Geotechnical Analysis and Levee Certification Report Revised

North Shore Levee West Segment
Hoquiam, Washington

for
KPFF Consulting Engineers, Inc.

March 17, 2020

GeoEngineers
Earth Science + Technology

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1.0 INTRODUCTION AND SCOPE OF SERVICES

This report provides geotechnical analysis and certification for the City of Hoquiam North Shore Levee West Segment project in Hoquiam, Washington. The City of Hoquiam (Hoquiam) is planning to construct approximately 5 miles of levees and floodwalls. The purpose of the project is to construct a levee that will be accredited by the Federal Emergency Management Agency (FEMA) and considered by the National Flood Insurance Program in revising the flood insurance rate map (FIRM) for portions of Hoquiam.

The purpose of this report is to provide analysis demonstrating that the proposed levee and floodwall system will meet the geotechnical stability requirements of 44 Code of Federal Regulations (CFR) 65.10 based on the 100-year flood event. Additional requirements of 44 CFR 65.10 will be addressed in separate reports prepared by the team lead. KPFF Consulting Engineers (KPFF) and the team hydraulics engineer Watershed Science & Engineering (WSE). Our analysis is based on the Geotechnical Evaluation Guidance from the United States Army Corps of Engineers (USACE) Engineering Circular 1110-2-6067 "USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation". USACE Engineering Manual 1110-2-1913 "Design and Construction of Levees," and sound engineering practices.

Our services have been provided in accordance with our agreement dated September 16, 2019. Our scope of services for the geotechnical analysis presented in this report includes:

- Reviewing existing subsurface data.
- Performing 17 subsurface explorations: seven cone penetrometer tests (CPTs), six borings and three electric vane shear tests (eVSTs).
- Performing primary laboratory or index tests on representative soil samples including moisture contents, Atterberg limits, and percent fines passing no. 200 (0.075 mm) sieve.
- Performing secondary strength laboratory tests laboratory tests on representative soil samples, including triaxial unconsolidated undrained (TXUU) testing.
- Performing stability and seepage analyses under the three design conditions (end-of-construction, steady state seepage, and rapid drawdown).
- Performing settlement analysis of the levee embankment to assess the potential settlement of the levee that could reduce freeboard over time.
- Developing geotechnical design recommendations for levee construction.
- Preparing this Geotechnical Analysis and Levee Certification Report summarizing the results of our exploration program, laboratory testing, analyses, and providing conclusions and recommendations.

2.0 DESIGN CONDITIONS

2.1. Design Hydraulic Conditions

Hydraulic conditions have been analyzed by WSE and will be described in more detail in their accompanying technical memorandum in the Conditional Letter of Map Revision (CLOMR) application.

The project is in Hoquiam, Washington. The proposed alignment is along the Hoquiam River (north and east portion of proposed alignment) and north of Grays Harbor (southern portion of alignment). A Vicinity Map is provided as Figure 1. An overall Site Plan is presented in Figure 2. Grays Harbor and the Hoquiam River are primarily tidally influenced within the project area. Hydraulic analysis has shown that variations in the water level in Grays Harbor influences predicted flood elevations more than variations in the flow of the Hoquiam River. FEMA Base Flood Elevations (BFEs) in the project area have been determined based on coastal flooding criteria rather than riverine flooding.

WSE estimates the stillwater elevation within the project area to be Elevation 13.1 feet. Wave run up under a design storm has been predicted to be ranging from Elevation 13.8 feet to 15.1 feet (WSE 2017). The currently effective FEMA mapping for Hoquiam shows BFEs of 13.0 feet along the shoreline of Grays Harbor transitioning to Elevation 14.0 feet upstream from the Puget Sound and Pacific Railroad bridge crossing the Hoquiam River. WSE believes that the change in BFE (from Elevation 13.0 to 14.0 feet) is a mapping error. The BFE for this project in Hoquiam has been established at Elevation 14.0 feet. The top of the levees and floodwalls will be established at Elevation 15.2 feet. All elevations referenced in this report use the National American Vertical Datum of 1988 (NAVD88). The BFEs are based on coastal flooding and, as a result, are driven in a large part by the tide cycles. According to WSE's 2017 hydraulic analysis report for Aberdeen, Washington: high water events that rise above the surrounding ground surface, at about Elevation 10 feet (NAVD88), are anticipated to recede within 4 to 6 hours.

2.2. Existing Site Conditions

The proposed alignment of the North Shore Levee West Segment is located within the city of Hoquiam on the north side of Grays Harbor and to the west of the Hoquiam River. The proposed alignment extends through residential, commercial, and light industrial areas. Existing surface conditions are relatively flat and generally range between Elevation 11 and Elevation 16 feet (NAVD88). Existing high ground tie-ins have been established to be Elevation 15.2 feet or greater.

Structures along the Hoquiam River and Grays Harbor include a shipyard, pump stations, local businesses, light industrial buildings, railroad tracks, highway bridges, and abandoned timber piles that once supported structures built on or adjacent the riverbank. There are two highway bridges (Riverside Avenue Bridge and Simpson Avenue Bridge) and one Puget Sound and Pacific Railroad bridge (proposed levee Station 101+00 to Station 101+50). A seawall with riprap revetment at the base is also present along the Hoquiam River from Karr Avenue (proposed levee Station 96+00) to 10th Street (proposed levee Station 121+50). In addition, old timber piles are present along the bank of the Hoquiam River and docking facilities. The piles are generally located offshore and within the riverbank that is exposed during low tides.

2.3. Proposed Levee System

The approximately 5-mile-long levee system consisting of a combination of earth embankment levees and various floodwalls (i.e., concrete, sheet pile, stop log closures) is proposed to provide flood protection for portions of Hoquiam. The north and west portion of the proposed alignment consists of approximately 2.7 miles along the west bank of the Hoquiam River. The 2.7-mile section of alignment extends from approximate intersection of Endressen Road and Perry Avenue to the southern mouth of the Hoquiam River near the confluence of Grays Harbor. The southern portion of the proposed alignment continues west from the southern mouth of the Hoquiam River, parallel to the railroad tracks located inland of Grays Harbor. Both the north and southwest extents of the levee system will tie-in to existing natural high ground. The levee system alignment will intersect bridge approach embankments in two locations: Riverside Avenue Bridge and Simpson Avenue Bridge.

The levee crest elevation will be designed at Elevation 15.2 feet. To account for future expansion, modifications, or overbuilding for long-term settlement considerations, we have evaluated all earth embankment levee sections assuming a crest Elevation 16.0 feet.

For our analysis, we have divided the proposed levee system into five reaches based on the observed subsurface conditions. These areas are shown on Figure 2. Referenced project stationing is based on the plan set titled "North Shore Levee West Segment CLOMR Plans," dated March 3, 2020 provided to us by KPFF on March 13, 2020. The project stationing has been estimated to the nearest 50 feet.

TABLE 1. LEVEE REACHES

Reach	Approximate Station Limits	Representative Cross Sections (Approximate Station)	General Description
Reach 1: North Alignment Design Group	0+80 (Existing High Ground Tie-In) to 32+00	Cross sections are not provided for this reach. In our opinion the proposed alignment maintains sufficient setback through this reach and in our opinion slope stability is not a concern. This design group was analyzed for settlement and bearing capacity.	Reach 1 extends from the high ground tie-in near the intersection of Highway 101 and Queen Avenue through residential neighborhoods and light industrial areas inland of the Hoquiam River. The flood protection system will consist of concrete floodwalls and a section of earthen embankment with stop log closures at some of the street intersections and private drives.
Reach 2: Hoquiam River Design Group	32+00 to 87+50	2A (55+00)	Reach 2 extends from the north of the previously occupied lumber mill and continuing south along the Hoquiam River through mostly undeveloped property privately owned property as well as residential neighborhoods. The flood protection system will consist of earthen embankment sections tied into existing high ground as well as sheet pile floodwalls with stop log closures at some of the street intersections and private drives.
Reach 3: North Hoquiam Design Group	87+50 to 106+00 (north side of Riverside Avenue Bridge West Approach)	3A (95+00), 3B (104+50)	Reach 3 extends from Chenault Avenue (Levee Station 87+50) through light industrial and commercial property to the north side of the Riverside Avenue Bridge approach. The flood protection is within the City of Hoquiam right-of-way and will consist of earthen embankments, concrete and sheet pile floodwalls.

Reach	Approximate Station Limits	Representative Cross Sections (Approximate Station)	General Description
Reach 4: South Hoquiam Design Group	106+00 (south side of Riverside Avenue West Approach) to 130+00	4A (107+00), and 4B (123+50)	Reach 4 extends from the south side of the Riverside Avenue Bridge west approach along Levee Street through commercial areas and property. The flood protection is within the City of Hoquiam right-of-way and will consist of earthen embankment and concrete floodwalls
Reach 5: Grays Harbor Design Group	130+00 (Simpson Ave. Bridge) to 201+00 (Southwest Tie-in)	Cross sections are not provided for this reach. In our opinion the proposed alignment maintains sufficient setback through this reach and slope stability in our opinion is not an issue. Reach 5 was analyzed for settlement, bearing capacity and lateral earth pressures.	Reach 5 extends from the Simpson Avenue Bridge intersection through residential neighborhoods, light industrial areas and the Puget Sound & Pacific Railroad to the southwest high ground tie-in near the intersection of Paulson Road and West Emerson Avenue. The flood protection will consist of concrete t-walls, earthen embankments (access road) and sheet pile floodwall at the southwest tie-in and utilizing existing high ground along the alignment.

3.0 LEVEE STRUCTURAL ANALYSIS

3.1. Embankment Protection and Scour

The BFE along Grays Harbor and along the Hoquiam River in the project area has been determined by WSE to be Elevation 14.0 feet (NAVD88). We understand from WSE that this elevation is based on coastal flooding in Grays Harbor. In Reaches 1 and 5 the North Shore Levee alignment is significantly inland from the water and wave run up or flowing flood water is not expected to reach the levee. In Reaches 2, 3 and 4, the levee is closer to the water. According to the 2017 report completed by WSE, the fetch is limited to the width of the Hoquiam river or a narrow section of Grays Harbor. Therefore, erosion from wind generated waves are not expected to be significant along the length of the proposed levee alignment and wave run-up on the levee prism or floodwalls is expected to be minor, if it occurs at all.

Based on WSE's 2017 hydraulic modeling of the levee system in Aberdeen and Hoquiam; models indicated that shallow flooding along rivers might occur in the 100-year flood. Any overbank flows would be shallow and largely confined to street flooding less than 2 feet deep. Overbank flows from the Hoquiam river reaching the proposed levee are expected to have velocities of less than 0.9 feet per second. Based on our understanding of this potential hydraulic loading, it is our opinion that the proposed earth levees can be protected from erosion by maintaining a grass covering.

Based on available information for the 2017 North Shore Levee project in Aberdeen, Washington, it is our opinion that the effects of long-term scour do not need to be included in our stability analyses.

3.2. Levee Crossings and Adjacent Structures

The impacts of adjacent structures on the levee, including roads, bridges, buildings, and utilities have been considered in our analysis. Structures that are constructed primarily of soil (i.e., roads, railroad embankments, and bridge approach embankments) were included in the stability analyses where appropriate. For example, where roads are located on top or adjacent to the levee or floodwall, the roadway is included in the analysis.

Significant structures that are adjacent to or cross the proposed levee alignment that are not constructed of soil include: multiple buildings between the bank of the Hoquiam River and Levee Street, an abandoned railroad bridge, railroad embankments, the Simpson Avenue Bridge (State Route [SR] 101), and the Riverside Avenue Bridge (SR 101). The bridge structures are confirmed, either through direct observation or review of as-built plans, to be supported on deep foundations. Structures supported on deep foundations will not interfere or add load to the levee structure or levee foundation. Accordingly, no additional structural analysis is warranted for these existing structures.

3.3. Subsurface Conditions

3.3.1. Foundation Material Characteristics

3.3.1.1. Geologic Setting

The site is located on the north side of Grays Harbor and along the west bank of the Hoquiam River. The geologic map "Geologic Map of the Humptulips Quadrangle and Adjacent Areas, Grays Harbor County, Washington" (Weldon W. Rau 1986) indicates the soils are Quarternary Deposits (Qd), with includes alluvium and glacial drift of alpine origin. The hills where the north high ground tie-in is located are mapped as the Montesano Formation (Tmss), which is described as sandstone and conglomerate. The Montesano Formation also borders a thin strip of brecciated basalt (Tab), located along the tree line running south from the intersection of Highway 101 and Endresen Road to the intersection of Lincoln Street and Ramer Avenue.

3.3.1.2. Subsurface Explorations

Subsurface conditions along the proposed North Shore Levee Alignment West Segment were explored by advancing seven CPTs and three eVSTs and performing six geotechnical borings using mud-rotary techniques. The explorations occurred between June 5 and November 15, 2019. The locations of these explorations are shown of Figure 2. Additional details regarding our explorations and laboratory testing program are provided in Appendix A.

3.3.1.3. Reviewed Subsurface Information

We also reviewed existing subsurface information obtained internally and through a search of public records from the Washington Department of Transportation (WSDOT) and the Washington Department of Natural Resources' (DNR) Washington State Geologic Information Portal. Relevant documents included subsurface data and soils testing information from the WSDOT SR 520 Pontoon Construction Project (Grays Harbor), Hoquiam River Woodlawn Water Pipeline Crossing project, and from design studies for the bridges that cross the Hoquiam River (Riverside Avenue Bridge and Simpson Avenue Bridge). A summary of the documents and the information used as reference and directly in our analysis is provided in Table 2 below.

TABLE 2. REVIEWED SUBSURFACE INFORMATION NEAR THE PROPOSED LEVEE

Document; Author	Date of Study	Pertinent Information
Foundation Recommendations Letter – SR-101, C.S. 1402, L-7262 West Hoquiam Connection Little Hoquiam River Bridge No. 101/130 Widening; WSDOT	May 1983	Generalized soil profiles, properties and descriptions of soil units.
Geotechnical Engineering and Environmental Evaluation Report – Hoquiam River Woodlawn Water Pipeline Crossing; AGRA Earth & Environmental	December 1997	Subsurface soil descriptions and moisture contents.
WSDOT – Aberdeen Hoquiam Couplet	1967 – 1997	Subsurface soil conditions; consolidation lab test results; TXUU and TXCU lab testing data and results
Geotechnical Report – Hoquiam River-Simpson Bridge No. 101/125W-Maintenance Turnout; WSDOT	March 2004	Pile and drilled shaft foundation design plans, parameters and calculations including liquefaction analysis; subsurface conditions at the bridge crossing; in-situ testing results (vane shear testing); TXUU and TXCU lab testing data and results; index testing results including sieve analysis, moisture content determinations and Atterberg limits.
Geotechnical Design Study – WSDOT SR 520 Pontoon Construction Project; Landau Associates	March 2009	Generalized soil profiles, properties and descriptions of units modeled.
Geotechnical Engineering Report – BHP Potash Export Terminal; Clarity Engineering LLC and Shannon & Wilson	June 2019	Generalized soil profiles and descriptions of encountered subsurface soil type.

The reference material listed in Table 2 was reviewed for pertinent subsurface information to evaluate general geologic conditions and to evaluate site variability. A select number of the reviewed reference materials are used within this study in direct support of design soil properties and levee system analysis. The subsurface soil study referenced the most in this report is "Landau Associates, Geotechnical Design Study for the WSDOT SR 520 Pontoon Construction Project" report dated March 25, 2009. Study is referred to in this report as the 2009 Landau report. The locations of explorations used directly to develop design soil properties are shown on Figure 2.

3.3.1.4. Groundwater

CPT data is interpreted to indicate a groundwater level at a depth ranging from approximately 3 to 5 feet below ground surface (bgs). Water levels in the borings could not be measured directly due to the drilling method used. Groundwater levels used during analysis are based on the anticipated flood conditions.

3.3.2. Site Soils and Design Soil Parameters

3.3.2.1. General

The site soils observed in our explorations consist of native alluvium typically overlain by a relatively thin (5- to 10-foot) layer of fill. We divided the project site into five general groups based on observed differences in the alluvium soil type. These groups are: North Alignment (Reach 1), Hoquiam River (Reach 2), North Hoquiam (Reach 3), South Hoquiam (Reach 4), and Grays Harbor (Reach 5).

3.3.2.2. Fill Material

Fill was observed in all reaches of the project, typically where the explorations were advanced in paved or previously developed areas. It is not clear how much fill is present in vacant lots or other underdeveloped areas. The observed fill consisted of combinations of variable clay, silt, sand, gravel, and organic matter (i.e., tree roots and wood debris). Relative density in terms of blow counts or equivalent blow counts measured in the field within non-cohesive materials in this study as well as previous studies completed in this area indicate an N value typically between 10 and 40 (medium dense to dense).

3.3.2.3. North Alignment Alluvium (Reach 1)

Data from CPT exploration, CPT-1-19, was used to determine material type and evaluate the soil strength properties using correlations presented by NCHRP Project 20-05 report. The correlation uses a bearing factor (K_{kt}) that is calibrated to the TXUU data. A N_{kt} value of 7 was determined to provide the best fit for calibrating the CPT with the TXUU lab results. A lower value of N_{kt} tends to indicate sensitive fine-grained soils. Figure A-33 shows the calibrated CPT data and strength properties used in design plotted against elevation for the North Alignment area (Reach 1).

The upper alluvium generally consists of clay with varying quantities of organics and sand particles. The consistency of the soil ranges from very soft to medium stiff. The upper alluvium generally extends from the ground surface to approximately Elevation -25 feet. The correlated CPT blow counts (N) measured for this material are generally between 1 to 7 blows per foot. Based on CPT correlations used to determine soil shear strength, these fine grained cohesive materials have an estimated undrained shear strength ranging from 500 pounds per square foot (psf) at approximate Elevation 9 (organic interbed deposit 300 psf, Elevation 2 to -1 feet) to 1,000 psf at approximate Elevation -12 feet.

The lower alluvium includes layers of silt (ML) with intermittent layers of sensitive fine-grained materials (i.e., organics). The consistency of the soils for the lower alluvium is on the order of a stiff soil. The lower alluvium is generally below approximate Elevation -40 feet. Based on CPT correlations, soil shear strength for these encountered fine-grained cohesive materials have an estimated undrained shear strength of 1,300 psf.

The unit weight of the alluvium was also evaluated from the CPT data using correlations published in the NCHRP project 20-05 report and calibrated to densities measured from Shelby tube samples. A unit weight of 104 and 106 pounds per cubic foot (pcf) was used for the upper and lower alluvium, respectively.

3.3.2.4. Hoquiam River Alluvium (Reach 2)

Data from CPT exploration, CPT-2-19, was used to determine material type and evaluate the soil strength properties using correlations presented by NCHRP Project 20-05 report. Additionally, boring logs B-3 and B-4 completed by AGRA Earth and Environment (1997) were reviewed to develop a subsurface design profile along with the CPT correlated soil types. Figures A-33 and A-34 show the calibrated CPT data with correlated strength and unit weight properties, respectively. The boring logs for B-3 and B-4 are provided within Appendix B of this report. These soil properties were plotted against elevation to generate a soil design profile for the Hoquiam River area (Reach 2).

CPT-2-19 displays results indicating the upper 5 to 10 feet consists of earth fill along the Hoquiam River. The fill generally consists of a mixture of sandy silt and silty sand. The fill is underlain by fine-grained alluvium (i.e., clay) with variable interbeds of sand deposits. The consistency of the soil ranges from medium stiff to stiff. The upper alluvium generally extends from approximate Elevation 2 feet to approximately Elevation -20 feet. Based on CPT correlations used to determine soil shear strength, these fine-grained cohesive materials have an estimated undrained shear strength ranging from 600 pounds per square foot (psf) at approximate Elevation 6 to 1,200 psf at approximate Elevation -20 feet.

The review of boring logs B-3 and B-4 (Agra 2007) document fill in the upper approximate 5 to 8 feet consisting of silt with variable sand, clay, gravel and organics. The consistency of the fill material is generally medium dense based on documented blow counts (N) ranging from 5 to 8 blows per foot. The fill is underlain by fine-grained alluvium (i.e. silt) with variable fine sand and organics. The consistency the upper alluvium soil shown in boring logs B-3 and B-4 is generally very soft. The upper alluvium shown in boring logs B-3 and B-4 generally extends from approximate Elevation 5 feet to an elevation ranging from -18 to -23 feet. The documented blow counts (N) shown on boring logs B-3 and B-4 are 0 blows per foot (0 to 250 psf).

CPT-2-19 shows the lower alluvium includes layers of silty clay (CL). The consistency of the soils within the lower alluvium is on the order of stiff to very stiff. The lower alluvium is generally below approximate Elevation -20 feet and extends to CPT termination Elevation -58 feet. Based on CPT correlations, the soil shear strength of these fine-grained cohesive materials have an estimated undrained shear strength of 1,200 to 2,000 psf.

The review of boring logs B-3 and B-4 (Agra 2007) document the lower alluvium to consist of consolidated silt and siltstone with variable amounts of fine sand. The consistency of the soils within the lower alluvium unit is generally very stiff to hard based on documented blow counts (N) ranging from 20 to 85 blows per foot (2,000 to 4,000 psf).

The subsurface design profile is provided in Figure A-33, showing estimated soil shear strength versus elevation design profile. The subsurface strength design profile was developed based on the results of CPT-2-19 and the review of boring logs B-3 and B-4. The upper alluvium strength design is based on the correlation results of CPT-2-19 and the documented blow counts in borings B-3 and B-4 (Agra 2007) and based on an approximate average of the three exploration we have provided a shear strength of 400 psf from ground surface to Elevation -10 feet. The strength design profile increases from Elevation -10 feet (400 psf) with depth to 1,200 psf at approximate Elevation -20 feet. The provided design strengths for the lower alluvium (Elevation -10 to -58 feet) range from 1,200 to 2,000 psf.

The unit weight of the alluvium was also evaluated from the CPT data using correlations published in the NCHRP project 20-05 report and calibrated to densities measured from Shelby tube samples. A unit weight of 106 to 110 pounds per cubic foot (pcf) was used for the upper alluvium and 108 to 110 pcf for the lower alluvium. See Figure A-34 for details, estimated soil unit weight versus elevation.

3.3.2.5. North Hoquiam Alluvium (Reach 3)

Data collected from the CPT exploration, CPT-6-19, was used to determine material type and evaluate the soil strength properties using correlations presented by NCHRP Project 20-05 repot. Additionally, selected samples from GEI-5-19 and GEI-6-19 were evaluated for pertinent engineering properties by completing primary and secondary laboratory testing. We also completed an eVST within Reach 3 to obtain in-situ shear strength properties. Figures A-35 and A-36 show the calibrated CPT data with correlated soil strength with TXUU and unit weight properties, respectively.

The upper 4 to 10 feet is made up of fill material along west bank of the Hoquiam River. The fill material consists of mixture of sand, silty sand and clay with CPT correlated blow counts (N) ranging from 41 to 72 blows per foot. The fill material is underlain by alluvial river deposits. We obtained poor testing results in CPT-6-19 for the upper 30 feet, and the correlated soil type encountered was inconsistent with the obtained soil samples for GEI-5-19 and GEI-6-19. CPT-6-19 shows results that correlate to clay alluvium in the upper 30 feet. The selected soil samples from GEI-5-19 and GEI-6-19 show the upper 20 to 35 feet consists of silty fine sand. Our analyses and assigned soil properties are based on the completed soil borings for GEI-5-19 and GEI-6-19. For analyses purposes we evaluated the upper alluvium as a silty sand.

The upper alluvium consists of silty fine sand with an interbedded, non-plastic, silt layer (approximate Elevation -8 to -13 feet). The soil samples within this zone were obtained by piston sampling. Based on our experience in this project area for cohesionless alluvium deposits, we assumed an internal soil friction angle (φ) of 28°. The upper alluvium generally extends to approximate Elevation -18 feet.

The lower alluvium includes fine-grained material, primarily consisting of silt (ML). The consistency of the soils for the lower alluvium is on the order of medium stiff to stiff. The lower fine-grained alluvium is generally below approximate Elevation -18. The results of eVST within Reach 3 display a lower alluvium shear strength of 1,300 to 1,600 psf. Based on CPT correlation, TXUU data, and eVST results; we have estimated an unconsolidated undrained shear strength for the lower alluvium to range from 500 to 1,200 psf. See Figure A-35 for details on estimated soil shear strength versus elevation design profile.

The unit weight of the alluvial deposits was evaluated using CPT correlation (NCHRP project 20-05 repot) and calibrated to densities measured from Shelby tube samples (TXUU). A unit weight of 104 to 113 pcf was used for the upper alluvium and 108 for the lower alluvium. See Figure A-36 for details on estimated soil unit weight versus elevation design profile.

3.3.2.6. South Hoquiam Alluvium (Reach 4)

Data from the CPT exploration, CPT-7-19, was used to determine material type and evaluate the soil strength properties using correlations presented by NCHRP Project 20-05 report. Additionally, selected samples from GEI-1-19, GEI-2-19, GEI-3-19, and GEI-4-19 were evaluated for pertinent engineering properties by completing primary and secondary laboratory testing. We also completed two eVST within Reach 4 to obtain in-situ shear strength properties at selected test depths. Figures A-37 and A-38 show the calibrated CPT data with correlated soil strength with TXUU and unit weight properties, respectively.

The upper 5 to 10 feet is made up of fill material along west bank of the Hoquiam River. The fill material consists of mixture of sand, silty sand and clay. The fill material is underlain by alluvial river deposits. We completed CPT-7-19 with Reach 4. The correlated CPT results indicate an upper fine-grained alluvium (i.e., silt and clay) that extends to approximate Elevation -35 feet. The upper fine-grained alluvium ranges in consistency from soft to stiff. Based on CPT correlations and TXUU strength testing results; we have estimated an unconsolidated undrained shear strength for the upper alluvium to range from 325 psf to 1,000 psf. See Figure A-37 for details on estimated soil shear strength versus elevation design profile.

The lower alluvium consists of silty fine sand with an interbedded. The CPT correlation for internal friction angle (φ), for the lower alluvium results in an average of 28°. The soil samples obtained from the geotechnical borings (GEI-1-19, GEI-2-19, GEI-3-19 and GEI-4-19) were collected by piston sampling, as a result representative blow counts were not obtained. We reviewed the collected soil samples and assigned pertinent lab testing to correlate the CPT data to the collected soil samples. Based on our experience in this project area, the collected CPT data and the soil testing results, we assumed an internal soil friction angle (φ) of 28°. The lower alluvium generally extends to the bottom of our CPT and soil boring explorations (Elevation -58 feet).

The unit weight of the alluvial deposits was evaluated using CPT correlation (NCHRP project 20-05 repot) and calibrated to densities measured from Shelby tube samples (TXUU). A unit weight of 98 to 110 pcf was used for the upper fine-grained alluvium and 108 to 118 for the lower alluvium. See Figure A-38 for details on estimated soil unit weight versus elevation design profile.

3.3.2.7. Grays Harbor Alluvium (Reach 5)

The soil properties and assumptions made for Grays Harbor (Reach 5) are based on the Geotechnical Design Study by Landau Associates for the WSDOT SR 520 Pontoon Construction Project (2009). The borings used for the development of soil properties for Reach 5 are shown in Figure 2. The boring logs and cross-section of the selected borings are presented in Appendix B. The obtained soil properties were used for the analysis of the proposed access road near the K Street Pump Station and the southwest tie-in near the intersection of West Emerson Avenue and Paulson Road. The generalized subsurface profile developed by Landau Associates shows approximately 5 to 10 feet of fill overlying alluvial deposits.

The upper alluvium consists of fine-grained silt of variable plasticity (MH and ML) and was generalized as Soil Unit 1. The consistency of the soils for the upper alluvium is on the order of very soft to soft. The upper alluvium silt extends to approximate Elevation -30 feet. The measured blow counts recorded on the select boring logs from Landau Associates range from 0 to 3 blows per foot. Landau Associates estimated TXUU shear strength (reported as UU in Landau 2008) of 540 psf (low TXUU of 240 psf). We used an estimated shear strength of 300 psf for the upper alluvium for our analyses for Reach 5. The upper alluvium is underlain by a generalized soil unit, labeled Soil Unit 2B, which consists of silty sand with sandy silt interbeds. Soil Unit 2B extends to approximate Elevation -60 feet. The recorded blow counts for Soil Unit 2B presented by Landau Associates, ranges from 0 to 13 blows per foot.

3.3.2.8. Levee Embankment Fill

Levee embankment fill placed as part of this project will be a silty/clayey sand. Specific recommendations for levee embankment fill have been provided in our report "Preliminary Design and Construction Recommendations for Floodwalls and Embankment Levees North Shore Levee West Segment Hoquiam, Washington" dated March 10, 2020. In addition to meeting the more stringent specifications, we recommend this material also meet the requirements of WSDOT Standard Specification 9-03.14(3) (Common Borrow). The WSDOT Geotechnical Design Manual (GDM) presumes that common borrow has a friction angle between 30 and 34 degrees and a unit weight between 115 and 130 pcf. We used a friction angle of 34 degrees and a unit weight of 120 pcf to model the levee fill embankment.

3.4. Embankment Seepage Analysis

3.4.1. Seepage Analysis Method

Groundwater flow through each design section was analyzed using the computer program Seep/W (GEO-SLOPE International, Ltd., 2016). Seep/W is used to analyze a numerical groundwater flow model using groundwater flow equations with the finite-element method. We used the program to model the proposed levee sections as a 2-dimensional cross section. The design sections were analyzed under steady state conditions to estimate seepage and uplift forces. Alluvial foundation soils were assumed to be fully saturated.

Horizontal hydraulic conductivity or Kh values for the soils were selected based on correlations with soil classifications and field observations using guidance from existing literature (Powers, et al. 2007). Observations from the explorations were also used to estimate the anisotropy, or hydraulic conductivity ratio (horizontal hydraulic conductivity divided by vertical hydraulic conductivity, Kh/Kv), for the generalized soil unit. The hydraulic conductivity at saturation (K-Sat), hydraulic conductivity ratio (Kh/Kv), volumetric water content (θ), coefficient of volume compressibility (mv), used in the analyses are shown on the output Figures S-2A, S-3A, S-4A and S-4B.

For our analysis, we assumed that the groundwater on the land side of the levee is located at the ground surface and that steady state seepage develops in the profile. The base flood is tidally influenced and, therefore, is not likely to persist for more than about 6 hours. Based on these factors, it is our opinion that it is unlikely that full steady state seepage conditions will develop in the levee. Accordingly, we consider our analysis to be conservative.

3.4.2. Analysis Results

The simulated head equipotentials for the design sections are shown in Figures S-2A, S-3A, S-4A and S-4B. The color shading in the figures represents the regions between the equipotentials. Where multiple cross sections were evaluated in a reach, the critical cross section with regard to seepage forces and seepage flow is reported in Table 3.

TABLE 3. SEEPAGE SUMMARY OF RESULTS

Analysis Reach	Critical Section	Seepage per 100 feet of Levee (ft^3/hr)	Vertical Exit Gradient at Landside Toe (ft/ft)	Exit Velocity at Landside Toe (ft/sec)
Reach 2	2A (55+00) Figure S-2A	7.68×10^{-3}	0.051	4.37×10^{-10}
Reach 3	3A (104+50) Figure S-3A	9.68×10^{-4}	0.074	7.72×10^{-11}
Reach 4	4A (107+00) Figure S-4A	2.20×10^{-2}	0.085	5.97×10^{-10}
Reach 4	4B (124+00) Figure S-4B	1.89×10^{-2}	0.051	1.94×10^{-9}

As shown above, the maximum exit velocity is estimated to be 1.94×10^{-9} ft/s, or more than an order of magnitude below the transport velocity for silt or clay. The maximum vertical exit gradient is of the sections analyzed is estimated to be 0.05, below the USACE's recommended limit of 0.5. Accordingly, it is our opinion that the risk of piping, boiling, or soil transport due to seepage forces is low.

The seepage analysis results for Reach 4, Section 4B are also applicable to the north alignment (north tie-in to Queen Street Pump Station) due to similar improvements and subsurface conditions. Some seepage through the levee may occur during high water periods in localized areas of higher permeability. The seepage does not necessarily affect the stability of the levee provided that the seepage does not heave or transport soil (piping). Levee monitoring or "levee patrols" during high water periods must check the toe areas of the levees for seepage areas.

Measures for controlling detrimental seepage or piping during flood fighting are described in the USACE manual "Levee Owner's Manual for Non-Federal Flood Control Works". If piping or sediment transport is observed during high water periods, these measures must be quickly enacted. We recommend that these measures be included in the "Operations and Maintenance Manual" and that the individuals designated for high water levee monitoring be familiar with the requirements of the monitoring program.

3.5. Embankment Stability Analysis

3.5.1. Analysis Method

Slope stability analyses are completed using the computer program SLOPE/W (GEO-SLOPE International, Ltd., 2016). SLOPE/W evaluates the stability of numerous trial shear surfaces using a vertical slice limit-equilibrium method. This method compares the ratio of forces and moments driving slope movement versus forces and moments resisting slope movement for each trial shear surface and presents the result as the factor of safety. The program then sorts the trial shear surfaces and identifies the surface with the lowest factor of safety, or the "critical" shear surface. We assumed a circular arc failure surface and used the Morgenstern-Price method to calculate the forces. The failure surface was optimized using an algorithm within the SLOPE/W program.

We evaluated the proposed embankments for the following USACE design cases:

1. **End of Construction.** The end of construction case is based on the current condition of existing levees or the post-construction condition of improved levees. The water level in the river is assumed to be at mean lower low water (MLLW) flow for this analysis at Elevation 1.6 feet NAVD88.
2. **Steady State Seepage.** The levee stability is evaluated under flood conditions assuming a river level at the BFE and assuming that seepage through the levee has achieved a steady state as modeled in the Seep/W analysis. We evaluated the stability for both the river side and the land side of the levee.
3. **Drawdown.** The levee stability under drawdown conditions is evaluated using an undrained strength analysis using piezometric lines derived from a parent Seep/W analysis. The analysis is completed by first assuming steady state seepage has developed through the levee at flood stage and then conservatively assuming the piezometric line follows the ground surface on the waterside of the levee/floodwall in a drawdown condition to the elevation of MLLW, Elevation 1.6 feet NAVD88.

For the purposes of levee analysis, only shear surfaces that would result in a risk of a levee breach are considered. Shear surfaces that would reduce the crest of the levee to less than 10 feet of undisturbed material are considered to be a risk to the levee. Shear surfaces that did not encroach on this 10-foot crest width would not affect the function of the levee and are, therefore, considered a riverbank maintenance issue rather than a levee stability issue.

3.5.2. Slope Stability Analysis Results

The results of the slope stability analyses are provided in Figures 2A-2 through 4B-4. An error message of "E996" indicates a factor of safety that is too large to accurately calculate (i.e., sliding uphill). An error message of "E984" indicates that critical slip surfaces intersect the structure and, therefore, global stability does not control. Table 4 summarizes the results of our analyses.

TABLE 4. SLOPE STABILITY ANALYSIS RESULTS

Levee Reach	Approximate Station	Figure Series	Calculated Factor of Safety			
			End of Construction	Critical Flood Stage		Sudden Drawdown
			Water Side	Waterside	Landside	Water Side
USACE Recommended Factor of Safety			**1.3**	**1.4**	**1.4**	**1.0**
2	55+00	2A	1.65	3.14	5.36	1.65
3	104+50	3A	1.60	1.95	3.81	1.14
4	107+00	4A	1.53	2.72	1.85	1.49
4	123+50	4B	2.32	4.79	>5	2.29

The proposed levee cross sections we analyzed meet or exceed USACE recommended minimum factors of safety for slope stability in all cases.

We chose these analysis cross sections based on the steepest observed riverbanks in the area and have analyzed them using the lower end of the observed soil strengths. This conservatism is inherent in the analysis method. Additionally, should this type of slope instability occur, it would be during construction and could be managed by repairing the segment and modifying the construction sequence. Based on these considerations, it is our opinion that the calculated factor of safety is appropriate for these conditions.

3.6. Floodwalls

Floodwalls were included in our seepage and slope stability models to evaluate the global stability of the walls and the foundations. The evaluation of the internal stability of the wall, including evaluation for overturning and sliding will be provided by KPFF.

3.7. Settlement

Settlement analyses of the levee system were completed using the computer program Settle3D (Rocscience Inc. 2016). Settle3D evaluates the settlement using a computer model of different soil layers with compression properties. The model uses a Boussinesq soil stress distribution to calculate soil loading that induces initial elastic settlement and primary consolidation settlement. Secondary compression, or creep, was not included in our settlement analysis.

We evaluated settlement using soil properties determined from the results of our consolidations tests, correlations with moisture content, and the results of consolidation tests from previous studies. For each soil profile we estimated a high and low value for the compression index (Cc). These values were used to provide a range of predicted settlements.

We evaluated settlements using a time dependent consolidation analysis. We used coefficients of consolidation (Cv) based on the consolidation test results. We also performed a sensitivity analysis where we varied the coefficient of consolidation. The variations in predicted settlement at different times due to changes in the coefficient of consolidation were much less than the variations that were a result of the different compression indexes. Accordingly, we determined that the results were not sensitive to the coefficient of consolidation and did not vary this parameter in our analyses.

We calculated the predicted settlement for a typical embankment section and access road section using the Grays Harbor Subsurface Design Profile (Reach 5). This design profile contains the most compressible layers and is where settlement is expected to be critical. We also calculated the predicted settlement using years. The results of our analyses and the input values we used are presented in our output results in Appendix C. A summary of our results is provided in Table 5 and Table 6 below.

TABLE 5. SETTLEMENT ANALYSIS RESULTS OF TYPICAL EMBANKMENT SECTION

Months	Low Estimate (inches)	High Estimate (inches)
2	6.3	6.5
12	7.2	8.9
120	8.1	10.3
1,200	9.1	11.2

TABLE 6. SETTLEMENT ANALYSIS RESULTS OF ACCESS ROAD SECTION

Months	Low Estimate (inches)	High Estimate (inches)
2	5.2	5.5
12	6.0	7.3
120	6.9	8.7
1,200	8.0	9.5

The settlement that is predicted between 0 and 2 months is expected to occur during construction and can be managed by placing additional fill during construction. The settlement that is predicted to occur between 2 months and 1 year (12 months) could be managed by scheduling a follow-up minor regrading project. In roadways, this may require repairing cracks and repaving. The additional settlement that occurs beyond one year (120 and 1,200 months) is the predicted long-term settlement. This settlement should be accounted for by overbuilding embankments so that freeboard is maintained for the entire certification period. The floodwalls, unlike an embankment levee, cannot be added to easily during construction. In this case, preloading should be considered where floodwalls will be used in conjunction with earth fills.

We recommend that settlement monitoring points be used to evaluate the rate and amount of settlement that occurs during construction. This data can then be used to refine the model and adjustments to the finished design grade can be made during construction.

4.0 CONCLUSIONS

We conclude, based on the results of our analyses, that the proposed Hoquiam North Shore Levee West Segment as currently envisioned will meet the geotechnical requirements of 44 CFR 65.10 and USACE Engineering Circular EC 1110-2-6067 "USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation" for the 100-year (1-percent-annual-chance) design flood and will provide protection over the certification period of 10 years provided that maintenance is performed, as recommended, on a regular and timely basis.

The recommendations and analysis included in this report are considered to be final based on our site explorations, analyses and the plan set titled, "North Shore Levee West Segment CLOMR Plans", dated March 3, 2020; but may change based on modifications to the levee design made during final design or based on different soil conditions observed during construction. We must be retained to monitor the geotechnical aspects of levee construction in order to confirm that soil conditions in the field are as we assumed in our analysis and we must be given the opportunity to revise our recommendations as needed. At the completion of the project, we will provide a Levee Certification Letter documenting our observations and additional recommendations for submittal with the final Letter of Mapped Revision (LOMR) application.

5.0 LIMITATIONS

We have prepared this report for the exclusive use of KPFF Consulting Engineers, Inc. KPFF may distribute copies of this report to the City of Hoquiam, the City's authorized agents, and regulatory agencies including FEMA and FEMA's designated reviewers, as may be required for the project.

Levee certification within the context of this report follow the definition provided in 44 CFR 65.2, which states that "certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed or implied. Certification of data is a statement that the data is accurate to the best of the certifier's knowledge. Certification of analyses is a statement that the analyses have been performed correctly and in accordance with sound engineering practices."

Qualified engineering and construction practices can help mitigate flooding risks, but they cannot completely eliminate those risks. Favorable performance of structures in the recent past provides useful information for anticipating likely near-term future performance, but it cannot predict or imply a certainty of similar long-term performance. Levee systems require periodic inspection to confirm that all critical components continue functioning as intended. Confirmation that design flood flows and/or elevations have not significantly changed also requires the periodic review of design criteria and other potential contributing factors including, but not limited to, changes in surrounding development, weather patterns, system operational policies, or sedimentation.

The conclusions and recommendations presented in this report are based on an assumed subsurface profile developed through interpolation between widely spaced subsurface explorations and review of plans, titled "North Shore Levee West Segment CLOMR Plans", dated March 3, 2020. GeoEngineers must be involved with the final design and construction of the project to confirm that our recommendations are being properly interpreted and that the soil conditions are consistent with our assumptions.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. The conclusions, recommendations and opinions presented in this report are based on our professional knowledge, judgement and experience. No warranty or other conditions, expressed or implied, should be understood.

Please refer to Appendix D titled "Report Limitations and Guidelines for Use" for additional information pertaining to the use of this report.

6.0 REFERENCES

AGRA Earth & Environmental. 1997. "Geotechnical Engineering and Environmental Evaluation, Hoquiam River Woodlawn Water Pipeline Crossing, Hoquiam, Washington." December 1997.

GEO-SLOPE. GeoStudio 2016 version 8.16.1.13452. Seep/W. Calgary, Alberta, Canada.

Landau Associates. 2009. Geotechnical Design Study. 2009. WSDOT SR 520 Pontoon Construction Project, Grays Harbor, Washington. March 25, 2009.

Rocscience, Inc. Settle3 2019 version 5.001. Toronto, Ontario, Canada.

Shannon & Wilson and Clarity Engineering LLC. 2019. Geotechnical Engineering Report, BHP Potash Export Terminal, Hoquiam, Washington, June 10, 2019.

U.S. Army Corps of Engineers. "EM-1110-2-1901. Seepage Analysis and Control for Dams." April 30, 1993.

U.S. Army Corps of Engineers. "EM 1110-2-1913. Design and Construction of Levees." April 30, 2020.

Washington State Department of Natural Resources. Geologic Information Portal – Subsurface Database. https://geologyportal.dnr.wa.gov/. Accessed July 2019.

Washington State Department of Natural Resources. Geologic Information Portal – Geologic Mapping. https://geologyportal.dnr.wa.gov/. Accessed July 2019.

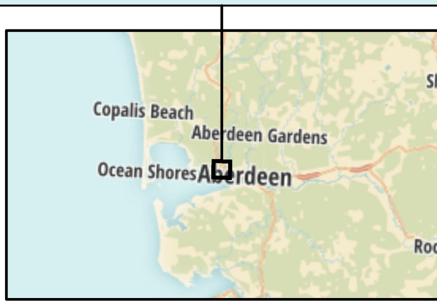
Washington State Department of Transportation. 1983. Letter to C.S. Gloyd, SR-101, C.S. 1402, L-7262, Little Hoquiam River Bridge#101/130, Widening Foundation Report. May 23, 1983.

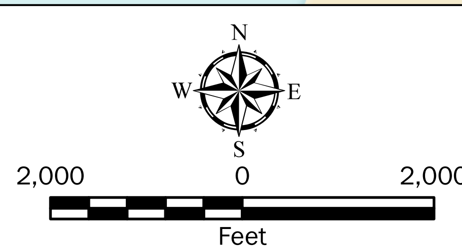
Washington State Department of Transportation. 1968. Letter to George Stevens, C.S. 1416, SR-101, L-3092, Aberdeen-Hoquiam One-Way Couplet, Foundation Investigation. July 16, 1968.

Washington State Department of Transportation. 2004. Geotechnical Report to J. Kapur/M. Anderson, SR101, XL1640A, Hoquiam River and Simpson Avenue Bridge 101/125W, Maintenance Turnout, Geotechnical Report. March 1, 2004.

Washington State Department of Transportation. 2019. "Geotechnical Design Manual." July 2019.

Washington State Department of Transportation. Geotechnical Web Mapping App. https://wsdot.maps.arcgis.com/apps/webappviewer/index.html?id=03b9e16243ef480988e470c325e4f020. Accessed July 2019.





Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Mapbox Open Street Map, 2016

Projection: NAD 1983 UTM Zone 10N

Vicinity Map

North Shore Levee West Segment
Hoquiam, Washington

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Figure 1

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Legend

- Hoquiam Flood Protection Alignment
- Extent of Design Group
- CPT-1-19 — CPT Soil Boring by GeoEngineers, Inc., 2019
- GEI-1-19 — Boring by GeoEngineers, Inc., 2019
- VST-2-19 — Electric Vane Shear Testing by GeoEngineers, Inc., 2019
- TH-34-08 — Boring by Landau, 2008
- TH-3-03 — Boring by WA State Dept. of Trans., 2003
- CPT-2-03 — CPT by WA State Dept. of Trans., 2003
- B-3 — Boring by AGRA Earth and Environmental, inc., 1997
- H-2 — Boring by WA State Dept. of Trans., 1967
- H-1 — Borings by WA State Dept. of Trans., 1957

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from Google Earth Pro dated 7/21/2018.
Hoquiam flood protection alignment obtained on 12/06/2019 from KPFF Consulting Engineers.

Projection: NAD83 Washington State Planes, South Zone, US Foot

N
W E
S

1000 0 1000
Feet

Site Plan

North Shore Levee West Segment
Hoquiam, Washington

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Figure 2

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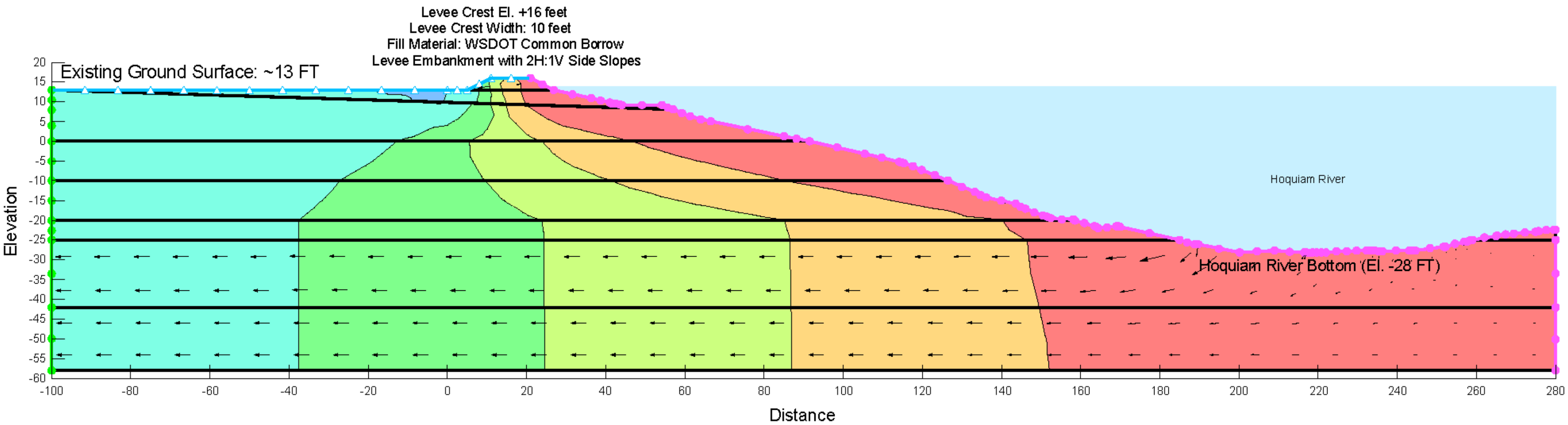
Color	Name	Model	K-Function	Ky'/Kx' Ratio	Vol. WC. Function
	Silt and Clay with Org. Dep._Upper Alluvium (El. 13 to 0 FT)	Saturated / Unsaturated	Upper Alluvium El. 13 to 0	0.2	Upper Alluvium El. 13 to 0
	Silt and Clay Upper Alluvium (El. -10 to -20 FT)	Saturated / Unsaturated	Upper Alluvium El -10 to -20	0.2	Upper Alluvium El -10 to -20
	Earth Levee Section (El. 16 to 13 FT)	Saturated / Unsaturated	Levee Fill (WSDOT Common Borrow)	0.75	Levee Embankment Fill (WSDOT Common Borrow)
	Silt and Clay Upper Alluvium (El. 0 to -10 FT)	Saturated / Unsaturated	Upper Alluvium El. 0 to -10	0.2	Upper Alluvium El. 0 to -10
	Silt and Clay, Lower Alluvium (El. -20 to -25 FT)	Saturated / Unsaturated	Upper Alluvium El. -20 to -25	0.2	Upper Alluvium El. -20 to -25
	Silt and Clay, Lower Alluvium (El. -25 to -42)	Saturated / Unsaturated	Lower Alluvium El. -25 to -42	0.2	Lower Alluvium El. -25 to -42
	Silt and Clay, Lower Alluvium (El. -42 to -58 FT)	Saturated / Unsaturated	Lower Alluvium El. -42 to -58	0.2	Lower Alluvium El. -42 to -58
	Existing Fill Material (El. 13 to 8 FT)	Saturated / Unsaturated	Existing Fill Material El 13 to 8	0.6	Existing Fill Material El. 13 to 8



Seep/W Steady State Seepage (Station 55+00)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure S-2A

See report text for additional explanation

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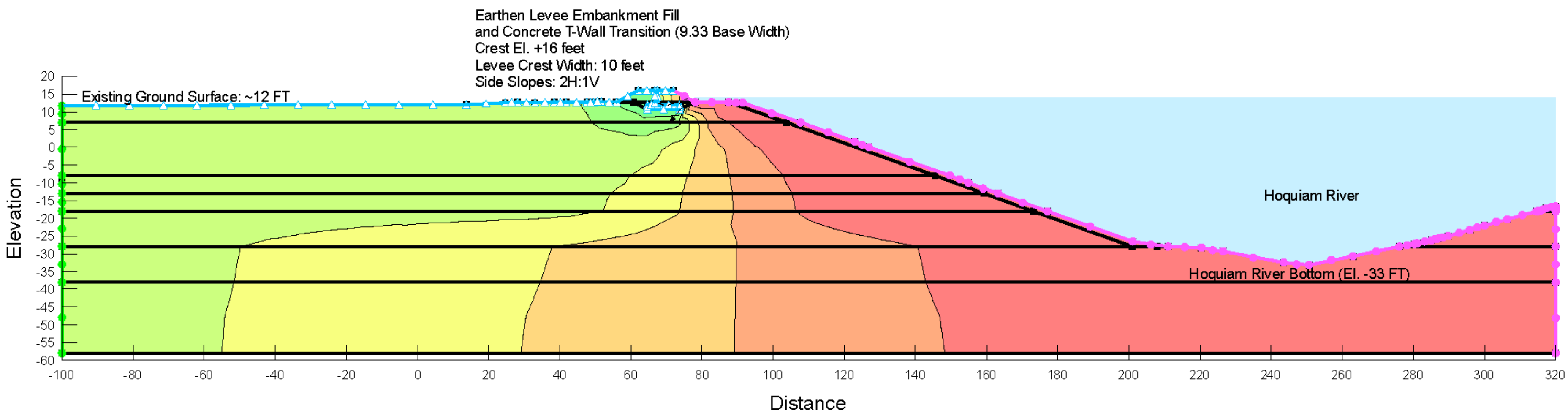
Color	Name	Model	K-Function	Ky'/Kx' Ratio	Vol. WC. Function
	Upper SM Alluvium (El 11 to -18 FT)	Saturated / Unsaturated	Upper SM Alluvium El 7 to -18	0.6	Upper SM Alluvium El 7 to -18
	Cohesive Alluvium (El -18 to -28 FT)	Saturated / Unsaturated	Cohesive Alluvium ML El -18 to -28	0.2	Cohesive Alluvium (ML) El -18 to -28
	Cohesive Alluvium (El -28 to -38 FT)	Saturated / Unsaturated	Cohesive Alluvium (ML) El -28 to -38	0.2	Cohesive Alluvium (ML) El -28 to -38
	Cohesive Alluvium (El -38 to -58 FT)	Saturated / Unsaturated	Cohesive Alluvium (ML) El -38 to -58	0.2	Cohesive Alluvium (ML) El -38 to -58
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Saturated / Unsaturated	Backfill (WSDOT Common Borrow)	1	Backfill (WSDOT Common Borrow)
	Concrete Floodwall	Interface		1	
	Existing Rip Rap	Saturated / Unsaturated	Rip Rap	1	Rip Rap



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See report text for additional explanation

Seep/W Steady State Seepage (Station 104+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure S-3A

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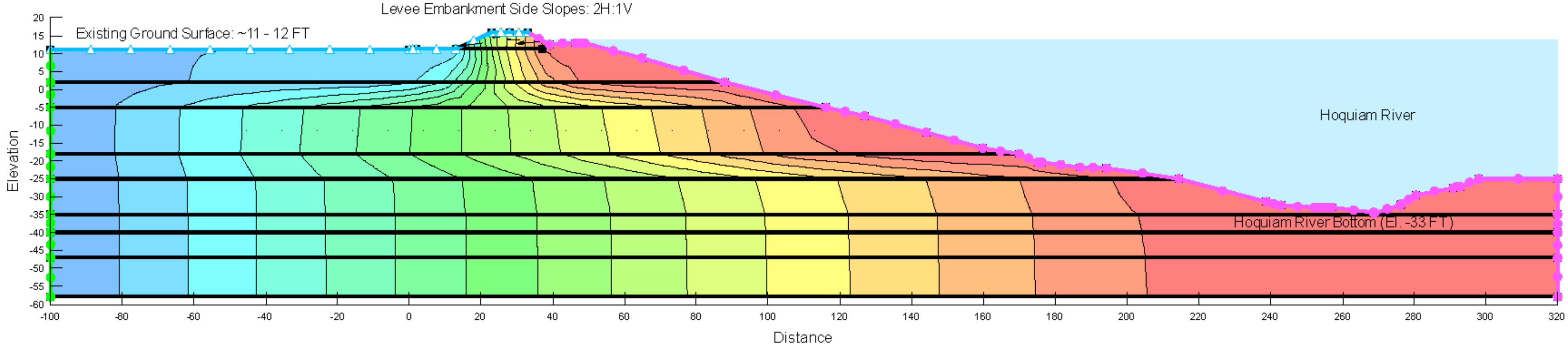
Color	Name	Model	K-Function	Ky'/Kx' Ratio	Vol. WC. Function
	Lower SM Alluvium (El -35 to -40 FT)	Saturated / Unsaturated	Lower SM Alluvium (El -35 to -40)	1	Lower SM Alluvium El -35 to -40
	Cohesive Alluvium (El -18 to -25 FT)	Saturated / Unsaturated	Cohesive Alluvium (ML) El -18 to -25	0.2	Cohesive Alluvium (ML) El -18 to -28
	Cohesive Alluvium (El -5 to -18 FT)	Saturated / Unsaturated	Lower SM Alluvium (El -35 to -40)	0.2	Lower SM Alluvium El -35 to -40
	Upper Cohesive Alluvium (El 12 to -5 FT)	Saturated / Unsaturated	Cohesive Alluvium (ML) El 12 to -5 FT	0.2	Cohesive Alluvium (ML) El -18 to -25
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Saturated / Unsaturated	Backfill (WSDOT Common Borrow)	1	Backfill (WSDOT Common Borrow)
	Existing Fill Material	Saturated / Unsaturated	Existing Fill Material El 11 to 7	0.8	Existing Fill Material El. 11 to 7
	Lower SM Alluvium (El -40 to -47 FT)	Saturated / Unsaturated	Lower SM Alluvium El -40 to -47	1	Lower SM Alluvium El -40 to -47
	Lower SM Alluvium (El -47 to -58 FT)	Saturated / Unsaturated	Lower SM Alluvium El -47 to -58	1	Lower SM Alluvium El -47 to -58
	Cohesive Alluvium (El -25 to -35 FT)	Saturated / Unsaturated	Lower SM Alluvium (El -35 to -40)	0.2	Lower SM Alluvium El -35 to -40

Levee Fill Embankment, Top El. +16 feet
Levee Height: ~5 FT
Crest Width: 10 FT
Levee Embankment Side Slopes: 2H:1V



See report text for additional explanation

Seep/W Steady State Seepage (Station 107+00)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure S-4A

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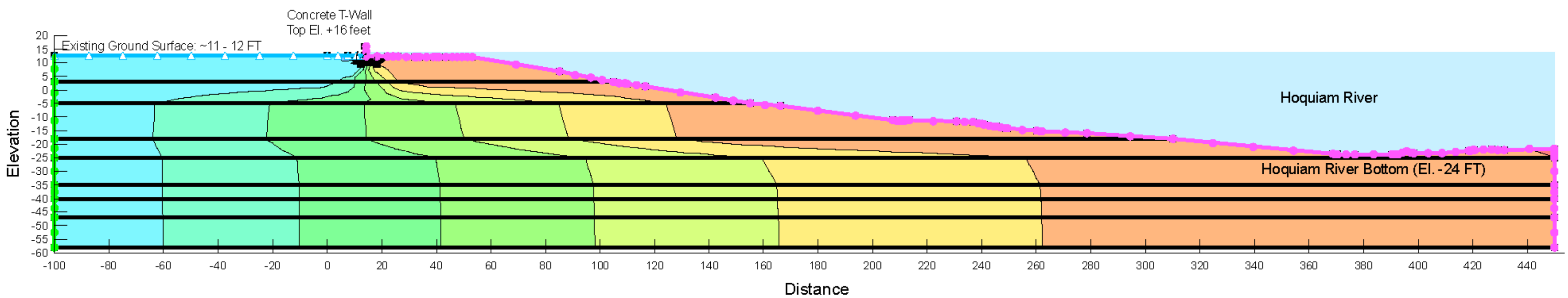
Color	Name	Model	K-Function	Ky'/Kx' Ratio	Vol. WC. Function
	Lower SM Alluvium (El -35 to -40 FT)	Saturated / Unsaturated	Lower SM Alluvium (El -35 to -40)	1	Lower SM Alluvium El -35 to -40
	Cohesive Alluvium (El -18 to -25 FT)	Saturated / Unsaturated	Cohesive Alluvium (ML) El -18 to -25	0.2	Cohesive Alluvium (ML) El -18 to -28
	Cohesive Alluvium (El -5 to -18 FT)	Saturated / Unsaturated	Lower SM Alluvium (El -35 to -40)	0.2	Lower SM Alluvium El -35 to -40
	Upper Cohesive Alluvium (El 12 to -5 FT)	Saturated / Unsaturated	Cohesive Alluvium (ML) El 12 to -5 FT	0.2	Cohesive Alluvium (ML) El -18 to -25
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Saturated / Unsaturated	Backfill (WSDOT Common Borrow)	1	Backfill (WSDOT Common Borrow)
	Concrete Floodwall	Interface		1	
	Existing Fill Material	Saturated / Unsaturated	Existing Fill Material El 11 to 7	0.8	Existing Fill Material El. 11 to 7
	Lower SM Alluvium (El -40 to -47 FT)	Saturated / Unsaturated	Lower SM Alluvium El -40 to -47	1	Lower SM Alluvium El -40 to -47
	Lower SM Alluvium (El -47 to -58 FT)	Saturated / Unsaturated	Lower SM Alluvium El -47 to -58	1	Lower SM Alluvium El -47 to -58
	Cohesive Alluvium (El -25 to -35 FT)	Saturated / Unsaturated	Lower SM Alluvium (El -35 to -40)	0.2	Lower SM Alluvium El -35 to -40



See report text for additional explanation

Seep/W Steady State Seepage (Station 123+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure S-4B

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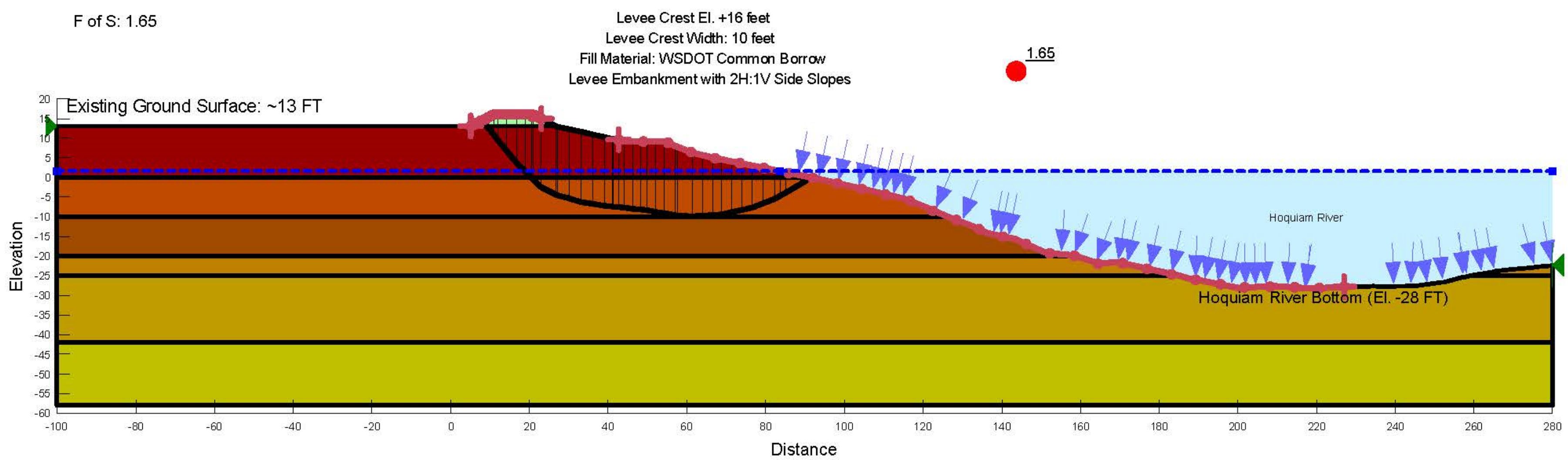
Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	C-Datum (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)	Datum (Elevation) (ft)	Cohesion' (psf)	Phi' (°)
	Silt and Clay with Org. Dep._Upper Alluvium (El. 13 to 0 FT)	Undrained (Phi=0)	110	400						
	Silt and Clay Upper Alluvium (El. -10 to -20 FT)	S=f(datum)	110		400	80	1,200	-10		
	Earth Levee Section (El. 16 to 13 FT)	Mohr-Coulomb	120						0	34
	Silt and Clay Upper Alluvium (El. 0 to -10 FT)	S=f(datum)	106		250	15	400	0		
	Silt and Clay, Lower Alluvium (El. -20 to -25 FT)	Undrained (Phi=0)	110	1,200						
	Silt and Clay, Lower Alluvium (El. -25 to -42)	Undrained (Phi=0)	108	1,600						
	Silt and Clay, Lower Alluvium (El. -42 to -58 FT)	S=f(datum)	120		1,600	250	2,000	-42		



Slope/W Stability – End of Construction
Minimum Levee Setback (Station 55+10)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 2A-1

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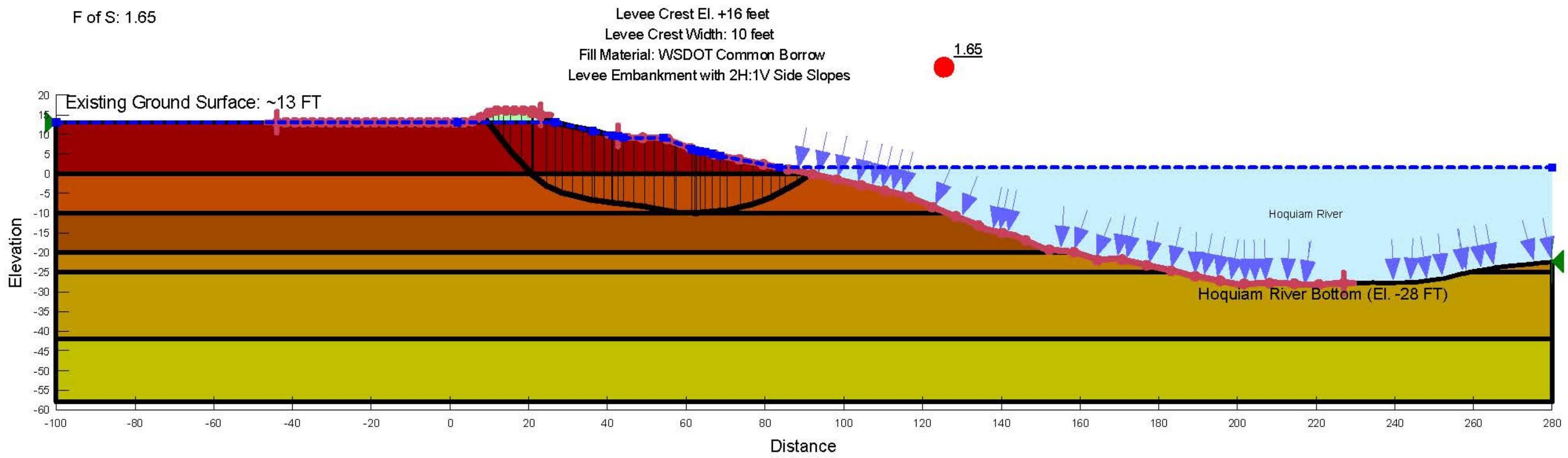
Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	C-Datum (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)	Datum (Elevation) (ft)	Cohesion' (psf)	Phi' (°)
	Silt and Clay with Org. Dep._Upper Alluvium (El. 13 to 0 FT)	Undrained (Phi=0)	110	400						
	Silt and Clay Upper Alluvium (El. -10 to -20 FT)	S=f(datum)	110		400	80	1,200	-10		
	Earth Levee Section (El. 16 to 13 FT)	Mohr-Coulomb	120						0	34
	Silt and Clay Upper Alluvium (El. 0 to -10 FT)	S=f(datum)	106		250	15	400	0		
	Silt and Clay, Lower Alluvium (El. -20 to -25 FT)	Undrained (Phi=0)	110	1,200						
	Silt and Clay, Lower Alluvium (El. -25 to -42)	Undrained (Phi=0)	108	1,600						
	Silt and Clay, Lower Alluvium (El. -42 to -58 FT)	S=f(datum)	120		1,600	250	2,000	-42		



Slope/W Stability – Sudden Drawdown
Minimum Levee Setback (Station 55+10)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 2A-2

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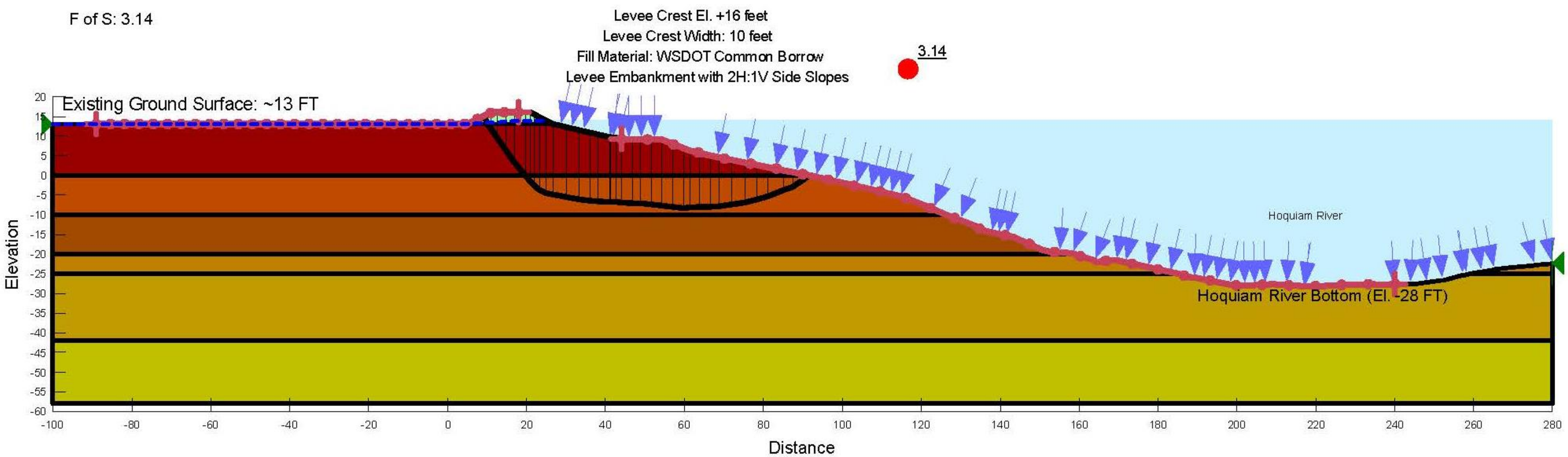
Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	C-Datum (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)	Datum (Elevation) (ft)	Cohesion' (psf)	Phi' (°)
	Silt and Clay with Org. Dep._Upper Alluvium (El. 13 to 0 FT)	Undrained (Phi=0)	110	400						
	Silt and Clay Upper Alluvium (El. -10 to -20 FT)	S=f(datum)	110		400	80	1,200	-10		
	Earth Levee Section (El. 16 to 13 FT)	Mohr-Coulomb	120						0	34
	Silt and Clay Upper Alluvium (El. 0 to -10 FT)	S=f(datum)	106		250	15	400	0		
	Silt and Clay, Lower Alluvium (El. -20 to -25 FT)	Undrained (Phi=0)	110	1,200						
	Silt and Clay, Lower Alluvium (El. -25 to -42)	Undrained (Phi=0)	108	1,600						
	Silt and Clay, Lower Alluvium (El. -42 to -58 FT)	S=f(datum)	120		1,600	250	2,000	-42		



Slope/W Stability – Critical Flood State - River Side
Minimum Levee Setback (Station 55+10)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 2A-3

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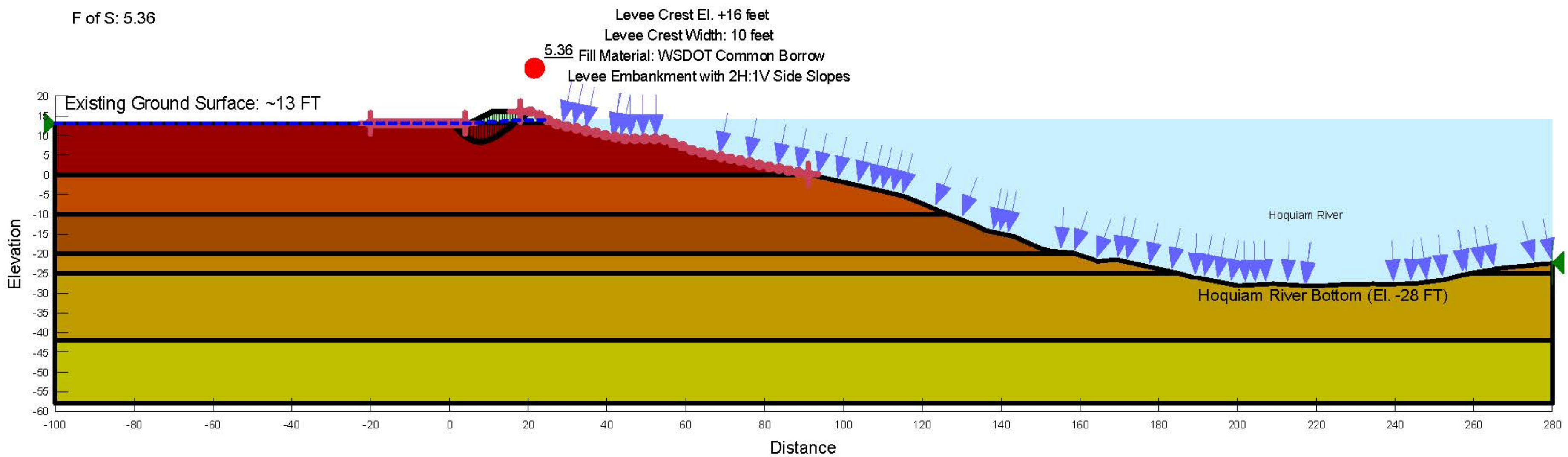
Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	C-Datum (psf)	C-Rate of Change ((lbs/ft²)/ft)	C-Maximum (psf)	Datum (Elevation) (ft)	Cohesion' (psf)	Phi' (°)
	Silt and Clay with Org. Dep._Upper Alluvium (El. 13 to 0 FT)	Undrained (Phi=0)	110	400						
	Silt and Clay Upper Alluvium (El. -10 to -20 FT)	S=f(datum)	110		400	80	1,200	-10		
	Earth Levee Section (El. 16 to 13 FT)	Mohr-Coulomb	120						0	34
	Silt and Clay Upper Alluvium (El. 0 to -10 FT)	S=f(datum)	106		250	15	400	0		
	Silt and Clay, Lower Alluvium (El. -20 to -25 FT)	Undrained (Phi=0)	110	1,200						
	Silt and Clay, Lower Alluvium (El. -25 to -42)	Undrained (Phi=0)	108	1,600						
	Silt and Clay, Lower Alluvium (El. -42 to -58 FT)	S=f(datum)	120		1,600	250	2,000	-42		



Slope/W Stability – Critical Flood State – Land Side Minimum Levee Setback (Station 55+10)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 2A-4

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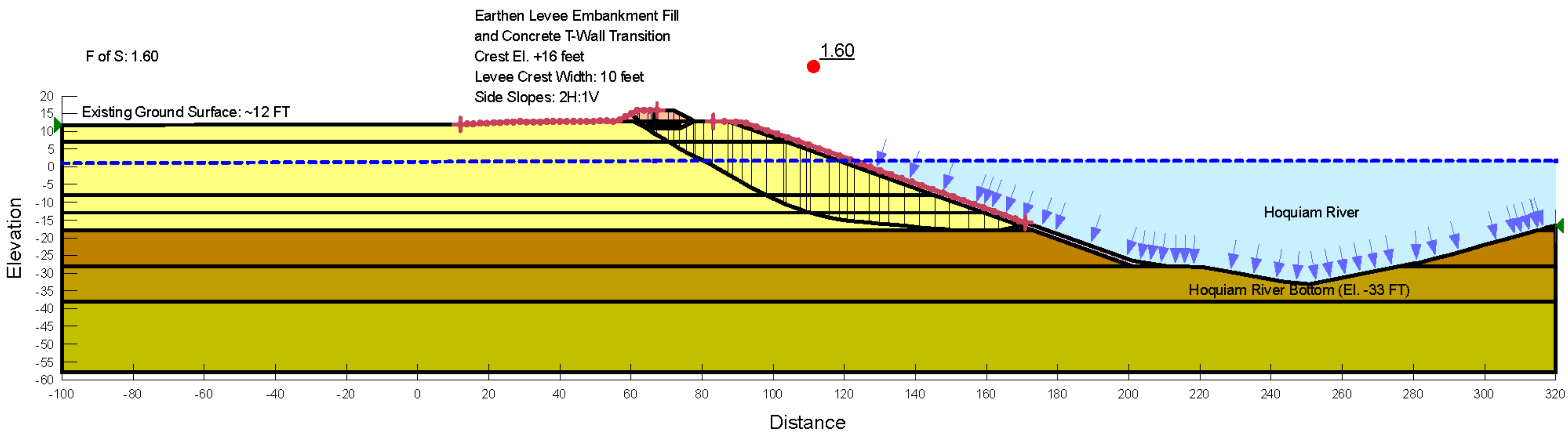
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Upper SM Alluvium (El 11 to -18 FT)	Mohr-Coulomb	110	0	28	
	Cohesive Alluvium (El -18 to -28 FT)	Undrained (Phi=0)	112			1,200
	Cohesive Alluvium (El -28 to -38 FT)	Undrained (Phi=0)	108			500
	Cohesive Alluvium (El -38 to -58 FT)	Undrained (Phi=0)	108			900
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Concrete Floodwall	High Strength	150			
	Existing Rip Rap	Mohr-Coulomb	130	0	40	



Slope/W Stability – End of Construction
Levee Fill/T-wall Transition (Station 104+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 3A-1

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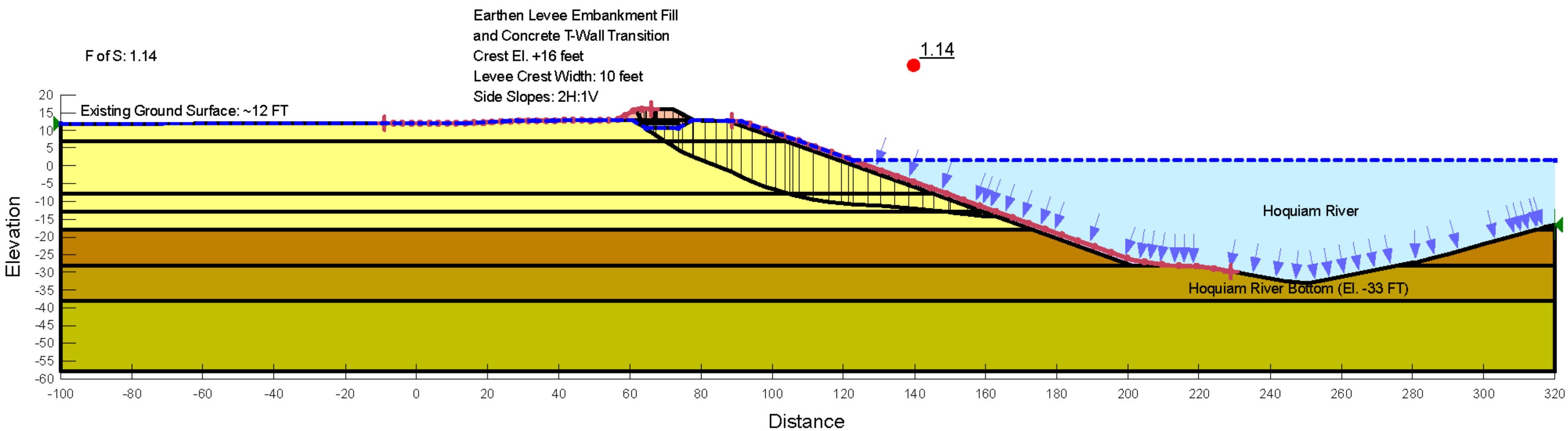
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Upper SM Alluvium (El 11 to -18 FT)	Mohr-Coulomb	110	0	28	
	Cohesive Alluvium (El -18 to -28 FT)	Undrained (Phi=0)	112			1,200
	Cohesive Alluvium (El -28 to -38 FT)	Undrained (Phi=0)	108			500
	Cohesive Alluvium (El -38 to -58 FT)	Undrained (Phi=0)	108			900
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Concrete Floodwall	High Strength	150			
	Existing Rip Rap	Mohr-Coulomb	130	0	40	



Slope/W Stability – Sudden Drawdown
Levee Fill/T-wall Transition (Station 104+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 3A-2

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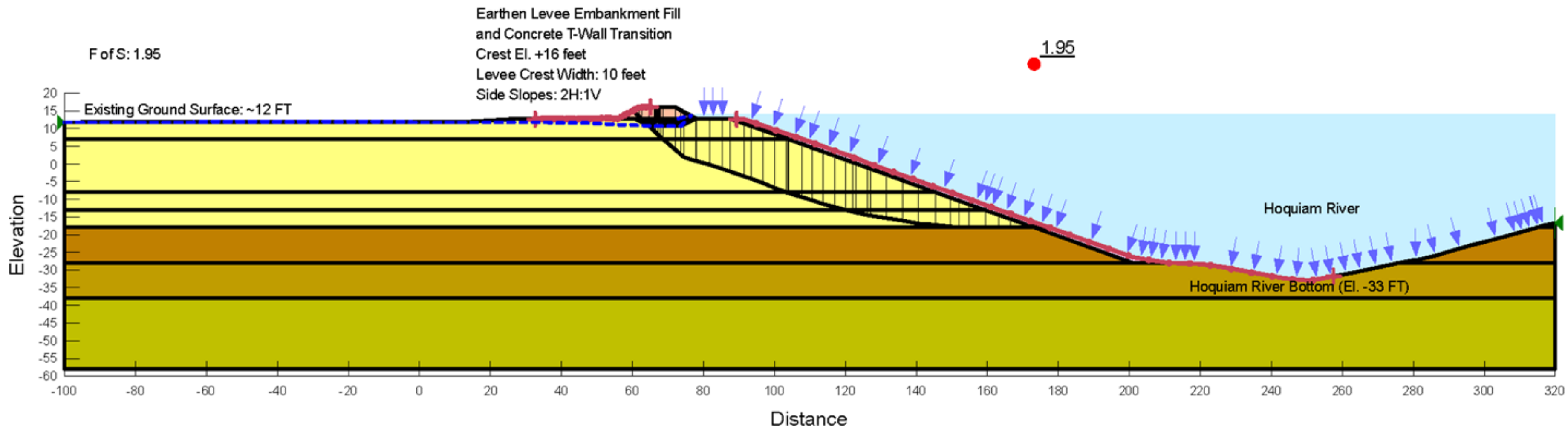
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Upper SM Alluvium (El 11 to -18 FT)	Mohr-Coulomb	110	0	28	
	Cohesive Alluvium (El -18 to -28 FT)	Undrained (Phi=0)	112			1,200
	Cohesive Alluvium (El -28 to -38 FT)	Undrained (Phi=0)	108			500
	Cohesive Alluvium (El -38 to -58 FT)	Undrained (Phi=0)	108			900
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Concrete Floodwall	High Strength	150			
	Existing Rip Rap	Mohr-Coulomb	130	0	40	



