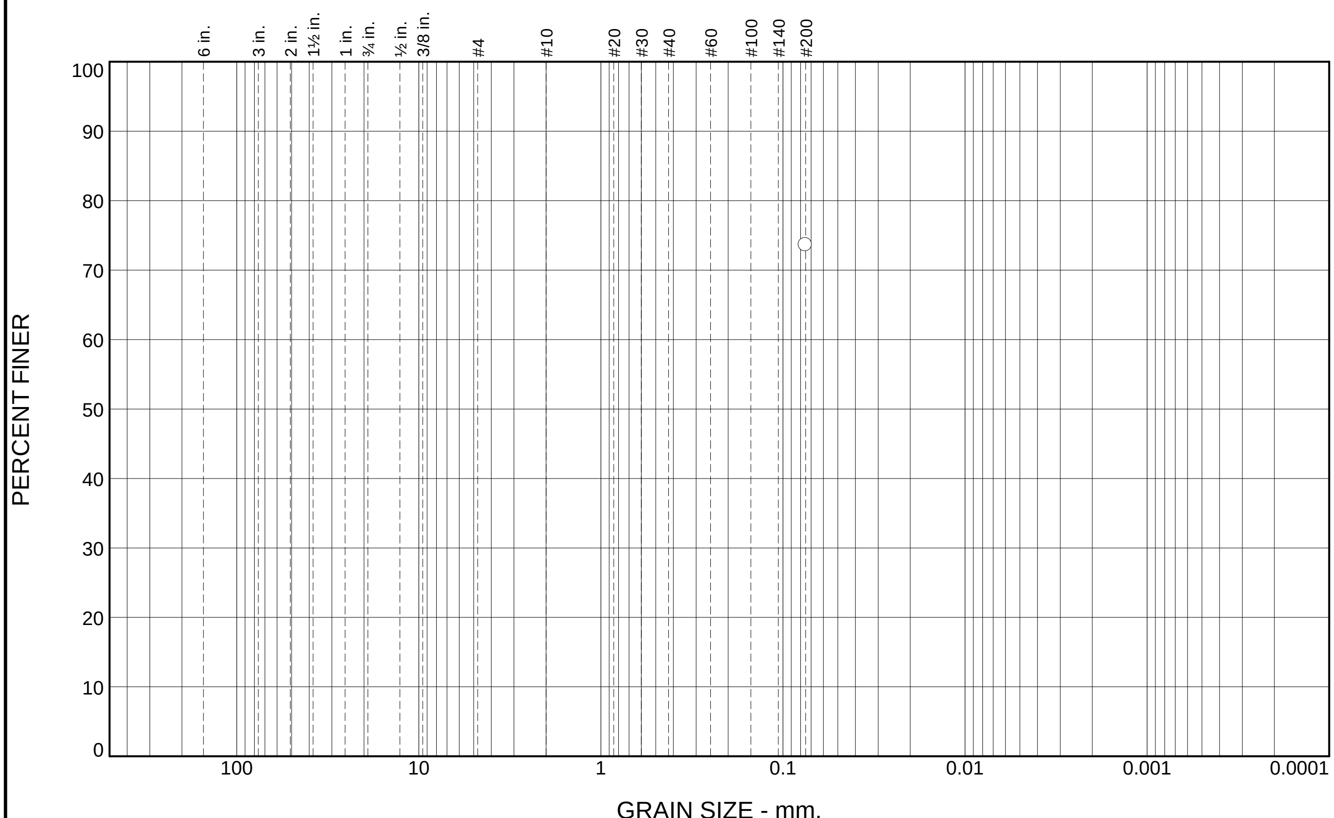
Source of Sample: GEI_Hood_003C **Depth:** 5-7'
Sample Number: S01,S02 A/B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						73.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	73.6		

* (no specification provided)

Material Description

brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

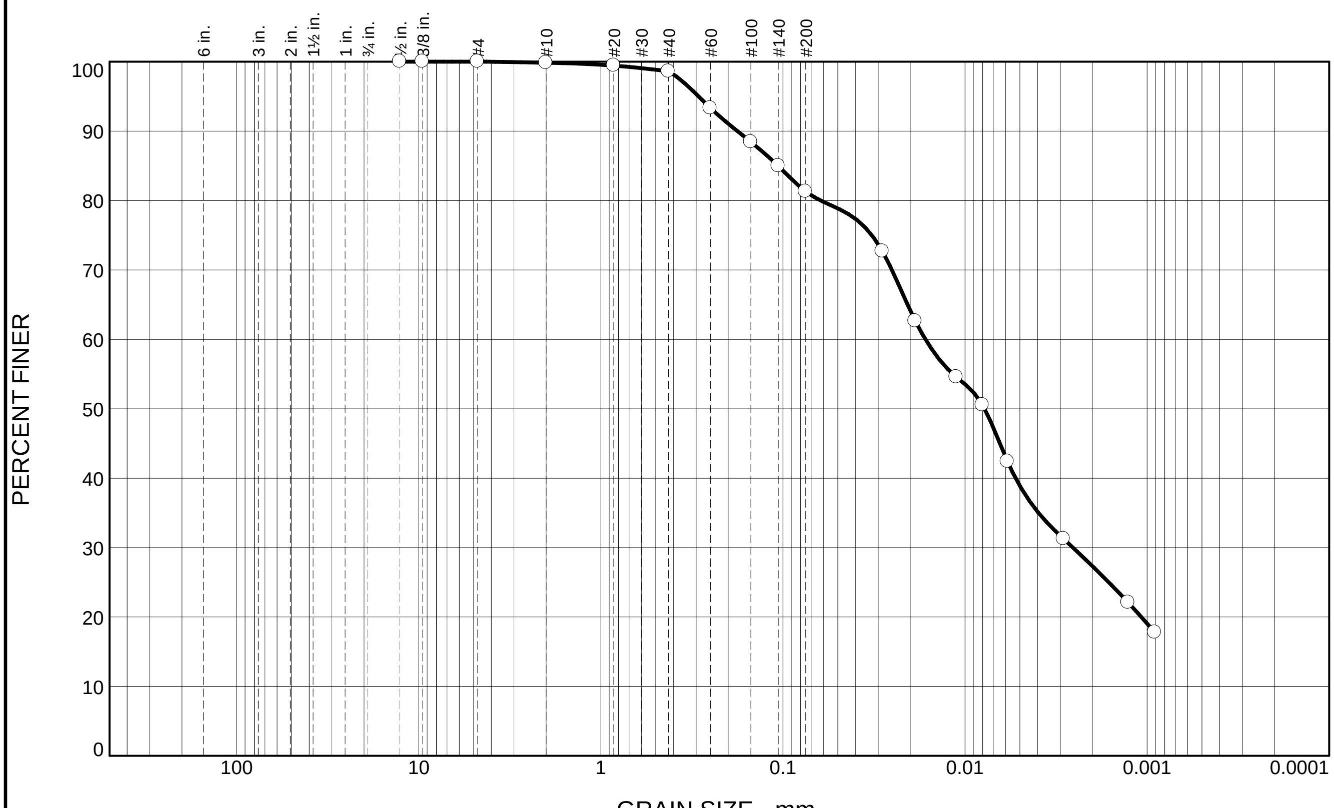
Source of Sample: GEI_Hood_003C **Depth:** 9-11'
Sample Number: S03,S04 A/B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.2	1.2	17.3	42.4	38.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100.0		
3/8"	100.0		
#4	100.0		
#10	99.8		
#20	99.4		
#40	98.6		
#60	93.3		
#100	88.4		
#140	85.0		
#200	81.3		

* (no specification provided)

Material Description

Lean CLAY with SAND, dark grayish brown

Atterberg Limits

PL= 21 LL= 43 PI= 22

Coefficients

D_{90}= 0.1782 D_{85}= 0.1064 D_{60}= 0.0165
D_{50}= 0.0078 D_{30}= 0.0026 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(18)

Remarks

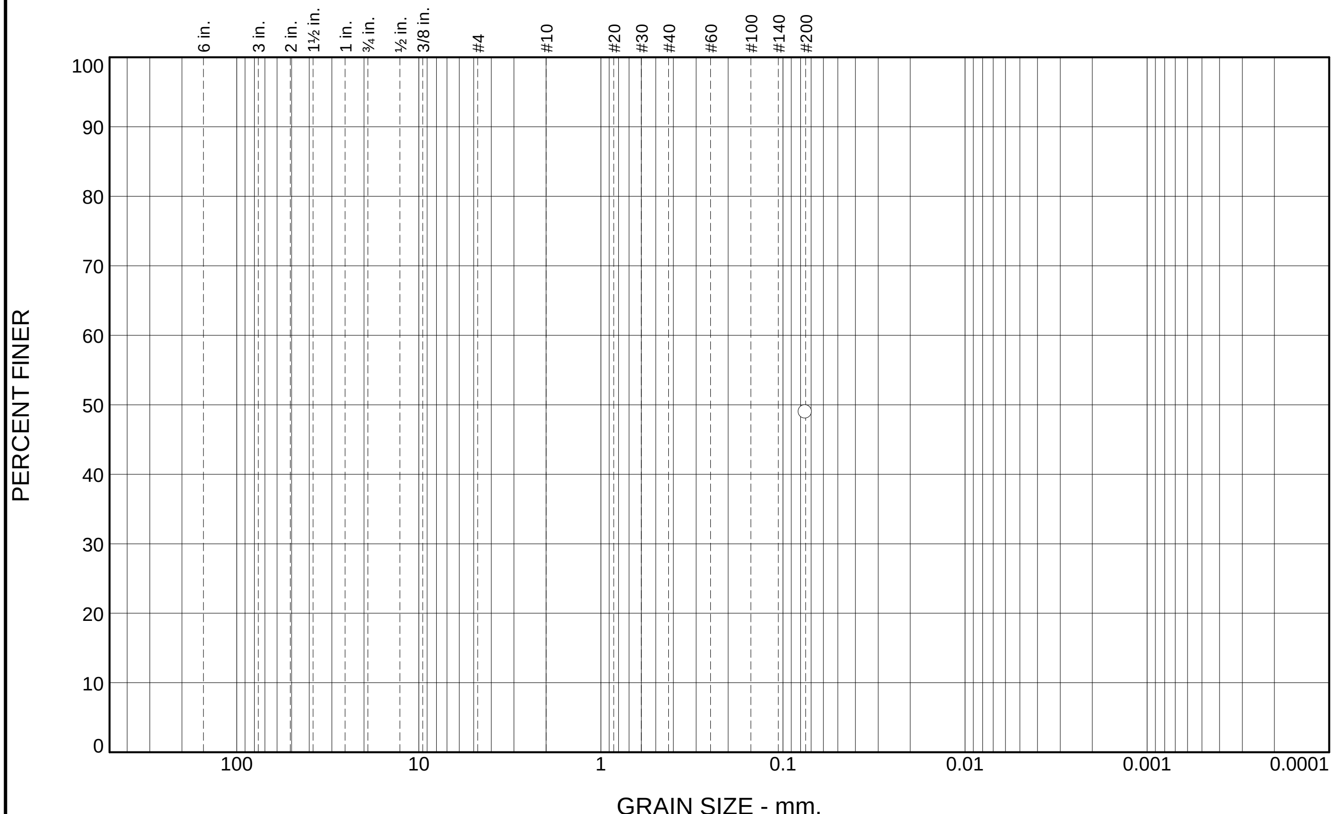
Source of Sample: GEI_Hood_003C **Depth:** 15-17'
Sample Number: S05,S06 A/B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						48.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	48.9		

* (no specification provided)

Material Description

dark brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Source of Sample: GEI_Hood_004C **Depth:** 7-9'
Sample Number: S1,S02 A/B **Date:**

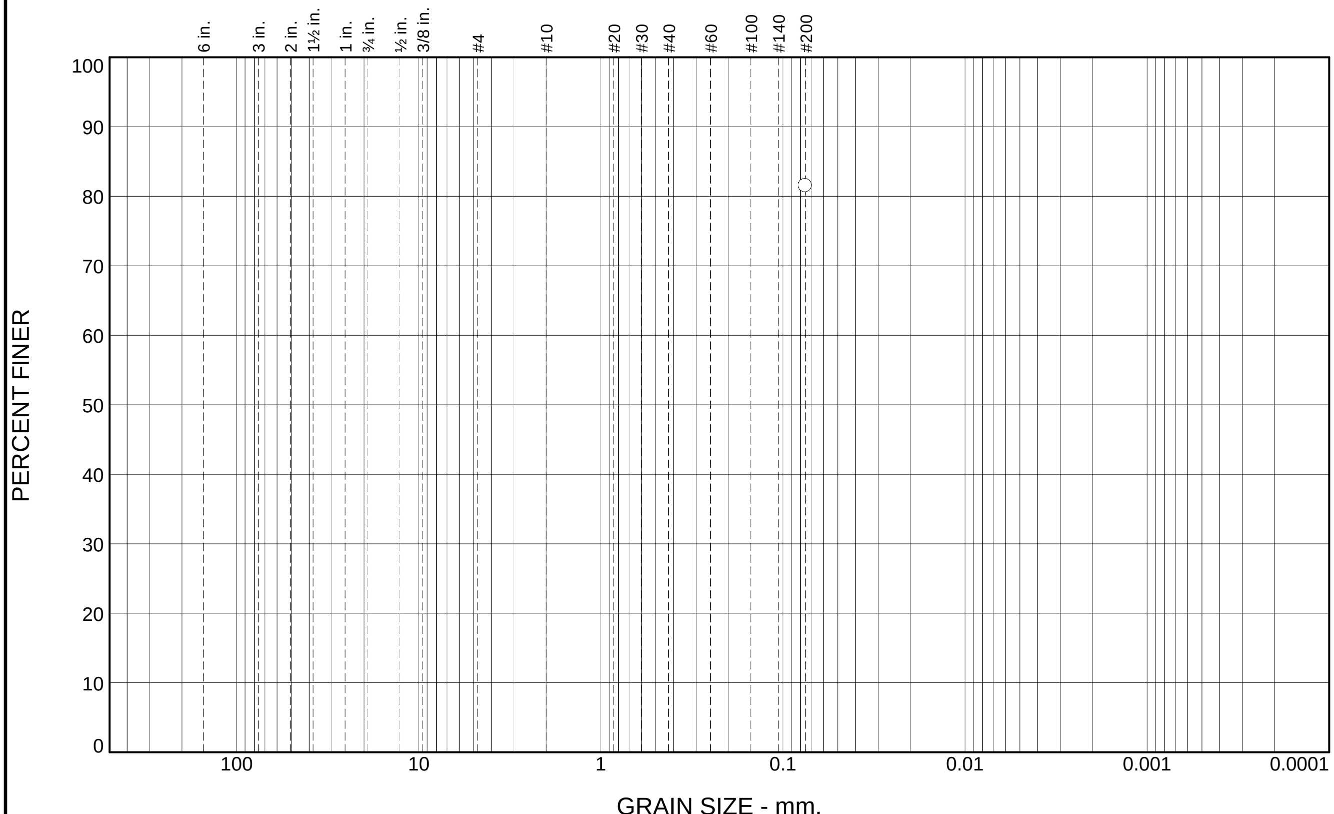
Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)

Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						81.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	81.5		

* (no specification provided)

Material Description

Lean CLAY with SAND, grayish brown

Atterberg Limits

PL= 20 LL= 41 PI= 21

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: GEI_Hood_004C **Depth:** 19-21'
Sample Number: S05,S06 A/B **Date:**

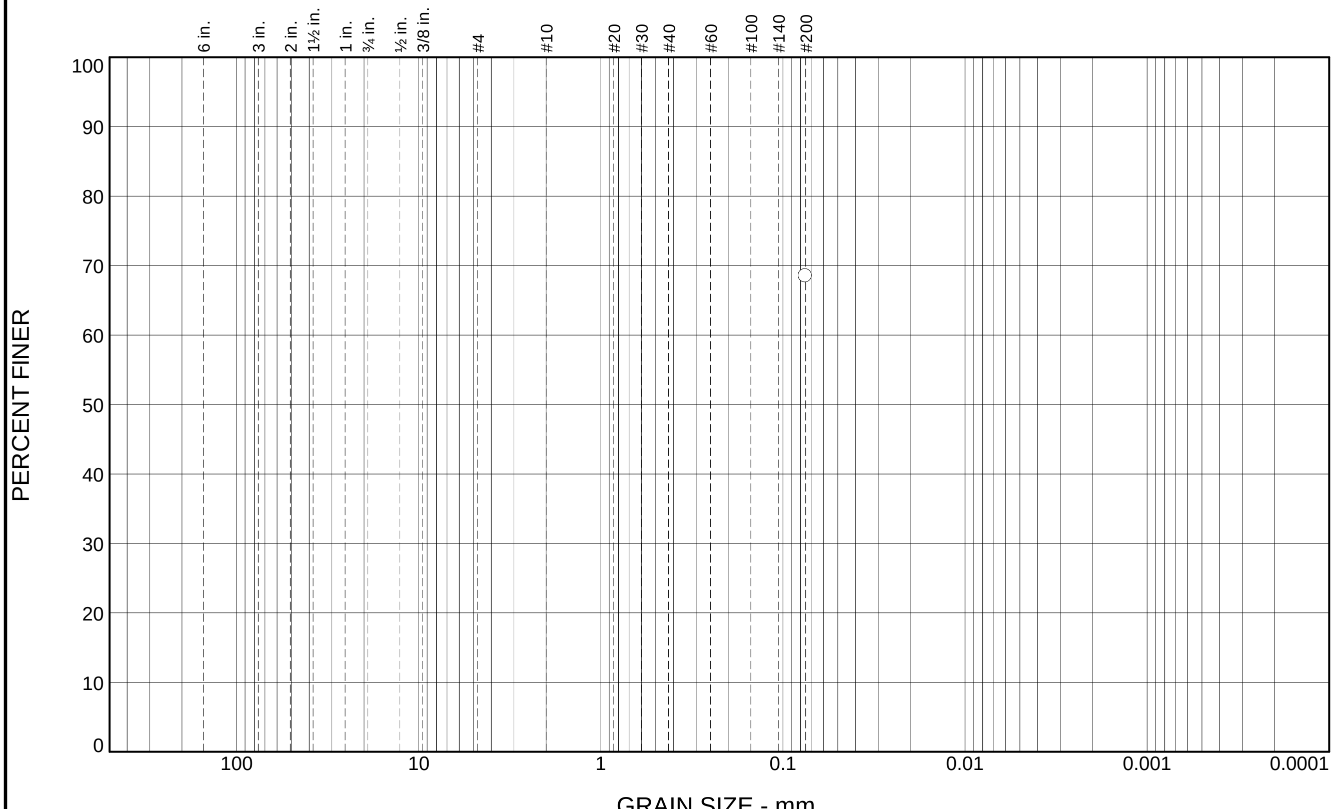
Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)

Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						68.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	68.5		

* (no specification provided)

Material Description

SANDY lean CLAY, dark grayish brown

Atterberg Limits

PL= 21 LL= 40 PI= 19

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

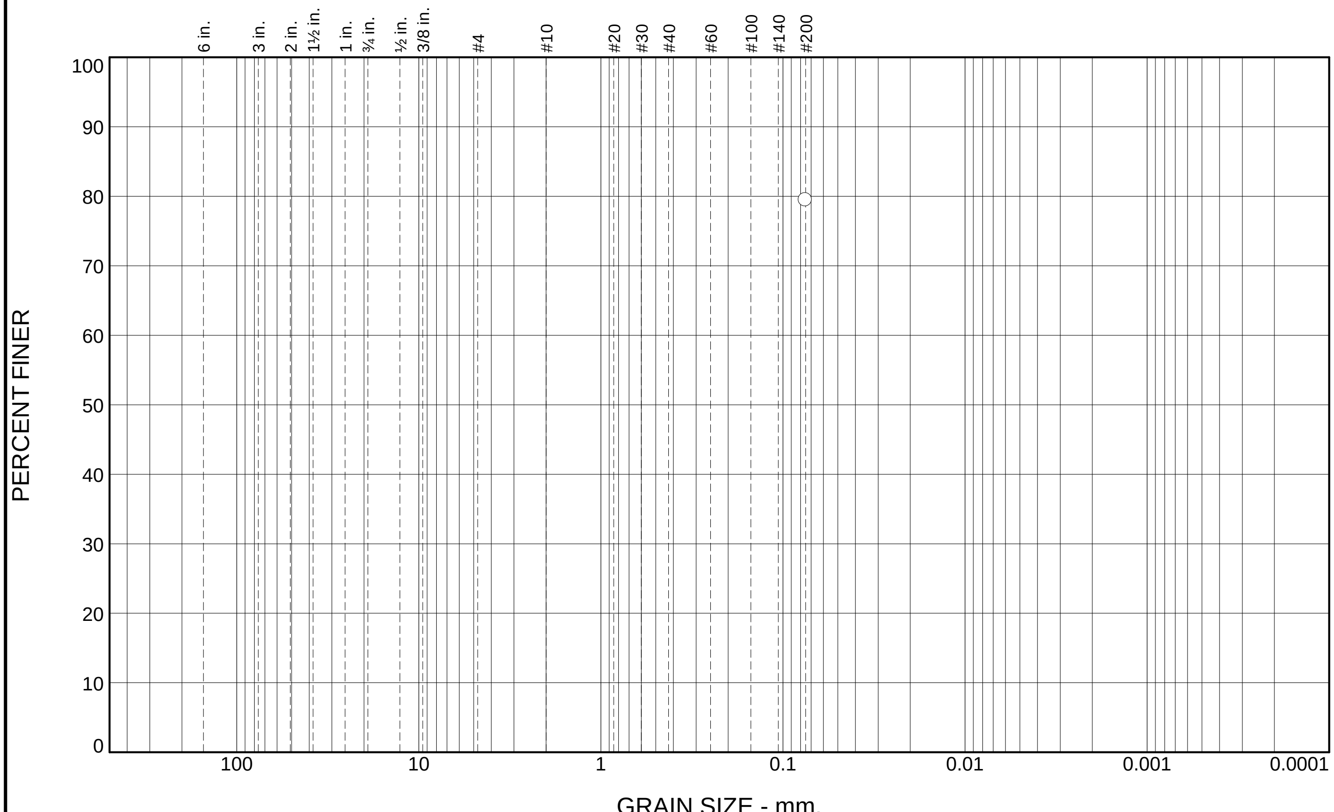
Source of Sample: GEI_Hood_006C **Depth:** 10.3-11',17-18'
Sample Number: S01,S02 A/B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						79.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	79.4		