Slope/W Stability – Critical Flood State – River Side Levee Fill/T-wall Transition (Station 104+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 3A-3

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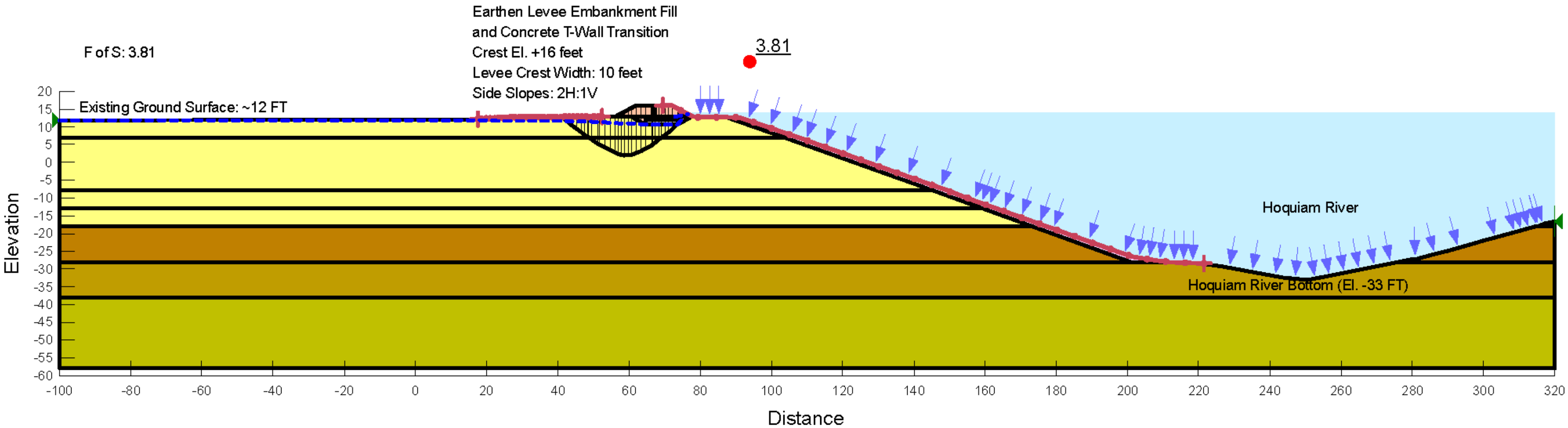
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Upper SM Alluvium (El 11 to -18 FT)	Mohr-Coulomb	110	0	28	
	Cohesive Alluvium (El -18 to -28 FT)	Undrained (Phi=0)	112			1,200
	Cohesive Alluvium (El -28 to -38 FT)	Undrained (Phi=0)	108			500
	Cohesive Alluvium (El -38 to -58 FT)	Undrained (Phi=0)	108			900
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Concrete Floodwall	High Strength	150			
	Existing Rip Rap	Mohr-Coulomb	130	0	40	



Slope/W Stability – Critical Flood State– Land Side Levee Fill/T-wall Transition (Station 104+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 3A-4

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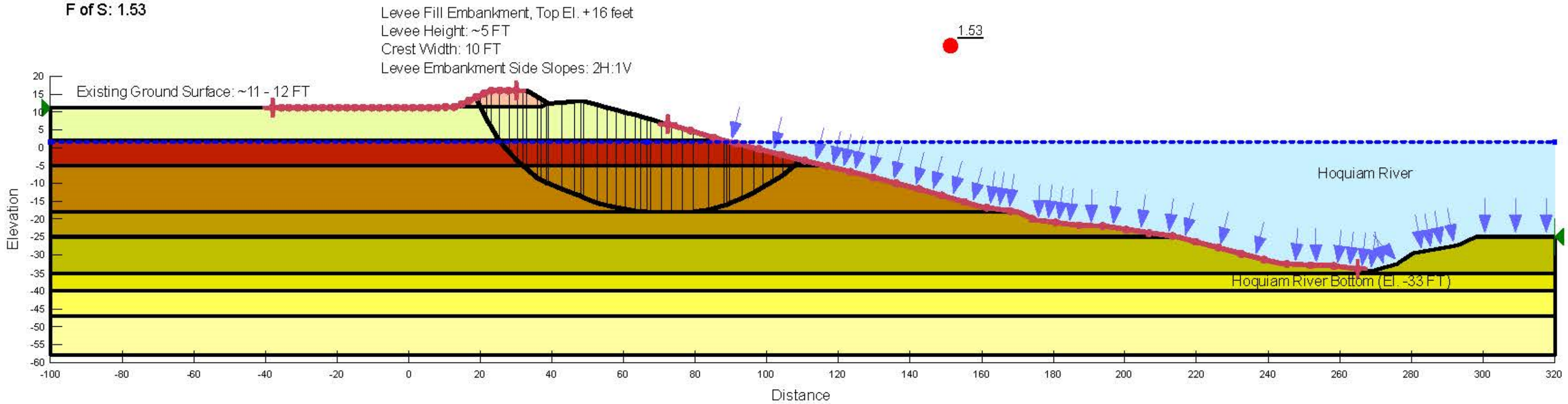
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Lower SM Alluvium (El -35 to -40 FT)	Mohr-Coulomb	114	0	28	
	Cohesive Alluvium (El -18 to -25 FT)	Undrained (Phi=0)	106			575
	Cohesive Alluvium (El -5 to -18 FT)	Undrained (Phi=0)	106			450
	Upper Cohesive Alluvium (El 12 to -5 FT)	Undrained (Phi=0)	98			325
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Existing Fill Material	Mohr-Coulomb	110	0	32	
	Lower SM Alluvium (El -40 to -47 FT)	Mohr-Coulomb	118	0	30	
	Lower SM Alluvium (El -47 to -58 FT)	Mohr-Coulomb	110	0	30	
	Cohesive Alluvium (El -25 to -35 FT)	Undrained (Phi=0)	118			825

F of S: 1.53



Slope/W Stability – End of Construction
Levee Fill Embankment (Station 107+00)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 4A-1

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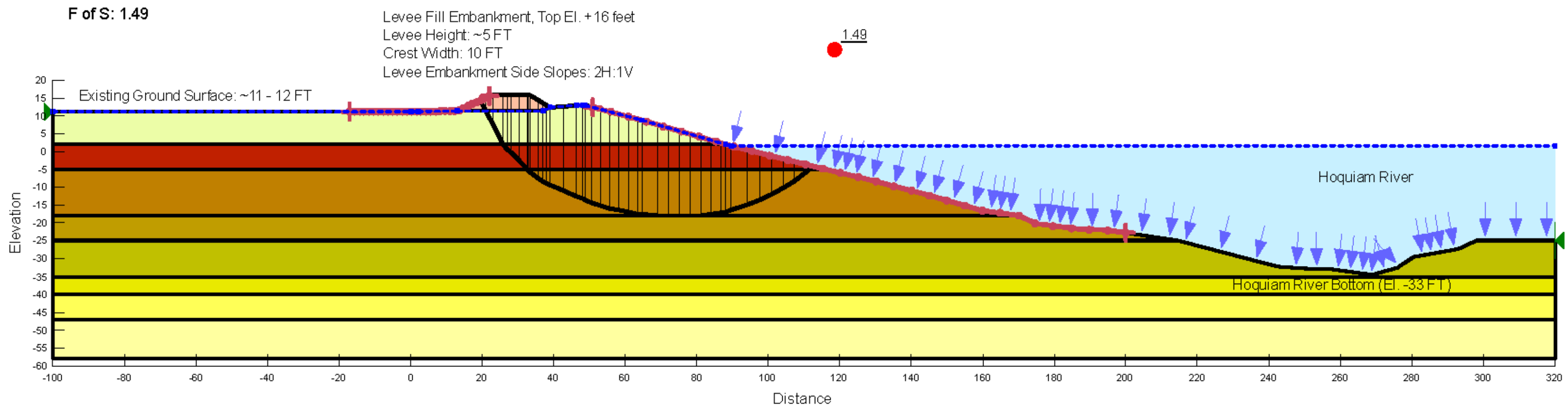
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Lower SM Alluvium (El -35 to -40 FT)	Mohr-Coulomb	114	0	28	
	Cohesive Alluvium (El -18 to -25 FT)	Undrained (Phi=0)	106			575
	Cohesive Alluvium (El -5 to -18 FT)	Undrained (Phi=0)	106			450
	Upper Cohesive Alluvium (El 12 to -5 FT)	Undrained (Phi=0)	98			325
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Existing Fill Material	Mohr-Coulomb	110	0	32	
	Lower SM Alluvium (El -40 to -47 FT)	Mohr-Coulomb	118	0	30	
	Lower SM Alluvium (El -47 to -58 FT)	Mohr-Coulomb	110	0	30	
	Cohesive Alluvium (El -25 to -35 FT)	Undrained (Phi=0)	118			825



Slope/W Stability – Sudden Drawdown
Levee Fill Embankment (Station 107+00)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 4A-2

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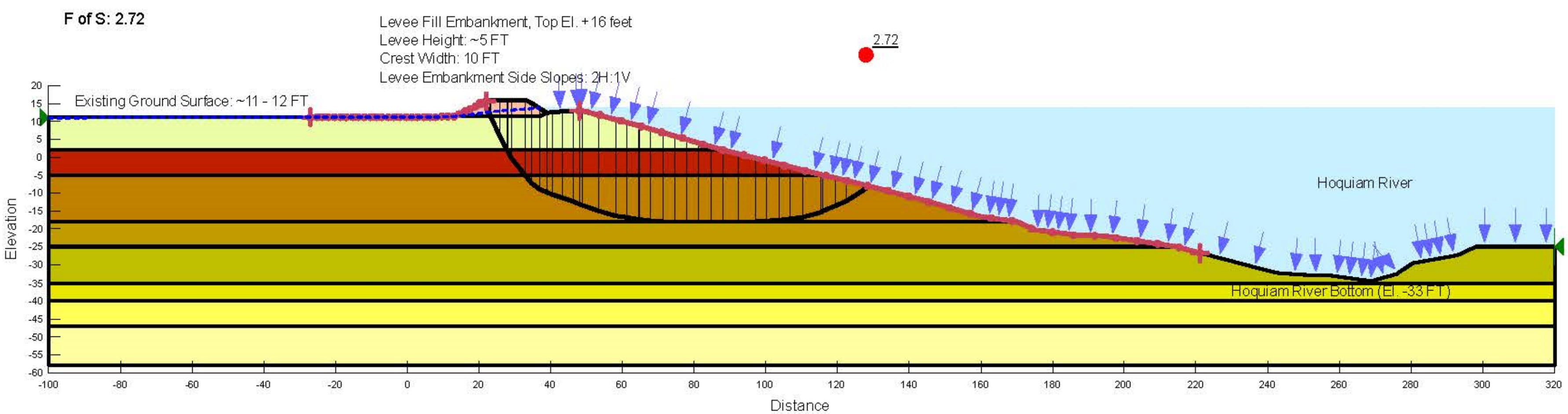
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Lower SM Alluvium (El -35 to -40 FT)	Mohr-Coulomb	114	0	28	
	Cohesive Alluvium (El -18 to -25 FT)	Undrained (Phi=0)	106			575
	Cohesive Alluvium (El -5 to -18 FT)	Undrained (Phi=0)	106			450
	Upper Cohesive Alluvium (El 12 to -5 FT)	Undrained (Phi=0)	98			325
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Existing Fill Material	Mohr-Coulomb	110	0	32	
	Lower SM Alluvium (El -40 to -47 FT)	Mohr-Coulomb	118	0	30	
	Lower SM Alluvium (El -47 to -58 FT)	Mohr-Coulomb	110	0	30	
	Cohesive Alluvium (El -25 to -35 FT)	Undrained (Phi=0)	118			825



Slope/W Stability – Critical Flood State – River Side Levee Fill Embankment (Station 107+00)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 4A-3

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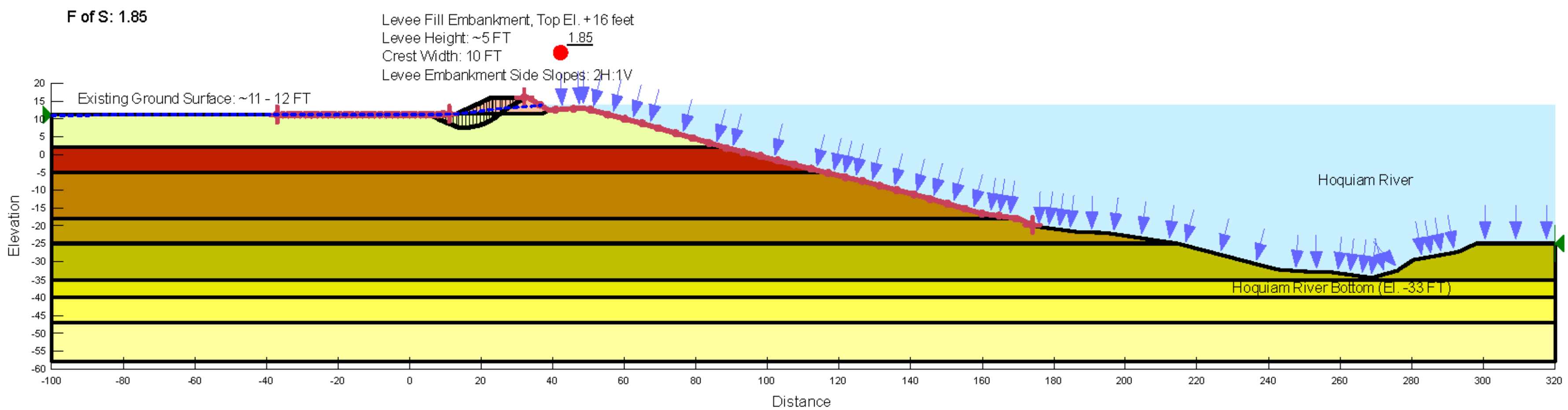
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Lower SM Alluvium (El -35 to -40 FT)	Mohr-Coulomb	114	0	28	
	Cohesive Alluvium (El -18 to -25 FT)	Undrained (Phi=0)	106			575
	Cohesive Alluvium (El -5 to -18 FT)	Undrained (Phi=0)	106			450
	Upper Cohesive Alluvium (El 12 to -5 FT)	Undrained (Phi=0)	98			325
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Existing Fill Material	Mohr-Coulomb	110	0	32	
	Lower SM Alluvium (El -40 to -47 FT)	Mohr-Coulomb	118	0	30	
	Lower SM Alluvium (El -47 to -58 FT)	Mohr-Coulomb	110	0	30	
	Cohesive Alluvium (El -25 to -35 FT)	Undrained (Phi=0)	118			825



Slope/W Stability – Critical Flood State– Land Side Levee Fill Embankment (Station 107+00)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 4A-4

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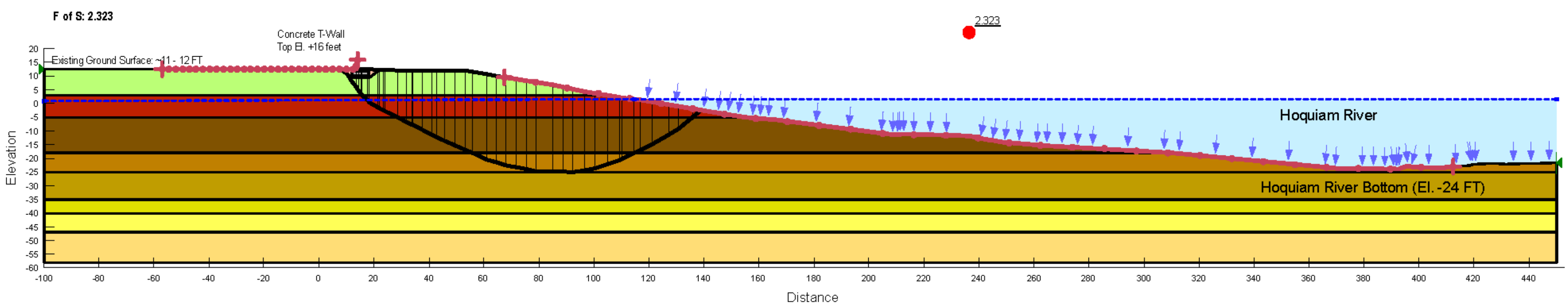
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Lower SM Alluvium (El -35 to -40 FT)	Mohr-Coulomb	114	0	28	
	Cohesive Alluvium (El -18 to -25 FT)	Undrained (Phi=0)	106			575
	Cohesive Alluvium (El -5 to -18 FT)	Undrained (Phi=0)	106			450
	Upper Cohesive Alluvium (El 12 to -5 FT)	Undrained (Phi=0)	98			325
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Concrete Floodwall	High Strength	150			
	Existing Fill Material	Mohr-Coulomb	110	0	28	
	Lower SM Alluvium (El -40 to -47 FT)	Mohr-Coulomb	118	0	30	
	Lower SM Alluvium (El -47 to -58 FT)	Mohr-Coulomb	110	0	30	
	Cohesive Alluvium (El -25 to -35 FT)	Undrained (Phi=0)	110			825



Slope/W Stability – End of Construction
Concrete T-Wall (Station 123+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 4B-1

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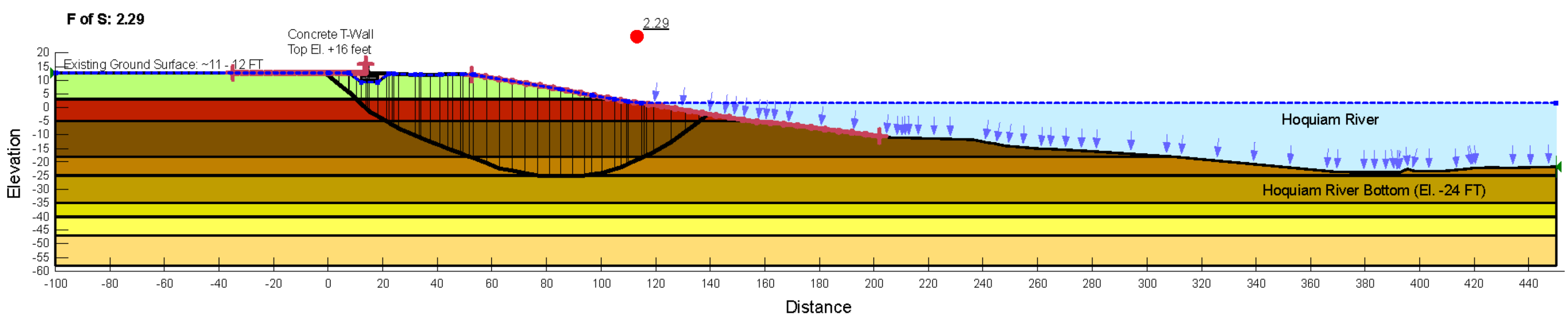
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Lower SM Alluvium (El -35 to -40 FT)	Mohr-Coulomb	114	0	28	
	Cohesive Alluvium (El -18 to -25 FT)	Undrained (Phi=0)	106			575
	Cohesive Alluvium (El -5 to -18 FT)	Undrained (Phi=0)	106			450
	Upper Cohesive Alluvium (El 12 to -5 FT)	Undrained (Phi=0)	98			325
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Concrete Floodwall	High Strength	150			
	Existing Fill Material	Mohr-Coulomb	110	0	28	
	Lower SM Alluvium (El -40 to -47 FT)	Mohr-Coulomb	118	0	30	
	Lower SM Alluvium (El -47 to -58 FT)	Mohr-Coulomb	110	0	30	
	Cohesive Alluvium (El -25 to -35 FT)	Undrained (Phi=0)	110			825



Slope/W Stability – Sudden Drawdown
Concrete T-Wall (Station 123+50)

North Shore Levee – West Segment
Hoquiam, Washington

Figure 4B-2

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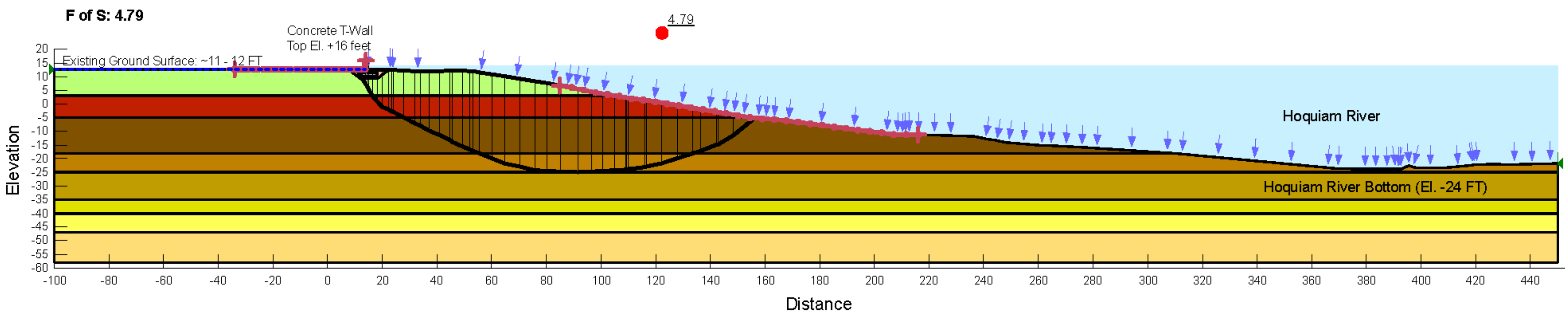
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Lower SM Alluvium (El -35 to -40 FT)	Mohr-Coulomb	114	0	28	
	Cohesive Alluvium (El -18 to -25 FT)	Undrained (Phi=0)	106			575
	Cohesive Alluvium (El -5 to -18 FT)	Undrained (Phi=0)	106			450
	Upper Cohesive Alluvium (El 12 to -5 FT)	Undrained (Phi=0)	98			325
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Concrete Floodwall	High Strength	150			
	Existing Fill Material	Mohr-Coulomb	110	0	28	
	Lower SM Alluvium (El -40 to -47 FT)	Mohr-Coulomb	118	0	30	
	Lower SM Alluvium (El -47 to -58 FT)	Mohr-Coulomb	110	0	30	
	Cohesive Alluvium (El -25 to -35 FT)	Undrained (Phi=0)	110			825



Slope/W Stability – Critical Flood State – River Side
Concrete T-Wall (Station 123+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 4B-3

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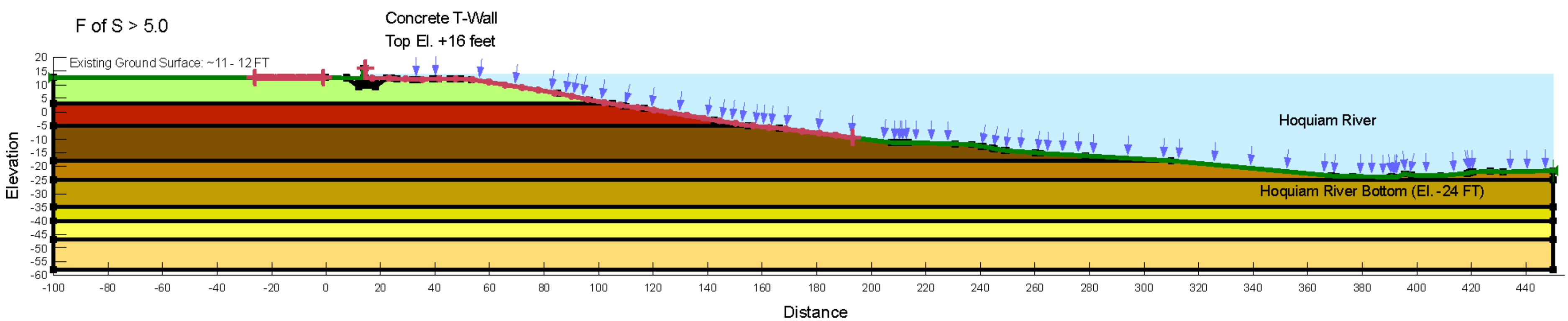
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
	Lower SM Alluvium (El -35 to -40 FT)	Mohr-Coulomb	114	0	28	
	Cohesive Alluvium (El -18 to -25 FT)	Undrained (Phi=0)	106			575
	Cohesive Alluvium (El -5 to -18 FT)	Undrained (Phi=0)	106			450
	Upper Cohesive Alluvium (El 12 to -5 FT)	Undrained (Phi=0)	98			325
	Levee Fill/Floodwall Backfill (Floodwall Subgrade Prep.)	Mohr-Coulomb	128	0	34	
	Concrete Floodwall	High Strength	150			
	Existing Fill Material	Mohr-Coulomb	110	0	28	
	Lower SM Alluvium (El -40 to -47 FT)	Mohr-Coulomb	118	0	30	
	Lower SM Alluvium (El -47 to -58 FT)	Mohr-Coulomb	110	0	30	
	Cohesive Alluvium (El -25 to -35 FT)	Undrained (Phi=0)	110			825



Slope/W Stability – Critical Flood State– Land Side Concrete T-Wall (Station 123+50)

North Shore Levee – West Segment
Hoquiam, Washington

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Figure 4B-4

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APPENDIX A
Subsurface Explorations and Laboratory Testing

APPENDIX A
SUBSURFACE EXPLORATIONS AND LABORATORY TESTING

General

Subsurface conditions were explored by advancing six mud-rotary borings and eight Cone Penetration Tests (CPTs) and three electric vane shear tests (eVST). Subsurface exploratory services were completed by Holocene Drilling, Inc., In-Situ Engineering and ConeTec Inc. under subcontract to GeoEngineers, Inc.

Borings

The second phase of the subsurface exploration program consisted of completing six geotechnical borings. The borings were completed between October 14, 2019 and October 16, 2019. The locations of the borings were determined by measuring from existing site features such as roadways and structures. The elevations presented on the boring logs are based on the topographic survey data provided by KPFF Consulting Engineers, Inc. The location and elevation of the explorations should be considered approximate. The exploration locations and other site features are included on the Site Plan, Figure 2.

Our field representative obtained representative soil samples, classified soils, maintained a detailed log of the exploration and observed groundwater conditions were applicable. The samples were taken with a standard split spoon sampler as well as a Shelby tube sampler in general accordance with ASTM International (ASTM) D 1586 and D 1587/D 6519, respectively. ASTM D 6519 is the ASTM standard practice for sampling soil using a hydraulically operated stationary piston sampler.

The samples collected with the split spoon sampler were retained in sealed plastic bags. The soils were classified visually in general accordance with the system described in Figure A-1, which includes a Key to the Exploration Logs. Summary Logs of each exploration are included as Figures A-2 through A-7.

Electronic Vane Shear Tests

The eVSTs were completed as part of the second phase of the subsurface exploration program. The eVSTs were completed between October 24, 2019 and November 15, 2019. The eVSTs were completed using truck-mounted hydraulically driven vane blade. The eVST is completed by applying a torque to the vane blade at a constant rate up to and beyond the yield stress for each test depth. The undrained shear strength is then calculated from the torque measurements in general accordance with ASTM D 2573.

The eVST results are presented in the attached report titled "Presentation of Site Investigation Results, North Shore Levee West", prepared by ConeTec, Inc. No soil samples are obtained by eVSTs.

Cone Penetration Tests

The CPTs were completed as part of the first phase of the subsurface exploration program. The CPTs were completed between June 5 and 6, 2019. CPT soundings were completed using truck-mounted hydraulically driven cone penetrometers. Soil friction, tip resistance and dynamic pore pressures were recorded using electronic methods.

The CPT soundings were advanced to depths ranging from approximately 40 to 70 feet below ground surface (bgs). The CPTs data are presented as Figures A-8 through A-15. No soil samples are obtained during CPT soundings. Soil types are interpreted based on empirical relationships between measured CPTs data and the parameters described above.

Laboratory Testing

Soil samples obtained from the borings were returned to our laboratory for further examination and testing. Representative soil samples were selected for testing to assist in our evaluation of pertinent geotechnical engineering properties and to confirm our field classifications. Laboratory test descriptions are provided below.

Primary Testing

Moisture Content

The moisture content of selected samples was determined in general accordance with ASTM Test Method D 2216. The test results are used to aid in soil classification and correlation with other pertinent engineering soil properties. The results are presented on the exploration logs at the respective sample depths.

Percent Fines Determination

Selected samples were "washed" through the U.S. No. 200-mesh sieve to estimate the relative percentages of coarse- and fine-grained particles in the soil. The tests were conducted in general accordance with ASTM D 1140. The percent passing value represents the percentage by weight of the sample finer than the U.S. No. 200 sieve. These tests were conducted to verify field descriptions and to estimate the fines content for analysis purposes. The test results are shown on the exploration logs at the respective sample depths.

Atterberg Limits

Atterberg Limit tests were performed on selected samples in general accordance with ASTM Test Method D 4318. This test method determines the liquid limit, plastic limit and plasticity index of soil particles passing the No. 40 sieve. The results of the tests are used to assist in soil classification and determine pertinent engineering characteristics. Results for plastic soils are presented in Figures A-16 through A-19. Liquid limits and plasticity index are also presented on the exploration logs at the respective sample depths.

Secondary Testing

Unconsolidated-Undrained Triaxial Tests

Unconsolidated undrained triaxial tests (TXUU) were performed on relatively undisturbed samples obtained from the borings. The samples were collected during drilling using Thin-Walled Tube Samplers (Shelby Tubes) in general accordance with ASTM D 1587. The sample was prepared and tested in general accordance with ASTM D 2850.

The TXUU is completed by subjecting the sample to an axial load at a constant strain rate in an undrained state. A sample is considered undrained if pore water is prevented from draining from the sample during testing. The undrained state is achieved by closing the drainage lines, which allow consolidation prior to the application of axial load. Because the axial load is applied in the undrained state, volume change of the sample is not permitted during loading resulting in the development of pore pressure changes in compensation for the sample attempting to contract or dilate. Effective confining pressures were selected to generally match the effective stresses in the in-situ stress state to develop shear strength parameters that are applicable to the anticipated loading. Axial load, strain and pore pressure are recorded during the test.

The recorded data was used to estimate the undrained shear strength of the sample. The results of the TXUU tests are presented on the Figures A-20 through A-32. Dry density and shear strength are also presented on the exploration logs at the respective sample depths.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

Sampler Symbol Descriptions

- 2.4-inch I.D. split barrel
- Standard Penetration Test (SPT)
- Shelby tube
- Piston
- Direct-Push
- Bulk or grab
- Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

"P" indicates sampler pushed using the weight of the drill rig.

"WOH" indicates sampler pushed using the weight of the hammer.

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	SOD	Sod/Forest Duff
	TS	Topsoil

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata

Approximate contact between soil strata

Material Description Contact

Contact between geologic units

Contact between soil of the same geologic unit

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DD	Dry density
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
Mohs	Mohs hardness scale
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PL	Point lead test
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

Key to Exploration Logs

GeoEngineers

Figure A-1

Rev 07/2019

Drilled Start 10/14/2019 End 10/14/2019	Total Depth (ft) 61.5	Logged By CJL Checked By CAH	Driller Holocene Drilling	Drilling Method Mud Rotary
Surface Elevation (ft) Vertical Datum: Undetermined		Hammer Data: Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment: Diedrick D-120 Truck mounted drill rig
Easting (X) Northing (Y)		System Datum		Groundwater not measured
Notes:				

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0						AC	Approximately 3 inches asphalt concrete pavement			
							GP-GM	Brown fine to coarse gravel with silt and sand (loose, moist) (fill material)			
	5		6	6		S-1 / MC			15		
	10		8	*WOH		S-2 / MC	ML	Dark gray silt with occasional gravel (very loose, moist) (alluvium)	59		No recovery with Shelby tube, use split spoon for sample recovery. *Blow counts potentially understated.
	15		0					No recovery			
			18	16		S-3		Dark gray silt with sand and trace organic matter (wood) (very stiff, moist)			Drilled to 17 feet, SPT
	20		24			S-4 / UU		Dark gray silt with sand (medium stiff, moist)	49		Dry density = 73.5 pcf Shear strength = 0.69 ksf
	25		18	*WOH		S-5		Dark gray silt with sand and organic matter (very soft, moist)			No recovery with Shelby tube, use split spoon for sample recovery. *Blow counts potentially understated.
	30							No recovery			
			30			S-6 / AL / UU	MH	Dark gray silt with occasional sand and organic matter (medium stiff, moist)	67		Dry density = 61.9 pcf Shear strength = 0.75 ksf AL (LL = 73; PI = 33)
	35										

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Date:3/4/20 Path:P:\23\23944001\GINT\2394400100.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring GEI-1-19

GeoEngineers

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		16			S-7						
	40		0						Dark gray silty fine sand No recovery			No recovery with Shelby tube. Drilled down to 42.5 feet.
			21			S-8 %F				32	14	
	45		14			S-9						
	50		27.5			S-10 %F				41	24	
	55		27.5			S-11						
	60		0						No recovery			Driller notes last 12 inches pushed like sand. Lost Shelby tube downhole. SPT refusal.

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Log of Boring GEI-1-19 (continued)

GeoEngineers

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Drilled	Start 10/16/2019	End 10/16/2019	Total Depth (ft) 52.5	Logged By CJL	Checked By CAH	Driller Holocene Drilling	Drilling Method Mud Rotary

Surface Elevation (ft) Vertical Datum	Undetermined	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop
Drilling Equipment	Diedrick D-120 Truck mounted drill rig		
Easting (X) Northing (Y)		System Datum	
Groundwater not measured			

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							AC	Approximately 3 inches of asphalt concrete pavement			
								GP-GM	Brown fine to coarse gravel with silt and sand (loose, moist) (fill material)			
	5		12	4		S-1 MC		ML	Dark gray silt with occasional sand and organic matter (wood fragments) (loose, moist) (alluvium)	58		
	10		24			S-2 AL UU		MH	Dark gray silt (soft, moist)	76		Dry density = 55.2 pcf Shear strength = 0.37 ksf AL (LL = 68; PI = 32)
	15		9			S-3 MC		ML	Silt with sand and occasional gravel (soft, moist)	47		
	20		17			S-4 AL UU		MH	Dark gray silt (soft, moist)	66		Dry density = 62.8 pcf Shear strength = 0.41 ksf AL (LL = 56; PI = 23)
	25		10			S-5 MC			Grades to with occasional sand	83		
	30		6	*WOH		S-6 AL				67		No recovery from Shelby tube, use split spoon to obtain sample. *Blow counts potentially understated AL (LL = 60; PI = 20)
	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Boring GEI-2-19

GeoEngineers

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Figure A-3
Sheet 1 of 2

Date:3/4/20 Path:P:\23\23944001\GINT\2394400100.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		21			S-7 / MC		SM	Silty fine sand (moist)	48		
	40			*WOH		S-8 / %F		ML	Dark gray sandy silt (very soft, wet)	59	63	Shelby tube sample fell downhole. Sample obtained by split spoon. *Blow counts potentially understated
	45		4			S-9 / MC			Dark gray silt with organic matter (wet)	118		
	50		26			S-10 / UU			Dark gray silt with sandy lenses (very stiff, moist)	40		Dry density = 82.0 pcf Shear strength = 2.01 ksf

Log of Boring GEI-2-19 (continued)

GeoEngineers

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Drilled	Start 10/14/2019	End 10/15/2019	Total Depth (ft)	71.5	Logged By CJL / Checked By CAH	Driller Holocene Drilling	Drilling Method Mud Rotary

Surface Elevation (ft) / Vertical Datum: Undetermined	Hammer Data: Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment: Diedrick D-120 Truck mounted drill rig	
Easting (X) / Northing (Y)	System / Datum	Groundwater not measured	
Notes:			

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							AC	Approximately 2 inches of asphalt concrete pavement			
								GP-GM	Brown fine to coarse gravel with sand and occasional wood debris (loose, moist) (fill material)			
	5		2	1		S-1						
	10		14			S-2		ML	Dark gray sandy silt (medium stiff, moist) (alluvium)			Top of sample contains gravel (fill)
	15		25			S-3 AL UU				46		Dry density = 78.8 pcf Shear strength 0.98 ksf AL (LL = 47; PI = 17)
	20		25			S-4						
	25		18	*6		S-5 AL		MH	Dark gray silt with occasional gravel (medium stiff, moist)	48		No recovery with Shelby tube, use SPT for sample recovery. *Blow counts potentially understated AL (LL = 70; PI = 29)
	30		27			S-6 AL UU			Dark gray silt with occasional sand (soft, moist)	66		Dry density = 67.1 pcf Shear strength = 0.44 ksf AL (LL = 69; PI = 27)
	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

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Log of Boring GEI-3-19

GEOENGINEERS

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		0	25		S-7		SM	No recovery (medium dense)			Driller pushed Shelby tube, noted sand at approximately 35 feet. SPT, no recovery
	40		18	4		S-8 / AL		MH	Dark gray silt with occasional sand (medium stiff, wet)	63		AL (LL = 61; PI = 24)
	45		27.5			S-9		SM	Dark gray silty fine to medium sand with trace organic matter (wood) (moist)			Driller notes difficulty in pushing Shelby tube
	50		12	20		S-10 / %F			Dark gray silty fine sand (medium dense, wet)	30	14	
	55		16	28		S-11 / %F				31	19	
	60		10	32		S-12			Grades to dense			
	65		18	21		S-13 / %F			Grades to medium dense	37	27	
	70		9	25		S-14						

Date:3/4/20 Path:P:\23\23944001\GINT\2394400100.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring GEI-3-19 (continued)

GeoEngineers

Project: North Shore Levee West Segment

Project Location: Hoquiam, Washington

Project Number: 23944-001-00

Drilled	Start 10/15/2019	End 10/15/2019	Total Depth (ft) 71.5	Logged By CJL / Checked By CAH	Driller Holocene Drilling	Drilling Method Mud Rotary

Surface Elevation (ft) / Vertical Datum	Undetermined	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrick D-120 Truck mounted drill rig
Easting (X) / Northing (Y)		System / Datum		Groundwater not measured	

Notes:

Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
0						SOD	Grassy-sod surface, approximately 3 inch roots			
						GP-GM	Brown fine to coarse gravel with silt and sand (loose, moist) (fill material)			
5		1	6		S-1					Observed wood debris in cuttings
10		0	*15		S-2		No recovery			*Blow counts potentially overstated due to wood/log debris.
15		6	*WOH		S-3 MC	ML	Dark gray silt (very soft, wet) (alluvium)	51		No recovery with Shelby tube. Sample recovery with split spoon. *Blow counts potentially understated
20		12	*WOH		S-4	MH	Dark gray elastic silt with sand and occasional organic matter (very soft, wet)			No recovery with Shelby tube. Sample recovery with split spoon. *Blow counts potentially understated
25		25			S-5 AL UU		Becomes medium stiff	63		Dry density = 71.6 pcf Shear strength = 0.59 ksf AL (LL = 69; PI = 33)
30		27.5			S-6					
35										

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

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Log of Boring GEI-4-19

GEOENGINEERS

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		15			S-7 / AL		ML	Dark gray silt with occasional sand (very soft, wet)	63		AL (NP)
	40		14			S-8						
	45		9.5			S-9 / %F				30	16	Dense sand layer at approximately 46 feet
								SM	Dark gray silty fine sand (wet)			
	50		16	37		S-10 / MC		SP-SM	Dark gray fine sand with silt (dense, wet)	27		
	55			31		S-11 / %F			Grades to fine to medium sand	32	21	
	60		18	9		S-12		ML	Dark gray silt with sand (stiff, wet)	51		Silty fine to coarse sand with gravel in shoe
	65		14	16		S-13 / %F		SM	Dark gray fine sand with trace organic material (medium dense, wet)	38	31	
	70		0	27		S-14			No recovery			Driller indicated same drilling conditions as above

Log of Boring GEI-4-19 (continued)

GEOENGINEERS

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Drilled	Start 10/15/2019	End 10/15/2019	Total Depth (ft) 72.5	Logged By CJL / Checked By CAH	Driller Holocene Drilling	Drilling Method Mud Rotary

Surface Elevation (ft) / Vertical Datum: Undetermined	Hammer Data: Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment: Diedrick D-120 Truck mounted drill rig
Easting (X) / Northing (Y)	System / Datum	Groundwater not measured

Notes:

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							GP-GM	Brown fine to coarse gravel with silt and sand (loose, moist) (fill material)			
	5		4	7		S-1 / MC		GP	Gray fine gravel (loose, moist)	20		
	10		0	WOH				SM	No recovery			
	15		17			S-2 / MC			Gray silty fine sand (alluvium)	51		
	20		24			S-3 / AL		MH	Gray silt	86		AL (LL = 65; PI = 27)
	25		20			S-4 / %F		SM	Dark gray silty fine sand with trace gravel, organic matter and shells (moist)	40	39	Sample fell out of Shelby tube, bagged sample.
	30		2	*5		S-5			Dark gray silty fine sand with trace gravel (loose, moist)			No recovery in Shelby tube, poor sample recovery by split spoon. *Blow counts potentially understated
	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Boring GEI-5-19

GeoEngineers

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Date:3/4/20 Path:P:\23\23944001\GINT\2394400100.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		28			S-6 UU		MH	Dark gray sandy silt with organic matter (stiff, moist)	54		Dry density = 73.0 pcf Shear strength = 1.39 ksf
	40		26			S-7 AL UU			Dark gray wilt with sand and organic matter (medium stiff, moist)	57		Dry density = 68.4 pcf Shear strength = 0.65 ksf AL (LL = 64; PI = 27)
	45		1			S-8 MC			Organic matter grades out	51		
	50		18	*8		S-9 MC			Dark gray sandy silt (stiff, moist)	49		No recovery with Shelby tube. Split spoon recovery. *Blow counts potentialy understated
	55		22			S-10			Dark gray silt with sand an organic matter (stiff, moist)			Pocket pen = 1.1 tsf
	60		24			S-11 UU			Dark gray sandy silt with organic matter (medium stiff to stiff, moist)	44		Dry density = 76.8 pcf Shear strength = 0.96 ksf
	65		25			S-12			Becomes stiff			6-inch silty sand layer at 65 feet below ground surface. Pocket pen = 1.4 tsf
	70		25			S-13						

Date:3/4/20 Path:P:\23\23944001\GINT\2394400100.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Log of Boring GEI-5-19 (continued)

GeoEngineers

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Drilled	Start 10/16/2019	End 10/16/2019	Total Depth (ft) 66.5	Logged By CJL Checked By CAH	Driller Holocene Drilling	Drilling Method Mud Rotary

Surface Elevation (ft) Vertical Datum: Undetermined	Hammer Data: Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment: Diedrick D-120 Truck mounted drill rig
Easting (X) Northing (Y)	System Datum	Groundwater not measured

Notes:

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							GP-GM	Gravel with silt and sand (fill material)			
	5		8	2		S-1 / MC		ML	Dark gray silt (soft, moist) (alluvium)	59		
	10		11			S-2		SM	Dark gray silty fine sand			
	15		5			S-3						
	20		15			S-4 / AL / UU		MH	Dark gray silt with sand and organic matter (medium stiff, moist)	60		Dry density = 66.4 pcf Shear strength = 0.52 ksf AL (LL = 59; PI = 22)
	25		23			S-5		ML				
	30		0			S-6 / AL			Dark gray silt	49		AL (LL = 47; PI = 13)
	35											

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on . Vertical approximated based on .

Log of Boring GEI-6-19

GEOENGINEERS

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Date:3/4/20 Path:P:\23\23944001\GINT\2394400100.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

Elevation (feet)	Depth (feet)	Recovered (in)	Blows/foot	Sample Name / Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	4		S-7 / AL	MH	Dark gray sandy silt	92		AL (LL = 51; PI - 17)
	40	24		S-8					
	45	24		S-9 / MC		Dark gray silt with occasional sand and organic matter	52		
	50	24		S-10 / UU		Becomes stiff	55		Dry density = 67.8 pcf Shear strength = 1.0 ksf
	55	6	16	S-11 / %F	GM	Dark gray silty fine gravel with sand (medium dense, wet)	19	23	Driller indicates harder drill conditions at approximately 54 feet below ground surface
	60	15	64	S-12 / %F	ML	Bluish gray silt with sand (hard, moist)	41	73	
	65	18	53	S-13					

Log of Boring GEI-6-19 (continued)

GEOENGINEERS

Project: North Shore Levee West Segment
Project Location: Hoquiam, Washington
Project Number: 23944-001-00

Figure A-7
Sheet 2 of 2

Date:3/4/20 Path:P:\23\23944001\GINT\2394400100.GPJ DBLibrary/Library:GEOENGINEERS_DF_STD_US_JUNE_2017.GLB/GEI8_GEOTECH_STANDARD_%F_NO_GW

PRESENTATION OF SITE INVESTIGATION RESULTS

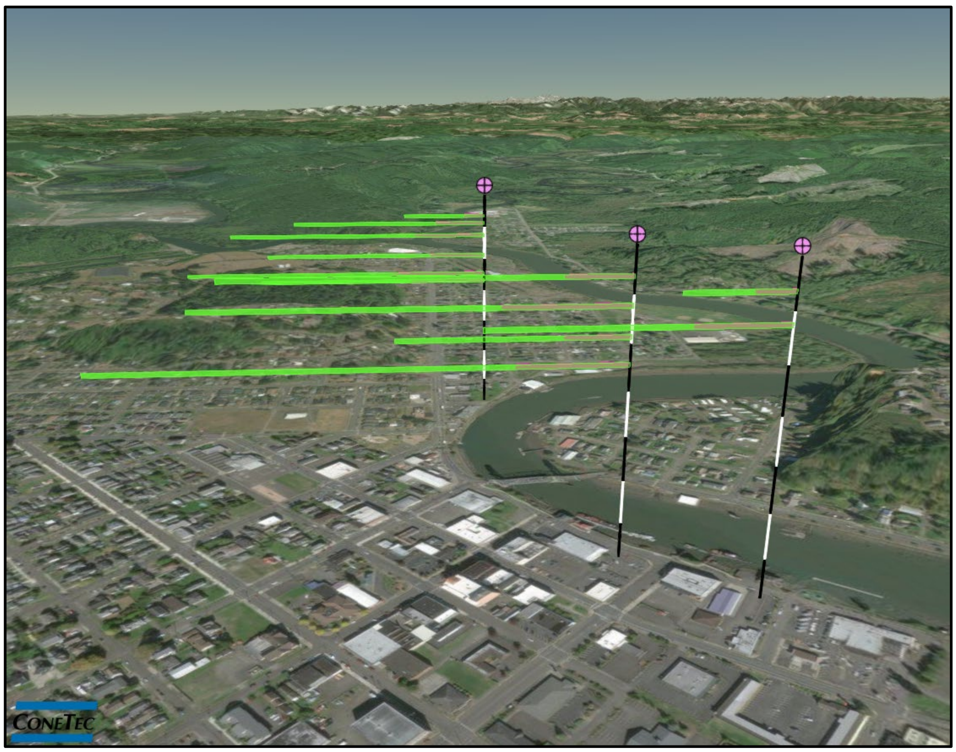
North Shore Levee West

Prepared for:

GeoEngineers, Inc.

ConeTec Job No: 19-59053

Project Start Date: 24-Oct-2019
Project End Date: 15-Nov-2019
Report Date: 18-Nov-2019



Prepared by:

ConeTec Inc.
1508 O Street SW, Unit 103-104
Auburn, WA 98001

Tel: (801) 973-3801

ConeTecWA@conetec.com
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www.conetecdataservices.com

Introduction

The enclosed report presents the results of the site investigation program conducted by ConeTec Inc. for GeoEngineers, Inc. at Hoquiam, WA. The program consisted of three electric vane shear tests (eVST).

Project Information

Project	
Client	GeoEngineers, Inc.
Project	North Shore Levee West
ConeTec project number	19-59053

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

Rig Description	Deployment System	Test Type
CPT truck rig (M7)	14 ton rig cylinder	eVST
CPT truck rig (C20)	14 ton rig cylinder	eVST

Coordinates		
Test Type	Collection Method	EPSG Number
eVST	Consumer grade GPS	4326

Electric Field Vane Shear Test (VST)	
Depth reference	Depths are referenced to the existing ground surface at the time of each test.
Load cell capacity	100 N·m
Load cell location	Surface

Limitations

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

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

The electric field vane system is manufactured by Adara Systems Ltd., a subsidiary of ConeTec. An illustration of the uphole vane system configuration is presented in Figure eVST.

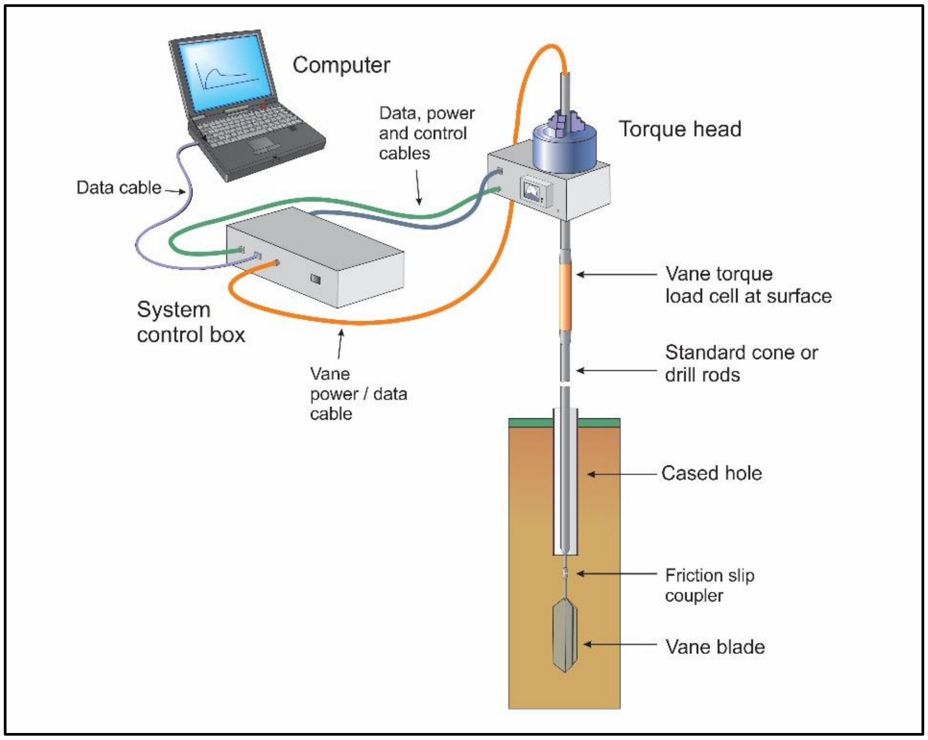


Figure eVST. Illustration of the uphole electric field vane system configuration

The vane system is designed with an array of strain gauges in a load cell that measure the applied torque. The torque signal is amplified and converted to digital data within the tool and transmitted to the data acquisition system through a shielded cable. The system uses a friction slip coupler to permit the free slip or play of approximately fifteen degrees between the rods and the vane blade in order to isolate and record rod friction from the soil before rotation of the vane blade starts. The system is designed to use vane blades of various sizes and configurations that connect to the friction slip coupler. The vane blades manufactured by Adara have dimensions and tolerances that are in general accordance with the current ASTM D2573 standards. In very soft soil conditions and at the request of the client, ConeTec may use a large diameter vane blade that exceeds the ASTM D2573 maximum size specifications in order to maximize torque resolution. In very stiff soil conditions and at the request of the client, ConeTec may use a smaller diameter vane blade than the minimum size specified in ASTM D2573 in order to obtain a peak torque below the capacity of the load cell.

The electric motor (capable of 100 Newton-meters of torque) is designed to clamp onto and rotate the rods and vane blade at a constant rate.

ConeTec's calibration criteria of the load cells are in accordance with the current ASTM D2573 standard.

The data acquisition system consists of a computer that records the vane data every 0.2 degrees of rotation. The system records the following parameters and saves them to a file as the test is conducted:

- Torque in Newton-meters
- Rotation in degrees
- Elapsed time in seconds (from the start of the test)

All testing is performed in accordance to ConeTec's field vane testing operating procedures and in general accordance with the current ASTM D2573 standard. For additional information on vane shear testing refer to Greig et al. (1987).

Prior to the start of a vane shear test profile, a suitable sized vane blade is selected, the vane system is powered on and the vane load cell baseline reading is recorded with the load cell hanging freely in a vertical position.

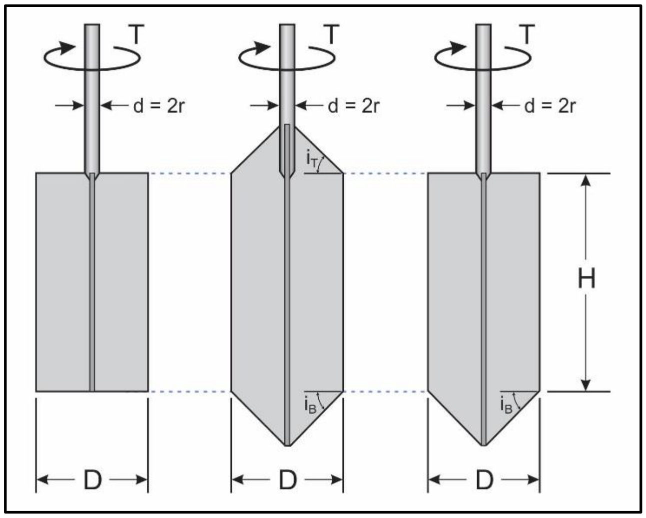
The vane blade, slip coupler and rods are advanced to the desired test depth through a cased hole, typically using AWJ drill rods or one-meter length rods with an outer diameter of 1.5 inches (38.1 millimeters). Test depths are referenced to the middle of the rectangular portion of the vane blade. The motor rotates the rods at a near constant rate up to and beyond the yield stress (peak) until the load remains near constant (post peak). Following post peak readings, the vane blade is then rapidly rotated clockwise ten times to completely remold the soil. The test procedure is repeated in order to record the remolded strength of the soil. The vane blade is then advanced to the next depth and the procedure is repeated or the vane blade is retracted to allow for drilling and vane blade size changes. Once the vane profile is complete, the final baseline of the load cell is recorded and compared to previous reading as a QA/QC check.

Undrained shear strength from the field vane, $(S_u)_{fv}$, is calculated from torque measurements using the following general equation (ASTM D2573) taking into consideration the case of rectangular or tapered ends at the top and/or bottom of the vane blade.

$$(S_u)_{fv} = \frac{12 \cdot T_{max}}{\pi D^2 \left(\frac{D}{\cos(i_T)} + \frac{D}{\cos(i_B)} + 6H \right)}$$

where:

$(S_u)_{fv}$	=	undrained shear strength from the field vane
T_{max}	=	maximum value of torque
D	=	vane diameter
H	=	height of the rectangular portion of the vane
i_T	=	angle of taper at vane top (with respect to horizontal)
i_B	=	angle of taper at vane bottom (with respect to horizontal)



For rectangular vane blades where H/D = 2, the above equation simplifies to:

$$(S_u)_{fv} = \frac{6 \cdot T_{max}}{7\pi D^3}$$

The recorded rod friction is subtracted from the peak and remolded torque. No correction factors are applied to the vane results to derive the mobilized shear strength ($\tau_{mobilized}$).

A summary of the vane shear tests, a table of results and individual VST plots are provided in the relevant appendices. Tabular data in Excel format is provided in the data release folder.

References

ASTM D2573 / D2573M-18, 2018, "Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils", ASTM International, West Conshohocken, PA. DOI: 10.1520/D2573_D2573M-18.

Greig, J.W., R.G. Campanella and P.K. Robertson, 1987, "Comparison of Field Vane Results With Other In-Situ Test Results", International Symposium on Laboratory and Field Vane Shear Strength Testing, ASTM, Tampa, FL, Proceedings.

The appendices listed below are included in the report:

- Electric Field Vane Shear Test Profile Summary and Results
- Electric Field Vane Shear Test Plots

Electric Field Vane Shear Test Profile Summary and Results

Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Start Date: 24-Oct-2019
End Date: 15-Nov-2019

ELECTRIC FIELD VANE SHEAR TEST SUMMARY

Sounding ID	File Name	Rig	Date From	Date To	Latitude[1]	Longitude[1]	Refer to Notation Number
VST-2-19	19-59053_VST-2-19	M7	24-Oct-2019	24-Oct-2019	46.977180	-123.882020	
VST-3-19	19-59053_VST-3-19	C20	14-Nov-2019	14-Nov-2019	46.977870	-123.883480	
VST-6-19	19-59053_VST-6-19	C20	15-Nov-2019	15-Nov-2019	46.981990	-123.884770	

1. Coordinates were collected using a consumer grade GPS in datum WGS84.

Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Start Date: 24-Oct-2019
End Date: 15-Nov-2019

ELECTRIC FIELD VANE SHEAR TEST RESULTS

Sounding ID	File Name	Date	Load Cell Serial Number	Load Cell Location	Casing/Drillout Depth (ft)	Test Depth[1] (ft)	Vane Diameter D (mm)	Vane Height H (mm)	Top Taper Angle i_T (deg)	Bottom Taper Angle i_B (deg)	Vane Factor (kPa/Nm)	Peak Torque (Nm)	Remolded Torque (Nm)	Peak Stress (tsf)	Remolded Stress (tsf)	Peak Frictional Stress (tsf)	Remolded Frictional Stress (tsf)	Su Peak (tsf)	Su Remolded (tsf)	Sensitivity	Refer to Notation Number
VST-2-19	19-59053_VST-2-19	24-Oct-2019	AVLC013	Surface	7.50	10.50	60	120	45	45	1.1926	19.20	8.10	0.24	0.10	0.05	0.03	0.193	0.072	2.69	2
VST-2-19	19-59053_VST-2-19	24-Oct-2019	AVLC013	Surface	17.50	20.50	60	120	45	45	1.1926	45.21	16.86	0.56	0.21	0.04	0.04	0.520	0.170	3.06	2
VST-3-19	19-59053_VST-3-19	14-Nov-2019	AVLC-035	Surface	8.90	10.40	60	120	45	45	1.1926	65.58	13.92	0.82	0.17	0.07	0.04	0.751	0.130	5.79	
VST-3-19	19-59053_VST-3-19	14-Nov-2019	AVLC-035	Surface	18.60	20.10	60	120	45	45	1.1926	83.20	27.64	1.04	0.34	0.23	0.10	0.808	0.245	3.29	
VST-3-19	19-59053_VST-3-19	14-Nov-2019	AVLC-035	Surface	28.80	30.50	60	120	45	45	1.1926	39.69	13.24	0.49	0.16	0.05	0.04	0.439	0.127	3.45	
VST-3-19	19-59053_VST-3-19	14-Nov-2019	AVLC-035	Surface	38.50	40.00	60	120	45	45	1.1926	86.07	20.50		0.26	0.07	0.04		0.217		3
VST-6-19	19-59053_VST-6-19	15-Nov-2019	AVLC-035	Surface	9.20	10.70	60	120	45	45	1.1926	21.40	6.57	0.27	0.08	0.03	0.02	0.232	0.059	3.91	
VST-6-19	19-59053_VST-6-19	15-Nov-2019	AVLC-035	Surface	12.90	14.40	60	120	45	45	1.1926	47.21	13.93	0.59	0.17	0.04	0.03	0.549	0.143	3.85	
VST-6-19	19-59053_VST-6-19	15-Nov-2019	AVLC-035	Surface	19.00	20.50	60	120	45	45	1.1926	63.64	20.18	0.79	0.25	0.06	0.05	0.732	0.206	3.55	
VST-6-19	19-59053_VST-6-19	15-Nov-2019	AVLC-035	Surface	29.20	30.70	60	120	45	45	1.1926	58.33	16.99	0.73	0.21	0.10	0.05	0.630	0.160	3.93	
VST-6-19	19-59053_VST-6-19	15-Nov-2019	AVLC-035	Surface	38.70	40.20	60	120	45	45	1.1926	75.49	25.41	0.94	0.32	0.08	0.05	0.865	0.265	3.26	
VST-6-19	19-59053_VST-6-19	15-Nov-2019	AVLC-035	Surface	42.40	44.00	60	120	45	45	1.1926	69.99	27.81	0.87	0.35	0.22	0.13	0.654	0.219	2.99	

1. Test depths are referenced to the middle of the vane.
2. Remold test results were not fully achieved.
3. Peak not achieved due to equipment issues.

CONETEC

Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Start Date: 24-Oct-2019
End Date: 15-Nov-2019

ELECTRIC FIELD VANE SHEAR TEST TIMING

Sounding ID	Date	Test Depth[1] (ft)	Vane Insertion Time (HH:mm)	Peak Test Start Time (HH:mm)	Insertion to Start Interval (min)	Start to Failure Interval (sec)	Peak Test Avg Rate (deg/sec)	Remolding Completion Time (HH:mm)	Remold Test Start Time (HH:mm)	Remolding to Start Interval (min)	Remold Test Avg Rate (deg/sec)	Refer to Notation Number
VST-2-19	24-Oct-2019	10.50	10:02	10:03	2	982	0.10	10:44	10:45	1	0.09	2
VST-2-19	24-Oct-2019	20.50	11:56	11:57	2	3165	0.10	13:16	13:17	2	0.13	2
VST-3-19	14-Nov-2019	10.40	12:45	12:46	2	830	0.12	13:12	13:13	2	0.11	
VST-3-19	14-Nov-2019	20.10	14:10	14:11	1	629	0.11	14:31	14:32	2	0.11	
VST-3-19	14-Nov-2019	30.50	15:30	15:31	1	456	0.11	15:52	15:53	2	0.11	
VST-3-19	14-Nov-2019	40.00	17:04	17:05	1	835	0.12	17:38	17:39	1	0.12	3
VST-6-19	15-Nov-2019	10.70	11:10	11:11	1	249	0.11	11:26	11:28	2	0.11	
VST-6-19	15-Nov-2019	14.40	12:04	12:05	1	348	0.11	12:20	12:21	1	0.11	
VST-6-19	15-Nov-2019	20.50	12:57	12:58	1	518	0.11	13:12	13:14	2	0.11	
VST-6-19	15-Nov-2019	30.70	15:51	15:53	2	570	0.12	16:11	16:12	1	0.12	
VST-6-19	15-Nov-2019	40.20	16:57	16:58	1	820	0.12	17:16	17:17	2	0.12	
VST-6-19	15-Nov-2019	44.00	17:52	17:53	2	881	0.12	18:17	18:18	1	0.12	

1. Test depths are referenced to the middle of the vane.
2. Remold test results were not fully achieved.
3. Peak not achieved due to equipment issues.

Electric Field Vane Shear Test Plots

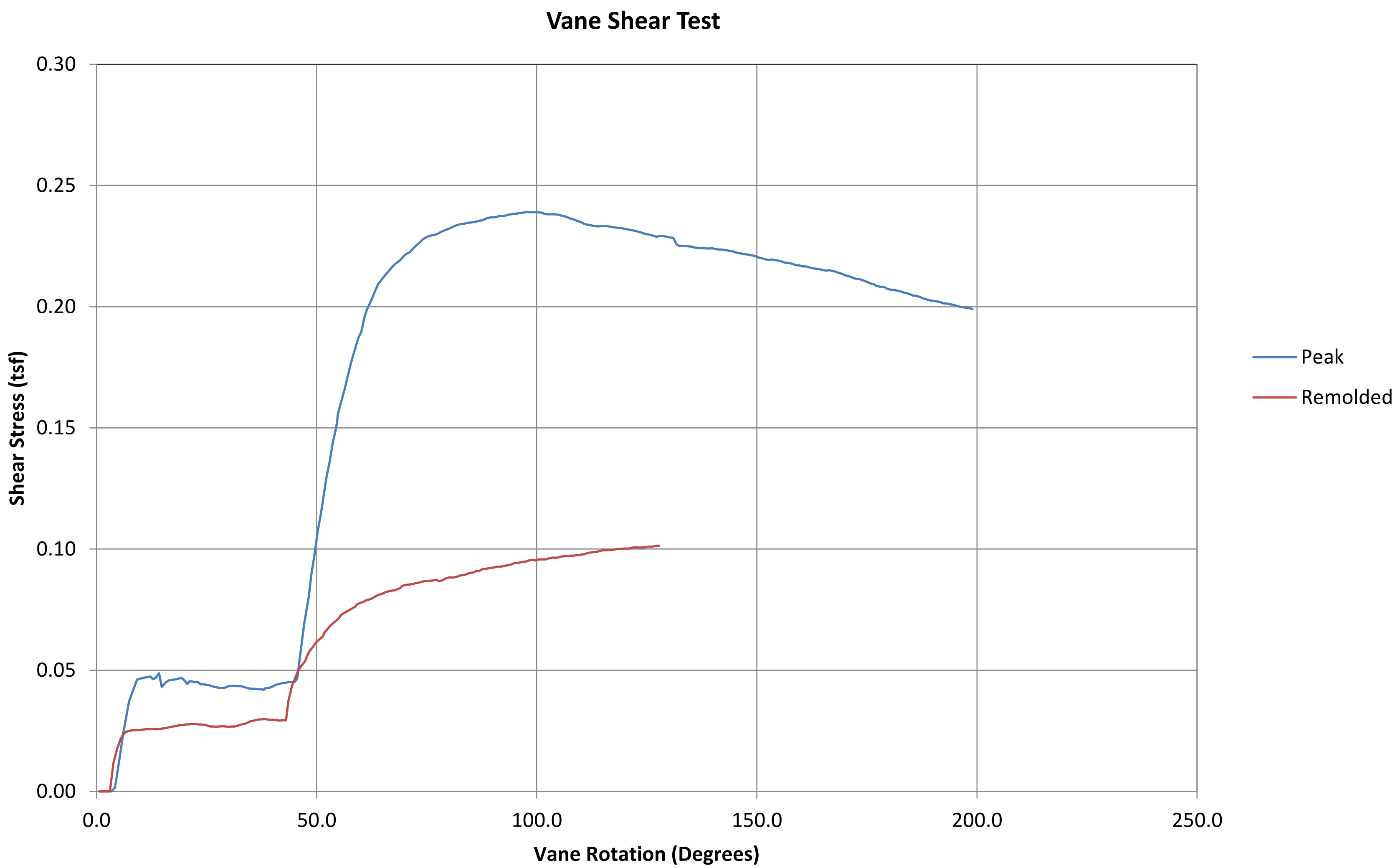
ConeTec

CONETEC

Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-2-19

Test Date: 24-Oct-2019 10:03
Test Depth (ft): 10.50
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

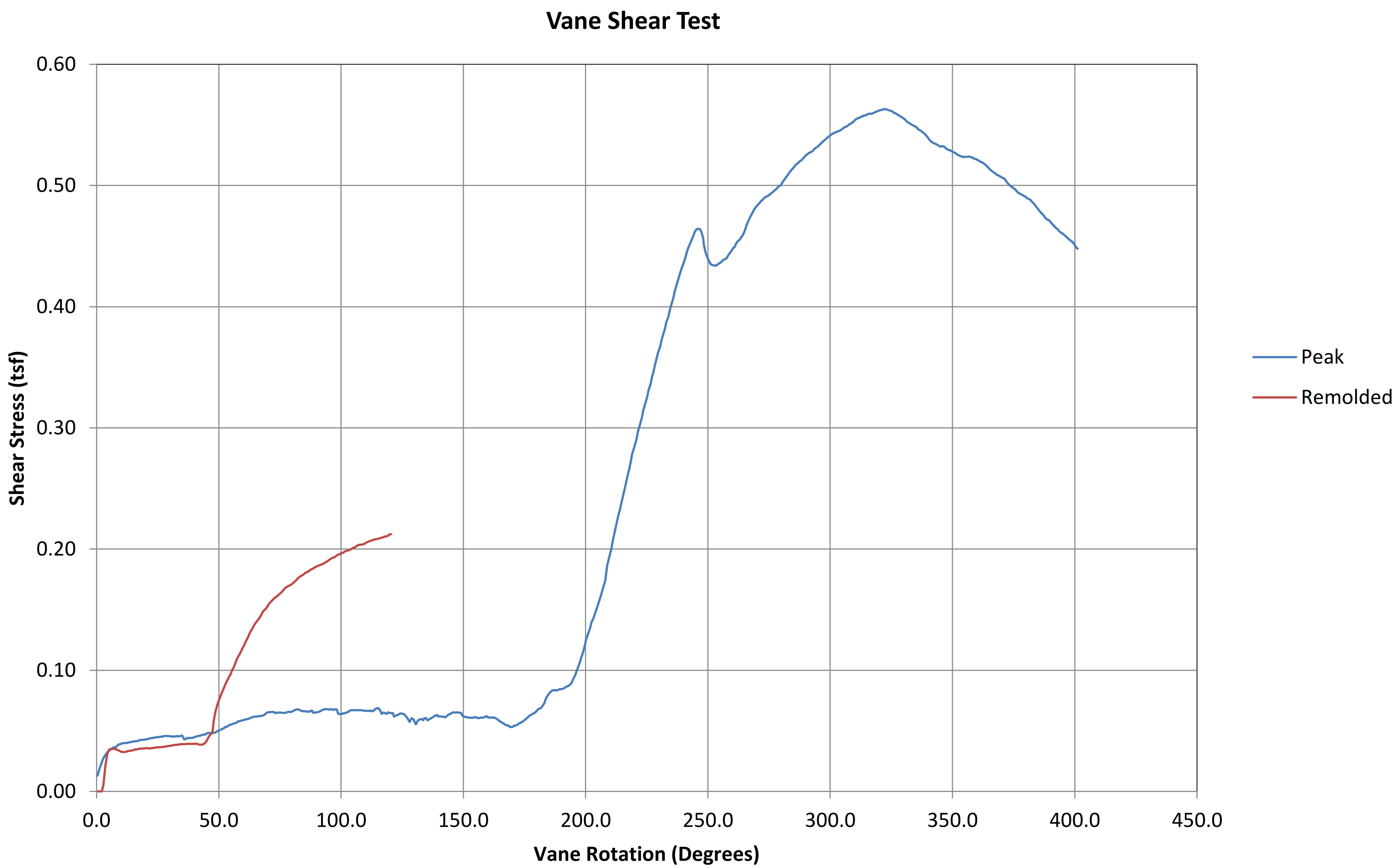
Coordinate System: WGS 84 Lat/Long
Latitude: 46.97718
Longitude: -123.88202



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-2-19

Test Date: 24-Oct-2019 11:57
Test Depth (ft): 20.50
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

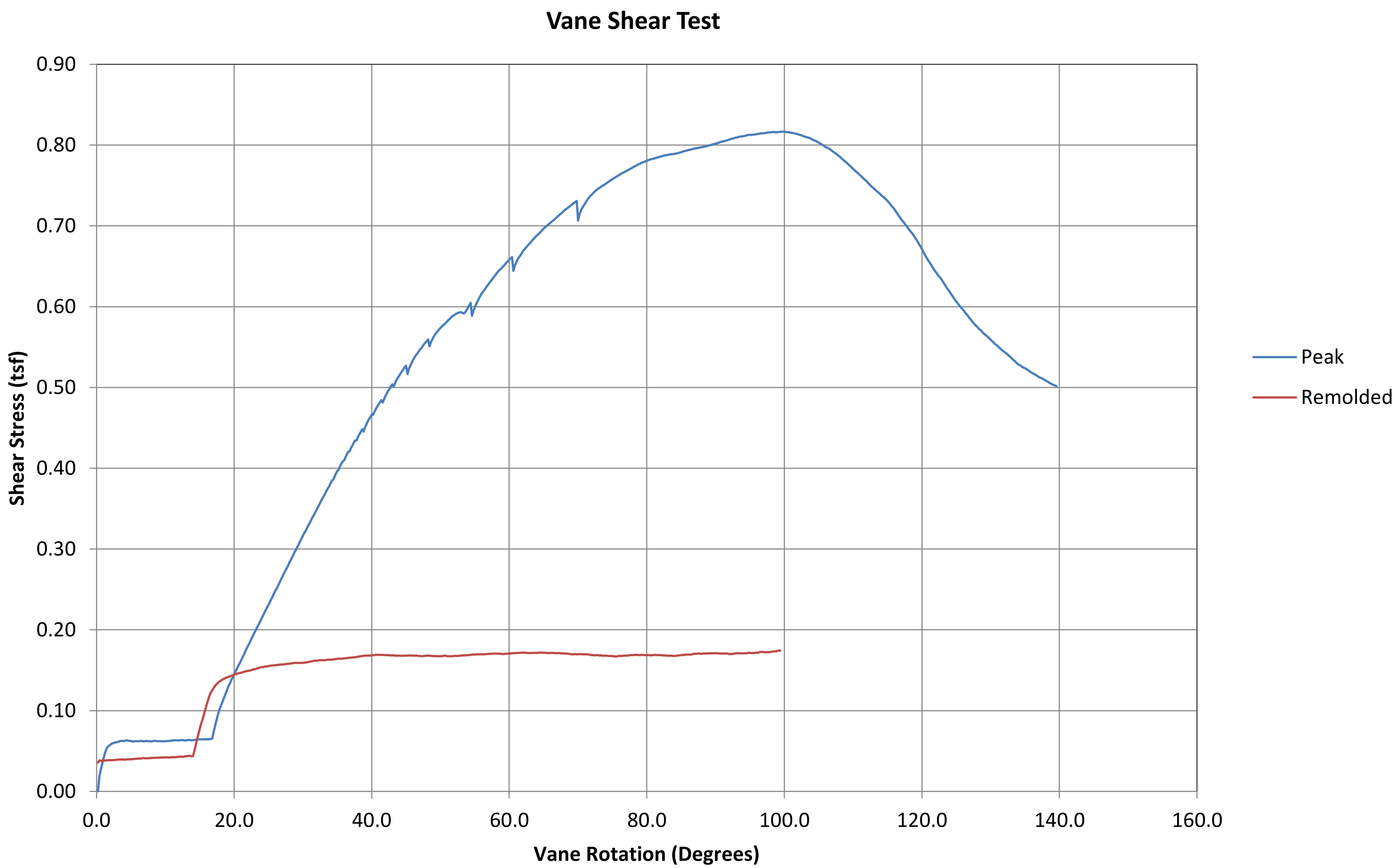
Coordinate System: WGS 84 Lat/Long
Latitude: 46.97718
Longitude: -123.88202



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-3-19

Test Date: 14-Nov-2019 12:46
Test Depth (ft): 10.40
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

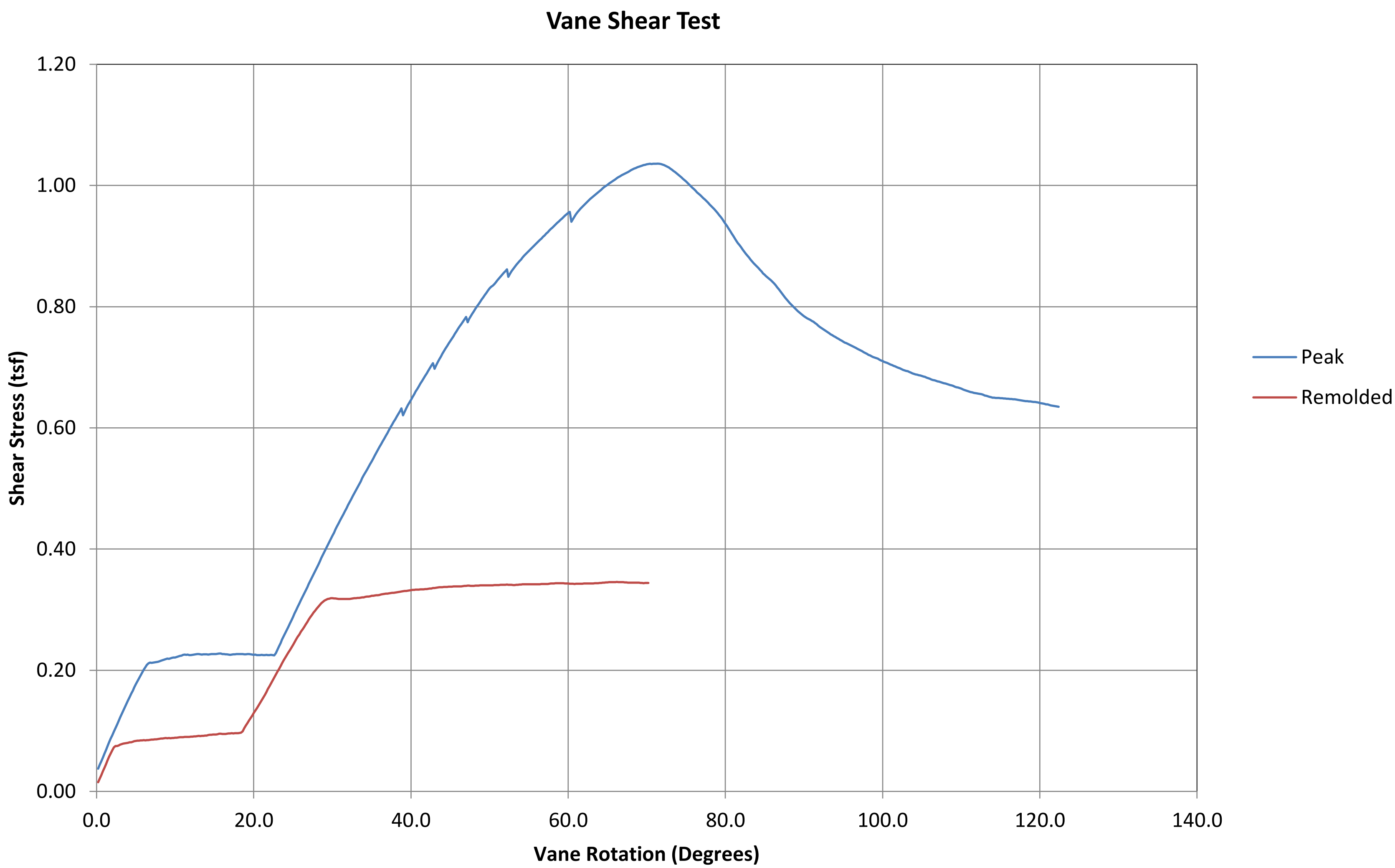
Coordinate System: WGS 84 Lat/Long
Latitude: 46.97787
Longitude: -123.88348



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-3-19

Test Date: 14-Nov-2019 14:11
Test Depth (ft): 20.10
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

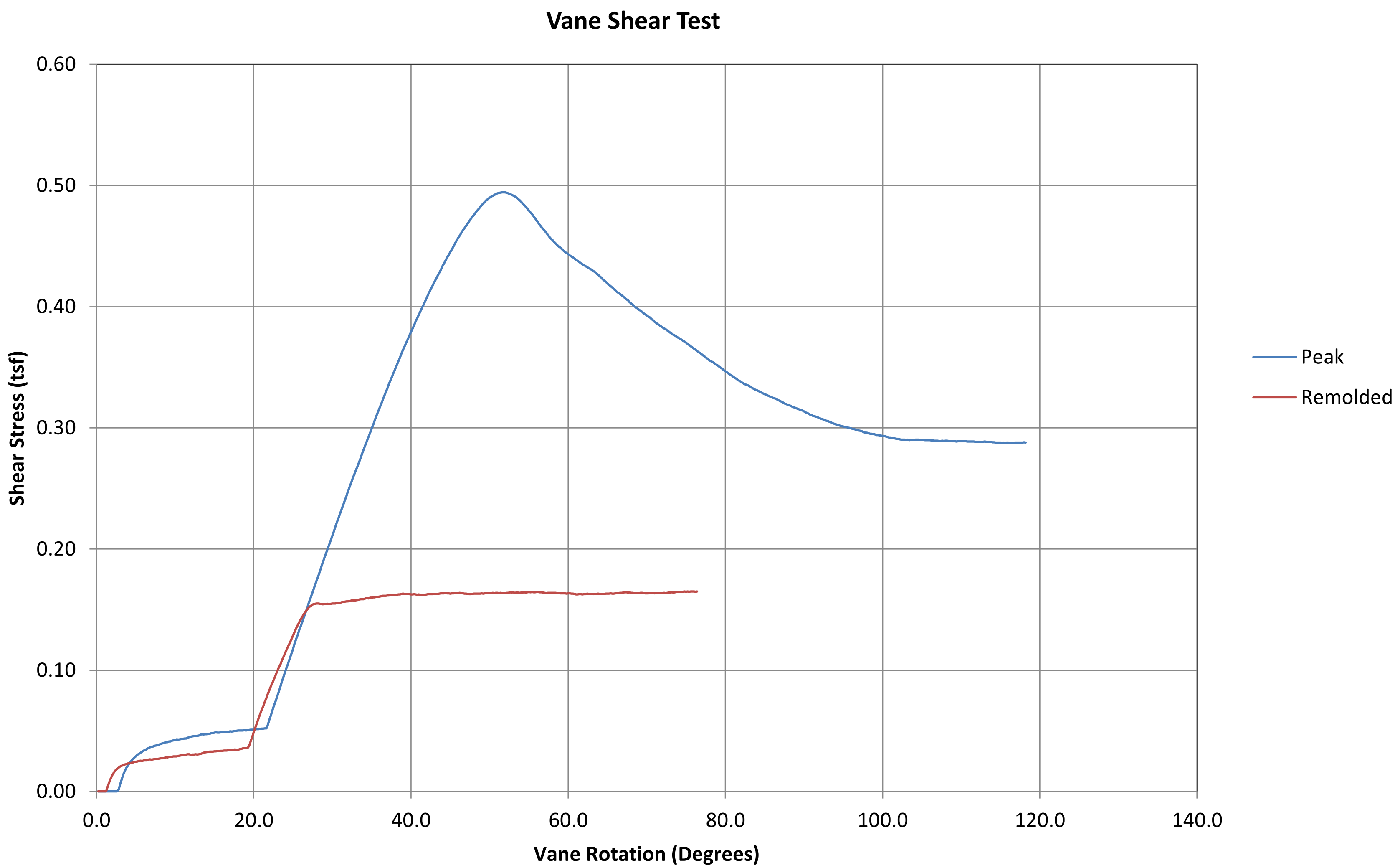
Coordinate System: WGS 84 Lat/Long
Latitude: 46.97787
Longitude: -123.88348