* (no specification provided)

Material Description

Lean CLAY with SAND, very dark grayish brown/dark blueish gray

Atterberg Limits

PL= 17 LL= 48 PI= 31

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: GEI_Hood_007C **Depth:** 3-5'
Sample Number: S01 **Date:**

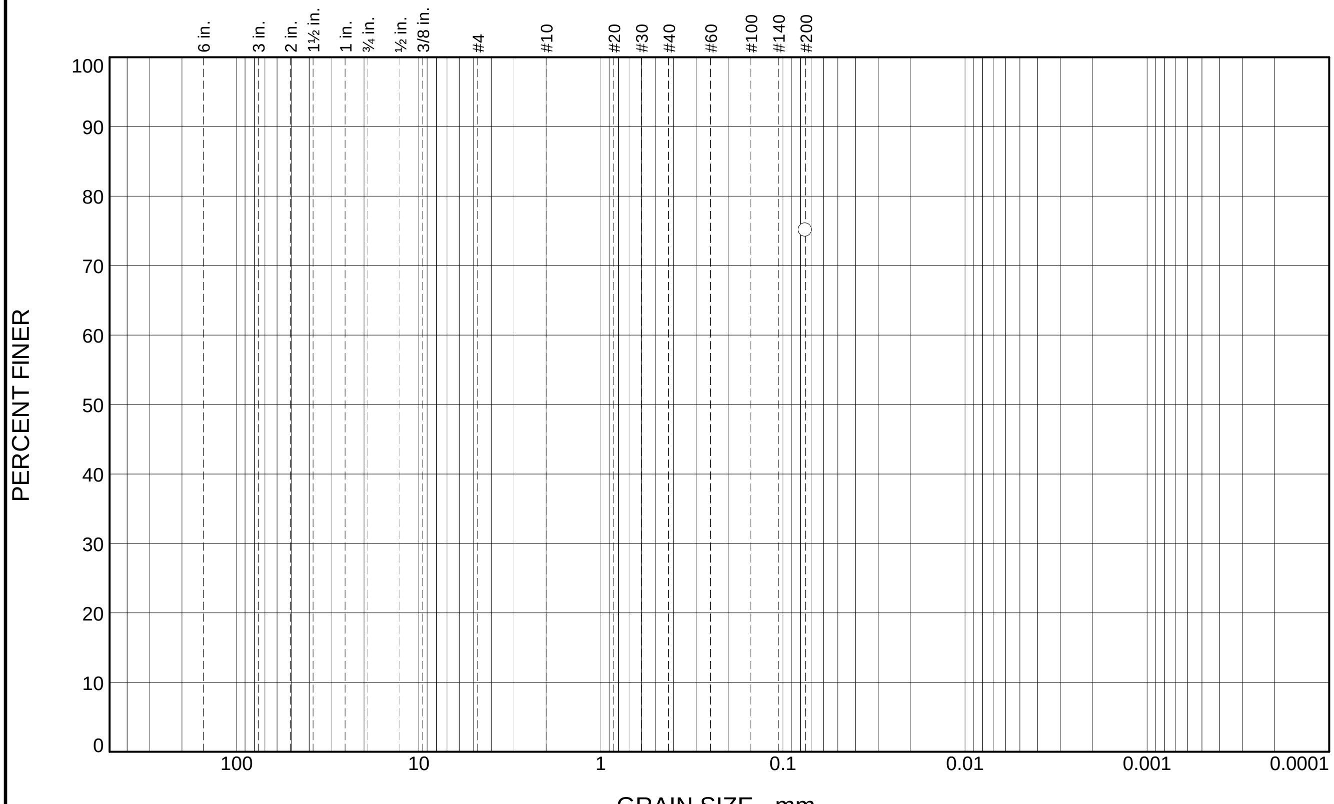
Blackburn Consulting

W. Sacramento, CA

Client: GEI
Project: Small Communitites - Hood (1800776)

Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						75.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	75.1		

* (no specification provided)

Material Description

SANDY lean CLAY, pale brown

Atterberg Limits

PL= 22 LL= 39 PI= 17

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: GEI_Hood_007C **Depth:** 15-17'
Sample Number: S04 **Date:**

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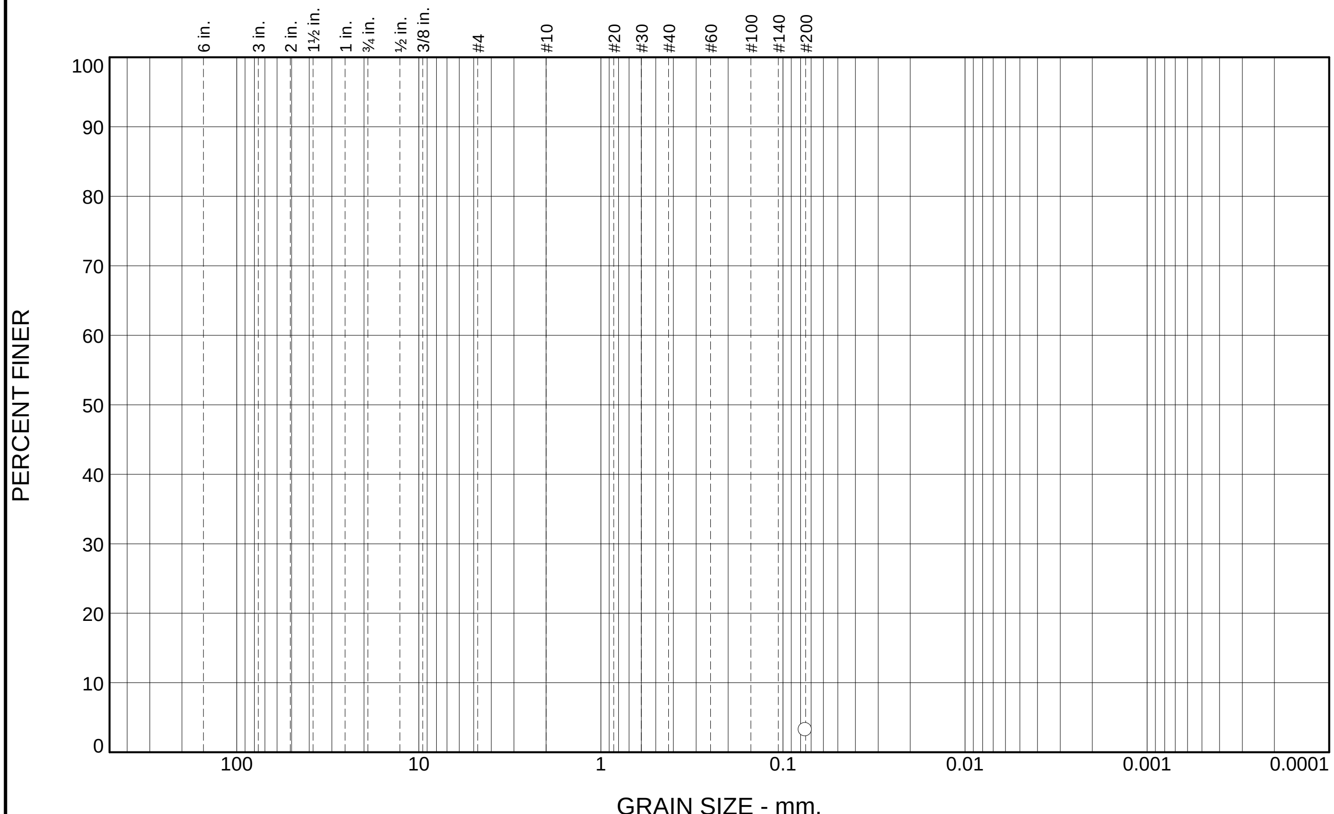
Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						3.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	3.2		

* (no specification provided)

Material Description

dark gray

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

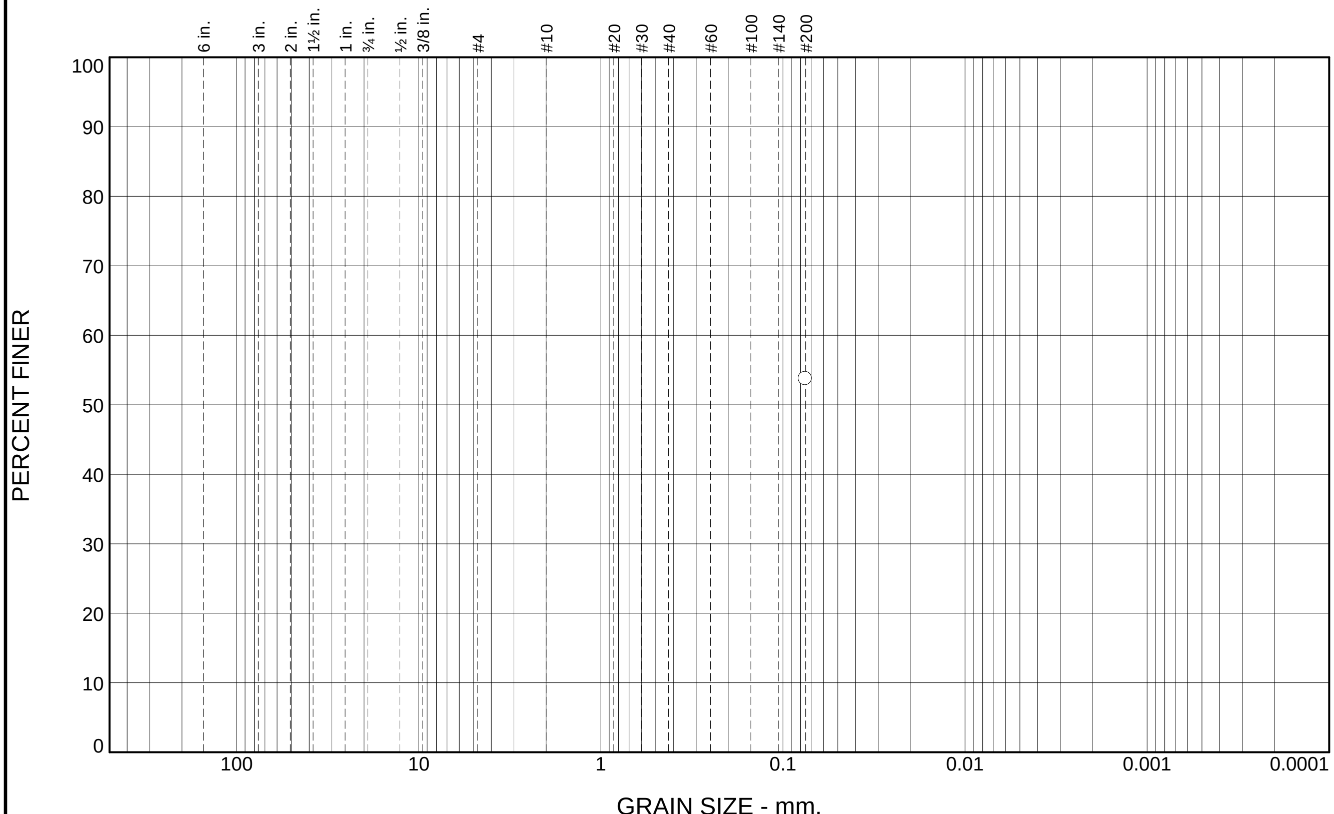
USCS= AASHTO=

Remarks

Source of Sample: GEI_Hood_007C **Depth:** 22-23.5'
Sample Number: S05 **Date:**

Blackburn Consulting W. Sacramento, CA	**Client:** GEI **Project:** Small Communitites - Hood (1800776) **Project No:** 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						53.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	53.7		

* (no specification provided)

Material Description

SANDY lean CLAY, olive brown

Atterberg Limits

PL= 22 LL= 36 PI= 14

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: GEI_Hood_009C **Depth:** 4-6'
Sample Number: S01 **Date:**

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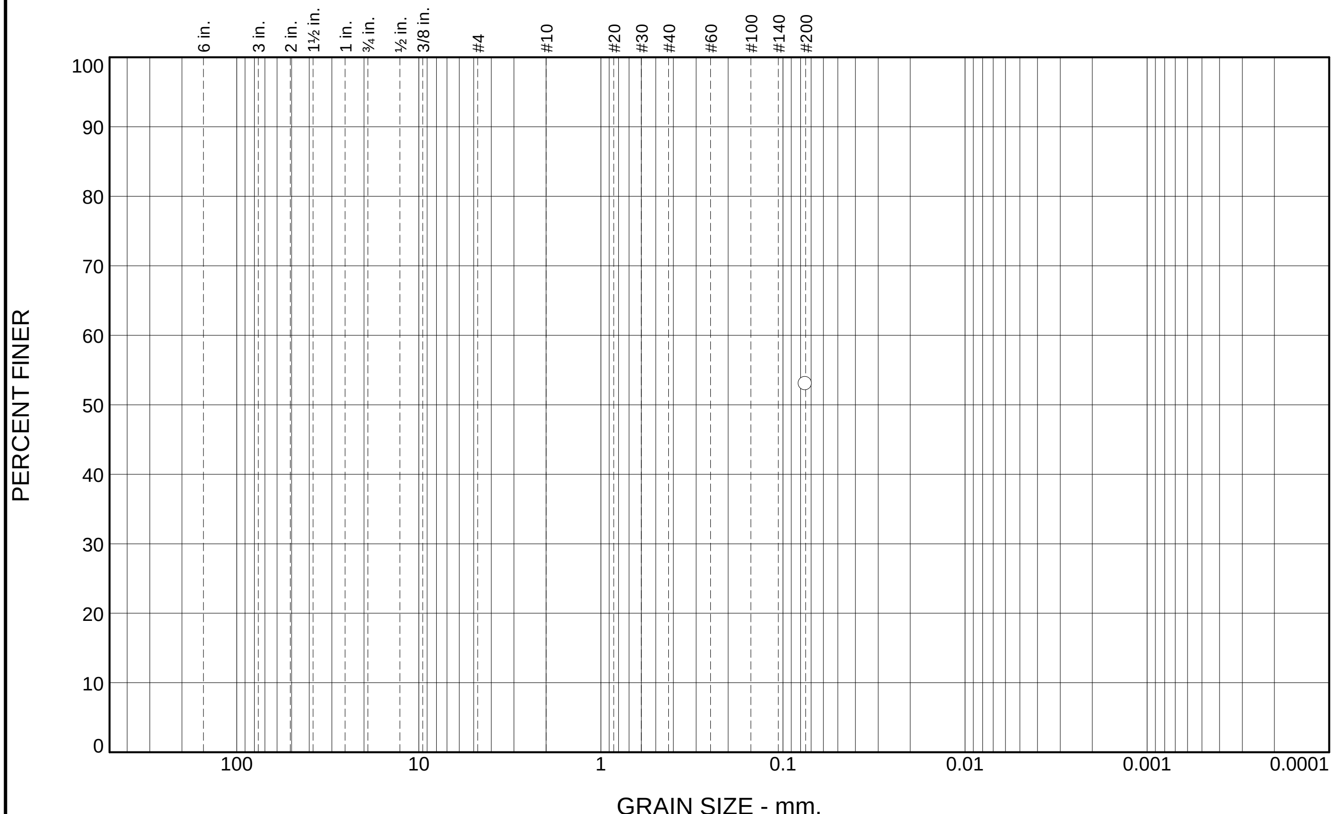
Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						53.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	53.0		

* (no specification provided)

Material Description

SANDY lean CLAY, brown

Atterberg Limits

PL= 17 LL= 31 PI= 14

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: GEI_Hood_009C **Depth:** 8-10'
Sample Number: S02 **Date:**

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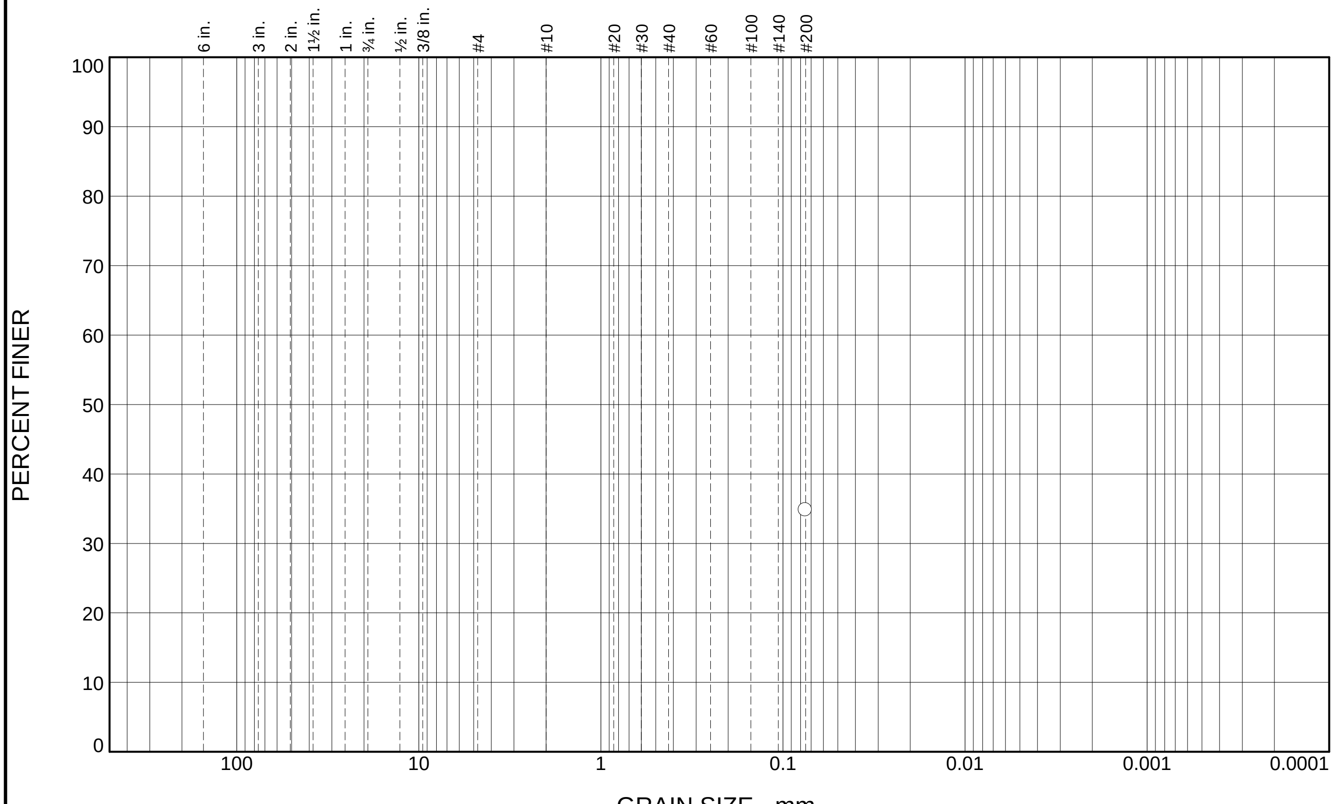
Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						34.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	34.8		

* (no specification provided)