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-3-19

Test Date: 14-Nov-2019 15:31
Test Depth (ft): 30.50
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

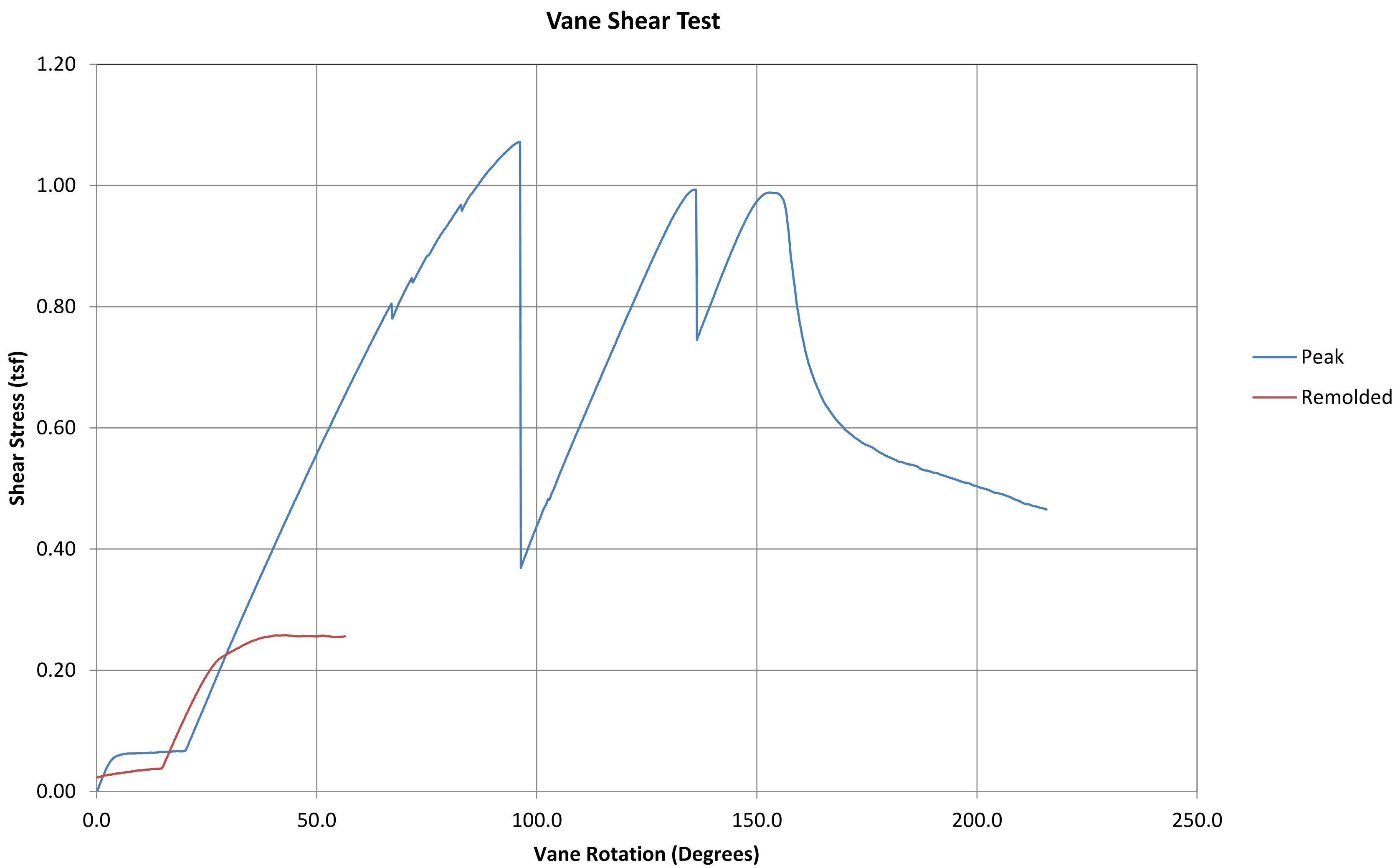
Coordinate System: WGS 84 Lat/Long
Latitude: 46.97787
Longitude: -123.88348



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-3-19

Test Date: 14-Nov-2019 17:05
Test Depth (ft): 40.00
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

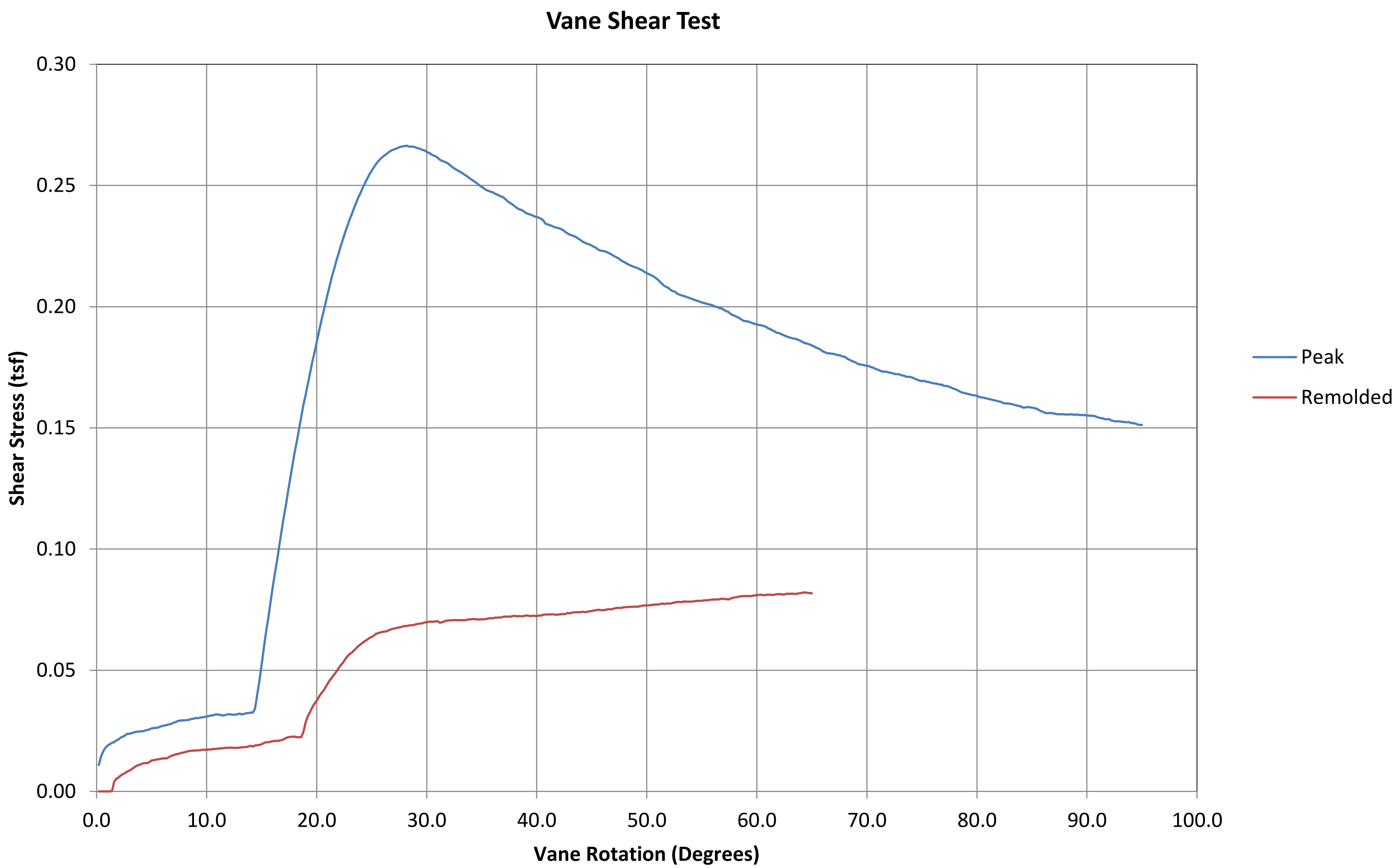
Coordinate System: WGS 84 Lat/Long
Latitude: 46.97787
Longitude: -123.88348



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-6-19

Test Date: 15-Nov-2019 11:11
Test Depth (ft): 10.70
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

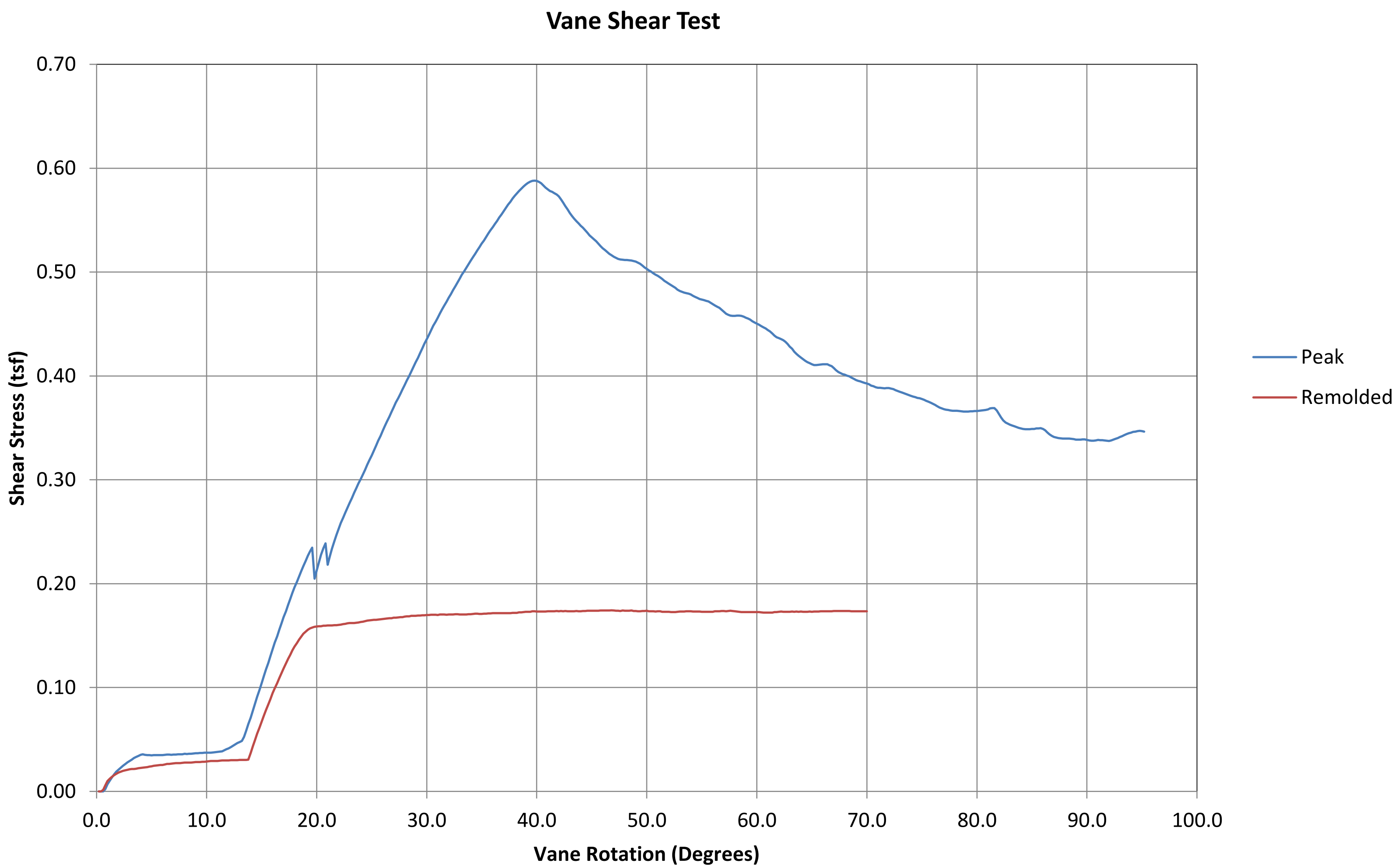
Coordinate System: WGS 84 Lat/Long
Latitude: 46.98199
Longitude: -123.88477



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-6-19

Test Date: 15-Nov-2019 12:05
Test Depth (ft): 14.40
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

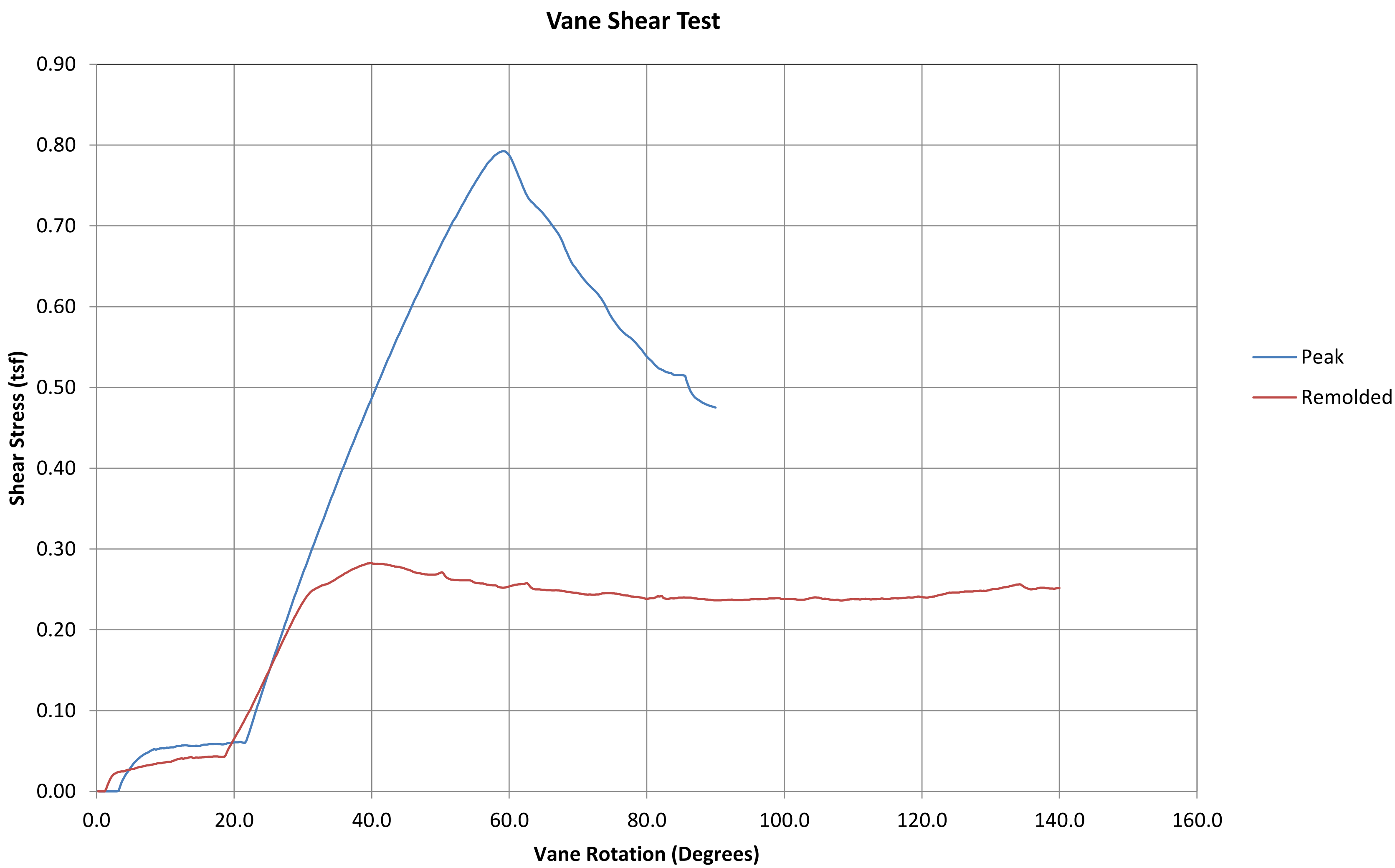
Coordinate System: WGS 84 Lat/Long
Latitude: 46.98199
Longitude: -123.88477



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-6-19

Test Date: 15-Nov-2019 12:58
Test Depth (ft): 20.50
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

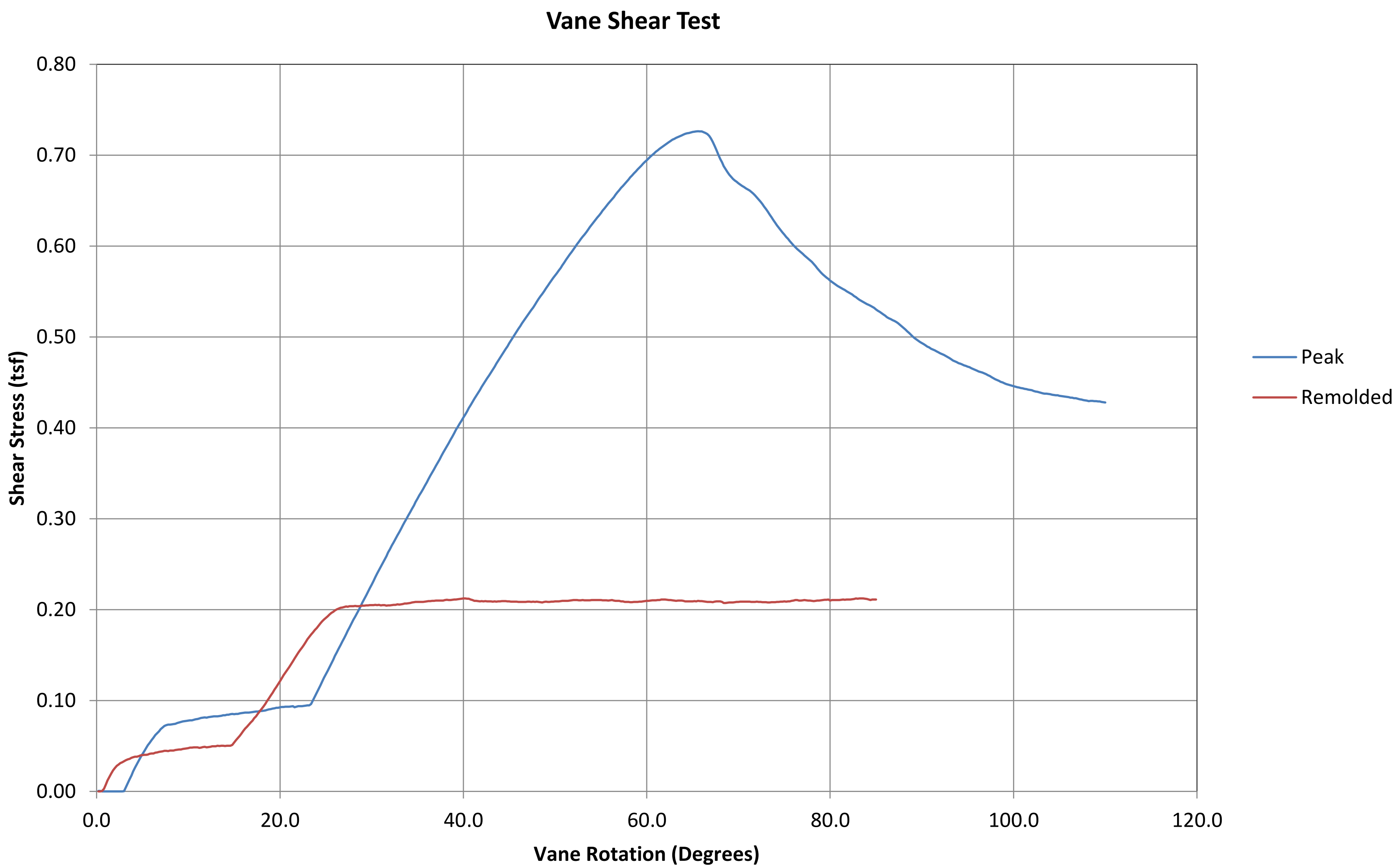
Coordinate System: WGS 84 Lat/Long
Latitude: 46.98199
Longitude: -123.88477



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-6-19

Test Date: 15-Nov-2019 15:53
Test Depth (ft): 30.70
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

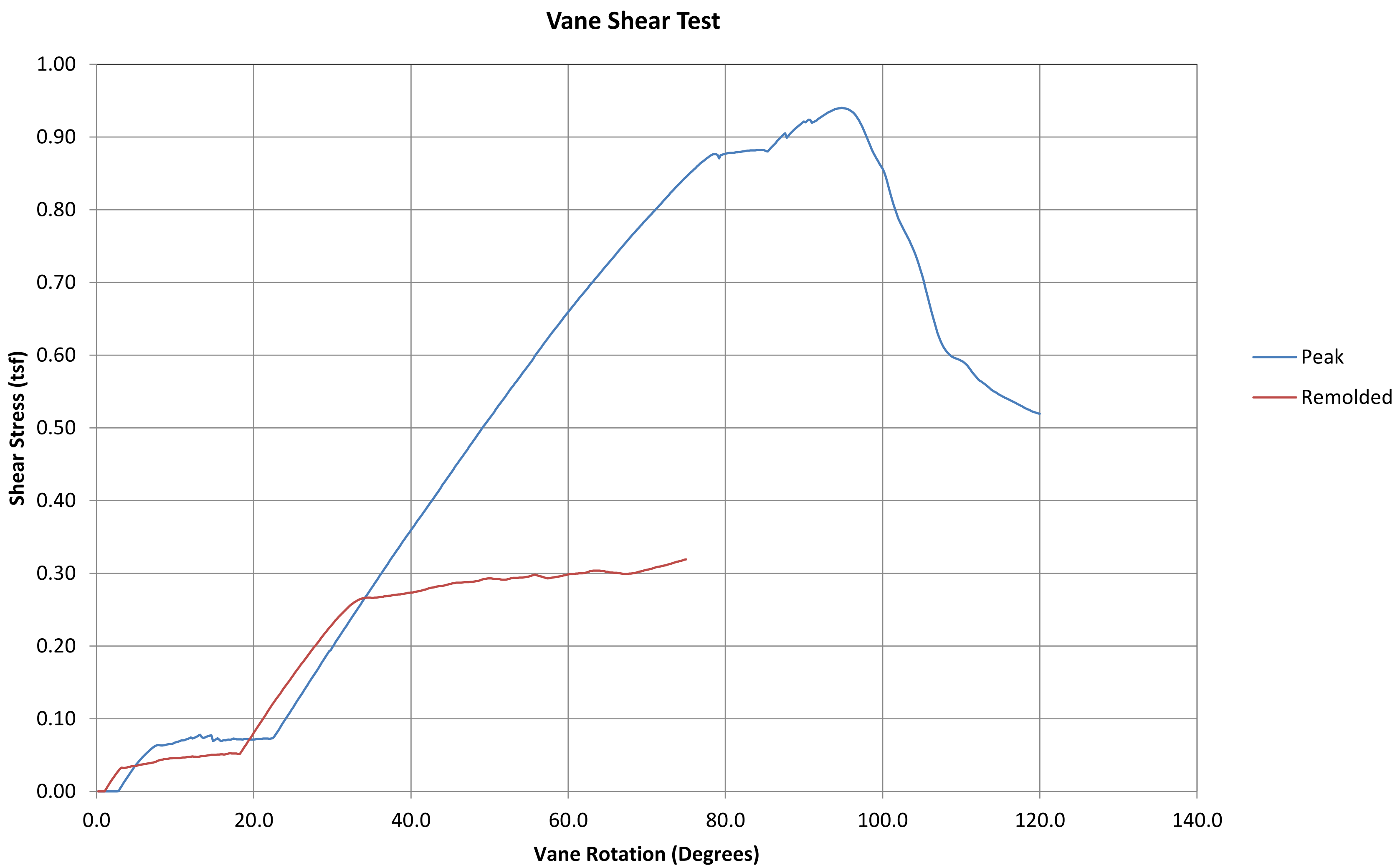
Coordinate System: WGS 84 Lat/Long
Latitude: 46.98199
Longitude: -123.88477



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-6-19

Test Date: 15-Nov-2019 16:58
Test Depth (ft): 40.20
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

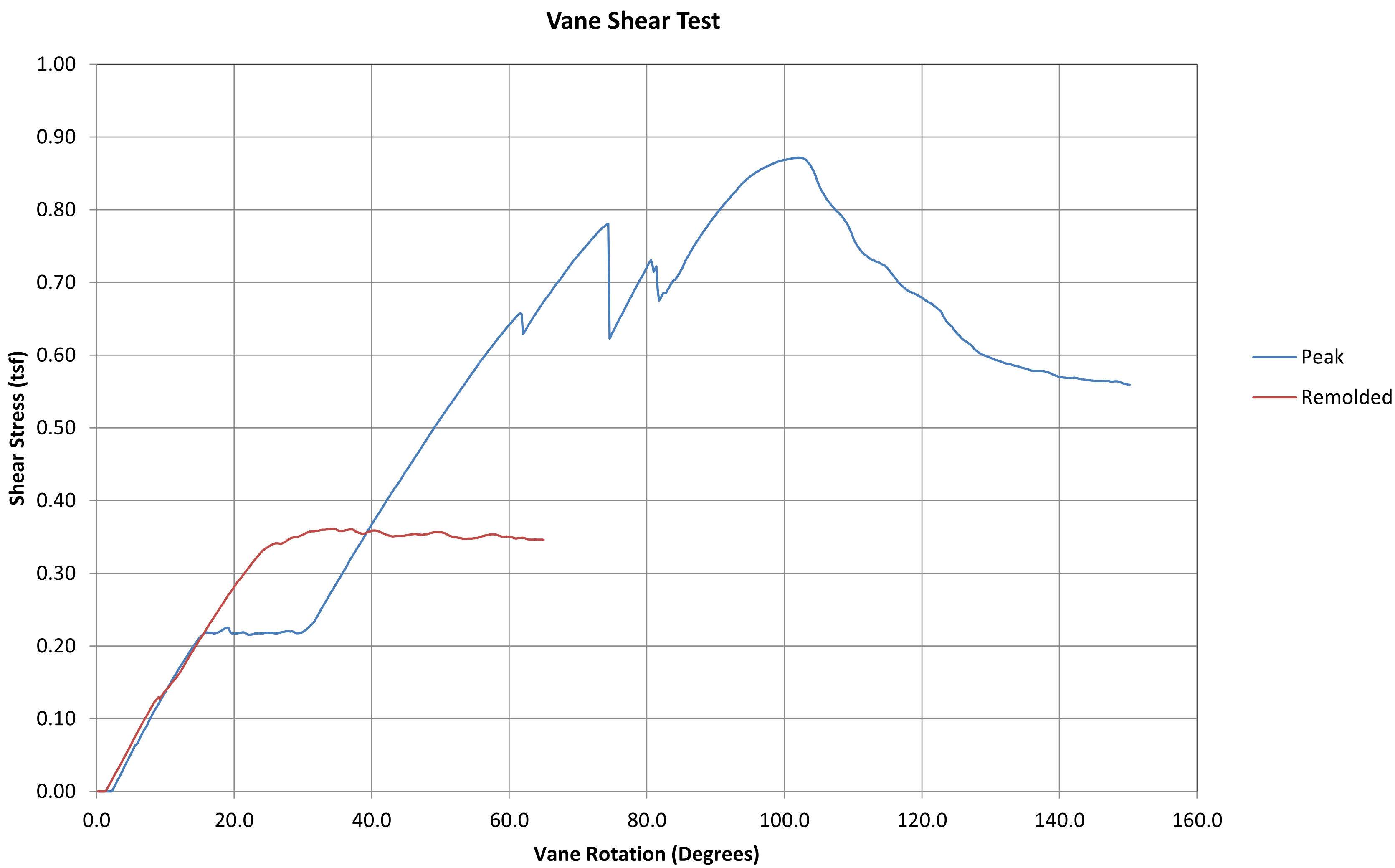
Coordinate System: WGS 84 Lat/Long
Latitude: 46.98199
Longitude: -123.88477



Job Number: 19-59053
Client: GeoEngineers, Inc
Project: North Shore Levee West
Sounding: VST-6-19

Test Date: 15-Nov-2019 17:53
Test Depth (ft): 44.00
Vane Type: Adara solid double tapered 60 x 120 mm (45°, 45°)

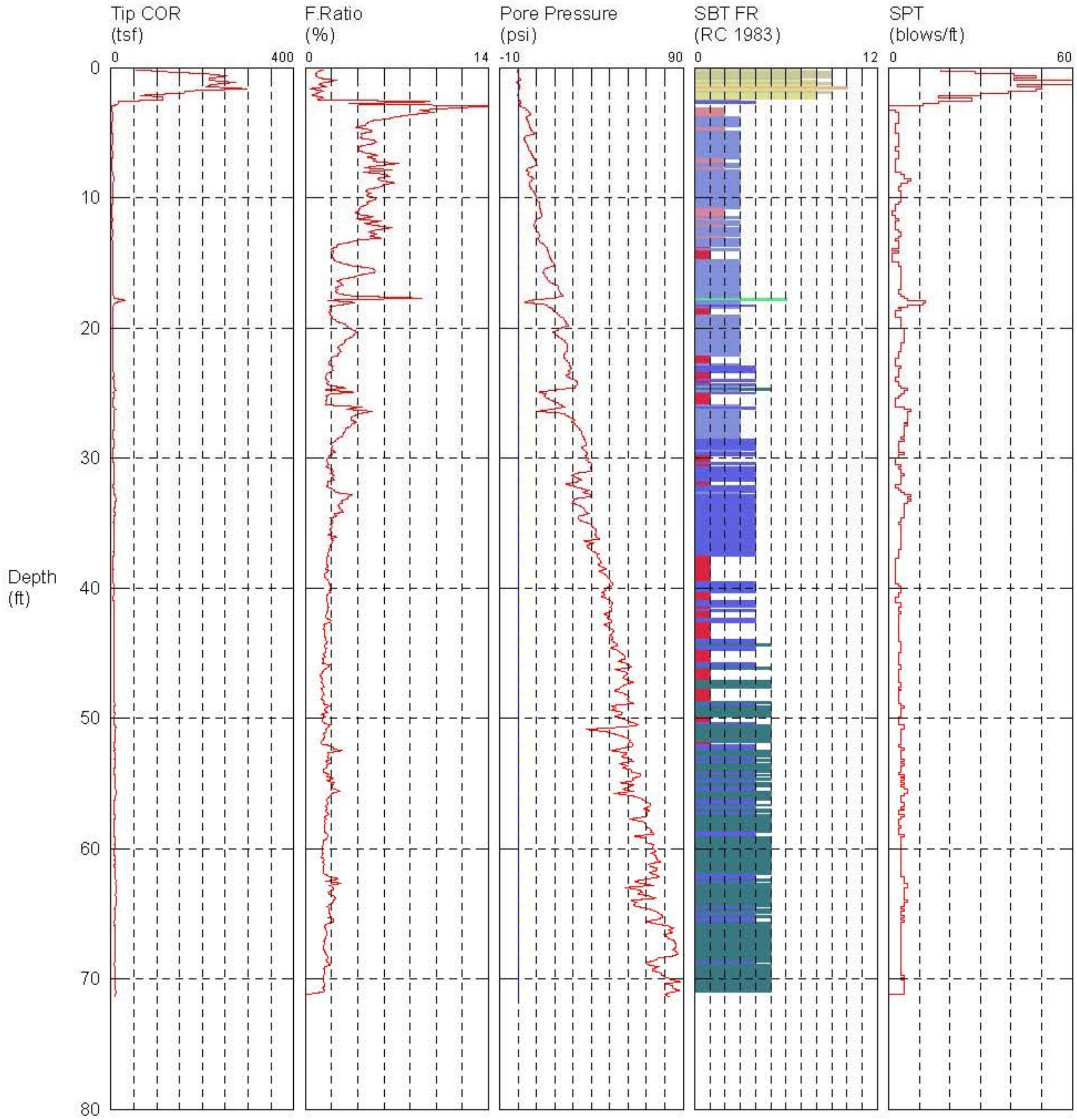
Coordinate System: WGS 84 Lat/Long
Latitude: 46.98199
Longitude: -123.88477



CPT-1-19

CPT Contractor: In Situ Engineering
CUSTOMER: GeoEngineers
LOCATION: Hoquiam
JOB NUMBER: 023944-001-00

OPERATOR: Mayfield
CONE ID: DDG1424
TEST DATE: 6/5/2019 8:40:12 AM
Predrill:
Backfill: 20% Bentonite Slurry
Surface Patch:



COMMENT:

1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

CPT-1-19

North Shore Levee West Segment
Hoquiam, Washington

GEOENGINEERS

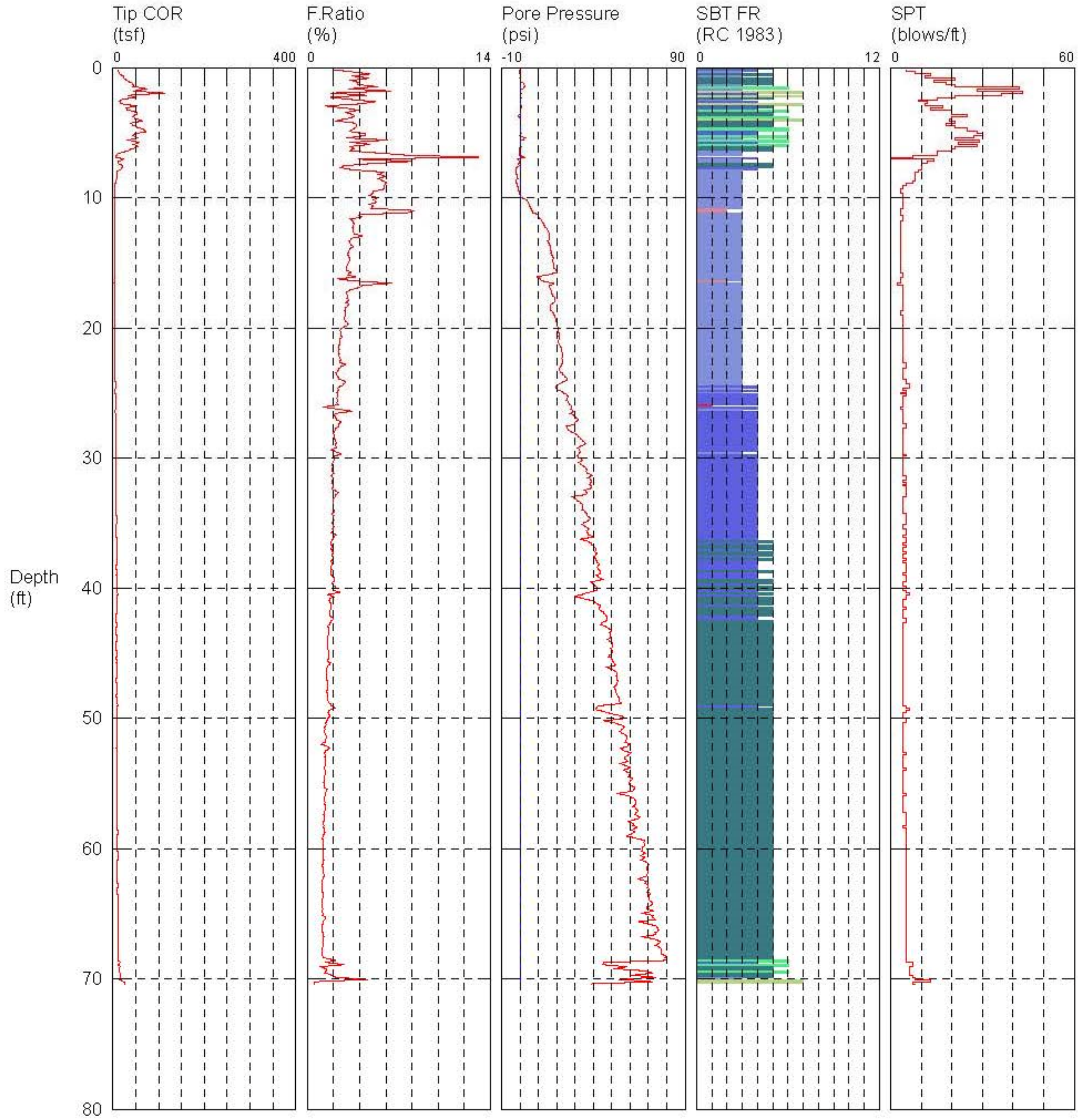
Figure A-8

23944-001-00 Date Exported: 12/26/2019

CPT-2-19

CPT Contractor: In Situ Engineering
CUSTOMER: GeoEngineers
LOCATION: Hoquiam
JOB NUMBER: 023944-001-00

OPERATOR: Mayfield
CONE ID: DDG1424
TEST DATE: 6/5/2019 1:04:58 PM
Predrill:
Backfill: 20% Bentonite Slurry
Surface Patch:



COMMENT:

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

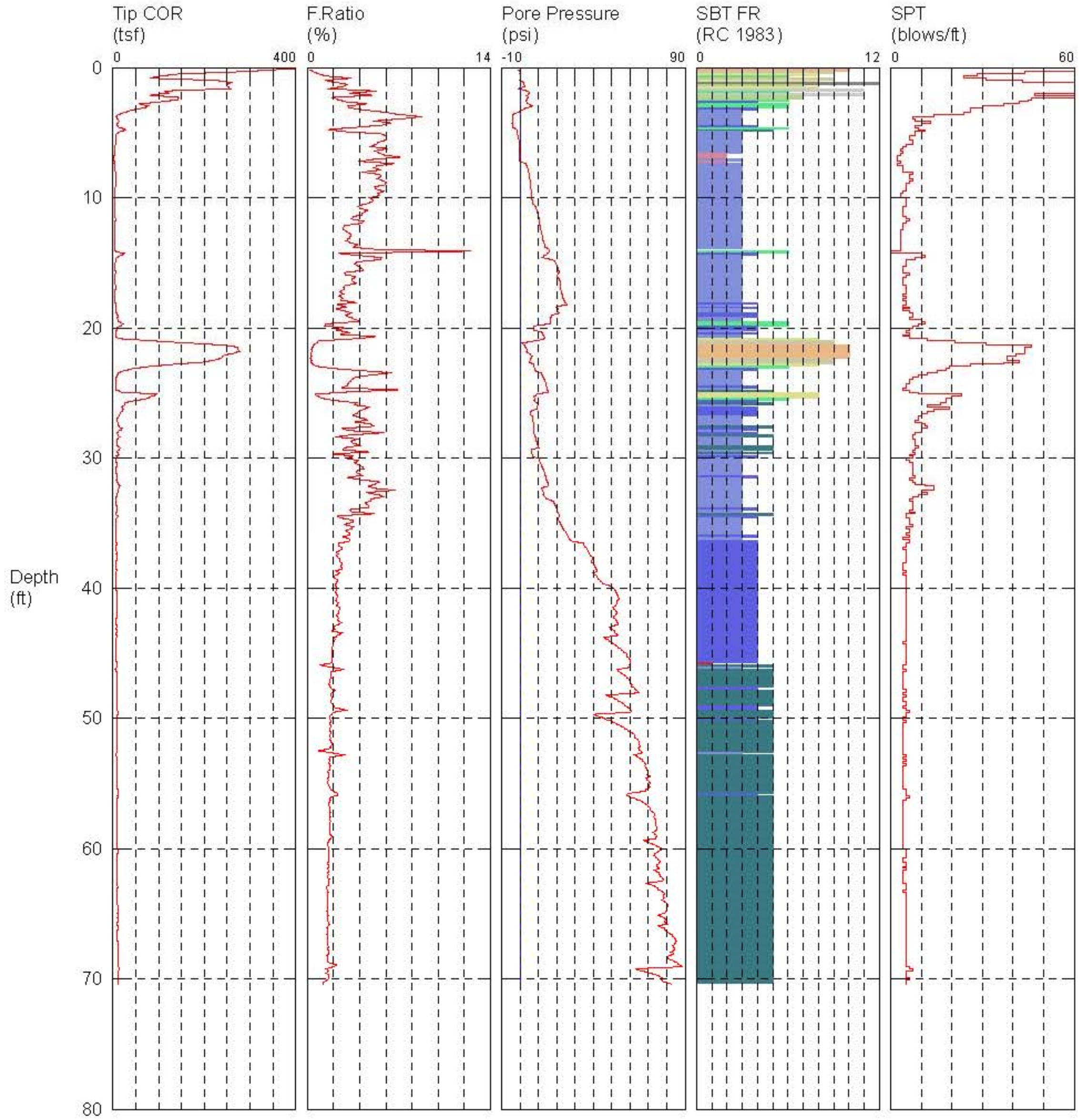
CPT-2-19	
North Shore Levee West Segment Hoquiam, Washington	
GEOENGINEERS	Figure A-9

23944-001-00 Date Exported: 12/26/2019

CPT-3-19

CPT Contractor: In Situ Engineering
CUSTOMER: GeoEngineers
LOCATION: Hoquiam
JOB NUMBER: 023944-001-00

OPERATOR: Mayfield
CONE ID: DDG1424
TEST DATE: 6/5/2019 10:08:36 AM
Predrill:
Backfill: 20% Bentonite Slurry
Surface Patch:



COMMENT:

1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

CPT-3-19

North Shore Levee West Segment
Hoquiam, Washington

GEOENGINEERS

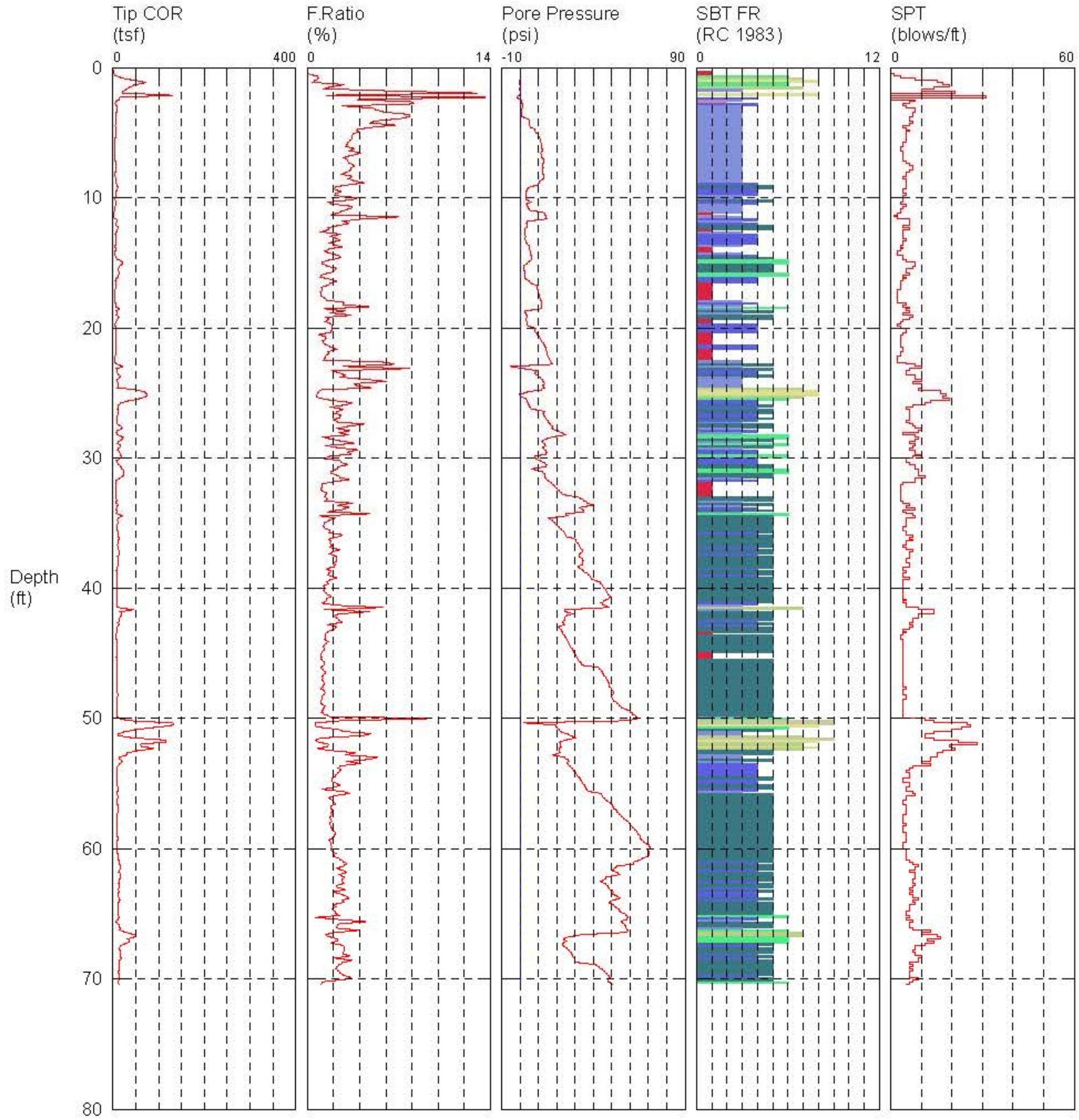
Figure A-10

23944-001-00 Date Exported: 12/26/2019

CPT-5c-19

CPT Contractor: In Situ Engineering
CUSTOMER: GeoEngineers
LOCATION: Hoquiam
JOB NUMBER: 023944-001-00

OPERATOR: Mayfield
CONE ID: DDG1424
TEST DATE: 6/5/2019 4:37:29 PM
Predrill: 3'
Backfill: 20% Bentonite Slurry
Surface Patch:



COMMENT:

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

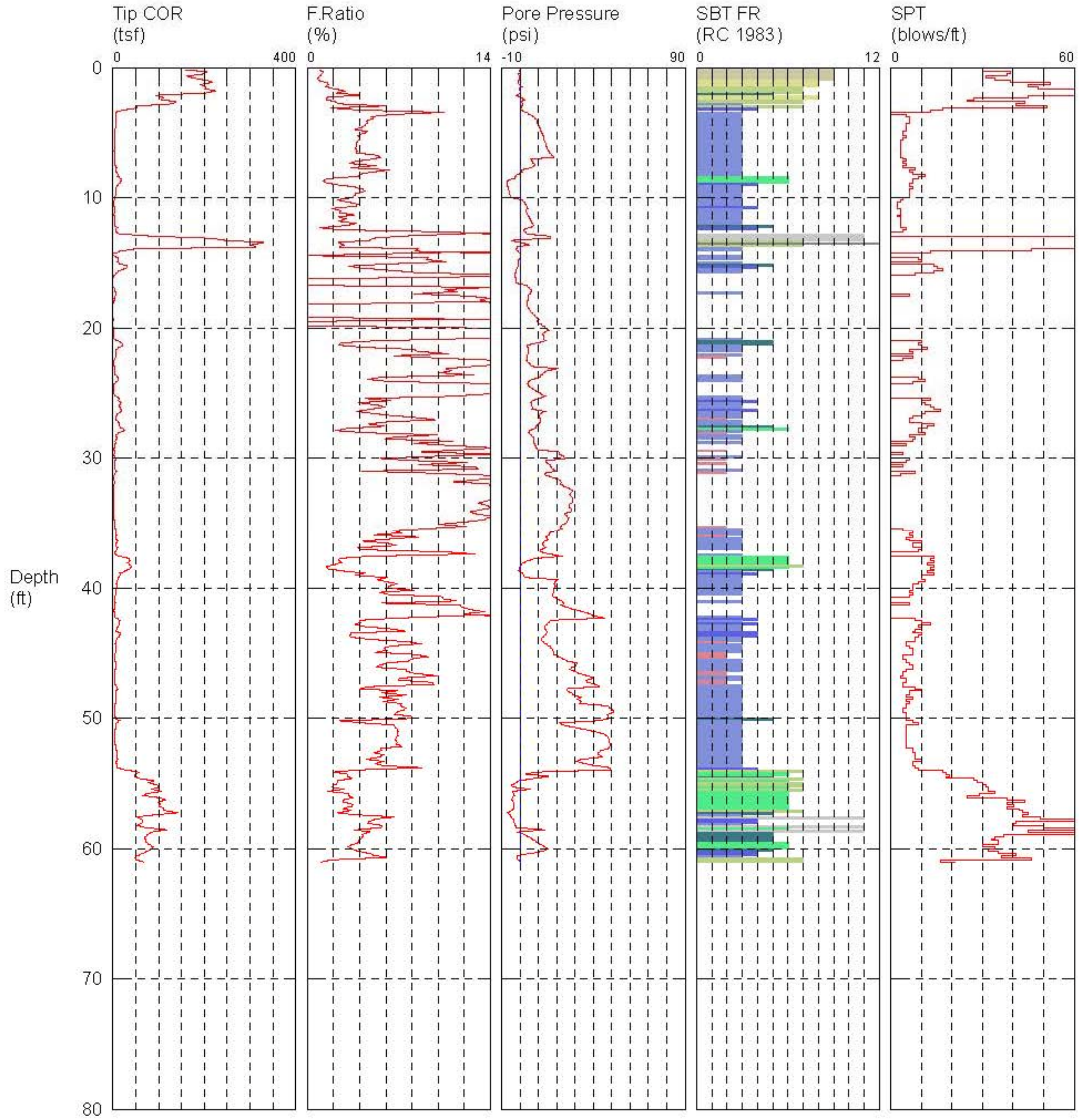
*SBT/SPT CORRELATION: UBC-1983

CPT-5c-19	
North Shore Levee West Segment Hoquiam, Washington	
GeoEngineers	Figure A-11

CPT-6-19

CPT Contractor: In Situ Engineering
CUSTOMER: GeoEngineers
LOCATION: Hoquiam
JOB NUMBER: 023944-001-00
NOTES: Please note blank values in SBT plot. Out of range values produced by CPT rods being pushed through buried wood material.

OPERATOR: Mayfield
CONE ID: DDG1424
TEST DATE: 6/6/2019 8:27:03 AM
Predrill:
Backfill: 20% Bentonite Slurry
Surface Patch:



COMMENT: Refusal at 61' due to loss of inclination greater than 10 degrees

1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

CPT-6-19

North Shore Levee West Segment
Hoquiam, Washington

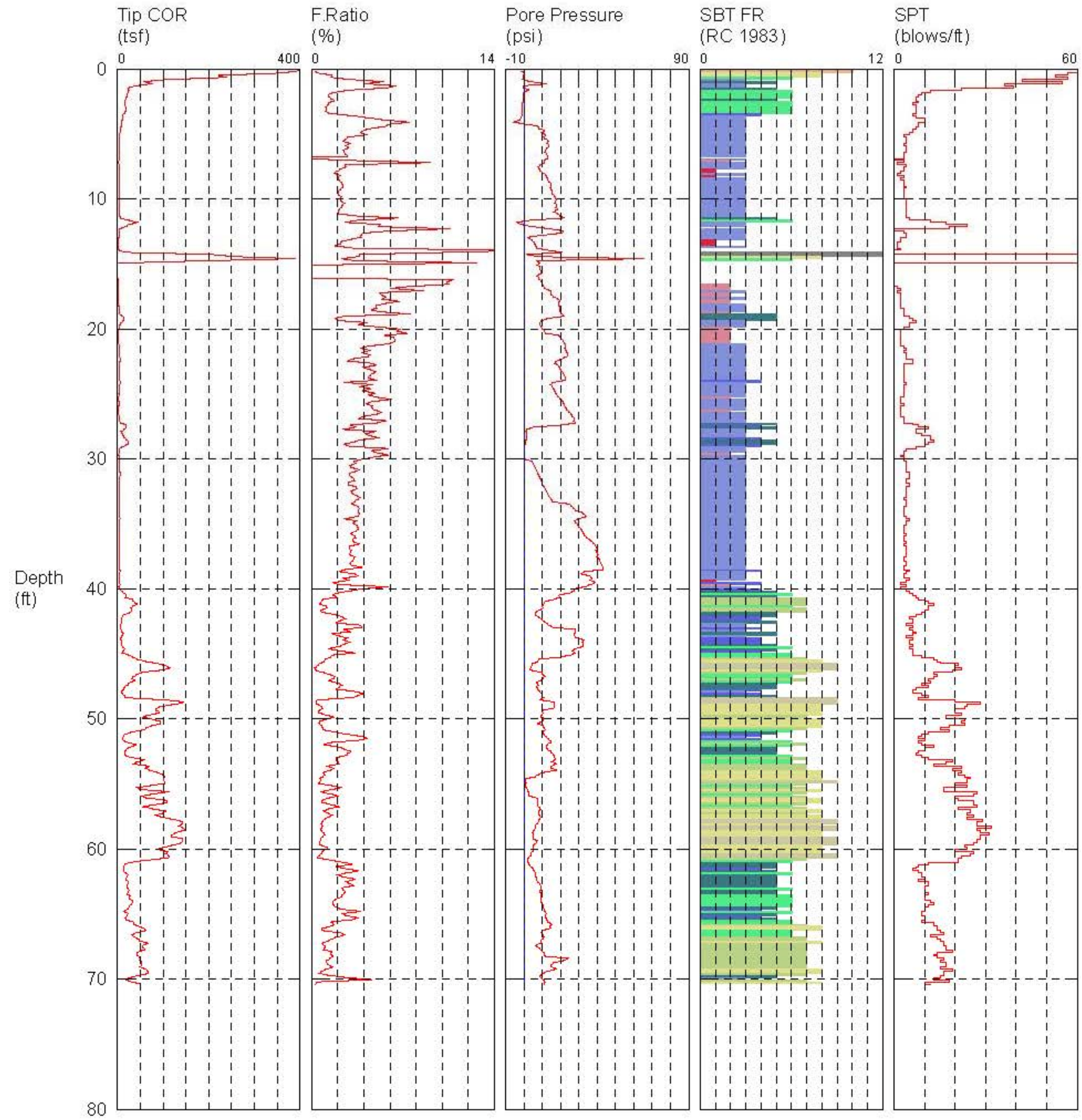
GEOENGINEERS

Figure A-12

CPT-7-19

CPT Contractor: In Situ Engineering
CUSTOMER: GeoEngineers
LOCATION: Hoquiam
JOB NUMBER: 023944-001-00
NOTES: Please note blank values in SBTplot. Out of range values produced by CPT rods being pushed through buried wood material.

OPERATOR: Mayfield
CONE ID: DDG1424
TEST DATE: 6/6/2019 10:04:03 AM
Predrill:
Backfill: 20% Bentonite Slurry
Surface Patch: Stained concrete



COMMENT:

1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

CPT-7-19

North Shore Levee West Segment
Hoquiam, Washington

GEOENGINEERS

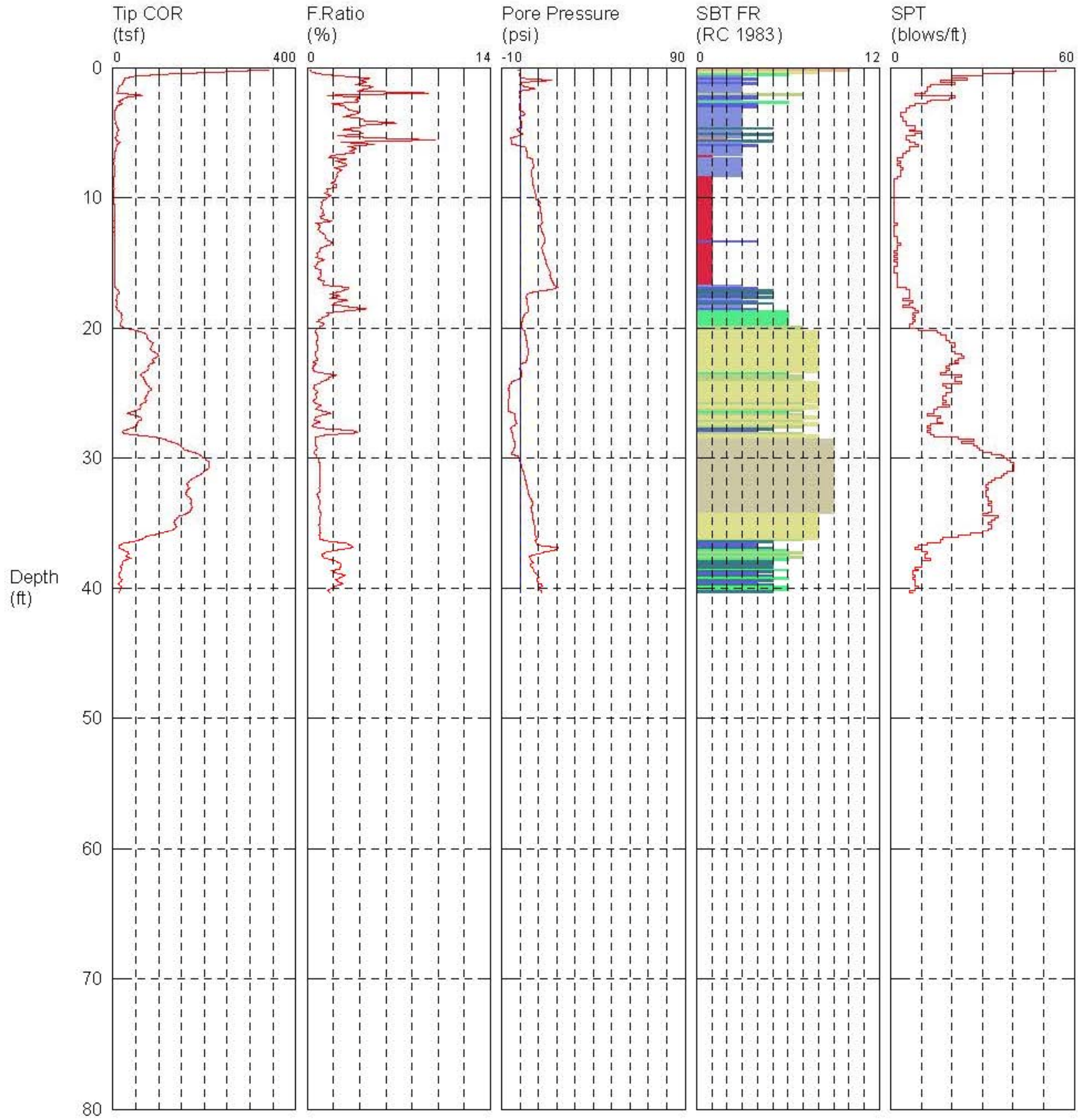
Figure A-13

23944-001-00 Date Exported: 12/26/2019

CPT-9-19

CPT Contractor: In Situ Engineering
CUSTOMER: GeoEngineers
LOCATION: Hoquiam
JOB NUMBER: 023944-001-00

OPERATOR: Mayfield
CONE ID: DDG1424
TEST DATE: 6/6/2019 12:07:12 PM
Predrill:
Backfill: 20% Bentonite Slurry
Surface Patch: Cold Patch



COMMENT:

1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

23944-001-00 Date Exported: 12/26/2019

CPT-9-19

North Shore Levee West Segment
Hoquiam, Washington

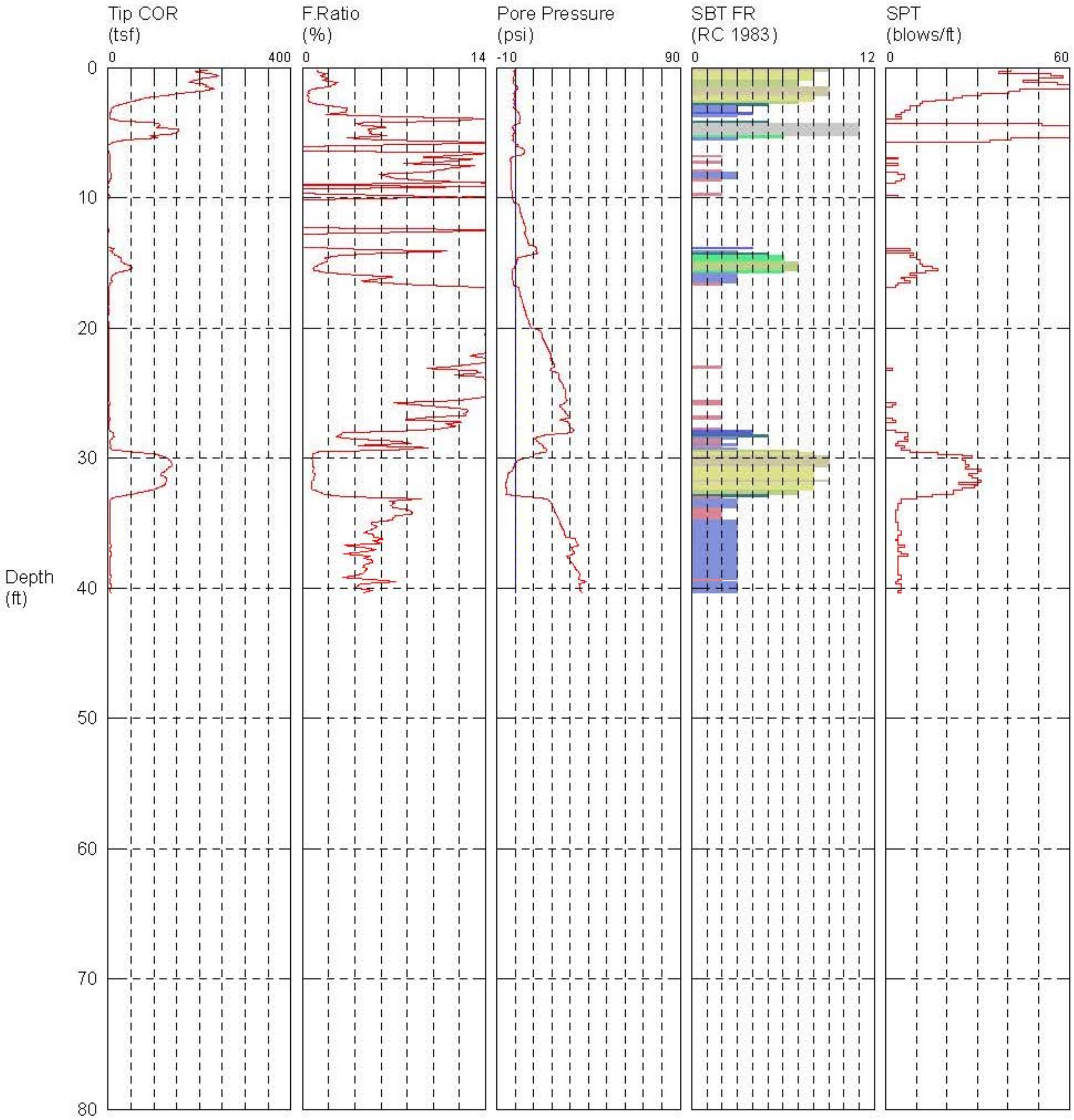
GeoEngineers

Figure A-14

CPT-10-19

CPT Contractor: In Situ Engineering
CUSTOMER: GeoEngineers
LOCATION: Hoquiam
JOB NUMBER: 023944-001-00
NOTES: Please note blank values in SBTplot. Out of range values produced by CPT rods being pushed through buried wood material.

OPERATOR: Mayfield
CONE ID: DDG1424
TEST DATE: 6/6/2019 1:04:09 PM
Predrill:
Backfill: 20% Bentonite Slurry
Surface Patch:



COMMENT:

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

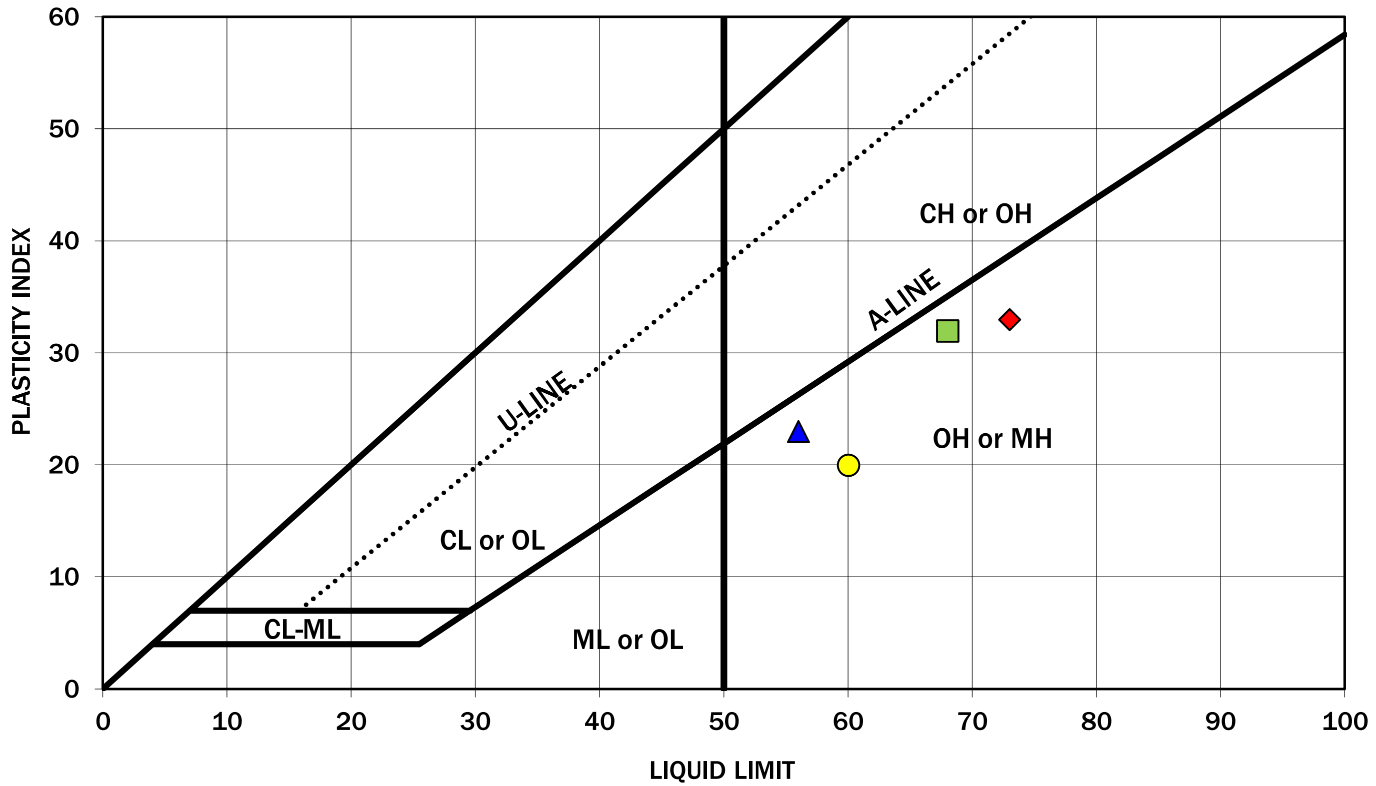
CPT-10-19

North Shore Levee West Segment
Hoquiam, Washington

GeoEngineers

Figure A-15

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆ (red diamond)	GEI-1	32.5	67	73	33	Elastic silt with occasional sand and o.m. (MH)
■ (green square)	GEI-2	10	76	68	32	Elastic silt (MH)
▲ (blue triangle)	GEI-2	20	66	56	23	Elastic silt (MH)
● (yellow circle)	GEI-2	30	67	60	20	Elastic silt with occasional sand (MH)

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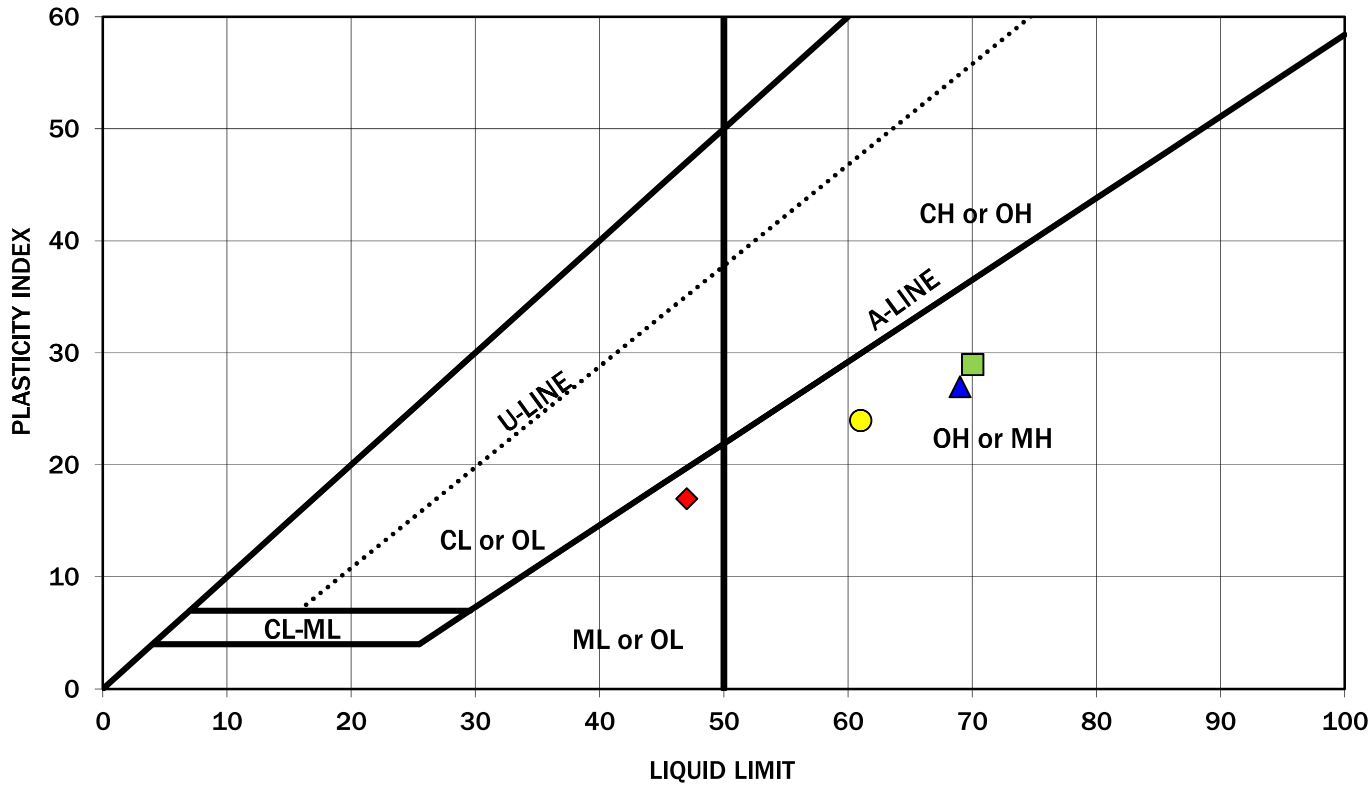
Atterberg Limits Test Results

North Shore Levee West Segment
Hoquiam, WA

GEOENGINEERS

Figure A-16



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	GEI-3	15	46	47	17	Sandy silt (ML)
■	GEI-3	25	48	70	29	Sandy elastic silt with occasional gravel (MH)
▲	GEI-3	30	66	69	27	Elastic silt with sand and o.m. (MH)
●	GEI-3	40	63	61	24	Elastic silt with occasional sand (MH)

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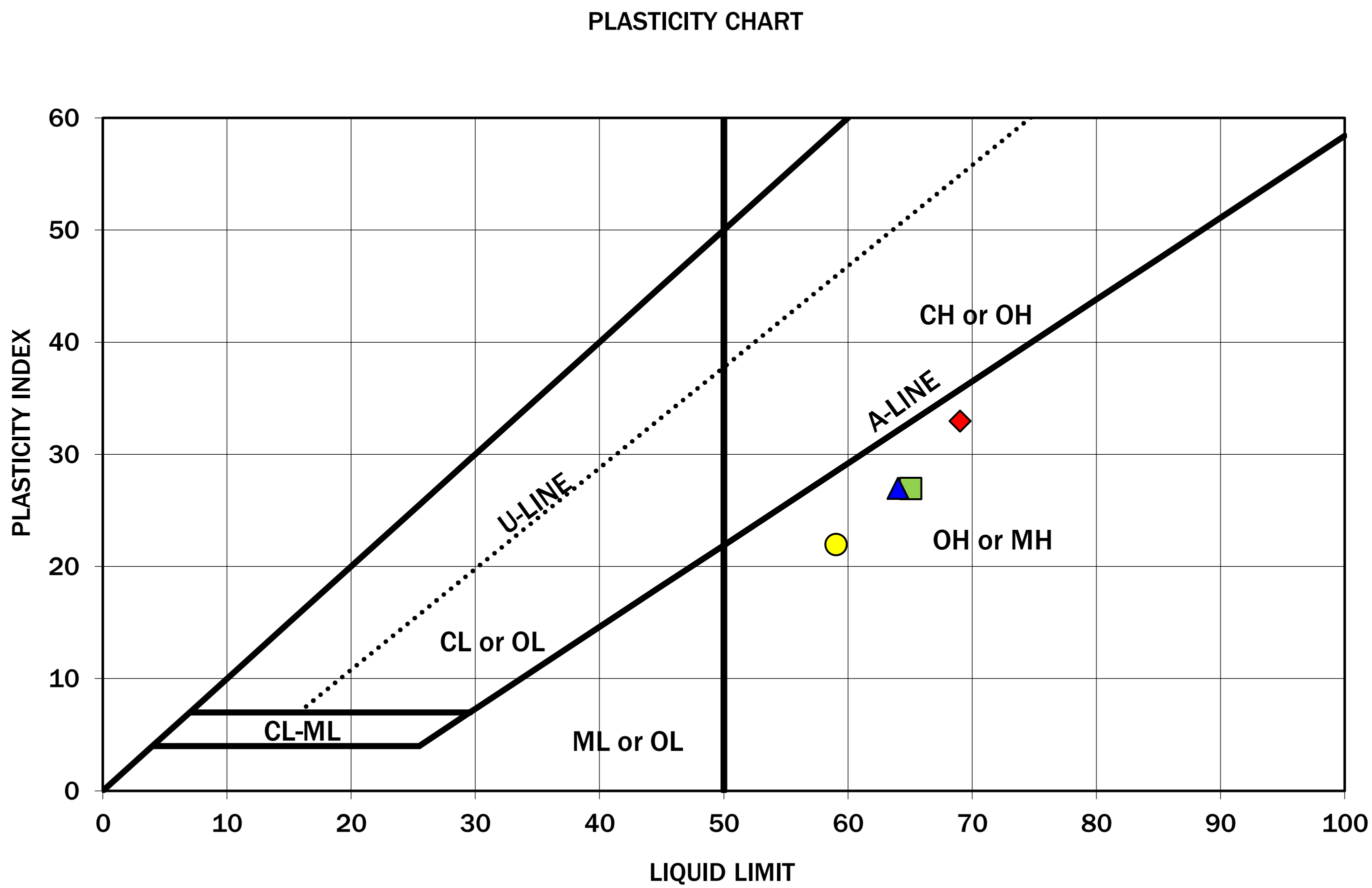
Atterberg Limits Test Results

North Shore Levee West Segment
Hoquiam, WA

GEOENGINEERS

Figure A-17



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	GEI-4	25	63	69	33	Elastic silt with sand and occasional o.m. (MH)
■	GEI-5	20	86	65	27	Elastic silt (MH)
▲	GEI-5	40	57	64	27	Elastic silt with sand and o.m. (MH)
●	GEI-6	20	60	59	22	Elastic silt with sand and o.m. (MH)

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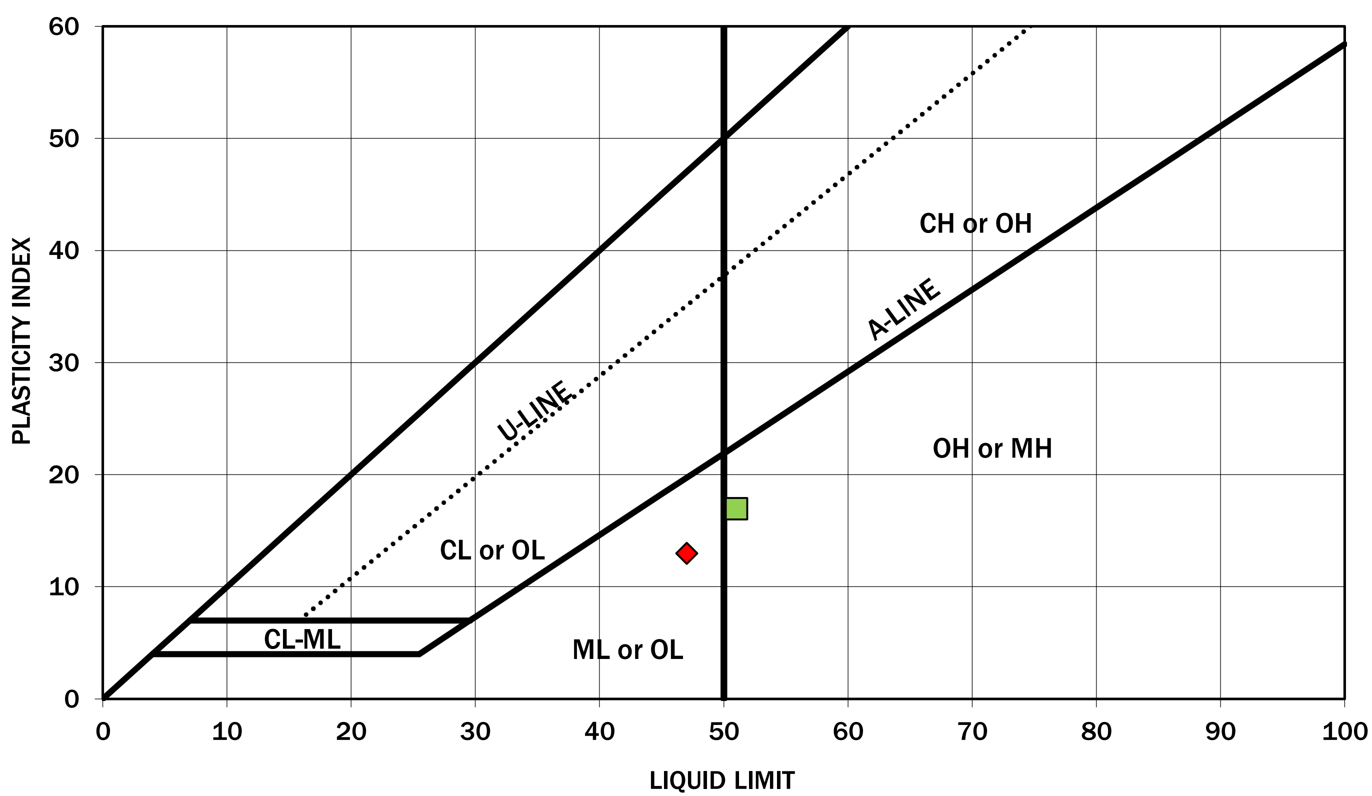
Atterberg Limits Test Results

North Shore Levee West Segment
Hoquiam, WA

GEOENGINEERS

Figure A-18

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	GEI-6	30	49	47	13	Silt (ML)
■	GEI-6	35	92	51	17	Sandy elastic silt (MH)

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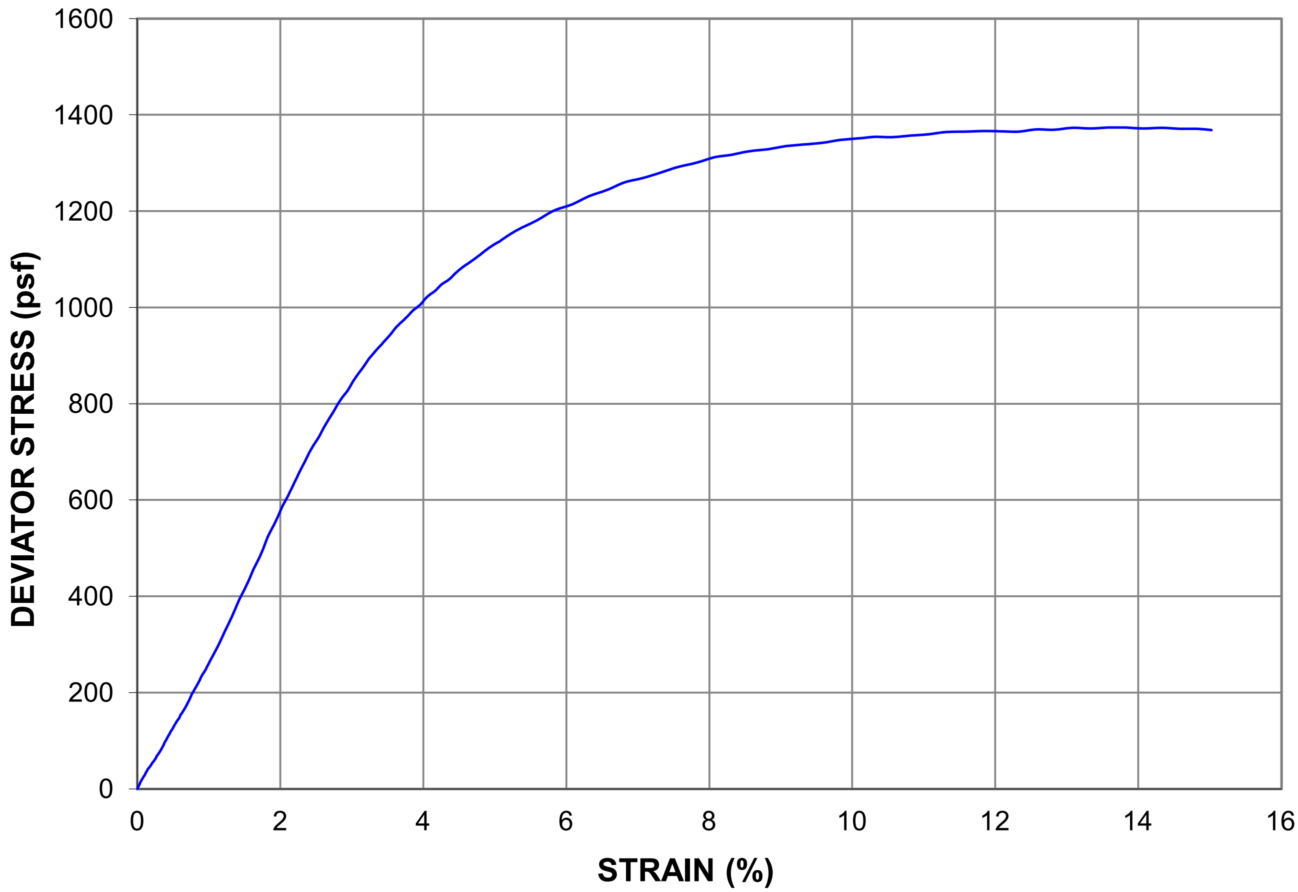
Atterberg Limits Test Results