Material Description

SILTY SAND, dark olive brown

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

Source of Sample: GEI_Hood_010C **Depth:** 4-6'
Sample Number: S01 **Date:**

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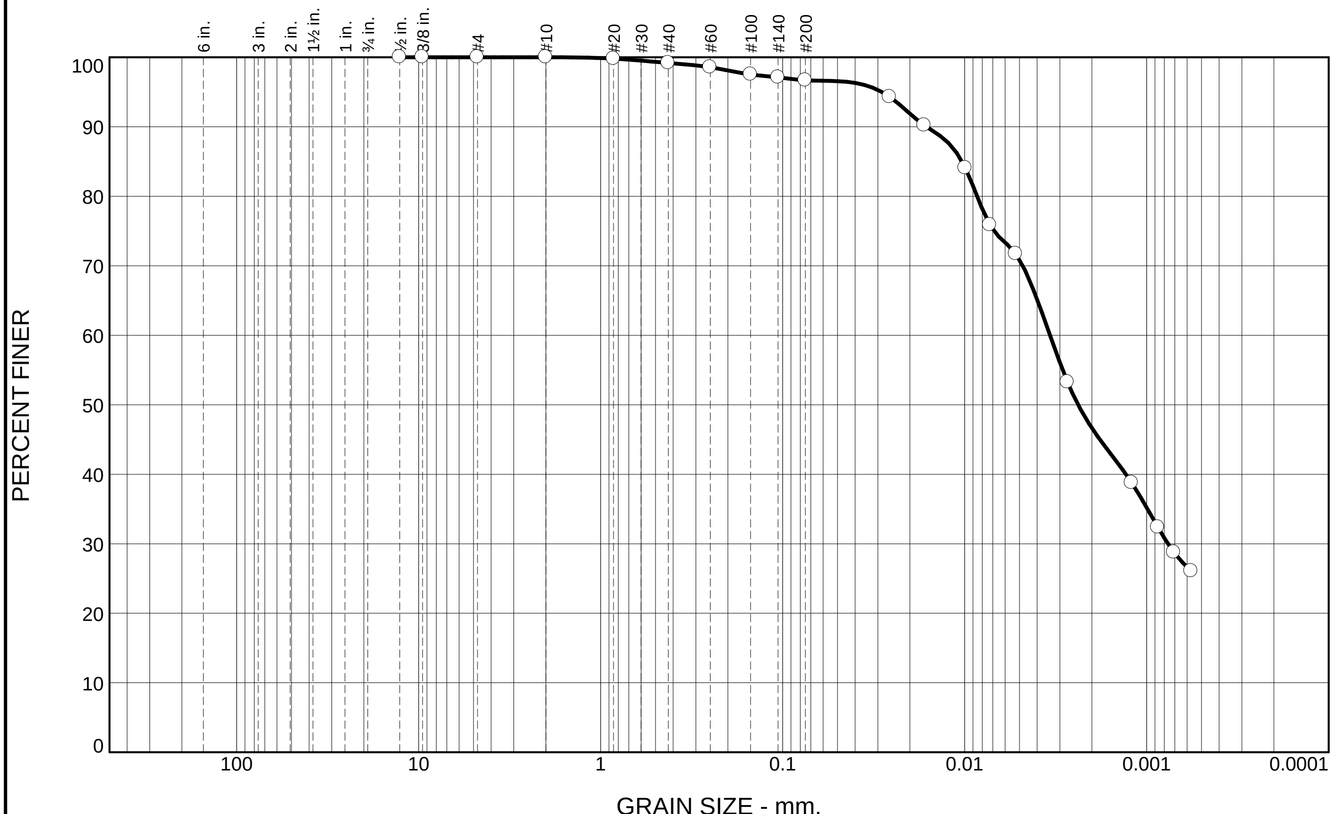
Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.8	2.5	25.8	70.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100.0		
3/8"	100.0		
#4	100.0		
#10	100.0		
#20	99.8		
#40	99.2		
#60	98.6		
#100	97.5		
#140	97.1		
#200	96.7		

* (no specification provided)

Material Description

ELASTIC SILT, very dark grayish brown

Atterberg Limits

PL= 33 LL= 64 PI= 31

Coefficients

D_{90}= 0.0162 D_{85}= 0.0103 D_{60}= 0.0034
D_{50}= 0.0024 D_{30}= 0.0008 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= MH AASHTO= A-7-5(37)

Remarks

Source of Sample: GEI_Hood_011C **Depth:** 1-3'
Sample Number: S01 A **Date:**

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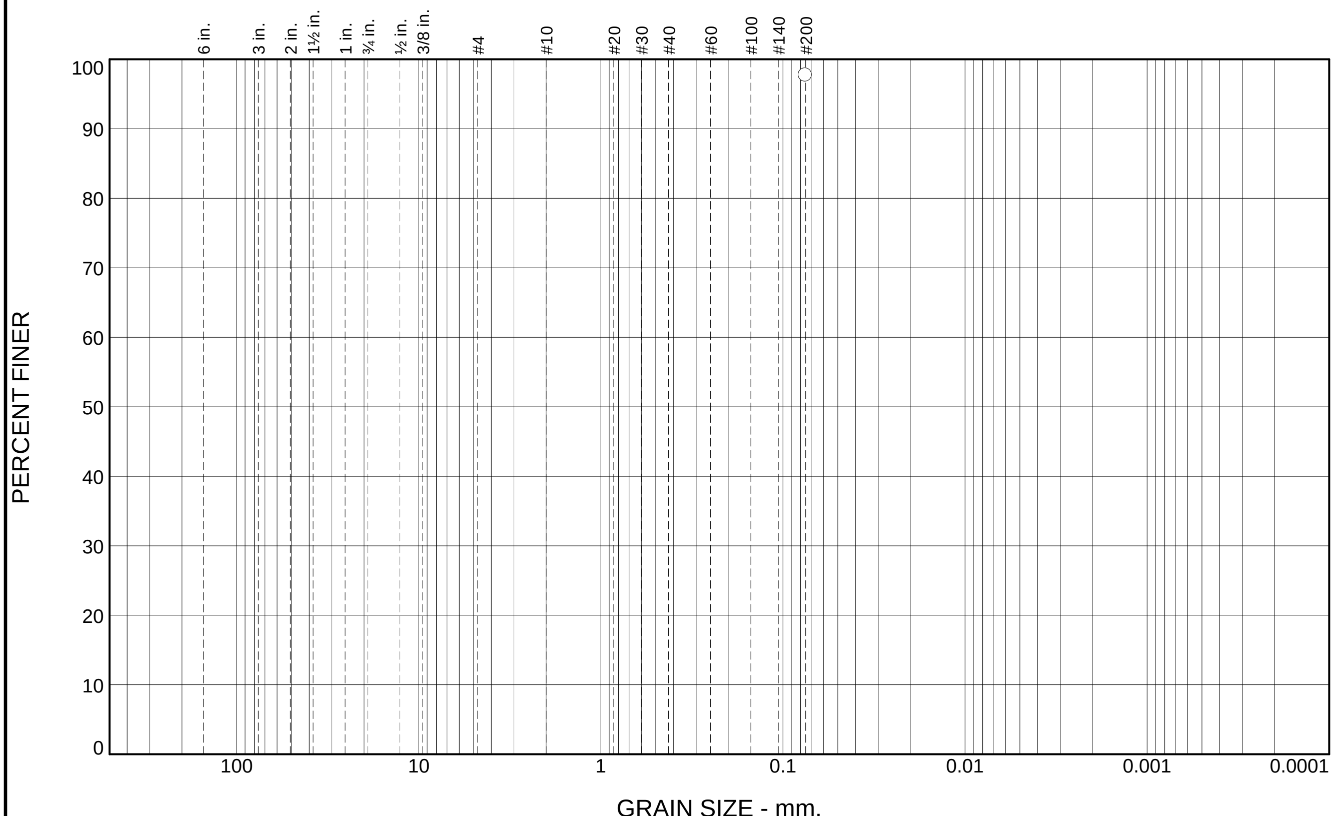
Client: GEI
Project: Small Communitites - Hood (1800776)

Project No: 3755.X 002 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						97.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	97.7		

* (no specification provided)

Material Description

Lean CLAY, blueish gray

Atterberg Limits

PL= 23 LL= 38 PI= 15

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: GEI_Hood_011C **Depth:** 12-14'
Sample Number: S02,S03 A/B **Date:**

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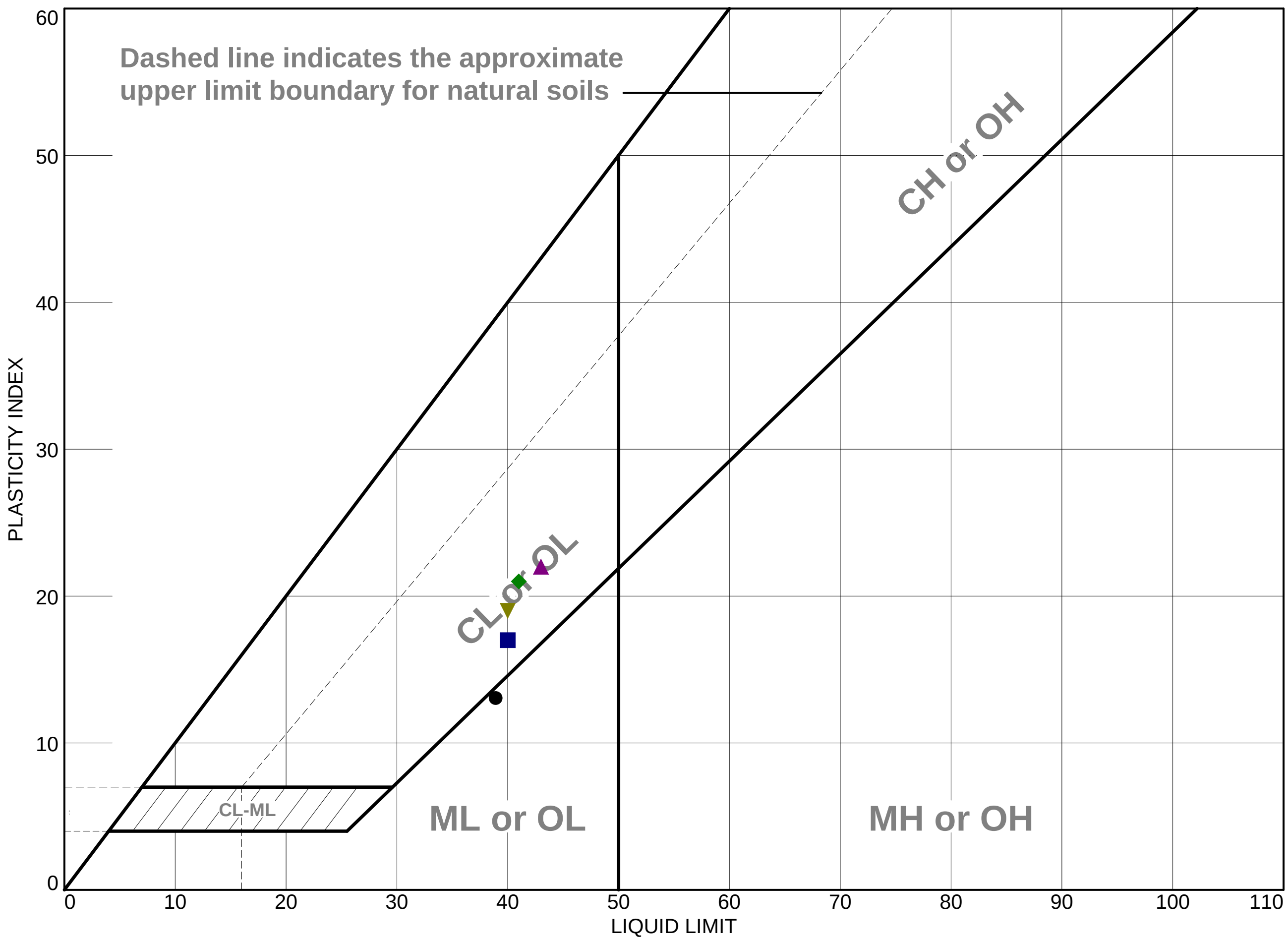
Client: GEI
Project: Small Communitites - Hood (1800776)
Project No: 3755.X 002 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SILT, dark grayish brown	39	26	13		89.6	ML
■	Lean CLAY, grayish brown	40	23	17		88.7	CL
▲	Lean CLAY with SAND, dark grayish brown	43	21	22	98.6	81.3	CL
◆	Lean CLAY with SAND, grayish brown	41	20	21		81.5	CL
▼	SANDY lean CLAY, dark grayish brown	40	21	19		68.5	CL