North Shore Levee West Segment
Hoquiam, WA

GEOENGINEERS

Figure A-19

23944-001-00 Date Exported: 11/19/19



SPECIMEN AT FAILURE	DESCRIPTION Silt with sand and o.m. (ML)

STRAIN RATE: 1%/min

UU COMP STRENGTH (psf): 1374

UU SHEAR STRENGTH (psf): 687

AXIAL STRAIN AT FAILURE: 13.6

FAILURE TYPE: Bulge

INITIAL	HEIGHT (in): 5.73
	DIAMETER (in): 2.83
	HEIGHT/DIAMETER: 2.0
	WATER CONTENT: 49
	WET DENSITY (pcf): 109.3
	DRY DENSITY (pcf): 73.5
	VOID RATIO: 1.3

BORING ID : GEI-1	SAMPLE NO: 4
DEPTH/ELEV(ft) : 20	DATE: 12/4/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

CELL PRESSURE: 13.9 psi

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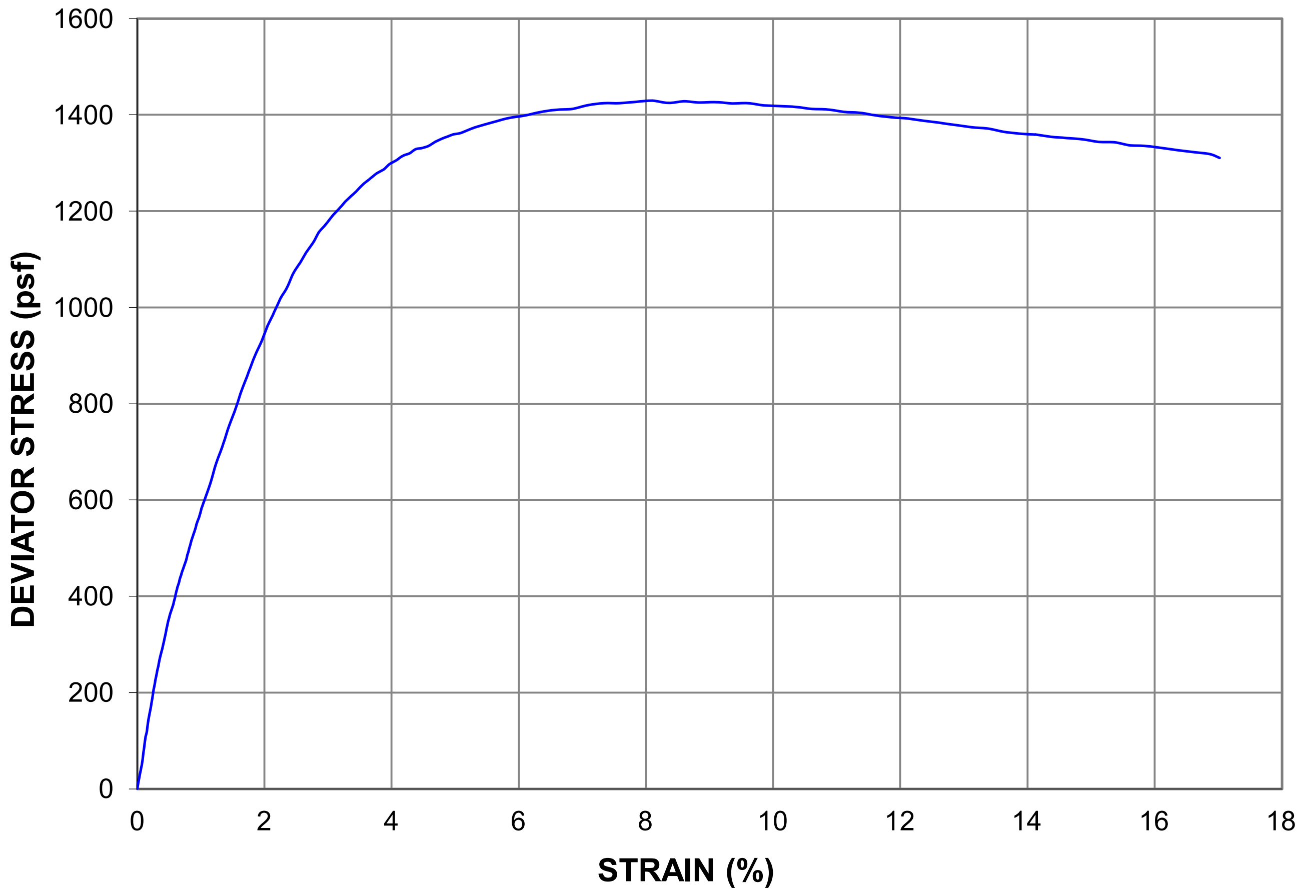
UNCONSOLIDATED UNDRAINED TEST

FIGURE A-20

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



SPECIMEN AT FAILURE

DESCRIPTION Elastic silt with occasional sand and o.m. (MH)	
STRAIN RATE: 1%/min	
UU COMP STRENGTH (psf): 1,430	
UU SHEAR STRENGTH (psf): 750	
AXIAL STRAIN AT FAILURE: 8.1	
FAILURE TYPE: Multiple Shear	
INITIAL	HEIGHT (in): 5.60
	DIAMETER (in): 2.85
	HEIGHT/DIAMETER: 2.0
	WATER CONTENT: 67
	WET DENSITY (pcf): 103.5
	DRY DENSITY (pcf): 61.9
	VOID RATIO: 1.7
BORING ID : GEI-1	SAMPLE NO: 6
DEPTH/ELEV(ft) : 32.5	DATE: 10/24/19
TECH: SAS	CHECKED: SAS
REMARKS:Gs assumed 2.7; γwater = 62.4pcf	
CELL PRESSURE: 22.6psi	

ASTM D-2850

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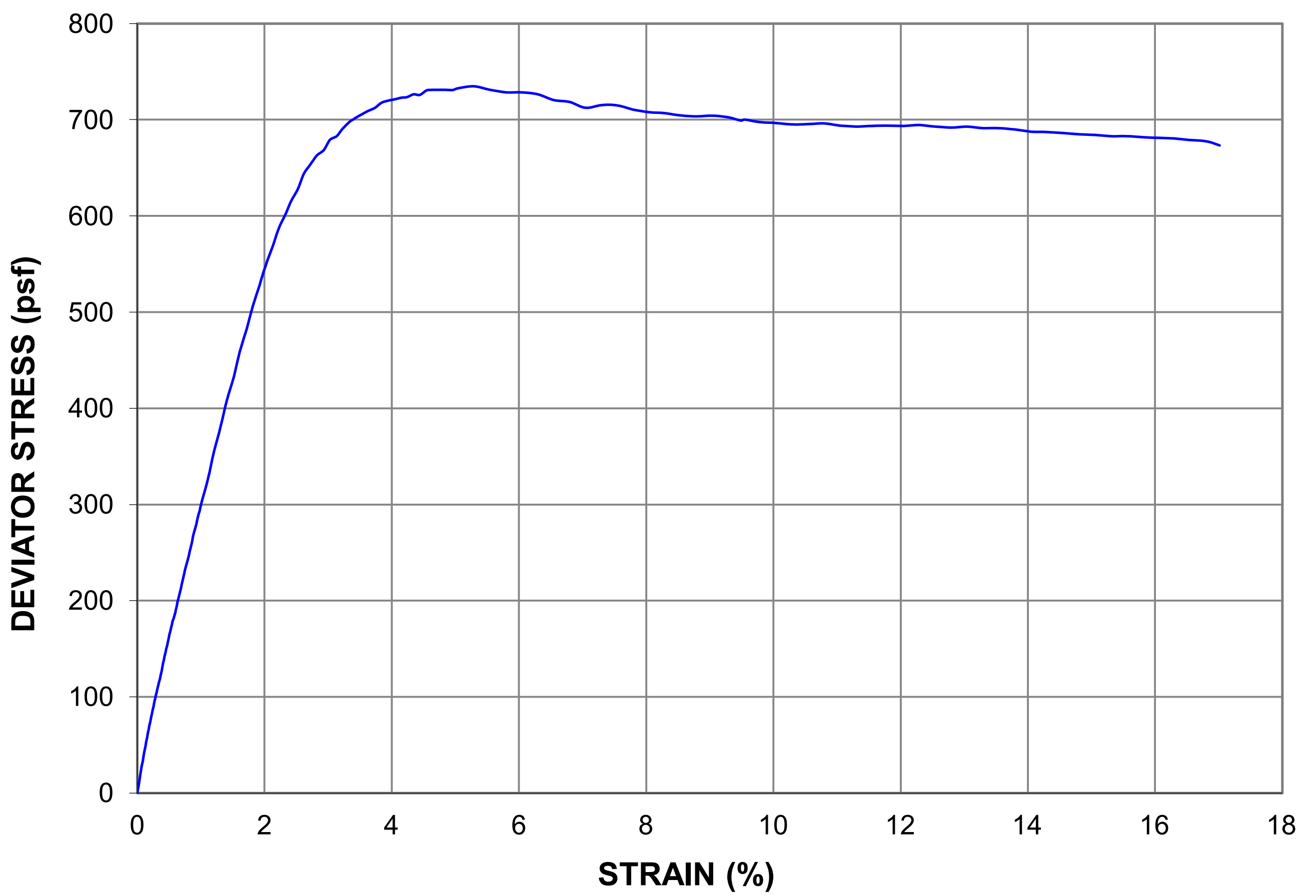
17425 NE Unin Hill Road Ste 250, Redmond, WA 98052

UNCONSOLIDATED UNDRAINED TEST

FIGURE A-21



SPECIMEN AT FAILURE	DESCRIPTION Silt with occasional o.m. (ML)

STRAIN RATE: 1%/min
UU COMP STRENGTH (psf): 735
UU SHEAR STRENGTH (psf): 367
AXIAL STRAIN AT FAILURE: 5.3
FAILURE TYPE: Multiple Shear

INITIAL	HEIGHT (in): 5.81
	DIAMETER (in): 2.82
	HEIGHT/DIAMETER: 2.1
	WATER CONTENT: 78
	WET DENSITY (pcf): 98.0
	DRY DENSITY (pcf): 55.2
	VOID RATIO: 2.1

BORING ID : GEI-2	SAMPLE NO: 2
DEPTH/ELEV(ft) : 10	DATE: 10/24/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

CELL PRESSURE: 6.9psi

ASTM D-2850

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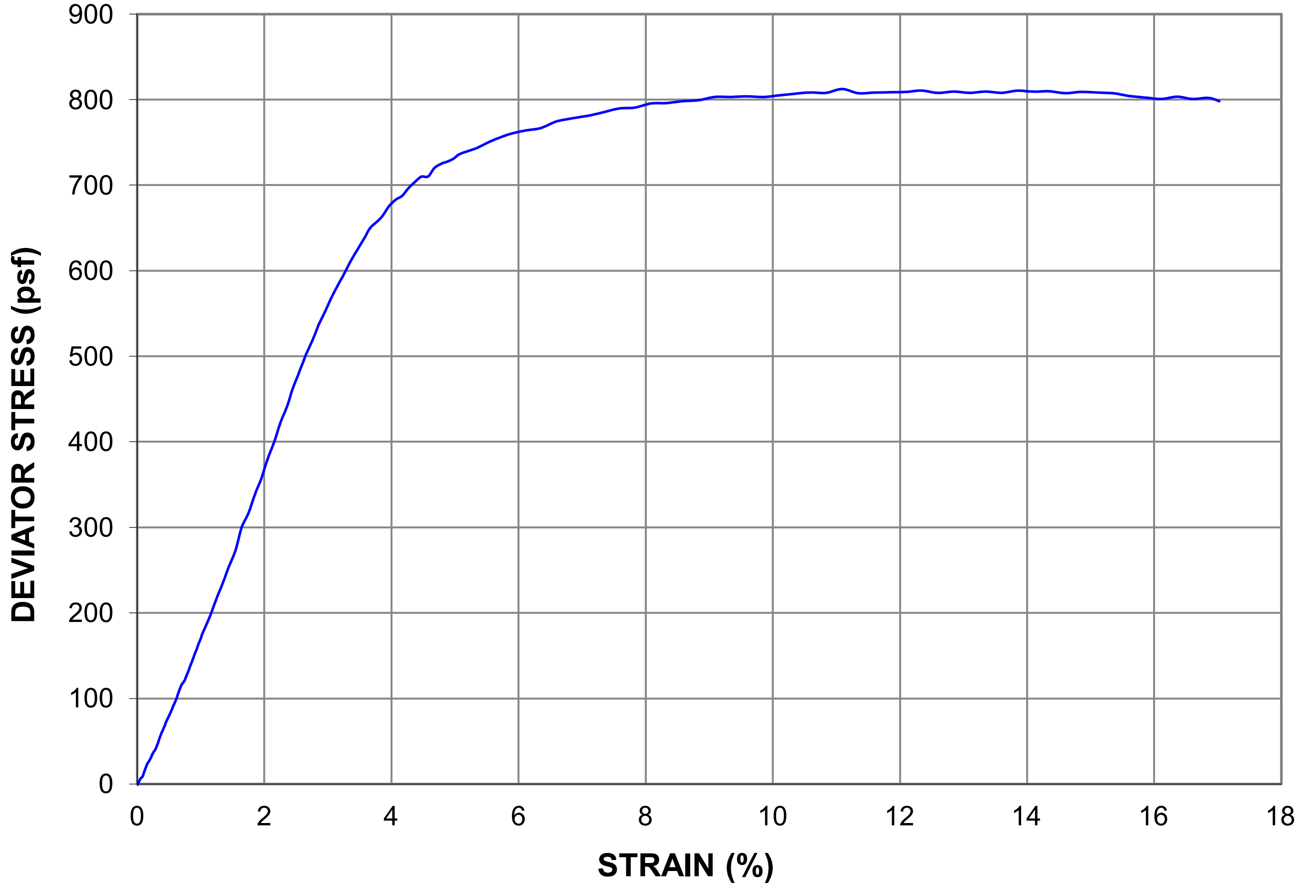
UNCONSOLIDATED UNDRAINED TEST

FIGURE A-22

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



SPECIMEN AT FAILURE	DESCRIPTION Elastic silt with occasional o.m. (MH)
	STRAIN RATE: 1%/min
	UU COMP STRENGTH (psf): 812
	UU SHEAR STRENGTH (psf): 406
	AXIAL STRAIN AT FAILURE: 11.1
	FAILURE TYPE: Angle Shear

INITIAL	HEIGHT (in): 6.04
	DIAMETER (in): 2.82
	HEIGHT/DIAMETER: 2.1
	WATER CONTENT: 67
	WET DENSITY (pcf): 104.8
	DRY DENSITY (pcf): 62.8
	VOID RATIO: 2.1

BORING ID : GEI-2	SAMPLE NO: 4
DEPTH/ELEV(ft) : 20	DATE: 10/25/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

CELL PRESSURE: 13.9psi

ASTM D-2850

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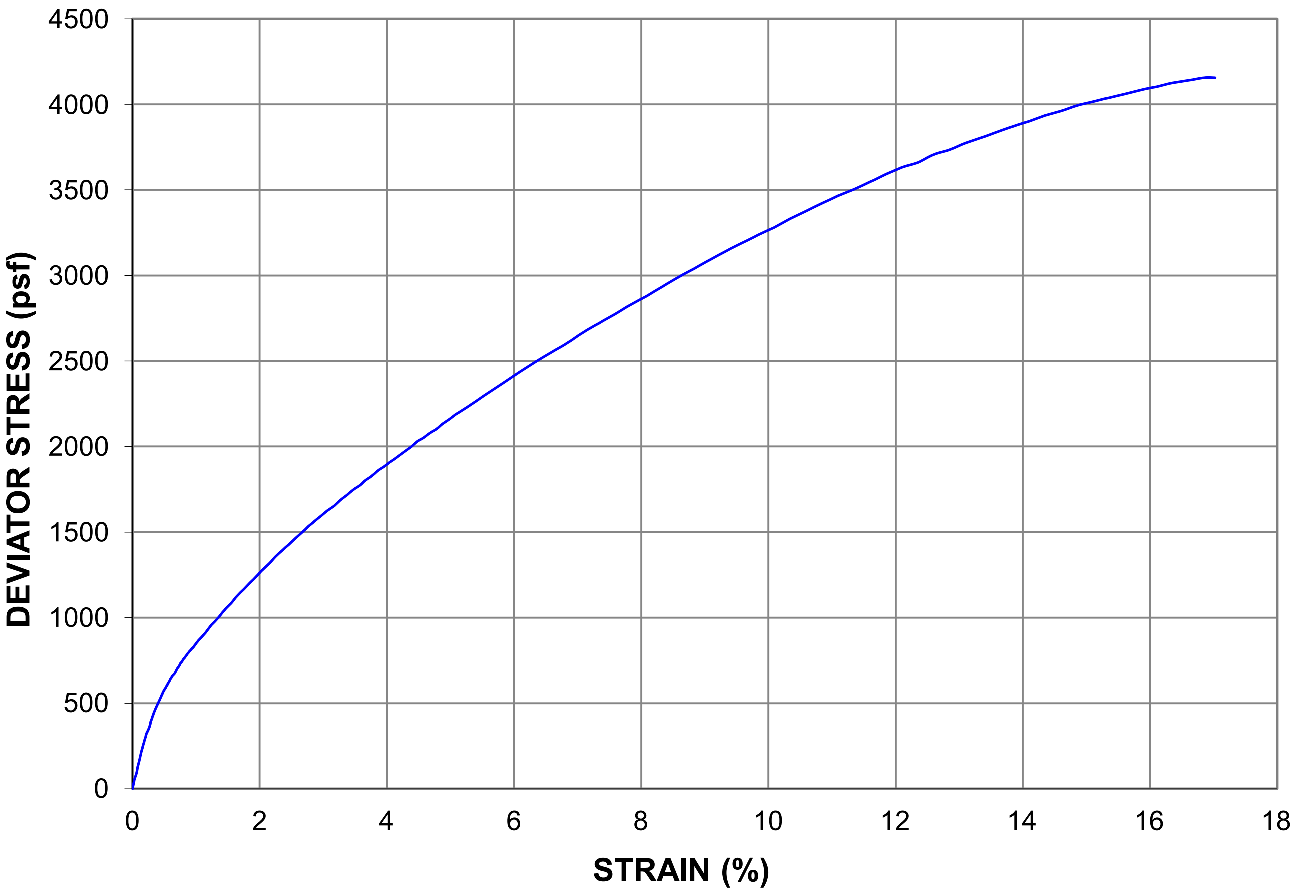
UNCONSOLIDATED UNDRAINED TEST

FIGURE A-23

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



SPECIMEN AT FAILURE	DESCRIPTION Silt with sand lense (ML)
	STRAIN RATE: 1%/min
	UU COMP STRENGTH (psf): 4016
	UU SHEAR STRENGTH (psf): 2008
	AXIAL STRAIN AT FAILURE: 15.0
	FAILURE TYPE: Bulge

INITIAL	HEIGHT (in): 5.81
	DIAMETER (in): 2.84
	HEIGHT/DIAMETER: 2.0
	WATER CONTENT: 40
	WET DENSITY (pcf): 114.6
	DRY DENSITY (pcf): 82.0
	VOID RATIO: 1.1

BORING ID : GEI-2	SAMPLE NO: 10
DEPTH/ELEV(ft) : 50	DATE: 10/28/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

CELL PRESSURE: 34.7psi

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GEOENGINEERS
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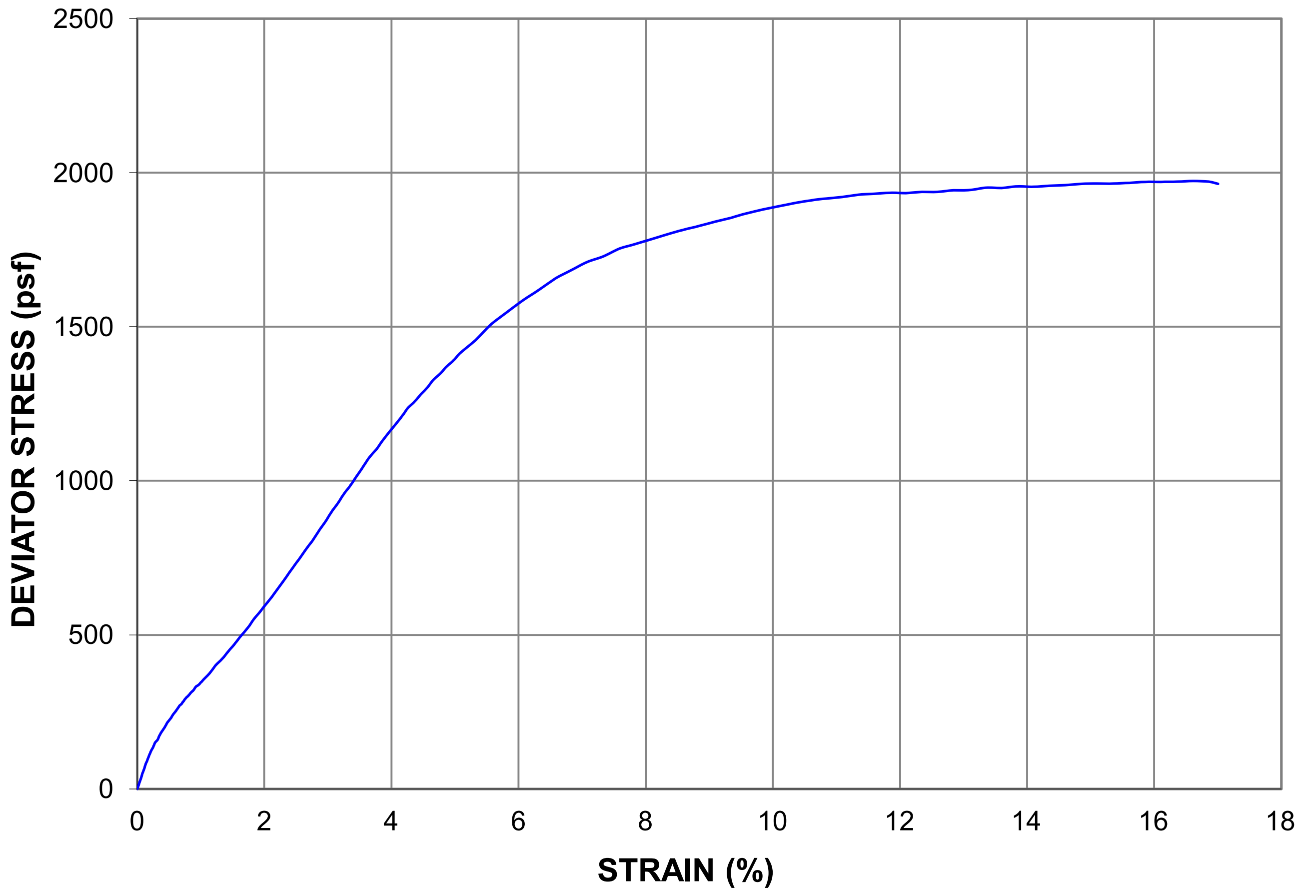
UNCONSOLIDATED UNDRAINED TEST

FIGURE A-24



SPECIMEN AT FAILURE	DESCRIPTION Sandy silt (ML)

STRAIN RATE: 1%/min		
UU COMP STRENGTH (psf): 1965		
UU SHEAR STRENGTH (psf): 983		
AXIAL STRAIN AT FAILURE: 15.0		
FAILURE TYPE: Multiple Shear		
INITIAL	HEIGHT (in): 5.91	
INITIAL	DIAMETER (in): 2.81	
INITIAL	HEIGHT/DIAMETER: 2.1	
INITIAL	WATER CONTENT: 41	
INITIAL	WET DENSITY (pcf): 111.0	
INITIAL	DRY DENSITY (pcf): 78.8	
INITIAL	VOID RATIO: 1.1	
BORING ID : GEI-3	SAMPLE NO: 3	
DEPTH/ELEV(ft) : 15	DATE: 10/25/19	
TECH: SAS	CHECKED: SAS	
REMARKS:Gs assumed 2.7; γwater = 62.4pcf		
CELL PRESSURE: 10.4psi		

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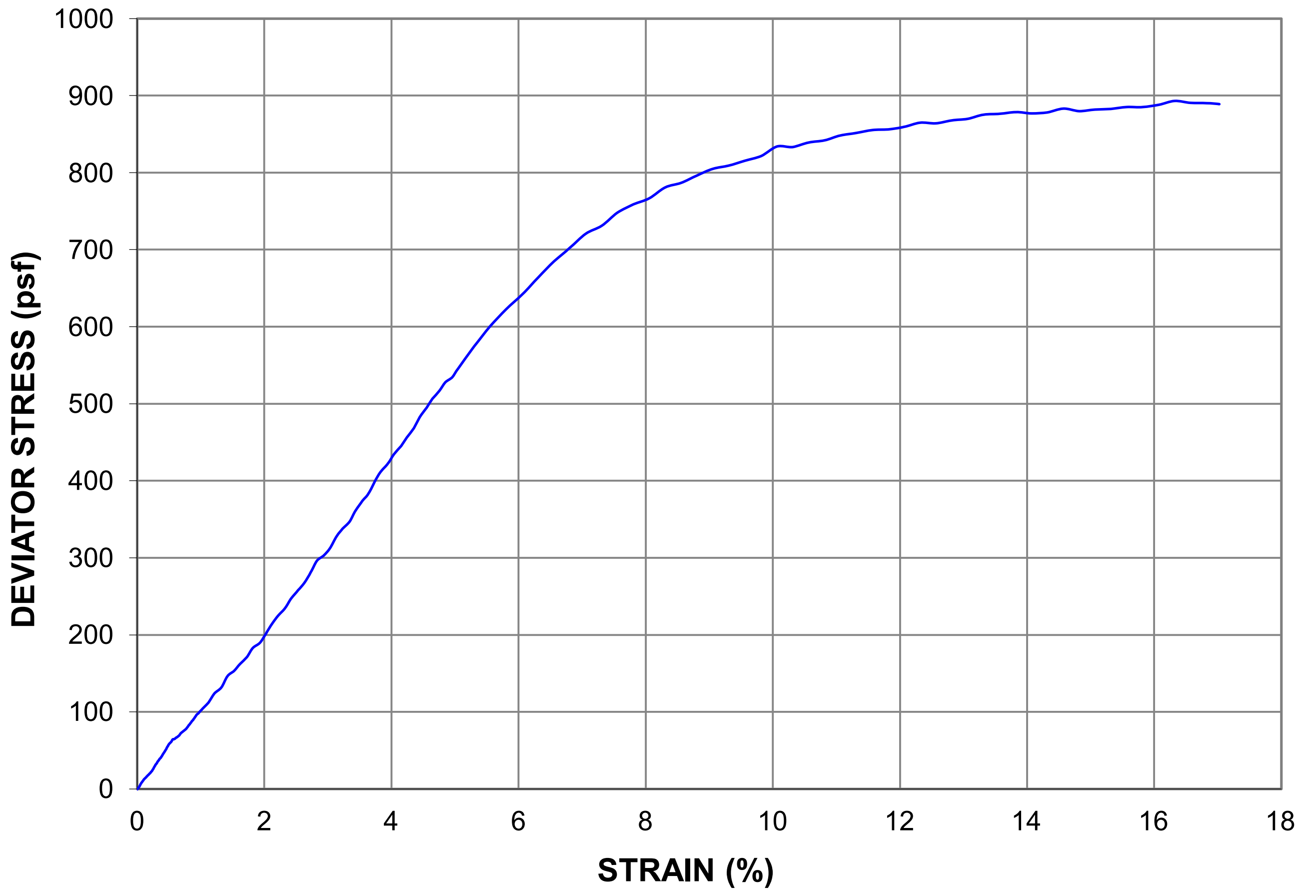
UNCONSOLIDATED UNDRAINED TEST

FIGURE A-25

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



SPECIMEN AT FAILURE	
	DESCRIPTION Elastic slt with sand and o.m. (MH)
	STRAIN RATE: 1%/min
	UU COMP STRENGTH (psf): 882
	UU SHEAR STRENGTH (psf): 441
	AXIAL STRAIN AT FAILURE: 15.0
	FAILURE TYPE: Multiple Shear

INITIAL	HEIGHT (in): 6.00
	DIAMETER (in): 2.82
	HEIGHT/DIAMETER: 2.1
	WATER CONTENT: 59
	WET DENSITY (pcf): 106.9
	DRY DENSITY (pcf): 67.1
	VOID RATIO: 1.5

BORING ID : GEI-3	SAMPLE NO: 6
DEPTH/ELEV(ft) : 30	DATE: 10/29/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

CELL PRESSURE: 20.8psi

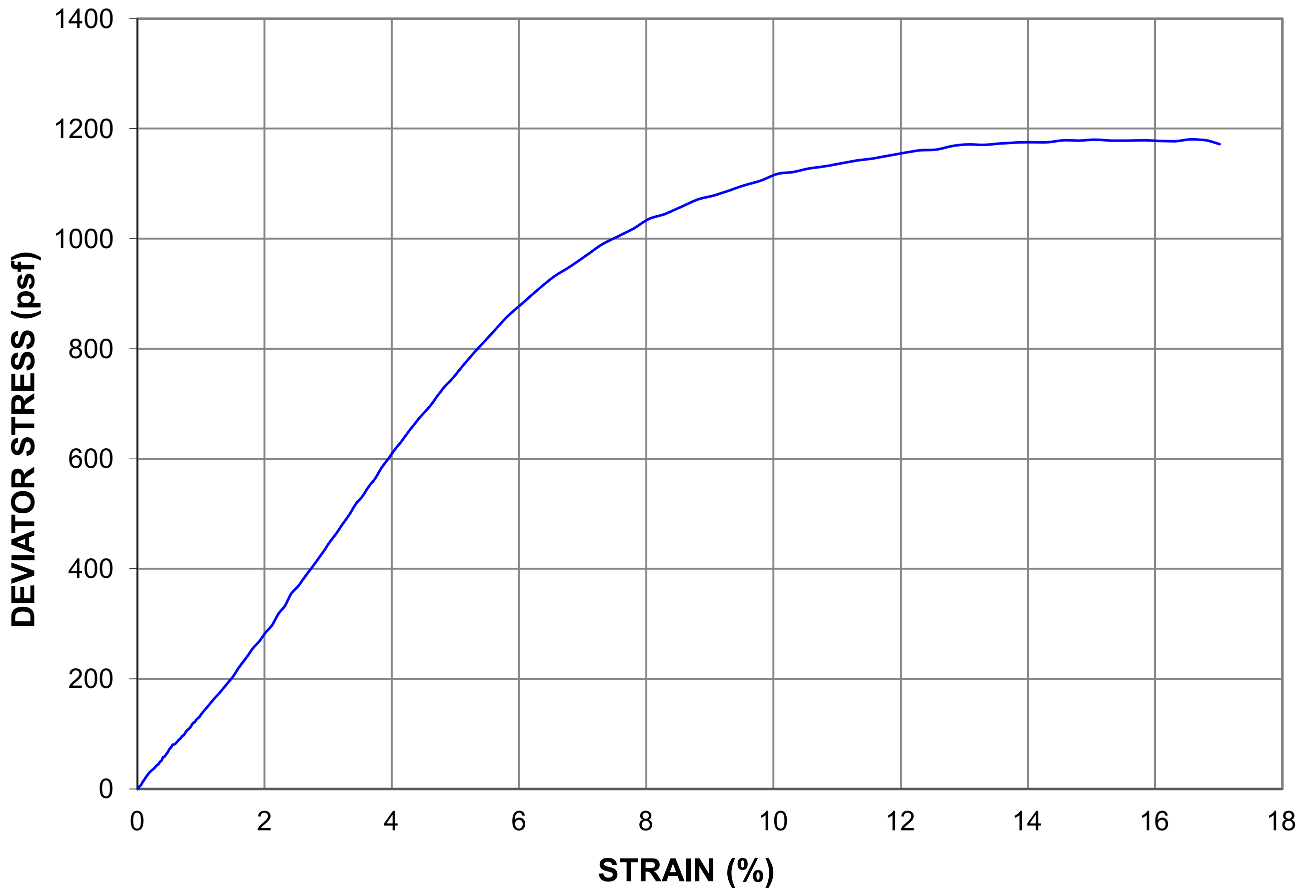
ASTM D-2850

GeoEngineers

UNCONSOLIDATED UNDRAINED TEST

FIGURE A-26

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



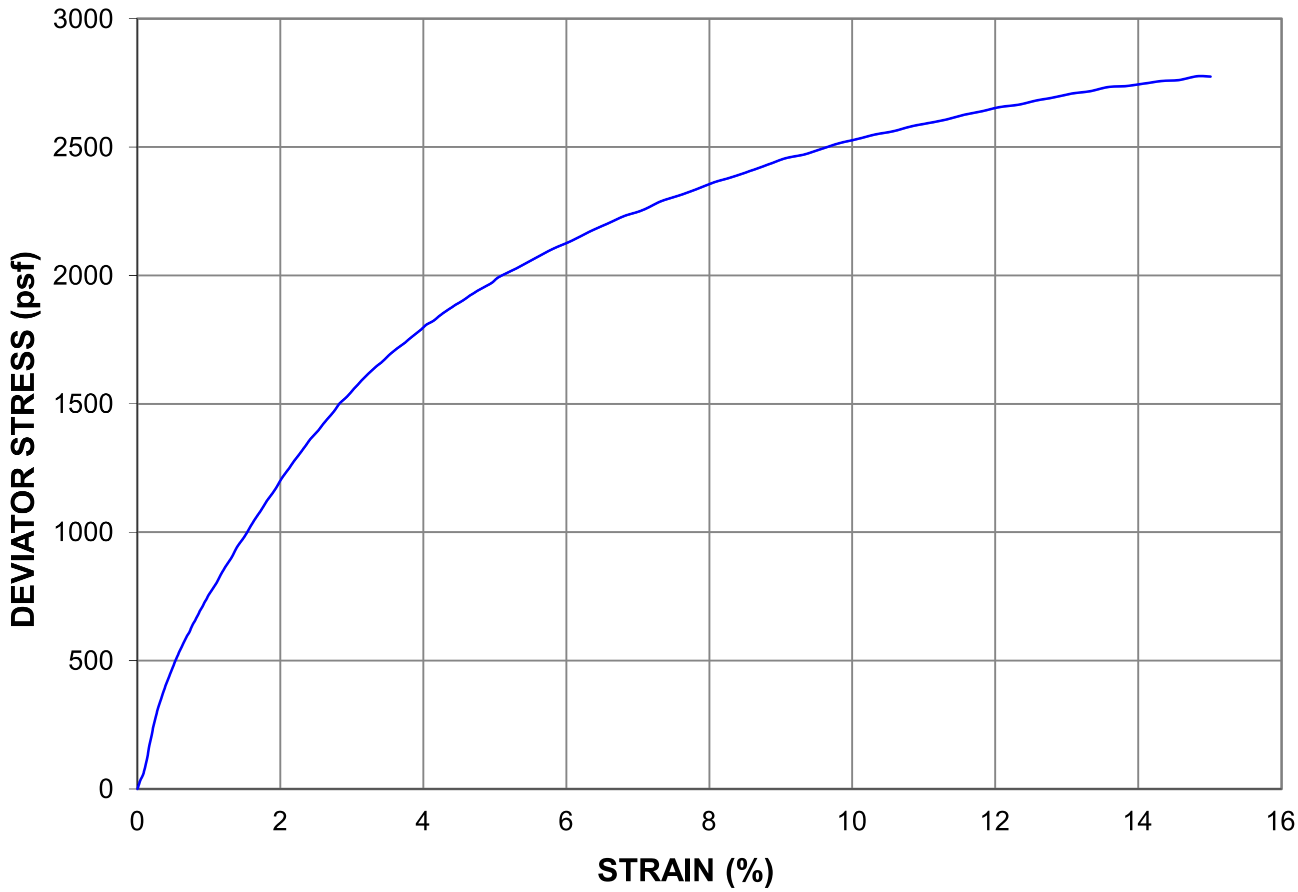
SPECIMEN AT FAILURE	DESCRIPTION Elastic silt with sand and occasional o.m. (MH)	
	STRAIN RATE: 1%/min	
	UU COMP STRENGTH (psf): 1180	
	UU SHEAR STRENGTH (psf): 590	
	AXIAL STRAIN AT FAILURE: 15.0	
	FAILURE TYPE: Angle Shear	
	INITIAL	HEIGHT (in): 5.99
		DIAMETER (in): 2.82
		HEIGHT/DIAMETER: 2.1
		WATER CONTENT: 49
		WET DENSITY (pcf): 106.5
		DRY DENSITY (pcf): 71.6
		VOID RATIO: 1.4
	BORING ID : GEI-4	SAMPLE NO: 4
	DEPTH/ELEV(ft) : 25	DATE: 10/30/19
	TECH: SAS	CHECKED: SAS
	REMARKS:Gs assumed 2.7; γwater = 62.4pcf	
	CELL PRESSURE: 17.4psi	
	ASTM D-2850	

GEOENGINEERS

UNCONSOLIDATED UNDRAINED TEST

FIGURE A-27

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



SPECIMEN AT FAILURE	DESCRIPTION Sandy silt with o.m. (ML)

STRAIN RATE: 1%/min

UU COMP STRENGTH (psf): 2776

UU SHEAR STRENGTH (psf): 1388

AXIAL STRAIN AT FAILURE: 14.8

FAILURE TYPE: Angle

INITIAL	HEIGHT (in): 5.73
	DIAMETER (in): 2.85
	HEIGHT/DIAMETER: 2.0
	WATER CONTENT: 54
	WET DENSITY (pcf): 112.4
	DRY DENSITY (pcf): 73.0
	VOID RATIO: 1.3

BORING ID : GEI-5	SAMPLE NO: 6
DEPTH/ELEV(ft) : 35	DATE: 12/4/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

CELL PRESSURE: 24.3 psi

ASTM D-2850

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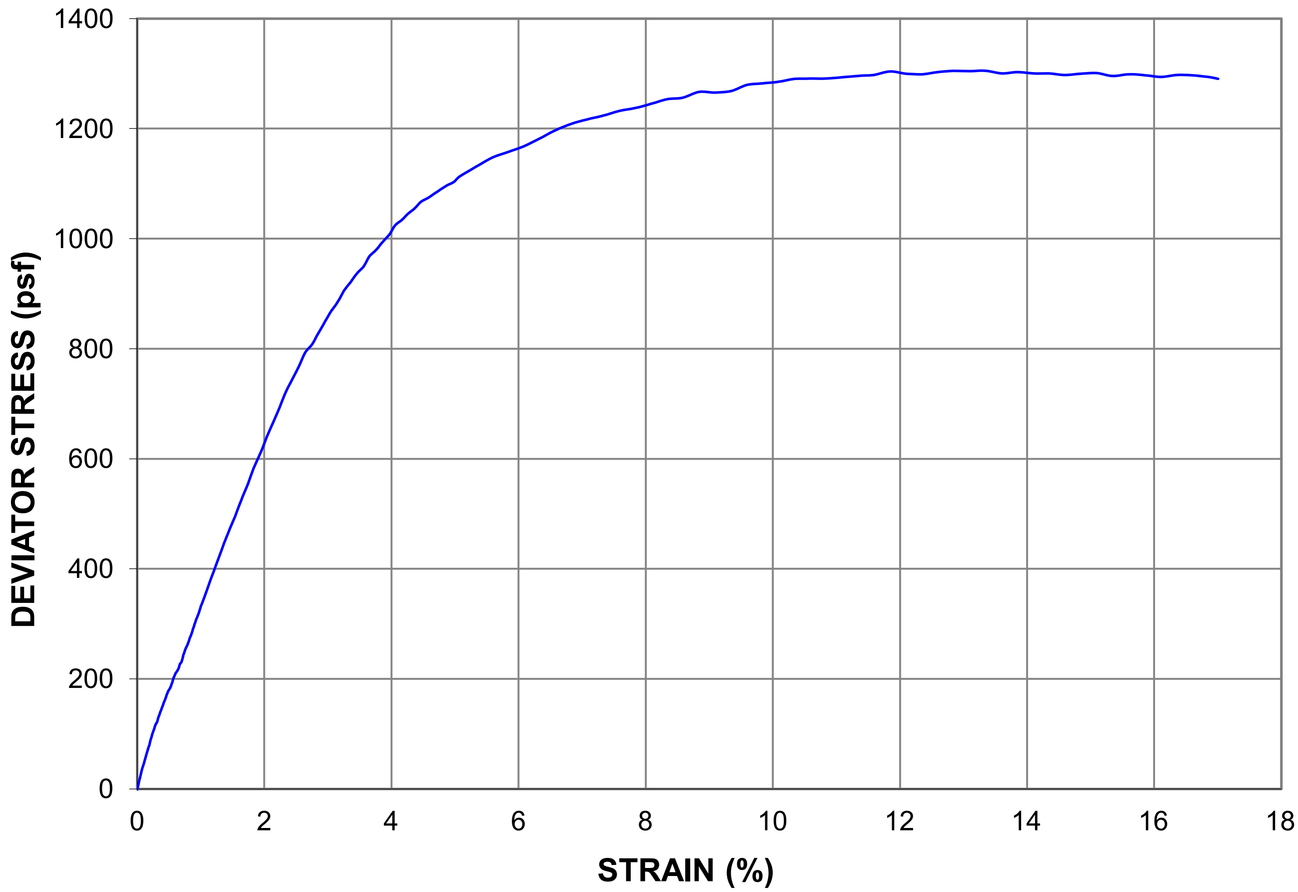
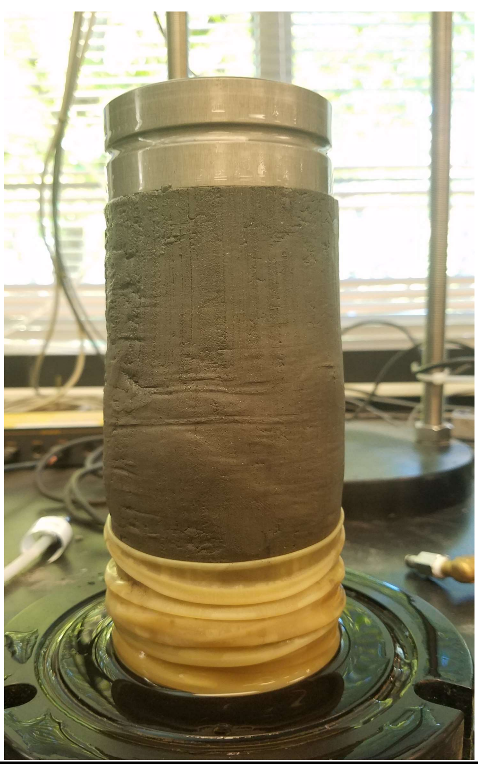
UNCONSOLIDATED UNDRAINED TEST

FIGURE A-28

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



SPECIMEN AT FAILURE



DESCRIPTION Elastic silt with sand and o.m. (MH)	
STRAIN RATE: 1%/min	
UU COMP STRENGTH (psf): 1305	
UU SHEAR STRENGTH (psf): 653	
AXIAL STRAIN AT FAILURE: 13.3	
FAILURE TYPE: Multiple Shear	
INITIAL	HEIGHT (in): 5.95
	DIAMETER (in): 2.84
	HEIGHT/DIAMETER: 2.1
	WATER CONTENT: 55
	WET DENSITY (pcf): 105.9
	DRY DENSITY (pcf): 68.4
	VOID RATIO: 1.5
BORING ID : GEI-5	SAMPLE NO: 7
DEPTH/ELEV(ft) : 40	DATE: 10/30/19
TECH: SAS	CHECKED: SAS
REMARKS:Gs assumed 2.7; γwater = 62.4pcf	
CELL PRESSURE: 27.8psi	

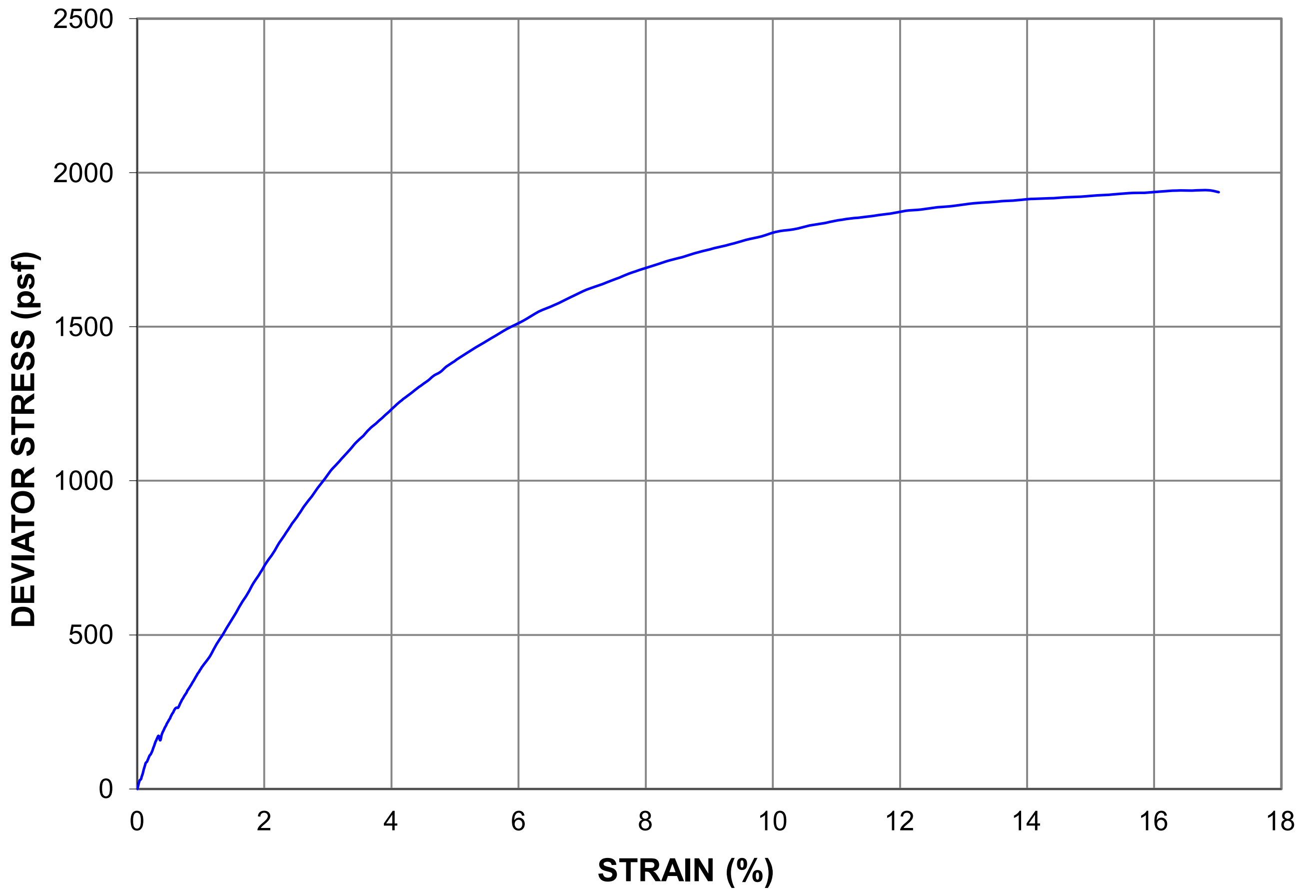
ASTM D-2850

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052

GEOENGINEERS

UNCONSOLIDATED UNDRAINED TEST

FIGURE A-29



SPECIMEN AT FAILURE

DESCRIPTION Sandy elastic silt with o.m. (MH)	
STRAIN RATE: 1%/min	
UU COMP STRENGTH (psf): 1927	
UU SHEAR STRENGTH (psf): 963	
AXIAL STRAIN AT FAILURE: 15	
FAILURE TYPE: Multiple Shear	

INITIAL	HEIGHT (in): 5.94
	DIAMETER (in): 2.85
	HEIGHT/DIAMETER: 2.1
	WATER CONTENT: 44
	WET DENSITY (pcf): 110.4
	DRY DENSITY (pcf): 76.8
	VOID RATIO: 1.2

BORING ID : GEI-5	SAMPLE NO: 11
DEPTH/ELEV(ft) : 60	DATE: 11/8/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

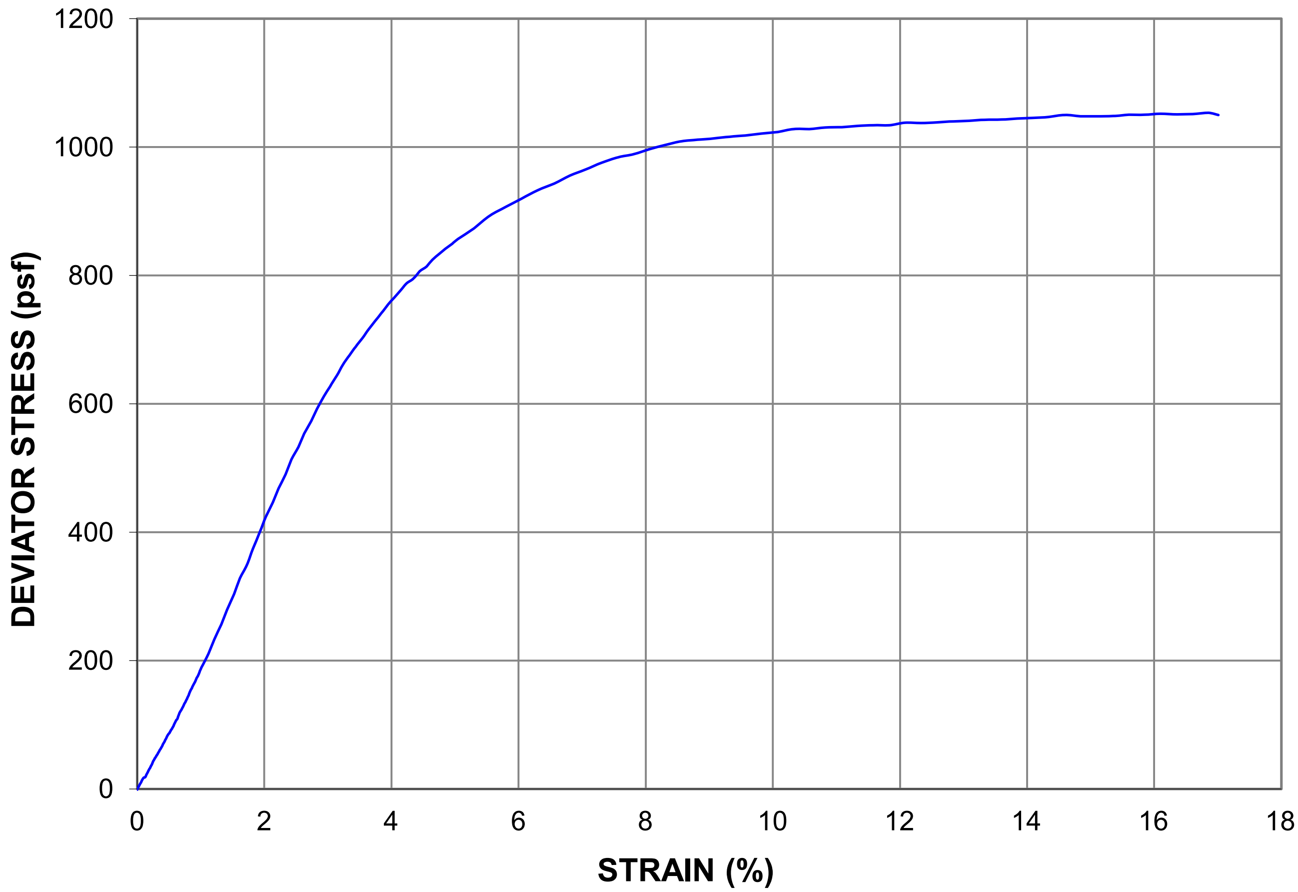
CELL PRESSURE: 41.7 psi

ASTM D-2850

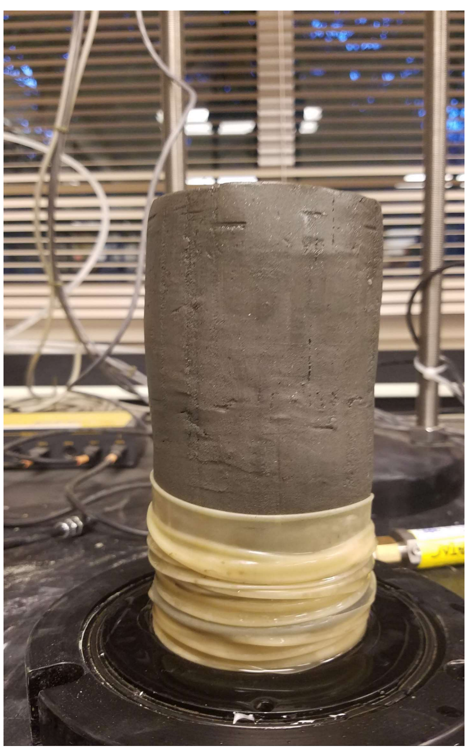
UNCONSOLIDATED UNDRAINED TEST

FIGURE A-30

GeoEngineers
17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



SPECIMEN AT FAILURE	DESCRIPTION Elastic silt with sand and o.m. (MH)
	STRAIN RATE: 1%/min
	UU COMP STRENGTH (psf): 1048
	UU SHEAR STRENGTH (psf): 524
	AXIAL STRAIN AT FAILURE: 15
	FAILURE TYPE: Bulge



INITIAL	HEIGHT (in): 5.72
	DIAMETER (in): 2.83
	HEIGHT/DIAMETER: 2.0
	WATER CONTENT: 60
	WET DENSITY (pcf): 106.4
	DRY DENSITY (pcf): 66.4
	VOID RATIO: 1.5

BORING ID : GEI-6	SAMPLE NO: 4
DEPTH/ELEV(ft) : 20	DATE: 11/8/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

CELL PRESSURE: 13.9 psi

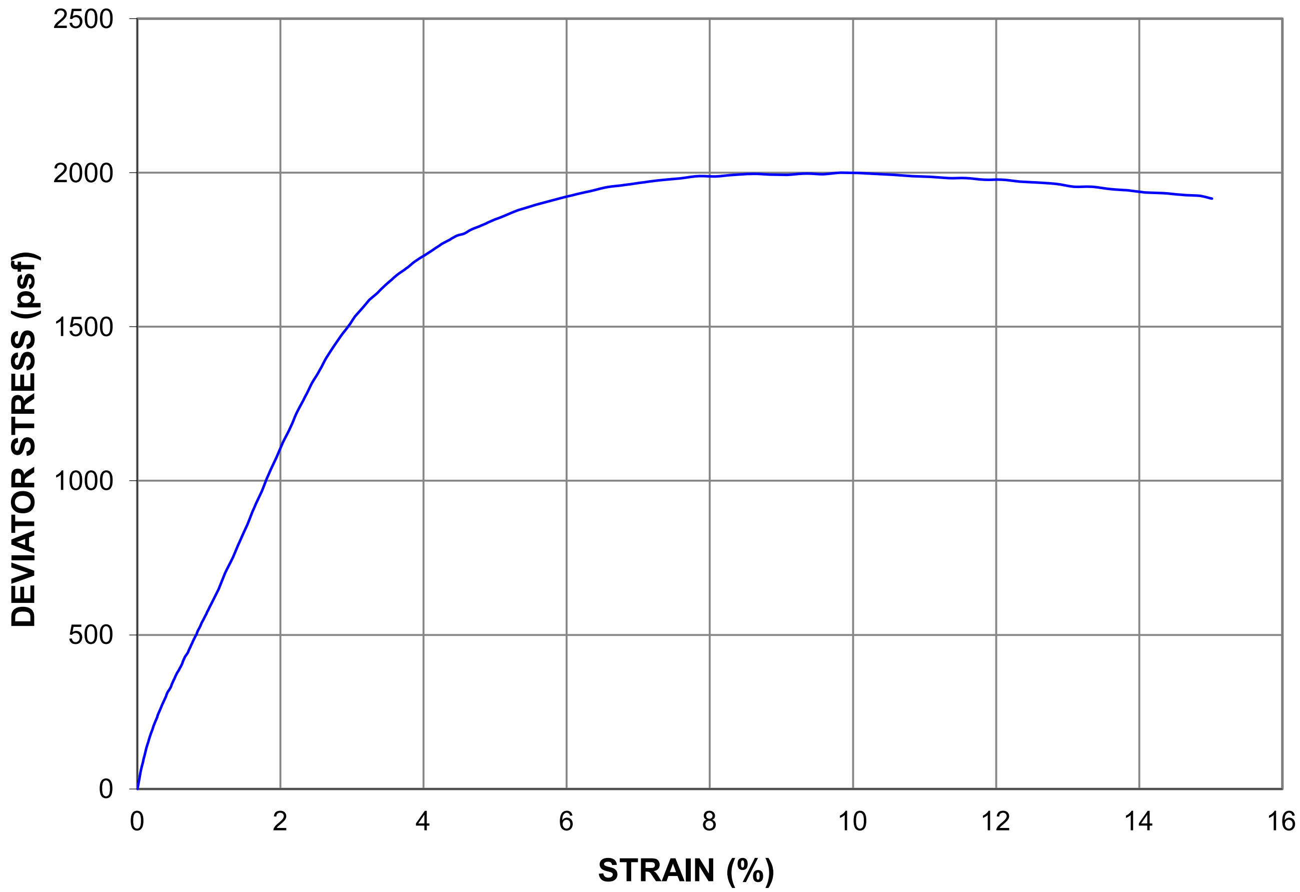
ASTM D-2850

UNCONSOLIDATED UNDRAINED TEST

FIGURE A-31

GeoEngineers

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



SPECIMEN AT FAILURE	
	DESCRIPTION Elastic silt with occasional sand and o.m. (MH)
	STRAIN RATE: 1%/min
	UU COMP STRENGTH (psf): 2000
	UU SHEAR STRENGTH (psf): 1000
	AXIAL STRAIN AT FAILURE: 9.8
	FAILURE TYPE: Bulge

INITIAL	HEIGHT (in): 5.75
	DIAMETER (in): 2.85
	HEIGHT/DIAMETER: 2.0
	WATER CONTENT: 55
	WET DENSITY (pcf): 105.0
	DRY DENSITY (pcf): 67.8
	VOID RATIO: 1.5

BORING ID : GEI-6	SAMPLE NO: 10
DEPTH/ELEV(ft) : 50	DATE: 11/8/19
TECH: SAS	CHECKED: SAS

REMARKS:Gs assumed 2.7; γwater = 62.4pcf

CELL PRESSURE: 34.7 psi

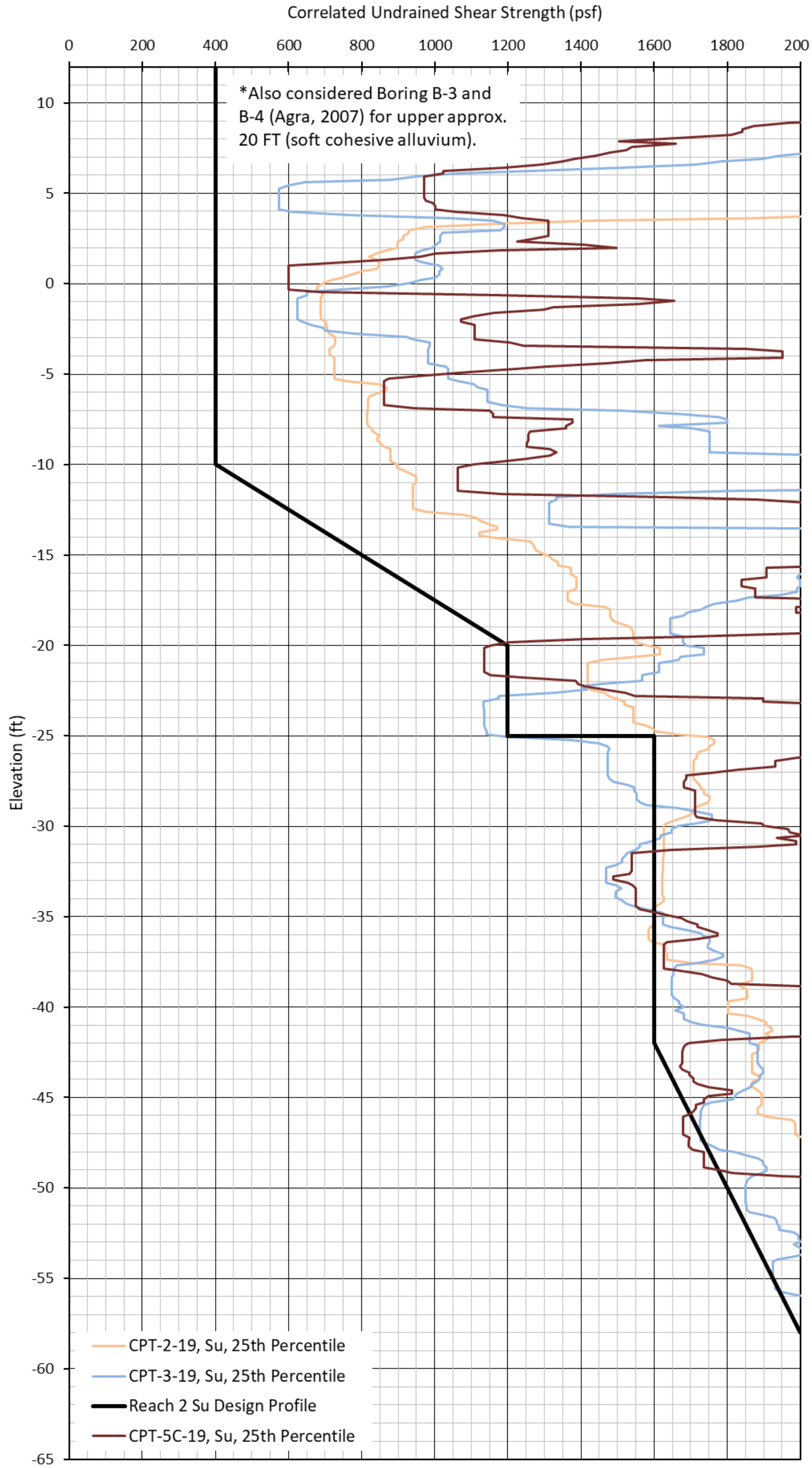
ASTM D-2850

GeoEngineers

UNCONSOLIDATED UNDRAINED TEST

FIGURE A-32

17425 NE Unin Hill Road Ste 250, Redmond, WA 98052



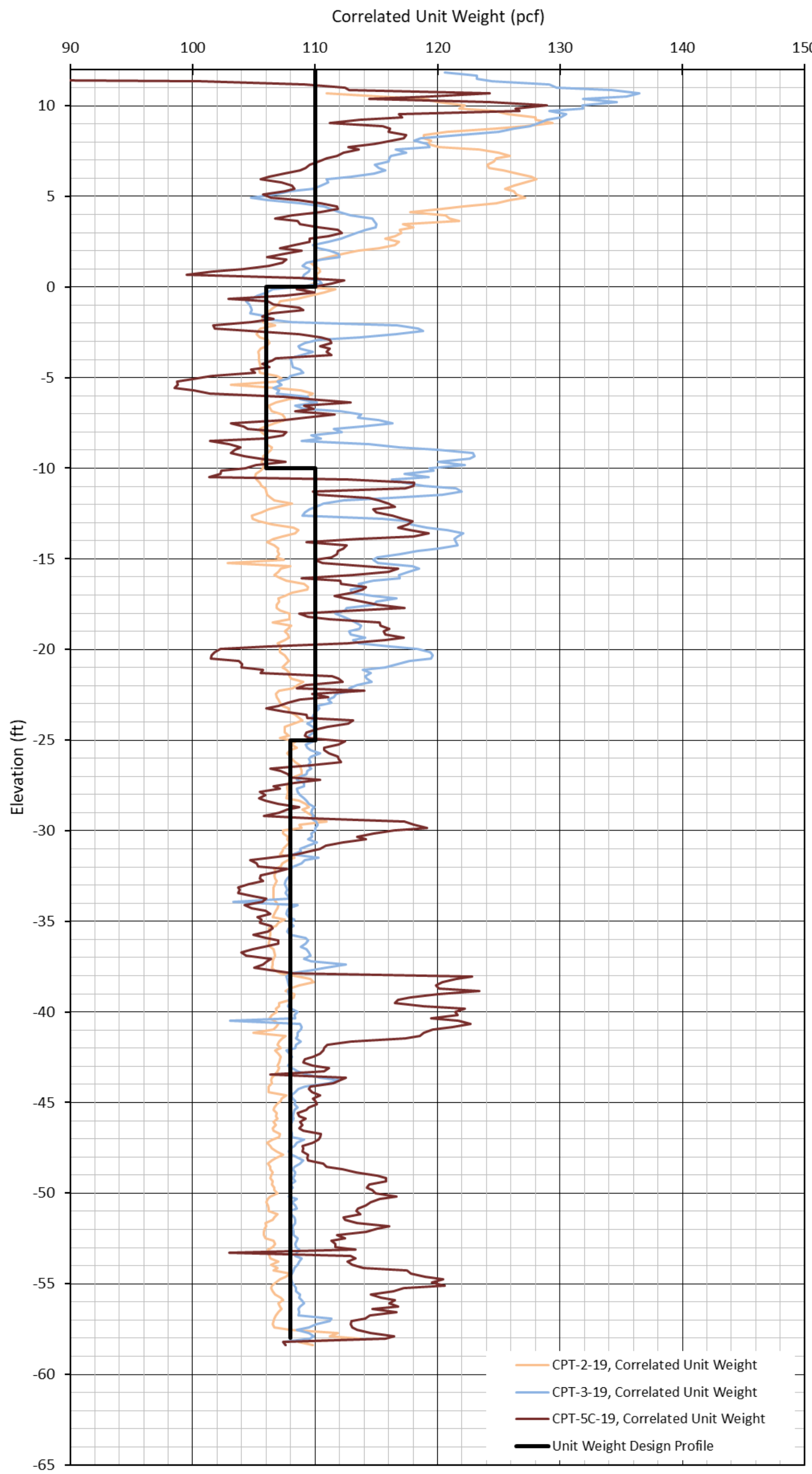
Hoquiam River Shear Strength Design Profile (Reach 2)

North Shore Levee West Segment
Hoquiam, Washington

GeoEngineers

Figure A-33

23944-001-00 Date Exported: 01/22/20



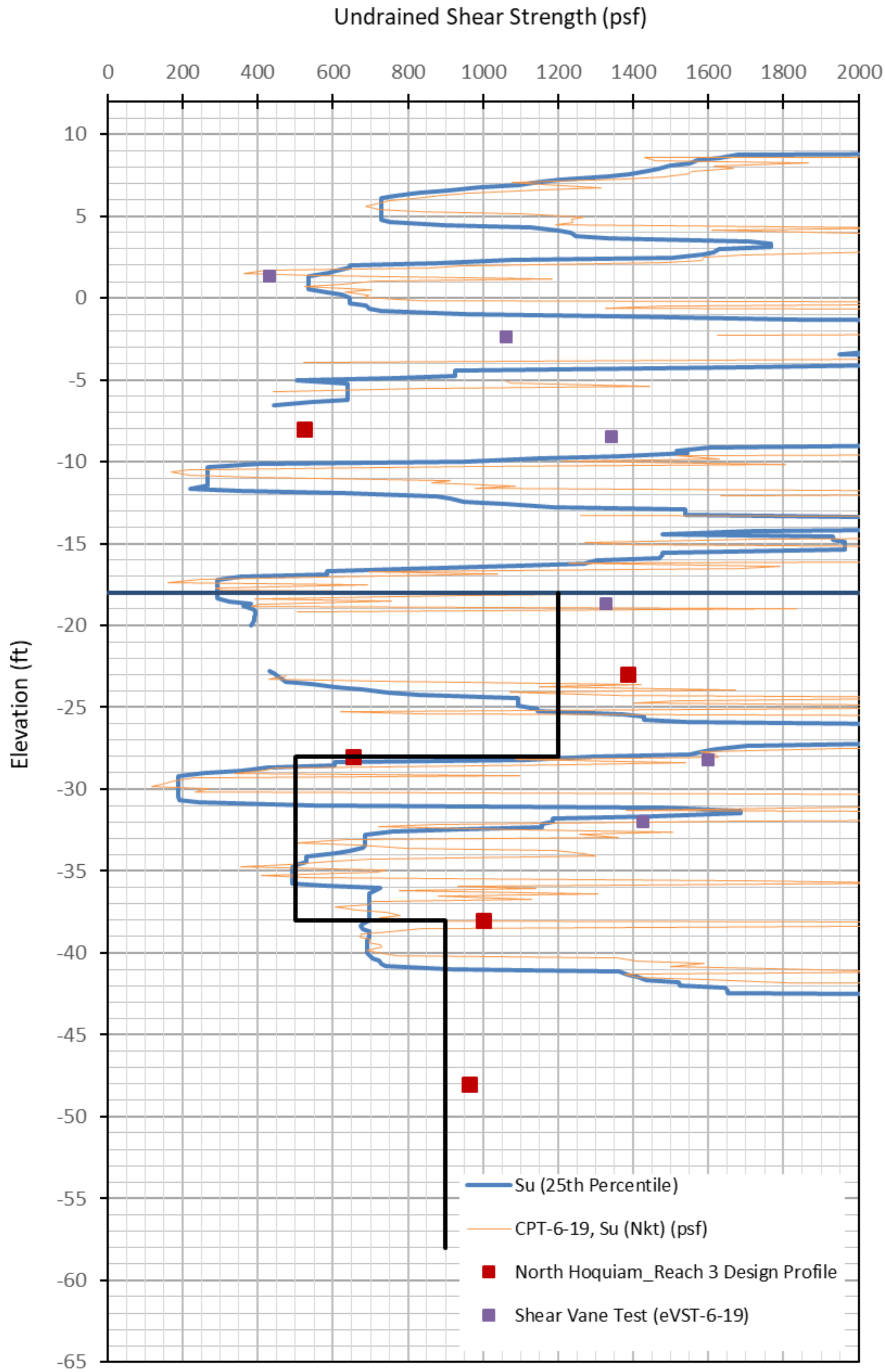
23944-001-00 Date Exported: 01/22/20

Hoquiam River Unit Weight Design Profile (Reach 2)

North Shore Levee West Segment
Hoquiam, Washington

GEOENGINEERS

Figure A-34



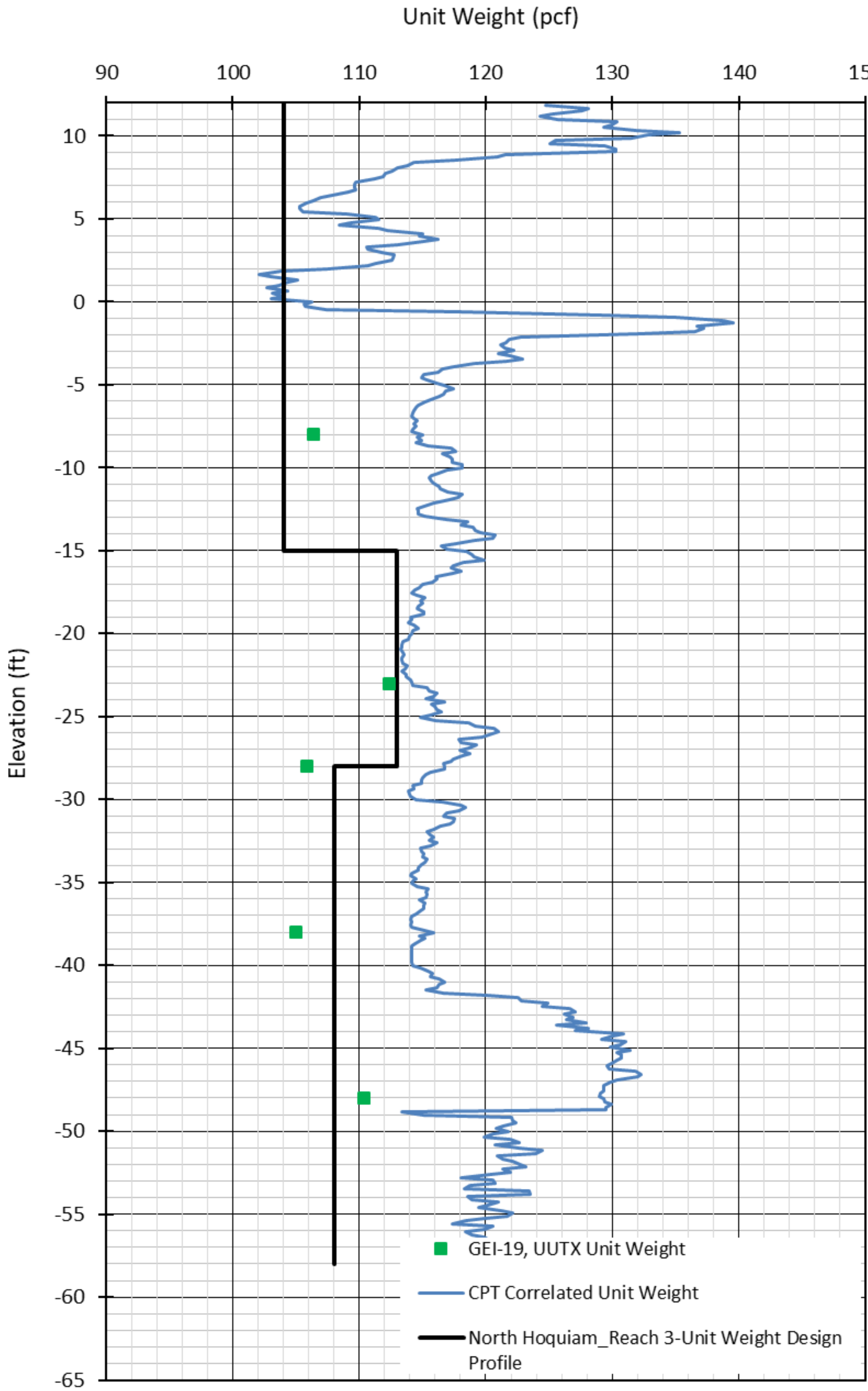
North Hoquiam Shear Strength Design Profile (Reach 3)

North Shore Levee West Segment
Hoquiam, Washington

GEOENGINEERS

Figure A-35

23944-001-00 Date Exported: 01/22/20

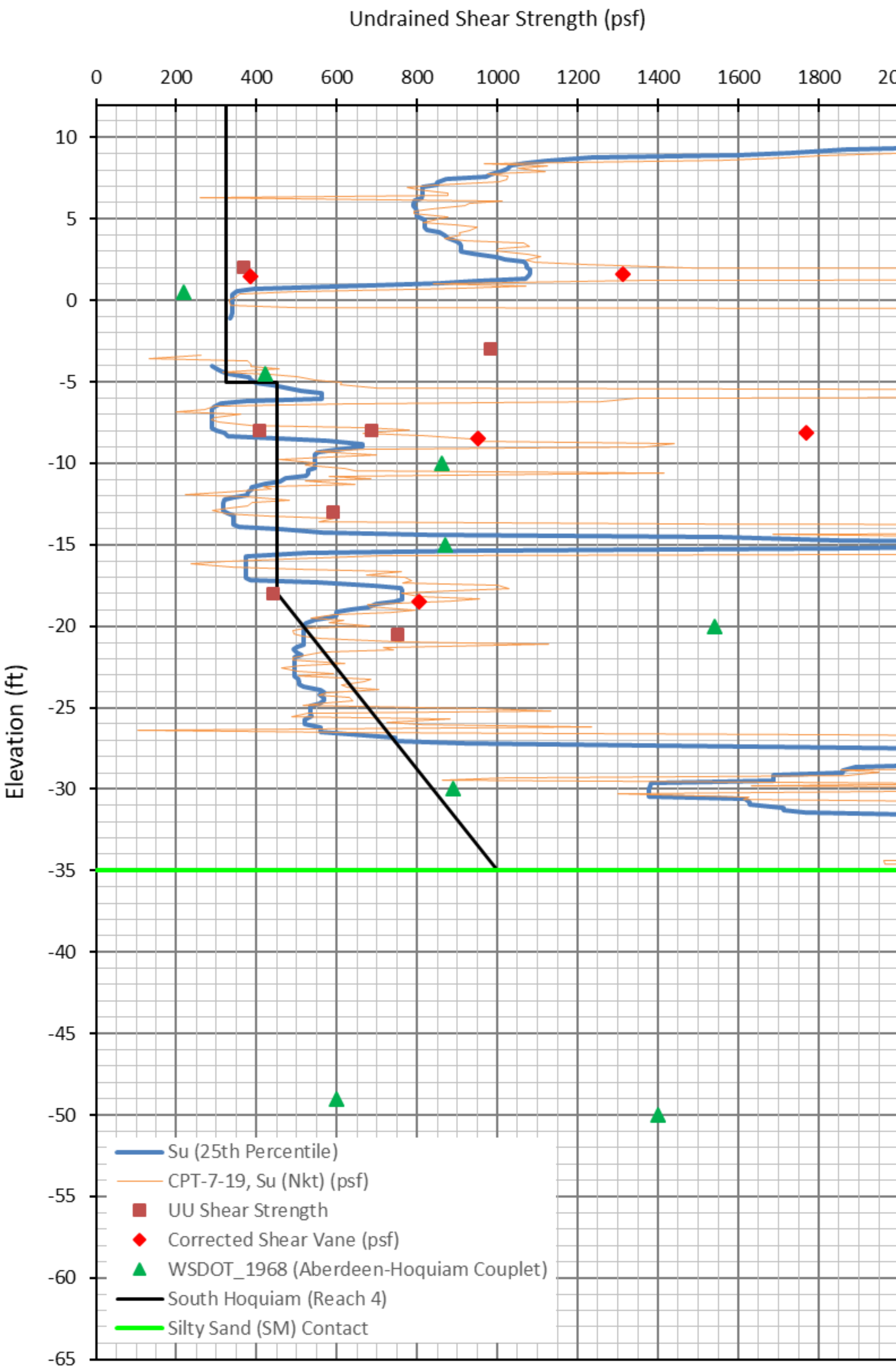


North Hoquiam Unit Weight Design Profile (Reach 3)

North Shore Levee West Segment
Hoquiam, Washington

GeoEngineers

Figure A-36



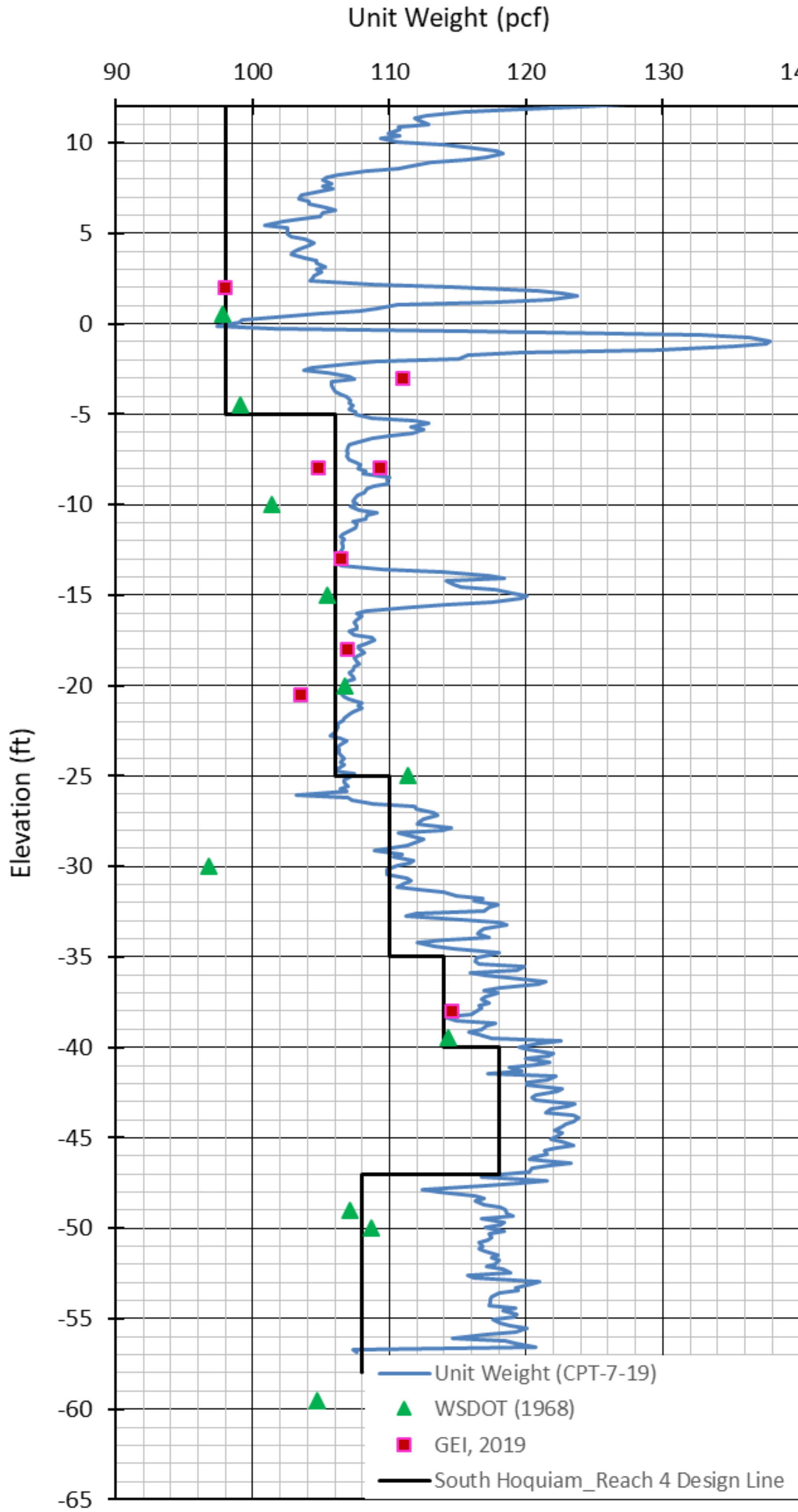
South Hoquiam Shear Strength Design Profile (Reach 4)

North Shore Levee West Segment
Hoquiam, Washington

GEOENGINEERS

Figure A-37

23944-001-00 Date Exported: 01/22/20



South Hoquiam Unit Weight Design Profile (Reach 4)

North Shore Levee West Segment
Hoquiam, Washington

GeoEngineers

Figure A-38

23944-001-00 Date Exported: 01/22/20

APPENDIX B
Previous Exploration Logs

Foundations

JOHN SPELLMAN
Governor

DUANE BERENTSON
Secretary

STATE OF WASHINGTON
DEPARTMENT OF TRANSPORTATION
Highway Administration Building • Olympia, Washington 98504 • (206) 753-6005

May 23, 1983

C. S. Gloyd
Bridge and Structures Engineer
Transportation Administration Building
Olympia, WA 98504

RE: SR-101, C.S. 1402, L-7262
West Hoquiam Connection
Little Hoquiam River Bridge
No. 101/130 Widening

Dear Sir:

This letter presents the foundation recommendations for the proposed widening of the existing Little Hoquiam River Bridge 101/130. The proposed construction consists of widening the existing structure almost 19 ft on the right. The structure type consists of a five-span reinforced-concrete flat-slab bridge. Approach construction will consist of widening the existing fills with a maximum height of new fill at 6 ft.