Project No. 3755.X 002 **Client:** GEI

Project: Small Communitites - Hood (1800776)

●**Source:** GEI_Hood_001C **Depth:** 6-9' **Sample No.:** S04,S05 A/B
■**Source:** GEI_Hood_002C **Depth:** 10-13' **Sample No.:** S06A,S07A,S08A/B
▲**Source:** GEI_Hood_003C **Depth:** 15-17' **Sample No.:** S05,S06 A/B
◆**Source:** GEI_Hood_004C **Depth:** 19-21' **Sample No.:** S05,S06 A/B
▼**Source:** GEI_Hood_006C **Depth:** 10.3-11',17-18' **Sample No.:** S01,S02 A/B

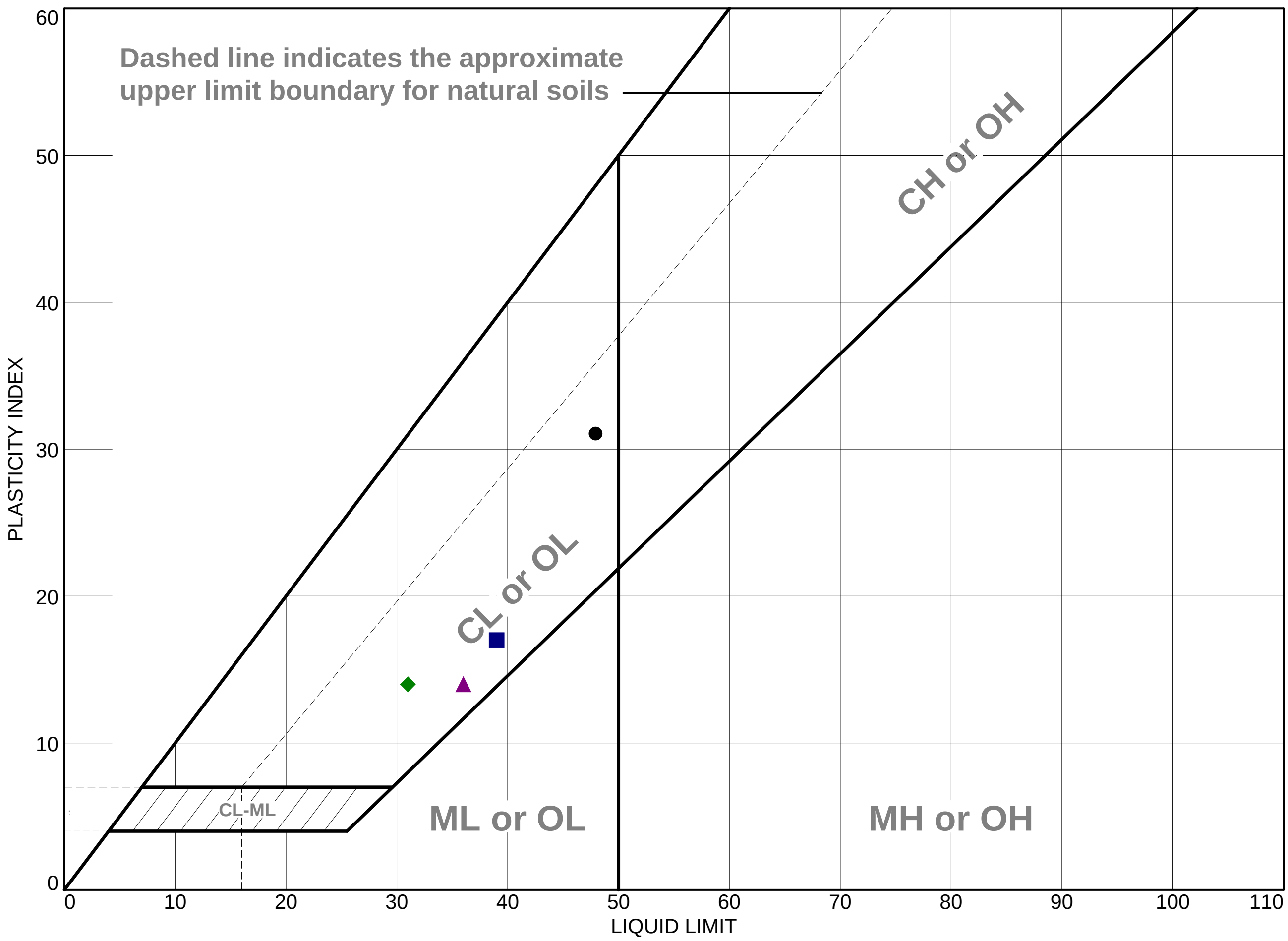
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, very dark grayish brown/dark blueish gray	48	17	31		79.4	CL
■	SANDY lean CLAY, pale brown	39	22	17		75.1	CL
▲	SANDY lean CLAY, olive brown	36	22	14		53.7	CL
◆	SANDY lean CLAY, brown	31	17	14		53.0	CL
▼	SILTY SAND, dark olive brown	NP	NP	NP		34.8	SM

Project No. 3755.X 002 **Client:** GEI

Project: Small Communitites - Hood (1800776)

●**Source:** GEI_Hood_007C **Depth:** 3-5' **Sample No.:** S01
■**Source:** GEI_Hood_007C **Depth:** 15-17' **Sample No.:** S04
▲**Source:** GEI_Hood_009C **Depth:** 4-6' **Sample No.:** S01
◆**Source:** GEI_Hood_009C **Depth:** 8-10' **Sample No.:** S02
▼**Source:** GEI_Hood_010C **Depth:** 4-6' **Sample No.:** S01

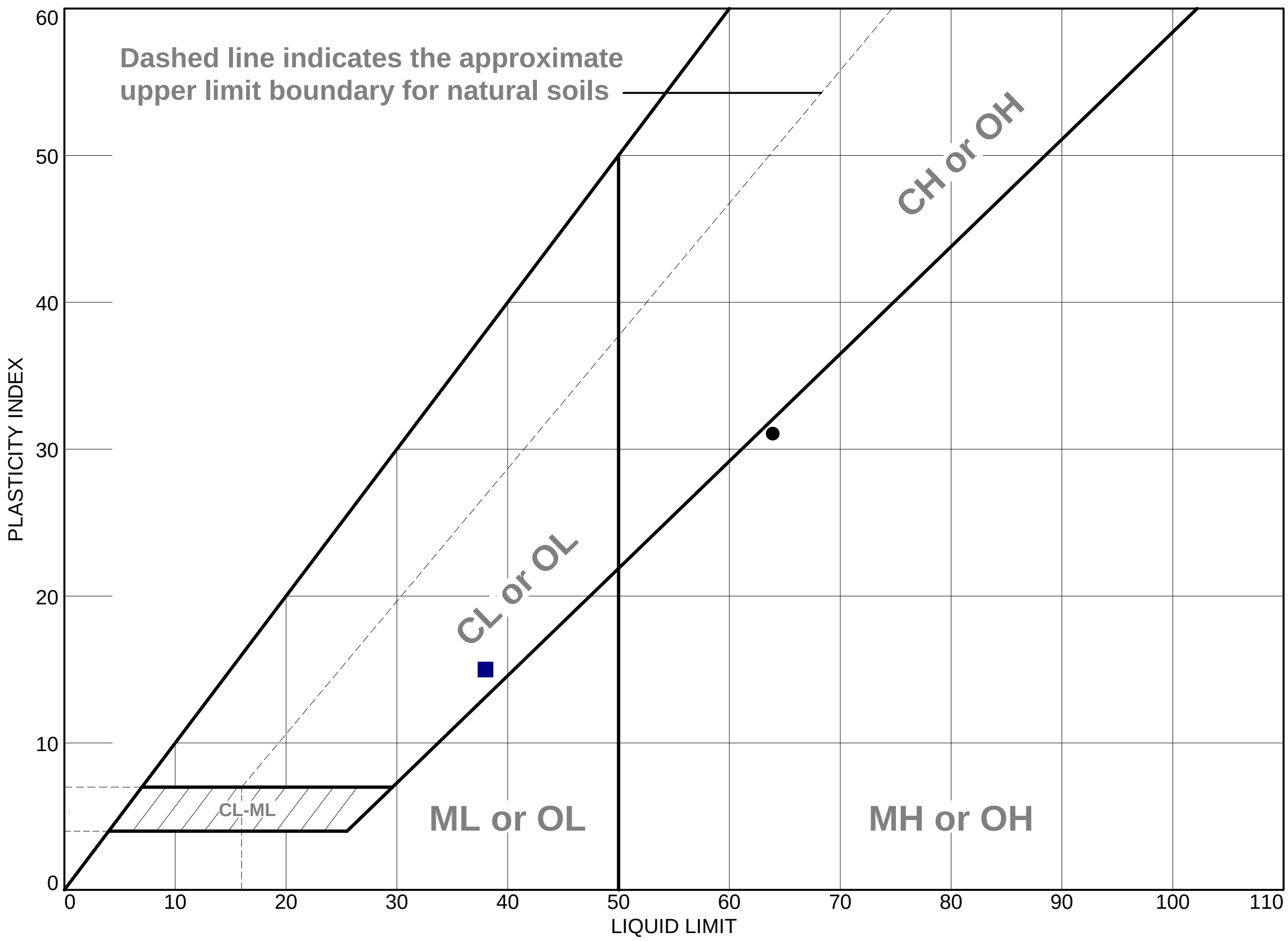
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	ELASTIC SILT, very dark grayish brown	64	33	31	99.2	96.7	MH
■	Lean CLAY, blueish gray	38	23	15		97.7	CL

Project No. 3755.X 002 **Client:** GEI

Project: Small Communitites - Hood (1800776)

● **Source:** GEI_Hood_011C **Depth:** 1-3' **Sample No.:** S01 A

■ **Source:** GEI_Hood_011C **Depth:** 12-14' **Sample No.:** S02,S03 A/B

Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

Appendix E

Appendix E. Preliminary Evaluation of Levees Protecting the Community of Hood with Exploration Recommendations