The foundation recommendations herein are based on the specific project description detailed in the bridge layout provided by the Structures Branch, and the existing soils conditions encountered during the field investigation and exploration. The exploratory borings are assumed to be representative of the subsurface conditions throughout the project area. In addition, the subsurface conditions found elsewhere are assumed not to differ significantly from those found in this investigation. If subsurface conditions different from those found by the exploration are encountered during construction, we should be notified so that we may assist you in reviewing these subsurface conditions and re-evaluate our foundation recommendations.

Field Investigation

The foundation investigation consisted of reviewing the nine test holes drilled for the existing structure, and the drilling of three supplemental test holes. The new test holes verified the soil deposition at the site and provided detailed stratigraphy at Piers 5 and 6 where bedrock is dipping steeply.

The foundation material, in general, consists of basalt conglomerate overlain by 4 ft to 10 ft of very dense silty gravelly sand, 10 ft to 95 ft of very soft to medium stiff organic sandy silt and by up to 10 ft of medium stiff sandy silty clay at Piers 1, 2, 3 and 4. At Piers 5 and 6, the organic silt is overlain by up to 17 ft of alternating layers of very loose silty sand, silt and gravel, and clayey gravelly silt. The groundwater level is controlled by the river level and tidal action. The generalized soil conditions at the site are presented on the soil profile in Appendix A. Detailed information is provided in the Logs of Test Borings in Appendix B.

Laboratory Testing

When the field samples were delivered to the Materials Laboratory, the samples were divided in groups of similar soil types. To verify the field identifications, sieve analysis and moisture content determinations were performed on selected samples. Moisture contents were determined in accordance with the procedures of ASTM D2216-80. Grain-size analyses were performed according to the procedures of AASHTOT88-78. From the test results, the soil samples were then classified under the Unified Soil Classification System. A total of 37 samples were identified and 22 sieve analysis done on samples from holes J-48, B-3 and B-8.

The Logs of Test Borings represent a summary description of samples identifications from both the field and laboratory data. The results of the laboratory testing are provided in Appendix C.

Approach Embankments

New approach construction will consist of widening the existing 8- to 10-ft high fills approximately 20 ft at grade level. The maximum height of new fill will be about 6 ft at the new edge of shoulder. The existing fills were built under controlled loading conditions because of the very soft nature of the foundation soil. The foundation soil beneath the existing fills has gained strength due to consolidation caused by the fills. This will permit a faster rate of loading than the 8-inch loose lift per day allowed under the original construction.

Single point end dumping should not be allowed in the approach fill areas. Fill should be placed in lifts, and terraced into the existing fills in accordance with Section 2-03.3(14) of the Standard Specifications. Fills can be built continuously to subgrade elevation.

Because of the variable depth of fill, embankment settlement will vary across the abutments. It is expected that settlement will vary from about 0.2 ft on the left to about 1.0 ft on the right shoulder. Settlement will be slow, with post-construction settlement in the order of 0.6 ft being possible.

Bridge Foundation Support

Piling is recommended for support of all piers of this structure. As an alternate, spread-footing support is feasible at Piers 5 and 6.

High-capacity piles, up to 100 tons each, are recommended at all piers. Concrete piling or steel "H" piles are both feasible. Regardless of the pile type, driving shoes must be provided to penetrate into the very dense gravelly sand and the basalt conglomerate. For estimating pile quantities, it can be assumed that piling will drive to elevation -105 at Pier 1, elevation -95 at Pier 2, elevation -90 at Pier 3, elevation -30 at Pier 4, elevation -8 on the left and elevation -17 on the right at Pier 5, and elevation +6 on the left and elevation -8 on the right at Pier 6. The allowable uplift capacity at Piers 2 and 3 is 9, 11, and 12 tons each for 13-, 16-, and 18-in. concrete piles respectively. No significant uplift capacity is available for Piers 4 and 5 because of shallow pile embedments.

As an alternative to pile support at Piers 5 and 6, spread-footing support is feasible. At Pier 5, the footing should be located on rock, elevation -10 on the left to elevation -20 on the right. For this condition, the footing can be designed for loads up to 10 tsf. At Pier 6, the footing can be located on rock or very dense sand and gravel, elevation +6 on the left to elevation -4 on the right. The footing at this pier can be designed for loads up to 7 tsf.

Conclusion

Foundation recommendations are detailed on the attached Foundation Recommendation sheet. In addition, the soil profile, Logs of Test Borings, and the Laboratory Test data are attached in Appendices A, B and C, respectively. Please note the Section 1-02.4 of the Standard Specifications allows the potential bidders to inspect all factual information which includes the boring logs and sample test data.

Very truly yours,

A. J. Peters

A. J. PETERS, P.E.
Materials Engineer

AJP:jdy
APK
Attach.

cc: J. D. Zirkle
D. D. Rude
C. L. Slemmer
A. H. Walley

WASHINGTON STATE TRANSPORTATION COMMISSION
Department of Transportation
MATERIALS LABORATORY

FOUNDATION DESIGN RECOMMENDATIONS

S.R. NO. 101 PROJECT West Hoquiam River Bridge Widening No. 101/130

JOB NO. L-7262 CONTROL SECTION 1402 DATE

		PILE SUPPORT			SPREAD FOOTINGS		
PIER NO.	STATION	ESTIMATED TIP ELEVATION	MINIMUM TIP ELEVATION	ALLOWABLE LOAD	FOOTING ELEV. AS SHOWN ON LAYOUT	RECOMMENDED FOOTING ELEVATION	ALLOWABLE BEARING VALUE
1	98+93	-105	-100	up to 100 TONS	concrete	or "H"	Pile
2	99+36	- 95	- 90	up to 100 TONS	concrete	or "H"	Pile
3	99+80	- 90	- 85	up to 100 TONS	concrete	or "H"	Pile
4	100+45	- 30	- 25	up to 100 TONS	concrete	or "H"	Pile
5	100+89	- 8 Lt. -17 Rt.	——	up to 100 TONS	concrete	or "H"	Pile
Alternate		——	——	——	——	-10 Lt. -20 Rt.	10 tsf
6	101+31	+ 6 Lt. - 8 Rt.	——	up to 100 TONS	concrete	or "H"	Pile
Alternate		——	——	——	——	- 6 Lt. - 4 Rt.	7 tsf.

REMARKS: Piling must be provided with driving shoes.

APPROACH FILLS

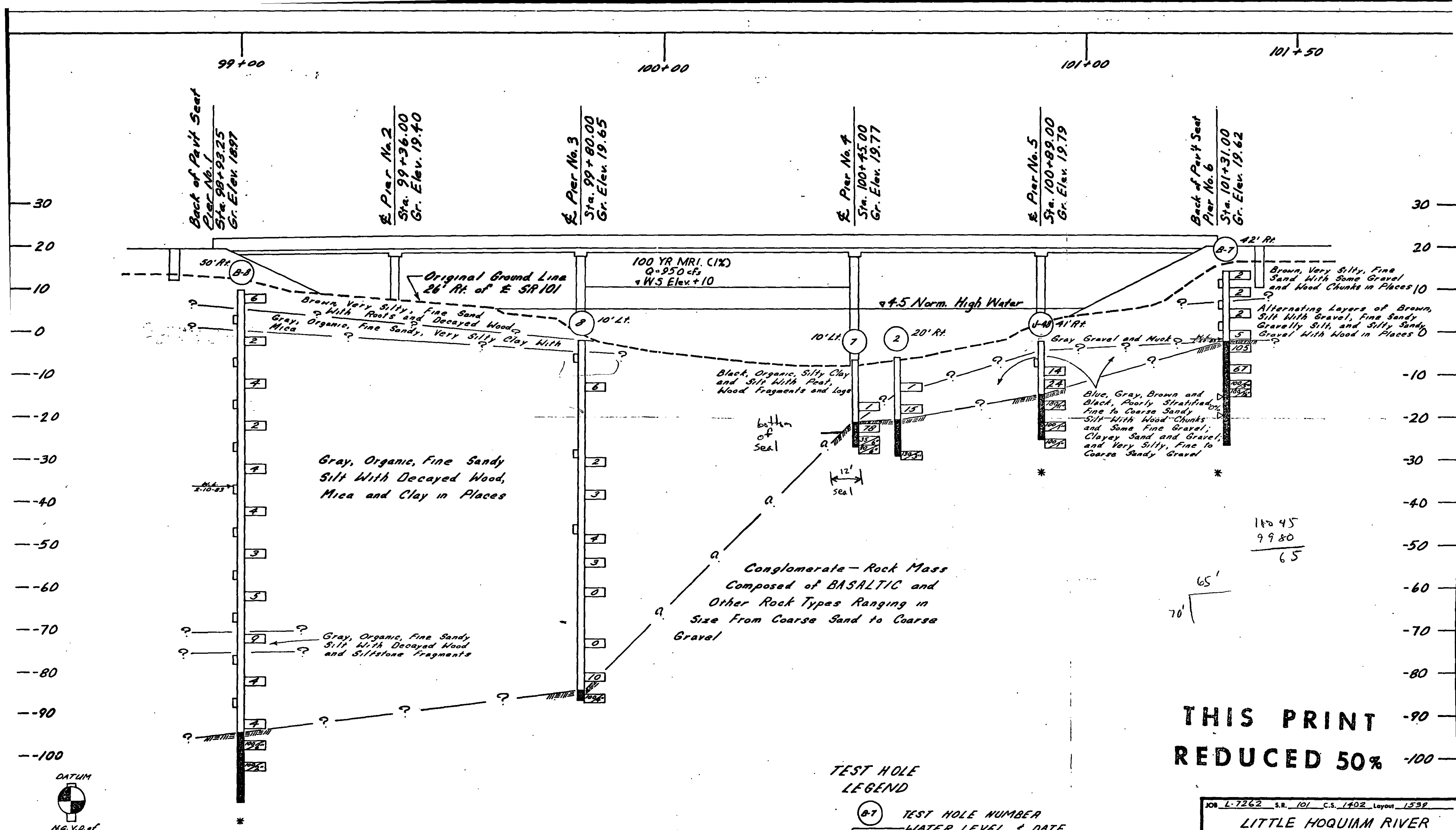
STABILITY: See body of report.

SETTLEMENT: See body of report.

DOT FORM 350-079 REVISED 2/80

APPENDIX A

Soil Profile



* Note: For additional test hole information, see cross section

HOLE NO.	SAMPLE NUMBERS
B-7	E-4135 to E-4142-6
B-8	E-4167 to E-4187 and E-4205-1 to E-4205-7
J-48	E-4259-1 to E-4259-5

TEST HOLE LEGEND

(B-7) TEST HOLE NUMBER
W.L. WATER LEVEL & DATE
2 STANDARD PENETROMETER TEST (BLOWS PER FOOT)
UNDISTURBED SAMPLE
? INDICATES SOIL STRATA MAY NOT BE CONTINUOUS BETWEEN TEST HOLES
INDICATES ROCK
0% ROCK QUALITY DESIGNATION

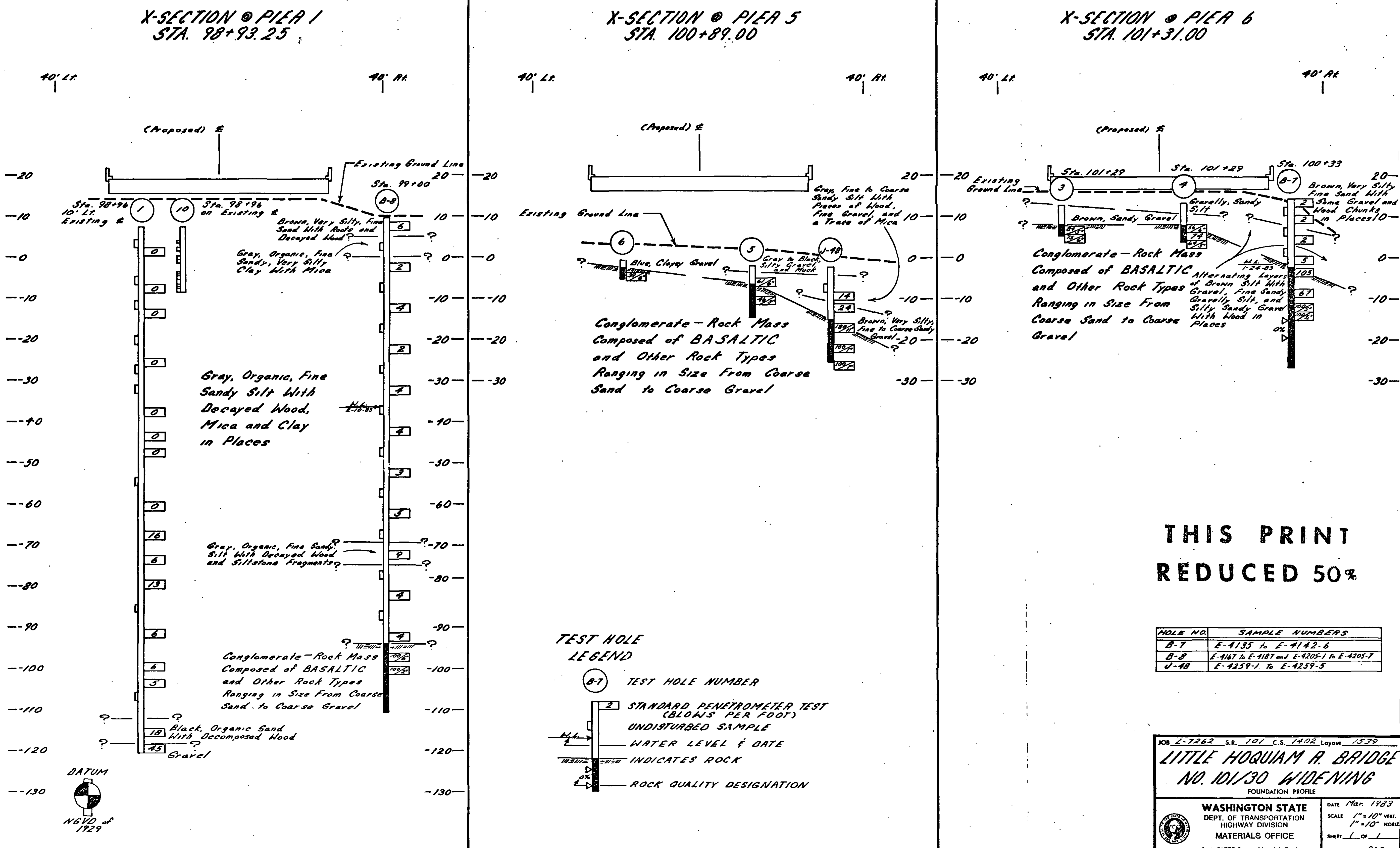
JOB L-7262 S.R. 101 C.S. 1402 Layout 1539

LITTLE HOQUIAM RIVER
BRIDGE NO. 101/130 WIDENING

FOUNDATION PROFILE

WASHINGTON STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
MATERIALS DIVISION

DATE Sept. 1982
SCALE 1" = 10' VERT. 1" = 10' HORIZ.
SHEET 1 OF 1



THIS PRINT
REDUCED 50%

HOLE NO.	SAMPLE NUMBERS
B-7	E-4135 to E-4142-6
B-8	E-4167 to E-4187 and E-4205-1 to E-4205-7
J-48	E-4259-1 to E-4259-5

JOB L-7262 S.R. 101 C.S. 1402 Layout 1539

LITTLE HOQUIAM R. BRIDGE
NO. 101/30 WIDENING
FOUNDATION PROFILE

WASHINGTON STATE
DEPT. OF TRANSPORTATION
HIGHWAY DIVISION
MATERIALS OFFICE
A. J. PETERS Materials Engineer

DATE Mar. 1983
SCALE 1" = 10" VERT. 1" = 10" HORIZ.
SHEET 1 OF 1
DRAWN BY CLC

APPENDIX B

Logs of Test Borings

LOG OF TEST BORING — **WASHINGTON STATE DEPARTMENT OF TRANSPORTATION**

S.H. ____ S.R. 101 SECTION Little Hoquiam River Bridge Job No. L-1441 (L-7262)

Hole No. 1 Sub Section ____ Cont. Sec. 1402

Station 98+96 Offset 10' Lt. Ground El. 7.2

Type of Boring Jet Casing 3" W.T. El. Not determined

Inspector ____ Date May 31, 1955 Sheet 1 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Brown, clayey SILT.
			U-1	No recovery.
5				
	0		0/24" STD PEN 2	Very soft, blue-gray, clayey SILT.
10				
			U-3	No recovery.
15	0		0/24" STD PEN 4	Very soft, blue-gray, organic, clayey SILT.
			B C D E F U-5	
20				

NOTE: This is a typed copy of the field log.

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

DOT FORM 351-003 REVISED 12/79

Hole No. 1 Sub Section Little Hoquiam River Bridge Sheet 2 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	0		0/24" STD PEN 6	Very soft, blue-gray, organic, clayey SILT.
25				
			A B C D E F U-7	
30				
	0		0/24" STD PEN 8	Very soft, blue-gray, organic, clayey SILT.
35				
40			A B C D E F U-9	
45	0		0/24" STD PEN	Very soft, blue-gray, organic, clayey SILT.

DOT FORM 351-003A REVISED 4/80

Hole No. 1 Sub Section Little Hoquiam River Bridge Sheet 3 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			10	
50				
	0		0/24" STD PEN 11	Very soft, blue-gray organic, clayey SILT.
55	0		0/24" STD PEN 12	Very soft, blue, peaty, clayey SILT.
60				
			A B C D E F U-13	
65				
	0		0/24" STD PEN 14	Very soft, blue, peaty, clayey SILT.
70				

Hole No. 1 Sub Section Little Hoquiam River Bridge Sheet 4 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
75	16		STD PEN 15	Very stiff, blue, peaty, clayey SILT.
80	6		STD PEN 16	Medium stiff, blue, peaty, clayey SILT.
85	13		STD PEN 17	Stiff, blue-gray, organic, clayey SILT.
90			A B C D E F U-18	
95				

Hole No. 1 Sub Section Little Hoquiam River Bridge Sheet 5 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	6		STD PEN 19	Medium stiff, blue-gray, organic, clayey SILT.
100				
105				
	6		STD PEN 20	Medium stiff, blue-gray, organic, clayey SILT.
110				
	5		STD PEN 21	Medium stiff, blue-gray, organic, clayey SILT.
			A B C D E F U-22	Decomposed WOOD
115				
120				

Hole No. 1 Sub Section Little Hoquiam River Bridge Sheet 6 of 6

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	18		STD PEN 23	Medium dense, black, organic SAND — with decomposed wood.
125				
	45		STD PEN 24	Dense GRAVEL.
130				Test boring stopped at 128' below ground elevation.

LOG OF TEST BORING

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 101 SECTION Little Hoquiam River Bridge Job No. L-1441 (L-7262)

Hole No. 8 Sub Section ____ Cont. Sec. 1402

Station 99+80 Offset 10' Lt. Ground El. -4.2

Type of Boring Jet Casing 3" W.T. El. Not determined

Inspector ____ Date June 28, 1955 Sheet 1 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Black, organic, silty CLAY.
			U-1	No recovery.
5				
10				
	6		STD PEN 2	
				Blue, silty CLAY.
15				
20				

DOT FORM 351-003 REVISED 12/79

NOTE: This is a typed copy of the field log.

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Hole No. 8 Sub Section Little Hoquiam River Bridge Sheet 2 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
25				
			A B C D E F U-3	
	2		STD PEN 4	Soft, blue, silty CLAY — with some peat and wood.
30				
35				
	3		STD PEN 5	Soft, blue, clayey SILT.
40				
			E D C B U-6	
45				

DOT FORM 351-003A REVISED 4/80

Hole No. 8 Sub Section Little Hoquiam River Bridge Sheet 3 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			A STD PEN 7	Soft, blue, clayey SILT.
	4			
50				
	3		STD PEN 8	Soft, blue, clayey SILT.
55				
	0		0/ 24" STD PEN 9	Very soft, blue, clayey SILT.
60				
65				
70				

DOT FORM 351-003A REVISED 4/80

Hole No. 8 Sub Section Little Hoquiam River Bridge Sheet 4 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	0		0/24" STD PEN 10	Very soft, blue, clayey SILT.
75				
	10		STD PEN 11	Stiff, blue, clayey SILT — with a trace of sand.
80				
				Black Basaltic Conglomerate.
	100/4"		100/4" STD PEN 12	
85				
				Test hole stopped at 84'4" below ground elevation.

DOT FORM 351-003A REVISED 4/80

LOG OF TEST BORING | **WASHINGTON STATE DEPARTMENT OF TRANSPORTATION**

S.H. ____ S.R. 101 SECTION Little Hoquiam River Bridge Job No. L-1441 (L-7262)

Hole No. 10 Sub Section ____ Cont. Sec. 1402

Station 98+96 Offset on ℄ Ground El. 7.4 at 99+00

Type of Boring Porter Casing 2" tubes W.T. El. Not determined

Inspector ____ Date September 23, 1957 Sheet 1 of 1

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Brown, clayey, silty GRAVEL.
				Brown, damp, clayey SILT — with 2" layer of black, organic, clayey silt.
			U-1	Brown and gray mottled, clayey SILT — with wood.
5				
			U-2	Dark gray, organic, clayey SILT — with roots.
			U-3	Dark gray, organic, clayey SILT — with roots.
			U-4	Dark gray, organic, clayey SILT — with bark and wood.
10				
			U-5	
			U-6	Brown, silty, woody PEAT.
				Dark gray, organic, clayey SILT.
			U-7	Dark gray, organic, clayey SILT.
			U-8	Dark gray, organic, clayey SILT.
15			U-9,10	Dark gray, organic, clayey SILT.
			U-11	Dark gray, organic, clayey SILT.
				Test hole stopped at 16' below ground elevation.
20				

NOTE: This is a typed copy of the field log.

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

DOT FORM 351-003 REVISED 12/79

Copy to ____

APPENDIX C

Laboratory Test Data

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place Tumwater
Date

Dear Sir:

I have forwarded by today's State car the following Foundation Samples.

Contract or Job No. L-7262 Section West Hoquiam by Pass
SR No. 101 Sub-Section Bridge Widening.

Station & Offset 99+00 50' Rt. Hole # B-8

Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
4167	D-1	1' 0" – 3' 0"	H_2O=92%	SM	m, tan, yellow-olive, V. Sty. F. SAND w/dk. Brn. & BLK. (1) Piece rotten wood, org. roots & grn. mold
4168	S-2	6' 0" – 8' 0"	I.D. only. H_2O= 38%	CL OL	m, Gr, w/tan outer Layer, F. Sdy. V. Sty. Clay w/ org. stems & mica
4169	D-3	11' 0" – 13' 0"	H_2O=82%	ML	m, GR-BLK. F. Sdy. SILT w/org. stems & twigs; w/ Trace clay
4170 -1	U-4	16' 4" – 16' 8"	B		
-2		16' 8" – 17' 0"	C		
-3		17' 0" – 17' 4"	D		
-4		17' 4" – 17' 8"	E		
-5		17' 8" – 18' 0"	F		
4171	D-5	21' 0" – 23' 0"	H_2O=69%	ML	m, Gr. w/BLK. Pockets of Org. F. Sdy. SILT w/stems & fibers

1 copy with samples
1 copy to addressee

Yours very truly,

Inspector.

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place ....

Date ....

Dear Sir:

I have forwarded by today's .... the following Foundation Samples.

Contract or Job No. L-7262 Section .... SR No. .... Sub-Section ....

Station & Offset 99+00 50' Rt. Hole # B-8

Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
4172	S-6	26' 0" – 28' 0"	H2O=58%	OH	m, Gr. Org., Cly. F. Sdy. SILT w/t. Mica (Org. embedded)
4173	D-7	31' 0" – 33' 0"	H2O=69%	ML	LIKE 4171 w/mica traces m, GR. w/BLK. Pockets of Org. F. Sdy. SILT w/stems & FIBERS
4174-1	U-8	36' 0" – 36' 4"	A		
-2		36' 4" – 36' 8"	B		
-3		36' 8" – 37' 0"	C		
-4		37' 0" – 37' 4"	D		
-5		37' 4" – 37' 8"	E		
4175	D-9	41' 0" – 43' 0"		ML	Like 4173 above
4176-1	U-10	46' 0" – 46' 4"	A		

1 copy with samples
1 copy to addressee

Yours very truly,

....
Inspector.

DOT FORM 351-002 REVISED 2/80

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place ....

Date ....

Dear Sir:

I have forwarded by today's .... the following Foundation Samples.

Contract or Job No. L 7262   Section ....
SR No. ....   Sub-Section ....

Station & Offset 99+00 50' RT   Hole # B-8

Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
4176 -2	W 10	46' 4" – 46' 8"	B		
-3		46' 8 – 47' 0	C		
-4		47' 0 – 47' 4	D		
-5		47' 4 – 47' 8	E		
4177	D 11	51'-0" – 53' 0"	H_2O=69%	ML	Like 4171 w/t. mica M. Gr. w/ Blk. Pockets of Org. F. Sdy. Silt w/ stems & fibers
4178 -1	W 12	56'-0 – 56' 4	A		
-2		56' 4 – 56' 8	B		
-3		56' 8 – 57' 0	C		
-4		57' 0 – 57' 4	D		

4179 D 13 61'-0 63'-0"   ML   Like 4171 w/ Blk Org. Mtr.

1 copy with samples
1 copy to addressee

Yours very truly,

....
Inspector.

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place ....

Date ....

Dear Sir:

I have forwarded by today's .... the following Foundation Samples.

Contract or Job No. L-7262 Section .... SR No. .... Sub-Section ....

Station & Offset 99+00 50' Rt. Hole # B-8

Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
4180 -1	U-14	66' 0" 66' 4"	A		
-2		66' 4" 66' 8"	B		
-3		66' 8" 67' 0"	C		
-4		67' 0" 67' 4"	D		
4181	D-15	71' 0" 73' 0"	H_2O = 69%	ML	Like 4171 w/ mold m. gr. w/ blk. pockets of org. F. Sdy. SILT w/ stems & fibers
4182 -1	U-16	76' 0" 76' 4"	A		
-2		76' 4" 76' 8"	B		
-3		76' 8" 77' 0"	C		
-4		77' 0" 77' 4"	D		

1 copy with samples
1 copy to addressee

Yours very truly,

....
Inspector.

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place ....

Date ....

Dear Sir:

I have forwarded by today's .... the following Foundation Samples.

Contract or Job No. L-7262 Section .... SR No. .... Sub-Section ....

Station & Offset 99+00 50' Rt. Hole # B-8

Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
4183	D-17	81' 0" 83' 0"	H_2O = 40%	ML	moist, Gr. & tan F. Sdy. SILT w/org. & wood ; Stg. F. Sand
4184 -1	U-18	86' 4" 86' 8"	B		
-2		86' 8" 87' 0"	C		
-3		87' 0" 87' 4"	D		
-4		87' 4" 87' 8"	E		
4185	D-19	91' 0" 93' 0"	H_2O = 58%	ML	m, Gr. F. Sdy. SILT w/ mica
4186 -1	U-20	96' 4" 96' 8"	B		
-2		96' 8" 97' 0"	C		
-3		97' 0" 97' 4"	D		

1 copy with samples
1 copy to addressee

Yours very truly,

....
Inspector.

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place ....

Date ....

Dear Sir:

I have forwarded by today's .... the following Foundation Samples.

Contract or Job No. L-7262 Section .... SR No. .... Sub-Section ....

Station & Offset 99~ 50' Rt. Hole # B-8

Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
4186-4	U-20	97' 4" 97' 8"	E		
4187	D-21	101' 0" 103' 0"	63%	mu	m, GR F. Sdy. SILT

More samples to come

1 copy with samples
1 copy to addressee

Yours very truly,

....
Inspector.

DOT FORM 351-002 REVISED 2/80

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place Tumwater
Date 2-10-83

Dear Sir:

I have forwarded by today's State car the following Foundation Samples.

Contract or Job No. L-7262 Section west Hoquiam bypass SR No. 101 Sub-Section Bridge widening

Station & Offset 99 ~ 50' Rt. Hole # B-8

Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
4005-1	D-22	106' 0" – 106' 6"	H2O=11%	GW GM	Moist, Gr., Sty. F-C Sdy. F. & GRAVEL w/one 1½"(+) Rock & T. org. needles
-2	D-23	111' 0" – 111' 2"		GW GM	SAME
-3	ID# 24	111' 2" – 113' 0"	4%	SP	moist, BLK., Cln. Crs. SAND w/ F. < Gravels & one wood chip.
-4	ID# 25	113' 0" – 115' 0"		SP	SAME
-5	ID# 26	115' 0" – 117' 0"		SP	SAME w/ t. Org. hairs.
-6	ID# 27	117' 0" – 119' 0"	9%	SP	Moist, Blk. Cln. M-C SAND w/ F. Ang. gravels
-7	ID# 28	119' 0" – 120' 6"		SP	SAME

1 copy with samples
1 copy to addressee

Yours very truly,
Milford Sanders
Inspector.

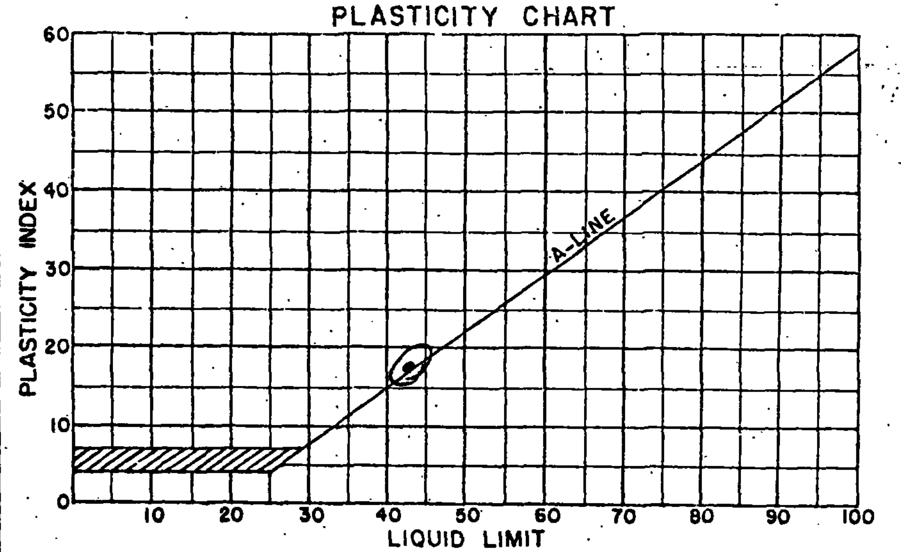
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 4168	JOB NO. Heg.	HOLE NO. 8-8
DATE 3-2-83	OPERATOR PB	

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL			
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: M, Gr, Tan outer Layer F. Sdy, V. Sty. Clay w/org. Stems & mica.



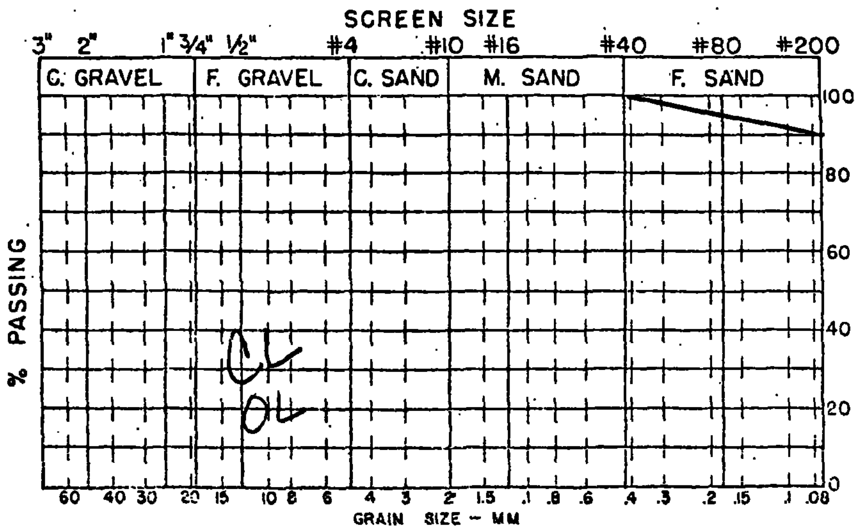
38% H_2O

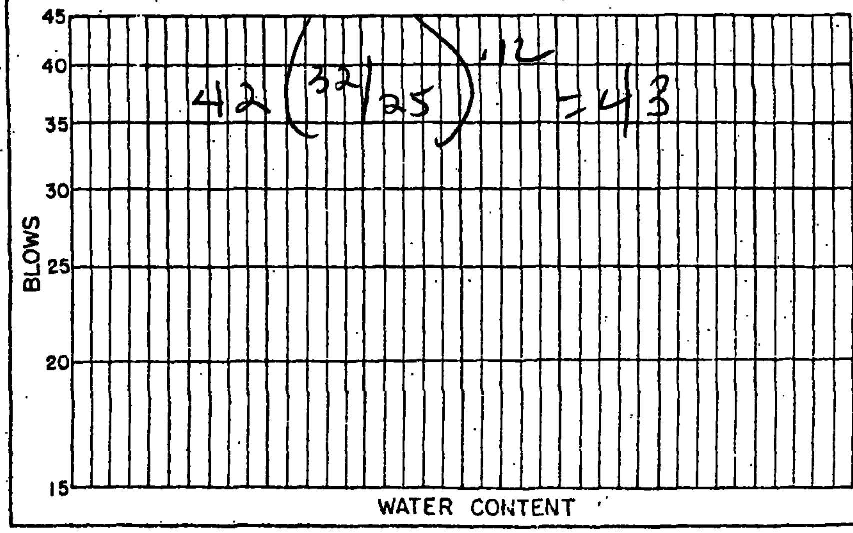
SIEVE ANALYSIS	% Passing 35.00		
	-40	3.59	100
-¾	-80		
-4	-140		
-10	-200	31.41	90%

LIQUID LIMIT DETERMINATION

	LIQUID LIMIT			PLASTIC LIMIT
Can No.	112			47
Wet Wt.	13.30			8.89
Dry Wt.	9.38			7.07
% H_2O	42%			PL= 26
Blows	32			PI= 17

GRAIN SIZE CURVE





SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. #167 JOB NO. X-139 HOLE NO. B-8
DATE 3-3-83 OPERATOR D. BOB

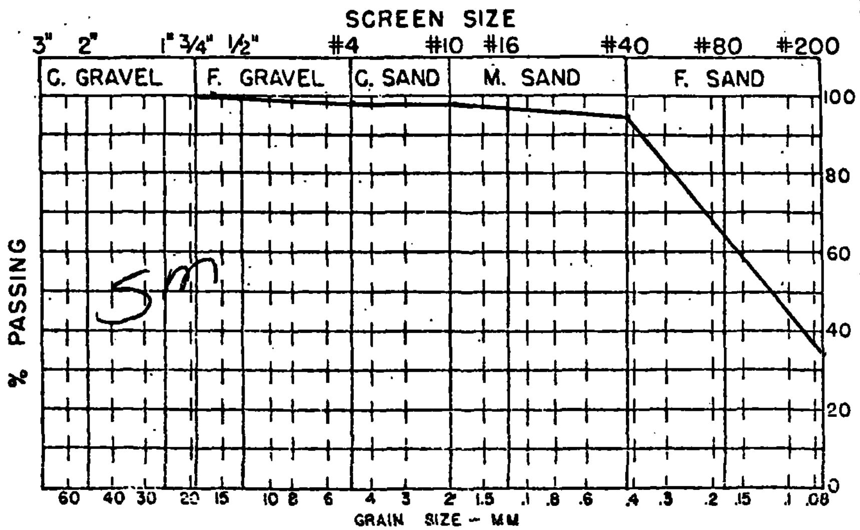
SOIL FIELD IDENTIFICATION			
TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST	✓	✓	
DILATANCY			
BITE			
TOUGHNESS	✓	✓	

DESCRIPTION: M, tan, yellow-olive v.sty. F. SAND w/ dk. Brn. & BLK. One Piece Rotten wood, org. roots & Green mold w/ f. gravel.

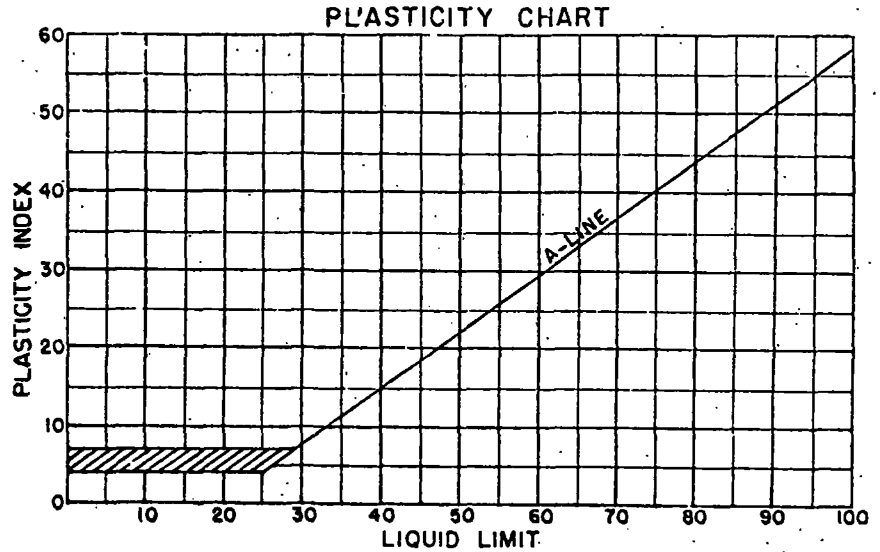
H2O = 92%

SIEVE ANALYSIS		% Passing 83.10			
			-40	50.40	94%
-3/4	1.89	100%	-80		
-4	.58	97%	-140		
-10	2.39	97%	-200	27.84	34%

GRAIN SIZE CURVE

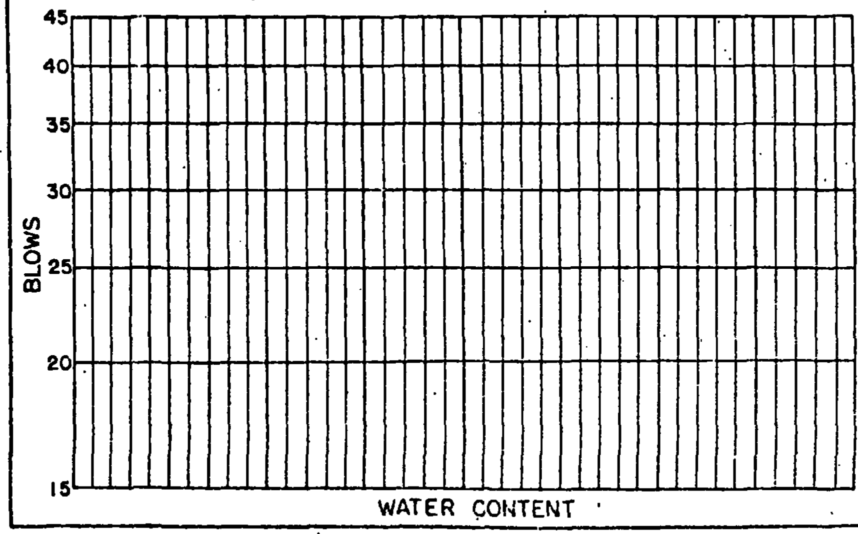


PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
$\% H_2O$					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 4169	JOB NO. H09	HOLE NO. B-8
DATE 3-3-83	OPERATOR BB	

SOIL FIELD IDENTIFICATION

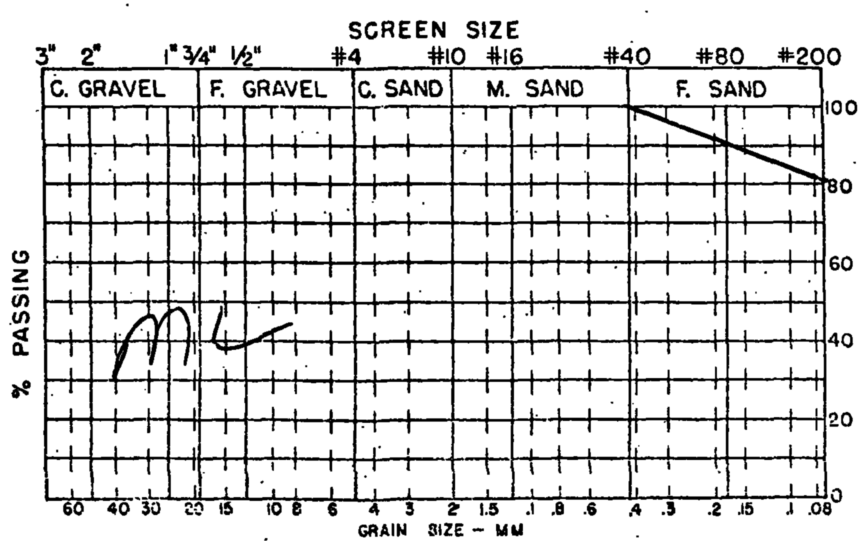
TEST	SAND	SILT	CLAY
VISUAL	✓	✓	✓
DRIED CAST	✓	✓	
DILATANCY			
BITE			
Slightly TOUGH~~NESS~~	✓	✓	✓

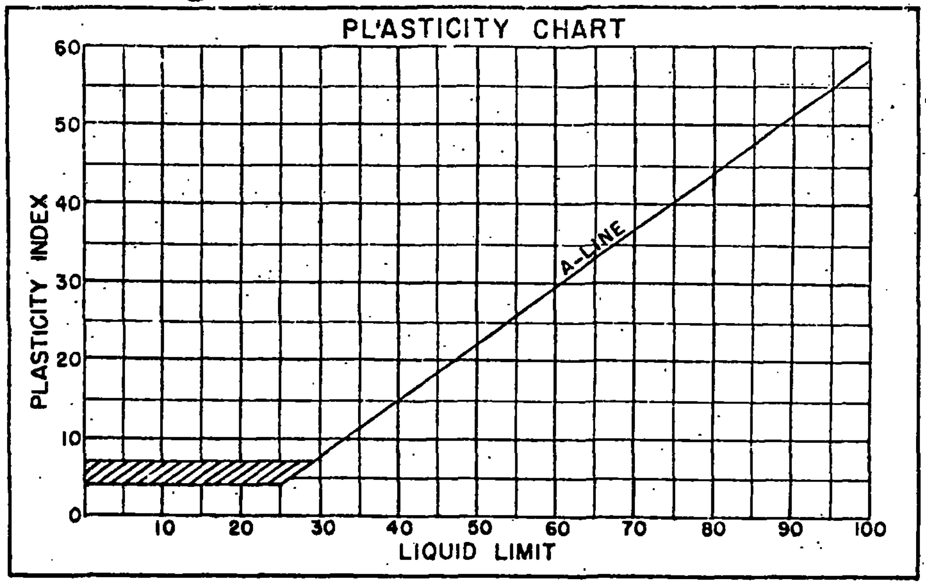
DESCRIPTION: M, GR-BLK. F. Sdy. SILT w/ org. Stems & twigs Tr. cly.

H20 = 82%

SIEVE ANALYSIS	% Passing 45.70	
	-40 8.53	100%
-3/4	-80	
-4	-140	
-10	-200 37.18	81%

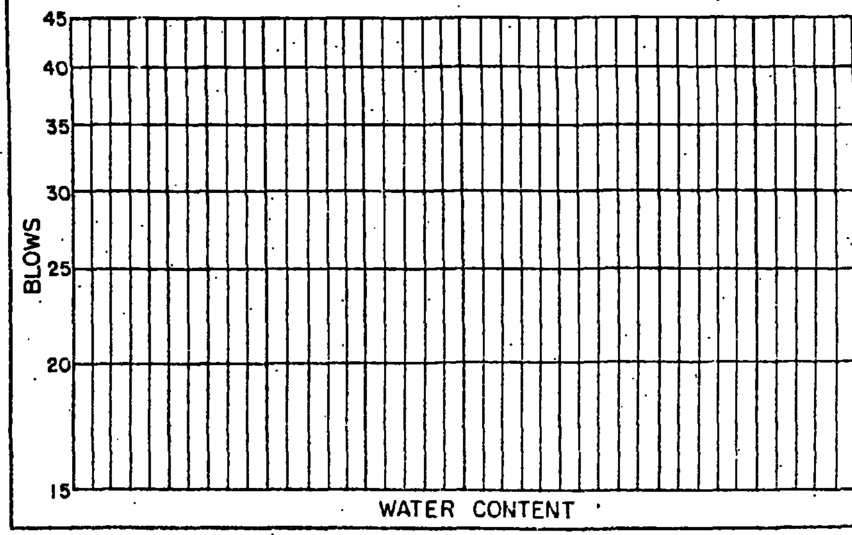
GRAIN SIZE CURVE





LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 4171	JOB NO. Hog.	HOLE NO. B-8
DATE 3-3-83	OPERATOR BB	

SOIL FIELD IDENTIFICATION

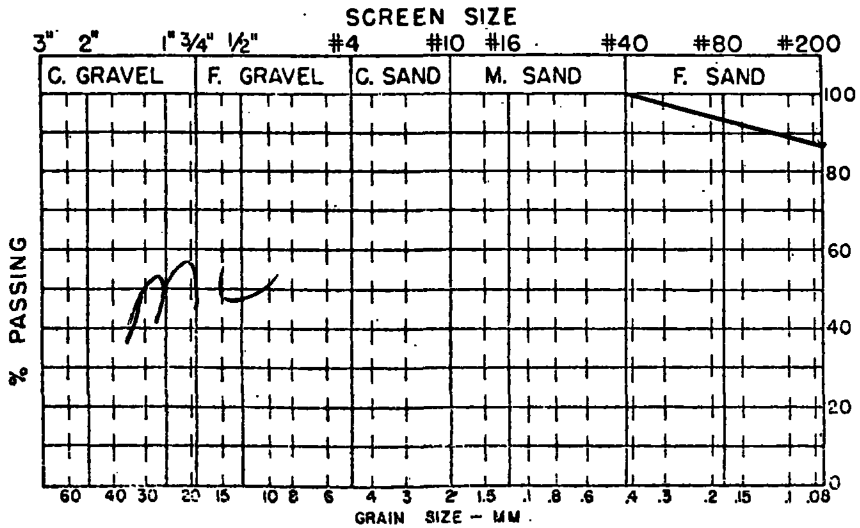
TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST	✓	✓	
DILATANCY			
BITE			
TOUGHNESS	✓	✓	

DESCRIPTION: M, GR. W/ BLK. Pockets & F. Sdy. SILT w/ org. Stems & FIBERS.

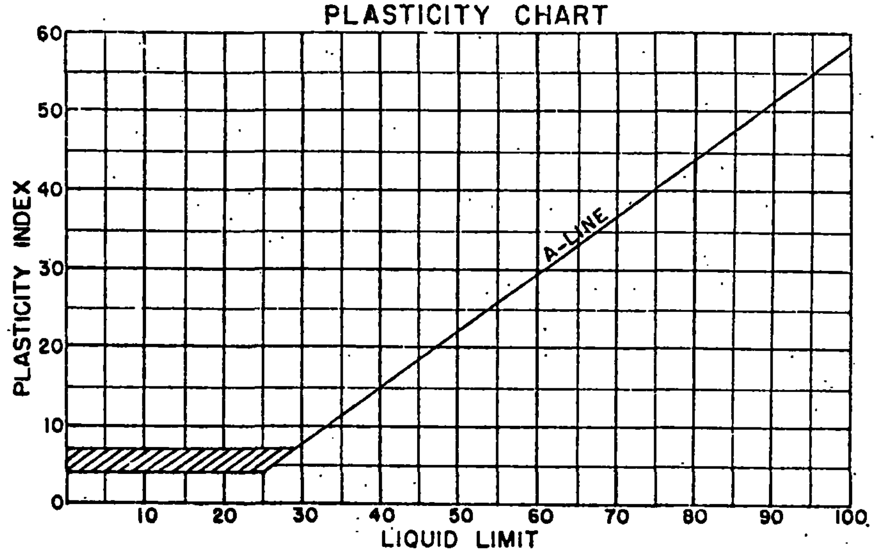
H20 = 69%

SIEVE ANALYSIS	% Passing 46.10
	-40 6.09 100%
-3/4	-80
-4	-140
-10	-200 40.01 87%

GRAIN SIZE CURVE

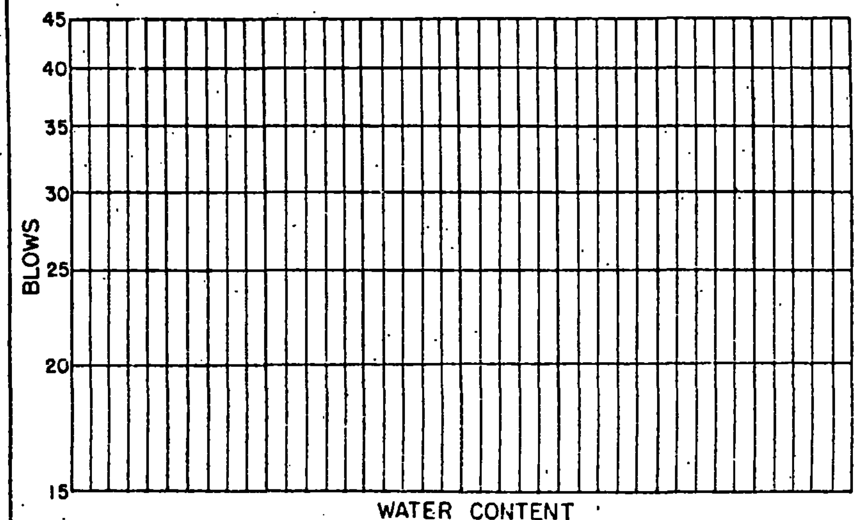


PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
$\% H_2O$					PL=
Blows					PI=

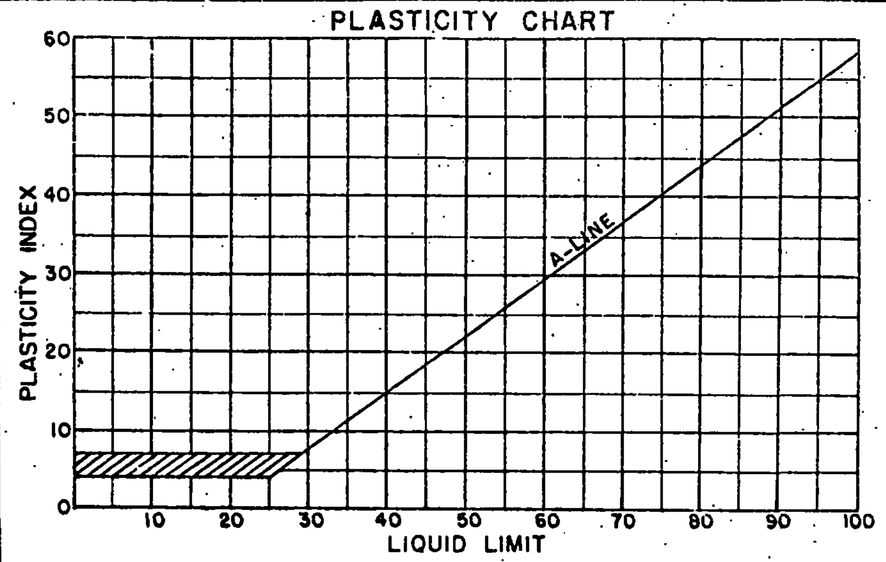


SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 4183 JOB NO. Hof. HOLE NO. B-8
DATE 3-3-83 OPERATOR BB

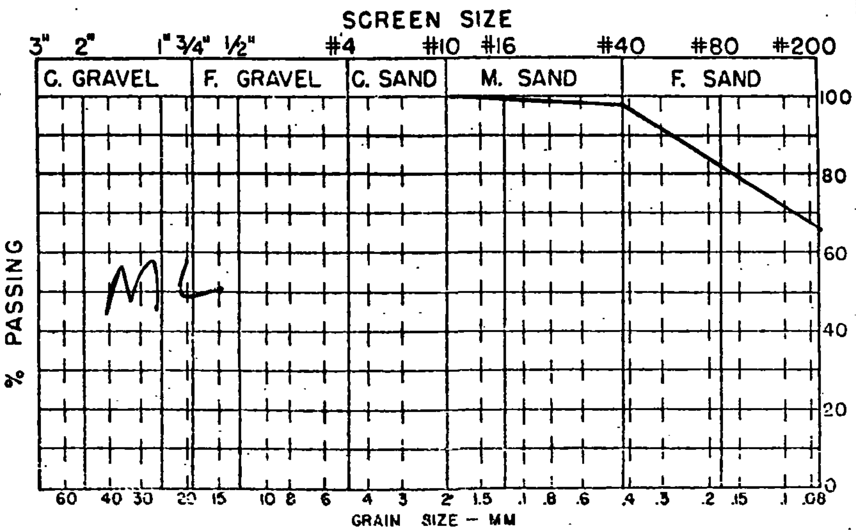
SOIL FIELD IDENTIFICATION			
TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST	✓	✓	
DILATANCY			
BITE			
TOUGHNESS	✓	✓	

DESCRIPTION: F. Sdy. SILT w/org. & Wood - Also Sty. F. SAND
- moist, GR & tan -



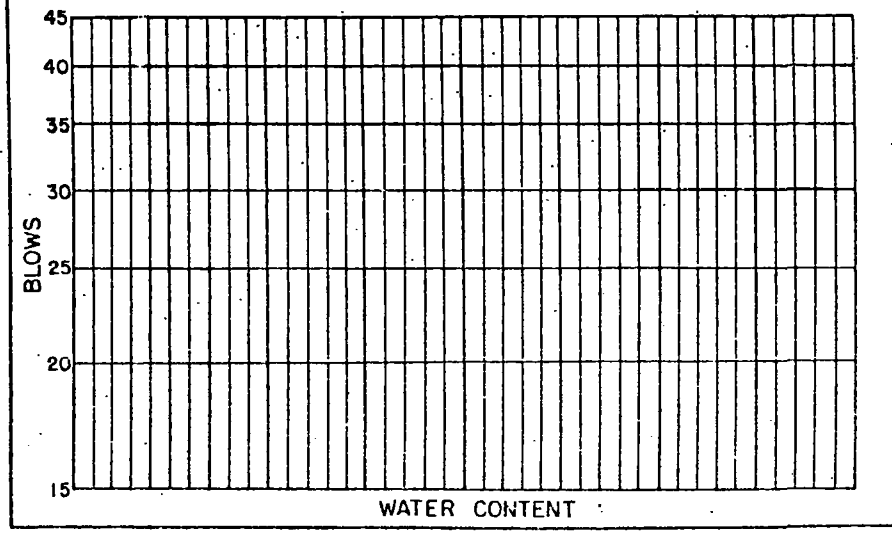
H_2O = 40%

SIEVE ANALYSIS	% Passing 28.42
	-40 8.68 97%
-3/4	-80
-4	-140
-10 .75 100%	-200 18.99 67%



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

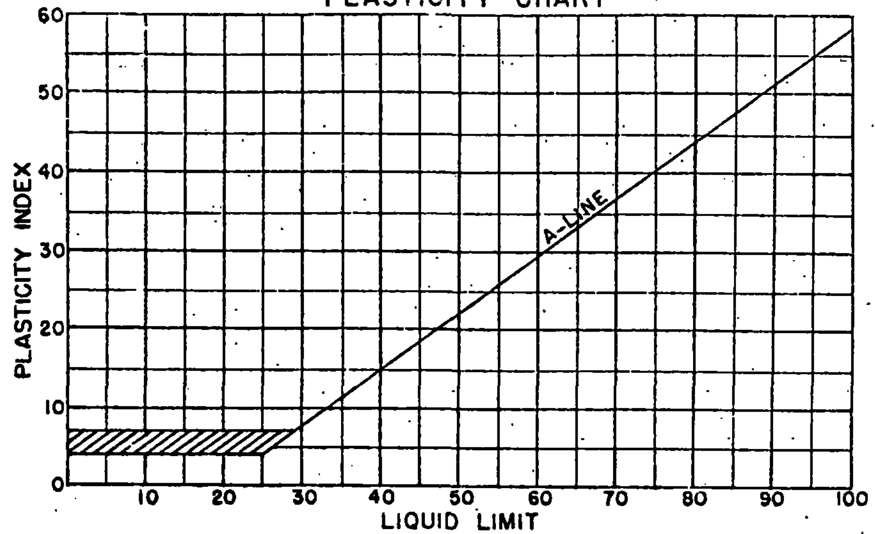
SAMPLE NO. 4185	JOB NO. 408	HOLE NO. U-8
DATE 3-3-83	OPERATOR BB	

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST	✓	✓	
DILATANCY			
BITE			
TOUGHNESS	✓	✓	

DESCRIPTION: M, GR. F. Sdy SiLT w/ Mica

PLASTICITY CHART



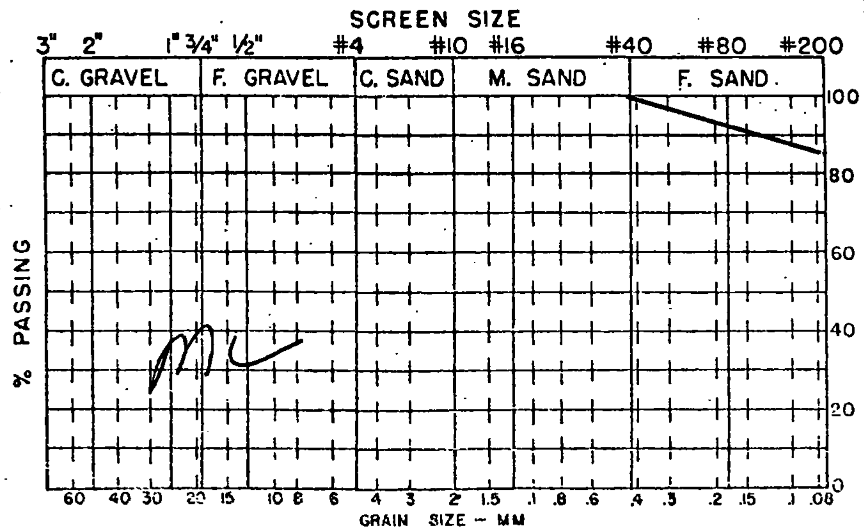
H_2O = 58 %

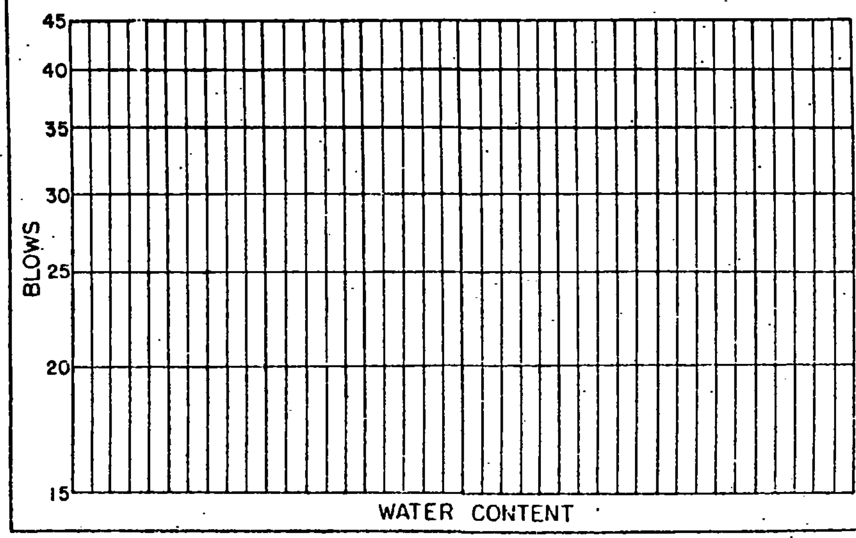
SIEVE ANALYSIS	% Passing 38.00
	-40 5.67 100%
-3/4	-80
-4	-140
-10	-200 32.33 85%

LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

GRAIN SIZE CURVE





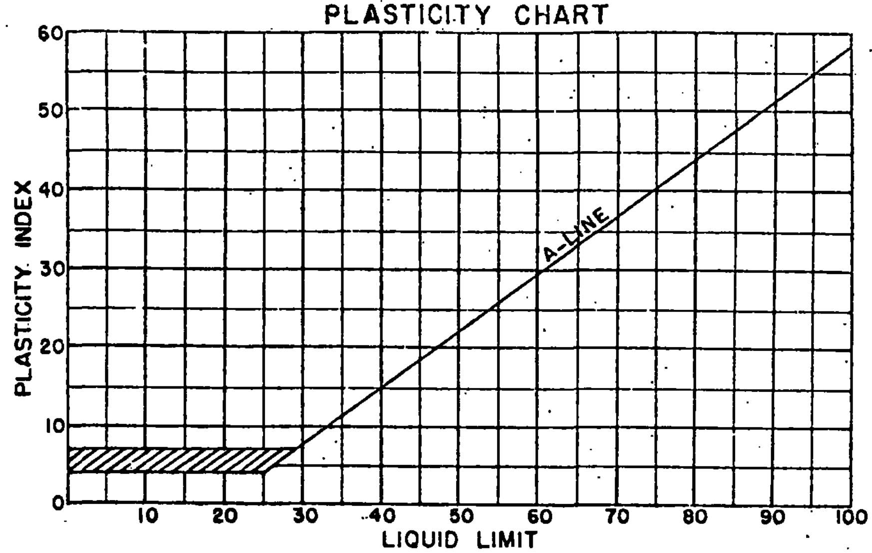
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 4187 JOB NO. Hez. HOLE NO. B-8
DATE 3-3-83 OPERATOR BB

SOIL FIELD IDENTIFICATION			
TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: M, Gr. F. Sdy. SILT

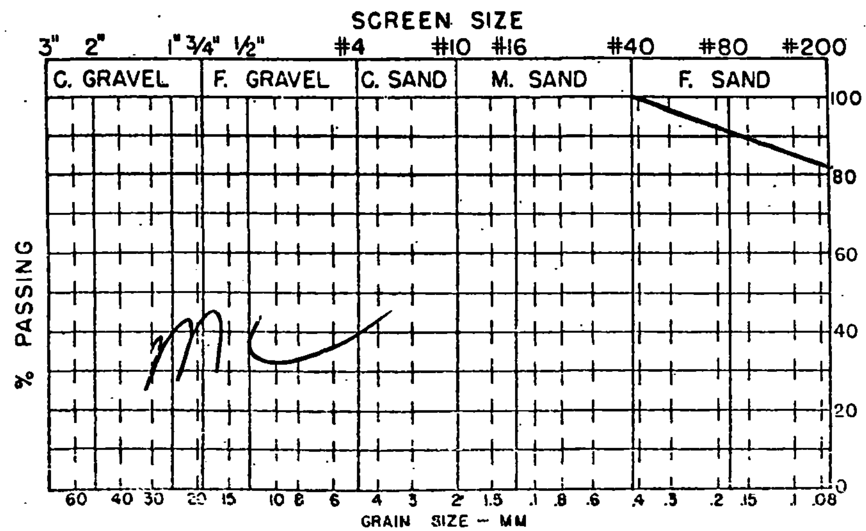
PLASTICITY CHART



H2O = 63 %

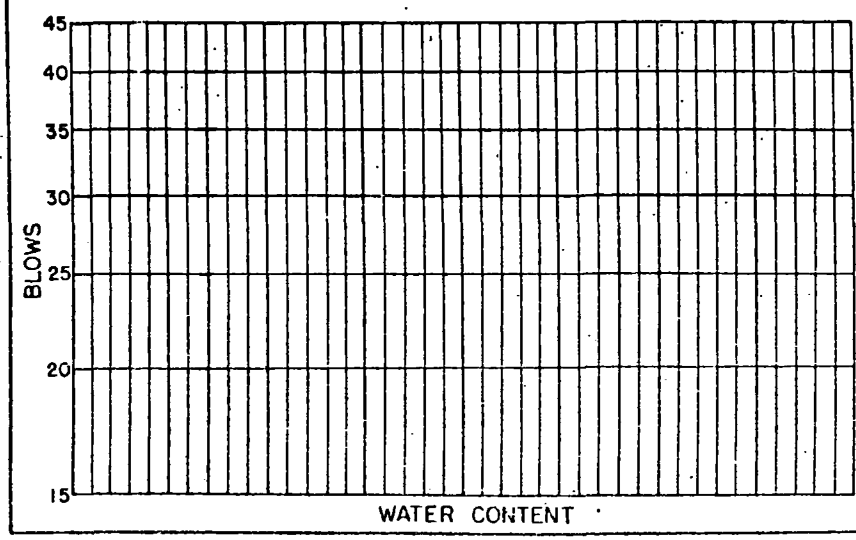
SIEVE ANALYSIS	% Passing 48.21
	-40 8.91 100%
-3/4	-80
-4	-140
-10	-200 39.30 82%

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows.					PI=



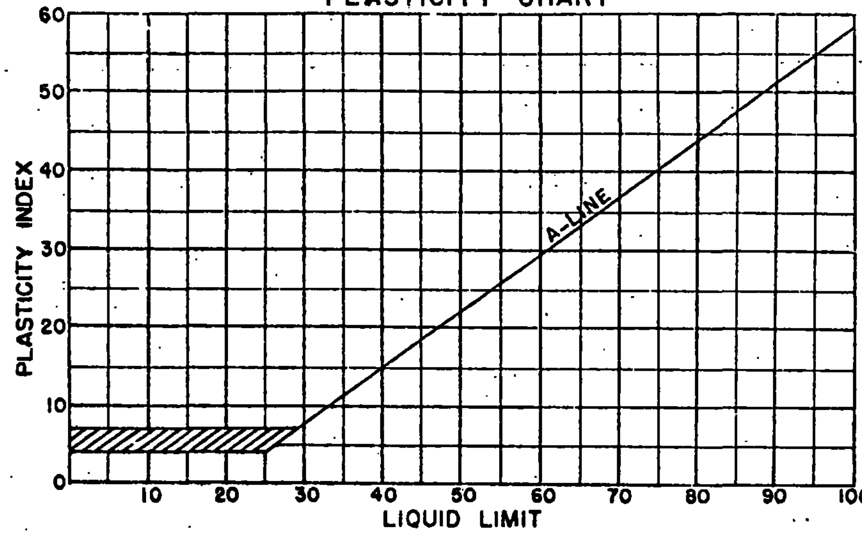
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 4205-1 JOB NO. Hog. HOLE NO. 68
DATE 3-24-83 OPERATOR BB

SOIL FIELD IDENTIFICATION			
TEST	SAND	SILT	CLAY
VISUAL			
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Moist, Gr., Sty. F-C Sdy. F.&GRAVEL w/ one 1½"(-) Rock & f. org. needles

PLASTICITY CHART



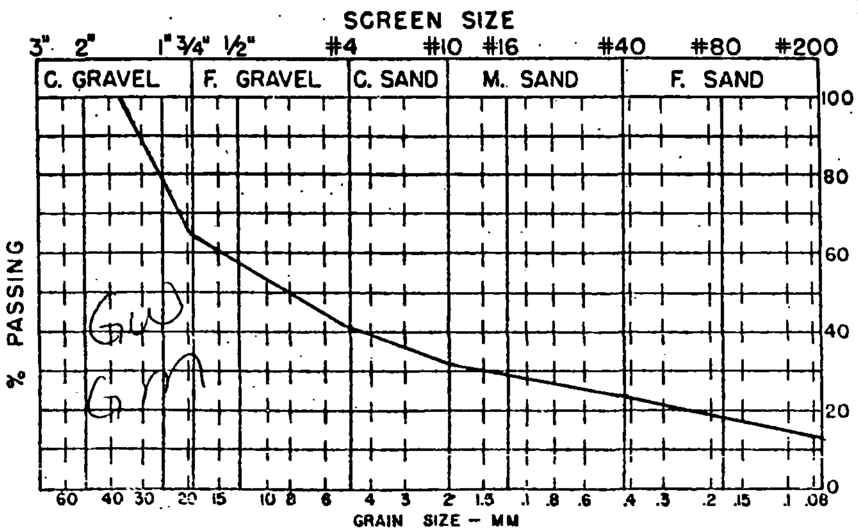
H_2O: 11%

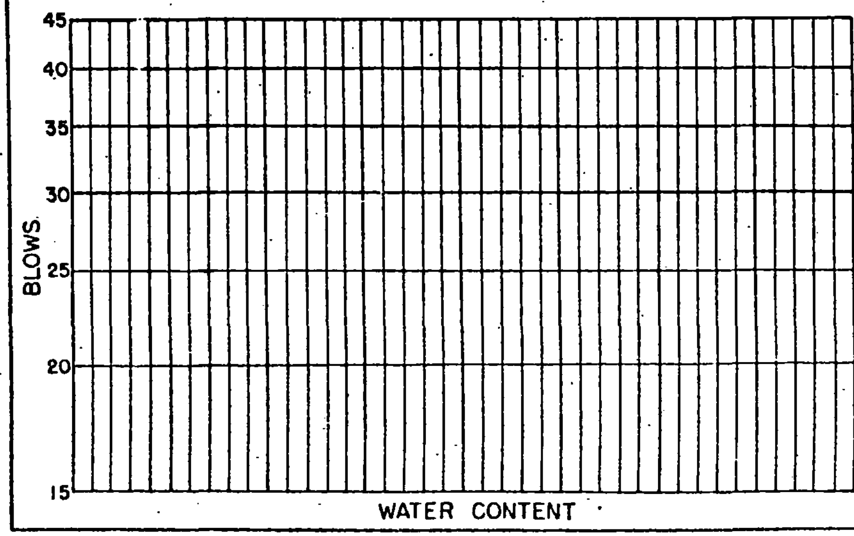
SIEVE ANALYSIS		% Passing 105.53			
1-1½	38.30	100	-40	11.30	23%
-¾	23.90	64	-80		
-4	10.97	41	-140		
-10	8.19	31%	-200	12.87	12%

LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

GRAIN SIZE CURVE





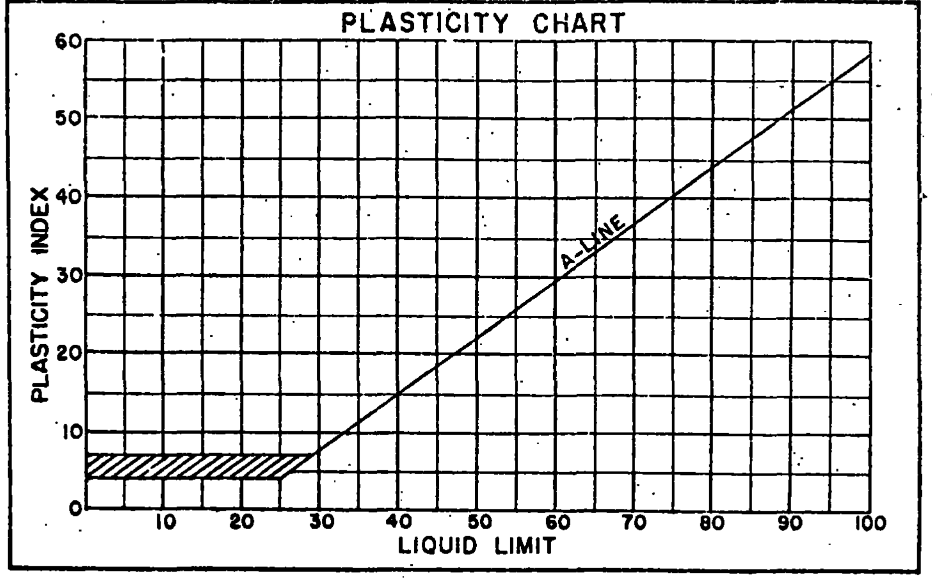
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 4205-3	JOB NO. Hg.	HOLE NO. B-8	
DATE 3-24-83	OPERATOR BB		

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST	✓	✓	
DILATANCY			
BITE			
TOUGHNESS	✓	✓	

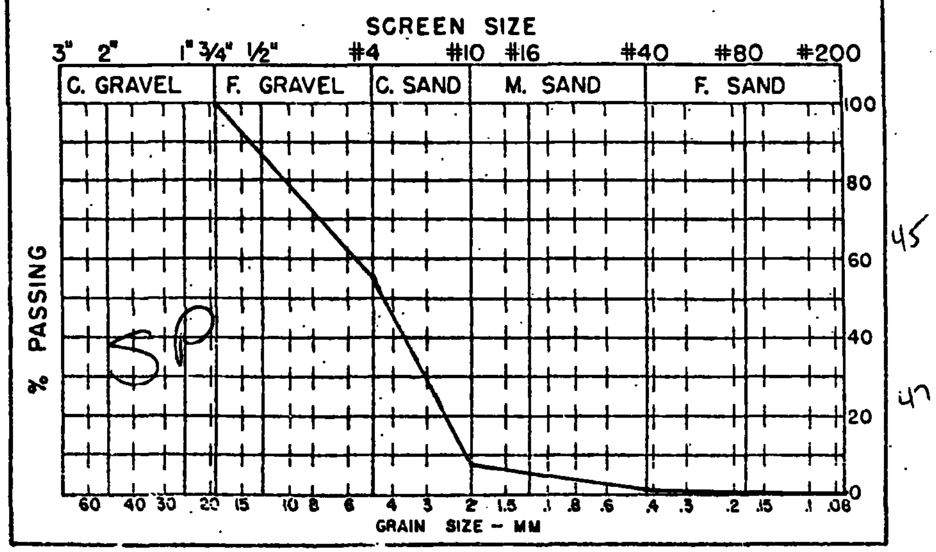
DESCRIPTION: Moist, BLK. clean Crs. SAND w/ F. Ang. gravels & one piece wood chip.



H20 = 4%

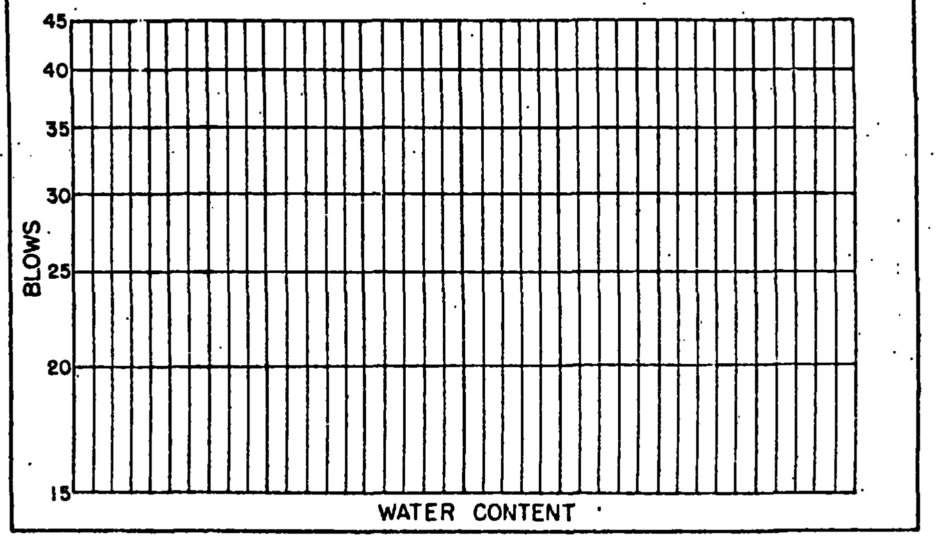
SIEVE ANALYSIS		% Passing	120.82	
		-40	,32	1
-3/4 54.03	100	-80		
-4 57.47	55	-140		
-10 8.49	8	-200	.51	0

GRAIN SIZE CURVE.