Segment	NULE Alignment ID	Reach	NULE Station	Levee Geometry: Crest Elev (ft)	LS Toe Elev (ft)	LS Levee Height (ft)	Crest Width (ft)	Base Width (ft)	Ditch Location	Bottom of Ditch Elev.	Average LS Slope (xH:1V)	Average WS Slope (xH:1V)	AWSE (ft)	Available Freeboard (ft)	Index Indicators: Net Head above toe (ft)	Net Head above ditch (ft)	Creep Ratio C_c=W/h_{cr}	Critical Blanket at Toe (ft)	Critical Blanket at Ditch (ft)	Exploration	Exploration Stationing	Blanket Thinkness-Each Expl (ft)	Selected Blanket Thickness at Toe (ft)	Selected Blanket Thickness at Ditch (ft)	Underseepage at Toe	Underseepage at Ditch	Shallow Foundation Material	Levee Material (CL, ML, SM)	Embankment Erodibility (*=assumed)	Base Width Bin	Confining/ Draining Shallow Foundation	T/S Max Net Head Criteria	Through Seepage	Past Performance (Green "X" = FSRP Site): Boils	Seepage	LS Slip/ Slough/ Subsidence	WS Erosion/ Slip/Slough	Reach	Preliminary Evaluation Notes
106	SACR-L	106-A	3110+00	26.1	13.2	12.9	102	168			1.9	17.0	23.2	2.9	10.0	--	16.8	16.1	NA											145							x	106-A	Reach Characteristics: - Predominantly underlain by historical overbank deposits with some Holocene overbank deposits on the landside - Average 9 feet of head above landside toe - History of seepage, boils, and waterside erosion throughout the reach - Seven explorations along reach – four indicate that there is a blanket condition ranging from 7 to 33-feet thick and three indicated a leaker condition with an average creep ratio of approximately 12 Levee Geometry: - Average Height: 16 feet - Average LS Slope: 2.4H:1V - Average WS Slope: 2.2H:1V - Average Crest Width: 33 feet Conclusions: - Underseepage: Identified as vulnerable due to the high head condition with a blanket condition in some portions and a leaker condition in others with creep ratios that do not meet criteria - Through Seepage: Identified as vulnerable due to an erodible embankment material and head that does not meet criteria - Slope Stability: Not identified as vulnerable due to wide levee crest indicating an overbuilt levee - Erosion: Not identified as vulnerable despite waterside slopes steeper than 3H:1V throughout the reach and the erodible embankment material because levee is overbuilt. Erosion could be addressed as a maintenance issue; however, left unmaintained could become vulnerable. - Freeboard: More than 3 feet freeboard present along the reach
106	SACR-L		3115+00	26.0	15.0	11.0	31	138			7.4	2.3	23.2	2.8	8.2	--	16.8	12.5	NA											120				x	x		x		
106	SACR-L		3120+00	30.8	15.3	15.5	28	96			2.4	2.0	23.2	7.5	8.0	--	12.1	12.0	NA	2f-91-41 2F-91-41A	3119+78 3119+81	0 13	0.0		DNM-Leaker		SM/ML	SAND, SM/ML	Erodible	95	draining	5.8	DNM		x		x		
106	SACR-L		3125+00	30.8	15.1	15.6	30	101			2.3	2.3	23.3	7.5	8.1	--	12.4	12.3	NA											95					x		x		
106	SACR-L		3130+00	31.3	14.7	16.6	42	119			2.3	2.4	23.3	8.0	8.5	--	13.9	13.1	NA											95					x		x		
106	SACR-L		3135+00	30.3	14.3	16.0	27	112			2.4	2.9	23.3	7.0	9.0	--	12.5	14.0	NA	sac-riv-10	3135+00	0.0	0.0		DNM-Leaker		ML		Erodible*	95	draining				x		x		
106	SACR-L		3140+00	30.3	14.9	15.4	27	116			3.2	2.6	23.4	6.9	8.5	--	13.7	13.0	NA											95					x		x		
106	SACR-L		3145+00	30.4	14.9	15.6	32	107			2.2	2.6	23.4	7.0	8.6	--	12.5	13.1	NA											95					x		x		
106	SACR-L		3150+00	31.1	15.1	16.0	32	101			2.1	2.2	23.5	7.6	8.4	--	12.1	12.7	NA											95							x		
106	SACR-L		3155+00	30.2	14.5	15.7	31	97			2.2	1.9	23.5	6.6	9.1	--	10.7	14.1	NA											95							x		
106	SACR-L		3160+00	30.2	14.1	16.1	29	102			2.2	2.3	23.6	6.6	9.5	--	10.7	15.0	NA											95						x	x		
106	SACR-L		3165+00	30.5	16.1	14.4	34	115			2.5	2.3	23.6	6.9	7.5	--	15.3	11.1	NA	Hood-001C	3165+00	33.0	33.0		Meets		ML (97.3%,89.6%)		Erodible*	95	confining				X		x		
106	SACR-L		3170+00	29.2	13.4	15.8	28	96			2.3	2.0	23.7	5.6	10.2	--	9.4	16.5	NA											95					X		x		
106	SACR-L		3175+00	29.9	13.8	16.1	33	99			2.3	1.8	23.7	6.2	9.9	--	10.0	15.8	NA	2f-64-10	3174+48	7.0	7.0		DNM-Grad		ML		Erodible*	95	confining			X	X		x		
106	SACR-L		3180+00	29.9	13.7	16.2	33	97			2.2	1.7	23.7	6.1	10.1	--	9.6	16.1	NA											95				x	x		x		
106	SACR-L		3185+00	30.4	17.1	13.3	36	117			3.1	1.6	23.8	6.6	6.7	--	17.5	9.4	NA											95				x	x		x		
106	SACR-L		3190+00	29.8	14.2	15.6	34	113			1.8	2.5	23.8	6.0	9.6	--	11.8	15.2	NA											95				x	x		x		
106	SACR-L		3195+00	30.0	14.1	15.9	37	104			2.0	2.2	23.9	6.1	9.8	--	10.6	15.6	NA	sac-riv-11	3195+00	0.0	0.0		DNM-Leaker		ML		Erodible*	95	draining			x	x		x		
106	SACR-L		3200+00	30.6	15.3	15.3	35	98			2.4	1.7	23.9	6.7	8.7	--	11.4	13.3	NA											95				X	X		x		
106	SACR-L		3205+00	30.6	13.4	17.2	34	109			2.2	2.2	24.0	6.7	10.5	--	10.3	17.1	NA	Hood-002C	3205+00	32.0	32.0		Meets		CL (88.7%)		Erodible*	95	confining			X	X		x		
106	SACR-L		3210+00	31.1	14.2	16.9	34	101			2.0	2.0	24.0	7.1	9.8	--	10.3	15.6	NA											95							x		
106	SACR-L		3215+00	31.1	13.9	17.2	34	115			2.1	2.6	24.0	7.1	10.1	--	11.4	16.2	NA											95							x		
106	SACR-L		3220+00	30.9	14.1	16.8	33	108			2.0	2.5	24.1	6.8	10.0	--	10.8	16.0	NA											95				X	X		x		
106	SACR-L		3225+00	30.8	14.2	16.6	35	107			2.6	1.7	24.1	6.7	9.9	--	10.8	15.8	NA											95							x		
106	SACR-L		3230+00	31.3	14.7	16.6	33	102			2.0	2.1	24.2	7.2	9.4	--	10.8	14.9	NA											95							x		
106	SACR-L		3235+00	32.0	14.7	17.3	32	95			2.0	1.7	24.2	7.8	9.5	--	10.1	15.0	NA											95							x		
North CL	HNCL	HNCL	0+00	33.0	12.0	21.0	150	480	At Toe	5	--	--	22.5	10.5	10.5	18.0	45.7	17.0	32.0	Hood-003C	1+65	20+	20.0	12.5	Meets	DNM-Grad	ML (73.6%)	ML (58.2%), SM	Erodible	245	confining	3.4	DNM					HNCL	Reach Characteristics: - Predominantly underlain by historical culturally deposited borrow pits with some historical overbank deposits on the landside; waterside is underlain by historical overbank deposits - Average 18 feet of head above landside toe - No documented past performance - Two explorations along reach – one indicated that there is a blanket condition at least 49 feet thick and one indicated a leaker condition with a average creep ratio of approximately 7 Levee Geometry: - Average Height: 17 feet - Average LS Slope: 1.4H:1V - Average WS Slope: 4.8H:1V - Average Crest Width: 39 feet Conclusions: - Underseepage: Identified as vulnerable due to the high head and a leaker condition that does not meet creep ratio criteria - Through Seepage: Identified as vulnerable due to an erodible embankment material and high head that does not meet criteria - Slope Stability: Not identified as vulnerable due to wide levee crest indicating an overbuilt levee - Erosion: Not identified as vulnerable despite waterside slopes steeper than 3H:1V throughout the reach and the erodible embankment material because levee is overbuilt. Erosion could be addressed as a maintenance
North CL	HNCL		5+00	22.0	12.0	10.0	47	133	At Toe	4	3.1	6.8	22.5	-0.5	10.5	18.5	12.6	17.0	33.0											120									
North CL	HNCL		10+00	20.4	12.0	8.4	31	80	At Toe	5	2.1	2.7	22.5	-2.1	10.5	18.0	7.6	17.0	32.0	Hood-004C	11+05	49+	49.0	41.5	Meets	Meets	CL (81.5%)	SM (48.9%), ML	Erodible	95	confining	3.4	DNM						
East RR	HDERR	HDERR-A	0+00	26.5	13.1	13.4	89	249			5.9	2.1	19.80	6.7	6.7	--	37.1	9.4	NA											245								HDERR-A	Reach Characteristics: - Predominantly underlain by Holocene overbank deposits with some historical overbank deposits on both landside and waterside. - Average 10 feet of head above landside toe - No documented past performance - Two explorations along reach indicated a blanket condition ranging from at least 49 feet to at least 65 feet thick Levee Geometry: - Average Height: 17 feet - Average LS Slope: 2.5H:1V - Average WS Slope: 1.9H:1V - Average Crest Width: 23 feet Conclusions: - Underseepage: Not identified as vulnerable due to the presence of a thick blanket condition meets criteria - Through Seepage: Identified as vulnerable due to an erodible embankment material and high head that does not meet criteria - Slope Stability: Not identified as vulnerable due to landside slopes that were predominantly flatter than 2H:1V and where steeper slope were noted, the crest width was wide indicating an overbuilt levee - Erosion: Identified as vulnerable due to waterside slopes steeper than 3H:1V, narrow crest width in some locations, and erodible embankment material - Freeboard: More than 3 feet freeboard present along the reach
East RR	HDERR		5+00	26.4	8.9	17.5	26	104			2.4	2.0	19.79	6.6	10.9	--	9.5	17.8	NA											95									
East RR	HDERR		10+00	26.1	8.1	17.9	28	91			1.8	1.7	19.78	6.3	11.6	--	7.8	19.3	NA											95									
East RR	HDERR		15+00	25.8	9.1	16.7	24	97			2.5	1.8	19.78	6.0	10.7	--	9.1	17.3	NA											95									
East RR	HDERR		20+00	25.4	9.9	15.5	31	97			2.2	2.0	19.77	5.6	9.8	--	9.9	15.7	NA											95									
East RR	HDERR		25+00	26.5	11.0	15.5	14	173			4.0	1.7	19.76	6.8	8.7	--	19.8	13.4	NA	Hood-005C	26+05	49+	49.0		Meets		CL	ML, CL	Erodible	170	confining	3.4	DNM						
East RR	HDERR		30+00	26.7	10.1	16.5	27	98			2.5	1.3	19.75	6.9	9.6	--	10.2	15.3	NA											95									
East RR	HDERR		35+00	25.2	7.8	17.4	6	104			3.1	2.5	19.75	5.5	11.9	--	8.7	19.8	NA											95									
East RR	HDERR		40+00	26.3	10.1	16.2	31	116			2.1	1.9	19.74	6.6	9.7	--	12.0	15.4	NA	Hood-006C	41+50	65+	65.0		Meets		CL (68.5%)	ML,CL (68.5%)	Erodible	95	confining	3.4	DNM						
East RR	HDERR		45+00	23.7	7.5	16.2	24	181			2.1	2.5	19.73	4.0	12.2	--	14.9	20.4	NA											170									
East RR	HDERR	HDERR-B	50+00	24.3	6.4	17.9	17	143	At Toe	6	1.4	3.6	19.72	4.5	13.4	13.4	10.7	22.7	22.8											120								HDERR-B	Reach Characteristics: - Predominantly underlain by Quaternary riverbank and historical marsh deposits with one location of Historical crevasse splay deposits - Average 16 feet of head above landside toe - No documented past performance - One exploration along reach indicated a blanket condition of approximately 21 feet thick Levee Geometry: - Average Height: 23 feet - Average LS Slope: 1.7H:1V - Average WS Slope: 1.6H:1V - Average Crest Width: 20 feet Conclusions: - Underseepage: Identified as vulnerable due to the presence of high head and blanket condition that does not meet criteria - Through Seepage: Identified as vulnerable due to an erodible embankment material and high head that does not meet criteria - Slope Stability: Identified as vulnerable due to landside slopes steeper than 2H:1V along the reach - Erosion: Identified as vulnerable due to waterside slopes steeper than 3H:1V and possible erodible embankment material - Freeboard: More than 3 feet freeboard present along the reach
East RR	HDERR		55+00	25.8	3.7	22.1	6	124	At Toe	4	2.0	2.9	19.72	6.1	16.0	15.9	7.7	28.0	27.8											120									
East RR	HDERR		60+00	26.4	2.4	24.0	21	126	At Toe	2	1.0	1.0	19.71	6.7	17.3	17.3	7.3	30.6	30.6											120									
East RR	HDERR		65+00	26.3	2.7	23.6	9	121	At Toe	3	1.6	1.0	19.70	6.6	17.0	17.2	7.1	30.0	30.4											120									
East RR	HDERR		70+00	26.8	-0.3	27.1	26	121	At Toe	0	1.6	1.1	19.69	7.1	20.0	20.0	6.1	36.0	36.0	Hood-007C	69+00	21.0	21.0	21.0	DNM-Grad	DNM-Grad	CL (79.4%, 75.1%)		Erodible*	120	confining								
East RR	HDERR		75+00	26.8	3.8	23.0	28	185			2.6	1.2	19.68	7.2	15.9	--	11.7	27.7	NA											170									
East RR	HDERR		80+00	26.9	5.2	21.7	28	148			1.8	1.1	19.68	7.2	14.5	--	10.2	25.0	NA											145									
East RR	HDERR		85+00	26.7	5.7	20.9	27	157			1.5	0.9	19.67	7.0	13.9	--	11.3	23.9	NA											145									