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

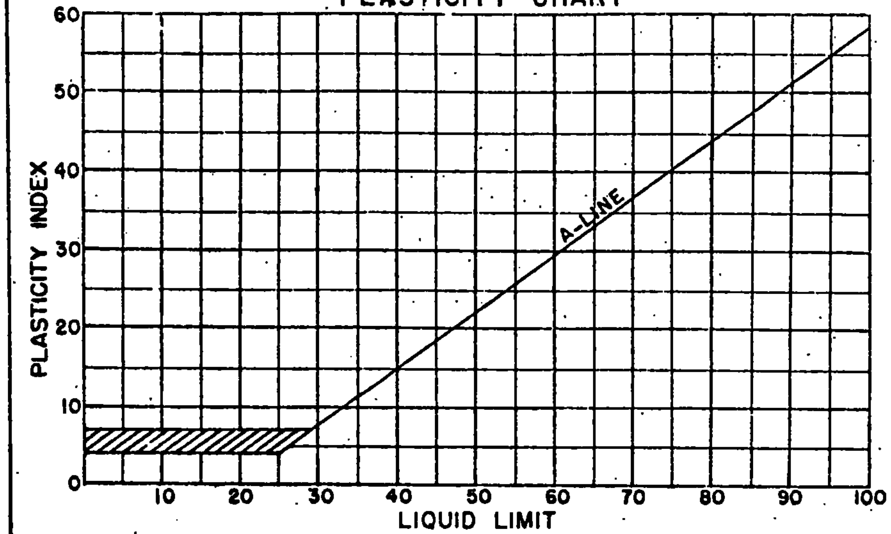


SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 4205-6 JOB NO. Hog HOLE NO. B8
DATE 3-24-83 OPERATOR BB

SOIL FIELD IDENTIFICATION			
TEST	SAND	SILT	CLAY
VISUAL			
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

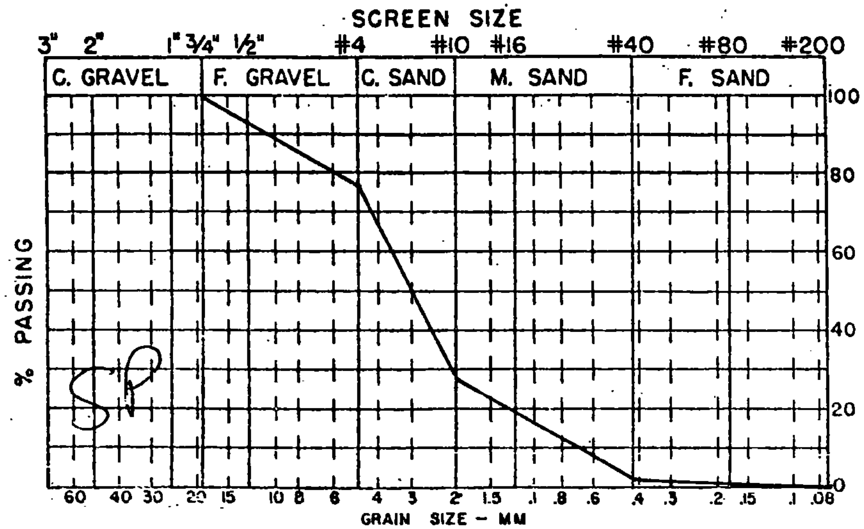
DESCRIPTION: Moist, Blk., Clean Med Crs. SAND w/F. Ang. gravels



H2O = 9%

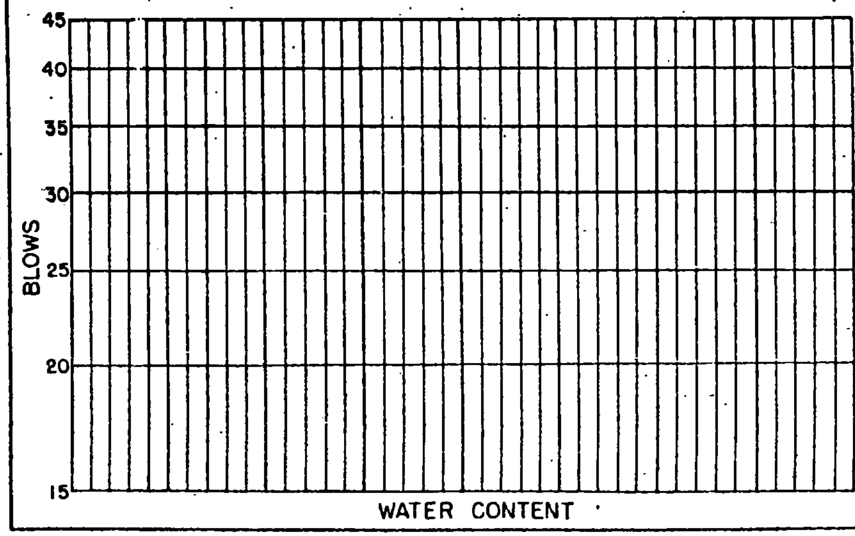
SIEVE ANALYSIS		% Passing 147.80			
			-40	1.22	1
-3/4	35.93	100	-80		
-4	70.90	76	-140		
-10	39.10	28	-200	.65	0

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



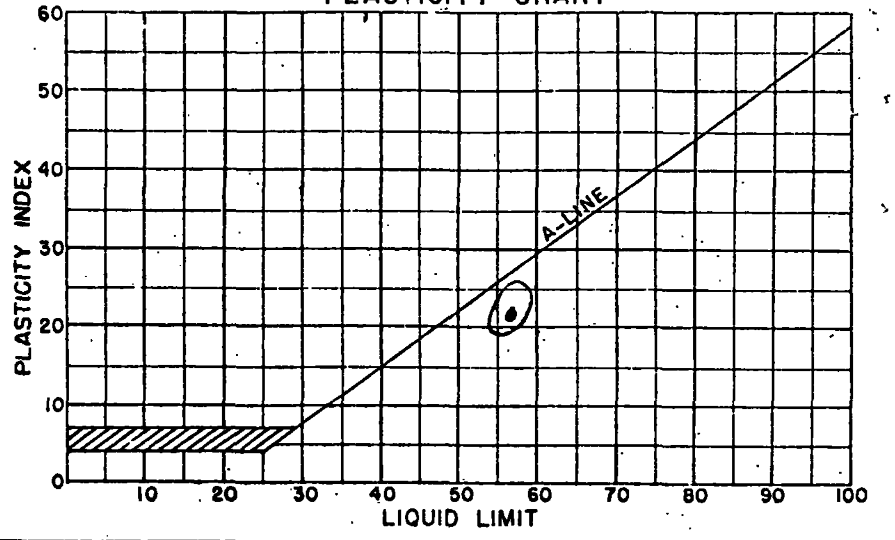
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

Shelby

SAMPLE NO. 4172	JOB NO. Hog.	HOLE NO. B-8	
DATE 3-31-83	OPERATOR		
SOIL FIELD IDENTIFICATION			
TEST	SAND	SILT	CLAY
VISUAL			
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: M, Gr. Org. Cly. F. Sdy. SILT w/ t. Mica - Org embedded

PLASTICITY CHART



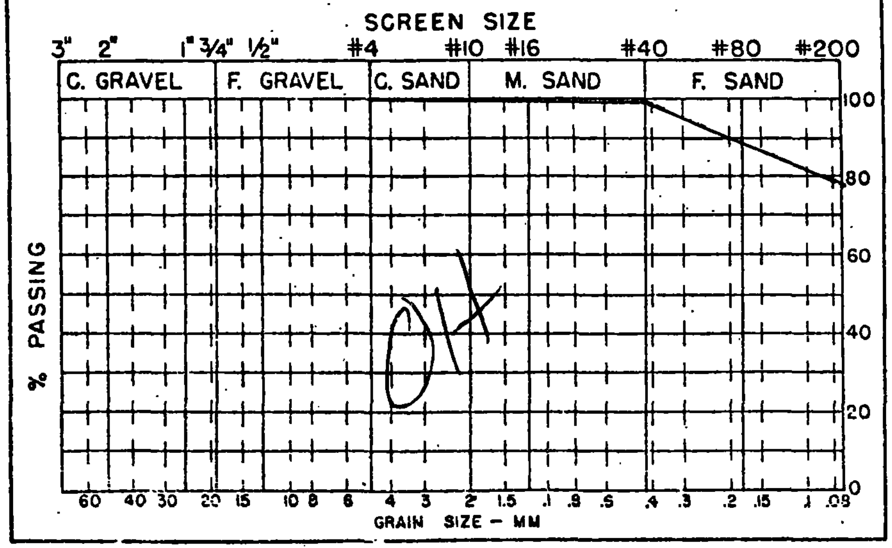
H_2O = 58%

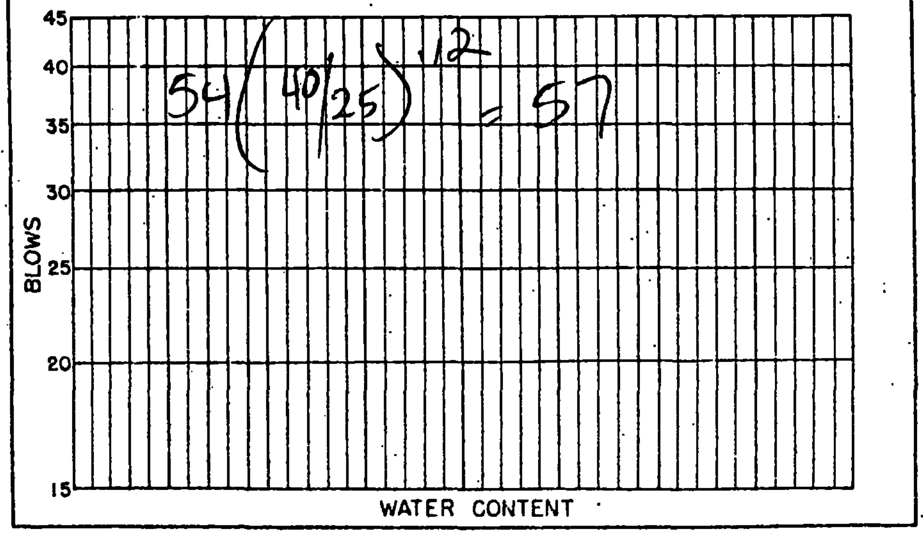
SIEVE ANALYSIS		% Passing 48.82	
		-40 10.23	99
-3/4		-80	
-4 .08	100	-140	
-10 .42	99	-200 38.09	78

LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.	51				118
Wet Wt.	10.97				6.65
Dry Wt.	7.12				4.92
$\%H_2O$	54				PL= 35
Blows	40				PI= 22

GRAIN SIZE CURVE





GEOTECHNICAL ENGINEERING AND ENVIRONMENTAL EVALUATION HOQUIAM RIVER WOODLAWN WATER PIPELINE CROSSING HOQUIAM, WASHINGTON

Submitted To:

Roger Lenius Engineering
208 North H Street
P.O. Box 1896
Aberdeen, Washington 98520

Submitted By:

AGRA Earth & Environmental, Inc.
11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

December 1997

7-91M-11957-0

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS

TABLE OF CONTENTS
7-91M-11957-0

1.0 PROJECT DESCRIPTION

The project site is located along Broadway Avenue near the intersection with Rayonier Avenue on the east side of the Hoquiam River and along Washington Avenue near the intersection with Tyler Street in the Woodlawn area on the west side of the Hoquiam River in Hoquiam, Washington. The east side site area has several single-family residences with lots which slope mildly to the west toward the Hoquiam River. The west side site area was formerly a lumber and shingle mill, and meat slaughter house, and is currently vacant and generally overgrown with small trees and surface brush.

Development plans call for directional drill installation of a 16-inch outside diameter (O.D.) high density polyethylene (HDPE) water pipeline below the Hoquiam River. We advanced test borings along two alternate routes classified as upstream and downstream crossings. We understand the upstream crossing is currently the more desirable route and as such we focused our geotechnical analysis along this area. The upstream crossing is on the order of 988 feet in length from the east side entry point and west side exit location. The entry and exit angle for the water pipeline is planned at 10 degrees below the horizontal. The current design shows the upstream pipe centerline low point approximately 70 feet below grade near the west bank of the Hoquiam River and a minimum of 14 to 15 feet below the river bottom on the east side of the channel.

Environmental sampling and testing was performed due to the concern with the previous site history of the west side site area and possible contaminated drill cuttings being encountered during the directional drilling. A subsurface soil assessment along the proposed alignment was performed to characterize the potential drill cuttings with respect to analytes consistent with the historical site activities.

It should be realized that the conclusions and recommendations contained in this report are based on our understanding of the currently proposed utilization of the project site, as derived from layout drawings, written information, and verbal information supplied to us. Consequently, if any changes are made in the currently proposed project, we may need to modify our conclusions and recommendations contained herein to reflect those changes.

2.0 EXPLORATORY METHODS

We explored surface and subsurface conditions at the project site from 12 through 15 November 1997. Our field exploration and testing program consisted of the following elements:

- A visual surface reconnaissance was made of the project site;

- A track-mounted excavator cleared the west side site area for drilling access.

- Six hollow stem auger and rotary borings, three borings each for the two alternate routes were advanced at strategic locations along the upstream and downstream crossings;

- Two grain size analyses, two Atterberg limits and fifteen moisture content tests were performed on selected soil samples obtained from strategic locations from the test borings;

- A review was made of published geologic maps and seismologic literature;

- Four hollow stem auger borings and additional sampling for environmental testing was accomplished along the west side site area. Soil samples were field screened for the presence of volatile hydrocarbons using an Organic Vapor Meter (OVM). Seven samples were collected and tested for petroleum hydrocarbons, halogenated volatile organics (HVOCs), pentachlorophenol (PCP), polycyclic aromatic hydrocarbons (PAHs) and RCRA metals.

Table 1, below, summarizes the approximate functional locations, surface elevations, and termination depths of all subsurface explorations, and our *Site & Exploration Plan* (Figure 2) depicts their approximate relative locations. Appendix A of this report describes our field exploration procedures and borings logs. Appendix B describes our geotechnical laboratory testing procedures and results and Appendix C describes our analytical test results.

TABLE 1
APPROXIMATE LOCATIONS, ELEVATIONS, AND DEPTHS OF EXPLORATIONS

Exploration	Functional Location	Surface Elevation (feet)	Termination Depth (feet)
B-1	Downstream crossing east side	20	50.5
B-2	Upstream crossing east side	10	51.5
B-3	Upstream crossing west side	13	76.5
B-4	Downstream crossing west side	12	91.5
B-5	Upstream crossing west side	12	31.5
B-6	Downstream crossing west side	12	31.5
B-7	Upstream crossing west side	12	26.5
B-8	Upstream crossing west side	12.5	21.5
B-9	Upstream crossing west side	13	16.5
B-10	Upstream crossing west side	12	11.5
Elevation datum: NAVD88 U.S. Feet			

The specific number, locations, and depths of our explorations were selected in relation to the existing and proposed site features, under the constraints of surface access, and budget considerations. Roger Lenius Engineering was contracted to perform the site survey and located our staked boring locations on the site plan. Elevations of our explorations were estimated by interpolating between spot elevations shown on this same plan. Consequently, the data listed in Table 1, and the locations depicted on Figure 2, should be considered accurate only to the degree permitted by our data sources and implied by our measuring methods.

It should be realized that the explorations performed for this evaluation reveal subsurface conditions only at discrete locations across the project site and that actual conditions in other areas could vary. Furthermore, the nature and extent of any such variations would not become evident until additional explorations are performed or until construction activities have begun. If significant variations are observed at that time, we may need to modify our conclusions and recommendations contained in this report to reflect the actual site conditions.

3.0 SITE CONDITIONS

The following sections of text present our observations, measurements, findings, and interpretations regarding development, utility, surface, soil, groundwater, and seismic conditions at the project site. Descriptive logs of our subsurface explorations and graphic results of our laboratory tests are included in Appendix A, Appendix B, and Appendix C of this report.

3.1 Development Conditions

The east side of the upstream Hoquiam River site area has several single-family residences and driveways which front on Broadway Avenue to the east. One residence apparently operates a wholesale operation which includes storage of salal and cedar for decorations. The downstream location on the east side of the site area consists of an access drive to a stockpile of crushed rock used by the City of Hoquiam's Department of Public Works.

The west side of the Hoquiam River site area was formerly a lumber and shingle mill and meat slaughter house over the past century. The buildings were removed from the site; the site is currently vacant and generally overgrown with small trees and surface brush. Washington Avenue formerly accessed the west side of the site area development but is blocked off at Tyler Street. The Washington Avenue right-of-way on the site is currently overgrown and serves as a trail. In review of historical documents regarding the west side site area development, the majority of the buildings were located south of the Washington Street right-of-way and are not within the proposed directional drilling alignments.

3.2 Utility Conditions

Our site reconnaissance and understanding of the site area indicates that utilities on the east side site area include overhead power and cable, underground phone, water and sanitary

APPENDIX A
FIELD EXPLORATION PROCEDURES AND RESULTS
7-91M-11957-0

Our field exploration program for this evaluation included ten borings, using hollow stem auger and rotary drilling methods. The following paragraphs describe our procedures associated with these explorations. Descriptive logs of our explorations are enclosed in this appendix.

Soil Boring Procedures

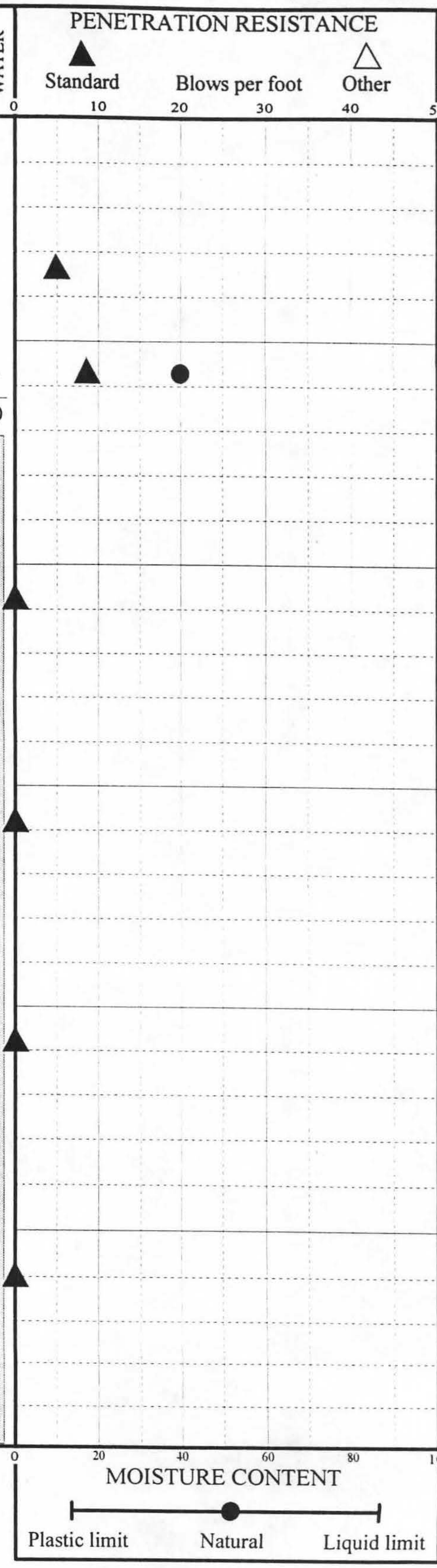
Our exploratory borings were advanced from 12 through 15 November 1997 with a hollow-stem auger, using a track-mounted drill rig operated by an independent drilling firm working under subcontract to AEE. Using the same drill rig we switched to mud rotary drilling methods to complete the deeper borings, B-3 and B-4. A geologist from our firm continuously observed the borings, logged the subsurface conditions, and collected representative soil samples. All samples were stored in watertight containers and later transported to our laboratory for further visual examination and testing. Soil samples were field screened for the presence of volatile hydrocarbons using an Organic Vapor Meter (OVM). Any readings greater than 0 and any unusual odors or discolorations of the samples are noted on the boring logs. After each boring was completed, the borehole was backfilled with a mixture of bentonite chips and soil cuttings, and the surface was patched with asphalt or concrete (where appropriate).

Throughout the drilling operation, soil samples were obtained at 2½- or 5-foot depth intervals by means of the Standard Penetration Test (SPT) per ASTM:D-1586. This testing and sampling procedure consists of driving a standard 2-inch-diameter steel split-spoon sampler 18 inches into the soil with a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is counted, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "SPT blow count." If a total of 50 blows is struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils. In addition, a 3-inch-diameter steel split spoon sampler was used to retrieve a larger sample for analytical testing. The blow counts for the 3-inch sampler were converted to the Standard Penetration Resistance.

The enclosed *Boring Logs* describe the vertical sequence of soils and materials encountered in each boring, based primarily on our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the borings, as well as any laboratory tests performed on these soil samples. If any groundwater was encountered in a borehole, the approximate groundwater depth is depicted on the boring log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted height on the drilling rods, and the water level measured in the borehole after the auger has been extracted.

PROJECT: *Hoquiam River Crossing* W.O. *7-91M-11957-0* BORING NO. *B-3*

DEPTH (feet)	SOIL DESCRIPTION Location: *Upstream crossing - 16 feet west of river* Approximate ground surface elevation: *13 feet*	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	TESTING
0	*Surface grass over TOPSOIL*				
	Medium stiff, moist to wet, brown-gray, sandy, clayey SILT with some gravel, wood chunks and organics (Dike Fill)	I	*S-1*		
5		I	*S-2*	P / ATD	
	Very soft, wet, gray with black, clayey SILT with some fine sand, wood chunks, root fibers and organics				
10		I	*S-3*		
15		I	*S-4*		
20	*Very soft, wet, gray, clayey SILT to silty CLAY with some fine sand, root fibers and mica flakes*	I	*S-5*		
25		I	*S-6*		
30	*(Continued)*				



LEGEND

I 2.00-inch O.D. split spoon sample

II 3.00-inch OD split-spoon sample

ATD Groundwater level at time of drilling

P / ATD Perched groundwater level at time of drilling

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ENGINEERING GLOBAL SOLUTIONS
11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

AGRA Earth and Environmental, Inc.

Drilling method: *HSA/MR* Hammer type: *Automatic* Date drilled: *13 November 1997* Logged by: *CRT*

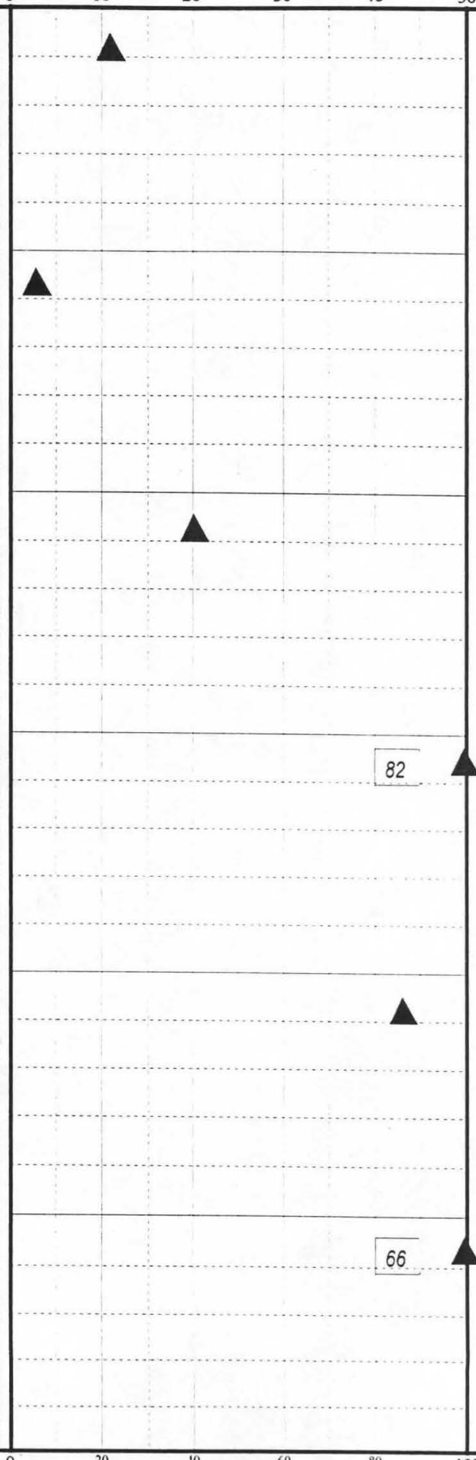
PROJECT: *Hoquiam River Crossing* W.O. *7-91M-11957-0* BORING NO. *B-3*

SOIL DESCRIPTION
Location: *Upstream crossing - 16 feet west of river*
Approximate ground surface elevation: *13 feet*

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER
30	*Clayey SILT to silty CLAY - as above*	I	S-7	
	Loose to medium dense, saturated, gray, silty, gravelly fine to coarse SAND interbedded with soft, wet, gray with black, clayey SILT with some sand and organics			
35		I	S-8	
40		I	S-9	
	Hard, wet, brown-gray with black, sandy SILT with some clay and green silt clasts			
45		I	S-10	
	Hard, wet, greenish-gray, with brown, clayey SILT with some fine sand and trace white volcanic ash (Siltstone)			
50		I	S-11	
55		I	S-12	
60	*(Continued)*			

PENETRATION RESISTANCE
▲ Standard △ Other
Blows per foot: 0 10 20 30 40 50

TESTING



0 20 40 60 80 100
MOISTURE CONTENT
Plastic limit Natural Liquid limit

LEGEND

I 2.00-inch O.D. split spoon sample

II 3.00-inch OD split-spoon sample

▽ ATD Groundwater level at time of drilling

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Kirkland, Washington 98034-6918

AGRA Earth and Environmental, Inc.

Drilling method: *HSA/MR* Hammer type: *Automatic* Date drilled: *13 November 1997* Logged by: *CRT*

PROJECT: *Hoquiam River Crossing* W.O. *7-91M-11957-0* BORING NO. *B-3*

DEPTH (feet)	SOIL DESCRIPTION Location: *Upstream crossing - 16 feet west of river* Approximate ground surface elevation: *13 feet*	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE (▲ Standard, △ Other; Blows per foot 0 10 20 30 40 50)	Page 3 of 3 TESTING
60	*Hard, moist to wet, greenish-gray with brown, clayey SILT with some fine sand, green silt clasts, mica flakes and white volcanic ash (Siltstone)*		S-13		68*	PL=41 LL=53 PI=12 Analytical Testing
65			S-14			
					← *Proposed Pipeline Invert*	
70			S-15		85	
75			S-16		54	
	Boring terminated at approximately 76.5 feet					
80						
85						
90						

MOISTURE CONTENT (0 20 40 60 80 100)

Plastic limit — Natural — Liquid limit

LEGEND

2.00-inch O.D. split spoon sample

3.00-inch OD split-spoon sample

ATD Groundwater level at time of drilling

* Blow count conversion to S.P.T.

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Kirkland, Washington 98034-6918

AGRA Earth and Environmental, Inc.

Drilling method: *HSA/MR* Hammer type: *Automatic* Date drilled: *13 November 1997* Logged by: *CRT*

PROJECT: *Hoquiam River Crossing* W.O. *7-91M-11957-0* BORING NO. *B-4*

DEPTH (feet)	SOIL DESCRIPTION Location: *Downstream crossing - 10 feet west of river* Approximate ground surface elevation: *12 feet*	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE	TESTING
0	*Surface grass over TOPSOIL*					
	Medium stiff, moist, brown-gray, sandy SILT, with some clay, gravel, wood chunks and organics (Dike Fill)	I	*S-1*			
5	*Very soft, wet, brown-gray, clayey SILT with some fine sand and organics*	I	*S-2*	P / ATD		
	Very soft, wet, gray with black, clayey SILT with some fine sand, wood chunks, root fibers and organics					
10		I	*S-3*			
15		I	*S-4*			
20	*Very soft, wet, gray, clayey SILT with some fine sand, organics, root fibers and mica flakes*	I	*S-5*			
25		I	*S-6*			
30	*(Continued)*					

LEGEND

- I 2.00-inch O.D. split spoon sample
- II 3.00-inch OD split-spoon sample
- ATD Groundwater level at time of drilling
- P / ATD Perched groundwater level at time of drilling

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ENGINEERING GLOBAL SOLUTIONS
11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

AGRA Earth and Environmental, Inc.

Drilling method: *HSA/MR* Hammer type: *Automatic* Date drilled: *13, 14 November 1997* Logged by: *CRT*

PROJECT: *Hoquiam River Crossing* W.O. *7-91M-11957-0* BORING NO. *B-4*

Location: *Downstream crossing - 10 feet west of river*
Approximate ground surface elevation: *12 feet*

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE (Standard ▲ / Other △, Blows per foot 0–50)	TESTING
30	*Very soft, wet, gray, clayey SILT with some fine sand, trace organics and root fibers*	I	S-7			
35		I	S-8			
	Medium stiff, wet, gray, clayey SILT with some sand, trace gravel and organics interbedded with loose, wet, gray, silty, gravelly SAND					
40	*Very stiff, wet, greenish-gray, clayey SILT with some fine sand and fine sand laminae and trace white volcanic ash*	I	S-9			
45		I	S-10			
50		I	S-11			
	Hard, moist to wet, greenish-gray, clayey SILT with some fine sand and trace fine sand laminae and white volcanic ash (Siltstone)					
55		I	S-12			
60	*(Continued)*					

MOISTURE CONTENT (0, 20, 40, 60, 80, 100)

Plastic limit — Natural — Liquid limit

LEGEND

- 2.00-inch O.D. split spoon sample
- 3.00-inch OD split-spoon sample
- ATD Groundwater level at time of drilling

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Kirkland, Washington 98034-6918

AGRA Earth and Environmental, Inc.

Drilling method: *HSA/MR* Hammer type: *Automatic* Date drilled: *13, 14 November 1997* Logged by: *CRT*

PROJECT: *Hoquiam River Crossing* W.O. *7-91M-11957-0* BORING NO. *B-4*

SOIL DESCRIPTION

Location: *Downstream crossing - 10 feet west of river*

Approximate ground surface elevation: *12 feet*

DEPTH (feet)	SOIL DESCRIPTION	SAMPLE NUMBER	PENETRATION RESISTANCE (Blows per foot)	TESTING
60	*Hard, moist to wet, greenish-gray, clayey SILT with some fine sand, trace fine sand laminae and white volcanic ash (Siltstone)*	*S-13*		
65		*S-14*		
70	*Hard, moist to wet, greenish-gray, clayey SILT with some fine sand and trace fine gravel (Siltstone)*	*S-15*		
75		*S-16*		
80		*S-17*	*55**	*Analytical Testing*
85	*Very stiff to hard, moist to wet, greenish-gray clayey SILT with some fine sand and white volcanic ash (Siltstone)*	*S-18*		
90	*(Continued)*			

PENETRATION RESISTANCE: ▲ Standard — Blows per foot — △ Other (0, 10, 20, 30, 40, 50)

MOISTURE CONTENT (0, 20, 40, 60, 80, 100): Plastic limit — Natural — Liquid limit

LEGEND

- 2.00-inch O.D. split spoon sample
- 3.00-inch OD split-spoon sample
- ATD Groundwater level at time of drilling
- * Blow count conversion to S.P.T.

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ENGINEERING GLOBAL SOLUTIONS
11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

AGRA Earth and Environmental, Inc.

Drilling method: *HSA/MR* Hammer type: *Automatic* Date drilled: *13, 14 November 1997* Logged by: *CRT*

PROJECT: *Hoquiam River Crossing* W.O. *7-91M-11957-0* BORING NO. *B-4*

DEPTH (feet)	SOIL DESCRIPTION Location: *Downstream crossing - 10 feet west of river* Approximate ground surface elevation: *12 feet*	SAMPLE TYPE	SAMPLE NUMBER	GROUND WATER	PENETRATION RESISTANCE ▲ Standard · Blows per foot · △ Other 0 10 20 30 40 50	Page 4 of 4 TESTING
90	*Clayey SILT - as above*		*S-19*		▲	
	Boring terminated at approximately 91.5 feet					
95						
100						
105						
110						
115						
120						

MOISTURE CONTENT

0 20 40 60 80 100

Plastic limit Natural Liquid limit

LEGEND

2.00-inch O.D. split spoon sample

3.00-inch OD split-spoon sample

ATD Groundwater level at time of drilling

AGRA Earth and Environmental, Inc.

AGRA Earth & Environmental
ENGINEERING GLOBAL SOLUTIONS
11335 NE 122nd Way, Suite 100
Kirkland, Washington 98034-6918

Drilling method: *HSA/MR* Hammer type: *Automatic* Date drilled: *13, 14 November 1997* Logged by: *CRT*

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OLYMPIA

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NO. 4 VANCOUVER 96663
4200 MAIN STREET
NO. 5 YAKIMA 98901
P. O. BOX 52
NO. 6 SPOKANE 99205
N. 2714 MAYFAIR ST.
NO. 7 SEATTLE 98109
509 FAIRVIEW AVE. NO.

July 16, 1968

Mr. George Stevens
Bridge Engineer
Room 641
Highways-Licenses Building
Olympia, Washington

C.S. 1416, SR-101, L-3092
Aberdeen - Hoquiam One-Way Couplet
Foundation Investigation

Dear Sir:

The foundation investigation for the subject structure consisted of four test borings. The test hole locations and the foundation soil stratification are shown on the attached soil profile.

The foundation consists of fine grained friable sandstone bedrock overlain by 70 to 160 ft of very loose to loose silt, silty clay and silty fine sand. The sandstone dips on a 4:1 slope from Pier 1 to Pier 5 at which point it becomes essentially horizontal.

The 3- to 5-ft approach embankments should be stable; however, they will be subjected to 0.3 to 0.5 ft of settlement which should occur over a period of years. Fill settlement could be virtually eliminated by placing a small overload on each of the embankments. A 3-ft overload left in place for approximately 3 months should reduce fill settlement to a tolerable magnitude.

Pile support is recommended for all piers. The piling will, with the possible exception of those beneath Pier 6, develop bearing in the underlying sandstone. The depth to sandstone at Pier 6 is in the order of 160 ft which appears to be excessive and therefore, it may be preferable to use an essentially skin friction pile rather than attempting to penetrate to the sandstone. The lift span piers (4 and 5) are to be supported by 6-ft diameter cast-in-place piling. It is our opinion that casing should be required throughout the total length of the shaft with the casing being driven into the sandstone to insure that no sloughing occurs at the pile tips. This is quite important since it is our understanding that these piers can tolerate very little if any settlement. It is also suggested that the casing be left in place since extraction of the casing would be very critical due to the very high water head. In order to safely support the design load of ~~500~~ tons per pile, it will be necessary that the shafts extend approximately 10 ft into the sandstone.

825
PER 7/25/68
IDC

Detailed foundation recommendations, including pile tip elevations where applicable, are attached.

Very truly yours,

C. G. PRAHL, P.E.
DIRECTOR OF HIGHWAYS

By: R. V. LE CLERC, P.E.
MATERIALS ENGINEER

CGP:ar
RVL/AJP/JMB

cc: R. W. Kerslake
D. B. House
V. G. Rinehart
BPR

Attach: 1. Data Summary Sheets
2. Soil Profile
3. Foundation Recommendations

Check Cont. Plans 1-22-69 RW

WASHINGTON STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
MATERIALS LABORATORY

FOUNDATION DESIGN RECOMMENDATIONS

S.H NO. SR-101 PROJECT Hoquiam River Bridge

JOB NUMBER L-3092 CONTROL SECTION 1416 DATE

PIER NO.	STATION	PILE SUPPORT	MINIMUM TIP ELEVATION	SPREAD FOOTINGS	FOOTING ELEV. AS SHOWN ON LAYOUT	RECOMENDED FOOTING ELEVATION	ALLOWABLE BEARING VALUE
1	158+81	yes	-55 *	--	--	--	--
2	159+34	yes	-68 *	--	--	--	--
3	159+85	yes	-80 *	--	--	--	--
4	160+49	yes	-100 **	--	--	--	--
5	162+83	yes	-162 **	--	--	--	--
6	163+46	yes	***	--	--	--	--

REMARKS: Water table is at river elevation.

*This is the approximate elevation of bedrock and all piles should be driven to practical refusal in bedrock.

** 6 ft diameter concrete piles should be predrilled approximately 10 ft into competent sandstone, approximately the elevation shown.

*** To be determined by test pile.

APPROACH FILLS

STABILITY The proposed 3 to 5 ft approach fills should be stable.

SETTLEMENT 0.3 to 0.5 ft of settlement is anticipated occurring over several years. A 3 ft overload for 3 months will reduce future settlement to a tolerable magnitude.

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UNDISTURBED SAMPLES - TEST DATA

P S.H.No. 9 Section Hoquiam Riv. Br.

Job No. L3092 Date Sampled Oct. 1967

Field Sample No.	Lab.No.	Station & Offset	Depth	Description	% H_2O	Density Wet (#/ft^3)	One-Half Unconfined Compressive Strength (#/ft^2)	Cohesion (#/ft^2)	Angle of Internal Friction
Hole #	H-1	159+08							
D-1	39939	℄	0' - 2'	Red-brn silt, trace org. mat'l.			I.D. only		
U-2-B	40-1		6' 4" - 6' 8"	Gray org. silty clay	85.9	90.9	310		
C	2		6' 8" - 7' 0"	Gray highly org. soft clay	81.9	92.8	Consol		
D-4	41		10' - 12'	Brn silt, sand pockets			I.D. only		
U-5-A	42-1		12' 0" - 12' 4"	Gray silty clay - trace fine sand	71.7	96.8		200	4
U-6-C	43-1		16' 6" - 16' 10"	Gray clay silt	64.3	99.5	500		
D	2		16' 10" - 17' 2"	Gray silt	66.1	98.8	Consol		
D-7	44		18' - 20'	Brn silt, sand pockets			I.D. only		
U-8-B	45-1		21' 4" - 21' 8"	Gray clay silt, trace fine sand	71.5	96.1		275	5
D-9	46		23' - 25'	Gray silt			I.D. only		
U-10-D	47-1		26' 10" - 27' 2"	Gray clay-silt	78.5	95.5	430		
E	2		27' 2" - 27' 6"	Gray silt	71.7	96.1	Consol		
D-11	48		28' - 30'	Gray fine sandy silt			I.D. only		
U-12-B	49-1		31' 2" - 31' 6"	Gray decomposing siltstone to 1"	66.8	103.4		250	8
D-13	50-1		33' - 35'	Gray gravelly sand, clay binder			I.D. only		
D-14	2		36' - 38'	Gray silty sand			"		
U-15-A	51-1		41' 0" - 41' 4"	Gray silty fine sand, 1/4" silt layers	37.6	107.7		50	20
U-17-B	52-1		51' 4" - 51' 8"	Gray fine sandy clay-silt	61.8	100.1		100	5
C	2		51' 8" - 52' 0"	Gray silt, trace fine sand	59.0	99.1	Consol		

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UNDISTURBED SAMPLES - TEST DATA

P S.H.No. 9 Section Hoquiam Riv. Br.

Job No. L3092 Date Sampled Oct 1967

Field Sample No.	Lab.No.	Station & Offset	Depth	Description	% H_2O	Density Wet (#/ft^3)	One-Half Unconfined Compressive Strength (#/ft^2)	Cohesion (#/ft^2)	Angle of Internal Friction
D-18	B9953		56.5'-58.5'	Gray silt			I.D. only		
U-19-D	54-1		61' 10" / 62' 2"	Gray sandy org. silt, some pea-gravel	63.2	97.1		250	15
D-20	55-1		66' - 68'	Gray silty very fine sand			I.D. only		
D-21	2		71.5' - 71.8'	" " " " "			"		
D-22	3		73' - 78'	Gray fine grained sandstone			CORE		
Hole #	H-2	163+37							
D-1	B9956	30' Lt.	6' - 8'	Gray clay silt			I.D. only		
U-2-C	57-1		11' 8" / 12' 0"	Gray mottled highly org. silt	60.1	97.8		30	9
D	2		12' 0" / 12' 4"	Gray silt, trace fine sand	56.1	101.8	Consol		
D-3	58		13' - 15'	Gray fine sandy silt			I.D. only		
U-4-C	59-1		16' 8" / 17' 0"	Gray silt, trace organic	60.2	99.1		30	13
D	2		17' 0" / 17' 4"	Gray silt	53.5	107.0	Consol		
D-5	60		18' - 20'	Gray fine sandy silt			I.D. only		
U-6-D	61-1		22' 0" / 22' 4"	Gray silt	59.5	101.4		340	13
D-7	62		23' - 25'	Gray fine sandy silt			I.D. only		
U-8-C	63-1		26' 8" / 27' 0"	Gray silt, sand lenses	53.1	105.4		380	10
D-9	64		28' - 30'	Gray silt			I.D. only		
U-10-C	65-1		31' 8" / 32' 0"	Gray sandy silt, trace clam shells	49.7	106.7		0	25
D-11	66		33' - 35'	Gray fine sandy silt			I.D. only		

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UNDISTURBED SAMPLES - TEST DATA

P S.H.No. 9 Section Hoquiam Riv. Br.

Job No. L 3092 Date Sampled Oct. 1967

Field Sample No.	Lab.No.	Station & Offset	Depth	Description	% H2O	Density Wet (#/ft³)	One-Half Unconfined Compressive Strength (#/ft²)	Cohesion (#/ft²)	Angle of Internal Friction
U-12-C	B9967-1		36' 8" 37' 0"	Gray silty fine sand	33.9	111.3		250	26
D-13	68		38' - 40'	" " " "			I.D. only		
U-14-C	69-1		41' 8" 42' 0"	Alternate layers silty clay & silty sand	57.5	96.8		50	11
D-15	70-1		43' - 45'	Gray silty fine sand			I.D. only		
D-16	2		47' - 49'	" " " "			"		
U-17-B	71-1		51' 4" 51' 8"	Gray silty fine sand, trace org.	35.3	114.3		230	25
D-18	72		57' - 59'	Gray silty fine sand			I.D. only		
U-19-A	73-1		61' 0" 61' 4"	Gray sandy clay, trace org.	53.7	102.1		50	5
B	2		61' 4" 61' 8"	Gray fine sandy silt	55.1	101.1	Consol		
C	3		61' 8" 62' 0"	Gray silt, fine sand lenses	46.4	108.7		40	12
D-20	74		66' - 68'	Gray silty fine sand			I.D. only		
U-21-B	75-1		71' 4" 71' 8"	" " " "	42.9	104.7		130	22
D-22	76-1		77' - 78'	Gray gravelly sandy silt, gravel to ½"			I.D. only		
D-23	2		81' - 83'	" " " ", gravel to ¾"			"		
D-24	3		86' - 88'	" " " ", gravel to ½"			"		
D-25	4		91' - 93'	Gray fine sandy silt			"		
D-26	5		97' - 99'	" " " "			"		
D-27	6		102' - 104'	Gray pea-gravelly sandy silt			"		
U-28-C	77-1		107' 8" 108' 0"	Gray silty clay, sand lenses	47.7	100.8	I.D. only		
D	2		108' 0" 108' 4"	Gray silt, fine sand lenses	56.0	97.1	Consol		

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UNDISTURBED SAMPLES – TEST DATA

P S.H.No. 9 Section Hoquiam Rv. Br.
Job No. L3092 Date Sampled Oct. 1967

Field Sample No.	Lab.No.	Station & Offset	Depth	Description	% H2O	Density Wet (#/ft^3)	One-Half Unconfined Compressive Strength (#/ft^2)	Cohesion (#/ft^2)	Angle of Internal Friction
D-28-E	B9977-3		108' 4" – 108' 8"	Gray silt, sand lenses	48.8	100.4		0	20
D-29	78-1		117'-119'	Gray silt			I.D. only		
D-30	2		127'-129'	Gray silt, trace fine sand			"		
D-31	3		137'-139'	Gray silt			"		
D-33	4		157'-159'	Gray very fine sandy silt			"		
D-34	5		161.5'-161.6'	Gray highly fract. basalt			CORE		
Hole #	H-3	160+20							
D-1	C193-1	5' Lt.	0' - 4'	Blk highly org. silt			I.D. only		
D-2	2		5.5'-7.5'	Blk soft silt			"		
D-3	3		12' - 14'	Dk gray soft silt			"		
D-4	4		18' - 20'	Dk gray org. silt			"		
D-5-A	5		24'-24.5'	Dk gray org. silt, trace pea-grav.			"		
B	6		24.5'-26'	Dk gray silt, lumps of clay			"		
D-6	7		27'-29'	" " " " " "			"		
D-7	8		32'-34'	Gray silty fine sand, wood chips			"		
D-8	9		37.5'-39.5'	Gray silt, fine sand pockets			"		
D-9	10		40'-42'	Gray silt, fine sand lenses			"		
D-10	11		47'-49'	Gray sandy silt, wood chips			"		
D-12	12		64'-65'	Gray silty sandy gravel to 3/4"			"		

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DEPARTMENT OF HIGHWAYS
Materials Laboratory

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UNDISTURBED SAMPLES - TEST DATA

P S.H.No. 9 Section Hoquiam Riv. BR.

Job No. L3092 Date Sampled Oct. 1967

Field Sample No.	Lab.No.	Station & Offset	Depth	Description	% H2O	Density Wet (#/ft3)	One-Half Unconfined Compressive Strength (#/ft2)	Cohesion (#/ft2)	Angle of Internal Friction
D-13	C193-13		70'-72'	Gray fine sandy silt			I.D. only		
D-14	14		74.5'-76.5'	Gray silty sand, trace gravel to 1¼"			"		
D-15	15		78'-80'	Gravel, grav. to ½" sub-angl.			"		
D-16	16		83'-83.5'	Gray silty fine sand			"		
D-17	C194		83.5'-86'	Gray friable clay filled sandstone			CORE		
Hole #	H-4	162+75							
D-1	C248-1	℄	0'-2'	DK. gray soft silt			I.D. only		
D-2	2		2.5'-4.5'	" " " "			"		
D-3	3		10'-12'	Gray soft silt, trace gravel to ¾"			"		
D-4	4		14.5'-16.5'	Gray silty fine sand			"		
D-5	5		19'-21'	" " " "			"		
D-6	6		25'-27'	" " " "			"		
D-7	7		30'-32'	" " " "			"		
D-8	8		36'-38'	" " " "			"		
D-9	9		42'-44'	" " " "			"		
D-10	10		47'-49'	Gray silty sandy gravel to ¾" sub-angl.			"		
D-11	11		54'-56'	Gray silty sand, trace pea-gravel			"		
D-12	12		59'-61'	Gray alternate layers clay & fine sand			"		
D-13	13		64.5'-66.5'	" " " " & " "			"		

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UNDISTURBED SAMPLES - TEST DATA

P S.H.No. 9 Section Hoquiam Riv. Br.

Job No. L3092 Date Sampled Oct. 1967

Field Sample No.	Lab.No.	Station & Offset	Depth	Description	% H2O	Density Wet (#/ft3)	One-Half Unconfined Compressive Strength (#/ft2)	Cohesion (#/ft2)	Angle of Internal Friction
D-14	C248-14		70'-72'	Gray silty clay & very fine sand			I.D. only		
D-15	15		76'-78'	Gray silty very fine sand			"		
D-16	16		81'-83'	Gray silty clay, some fine sand			"		
D-17	17		88'-90'	Gray clay silt, fine sand lenses			"		
D-18	18		96'-98'	" " " , " " "			"		
D-19	19		103'-105'	Gray silty sand, 1½" silty clay			"		
D-20	20		111'-113'	Gray silty clay			"		
D22	22		126'-128'	Gray sandy silt, 1" sandy clay			"		
C-24	C291		133'-136'	Gray sandstone			Core		

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FILE

Washington State
Department of Transportation

Memorandum

March 1, 2004

TO: J. Kapur/M. Anderson
Bridge and Structures, 47340

FROM: T.M. Allen/D.V. Jenkins
EEP Geotechnical Division, 47365

SUBJECT: SR101, XL1640A
Hoquiam River and Simpson Avenue Bridge 101/125W
Maintenance Turnout
Geotechnical Report

Attached with this memorandum is the *Geotechnical Report* for the design and construction of the proposed maintenance turnout for the Hoquiam River – Simpson Avenue Bridge 101/125W. The report addresses the following:

- Field investigation and testing
- Subsurface conditions and site seismicity
- Recommendations for drilled shaft foundations
- Construction considerations

If you have questions or require further information, please contact David Jenkins at (360) 709-5455 or Jim Cuthbertson at (360) 709-5452.

TMA
DTM:dtm
Enclosure

cc: John Hart, OR, WA48
Mike Morishigi, OR, 47440
Mel Hitzke, OR, 47440
Mohammad Sheikhizadeh, Bridge Construction Engineer, 47354
Alex Young, Bridge and Structures, 47340

GEOTECHNICAL REPORT

Hoquiam River – Simpson Bridge No. 101/125W – Maintenance Turnout

Grays Harbor County, Washington

XL-1640A

Tony M. Allen, P.E.
State Geotechnical Engineer

3/3/04

TONY M. ALLEN
STATE OF WASHINGTON
25339
REGISTERED
PROFESSIONAL ENGINEER

EXPIRES 07-01-05

Prepared by:
David V. Jenkins, L.E.G.
Consultant Liaison Engineer

Reviewed by:
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Chief Foundation Engineer

March 1, 2004

Washington State Department of Transportation
Douglas MacDonald
Secretary of Transportation

Environmental and Engineering Programs Division
Materials Laboratory
Geotechnical Division
P.O. Box 47365
Olympia, WA 98504-7365

Contents

1. INTRODUCTION

1.1. GENERAL

This report presents the results of our geotechnical investigation for the addition of the maintenance turnout of the SR-101 Hoquiam River – Simpson Avenue Bridge No. 101/125W. A vicinity map illustrating the project location is presented in Figure 1, Appendix A. Figure 2 presents a plan view showing the locations of all field test borings and Figure 3 provides a profile view showing the details of the subsurface conditions present at the site. This report provides geotechnical recommendations in LRFD format for foundation support of the new bridge. When the PS&E is completed for this project, our office will provide a *Summary of Geotechnical Conditions* for inclusion in the Special Provisions.

The analyses, conclusions, and recommendations provided in this report are based on the project description, and site conditions existing at the time of the field explorations. The exploratory borings are assumed to be representative of the subsurface conditions throughout the project area. If during construction, subsurface conditions differ from those described in the explorations, we should be advised immediately so that we may reevaluate our recommendations and provide assistance.

1.2. PROJECT DESCRIPTION

The existing bridge consists of a 1978 ft long double bascule bridge constructed in 1927 under contract C1084. All piers of the bridge are supported on low capacity timber piles. The maintenance turnout bridge will be constructed south of the westerly approach between timber bents #36 and #39. The parking structure is supported on two columns. The single span structure is 46.5 ft long and approximately 13 ft wide. This new structure will be used to park vehicles during bridge inspection, maintenance and lift span operation. A sidewalk, cantilevered off the existing bridge, will be constructed between the parking structure and lift-span control house. A pre-cast concrete flat slab will support the roadway section of the parking structure. We understand the maintenance turnout will be structurally independent of the existing bridge. We are proposing that both piers of the maintenance turnout structure be supported on drilled shafts utilizing permanent steel casing during construction.

2. PROJECT SUBSURFACE CONDITIONS

Subsurface conditions in the project area were explored by rotary drilling, standard penetrometer testing, cone penetrometer testing and a laboratory testing program. Appendix C provides a detailed discussion and all test hole data obtained in the field exploration program. Please note that the edited logs of the test borings should be made available to all prospective bidders, and included in the contract documents. Appendix D provides a discussion and all data obtained in the laboratory testing program.

2.1. Regional Geology

The geological units identified in the area are generally grouped based on geologic history and engineering characteristics. Quaternary alluvium is predominantly silt and/or sand with lesser and varying amounts of clay, organics, sea shells and gravel. The alluvium is typically very loose to loose in the upper 70 ft and increases in density with depth to loose to medium dense. In addition, the density of the material also increases with grain size (i.e. sand zones are typically more dense than silt zones).

At a depth of between 125 and 134 ft below the existing ground surface, the alluvium is underlain by Tertiary sedimentary bedrock. The sedimentary bedrock likely corresponds to the Montesano Formation mapped on the hills a few thousand feet north and east of the bridge site. Based on material recovered from the standard penetration test, we have interpreted the bedrock to consist of a conglomerate. A conglomerate is a weakly cemented sedimentary rock consisting of sand and gravels cemented with either silica and/or calcium carbonate. The Montesano Formation is described as middle to upper Miocene marine sedimentary rock consisting of coarse to fine grained sandstone, conglomerate, siltstone and mudstone.

2.2. Site Surface Conditions

A site plan illustrating the locations of test holes and surface features is provided in Appendix A, Figure 2. The topography in the area is quite level with a very gentle slope breaking to the Hoquiam River. This area represents old tidal mud flats typical of land surrounding Grays Harbor. The elevation of the existing ground surface is approximately 12 ft above mean sea level.

2.3. Site Subsurface Conditions

The soil deposits encountered in the test borings at the Hoquaim River - Simpson Avenue Bridge have been grouped into soil units for geotechnical distinction. The soil units are grouped primarily on the basis of engineering properties and classification, and in general, reflect depositional environments as well. Subsurface profiles for the structure illustrating subsurface data and the interpreted conditions are provided in Appendix A, Figure 3.

Four soil units were identified during the field investigation. They are as follows:

Unit 1 generally consists of very loose sandy silt with organics. Based on test boring TH-1-03, creosote treated piling and old concrete and brick foundations may be encountered in the upper portion of this unit. Unit 1 varies in thickness between 30 and 40 ft.

Unit 2 consists of very loose to medium dense stratified layers of silty sand, poorly graded sand and sandy silt. All layers contain varying amounts of organics and sea shells. This layer averages 60 ft in thickness.

Unit 3 consists of a very loose to loose sandy silt with organics. This layer varies in thickness between 24 and 30 ft.

Unit 4 consists of a very dense conglomerate sedimentary rock. Conglomerate is composed of cemented gravels and sand. The contact elevation of this layer varies between –114 ft and –117 ft.

Logs of test boring and cone penetrometer data are contained in Appendix C. Laboratory test data is contained in Appendix D.

3. GROUND WATER

Piezometers were not installed to monitor groundwater. Groundwater level observed during test drilling indicated water levels consistent with the water elevation in Hoquiam River. This area of the Hoquiam River is affected by tidal changes therefore the groundwater elevation is expected to vary daily with tide fluctuation.

4. SEISMOLOGICAL CONSIDERATIONS

4.1. SITE SEISMICITY

A convergence of the North American crustal plate and Juan de Fuca Plate is situated west of the project. The Juan de Fuca plate is subducting beneath the North American plate resulting in tectonic strain accumulation along the interface. The plate convergence can result in shallow earthquakes along the plate interface (thrust events), deep earthquakes within the subducted Juan de Fuca plate (intraplate normal-faulting events), and shallow earthquakes within the North American crust.

4.2. DESIGN EARTHQUAKE PARAMETERS

For Seismic Design, an acceleration coefficient of 0.3g is recommended for this structure in accordance with the WSDOT Bridge Design Manual.

Design response spectra presented in the AASHTO guide specifications for seismic design of highway bridges are considered appropriate for seismic design. A type III soil profile response spectrum, with a site coefficient of 1.5 is recommended for seismic design. These recommendations are based on our review of a reported titled "WSDOT Special Bridges Seismic Evaluation, Aberdeen Washington" dated June 1997 prepared by Shannon and Wilson Inc.

4.3. LIQUEFACTION POTENTIAL

Liquefaction of saturated sands occurs when the sands are subject to cyclic loading. The cyclic loading causes the water pressure to increase in the sand reducing the intergranular stresses. As the intergranular stresses are reduced, the shearing resistance of the sand decreases. If pore pressures develop to the point where the effective stresses acting between the grains become zero, the soil will behave like a viscous fluid. Under this condition soil flow is possible. The effect of liquefaction can range from reduced shear strength to viscous fluid behavior.

The liquefaction potential of saturated soils is evaluated mainly on soil gradation, relative density, and the depth of the deposit, i.e., the vertical effective overburden stress. The potential for liquefaction is highest for loose, fine to medium grained, sandy and silty soils. Increasing fines content, i.e., silt and clay, decreases the potential for liquefaction. If a deposit has greater than 35% fines it is usually considered to be non-liquefiable. Due to their high hydraulic conductivity, gravel soils are less susceptible to liquefaction; however, they can liquefy depending on their fines content, thickness, areal extent and/or the drainage conditions at their boundaries. The potential for liquefaction of all cohesionless, granular soils decreases with increasing depth and relative density.

At the site of Hoquiam River-Simpson Bridge, the upper portion of unit 2 has many of the characteristics of liquefiable soils, i.e., it is loose, saturated and has relatively low fines content. The fines content of the unit varies between 7 and 61 percent. Ten of the 15 tested samples from unit 2 had fines contents from 7 to 30 percent.

Liquefaction potential of unit 2 was based on SPT results and was evaluated using the simplified procedure proposed by Seed and Idriss, 1982. An acceleration of 0.30g was assumed. The liquefaction analysis indicated that within unit 2 the factor of safety against liquefaction is generally less than 1.0. Current state-of-practice is to assume that liquefaction may occur at factors of safety less than 1.1. The liquefiable zone used in the subsequent analyses, e.g., calculation of downdrag loads, was assumed to lie between the elevations of 5 and -55 feet. The upper soil Unit 1 is assumed to contribute to downdrag forces along with approximately the upper 30 ft of Unit 2.

4.4. LIQUEFACTION INDUCED LATERAL SPREADING AND STRAIN

Although no embankments are planned for construction of the maintenance turnout the risk of lateral spreading from the sloping ground between the structure and river is moderate. However, designing this structure to withstand lateral spreading is cost prohibitive.

5. GEOTECHNICAL RECOMMENDATIONS

5.1. DRILLED SHAFT FOUNDATION RECOMMENDATIONS PIER 1 AND 2

A drilled shaft foundation is recommended for support of both piers. Drilled shafts transfer the load to deeper, more competent strata thus they will support the bridge if the upper soils settle due to the liquefaction of unit 2. Piles are not recommended due to the potential for pile driving induced liquefaction that could result in settlement of the existing pile supported bridge.

Recommendations for drilled shaft design are given below. Enclosed in Appendix A, Figure 4, shows the ultimate capacity for service, strength and extreme event limit states for Pier 1 and 2, for 6 ft diameter shafts. The figures show the net load that can be applied at the top of the shaft.

The weight of the shaft has not been deducted from the compressive capacity in the figures and is not included in the uplift capacity.

The capacity figures for shafts at Piers 1 and 2 are for 6 ft diameter. Separate plots for ultimate skin friction (Q_s) and ultimate end bearing (Q_p) are provided on the figures. At a given depth on the figures, the factored resistance (Q') can be determined by adding the ultimate skin friction multiplied by its resistance factor (ϕ_s) and the ultimate end bearing multiplied by its resistance factor (ϕ_p) as shown in the following equation:

$$Q' = Q_s \cdot \phi_s + Q_p \cdot \phi_p$$

For the service limit state, the settlement of the shaft foundations will be less than 1 inch provided the shafts are at or below the minimum tip elevation of –126 ft. Settlement will occur as the loads are applied. Post construction settlement should be negligible. We are recommending a minimum 12 ft embedment into Unit 4 (2-shaft diameters). Based on this recommendation, a minimum tip elevation for Piers 1 and 2 has been established at -126 ft. A deeper penetration into Unit 4 may be required for lateral stability.

For axial load reduction of shaft groups we recommend a group reduction factor of 1 be used for groups with center-to-center spacing of 3b or greater. A factor of 1 is recommended since 3 or fewer shafts are expected in each shaft group.

5.2. RESISTANCE FACTORS FOR SHAFT DESIGN

We recommend that the resistance factors shown in Table 1 be used when evaluating the different limit states.

Table 1

Limit State	Resistance Factor ϕ		
	Skin Friction Qs	**End Bearing Qb**	**Uplift**
Strength	0.65	0.5	0.55
Service	1.00	1.00	N/A
Extreme	1.00	1.00	0.75

5.3. LATERAL LOAD ANALYSIS (PIERS 1, AND 2)

We have evaluated the site conditions with regard to the *Design Manual for Foundation Stiffnesses Under Seismic Loading*. Based on our review, soil conditions at Piers 1 and 2 cannot be readily correlated to any of the standard soil profiles.

For this reason P-Y curve data for lateral load analysis of the drilled shafts Piers 1 and 2 are provided in Appendix B.

We recommend that the group reduction factors shown in Table 2 be used for lateral analysis.

Table 2

Pile or Shaft Spacing	Reduction factor for multiple row groups, or in direction parallel to single row	Reduction factor for single row groups for loading perpendicular to the row.
6D	0.9	1.0
5D	0.8	1.0
4D	0.65	0.9
3D	0.5	0.8
2D	0.4	0.6

5.4. DOWNDRAG LOADS AND SIDE FRICTION LOSSES

Downdrag loads are created when the soil moves downward relative to the shaft, thus transferring load onto the shaft. Excessive downdrag loads can result in either structural failure of the shaft or bearing capacity failure of the bearing layer. The usual mechanisms that generate downdrag loads are post-construction settlements due to the placement of an embankment and/or settlements induced by the liquefaction of one or more soil layers.

Downdrag loads caused by post-construction settlements most often occur in shafts that pass through a soft, compressible soil and then bear in a stiffer layer. As the new embankment fill initiates consolidation of the softer material, the side friction forces in the fill are reversed and begin acting downward on the shaft. Hence, settlement induced downdrag loads result in the loss of the side friction capacity of the shaft in the consolidating units.

When liquefaction occurs, it results in a sudden settlement of the liquefied layer. As this layer settles, i.e., as the excess pore pressure dissipates, it creates downdrag loads on the shaft which must be carried by the lower, non-liquefied soils. Soils overlying the liquefied layer also will generate downdrag loads on the shaft as they settle in response to the liquefaction of the underlying layer. Liquefaction also results in the loss of the side friction capacity of the shaft in the liquefied zone as well as in soils overlying it.

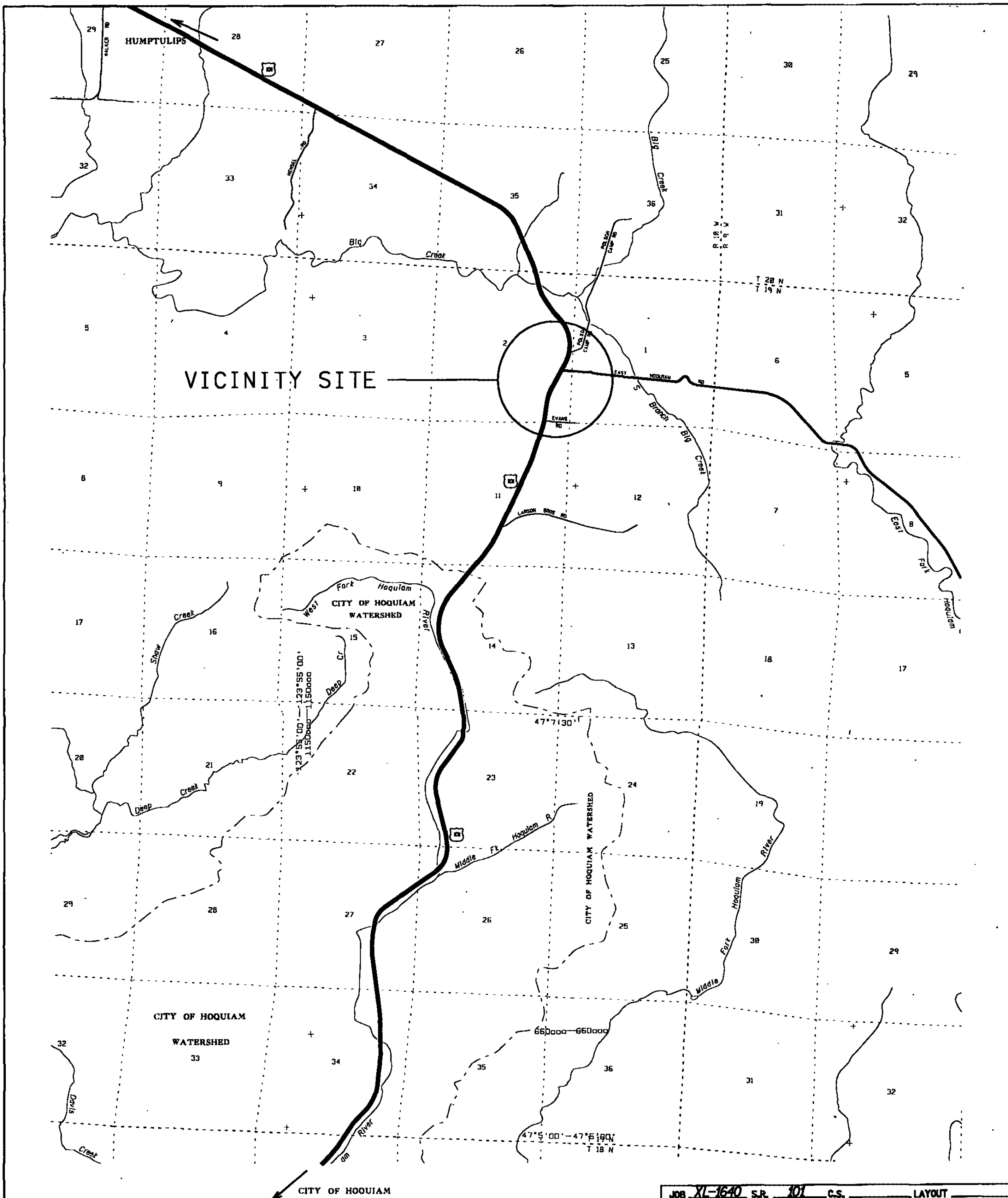
Estimated downdrag loads and side friction losses due to liquefaction induced settlements were estimated at 300 tons for 6 ft diameter shafts. The downdrag loads and side friction losses are numerically equivalent.

Downdrag loads should be added directly to the factored bridge loads when evaluating the shaft capacity required for the various limit states. Side friction losses should be subtracted from the unfactored side capacity curves (Figure 4).

6. CONSTRUCTION CONSIDERATIONS

It may be possible to drill the shafts full depth using polymer slurries, but due to the extreme looseness of the native soils, we recommend the use of permanent casing to prevent ground caving. Vibrating the casing is not recommended because of the potential of liquefaction and the effects that it may have on the existing bridge structure. Liquefaction induced settlement could result in several inches of deflection of the existing bridge. Therefore we recommend the contract specify casing advancement using a casing-oscillating or rotating method. The contract should be written to allow the use of temporary casing provided the contractor has a drill rig capable of removing the casing during shaft construction. The estimated bottom elevation of the permanent casing is –117 ft at both piers. The bottom elevation of the casing was established to insure the casing is seated several feet into the Unit 4 sedimentary rock. Slurry will be required during removal of the spoils.

APPENDIX A - FIGURES



JOB XL-1640 S.R. 101 C.S. LAYOUT

West Hoquiam Bridge Maintenance Turnout

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 2/2004
SCALE N.T.S. VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY W.M.

FIGURE 1: SITE MAP

...\revised prelim2_2.dgn 02/17/2004 07:12:55 AM

SEC. 12, T.17N., R.10W., W.M.
CITY OF HOQUIAM

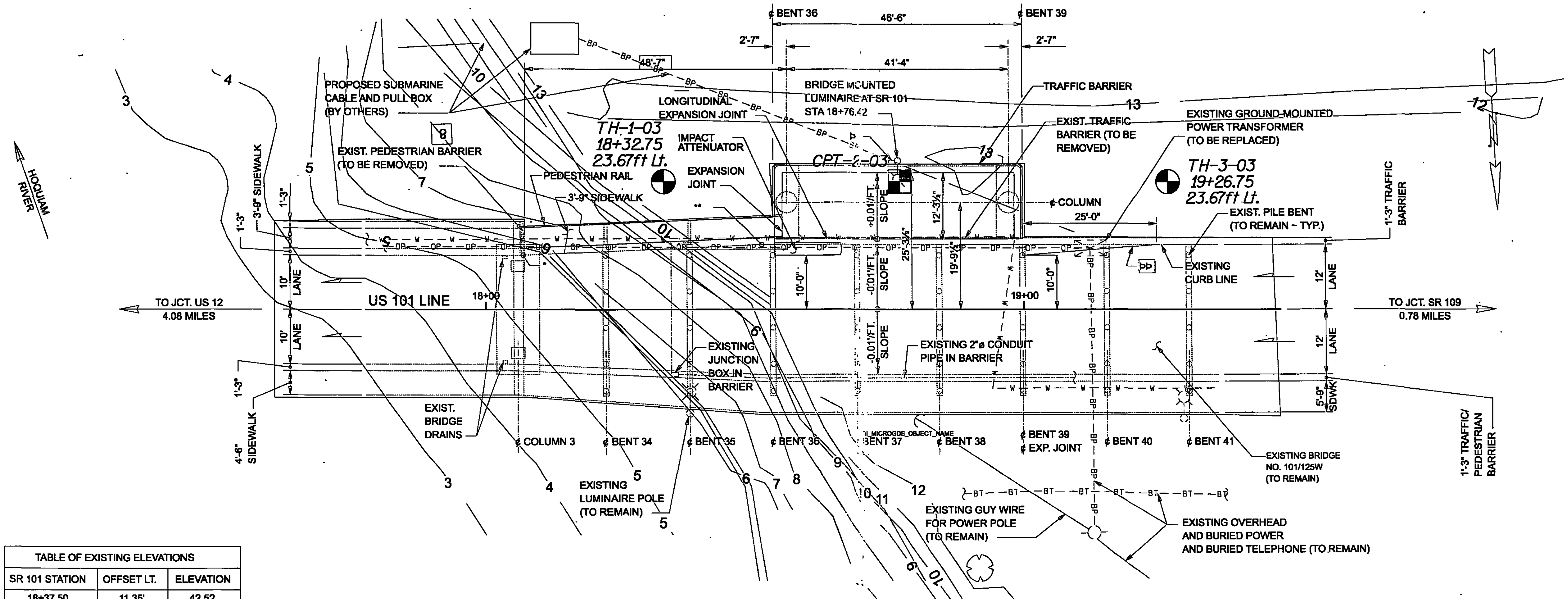


TABLE OF EXISTING ELEVATIONS		
SR 101 STATION	OFFSET LT.	ELEVATION
18+37.50	11.35'	42.52
18+68.71	12.01'	41.76
18+84.11	11.95'	41.41
19+00.07	12.08'	41.06

ELEVATIONS ARE AT TOP OF EXISTING ACP OVERLAY

Test Boring

Cone Penetrometer

FIGURE 2: PLAN

JOB XL-1640 S.R. 101 C.S. 1412

West Hoquiam Bridge Maintenance Turnout

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 2/2004
SCALE 1=20' VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY W.M.

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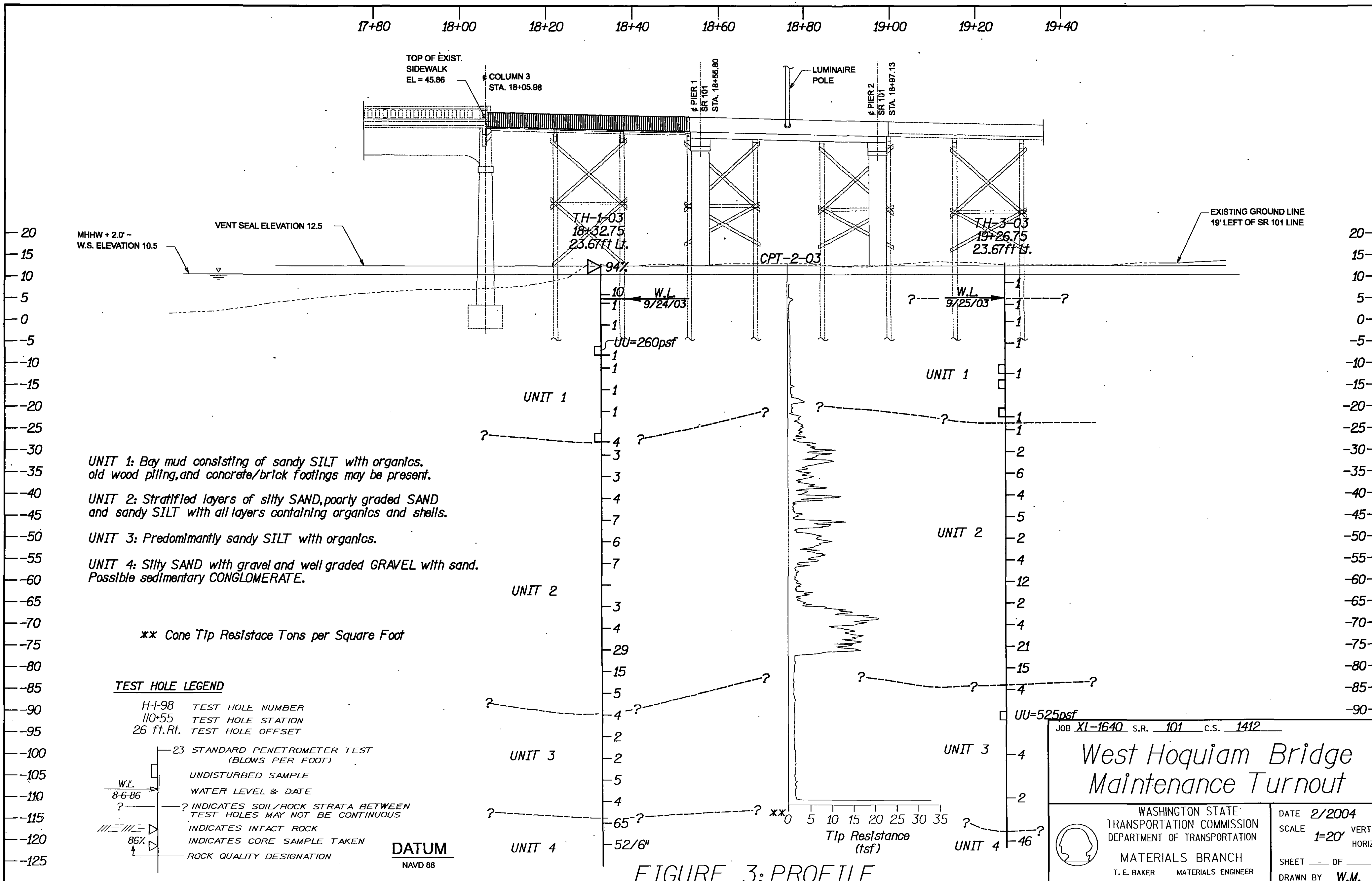


FIGURE 3: PROFILE

APPENDIX C – FIELD EXPLORATION

INTRODUCTION

The field exploration program for the project consisted of drilling 2 test borings, performing Standard Penetration Tests (SPT), and discretely sampling soil horizons. In addition 1 cone penetrometer test was performed. The information obtained during the field exploration was used in conjunction with existing information obtained from the previous studies and final construction records of the existing Hoquiam River Bridge were used to characterize the subsurface conditions throughout the project area. The edited logs of the field test are attached. The edited logs of the test borings and the results of the cone penetration test should be included in the contract documents.

TEST BORINGS

Standard Penetration Tests (SPT), in general, were performed at five-foot intervals in the test borings. Portable penetrometer tests were conducted every 1.5 feet. Disturbed soil samples from the SPT, and hand holes were visually classified in the field then submitted to the E&EP Materials Laboratory for more detailed classification and testing.

CONE PENETROMETER TESTING

Cone Penetration Testing uses a cylindrical cone, pushed vertically into the ground at a constant rate of penetration of 20mm/s. During penetration, measurements are made of the cone resistance, the side friction against the cylindrical shaft and, in piezocone tests, the pore water pressure generated at penetration by the cone.

The measurements are made and recorded using electrical devices, the frequency of the readings provides a detailed picture of the variation of the measured parameters with penetration depth. Cone diameters are 10 or 15 cm2. Depths up to 100 metres can be reached.

TEST BORING LOGS

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card S 23816

Job No. XL-1640 SR 101 Elevation 13.1 ft (4.0 m)

HOLE No. TH-3-03

Sheet 1 of 6

Project West Hoquiam Bridge - Maintenance-Turnout

Driller James Fetterly Lic# 2507

Site Address Vicinity Simpson Ave. and Hoquiam River Bridge

Inspector Cleo Andrews

Start September 24, 2003 Completion September 25, 2003 Well ID#

Equipment CME 850 w/ autohammer

Station 19+26.75 Offset 23.67' LT. Casing (HWT 4" x 12.0')(HQ 3" x 1140.0') Method Wet Rotary

Northing Easting Latitude Longitude

County Grays Harbor Subsection NW 1/4 of the SW 1/4 Section 12 Range 10 WWM Township 17 N

Depth (ft)	Meters (m)	SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater
0					Top surface crushed gravel, cobbles, boulders, straw. 0.0' to 4.5' rip-rap cobbles. boulders, sawdust fill material. 1005 drilling fluid return.	
5	1	1/18 (1)	D-1		ORGANIC SOIL, very soft, dark brown, moist, Homogeneous, no HCl reaction, (Sawdust), fill material. Length Recovered 1.0 ft, Length Retained 1.0 ft	
	2				09/25/2003	∇
10	3	1/18 (1)	D-2	GS MC	ML, MC=71% SILT with sand and organics, very loose, dark gray, moist, Stratified, no HCl reaction, (Note took moisten can MC-2a from same depth). Changed at 8.0' as indicated by drilling and wash return. Length Recovered 1.0 ft, Length Retained 1.0 ft	
15	4	1/18 (1)	D-3		SILT with sand with organics and seashell, very loose, dark gray, moist, Stratified, no HCl reaction, some pieces of wood fragement. (Took moisten can MC-3a from same depth). Length Recovered 1.5 ft, Length Retained 1.0 ft	
20	5, 6	1/18 (1)	D-4		SILT with sand with organics and seashell, very loose, dark gray, moist, Stratified, no HCl reaction, (Took moisten can sample MC-4a from same depth). Length Recovered 1.5 ft, Length Retained 1.0 ft	

Standard Penetration Blows/ft: 10 20 30 40

SOIL XL1640WEST HOQUIAM BRIDGE -MAINTENANCE-TURNOUT,SR101.GPJ SOIL.GDT 11/19/03,7:36:23 A11

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card S 23816

Job No. XL-1640 SR 101 Elevation 13.1 ft (4.0 m) HOLE No. TH-3-03

Sheet 2 of 6

Project West Hoquiam Bridge - Maintenance-Turnout Driller James Fetterly Lic# 2507

Depth (ft): 25, 30, 35, 40, 45 — Meters (m): 7, 8, 9, 10, 11, 12, 13

Standard Penetration Blows/ft: 10 20 30 40

SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
	U-5		No Recovery
1/18 (1)	D-6		SILT with sand with organics, very loose, dark gray, moist, Stratified, no HCl reaction, (Took moister can sample MC-6a from same depth). Length Recovered 1.5 ft, Length Retained 1.0 ft
	U-7 A to F		SILT with organics, very loose, dark gray, moist, Stratified, no HCl reaction, (Note sample sank with weight of rods and hammer 0 psi). Length Recovered 2.0 ft, Length Retained 2.0 ft
	U-9 A to F		SILT, very loose dark gray, moist, laminated with organic and sand lenses. Length Recovered 2.0 ft, Length Retained 2.0 ft
1/18 (1)	D-10		SILT with sand with organics, very loose, dark gray, moist, Stratified, no HCl reaction, laminated with fine grained sand lenses. (Took moister can sample MC-10a from same depth). 100% drilling fluid return. Length Recovered 1.5 ft, Length Retained 1.0 ft
1/18 (1)	D-11	GS MC	SM, MC=58% Silty SAND with organics, very soft, dark gray, moist, Stratified, no HCl reaction, (Took moister can sample MC-11a from same depth). Length Recovered 1.5 ft, Length Retained 1.0 ft
1/6 1 1 (2)	D-12	GS MC	SM, MC=56% Silty SAND, very loose, dark gray, moist, Homogeneous, no HCl reaction, traces of organic and mica sand. Very little drilling fluid loss in upper rip-rap zone. (Note

Depth (ft)	Meters (m)	SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
	14				changed to sand as indicated by drilling and wash return at 46.0'). Length Recovered 1.0 ft, Length Retained 1.0 ft
50	15	4 3 3 (6)	D-13	GS MC	SP-SM, MC=39% Poorly graded SAND with silt and organics and wood chunks, loose, grayish black, moist, Stratified, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.0 ft
55	16	2 2 2 (4)	D-14	GS MC	SM, MC=45% Silty SAND with organics and shells, very loose, dark gray, moist, Stratified, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.0 ft
60	17, 18	3 2 2 (5)	D-15	GS MC	SM, MC=37% Silty SAND with organics, very loose, dark gray, wet, Stratified, no HCl reaction. Length Recovered 1.0 ft, Length Retained 1.0 ft
65	19, 20	1 1 1 (2)	D-16	GS MC	ML, MC=58% Sandy SILT, very loose, dark gray, moist, Stratified, no HCl reaction, sand is fine grained layers are 1" and horizontal. (Took moister can sample MC-16a from same depth). Length Recovered 1.5 ft, Length Retained 1.0 ft
70	21	1 2 2 (4)	D-17		Silty SAND with organics, seashell and decayed wood debri, very loose, dark gray, moist, Stratified, no HCl reaction Length Recovered 1.0 ft, Length Retained 1.0 ft

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card S 23816

HOLE No. TH-3-03

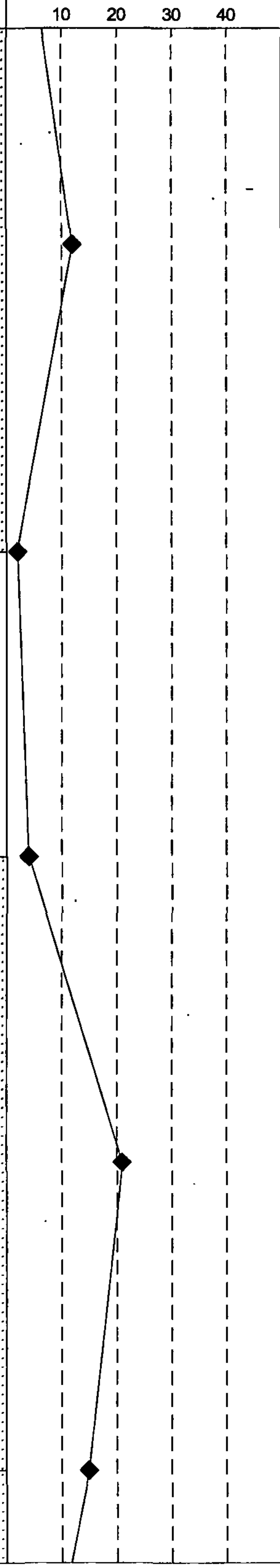
Sheet 4 of 6

Job No. XL-1640 SR 101 Elevation 13.1 ft (4.0 m)

Project West Hoquiam Bridge - Maintenance-Turnout

Driller James Fetterly Lic# 2507

Standard Penetration Blows/ft



Depth (ft) marks: 75, 80, 85, 90, 95. Meters (m) marks: 22, 23, 24, 25, 26, 27, 28.

SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
5 6 6 (12)	D-18	GS MC	SM, MC=31% Silty SAND, medium dense, dark gray, moist, Laminated, no HCl reaction, traces of organic. Length Recovered 1.5 ft, Length Retained 1.0 ft
33 2 2 (2)	D-19	GS MC	ML, MC=56% Sandy SILT with organics, sand, lenses, very loose, dark gray, moist, Laminated, no HCl reaction, some mica sand lenses. (Took moister can sample MC-19a from same depth). Length Recovered 1.5 ft, Length Retained 1.0 ft
2 2 2 (4)	D-20	GS MC	SM, MC=42% Silty SAND, very loose, dark gray, moist, Laminated, no HCl reaction, traces of wood wood particles. Length Recovered 1.5 ft, Length Retained 1.0 ft
6 11 10 (21)	D-21	GS MC	SM, MC=34% Silty SAND with organics, mica sand lenses, medium dense, dark gray, moist, Laminated, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.0 ft
8 9 6 (15)	D-22	GS MC	SP-SM, MC=25% Poorly graded SAND with silt, medium dense, dark gray, moist, Laminated, no HCl reaction Length Recovered 1.5 ft, Length Retained 1.0 ft

Groundwater | Instrument

LOG OF TEST BORING

Washington State Department of Transportation

Start Card S 23816

HOLE No. TH-3-03

Sheet 5 of 6

Job No. XL-1640 SR 101 Elevation 13.1 ft (4.0 m)

Project West Hoquiam Bridge - Maintenance-Turnout

Driller James Fetterly Lic# 2507

Depth (ft)	Meters (m)	SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
	29				
	30	2 2 2 (4)	D-23		SILT with sand with organics, wood particles, very loose, dark gray, moist, Stratified, no HCl reaction, wood particles are decayed. (Took moister can sample MC-23a from same depth). Length Recovered 1.5 ft, Length Retained 1.0 ft
100	31				
			U-24 A to F	GS MC AL UU	CH, MC=63%, PI=304 Fat CLAY with organics, very loose, dark gray, moist, Stratified, no HCl reaction, (Took 150 psi to push undisturbed sample 2.0'). Length Recovered 2.0 ft, Length Retained 2.0 ft
105	32				
	33				
110	34				
		1 1 3 (4)	D-25		SILT with sand with organics, very loose, dark gray, moist, Stratified, no HCl reaction, (Took moister can sample MC-25a from same depth). Length Recovered 1.5 ft, Length Retained 1.0 ft
115	35				
	36				
120					

Standard Penetration Blows/ft: 10 20 30 40

Columns: Profile, Sample Type, Groundwater, Instrument

Washington State
Department of Transportation

LOG OF TEST BORING

Start Card S 23816

HOLE No. TH-3-03

Job No. XL-1640 SR 101 Elevation 13.1 ft (4.0 m)

Project West Hoquiam Bridge - Maintenance-Turnout

Driller James Fetterly Lic# 2507

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	37									
125	38			1 1 1 (2)		D-26		SILT with sand with organics, very loose, dark gray, moist, Stratified, no HCl reaction, (Took moister can sample MC-26a from same depth). Note encountered some gravel at 132.0' as indicated by drilling. Length Recovered 1.5 ft, Length Retained 1.0 ft		
	39									
130	40									
135	41			9 20 26 (46)		D-27	GS MC	GW, MC=8% Well graded GRAVEL with sand, subrounded, dense, dark gray, moist, Homogeneous, no HCl reaction, (Till material). Length Recovered 0.8 ft, Length Retained 0.8 ft		
	42							Ended and abandoned hole using a bentonite cement slurry. End of test hole boring at 135 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
140	43									
145	44									

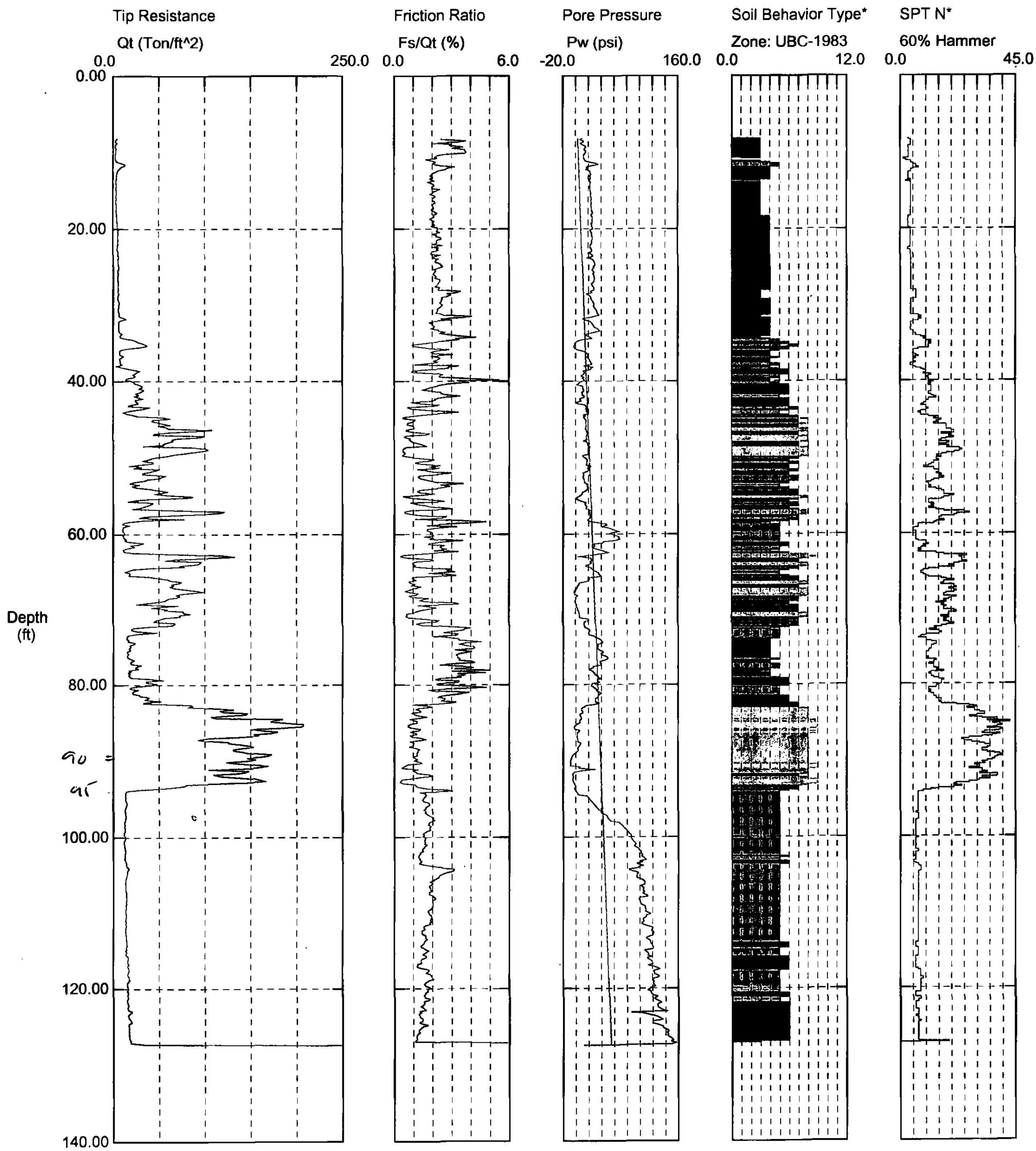
SOIL XL1640WEST HOQUIAM BRIDGE -MAINTENANCE-TURNOUT,SR101.GPJ SOIL.GDT 11/19/03,7:36:24 A11

*Soil behavior type and SPT based on data from UBC-1983

WSDOT GEOTECH DIVISION

Operator: Brian Hilts
Sounding: CPT-58
Elevation: 13.14

CPT Date/Time: 09-25-03 09:32
Location: 18+76.75 23.67 L
Job Number: XL-1640



Maximum Depth = 127.43 feet

Depth Step = 0.16 feet

1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

Sounding was pre-drilled to 8 feet.

APPENDIX D - LABORATORY TESTING

Summary of Laboratory Testing

Laboratory testing was performed on selected samples from the field exploration program. The samples are grouped into two categories, disturbed and undisturbed. Disturbed samples are those that were obtained during the Standard Penetration Test while undisturbed samples are those samples that were obtained using the WSDOT sampler.

All disturbed soil samples were visually examined and then grouped together based on particle size distribution, consistency, and color. Once groups of samples were established that had similar characteristics, a minimum of one sample per group was tested. The testing consisted of performing particle size analyses, determining the liquid limit if applicable, and determining the plastic limit and plasticity index if applicable. Specialized testing for the project included 2 unconsolidated undrained triaxial shear tests. The tests were done in accordance with AASHTO T-88, T-89, T-90, and T234 guide specifications respectively. After the testing was complete, the samples were classified using the Unified Soil Classification System (USCS).

Job No.	XL-1640	Date	November 19, 2003
Hole No.	TH-3-03	Sheet	1 of 3
Project	West Hoquiam Bridge - Maintenance-Turnout		

Laboratory Summary

Washington State Department of Transportation

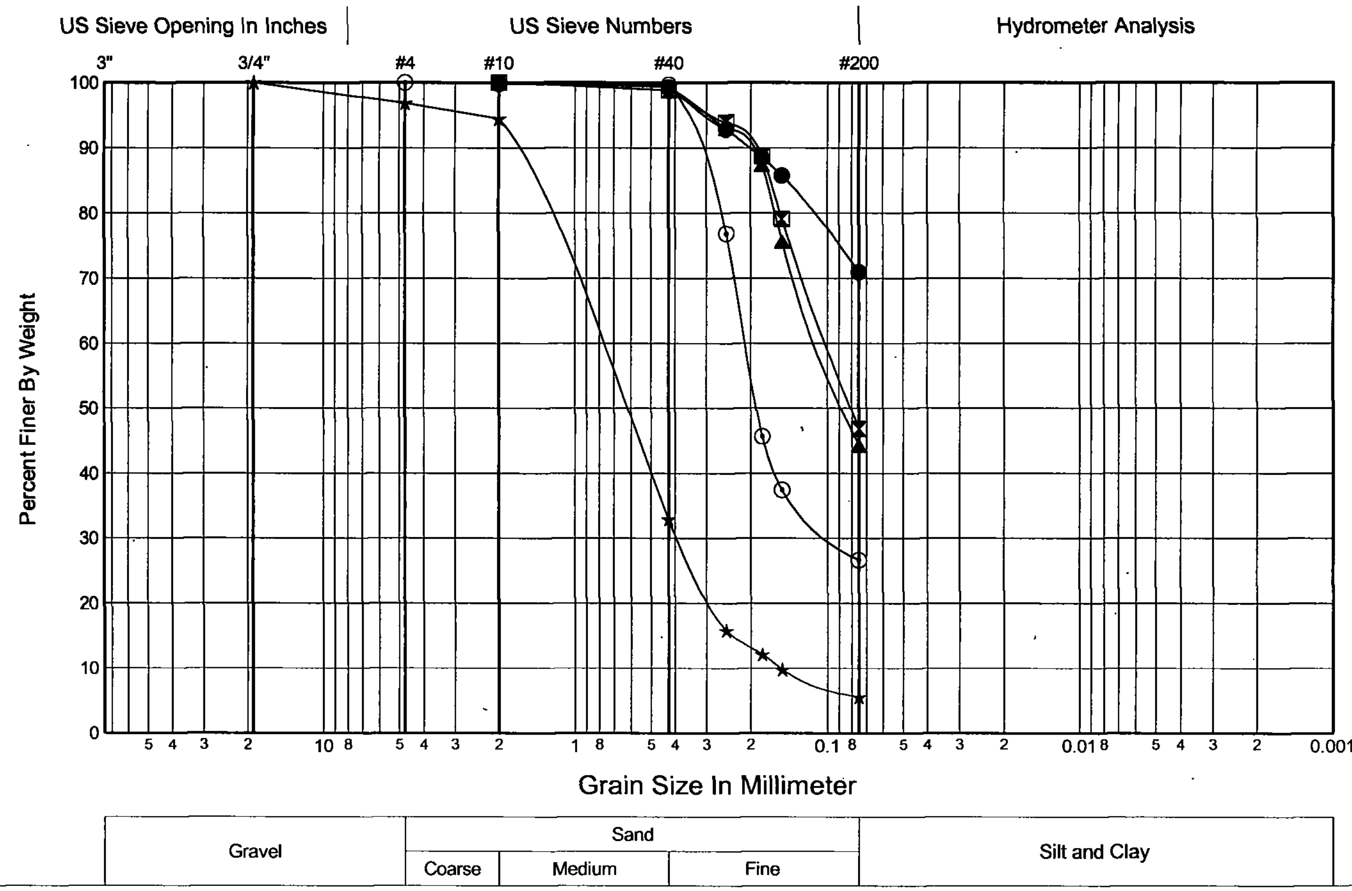
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	9.5	2.90	D-2	ML	See Boring Log	SILT with SAND with organic	71			
⊠	38.5	11.73	D-11	SM	See Boring Log	SILTY SAND with organic	58			
▲	43.5	13.26	D-12	SM	See Boring Log	SILTY SAND	56			
★	48.5	14.78	D-13	SP-SM	See Boring Log	POORLY GRADED SAND with SILT and organic and wood chunks	39			
⊙	53.5	16.31	D-14	SM	See Boring Log	SILTY SAND with organic and shells	45			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	0.0	29.1	70.9		
⊠	0.0	53.2	46.8		
▲	0.0	55.7	44.3		
★	3.1	91.3	5.6	1.2	5.5
⊙	0.0	73.4	26.6		

GRADATION VALUES

	D60	D50	D30	D20	D10
●					
⊠	0.100	0.08			
▲	0.106	0.09			
★	0.840	0.65	0.39	0.28	0.152
⊙	0.209	0.19	0.09		



Job No.	XL-1640	Date	November 19, 2003
Hole No.	TH-3-03	Sheet	2 of 3
Project	West Hoquiam Bridge - Maintenance-Turnout		

Laboratory Summary

Washington State Department of Transportation

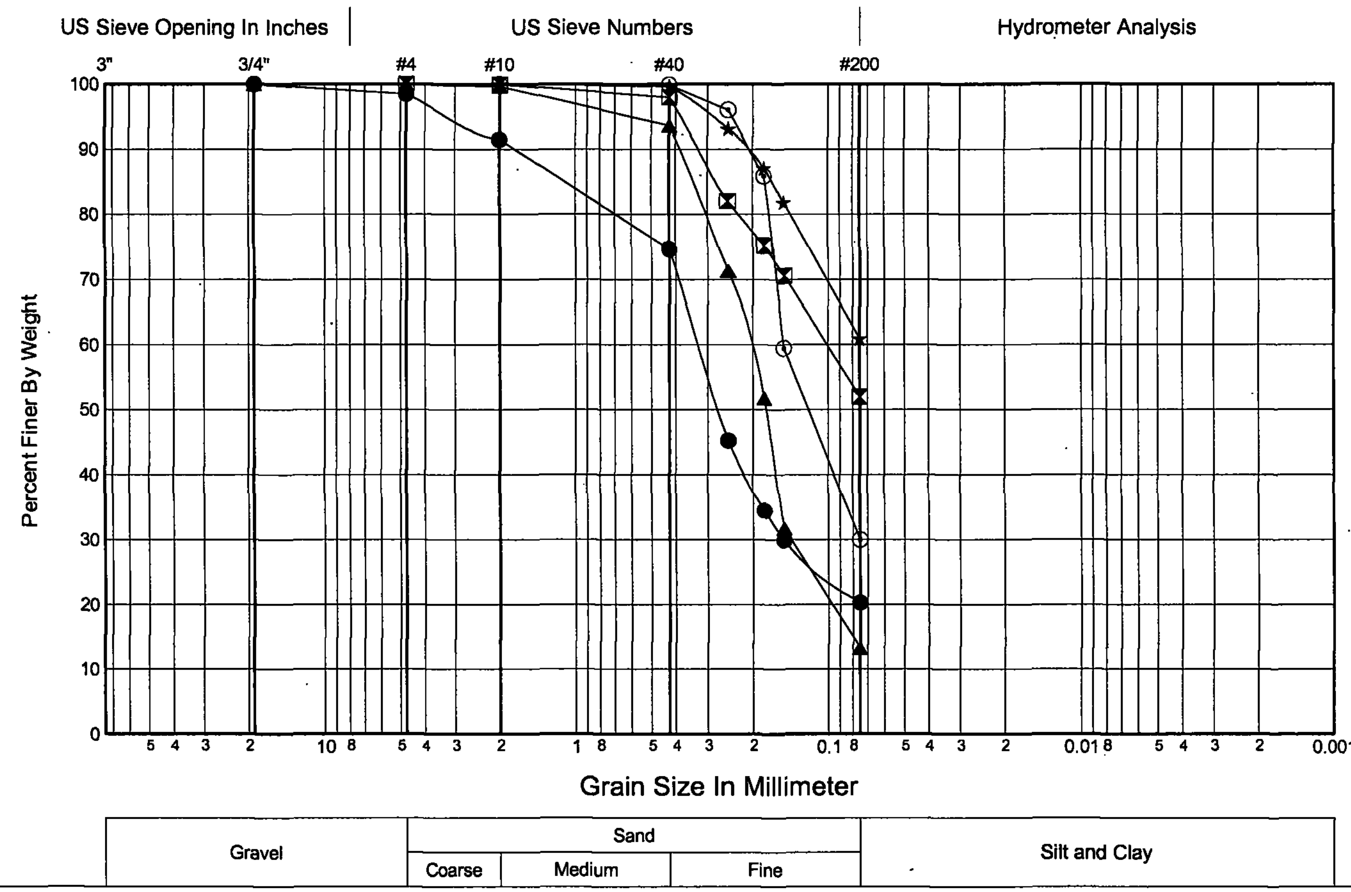
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	58.5	17.83	D-15	SM	See Boring Log	SILTY SAND with organic	37			
⊠	63.5	19.35	D-16	ML	See Boring Log	SANDY SILT	58			
▲	73.5	22.40	D-18	SM	See Boring Log	SILTY SAND	31			
★	78.5	23.93	D-19	ML	See Boring Log	SANDY SILT with organic	56			
⊙	83.5	25.45	D-20	SM	See Boring Log	SILTY SAND	42			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	1.5	78.2	20.3		
⊠	0.0	48.1	51.9		
▲	0.0	86.7	13.3		
★	0.0	39.1	60.9		
⊙	0.0	70.0	30.0		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.326	0.27	0.15		
⊠	0.101				
▲	0.207	0.18	0.14	0.10	
★					
⊙	0.151	0.12	0.08		



Job No.	XL-1640	Date	November 19, 2003	Laboratory Summary
Hole No.	TH-3-03	Sheet	3 of 3	
Project	West Hoquiam Bridge - Maintenance-Turnout			

Washington State Department of Transportation

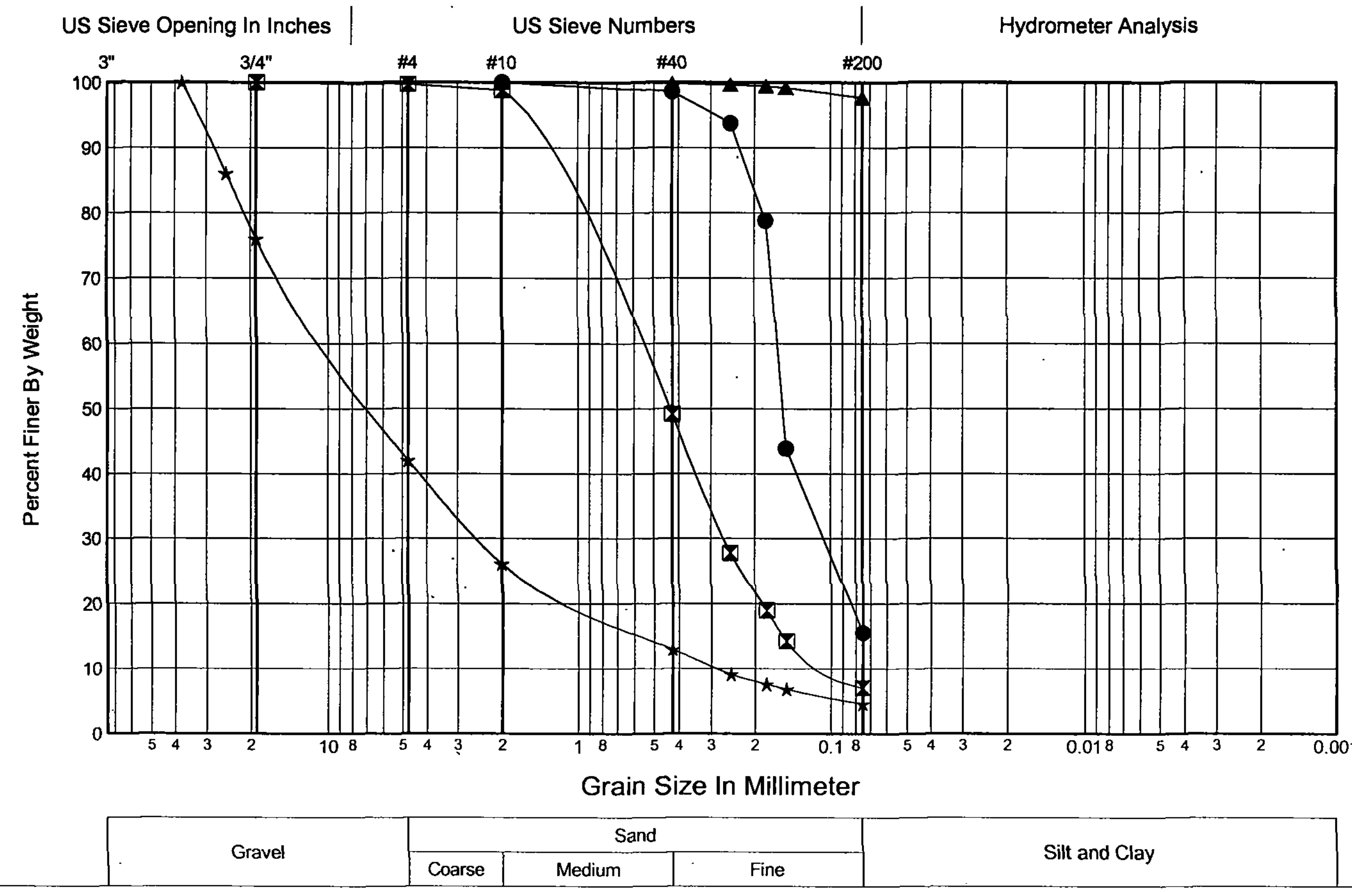
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	88.5	26.97	D-21	SM	See Boring Log	SILTY SAND with organic	34			
⊠	93.5	28.50	D-22	SP-SM	See Boring Log	POORLY GRADED SAND with SILT	25			
▲	104.7	31.91	U-24/D	CH	See Boring Log	FAT CLAY with organic	63	346	42	304
★	133.5	40.69	D-27	GW	See Boring Log	WELL-GRADED GRAVEL with SAND	8			

GRADATION FRACTIONS

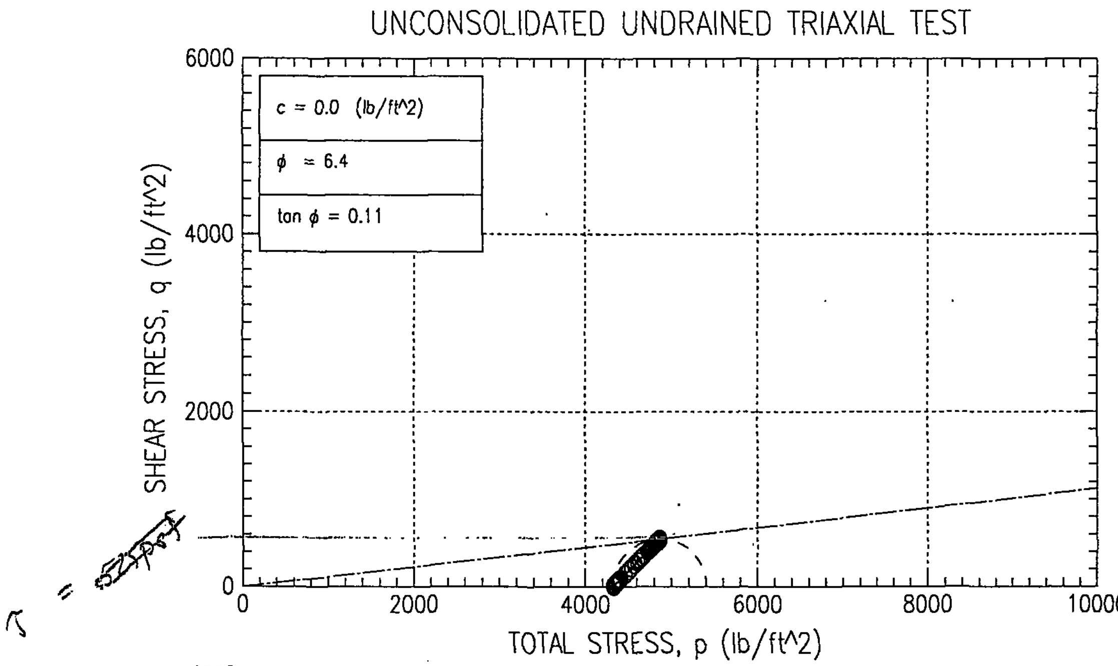
	%Gravel	%Sand	%Fines	Cc	Cu
●	0.0	84.4	15.6		
⊠	0.3	92.7	7.0	1.2	6.0
▲	0.0	2.4	97.6		
★	57.9	37.5	4.6	2.2	35.0

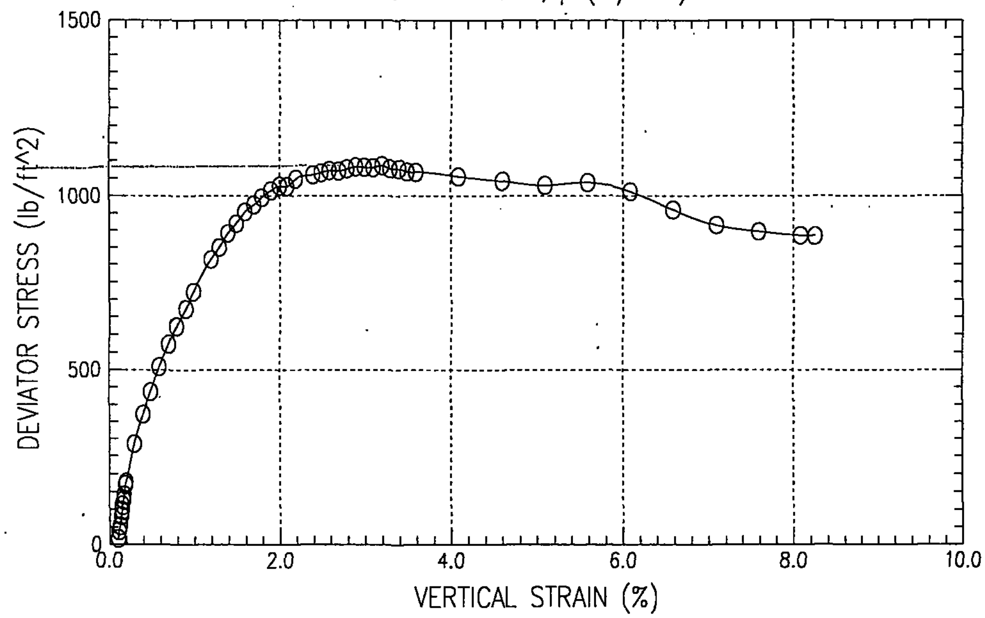
GRADATION VALUES

	D60	D50	D30	D20	D10
●	0.163	0.15	0.11	0.08	
⊠	0.596	0.44	0.26	0.19	0.100
▲					
★	9.885	6.57	2.47	0.97	0.282



TRIAXIAL TEST RESULTS





Unit #3

Washington State D.O.T.
Project Name : W. HOUQUIAM BR. MAINT

Project No : XL-1640	Boring No : H-3-03	Sample No : U-24/D
Test Date : 11/5/03	Test No : 502824D	~~Depth : 104.7 FT~~

Description : MOIST DARK GRAY SILT
Remarks :

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

Project : W. HOUQUIAM BR. MAINT   Location : SR-101
Project No. : XL-1640   Test No. : 502824D
Boring No. : H-3-03   Test Date : 11/5/03   Tested by : LHB
Sample No. : U-24/D   Depth : 104.7 FT   Checked by : DVJ
Sample Type : WSDOT TUBE   Elevation :
Soil Description : MOIST DARK GRAY SILT
Remarks :

Height : 4.000 (in)   Piston Diameter : 0.625 (in)   Filter Correction : 0.00 (lb/ft^2)
Diameter : 1.910 (in)   Piston Friction : 0.00 (lb)   Membrane Correction : 3.20 (lb/in)
Volume : 11.46 (in^3)   Piston Weight : 916.60 (gm)   Area Correction : Uniform

	TIME (min.)	VERTICAL STRAIN (%)	TOTAL VERTICAL STRESS (lb/ft^2)	TOTAL HORIZONTAL STRESS (lb/ft^2)	TOTAL p (lb/ft^2)	q (lb/ft^2)
1)	0	0.10	4336.77	4320.01	4328.39	8.38
2)	0.016666	0.11	4358.55	4320.01	4339.28	19.27
3)	0.033333	0.12	4373.07	4320.01	4346.54	26.53
4)	0.066666	0.14	4402.11	4320.01	4361.06	41.05
5)	0.083333	0.15	4416.62	4320.01	4368.32	48.31
6)	0.116667	0.15	4431.14	4320.01	4375.57	55.56
7)	0.133333	0.17	4445.64	4320.01	4382.82	62.81
8)	0.15	0.18	4460.15	4320.01	4390.08	70.07
9)	0.183333	0.19	4489.15	4320.01	4404.58	84.57
10)	0.2	0.20	4496.40	4320.01	4408.20	88.19
11)	0.4	0.29	4604.98	4320.01	4462.49	142.48
12)	0.616667	0.39	4691.59	4320.01	4505.80	185.79
13)	0.8	0.49	4756.36	4320.01	4538.19	218.17
14)	1.01667	0.59	4828.19	4320.01	4574.10	254.09
15)	1.23333	0.70	4892.61	4320.01	4606.31	286.30
16)	1.43333	0.79	4942.60	4320.01	4631.31	311.30
17)	1.65	0.90	4992.36	4320.01	4656.18	336.17
18)	1.85	0.99	5042.10	4320.01	4681.06	361.05
19)	2.28333	1.20	5134.01	4320.01	4727.01	407.00
20)	2.48333	1.29	5169.11	4320.01	4744.56	424.55
21)	2.7	1.39	5211.25	4320.01	4765.63	445.62
22)	2.88333	1.49	5239.04	4320.01	4779.53	459.52
23)	3.1	1.59	5273.86	4320.01	4796.94	476.93
24)	3.3	1.69	5294.32	4320.01	4807.16	487.15
25)	3.48333	1.79	5314.80	4320.01	4817.41	497.39
26)	3.7	1.90	5335.09	4320.01	4827.55	507.54
27)	3.9	2.00	5348.28	4320.01	4834.15	514.14
28)	4.08333	2.09	5347.36	4320.01	4833.69	513.68
29)	4.3	2.19	5367.63	4320.01	4843.82	523.81
30)	4.7	2.39	5379.63	4320.01	4849.82	529.81
31)	4.9	2.49	5385.69	4320.01	4852.85	532.84
32)	5.08333	2.58	5391.74	4320.01	4855.87	535.86
33)	5.3	2.69	5390.53	4320.01	4855.27	535.26
34)	5.48333	2.79	5396.56	4320.01	4858.28	538.27

35)	5.68333	2.89	5402.49	4320.01	4861.25	541.24
36)	5.88333	2.99	5401.35	4320.01	4860.68	540.67

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

Project : W. HOUQUIAM BR. MAINT Location : SR-101
Project No. : XL-1640 Test No. : 502824D
Boring No. : H-3-03 Test Date : 11/5/03 Tested by : LHB
Sample No. : U-24/D Depth : 104.7 FT Checked by : DVJ
Sample Type : WSDOT TUBE Elevation :
Soil Description : MOIST DARK GRAY SILT
Remarks :

	TIME (min.)	VERTICAL STRAIN (%)	TOTAL VERTICAL STRESS (lb/ft^2)	TOTAL HORIZONTAL STRESS (lb/ft^2)	TOTAL p (lb/ft^2)	q (lb/ft^2)
37)	6.08333	3.10	5400.21	4320.01	4860.11	540.10
38)	6.28333	3.20	5406.11	4320.01	4863.06	543.05
39)	6.5	3.29	5398.01	4320.01	4859.01	539.00
40)	6.7	3.39	5396.87	4320.01	4858.44	538.43
41)	6.9	3.49	5388.80	4320.01	4854.40	534.39
42)	7.1	3.59	5387.66	4320.01	4853.84	533.83
43)	8.08333	4.09	5375.19	4320.01	4847.60	527.59
44)	9.1	4.60	5362.64	4320.01	4841.32	521.31
45)	10.1167	5.10	5350.31	4320.01	4835.16	515.15
46)	11.1167	5.59	5358.65	4320.01	4839.33	519.32
47)	12.1167	6.09	5332.70	4320.01	4826.36	506.35
48)	13.1333	6.58	5279.80	4320.01	4799.91	479.90
49)	14.1	7.09	5234.10	4320.01	4777.05	457.04
50)	15.0833	7.59	5215.70	4320.01	4767.86	447.85
51)	16.05	8.08	5204.28	4320.01	4762.14	442.13
52)	16.3833	8.25	5202.66	4320.01	4761.34	441.33

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

Project : W. HOUQUIAM BR. MAINT
Location : SR-101
Project No. : XL-1640
Test No. : 502824D
Boring No. : H-3-03
Test Date : 11/5/03
Tested by : LHB
Sample No. : U-24/D
Depth : 104.7 FT
Checked by : DVJ
Sample Type : WSDOT TUBE
Elevation :
Soil Description : MOIST DARK GRAY SILT
Remarks :

Height : 4.000 (in)
Piston Diameter : 0.625 (in)
Filter Correction : 0.00 (lb/ft^2)
Diameter : 1.910 (in)
Piston Friction : 0.00 (lb)
Membrane Correction : 3.20 (lb/in)
Volume : 11.46 (in^3)
Piston Weight : 916.60 (gm)
Area Correction : Uniform

	TIME (min.)	CHANGE IN LENGTH (in)	VERTICAL STRAIN (%)	CORR. AREA (in^2)	DEV. LOAD (lb)	CORR. DEV. LOAD (lb)	DEV. STRESS (lb/ft^2)	VERTICAL STRESS (lb/ft^2)
1)	0	0.004	0.10	2.87	7.52	0.33	16.76	4336.77
2)	0.016666	0.004	0.11	2.87	7.96	0.77	38.54	4358.55
3)	0.033333	0.005	0.12	2.87	8.25	1.06	53.06	4373.07
4)	0.066666	0.006	0.14	2.87	8.83	1.64	82.10	4402.11
5)	0.083333	0.006	0.15	2.87	9.11	1.93	96.61	4416.62
6)	0.116667	0.006	0.15	2.87	9.40	2.21	111.13	4431.14
7)	0.133333	0.007	0.17	2.87	9.69	2.50	125.63	4445.64
8)	0.15	0.007	0.18	2.87	9.98	2.79	140.13	4460.15
9)	0.183333	0.008	0.19	2.87	10.56	3.37	169.14	4489.15
10)	0.2	0.008	0.20	2.87	10.71	3.52	176.39	4496.40
11)	0.4	0.012	0.29	2.87	12.88	5.69	284.97	4604.98
12)	0.616667	0.016	0.39	2.88	14.61	7.42	371.58	4691.59
13)	0.8	0.020	0.49	2.88	15.91	8.72	436.35	4756.36
14)	1.01667	0.024	0.59	2.88	17.36	10.17	508.18	4828.19
15)	1.23333	0.028	0.70	2.89	18.66	11.47	572.60	4892.61
16)	1.43333	0.032	0.79	2.89	19.68	12.49	622.59	4942.60
17)	1.65	0.036	0.90	2.89	20.69	13.50	672.35	4992.36
18)	1.85	0.040	0.99	2.89	21.70	14.51	722.09	5042.10
19)	2.28333	0.048	1.20	2.90	23.58	16.39	813.99	5134.01
20)	2.48333	0.052	1.29	2.90	24.31	17.12	849.10	5169.11
21)	2.7	0.056	1.39	2.91	25.17	17.98	891.24	5211.25
22)	2.88333	0.060	1.49	2.91	25.75	18.56	919.03	5239.04
23)	3.1	0.064	1.59	2.91	26.48	19.29	953.85	5273.86
24)	3.3	0.068	1.69	2.91	26.91	19.72	974.31	5294.32
25)	3.48333	0.072	1.79	2.92	27.34	20.15	994.79	5314.80
26)	3.7	0.076	1.90	2.92	27.78	20.59	1015.08	5335.09
27)	3.9	0.080	2.00	2.92	28.07	20.88	1028.27	5348.28
28)	4.08333	0.084	2.09	2.93	28.07	20.88	1027.35	5347.36
29)	4.3	0.088	2.19	2.93	28.50	21.31	1047.62	5367.63
30)	4.7	0.096	2.39	2.94	28.79	21.60	1059.62	5379.63
31)	4.9	0.100	2.49	2.94	28.93	21.75	1065.68	5385.69
32)	5.08333	0.103	2.58	2.94	29.08	21.89	1071.73	5391.74
33)	5.3	0.108	2.69	2.94	29.08	21.89	1070.52	5390.53
34)	5.48333	0.112	2.79	2.95	29.22	22.03	1076.55	5396.56

35)	5.68333	0.116	2.89	2.95	29.37	22.18	1082.48	5402.49
36)	5.88333	0.120	2.99	2.95	29.37	22.18	1081.34	5401.35

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

Project : W. HOUQUIAM BR. MAINT   Location : SR-101
Project No. : XL-1640   Test No. : 502824D
Boring No. : H-3-03   Test Date : 11/5/03   Tested by : LHB
Sample No. : U-24/D   Depth : 104.7 FT   Checked by : DVJ
Sample Type : WSDOT TUBE   Elevation :
Soil Description : MOIST DARK GRAY SILT
Remarks :

	TIME (min.)	CHANGE IN LENGTH (in)	VERTICAL STRAIN (%)	CORR. AREA (in^2)	DEV. LOAD (lb)	CORR. DEV. LOAD (lb)	DEV. STRESS (lb/ft^2)	VERTICAL STRESS (lb/ft^2)
37)	6.08333	0.124	3.10	2.96	29.37	22.18	1080.20	5400.21
38)	6.28333	0.128	3.20	2.96	29.51	22.32	1086.10	5406.11
39)	6.5	0.132	3.29	2.96	29.37	22.18	1078.00	5398.01
40)	6.7	0.136	3.39	2.97	29.37	22.18	1076.86	5396.87
41)	6.9	0.140	3.49	2.97	29.22	22.03	1068.79	5388.80
42)	7.1	0.144	3.59	2.97	29.22	22.03	1067.65	5387.66
43)	8.08333	0.164	4.09	2.99	29.08	21.89	1055.18	5375.19
44)	9.1	0.184	4.60	3.00	28.93	21.75	1042.62	5362.64
45)	10.1167	0.204	5.10	3.02	28.79	21.60	1030.30	5350.31
46)	11.1167	0.224	5.59	3.03	29.08	21.89	1038.64	5358.65
47)	12.1167	0.244	6.09	3.05	28.65	21.46	1012.69	5332.70
48)	13.1333	0.263	6.58	3.07	27.63	20.44	959.79	5279.80
49)	14.1	0.284	7.09	3.08	26.76	19.58	914.08	5234.10
50)	15.0833	0.304	7.59	3.10	26.48	19.29	895.69	5215.70
51)	16.05	0.323	8.08	3.12	26.33	19.14	884.27	5204.28
52)	16.3833	0.330	8.25	3.12	26.33	19.14	882.65	5202.66

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

Project : W. HOUQUIAM BR. MAINT   Location : SR-101
Project No. : XL-1640   Test No. : 502824D
Boring No. : H-3-03   Test Date : 11/5/03   Tested by : LHB
Sample No. : U-24/D   Depth : 104.7 FT   Checked by : DVJ
Sample Type : WSDOT TUBE   Elevation :
Soil Description : MOIST DARK GRAY SILT
Remarks :

Liquid Limit : 0   Plastic Limit : 0   Specific Gravity : 2.65

	WATER CONTENT BEFORE TEST	AFTER TEST
CONTAINER NO.		
WT CONTAINER + WET SOIL (gm)	0.00	0.00
WT CONTAINER + DRY SOIL (gm)	0.00	0.00
WT WATER (gm)	0.00	0.00
WT CONTAINER (gm)	0.00	0.00
WT DRY SOIL (gm)	0.00	0.00
WATER CONTENT (%)	0.00	0.00

Maximum Shear Stress = 543.05 (lb/ft^2) at a Vertical Strain of 3.20 %

Geotechnical Design Study
WSDOT SR 520 Pontoon Construction Project
Grays Harbor, Washington

March 25, 2009

Prepared for

WSDOT
and HDR Engineering, Inc.
Seattle, Washington

LANDAU ASSOCIATES
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Edmonds, WA 98020
(425) 778-0907

N

0 0.5 1
Miles

Data Source: ESRI 2008

Y:\Projects\122025\MapdocsFig1.mxd 10/24/2008

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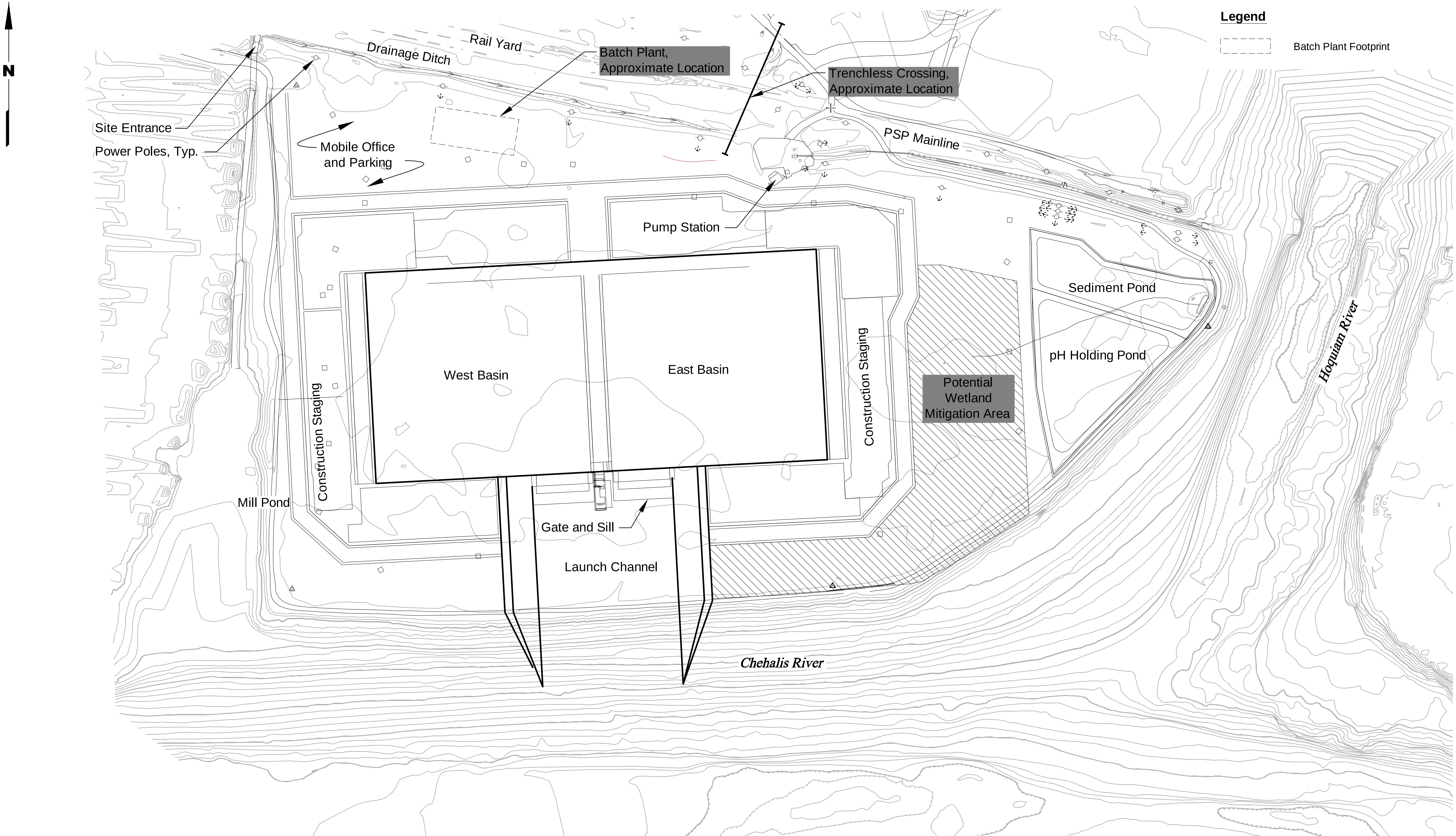
SR520 Pontoon Construction Project Port of Grays Harbor, Washington	**Vicinity Map**	Figure 1

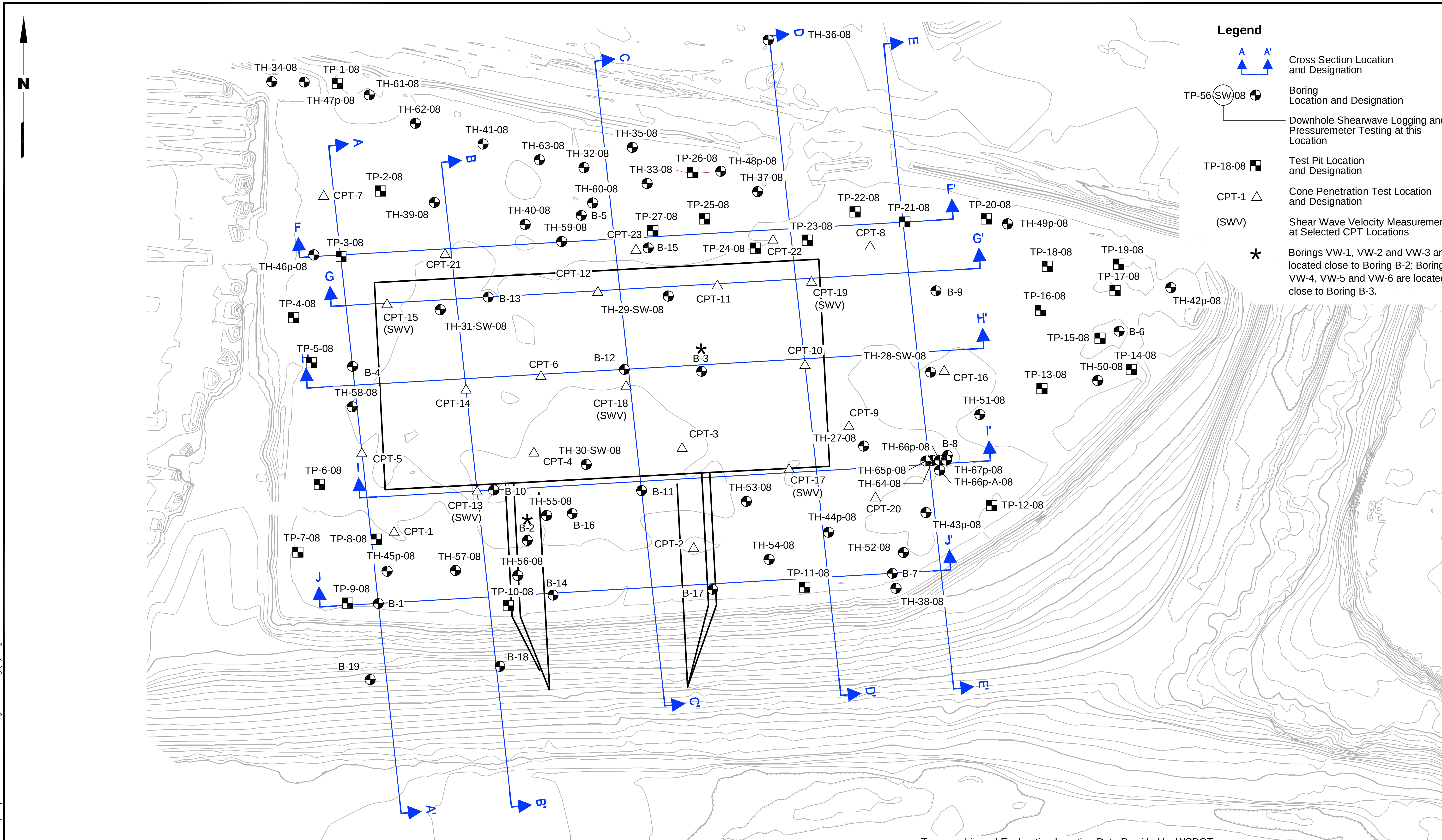


Topographic and Site Layout Data Provided by WSDOT

Geotech Report | V:\122\025\020\012\F\Figure 2-3.dwg (A) "Figure 2" 3/4/2009

Landau Associates

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	**Site Layout**	Figure 2



Geotech Report | V:\122\025\020\012\F\Figure 2-3.dwg (A) "Figure 3" 3/4/2009

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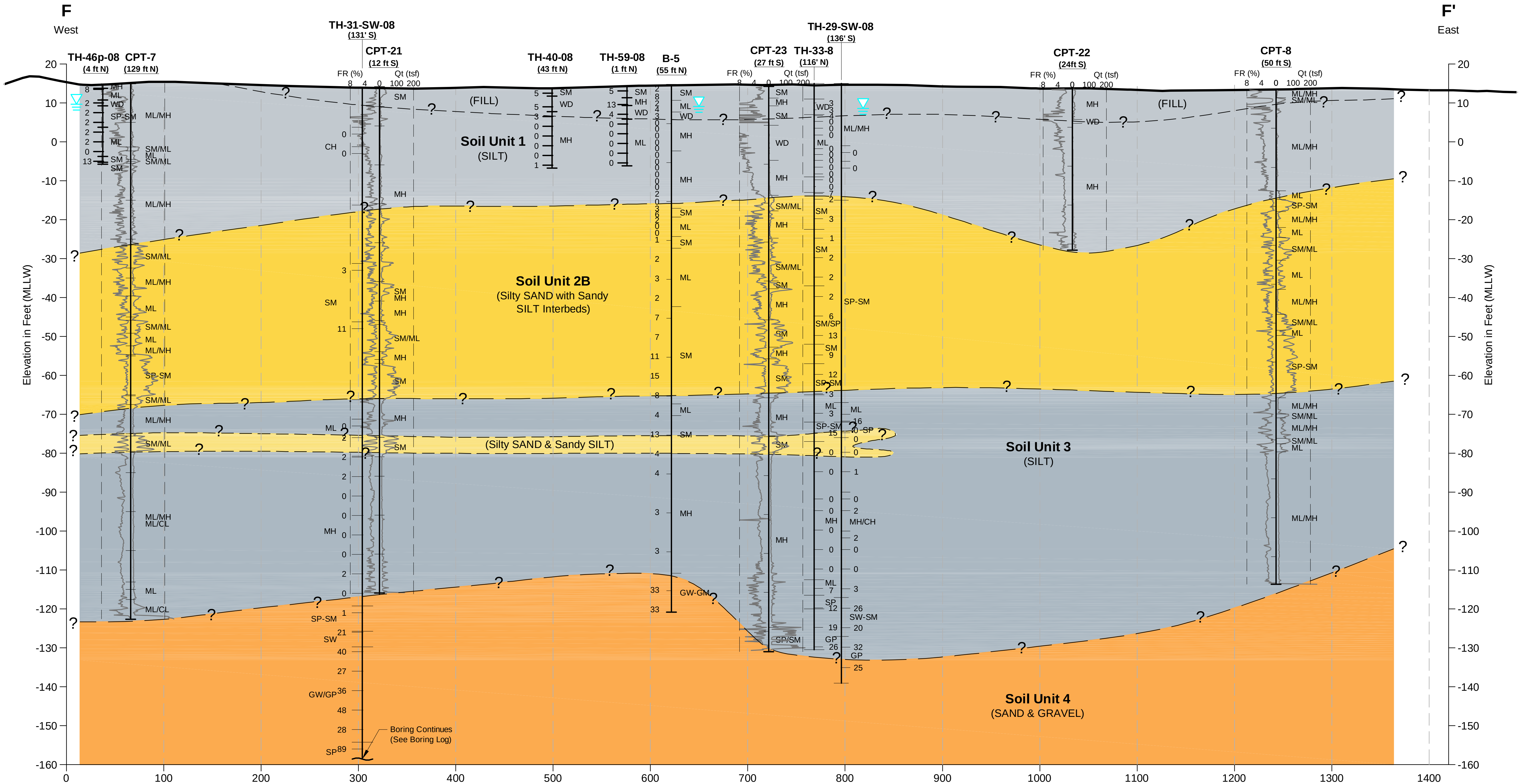
SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Site and Exploration Plan

Figure 3



Legend

B-2 (3 ft S) — Boring Number; Distance and Direction from Cross Section

Groundwater Elevation

ML — Unified Soil Classification Symbol

5 — Standard Penetration Test Blow Count (140 lb Hammer, 30" Drop)

—?— Major Soil Unit Contact

- -?- - Contact within the Same Soil Unit

Shelby Tube Sample (Pushed 24" with Rig Hydraulics)

CPT-4 — Cone Penetrometer Number

FR (%) Qt (tsf)

Friction Ratio — Cone Resistance

Note:

1. This cross section has been interpreted and generalized from project field data. Variations between this cross section and actual conditions may exist. The project boring logs and written report must be referenced for a proper understanding of the nature of the subsurface conditions.

2. Planned Casting Basin top of slab is approximately -13ft.

0 100 200

Scale in Feet

4x Vertical Exaggeration

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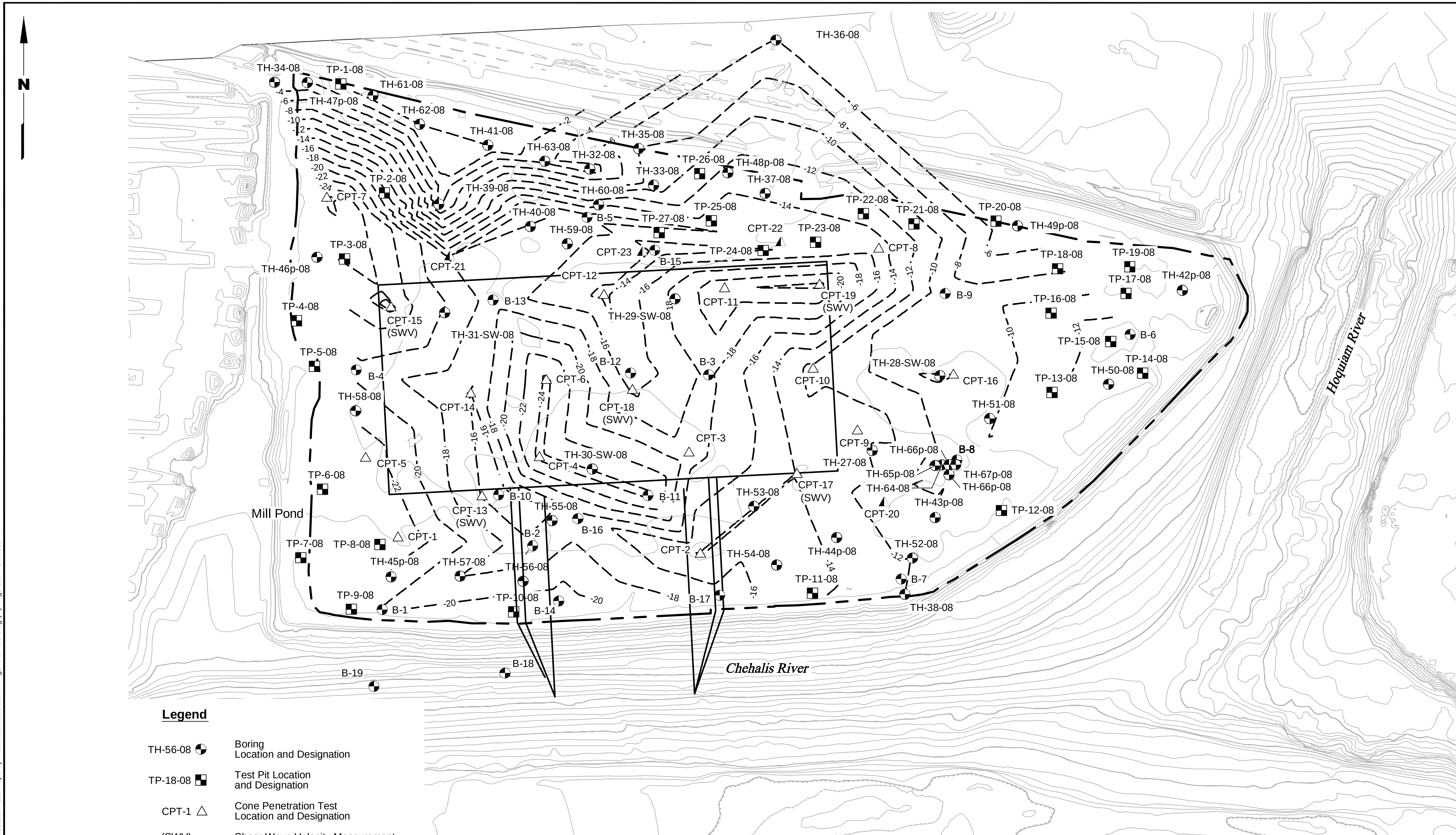
SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Cross Section F-F'

Figure 9

Geotech Report | V:\122\025\020\012\F\Figure 4-13.dwg (A) "Figure 9" 3/4/2009



Legend

TH-56-08	Boring Location and Designation
TP-18-08	Test Pit Location and Designation
CPT-1 △	Cone Penetration Test Location and Designation
(SWV)	Shear Wave Velocity Measurement
-22 — —	Interpreted Top of Unit 2 Elevation Contour

0 200 400
Scale in Feet

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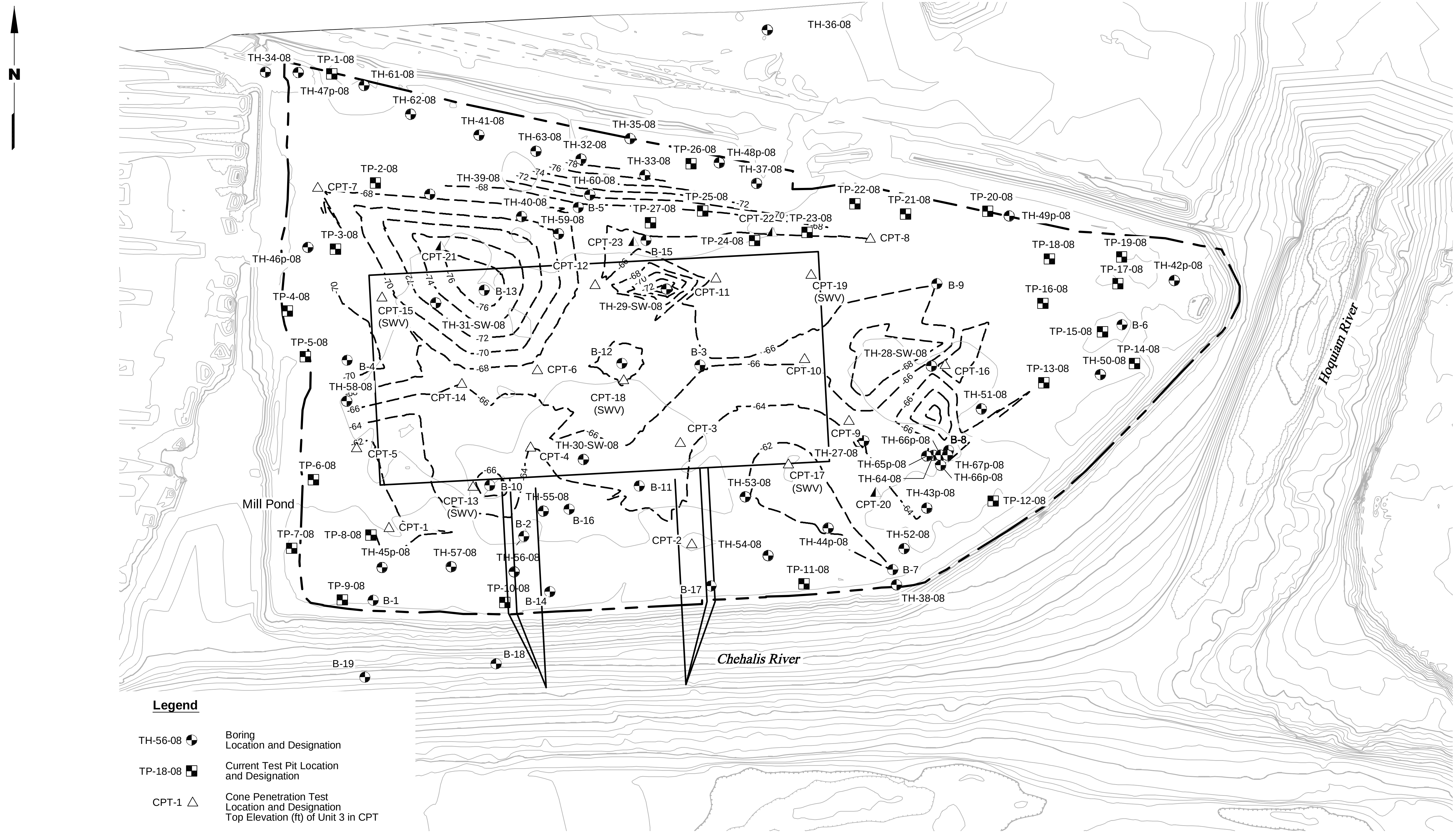
SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Top of Unit 2 Elevation Contour Map

Figure 14

WSDOT/Geotechnical Report | V:\122\025\020\012\F\Figure 14-16.dwg (A) "Figure 14" 3/4/2009



Legend

TH-56-08	Boring Location and Designation
TP-18-08	Current Test Pit Location and Designation
CPT-1	Cone Penetration Test Location and Designation Top Elevation (ft) of Unit 3 in CPT
(SWV)	Shear Wave Velocity Measurement
-22	Interpreted Top of Unit 3 Elevation Contour

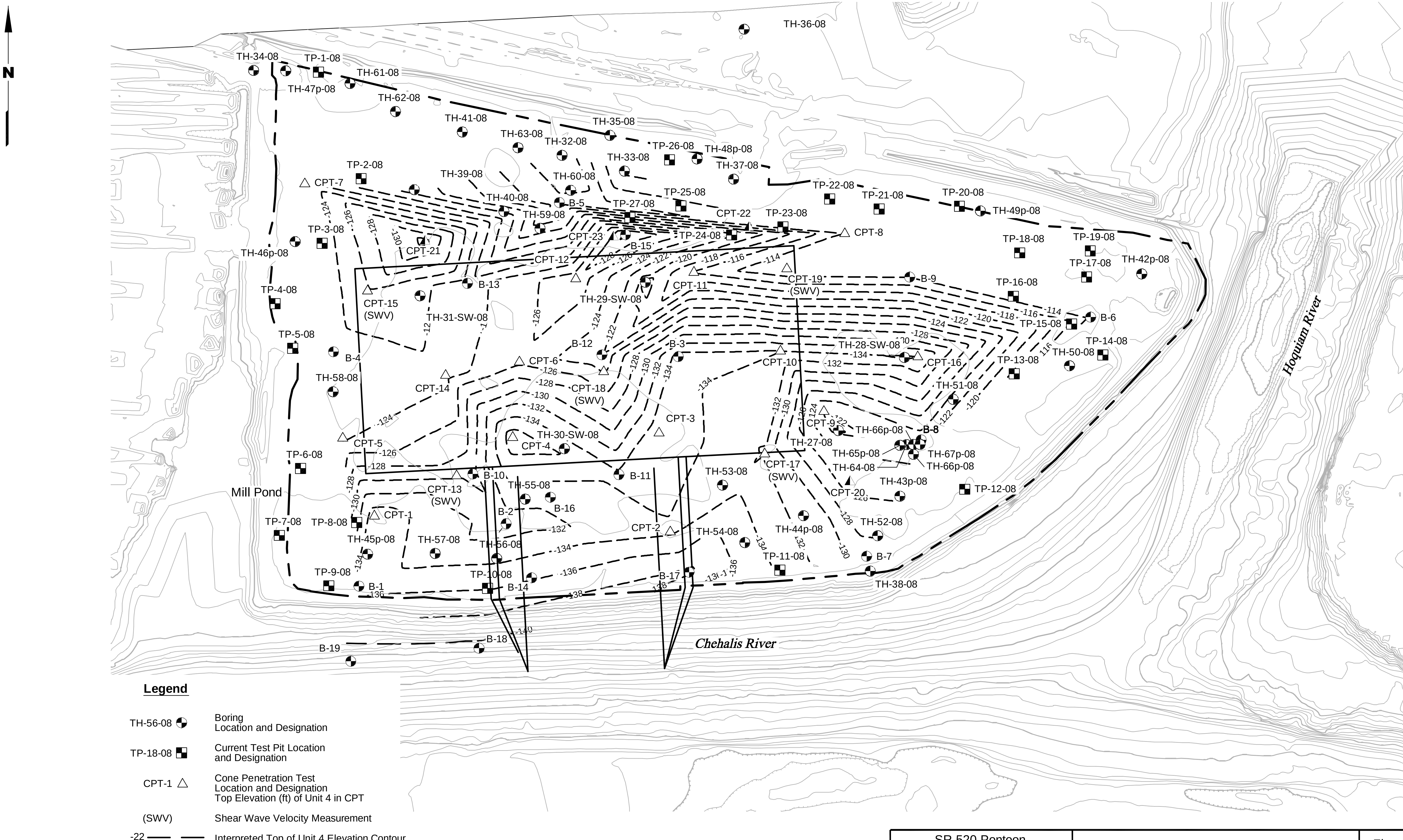
WSDOT/Geotechnical Report | V:\122\025\020\012\F\Figure 14-16.dwg (A) "Figure 15" 3/4/2009

Landau Associates

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Top of Unit 3
Elevation Contour Map

Figure 15



WSDOT/Geotechnical Report | V:\122\025\020\012\F\Figure 14-16.dwg (A) "Figure 16" 3/4/2009

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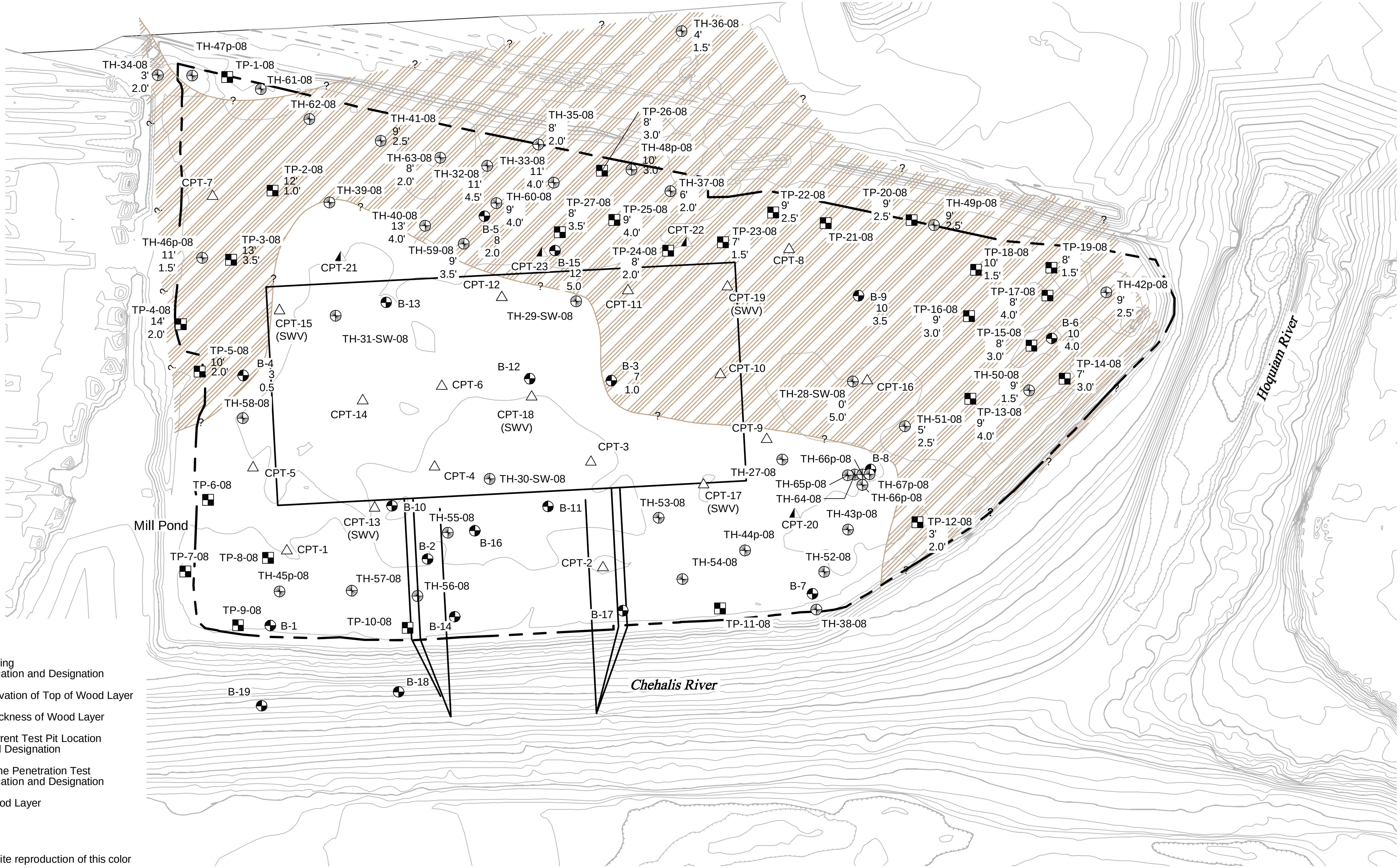
SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Top of Unit 4 Elevation Contour Map

Figure 16



Legend

TH-56-08 (8, 2.5)	Boring Location and Designation; Elevation of Top of Wood Layer; Thickness of Wood Layer
TP-18-08	Current Test Pit Location and Designation
CPT-1	Cone Penetration Test Location and Designation
	Wood Layer

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 200 400
Scale in Feet

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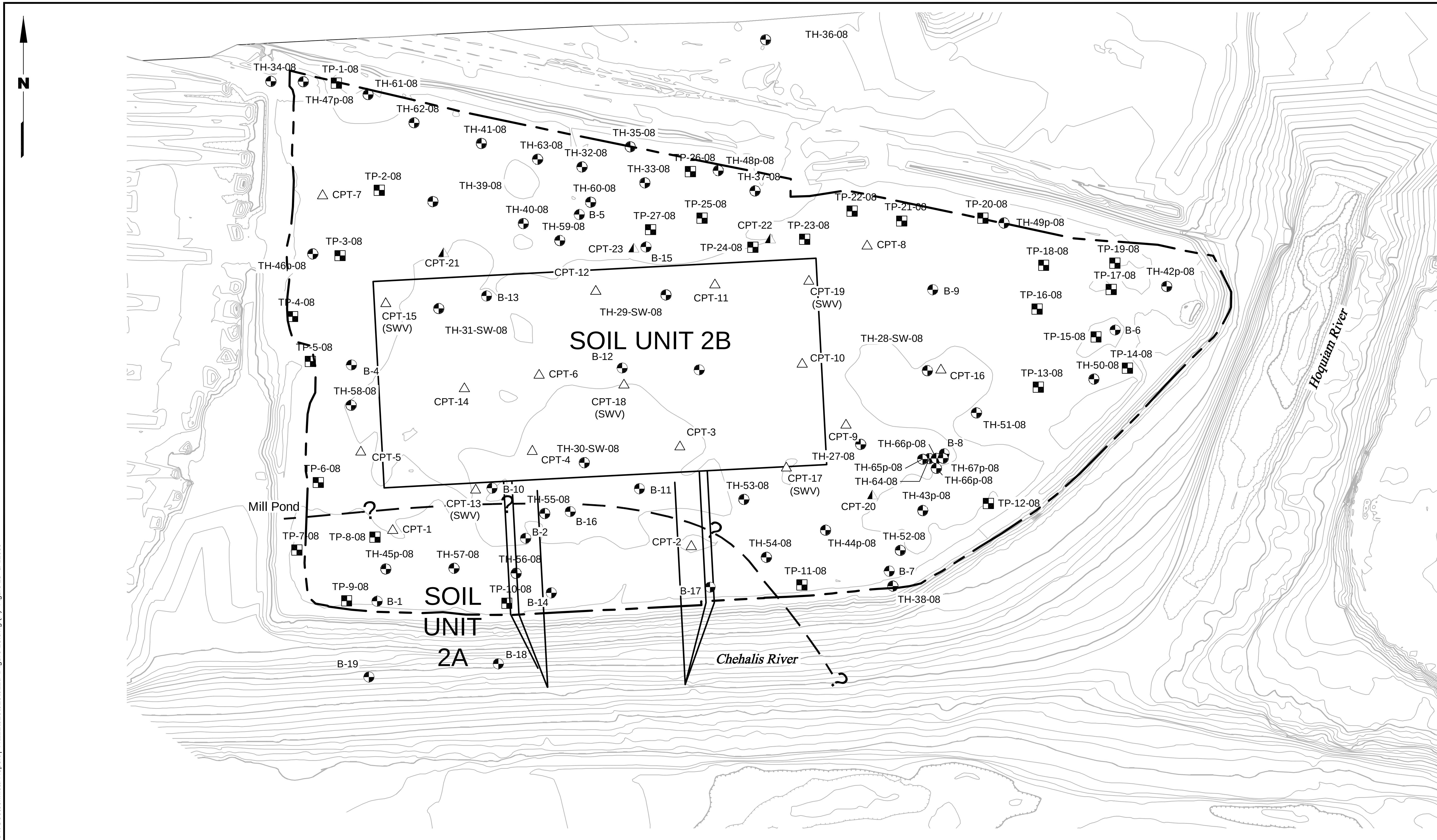
SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Approximate Extent of Shallow Wood Layer

Figure 17

WSDOT/Geotechnical Report | V:\122\025\020\012\F\Figure 17.dwg (A) "Figure 17" 3/4/2009



WSDOT/Geotechnical Report | V:\122\025\020\012\F\Figure 18.dwg (A) "Figure 18" 3/4/2009

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SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Approximate Extent of Areas A and B

Figure 18

APPENDIX A

Field Explorations

APPENDIX A
FIELD EXPLORATIONS

Subsurface conditions within the limits of the project area were explored during the current (phase II design) phase and during two earlier field exploration efforts. Exploration for the current phase also included one offsite boring (TH-36-08) to obtain subsurface information for a proposed utility crossing beneath railroad tracks near the northern boundary of the project site.

Exploration for earlier phases occurred in 2006. Previous explorations included 20 geotechnical borings (designated borings B-1 through B-20), 6 borings installed as monitoring wells with vibrating wire pressure transducers (designated as VW-1 through VW-6), and 23 cone penetration tests (CPTs) (designated CPT-1 through CPT-23). The results of the previous explorations are included in the appendices of our previous reports (Landau Associates 2006, 2007) and the boring and CPT logs for previous explorations are also included in this appendix.

The current exploration program included drilling and sampling a total of 42 exploratory boring locations (designated TH-27-08 through TH-67-08) and 28 test pits (designated TP-1-08 through TP-27-08). Because of refusal due to a very large log encountered in test pit TP-18-08, an additional test pit (TP-18A-08) was excavated nearby. At some boring locations, multiple borings were drilled within close proximity for pressuremeter testing and shearwave suspension logging, or to obtain additional samples. The locations of all explorations are shown on Figure 3. Where multiple borings or test pits were made in close proximity, only one location is indicated on the figure.

The field exploration program was coordinated and monitored by a geotechnical engineer or engineering geologist from our staff, who also obtained representative soil samples, maintained a detailed record of the observed subsurface soil and groundwater conditions, and described the soil encountered by visual and textural examination. Soil samples were taken to our laboratory for further examination and testing. Each representative soil type observed in our explorations was described using the soil classification system shown on Figure A-1, in general accordance with the American Society for Testing and Materials (ASTM) D2488, *Standard Recommended Practice for Description of Soils (Visual-Manual Procedure).*

The exploration logs represent our interpretation of subsurface conditions identified during the field exploration program. The stratigraphic contacts shown on the individual logs represent the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted are only for the specific date and locations reported and are not necessarily representative of other locations and times. A further discussion of the soil and groundwater conditions observed is contained in the text of this report.

Exploration locations were initially located in the field using a hand-held global positioning system (GPS) unit and later surveyed by the Washington State Department of Transportation (WSDOT). Locations shown on the report figures and the coordinates on the exploration logs indicate the surveyed locations of the explorations. Elevations shown on the exploration logs represent surveyed values.

EXPLORATORY BORINGS

Borings were advanced to depths ranging from about 20 to 250 ft below the existing ground surface (BGS). Most of the borings were advanced with WSDOT track- or truck-mounted drill rigs using mud rotary drilling techniques and a wire-line casing advancer system. Two offshore borings were advanced by WSDOT with mud rotary drilling methods using skid-mounted drilling equipment on a barge. Boring TH-64-08 was advanced by Boart Longyear (under contract to Landau Associates) using rotosonic techniques. Logs of the exploratory borings are presented on Figures A-2 through A-69.

Disturbed samples of the soil encountered from the borings were obtained at frequent intervals using a 1.5-inch inside-diameter (ID) Standard Penetration Test (SPT) split-spoon sampler. Select samples were also obtained during previous phases of the project for chemical analyses using a 2.0-inch ID modified California sampler. The sampler was driven up to 18 inches (or a portion thereof) into the undisturbed soil ahead of the drill bit with a 140-pound (lb) automatic hammer falling a distance of approximately 30 inches. The number of blows required to drive the sampler for the final 12 inches (or portion thereof) of soil penetration is noted on the boring logs adjacent to the appropriate sample notation. According to recent dynamic measurements conducted by WSDOT, the average efficiency of autohammers within the WSDOT drilling fleet is approximately 76 percent (Miner 2007). Samples collected in this manner were taken to our laboratory for further examination and index tests. A discussion of laboratory test procedures and the laboratory test results are presented in Appendix B.

Relatively undisturbed samples of fine-grained soil encountered in the borings were obtained by advancing a 3-inch outside-diameter (OD), thin-walled tube. During the preliminary 2006 exploration phase, the relatively undisturbed samples were obtained by pushing a 3-inch OD, thin-walled tube into the undisturbed soil ahead of the drill bit. The tube was advanced approximately 24 inches using the drill rig hydraulics. During the second phase of 2006 exploration, the 3-inch OD tubes were pushed using the aforementioned techniques in Soil Unit 1, Soil Unit 2A, and Soil Unit 2B. However, the 3-inch OD tubes were advanced into Soil Unit 3 using a hydraulic piston. The tubes for the most recent exploration phase were advanced using the piston sampler. The samples from offshore explorations B-18 and B-19 were obtained by pushing 1.75-inch OD, thin-walled tubes. After removal of the tube from the borehole, the ends of the tube were capped and sealed. Samples collected in this manner were taken to our laboratory for further examination and testing. A discussion of laboratory test procedures and the laboratory test results are presented in Appendix B.

Following completion of drilling and sampling of selected borings, piezometers consisting of either 2-inch-diameter PVC pipe with 0.010-inch machine-slotted screens (i.e., standpipe piezometers) or vibrating-wire piezometers (VWPs) were installed. Piezometers were installed in the following borings:

Boring	Total Depth	Piezometer Type
VW-1	40	VWP
VW-2	40	VWP
VW-3	40	VWP
VW-4	40	VWP
VW-5	40	VWP
VW-6	40	VWP
TH-42P-08	20.5	Standpipe
TH-43P-08	20.5	Standpipe
TH-44P-08	20.5	Standpipe
TH-45P-08	20.5	Standpipe
TH-46P-08	20.5	Standpipe
TH-47P-08	20.5	Standpipe
TH-49P-08	20.5	Standpipe
TH-66P-08	20	Standpipe
TH-65P-08	60.5	VWP
TH-66P-A-08	60.5	VWP
TH-67P-08	60.5	VWP

For standpipe piezometers, the screened interval was backfilled with clean sand and a bentonite seal was placed above the backfill. For VWPs, a tremied bentonite grout was placed to the planned depth of the vibrating-wire device. The device was then placed and held at the planned depth by attachment to ¾-inch diameter PVC pipe extending to the ground surface. In some VWP installations, VWPs were placed at multiple depths. For each piezometer, a lockable aboveground monument was installed to help protect the standpipe or VWP readout wires. One boring (TH-64-08) was installed by rotosonic drilling methods and used as an extraction well for pump testing. Pump testing results are presented in a separate report.

At borings TH-28-08 through TH-31-08, *in situ* pressuremeter testing was conducted at depths of up to 140 feet (ft) using a self-boring pressuremeter. Also at these borings, *in situ* shearwave suspension logging was conducted from the ground surface to depths of up to 230 ft to help estimate the seismic response of site soils. A discussion of these *in situ* test procedures and test results are presented in Appendix C of this report.

EXPLORATORY TEST PITS

Shallow subsurface soil and groundwater conditions at the project site were further explored by excavating 28 test pits at the locations shown on Figure 3. Test pits were excavated by a tracked excavator under subcontract to Landau Associates to depths ranging from approximately 8.5 to 18.5 ft BGS. Tabulated logs of the test pits are presented on Figures A-70 through A-97. Wood waste, wood debris, and logs were encountered in some of the test pits. Photographs showing some of the wood waste and debris are included as Figures A-98 through A-101.