Appendix E. Preliminary Evaluation of Levees Protecting the Community of Hood with Exploration Recommendations

Segment	NULE Alignment ID	Reach	NULE Station	Levee Geometry: Crest Elev (ft)	LS Toe Elev (ft)	LS Levee Height (ft)	Crest Width (ft)	Base Width (ft)	Ditch Location	Bottom of Ditch Elev.	Average LS Slope (xH:1V)	Average WS Slope (xH:1V)	AWSE (ft)	Available Freeboard (ft)	Index Indicators: Net Head above toe (ft)	Net Head above ditch (ft)	Creep Ratio C_c=W/h_{cr}	Critical Blanket at Toe (ft)	Critical Blanket at Ditch (ft)
East RR	HDERR	HDERR-C	90+00	27.1	11.3	15.8	24	82			1.6	2.0	19.66	7.4	8.4	--	9.7	12.8	NA
East RR	HDERR		95+00	27.1	10.8	16.3	31	86			1.6	1.8	19.65	7.4	8.9	--	9.7	13.8	NA
East RR	HDERR		100+00	26.3	11.4	14.9	31	104			2.3	1.7	19.65	6.6	8.3	--	12.6	12.6	NA
East RR	HDERR		105+00	26.1	7.6	18.5	35	123	At Toe	8	2.3	1.8	19.64	6.4	12.1	12.1	10.2	20.1	20.3
East RR	HDERR		110+00	26.6	11.2	15.5	29	94	38	9	1.9	2.4	19.63	7.0	8.4	10.6	11.2	12.9	17.3
East RR	HDERR		115+00	26.4	10.2	16.2	29	99			1.9	2.5	19.62	6.8	9.4	--	10.6	14.8	NA
East RR	HDERR		120+00	26.7	9.8	16.9	30	120			1.7	1.9	19.62	7.1	9.9	--	12.2	15.7	NA
East RR	HDERR		125+00	26.6	9.8	16.8	34	149			1.5	1.5	19.61	7.0	9.8	--	15.1	15.7	NA
East RR	HDERR		130+00	26.2	8.7	17.5	58	143	At Toe	9	2.1	1.1	19.60	6.6	10.9	10.9	13.0	17.9	17.8
South RR	HDSRR	HDSRR-A	0+00	26.2	4.5	21.6	42	174			1.8	2.1	21.4	4.8	16.9	--	10.3	29.7	NA
South RR	HDSRR		5+00	25.7	7.9	17.8	38	109	At Toe	8	2.0	2.0	21.4	4.3	13.5	13.4	8.1	23.0	22.8
South RR	HDSRR		10+00	26.2	7.1	19.1	19	138	At Toe	7	1.8	2.0	21.4	4.8	14.3	14.4	9.6	24.7	24.8
South RR	HDSRR		15+00	26.4	10.1	16.3	25	104			1.9	2.1	21.4	5.0	11.3	--	9.2	18.7	NA
South RR	HDSRR		20+00	26.3	11.6	14.6	20	92			2.0	2.4	21.4	4.9	9.8	--	9.5	15.5	NA
South RR	HDSRR		25+00	26.4	8.3	18.1	21	108			1.7	2.3	21.4	5.0	13.1	--	8.2	22.3	NA
South RR	HDSRR		30+00	26.1	12.2	13.9	54	160			1.8	2.4	21.4	4.7	9.2	--	17.3	14.5	NA

NULE Station	Exploration	Exploration Stationing	Blanket Thinkness-Each Expl (ft)	Selected Blanket Thickness at Toe (ft)	Selected Blanket Thickness at Ditch (ft)	Underseepage at Toe	Underseepage at Ditch	Shallow Foundation Material	Levee Material (CL, ML, SM)	Embankment Erodibility (*=assumed)	Base Width Bin	Confining/ Draining Shallow Foundation	T/S Max Net Head Criteria	Through Seepage	Past Performance (Green "X" = FSRP Site): Boils	Seepage	LS Slip/ Slough/ Subsidence	WS Erosion/ Slip/Slough	Reach
90+00											95								East RR-C
95+00											95								
100+00											95								
105+00	Hood-008C	103+00	42+	42.0	41.9	Meets	Meets	CL	CL, ML	Not Erodible	120	confining							
110+00											95								
115+00											95								
120+00											120								
125+00											145								
130+00											120								
0+00											170								South RR-A
5+00	Hood-009C	7+40	N/A					CL	CL (53.7%,53%)	Not Erodible	95								
10+00											120								
15+00											95								
20+00											95								
25+00	Hood-010C	26+65	32.0	32.0		Meets		CL	SM (34.8%), CL	Erodible	95	confining	3.4	DNM					
30+00											145								

Reach	Preliminary Evaluation Notes
East RR-C	Reach Characteristics: - Predominantly underlain by Quaternary riverbank deposits with one location of historical eolian deposits - Average 10 feet of head above landside toe - No documented past performance - One exploration along reach indicated a blanket condition of at least 42 feet thick Levee Geometry: - Average Height: 16.5 feet - Average LS Slope: 1.9H:1V - Average WS Slope: 1.9H:1V - Average Crest Width: 33 feet Conclusions: - Underseepage: Not identified as vulnerable due to the presence of a blanket condition that meets criteria; however, this is based on a single exploration and further explorations are necessary for design level considerations - Through Seepage: Not identified as vulnerable due to a non-erodible embankment material; however, this is based on a single exploration and further explorations are necessary for design level considerations - Slope Stability: Not identified as vulnerable due to wide levee crest indicating an overbuilt levee - Erosion: Not identified as vulnerable despite waterside slopes steeper than 3H:1V throughout the reach and the erodible embankment material because levee is overbuilt. Erosion could be addressed as a maintenance issue; however, left unmaintained could become vulnerable. - Freeboard: More than 3 feet freeboard along the reach
South RR-A	Reach Characteristics: - Predominantly underlain by historical culturally deposited borrow pits with some Pleistocene Eolian and historical overbank deposits on the landside; waterside is underlain by Holocene basin deposits and Pleistocene riverbank formation - Average 13 feet of head above landside toe - No documented past performance - One exploration along reach indicated a blanket condition of at 32 feet thick Levee Geometry: - Average Height: 17.5 feet - Average LS Slope: 1.9H:1V - Average WS Slope: 2.2H:1V - Average Crest Width: 31 feet Conclusions: - Underseepage: Not identified as vulnerable due to the presence of a blanket condition that meets criteria; however, this is based on a single exploration and further explorations are necessary for design level considerations - Through Seepage: Identified as vulnerable due to an erodible embankment material and high head that does not meet criteria - Slope Stability: Identified as vulnerable due to landside slopes steeper than 2H:1V along the reach - Erosion: Identified as vulnerable due to waterside slopes steeper than 3H:1V and erodible embankment

Appendix F