CONE PENETRATION TEST PROGRAM

The field exploration program included a CPT program to provide an overview of the subsurface soil conditions at the project site. The CPT program consisted of advancing 23 CPT soundings (CPT-1 through CPT-23) at the locations illustrated on Figure 3 of this report. The CPT soundings were advanced to depths ranging from about 41 to 152 ft BGS using truck-mounted CPT equipment. The CPT soundings were completed by WSDOT drilling crews.

At each CPT sounding location, a four-channel electronic cone was pushed at a rate of between 1 to 2 centimeters (cm) per second. The cone was used to simultaneously record tip resistance, sleeve friction, pore pressure, and inclination every 5 cm. Electrical energy was used to transmit the data to a receiver located at the ground surface. Upon completion of testing, the CPT soundings were abandoned in general accordance with the requirements of WAC 173-160.

WSDOT reduced the collected CPT data and plotted tip resistance, sleeve friction, friction ratio (sleeve friction divided by tip resistance), and pore water pressure as a function of sounding depth. WSDOT then used published correlations (Robertson and Campanella 1983) to estimate soil behavior types and Standard Penetration Test values at each interval where data were recorded (i.e., approximately every 2 inches). CPT logs produced by WSDOT are presented at the end of this appendix.

During the advancement of the CPT soundings, WSDOT drill crews performed 59 pore water dissipation tests. A discussion of the CPT dissipation tests and test results are presented in Appendix C of this report. WSDOT drill crews also performed shear wave velocity tests in the upper 80 ft of five of the CPT soundings. A discussion of the shear wave velocity tests and test results are presented in Appendix C of this report.

REFERENCES

Landau Associates. 2006a. *Geotechnical and Hydrogeologic Study, Bridge Pontoon Construction Facility, Grays Harbor, Washington.* Prepared for WSDOT. May 31.

Landau Associates. 2007a. Report: *Geotechnical Design Study WSDOT Special Projects Construction Site, Grays Harbor, Washington*. Prepared for WSDOT. March 29.

Miner. 2007. Letter Report: *Standard Penetration Test Energy Measurements, Washington State Department of Transportation Drilling Rigs, RMDT Job No. 06F11.* Prepared for the Washington State Department of Transportation. Robert Miner Dynamic Testing, Inc. April 20.

Robertson, P.K. and R.G. Campanella. 1983. *Interpretation of Cone Penetration Tests, Part I: Sand.* Canadian Geotechnical Journal. Volume 20. pp. 718-733.

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS[2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

NOTES:

1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50%	"GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50%	"very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30%	"gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15%	"with gravel," "with sand," "with silt," etc.
	≤ 5%	"trace gravel," "trace sand," "trace silt," etc., or not noted.

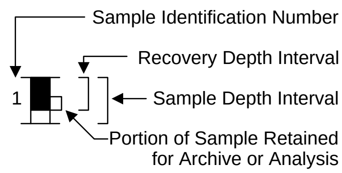
1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ SCS WSDOT 1OF2

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Rotosonic
5	Air Rotary (Rock)
6	Wash Rotary (Rock)
7	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
VST	Vane Shear Test
GT	Other Geotechnical Testing
CA	Chemical Analysis

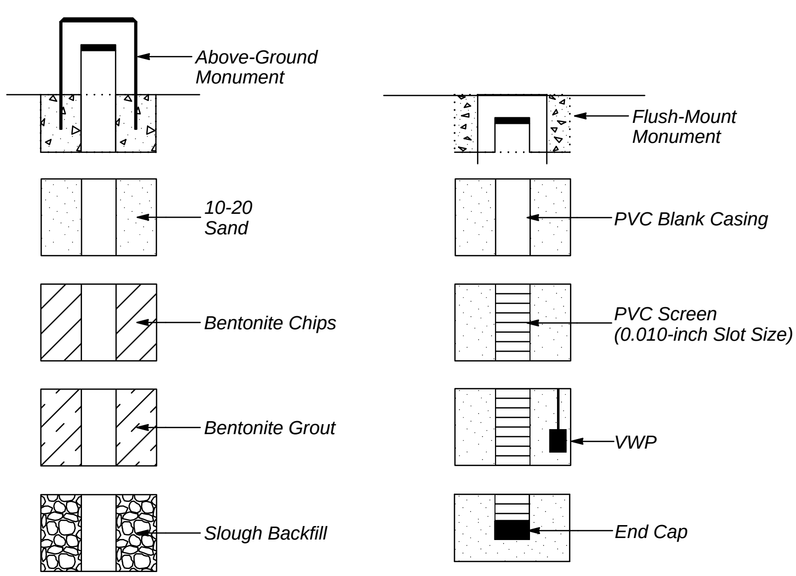
Groundwater

∇ Approximate water elevation at time of drilling (ATD).

▼ Approximate water elevation at other time(s). When multiple water levels are obtained other than ATD, only a representative range is shown. See text for additional information.

Note: Groundwater levels can fluctuate due to precipitation, seasonal conditions, and other factors.

Well Log Graphics



1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ SCS WSDOT 2OF2

TH-32-08

SAMPLE DATA / SOIL PROFILE

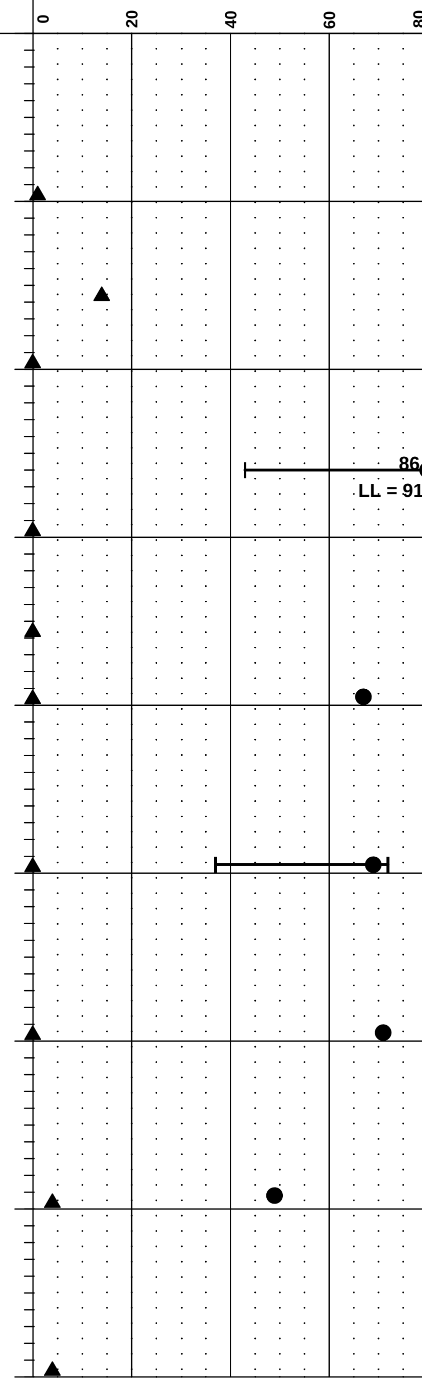
Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - D. Henderson Lic # 2742
Ground Elevation (ft): 14.94 (MLLW)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
5	S-1	b2	1	PID=0
	S-2	b2	14	PID=0
10	S-3	b2	0	PID=0
	S-4	c3		GT W = 86 AL
15	S-5	b2	0	PID=0
	S-6	b2	0	PID=0
20	S-7	b2	0	PID=0 W = 67
25	S-8	b2	0	PID=0 W = 69 AL
30	S-9	b2	0	PID=0 W = 71
35	S-10	b2	4	W = 49
40	S-11	b2	4	

USCS Symbol	Soil Profile Description
MH	Gray brown, SILT with trace sand and some fine organics (very soft to soft, wet) **(SOIL UNIT 1)** - log approximate 6 diameter encountered - log approximately 4 diameter encountered - silty, fine SAND interbeds - wood and shells
SM/ML	Gray brown, SILT with sand and interbedded silty, fine SAND (soft to medium stiff and loose to medium dense, wet) **(SOIL UNIT 2B)**

Groundwater

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Boring TH-32-08

Figure A-33 (1 of 4)

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

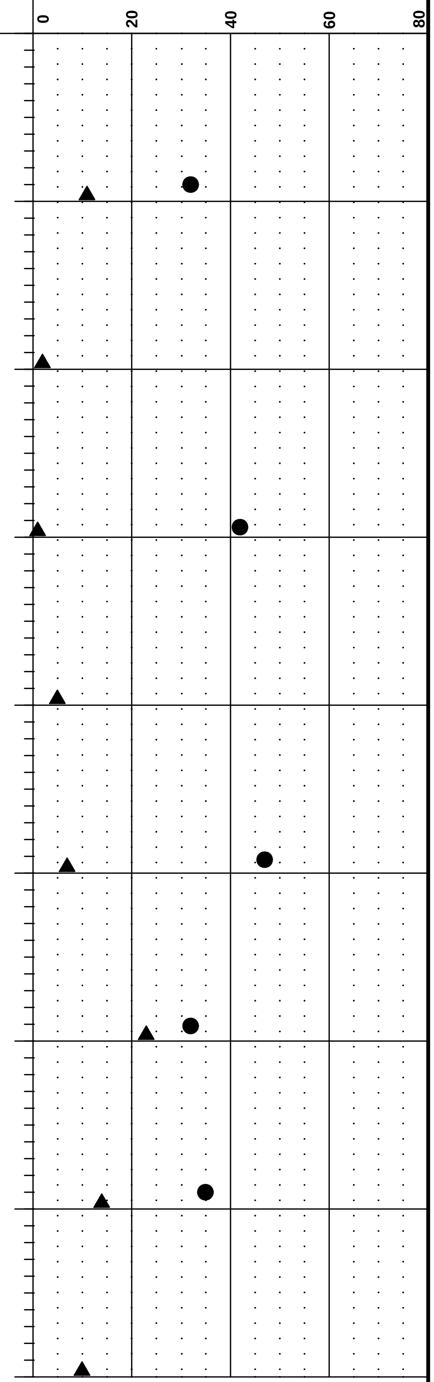
TH-32-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - D. Henderson Lic # 2742
Ground Elevation (ft): 14.94 (MLLW)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater
40					SM/ ML	Gray brown, SILT with sand and interbedded silty, fine SAND (soft to medium stiff and loose to medium dense, wet) **(SOIL UNIT 2B)** - shells	
45	S-12	b2	11	W = 32			
50	S-13	b2	2				
55	S-14	b2	1	W = 42		- decomposed wood fragments	
60	S-15	b2	5				
65	S-16	b2	7	W = 47			
70	S-17	b2	23	W = 32	SM	Gray, silty, fine SAND to fine SAND with silt and occasional thin (1/8 to 1/4 inch) interbedded light brown, SILT (loose to medium dense, wet)	
75	S-18	b2	14	W = 35		- decomposed wood debris	
80	S-19	b2	10			- trace shells	

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)



Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

TH-32-08

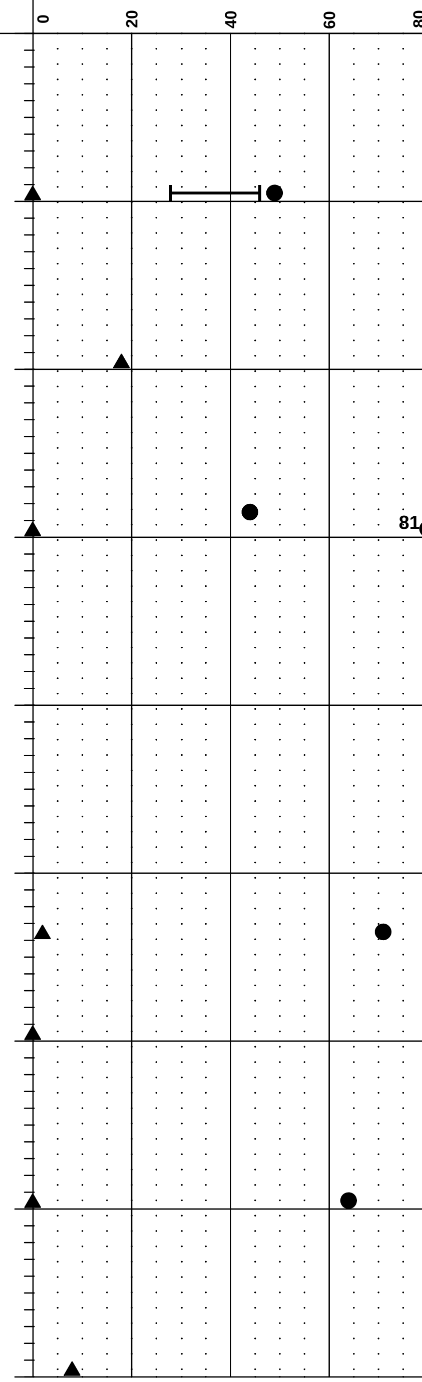
SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - D. Henderson Lic # 2742
Ground Elevation (ft): 14.94 (MLLW)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
80					SM	
					ML	Gray brown, SILT with thin (1/32 to 1/16 inch) interbedded fine SAND with silt and trace organics (very soft, wet) **(SOIL UNIT 3)**
85	S-20	b2	0	W = 49 AL		
					SP/ SM	Gray, fine SAND with silt grading to silty, fine SAND and trace shell fragments and occasional interbedded SILT (medium dense, wet)
90	S-21	b2	18			
95	S-22A S-22B	b2	0	W = 44 W = 81	MH	Light brown, SILT with scattered fine organics (very soft to soft, wet)
100	S-23	c3				
105	S-24	c3				
	S-25	b2	2	W = 71		
110	S-26	b2	0			
115	S-27	b2	0	W = 64		
					SM/ ML	Light brown, SILT with scattered fine organics grading to fine SAND with silt (medium stiff to stiff and loose, wet)
120	S-28	b2	8			

Groundwater

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)



Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Log of Boring TH-32-08	Figure A-33 (3 of 4)

TH-32-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - D. Henderson Lic # 2742
Ground Elevation (ft): 14.94 (MLLW)

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)
0 20 40 60 80

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater
120					SM/ ML	- trace thin (1/16 to 1/8 inch) interbedded fine SAND with silt Light brown, SILT with scattered fine organics grading to fine SAND with silt (medium stiff to stiff and loose, wet)	
					GP	Gray, very sandy to sandy GRAVEL (medium dense to very dense, wet) **(SOIL UNIT 4)**	
125	S-29	b2	41				
130	S-30	b2	42				
135	S-31	b2	28				
140	S-32	b2	61				

Boring Completed 08/29/08
Total Depth of Boring = 140.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: N/A

Point located at State Plane Coordinates:
North: 615777.36
East: 796064.14
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

145
150
155
160

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Boring TH-32-08

TH-35-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - D. Henderson Lic # 2742
Ground Elevation (ft): 15.21 (MLLW)

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
0					SM	Mottled brown, reddish brown, and gray, silty, fine SAND to fine SAND with silt (very loose, wet) **(SOIL UNIT 1)**
5	S1	g2	3	PID=0 W = 47		
	S2A	g2	4	PID=0	ML	Dark brown, SILT with trace sand with abundant fine organics (soft, wet)
	S2B					
	S3	g2	50/ 4"	PID=0	WD	Wood
					ML	Dark gray, SILT with trace sand (very soft to soft, wet)
10	S4	g2	1	PID=0 W = 71		
	S5	g2	0	PID=0		
	S6	g2	0	PID=0 W = 70		- grading to black, and occasional silty, fine SAND interbeds
15	S7	g2	0	PID=0		- trace shells 14 to 29 feet
	S8	g2	0	PID=0 W = 74		- grading to gray brown
	S9	g2	1	PID=0		- wood approximately 2" diameter
20	S10	g2	0	PID=0		- wood approximately 3" diameter
	S11	g2	0	PID=0		
	S12	g2	0	PID=0 W = 54		
25	S13	g2	0	PID=0		
	S14	g2	2	PID=0		- interbedded fine sandy SILT
	S15	g2	0	PID=0		- grading to SILT with sand and very fine sandy SILT with decomposed wood debris and twigs
30	S16	g2	1	PID=0 W = 54		
					SM/ ML	Gray brown, SILT with thin (1/2 to 1/16 inch) interbedded fine SAND with silt and trace shell and fragments and fine organics (very soft to soft, wet) **(SOIL UNIT 2B)**
35	S17	b2	1	PID=0 W = 70		
40	S18	b2	2	PID=0		

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Boring TH-35-08

Figure A-36 (1 of 2)

TH-35-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - D. Henderson Lic # 2742
Ground Elevation (ft): 15.21 (MLLW)

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

0 20 40 60 80

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater
40				W = 46	SM/ ML		
					SM	Gray, fine SAND with silt and thin (1/4 to 1/8 inch) interbedded light brown, SILT with some shells (loose, wet)	
45	S19	b2	5	PID=0 W = 27			
					SM/ ML	Gray brown, interbedded SILT with trace sand and gray, silty, fine SAND with trace shells (very soft to soft and very loose, wet)	
50	S20	b2	2	PID=0 W = 56			

Boring Completed 09/09/08
Total Depth of Boring = 50.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: N/A

Point located at State Plane Coordinates:
North: 615859.47
East: 796176.13
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

55

60

65

70

75

80

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

TH-36-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary

Casing: 4" ID (HW)

Driller (Lic.#): WSDOT - D. Henderson Lic # 2742

Ground Elevation (ft): 13.25 (MLLW)

Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
S1	b2	2	
S2	b2	6	W = 45
S3	b2	3	GT
S4	b2	0	W = 58 AL
S5	b2	0	CA W = 62
S6	b2	0	W = 67
S7	b2	0	W = 65 AL
S8	b2	0	W = 44
S9	b2	0	W = 70
S10	b2	2	W = 36
S11	b2	3	W = 46

USCS Symbol	Description
GP	Dark gray, fine to medium sandy GRAVEL with petroleum like odor (very loose, wet) **(ROAD FILL MATERIAL)**
ML	Dark gray, SILT with wood with petroleum like odor (soft to medium stiff, wet) **(SOIL UNIT 1)**
WD	Wood with petroleum like odor
MH	Gray brown, SILT (very soft, wet) - with trace thin (1/32 to 1/16 inch) interbedded fine SAND with silt (very soft, wet)
SM/MH	Gray brown, SILT with sand and interbedded silty, fine SAND (very soft and very loose, wet)
SM	Gray brown, silty, fine SAND with medium sand and some shell fragments and some thin interbedded SILT (very loose, wet)
ML	Gray brown, fine sandy SILT with some thin (1/2 to 1/4 inch) interbedded fine SAND with silt and some fine organics and trace shells (very soft, wet)
SM/ML	Dark gray, interbedded fine SAND with silt and SILT (soft and very loose, wet) **(SOIL UNIT 2B)**

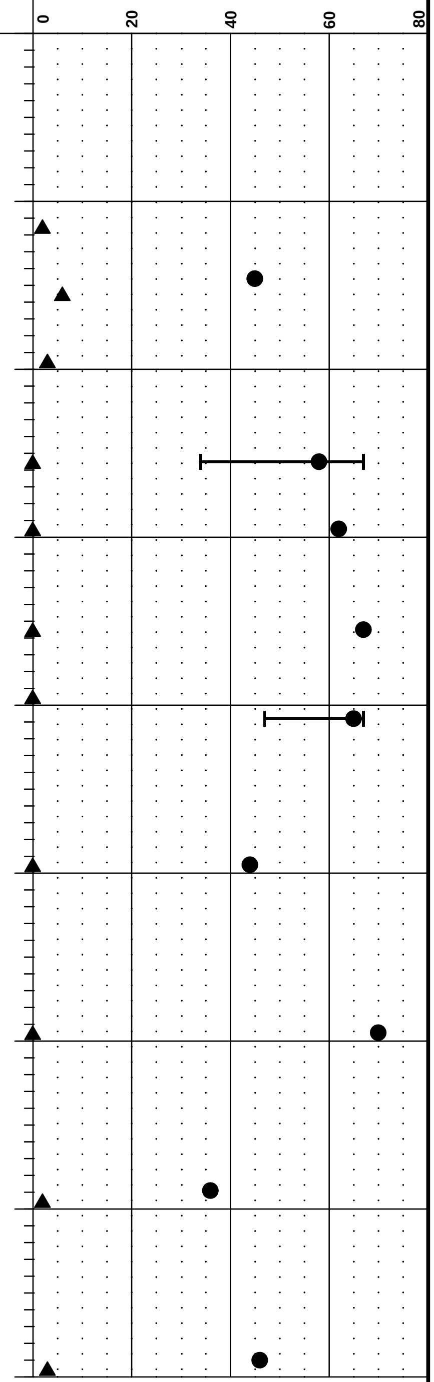
Groundwater

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer

△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A

● Moisture Content (%)

Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

TH-36-08

SAMPLE DATA					SOIL PROFILE				
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mud Rotary Casing: 4" ID (HW) Driller (Lic.#): WSDOT - D. Henderson Lic # 2742 Ground Elevation (ft): 13.25 (MLLW)	Groundwater	

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

0 20 40 60 80

40
45
50
55
60
65
70
75
80

Boring Completed 09/08/08
Total Depth of Boring = 40.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: N/A

Point located at State Plane Coordinates:
North: 616057.66
East: 796460.29
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

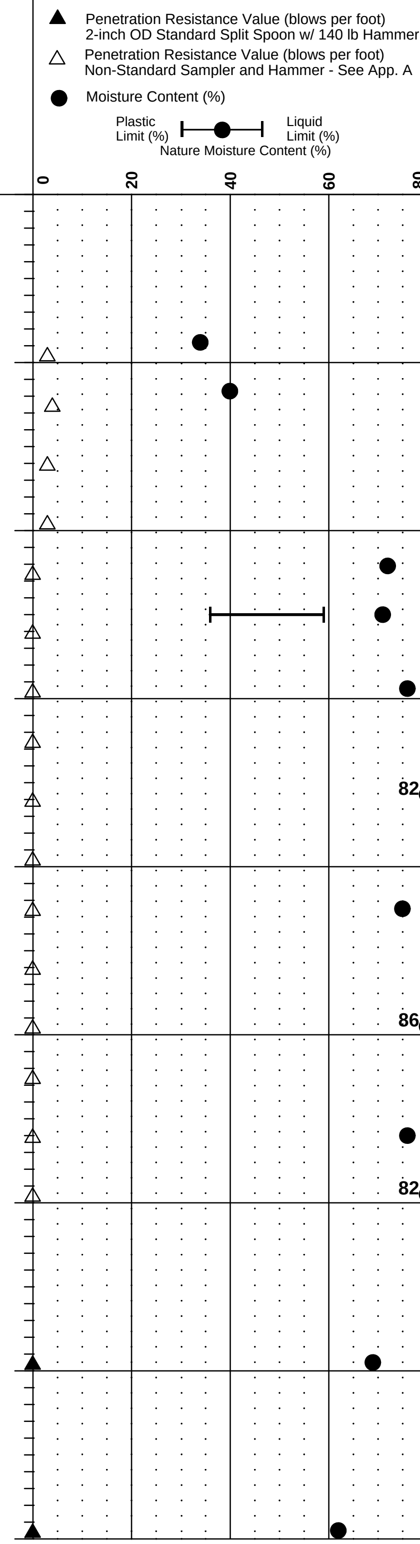
TH-37-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - D. Henderson Lic # 2742
Ground Elevation (ft): 14.43 (MLLW)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
0					SP-SM	Gray and light reddish brown, gravelly, fine SAND with silt and wood debris and coal fragments at 5 feet (very loose to loose, wet) **(SOIL UNIT 1)**
5	S1	g2	3	PID=0 W = 34 GS		
	S2	g2	4	PID=0 W = 40		
	S3A S3B	g2	3	PID=0		- grading to dark gray, very sandy SILT with organics
					WD	Wood and decomposed sawdust
10	S4	g2	3	PID=0		
					MH	Dark gray grading to gray brown, SILT with trace sand and trace organics, with some wood at 11 feet (very soft, wet)
	S5	g2	0	PID=0 W = 72		
	S6	g2	0	PID=0 W = 71 AL		
15	S7	g2	0	PID=0 W = 76		
	S8	g2	0	PID=0		
	S9	g2	0	PID=0 W = 82		- shell fragments
20	S10	g2	0	PID=0		
	S11	g2	0	PID=0 W = 75		- occasional fine sandy SILT interbeds
	S12	g2	0	PID=0		
25	S13	g2	0	PID=0 W = 86		
	S14	g2	0	PID=0		
	S15	g2	0	PID=0 W = 76		
30	S16	g2	0	PID=0 W = 82		
					ML	Gray brown, SILT with occasional thin (1/4 to 1/8 inch) interbedded fine SAND with silt (very soft, wet)
35	S17	b2	0	PID=0 W = 69		
40	S18	b2	0	PID=0		- increasing interbedded fine SAND with

Groundwater



Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Log of Boring TH-37-08	Figure A-38 (1 of 2)

TH-37-08

SAMPLE DATA				SOIL PROFILE			Groundwater
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	
40				W = 62			silt

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - D. Henderson Lic # 2742
Ground Elevation (ft): 14.43 (MLLW)

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)

Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

0 20 40 60 80

Boring Completed 09/09/08
Total Depth of Boring = 40.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: N/A

Point located at State Plane Coordinates:
North: 615724.44
East: 796434.54
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

40, 45, 50, 55, 60, 65, 70, 75, 80

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Log of Boring TH-37-08	Figure A-38 (2 of 2)

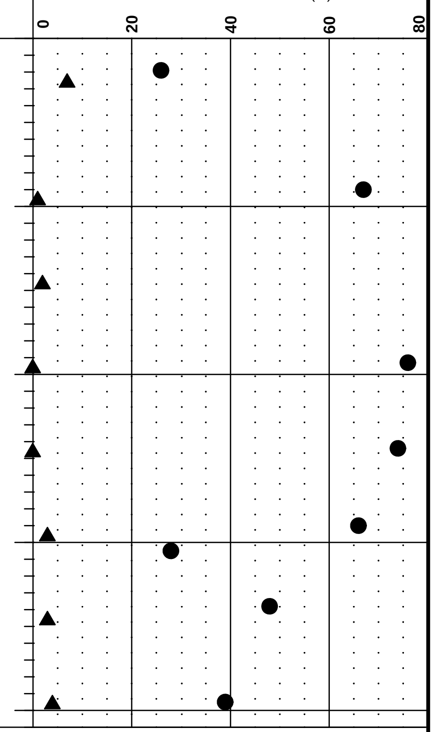
TH-41-08

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Soil Profile
0	S-1	b2	7	W = 26	SP-SM	Reddish brown, fine SAND with silt and fine to medium SAND with silt grading to with coarse sand and fine gravel (loose, moist) (SOIL UNIT 1)
5	S-2	b2	1	W = 67	ML	Gray, SILT with trace organics and fine sandy SILT with increasing decomposed wood (very soft, wet)
	S-3	b2	2		WD	WOOD and gray SILT with trace sand (very soft to soft, wet)
10	S-4	b2	0	W = 76	ML	Gray, SILT and interbedded SILT with sand (very soft, wet)
	S-5	b2	0	W = 74		
15	S-6A S-6B	b2	3	W = 66 W = 28	SM	Gray, silty, fine SAND with organics (very loose, wet)
	S-7	b2	3	W = 48		- with interbedded SILT with sand
20	S-8	b2	4	W = 39 -200 = 13	SM	Gray, fine SAND with silt (very loose, wet) (SOIL UNIT 2B)

SAMPLE DATA / **SOIL PROFILE** / Graphic Symbol / Groundwater

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - R. Shepherd Lic # 2710
Ground Elevation (ft): 14.84 (MLLW)

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)



Boring Completed 06/30/08
Total Depth of Boring = 20.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: N/A

Point located at State Plane Coordinates:
North: 615827.95
East: 795838.92
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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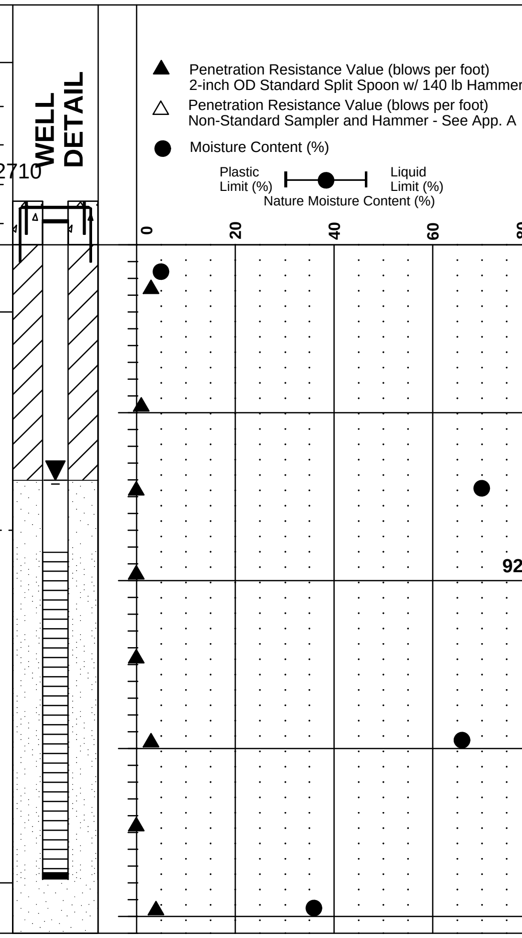
SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Boring TH-41-08

Figure A-42

TH-47P-08

SAMPLE DATA				SOIL PROFILE		
Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mud Rotary Casing: 4" ID (HW) Driller (Lic.#): WSDOT - R. Shepherd Lic # 2710 Ground Elevation (ft): 16.67 (MLLW)
S-1	b2	3	W = 5		GP-GM	Gray and brown, sandy GRAVEL with silt (very loose, moist) **(CRUSHED ROAD MATERIAL)**
S-2	b2	1			ML	Gray brown, sandy, clayey SILT with gravel and wood and trace organics (very soft, moist to wet) **(SOIL UNIT 1)**
S-3	b2	0	W = 70 GS			
S-4	b2	0	W = 92		ML	Gray brown, SILT with increasing interbedded fine organics and wood (very soft to soft, wet)
S-5	b2	0				- with thin interbedded silty, fine SAND and less organics and no wood
S-6	b2	3	W = 66			- with sand to trace sand and trace organics
S-7	b2	0				
S-8	b2	4	W = 36 -200 = 15		SM	Gray, fine SAND with silt (very loose to loose, wet) **(SOIL UNIT 2B)**



Boring Completed 07/02/08
Total Depth of Boring = 20.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: APJ-609

Point located at State Plane Coordinates:
North: 615962.27
East: 795451.18
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Total Depth of Piezometer = 20.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

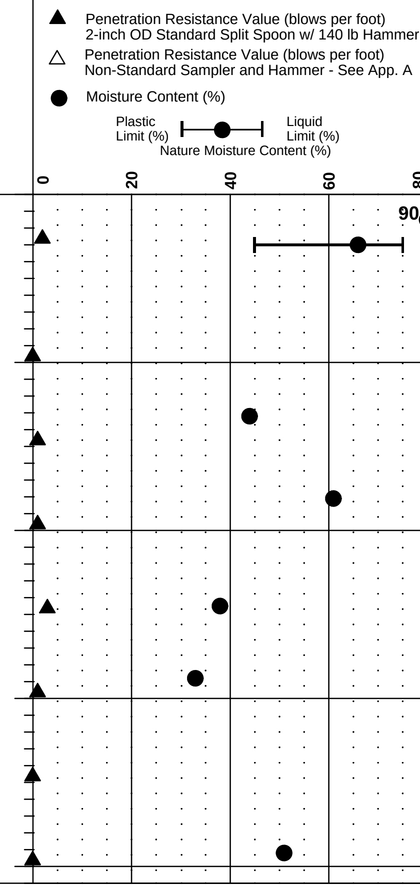
TH-61-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - R. Shepherd Lic # 2710
Ground Elevation (ft): 12.11 (MLLW)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
0	S-1A S-1B	b2	2	W = 90 W = 66 AL	ML/ OL MH	Dark brown, SILT with sand and abundant fine organics and roots (very soft to soft, wet) **(SOIL UNIT 1)** Mottled reddish brown and gray, SILT with trace sand (very soft to soft, wet)
5	S-2	b2	0			
	S-3	b2	1	W = 44 -200 = 0	SP	Gray, fine SAND with scattered interbedded fine organics (very loose, wet)
10	S-4	b2	1	W = 61	ML	Gray, very sandy SILT to very silty, fine SAND (very soft and very loose, wet)
	S-5	b2	3	W = 38 -200 = 29	SM	Gray, silty, fine SAND to fine SAND with silt (very loose, wet) **(SOIL UNIT 2B)**
15	S-6	b2	1	W = 33		
	S-7	b2	0			
20	S-8	b2	0	W = 51		

Groundwater



Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35, 40

Boring Completed 06/30/08
Total Depth of Boring = 20.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: N/A

Point located at State Plane Coordinates:
North: 615934.39
East: 795592.31
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Boring TH-61-08

Figure A-62

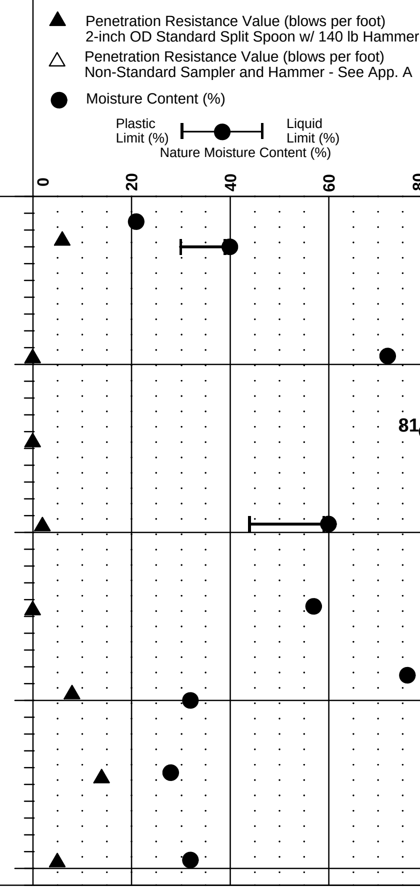
TH-62-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - R. Shepherd Lic # 2710
Ground Elevation (ft): 14.44 (MLLW)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
0					SM	Reddish brown, silty, fine SAND (loose, moist to wet)
	S-1A S-1B	b2	6	W = 21 W = 40 AL	ML	(SOIL UNIT 1) Reddish brown, SILT with interbedded fine sand to fine sandy SILT (medium stiff, wet)
					MH	Gray, clayey SILT with trace sand and scattered fine organics (very soft, wet)
5	S-2	b2	0	W = 72 GS		
	S-3	b2	0	W = 81		
					MH	Gray, SILT with sand and interbeds of abundant wood and shell fragments (very soft to soft, wet)
10	S-4	b2	2	W = 60 AL		
	S-5	b2	0	W = 57		
					ML	Brown, fine sandy SILT with abundant scattered fine organics (medium stiff to stiff, wet)
15	S-6A S-6B	b2	8	W = 76 W = 32	SM	Gray, silty, fine SAND with trace scattered fine organics (loose, wet)
	S-7	b2	14	W = 28	SP-SM	(SOIL UNIT 2B) Gray, fine SAND with silt (medium dense, wet)
20	S-8	b2	5	W = 32 -200 = 12		

Groundwater



Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35, 40

Boring Completed 06/30/08
Total Depth of Boring = 20.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: N/A

Point located at State Plane Coordinates:
North: 615872.87
East: 795692.29
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Log of Boring TH-62-08	Figure A-63

TH-63-08

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - R. Shepherd Lic # 2710
Ground Elevation (ft): 14.85 (MLLW)

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
0	S-1	b2	10	W = 24 GS	SM	Reddish brown, silty, fine SAND with trace gravel (loose to medium dense, moist to wet) **(SOIL UNIT 1)**
					ML	Gray, fine sandy SILT with decomposed wood (very soft, wet)
5	S-2	b2	1	W = 44 GS		
	S-3	b2	3		WD	Brown, partially decomposed WOOD (soft, wet)
10	S-4	b2	0	W = 80	ML	Gray brown, SILT with sand and some wood and scattered fine organics (very soft, wet)
	S-5	b2	0	W = 80 AL	MH	Gray to dark gray, SILT with scattered fine organics and trace shell fragments (very soft, wet)
15	S-6	b2	0	W = 67		
	S-7	b2	6	W = 50	ML	Gray brown, SILT with sand grading to fine sandy SILT with trace shells and fine organics (medium stiff, wet)
20	S-8	b2	3	W = 39	SM	Gray, silty, fine SAND with some decomposed wood and fine organics (very loose, wet) **(SOIL UNIT 2B)**

LL = 81

Boring Completed 07/01/08
Total Depth of Boring = 20.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: N/A

Point located at State Plane Coordinates:
North: 615793.41
East: 795961.23
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TH-64-08

SAMPLE DATA				SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol

Drilling Method: Rotosonic
Casing: 8" dia. cased
Driller (Lic.#): Boart Longyear Inc.
Ground Elevation (ft): 12.25 (MLLW)

WELL DETAIL

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

0 20 40 60 80

USCS Symbol	Description
ML	Brown, SILT with sand (soft, wet) **(SOIL UNIT 1)**
SM	Gray, silty, fine SAND (soft, wet)
ML	Gray, SILT with sand and trace organics and trace shell fragments (soft, wet) -increasing fine sand -decreasing fine sand
ML	Gray, SILT with trace sand, trace shells, and trace organics with occasional sand interbeds (soft, wet)
SM/ML	Gray, silty, fine SAND to fine sandy SILT (soft, wet)
ML	Gray, SILT with trace sand (soft, wet)
SM	Gray, silty, fine SAND with trace organics (soft, wet) **(SOIL UNIT 2A)** -Increasing fine sand
ML	Gray, SILT with SAND interbeds (soft, wet)
SM	Gray, silty, fine SAND (soft, wet)
ML	Gray, fine sandy SILT with silty, fine SAND interbeds (soft, wet)
SM	Gray, very silty, fine SAND with trace organics and with SILT interbeds (soft, wet) -no silt interbeds

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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TH-64-08

SAMPLE DATA					SOIL PROFILE			WELL DETAIL
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Rotosonic Casing: 8" dia. cased Driller (Lic.#): Boart Longyear Inc. Ground Elevation (ft): 12.25 (MLLW)	
40						ML	Gray, SILT with sand and trace organics and trace shell fragments and interbedded, silty, fine SAND (soft and wet)	
45						ML	Gray, fine sandy SILT (soft and wet)	
50						SM	Gray, silty, fine SAND (soft and wet)	
						SM	Gray, fine to medium SAND with silt and trace coarse sand (soft and wet)	
55								

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

0 20 40 60 80

Boring Completed 07/29/08
Total Depth of Boring = 55.6 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: BAJ-222

Point located at State Plane Coordinates:
North: 615141.51
East: 796813.97
Township: 17N
Range: 10W
Section: 11
Inspector: AJF

Total Depth of Well = 55.6 ft.

60
65
70
75
80

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

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SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

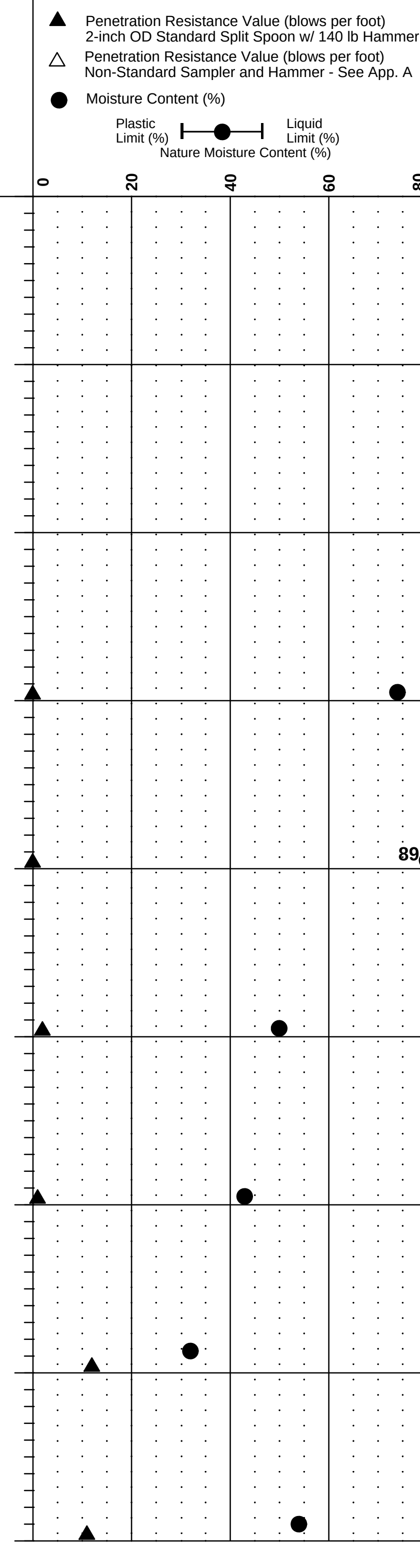
Log of Boring TH-64-08

Figure A-65
(2 of 2)

TH-65P-08

SAMPLE DATA					SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mud Rotary; Casing: 4" ID (HW); Driller (Lic.#): WSDOT - R. Shepherd Lic # 2710; Ground Elevation (ft): 12.51 (MLLW)
0						ML	Gray brown, SILT with trace sand and interbedded fine sandy SILT and trace organic interbeds and trace shell fragments (very soft, wet) **(SOIL UNIT 1)**
15	S-1	b2	0	W = 74			
20	S-2	b2	0	W = 89			
						SM	Gray, very silty, fine SAND with occasional interbedded fine sandy SILT some fine organics (very loose, wet)
25	S-3	b2	2	W = 50 -200 = 43			
						SM	Gray,very silty, fine SAND with interbedded silty, fine SAND and with occasional thin (1/4 to 1/8 inch) interbedded SILT with sand (very loose, wet) **(SOIL UNIT 2B)**
30	S-4	b2	1	W = 43 -200 = 36			
						SM	Gray, silty, fine SAND with trace organics and occasional thin (1/8 inch) interbedded SILT (medium dense, wet)
35	S-5	b2	12	W = 32			
						SP-SM	Gray, fine SAND with silt and trace shells (medium dense, wet)
40	S-6	b2	11	W = 54			

WELL DETAIL



Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Log of Boring TH-65P-08	Figure A-66 (1 of 2)

TH-65P-08

SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - R. Shepherd Lic # 2710
Ground Elevation (ft): 12.51 (MLLW)

WELL DETAIL

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) ├──●──┤ Liquid Limit (%)
Nature Moisture Content (%)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
40–47.5					ML	Gray, SILT with sand and occasional thin (1/8 inch) interbedded silty, fine SAND and fine SAND with silt with trace organics and shells (very soft, wet)
45	S-7	b2	0	W = 49		
47.5–52					SM/ ML	Gray, fine sandy SILT with interbedded silty, fine SAND and fine SAND with silt (very soft and very loose, wet)
50	S-8	b2	0	W = 51		
52–60.5					SM	Gray, silty, fine SAND with some partially decomposed wood and thin (1/8 to 1/2 inch) interbedded light brown SILT (loose, wet)
55	S-9	b2	9	W = 41		
60	S-10	b2	4	W = 40 -200 = 23		

Depth scale: 40, 45, 50, 55, 60, 65, 70, 75, 80
Chart scale: 0, 20, 40, 60, 80

Boring Completed 07/15/08
Total Depth of Boring = 60.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: APJ-613

Point located at State Plane Coordinates:
North: 615140.14
East: 796799.42
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Total Depth of Piezometer = 60.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

TH-66P-08

SAMPLE DATA					SOIL PROFILE		WELL DETAIL
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mud Rotary Casing: 4" ID (HW) Driller (Lic.#): WSDOT - J. Fetterly Lic # 2507 Ground Elevation (ft): 12.07 (MLLW)
0–20						ML	Gray, SILT with trace sand and trace organics (very soft, wet) **(SOIL UNIT 1)** (inferred from TH-66P-A-08) (no samples collected from this boring) - with occasional thin (1/8 inch) interbedded fine organics and trace shells

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

0 20 40 60 80

Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35, 40

Boring Completed 07/16/08
Total Depth of Boring = 20.0 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: APJ-614

Point located at State Plane Coordinates:
North: 615141.80
East: 796829.34
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Total Depth of Piezometer = 20.0 ft.

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Boring TH-66P-08

Figure
A-67

TH-66P-A-08

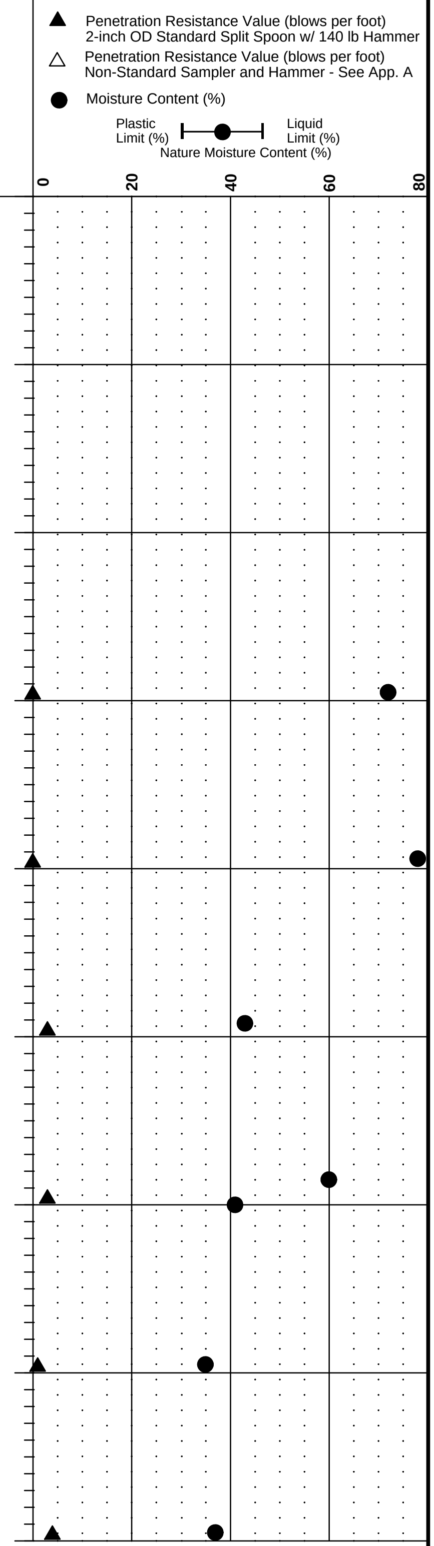
SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - J. Fetterly Lic # 2507
Ground Elevation (ft): 12.10 (MLLW)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
15	S-1	b2	0	W = 72
20	S-2	b2	0	W = 78
25	S-3	b2	3	W = 43
30	S-4A S-4B	b2	3	W = 60 W = 41
35	S-5	b2	1	W = 35 -200 = 18
40	S-6	b2	4	W = 37

Depth (ft)	USCS Symbol	Description
0	ML	Gray, SILT with trace sand and trace organics (very soft, wet) **(SOIL UNIT 1)** - with occasional thin (1/8 inch) interbedded fine organics and trace shells
~22	SM	Gray, silty, fine SAND with trace partially decomposed wood and thin interbedded fine organics and trace shells (very loose, wet)
~27	ML	Gray brown, SILT with trace to with sand and shells (soft, wet)
~29.5	SM	Gray, silty, fine SAND with silt and thin (1/4 to 1/8 inch) interbedded light brown, SILT with shells (very loose to loose, wet) **(SOIL UNIT 2B)**

WELL DETAIL



Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Boring TH-66P-A-08

Figure A-68 (1 of 2)

TH-66P-A-08

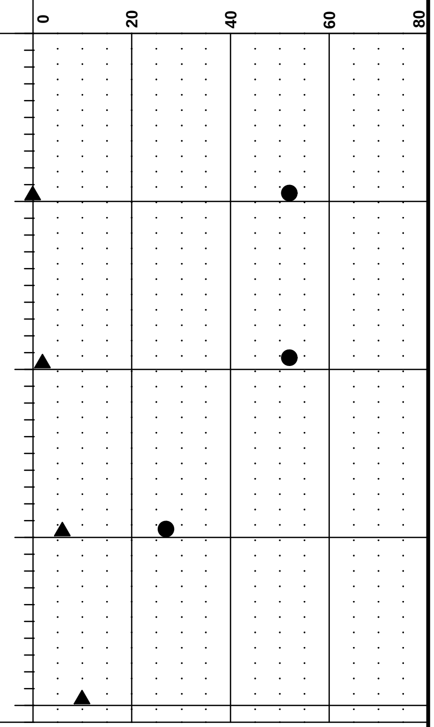
SAMPLE DATA / SOIL PROFILE

Drilling Method: Mud Rotary
Casing: 4" ID (HW)
Driller (Lic.#): WSDOT - J. Fetterly Lic # 2507
Ground Elevation (ft): 12.10 (MLLW)

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description
40				-200 = 17	SM	
					ML	Gray brown, SILT with sand to trace sand and occasional thin (1/4 inch) silty, fine SAND with some fine organics and trace partially decomposed wood and shells (very soft, wet)
45	S-7	b2	0	W = 52		
					SM/ ML	Gray and light brown, thin (1/16 to 1/4 inch) silty, fine SAND and SILT with occasional thin (1 inch) interbedded fine SAND with silt (very soft to soft and very loose, wet)
50	S-8	b2	2	W = 52		
					SP	Gray, fine to medium SAND with trace silt and trace decomposed wood (loose, wet)
55	S-9	b2	6	W = 27 -200 = 4		
					SM/ ML	Gray and light brown, thin (1/16 to 1/4 inch) silty, fine SAND and SILT with occasional thin (1 inch) interbedded fine SAND with silt (very soft to soft and very loose, wet)
					SP- SM	Gray, fine SAND with silt to trace silt with occasional thin (1/8 to 1/4 inch) light brown, SILT (loose to medium dense, wet)
60	S-10	b2	10			

WELL DETAIL

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)



Boring Completed 07/16/08
Total Depth of Boring = 60.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: APJ-622

Point located at State Plane Coordinates:
North: 615133.80
East: 796829.34
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Total Depth of Piezometer = 60.5 ft.

Depth (ft) scale: 65, 70, 75, 80

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TH-67P-08

SAMPLE DATA

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
15	S-1	c3		
	S-2	c3		GT W = 64 AL
	S-3	b2	0	W = 65 AL
25	S-4	b2	3	W = 57
30	S-5A S-5B	2 b2	8	W = 56 AL
35	S-6	b2	8	W = 27
40	S-7	b2	7	W = 31

SOIL PROFILE

Drilling Method: Mud Rotary

Casing: 4" ID (HW)

Driller (Lic.#): WSDOT - J. Fetterly Lic # 2507

Ground Elevation (ft): 11.94 (MLLW)

Depth (ft)	USCS Symbol	Description
0	MH	Gray brown and dark gray, SILT with occasional thin (I/8 inch) interbedded fine SAND with silt and occasional fine organics (very soft to soft, wet) **(SOIL UNIT 1)**
25		- with interbedded fine organics and trace shells
28	CL	Gray brown and dark gray, CLAY (medium stiff, wet)
30	SM	Gray, silty, fine SAND and fine SAND with silt and thin (1/16 to 1/8 inch) light brown, SILT with shells (loose, wet)
33	SP-SM	Gray, fine SAND with silt to trace silt (loose, wet) **(SOIL UNIT 2B)**
39		- trace shell fragments and fine organics

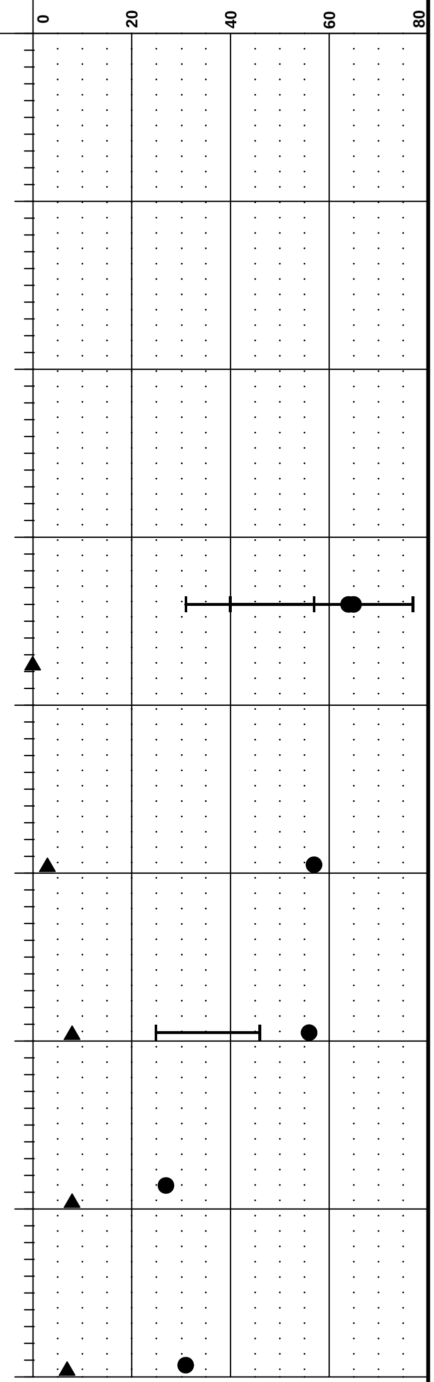
WELL DETAIL

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer

△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A

● Moisture Content (%)

Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)



Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TH-67P-08

SAMPLE DATA					SOIL PROFILE		
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Mud Rotary Casing: 4" ID (HW) Driller (Lic.#): WSDOT - J. Fetterly Lic # 2507 Ground Elevation (ft): 11.94 (MLLW)
40						SP-SM	
						ML	Gray brown, SILT with trace sand with occasional very thin (1/32 inch) interbedded silty, fine SAND and trace shell fragments (very soft, wet)
45	S-8	b2	0	W = 52 AL			
						SM/ML	Gray and light brown, interbedded thin (1/16 to 1/4 inch) silty, fine SAND to fine SAND with silt and SILT (very soft to soft and very loose, wet)
50	S-9	b2	2	W = 52			
						SP	Dark gray, fine to medium SAND with trace silt grading to fine SAND with silt and occasional thin (1/16 inch) interbedded light brown, SILT with trace shell and wood fragments (loose, wet)
55	S-10	b2	8	W = 43			
60	S-11A S-11B	b2	8	W = 29 W = 38		SM/ML	Gray brown and light brown, silty, fine SAND with occasional thin interbedded fine sandy SILT (loose, wet)
65							
70							
75							
80							

WELL DETAIL

▲ Penetration Resistance Value (blows per foot) 2-inch OD Standard Split Spoon w/ 140 lb Hammer
△ Penetration Resistance Value (blows per foot) Non-Standard Sampler and Hammer - See App. A
● Moisture Content (%)
Plastic Limit (%) — Nature Moisture Content (%) — Liquid Limit (%)

0 20 40 60 80

Boring Completed 07/16/08
Total Depth of Boring = 60.5 ft.
WSDOT Job #: XL 2672
Start Card #: Unknown
Ecology Well#: APJ-615

Point located at State Plane Coordinates:
North: 615142.12
East: 796843.91
Township: 17N
Range: 10W
Section: 11
Inspector: BEC

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SOIL BORING LOG W/ WELL 80

TP-01-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 11.70 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML	Mottled brown and gray clayey SILT (soft, moist to wet), numerous small plant roots in upper foot, occasional small wood debris. **(SOIL UNIT 1)**	
	1	d	W = 72				
					ML/CL	Gray clayey SILT/silty SLAY (soft, wet), occasional small wood debris to 2 inches. - 10-inch diameter log in sidewall from approximately 3.5 to 5 feet.	Slight Seepage
	2	d	W = 75				
5						- becomes less plastic with depth.	
	3	d	W = 79				
10							

Test Pit Completed 07/21/08
Total Depth of Test Pit = 10.5 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615959.42
East: 795523.10
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

15

20

25

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-02-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 15.01 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML	Mottled gray and brown, clayey, fine sandy SILT (medium stiff, wet)(sandier in upper foot, numerous small wood debris, with gravel in bottom foot) **(SOIL UNIT 1)**	
	1	d	W = 25				
					ML	Dark gray, sandy SILT with sawdust (medium stiff, wet). Numerous pieces of decaying dimension lumber.	Slight Seepage
					ML	Gray, clayey SILT with sand (soft to medium stiff, wet)	
5	2	d	CA W = 54				
10							
						- small broken shells and buried marsh grass at approximately 13 feet.	
					ML	Gray, clayey SILT (soft, moist to wet), numerous small broken shells.	
15	3	d	W = 64				
20							
25							

Test Pit Completed 07/21/08
Total Depth of Test Pit = 16.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615725.72
East: 795616.80
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-03-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 15.15 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SP-SM	Brown, fine SAND with silt to trace silt, numerous grass roots (loose, moist). **(SOIL UNIT 1)**	
					ML/CL	Mottled gray and brown clayey SILT, scattered fine wood debris (loose, moist)	
					SM	Dark gray, silty, gravelly SAND, numerous fine to large wood debris, including occasional logs to 20" in diameter.	
5					ML	Gray, fine sandy SILT with trace clay	Moderate Seepage
10	1	d	W = 51				

Test Pit Completed 07/21/08
Total Depth of Test Pit = 12.5 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615583.50
East: 795531.18
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Depth scale: 0, 5, 10, 15, 20, 25

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

TP-04-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.54 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SM	Brown, silty, fine SAND (loose, moist) **(SOIL UNIT 1)**	
					ML	Dark gray sandy silt w/ abundant cedar shake spalls (soft, moist to wet)	
					SP-SM	Gray, fine SAND with silt (loose, wet). Significant caving and slumping of test pit sides below 3 feet.	Rapid Seepage
5							
	1	d	W = 31 GS				
10						- small broken shells and fine roots at 11.5	

Test Pit Completed 07/21/08
Total Depth of Test Pit = 12.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615450.87
East: 795428.17
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

15

20

25

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Test Pit TP-04-08

Figure
A-73

TP-05-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 15.82 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SP-SM	Brown, fine to medium SAND with silt to trace of silt (medium dense, moist) with trace wood debris. **(SOIL UNIT 1)**	
	1	d	W = 19				
					SM	Gray, very silty, fine SAND (medium dense, moist to damp), scattered wood debris (small limbs).	
	2	d	W = 40 GS				
5							Slight Seepage
						- pocket of dark brown, decayed sawdust between 6 and 8 feet in one corner of test pit.	
10						- pocket of dark brown, decayed sawdust between 10 and 12 feet in one corner of test pit.	
					ML	Gray SILT with sand (soft to medium stiff, moist to damp), occasional shells.	
	3	d	W = 51				

Test Pit Completed 07/21/08
Total Depth of Test Pit = 14.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615353.20
East: 795466.49
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

15

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Notes:
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3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Log of Test Pit TP-05-08	Figure A-74

TP-06-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.61 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SP	Brown, fine SAND with trace silt (medium dense, moist) **(SOIL UNIT 1)**	
	1	d	W = 17				
	2	d	CA W = 16 GS		SP	Gray, fine to medium SAND with trace silt and gravel (medium dense, moist), occasional wood debris near upper contact.	
5							
							Moderate Seepage
	3	d	W = 44				
10							
	4	d	W = 56		ML	Gray, clayey SILT with sand. 1-inch layer of marsh grass at 11 feet	

Test Pit Completed 07/21/08
Total Depth of Test Pit = 12.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615089.39
East: 795483.92
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

15

20

25

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Log of Test Pit TP-06-08	Figure A-75

TP-07-08

Excavation Method: Tracked Excavator
Ground Elevation (ft): 14.11 (MLLW)
Excavated By: Chinook Exc. and Land Dev.

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Notes/Groundwater
0				SP	Brown, fine SAND with trace silt (medium dense to dense, moist) **(SOIL UNIT 1)**	
	1	d	W = 11	SP	Gray, fine SAND with trace silt (medium dense to dense, moist)	
5	2	d	W = 12 GS	SP	Brown, fine to medium SAND with trace silt (medium dense, moist).	
				SM	Gray, fine SAND with silt (loose to medium dense, wet).	Moderate Seepage
10	3	d	W = 41 GS			

Test Pit Completed 07/21/08
Total Depth of Test Pit = 10.5 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 614942.21
East: 795437.30
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

15

20

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Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Test Pit TP-07-08

Figure A-76

TP-08-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.72 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SP-SM	Brown, fine SAND with silt to trace of silt (medium dense, moist) **(SOIL UNIT 1)**	
					SP	Gray, fine SAND, occasional layers with silt (medium dense, damp to wet). Occasional wood debris below 8 feet. Test pit caves rapidly below 3 feet.	
5							
							Slight Seepage
10							
15							
20							
25							

Test Pit Completed 07/21/08
Total Depth of Test Pit = 9.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 614970.36
East: 795607.17
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Log of Test Pit TP-08-08	Figure A-77

TP-09-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.12 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SP-SM	Brown, fine SAND with silt (medium dense to dense, moist). **(SOIL UNIT 1)** - occasional wood debris	
	1	d	W = 13				
						- several thin pockets of gray fine sand at 3.5 feet.	
	2	d	W = 27		SP	Gray, fine SAND with trace silt (medium dense, moist to damp).	
5					SP-SM	Brown, fine SAND with silt (medium dense to dense, moist).	
					SP-SM	Gray, fine SAND with silt (medium dense, moist to damp).	Moderate Seepage
	3	d	W = 38 GS				
10							

Test Pit Completed 07/22/08
Total Depth of Test Pit = 12.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 614831.63
East: 795545.63
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

15

20

25

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-10-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.78 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SP-SM	Brown, fine SAND with silt to trace silt (medium dense, moist). **(SOIL UNIT 1)**	
	1	d	W = 33 GS		SP	Gray, fine SAND with trace silt (loose to medium dense, wet), 1-inch seam of organic-rich sand at 3.5 feet.	Moderate Seepage
5							
10							
	2	d	W = 59 GS		ML	Gray, SILT with sand (soft to medium stiff, wet), abundant wood debris from 11.5 to 12.5.	
15							
20							
25							

Test Pit Completed 07/22/08
Total Depth of Test Pit = 13.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 614826.17
East: 795894.18
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-11-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.19 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SM	Brown, fine SAND with silt to silty (loose, moist), occasional wood debris to 3-inch diameter. **(SOIL UNIT 1)**	
	1	d	W = 90 GS		ML	Dark gray, sandy, SILT (medium stiff, damp), numerous fine organic fibers, medium plasticity.	
5							Slight Seepage
					SM	Brown, silty, gravelly SAND (dense, damp), gravel consists of quarry spalls to 3 inches. Top contact slopes from 3 ft to 8.5 ft BGS over distance of 15 ft (2.75H:1V); depth shown is midway along test pit wall. **(DIKE STRUCTURE)**	

Test Pit Completed 07/22/08
Total Depth of Test Pit = 8.5 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 614866.22
East: 796536.36
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

10

15

20

25

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-12-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 11.86 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML	Mottled brown and light gray sandy SILT to SILT with sand (soft to medium stiff, moist), abundant small roots, occasional wood debris. **(SOIL UNIT 1)**	
	1	d	W = 53				
	2	d	W = 96		MH/CH	Dark gray, clayey SILT/silty CLAY (soft, moist), occasional wood debris.	
5					SP-SM	Gray SAND with silt (loose, wet) - pocket of gray, decaying sawdust at 6 feet.	
					ML	Gray, SILT with sand to sandy SILT (soft to medium stiff, damp to wet) - stacked dimensioned lumber from 9 to 11 feet. Strong Hydrogen Sulfide odor.	Slight Seepage
10							
15	3	d	W = 63 GS		ML	Gray, SILT with sand to sandy SILT (soft to medium stiff, wet), scattered fine broken shells and layer of marsh grass at 15 feet.	
20							
25							

Test Pit Completed 07/22/08
Total Depth of Test Pit = 16.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615043.62
East: 796942.31
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-13-08

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Notes/Groundwater
0				ML	Brown, SILT with sand (medium stiff, moist). **(SOIL UNIT 1)**	
				GP-GM	Gray, GRAVEL with silt and sand (dense, moist), pit run used for work yard	
				ML	Gray, SILT with sand (medium stiff, moist)	
				DB	Brown, dimensioned lumber debris with pockets of silty sand and sandy silt. Includes approximately 1 foot of small, charred wood debris at top of unit.	Moderate Seepage
				ML	Gray to dark gray, fine sandy SILT (soft, DAMP)	
15	1	d	W = 63	ML	Gray to dark gray, fine sandy SILT (soft, DAMP), thin layer of marsh grass at top of unit.	

Excavation Method: Tracked Excavator
Ground Elevation (ft): 13.24 (MLLW)
Excavated By: Chinook Exc. and Land Dev.

Test Pit Completed 07/22/08
Total Depth of Test Pit = 17.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615297.23
East: 797050.94
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-14-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.47 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML	Mottled gray and brown, fine sandy SILT (medium stiff, moist), scattered small roots **(SOIL UNIT 1)** - scattered concrete and brick debris around 2 feet.	
	1	d					
	2	d			SM	Dark brown, silty SAND with occasional ash and charred wood debris (loose, damp)	
5							
					WD	Dark brown, decaying fine wood debris (very loose, wet), mostly sawdust and wood chips. - methane above LEL at surface of pile (disperses quickly). Strong Hydrogen Sulfide odor.	Moderate Seepage
	3	d					
					ML	Gray SILT with sand (soft, damp), occasional wood debris throughout unit.	
10							
15							
	4	d					
20							
25							

Test Pit Completed 07/22/08
Total Depth of Test Pit = 18.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615338.51
East: 797245.28
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-15-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.42 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML	Mottled brown and gray sandy SILT and SILT with sand (medium stiff to stiff, moist) **(SOIL UNIT 1)**	
					GP-GM	Gray, GRAVEL with sand and silt (dense, moist), angular (pit run or quarry spalls placed for working surface). - 30-inch log encountered in corner of test pit at 4 feet.	
					SM	Light brown, silty SAND (dense, moist)	
5					SP-SM	Brown, fine SAND with silt (medium dense, damp)	
					WD	Dark brown, decaying sawdust and wood chips, occasional larger wood debris.	
					ML	Dark gray, fine sandy SILT (medium stiff, damp), occasional pockets of decaying sawdust.	Slight Seepage
10							
15							

Test Pit Completed 07/22/08
Total Depth of Test Pit = 16.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615406.58
East: 797176.90
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-16-08

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	SOIL PROFILE	NOTES/GROUNDWATER
					Excavation Method: Tracked Excavator Ground Elevation (ft): 13.52 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0				SM	Brown, very silty, fine SAND (medium dense to dense, moist), numerous roots to 3/16" in upper 1.5 feet. **(SOIL UNIT 1)**	
	1	d	W = 21 GS			
				DB	White and light gray, coarsely broken oyster shells with silt and fine sand, (loose, moist)	
5	2	d	W = 356	WD	Dark brown, decaying WOOD with silt (loose, wet), mostly cedar shake spalls and cut ends of small dimensioned lumber.	Moderate Seepage
				ML/ MH	Gray, clayey SILT with sand (soft, damp), occasional pockets of fine wood debris (sawdust) throughout unit	
10						
	3	d	W = 66 AL			
15						
20						
25						

Test Pit Completed 07/22/08
Total Depth of Test Pit = 18.5 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615467.33
East: 797048.55
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-17-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.48 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					SM	Brown, silty, fine SAND (medium dense, moist), abundant roots to 3/16" diameter **(SOIL UNIT 1)**	
	1	d	W = 6 GS		SP	Brown, fine to medium SAND with trace silt (loose to medium dense, moist), occasional fine roots	
					ML	Mottled gray and brown, clayey SILT and SILT with sand	
	2	d	W = 42		SM	Gray, silty, fine SAND (medium dense, moist), occasional wood debris at top, numerous oyster shells from 5 to 10 feet. - vertical timber pile encountered in corner of test pit from approximately 6 to 10 feet BGS	Slight Seepage
5							
10					ML	Gray, fine sandy SILT with clay (soft, moist), occasional dark gray pockets of clayey silt, occasional fine organics.	
15							
	3	d	W = 64 AL				
20							
25							

Test Pit Completed 07/22/08
Total Depth of Test Pit = 18.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615509.74
East: 797209.63
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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TP-18-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.10 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML/MH	Brown, clayey SILT with trace sand (medium dense, moist), scattered small roots. **(SOIL UNIT 1)**	
	1	d	W = 41			- becomes mottled gray and brown below 2 feet	
					DB	White to light gray, large broken oyster shells with silt and sand (loose, wet), several large logs and other wood debris. Moved to TP-18A to negotiate digging below 8.5 feet.	
5					ML	Gray, sandy SILT (soft, wet)	Rapid Seepage

Test Pit Completed 07/22/08
Total Depth of Test Pit = 8.5 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615561.58
East: 797072.54
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Test Pit TP-18-08

Figure A-87

TP-18A-08

SAMPLE DATA				SOIL PROFILE		NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.10 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0				ML	Brown, very snady SILT (medium dense, moist), scattered small roots. **(SOIL UNIT 1)**	
				DB	White to light gray, large broken oyster shells with silt and sand (loose, wet), several large logs and other wood debris	
5				WD	Dark gray to black, wood debris with silt and sand (loose, wet), mostly cedar shake spalls and dimensioned lumber cut-offs.	Rapid Seepage
10	1	d	W = 61	SM/ ML	Gray, silty, fine SAND/fine sandy SILT (loose/soft, damp to wet)	

Test Pit Completed 07/22/08
Total Depth of Test Pit = 13.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615541.58
East: 797072.54
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

TP-19-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.36 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0	1	d	W = 8		SP-SM	Brown, fine SAND with trace silt (with silt in upper foot)(loose, moist), scattered roots in upper foot. **(SOIL UNIT 1)**	
	2	d	W = 36 GS		SM	Mottled brown and gray, silty SAND (medium stiff, moist)	
5					SM	Gray, silty SAND (medium dense, wet), numerous oyster shells below 5 feet.	Moderate Seepage
					WD	Dark gray to black, WOOD debris with silt and sand (loose, wet), mostly short dimensioned lumber cut-offs.	
10	3	d	W = 58 AL		ML/MH	Dark gray, clayey SILT with sand (very soft to soft, damp)	
	4	d	W = 66		ML	Dark gray, fine sandy SILT (medium stiff, wet), numerous small shells.	

Test Pit Completed 07/22/08
Total Depth of Test Pit = 14.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615567.00
East: 797217.66
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

15 20 25

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Test Pit TP-19-08

Figure A-89

TP-20-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.08 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML/ MH	Brown, clayey SILT with sand (medium stiff, moist) **(SOIL UNIT 1)**	
					GM	Dark brown, sandy, silty GRAVEL (loose, moist), abundant roots to 1/4" diameter.	
5					WD	Dark brown to black, WOOD (loose, wet), mostly dimensioned lumber. **TRESTLE DEBRIS** - two vertical timber piles exposed in test pit sidewalls from 2 to 6 feet BGS.	Rapid Seepage
	1	d	W = 72 AL		ML/ MH	Dark gray, clayey SILT with trace sand (very soft to soft, damp), includes scattered broken shells.	
10							

Test Pit Completed 07/23/08
Total Depth of Test Pit = 12.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615665.07
East: 796930.34
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

TP-21-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.40 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0	1	d	W = 44		ML	Mottled gray-brown SILT with clay and trace sand (soft to medium stiff, moist), scattered fine roots **(SOIL UNIT 1)** - scattered concrete and brick rubble from 0.5 to 3.0 feet	Groundwater not encountered.
					SM	Dark brown, silty SAND (medium dense, moist), including concrete and brick rubble	
	2	d	W = 23		SP	Gray, fine SAND with trace silt (medium dense, moist), becomes darker gray with depth	
5					ML/MH	Dark gray, clayey SILT (very soft, moist), numerous organic fibers and broken shells	
	3	d	W = 76				

Test Pit Completed 07/23/08
Total Depth of Test Pit = 9.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615658.91
East: 796754.01
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-22-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.40 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0	1	d	W = 64 AL		ML	Mottled gray-brown, clayey SILT with trace sand (soft to medium stiff, moist), abundant small roots in upper foot **(SOIL UNIT 1)**	
					SP-SM	Brown, fine SAND with silt (loose, moist), numerous roots in upper 3", occasional roots throughout	
5					ML/OL	Dark gray to black, organic SILT (very soft, damp), numerous small fibers and occasional wood debris, fragments of porcelain dishware throughout - 20" diameter log located at 5 feet	Moderate Seepage
	2	d	W = 104		ML/MH	Dark gray, clayey SILT (very soft, damp) - numerous small shells in bedded layers	
10							

Test Pit Completed 07/23/08
Total Depth of Test Pit = 10.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615680.71
East: 796645.63
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-23-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 13.41 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML/ MH	Mottled gray-brown, fine sandy, clayey, SILT, grading downward to SILT with sand (soft to medium stiff, moist), numerous small roots in upper foot **(SOIL UNIT 1)**	Groundwater not encountered.
	1	d	W = 84 AL				
					ML	Gray, SILT with trace sand (soft to medium stiff, moist), occasional roots near top contact	
	2	d	W = 45				
5						- abundant dimensioned lumber debris from 6.0 to 7.5 feet	
					ML/ MH	Dark gray, clayey SILT with trace sand (very soft, damp), occasional small broken shells and decayed organic fibers	
	3	d	W = 74 AL				
10							

Test Pit Completed 07/23/08
Total Depth of Test Pit = 10.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615619.34
East: 796542.76
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

TP-24-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.18 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML	Mottled gray-brown, clayey SILT with trace sand (soft, moist), numerous roots in upper foot **(SOIL UNIT 1)**	
	1	d	W = 60				
	2	d	W = 48		ML	Gray, SILT with sand and clay (soft, damp), occasional wood debris, becomes more plastic with depth - concrete slab debris between 3.5 and 5.0 feet	
5	3	d	W = 53			- numerous pieces of dimensioned lumber in probe hole, strong Hydrogen Sulfide odor **- methane detected in test pit**	Moderate Seepage
					ML/ MH	Gray to dark gray, clayey SILT with occasion sandy SILT lamination (very soft to soft, damp), scattered organic fibers and roots	
10							
	4	d	W = 61				

Test Pit Completed 07/23/08
Total Depth of Test Pit = 14.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615601.87
East: 796430.06
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Log of Test Pit TP-24-08

Figure A-94

TP-25-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 14.52 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML	Mottled brown and gray, SILT with trace sand (loose, moist), scattered small plant roots in upper 1.5 feet **(SOIL UNIT 1)**	
	1	d	W = 61 GS				
	2	d	W = 58 AL		ML	Gray, clayey SILT (very soft to soft, moist), scattered fine organic fibers and small wood debris	
					ML/ MH	Gray, clayey SILT with sand (very soft, damp to wet)	
5					WD	- abundant dimensioned lumber between 5.5 and 9.5 feet (appears to be stacked) with strong Hydrogen Sulfide smell **- methane at 20ppm (>LEL) immediately around T-probe penetration**	Moderate Seepage
10					ML	Dark gray, SILT with sand and clay (very soft, damp), scattered shells and organic fibers	
	3	d	W = 54				
15							
20							
25							

Test Pit Completed 07/23/08
Total Depth of Test Pit = 14.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615665.36
East: 796319.13
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

TP-26-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 15.10 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML	Mottled gray-brown, sandy SILT, with clay (medium stiff, moist), occasional roots to 1.5 feet **(SOIL UNIT 1)**	
	1	d	W = 43 AL				
	2	d	W = 24		SP	Gray, fine SAND with trace silt (medium dense, damp).	
5							
					ML	Dark gray, sandy SILT (soft, damp to wet), abundant dimensioned lumber below 7.0 feet, strong Hydrogen Sulfide odor **- methane up to 10ppm next to T-probe hole**	Rapid Seepage
10					ML	Dark gray, SILT with sand and clay (very soft, damp), scattered small shells and small organic fibers	
	3	d	W = 57 AL				
15							

Test Pit Completed 07/23/08
Total Depth of Test Pit = 15.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615766.60
East: 796293.87
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122025.02 1/2/09 \\EDMDATA\GINT\GINT7\PROJECTS\122025.020.GPJ WSDOT SINGLE TEST PIT LOG

TP-27-08

SAMPLE DATA				SOIL PROFILE			NOTES/GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): 15.27 (MLLW) Excavated By: Chinook Exc. and Land Dev.	
0					ML/ MH	Mottled brown and gray, clayey, sandy SILT (medium stiff, moist), scattered roots in upper foot **(SOIL UNIT 1)**	
	1	d	W = 42 AL				
	2	d	W = 38		ML	Gray, sandy SILT (soft, moist), numerous fine organics, becomes darker gray with depth	
	3	d	W = 43		ML/ OL	Dark gray to black, sandy SILT, with clay (soft, damp), abundant fine organics and fire-brick debris	
5						- abundant dimensioned lumber debris from 7.0 to 10.5 feet	Moderate Seepage
10					ML/ MH	Dark gray to gray, clayey SILT with sand (soft, damp), scattered broken shells and marsh grass	
	4	d	W = 55 AL				

15

Test Pit Completed 07/23/08
Total Depth of Test Pit = 14.0 ft.
WSDOT Job #: XL 2672

Point located at State Plane Coordinates:
North: 615640.14
East: 796207.20
Township: 17N
Range: 10W
Section: 11
Inspector: CTM

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Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

APPENDIX B

Geotechnical Laboratory Testing

APPENDIX B
GEOTECHNICAL LABORATORY TESTING

Geotechnical laboratory testing performed on soil samples obtained during the current and previous exploration phases consisted of:

- Index tests (natural moisture content determinations, grain size analyses, Atterberg limit determinations)
- Triaxial unconsolidated undrained compression strength tests
- Triaxial consolidated undrained compression strength tests
- One-dimensional consolidation tests
- pH and resistivity tests.

Summaries of geotechnical laboratory testing of site soils for samples obtained during previous exploration phases are included in previous reports (Landau Associates 2006, 2007) and laboratory data obtained during those phases are included in this appendix.

The tests were performed on selected samples to aid in soil classification and to estimate the engineering characteristics of site soils. Geotechnical laboratory testing was performed in general accordance with American Society for Testing and Materials (ASTM) standard test procedures, which are described below. The samples were checked against the field log descriptions, which were updated where appropriate, in general accordance with ASTM D2487, *Standard Test Method for Classification of Soils for Engineering Purposes*.

Summary statistics for laboratory tests are presented by soil unit in Table 1 of the report text.

NATURAL MOISTURE CONTENT

Natural moisture content determinations were performed on selected soil samples recovered from the borings and test pits in general accordance with ASTM D2216. The results of these tests are plotted at the respective sample depth on the exploration logs, and are also indicated in the column labeled “Test Data” on the summary boring and test pit logs in Appendix A.

SIEVE ANALYSES

Grain size analyses were performed on representative soil samples obtained from the explorations in accordance with ASTM D422 to provide an indication of the grain size distribution. Samples selected for grain size analyses are designated with a “GS” in the column labeled “Test Data” on the summary logs in Appendix A. The results of the grain size analyses are presented by soil unit (Soil Unit 1, Soil Unit 2B, etc.) on Figures B-1 through B-25 in the form of grain size distribution curves.

FINES CONTENT

The fines content (the percentage of material passing the U.S. Standard No. 200 sieve) of selected soil samples obtained from our exploratory borings was determined in general accordance with ASTM D1140 test procedures. The test results are shown at the respective sample depth in the column labeled “Test Data” on the summary boring logs in Appendix A.

ATTERBERG LIMITS

Atterberg limit determinations were performed on representative soil samples obtained from the explorations in general accordance with ASTM D4318 to determine the liquid limit (LL), plastic limit (PL), and plasticity index (PI). The results of the Atterberg limit determinations are presented by soil unit on Figures B-26 through B-43 in this appendix. Samples on which Atterberg limit determinations were completed are designated by “AL” in the column labeled “Test Data” and are shown graphically on the summary boring logs.

TRIAXIAL UNCONSOLIDATED UNDRAINED COMPRESSION TEST

Triaxial unconsolidated undrained (UU) testing was performed on selected fine-grained soil samples obtained from Soil Units 1 and 3 to estimate undrained (short-term) strength. The testing was performed at the Soil Technology, Inc. laboratory in general accordance with ASTM D2850 test procedure. Samples on which this test (or other advanced laboratory tests) was completed are designated by “GT” in the column labeled “Test Data” on the summary logs. The test results are presented in reports by Soil Technology, Inc., which are included in this appendix.

TRIAXIAL CONSOLIDATED UNDRAINED COMPRESSION TEST

Triaxial consolidated undrained (CU) testing was performed on selected fine-grained soil samples obtained from Soil Units 1 and 3 to estimate undrained strength. The testing was performed at the Soil Technology, Inc. laboratory in general accordance with ASTM D2850 test procedure. Samples on which this test (or other advanced laboratory tests) was completed are designated by “GT” in the column labeled “Test Data” on the summary logs. The test results are presented in reports by Soil Technology, Inc., which are included in this appendix.

ONE-DIMENSIONAL CONSOLIDATION TEST

The consolidation characteristics of selected fine-grained soil samples obtained from Soil Units 1 and 3 were determined at the Soil Technology, Inc. laboratory in general accordance with ASTM D2435 test procedures. Samples on which this test (or other advanced laboratory tests) was completed are designated by "GT" in the column labeled "Test Data" on the summary logs. The test results are presented in a report by Soil Technology, Inc., which is included in this appendix.

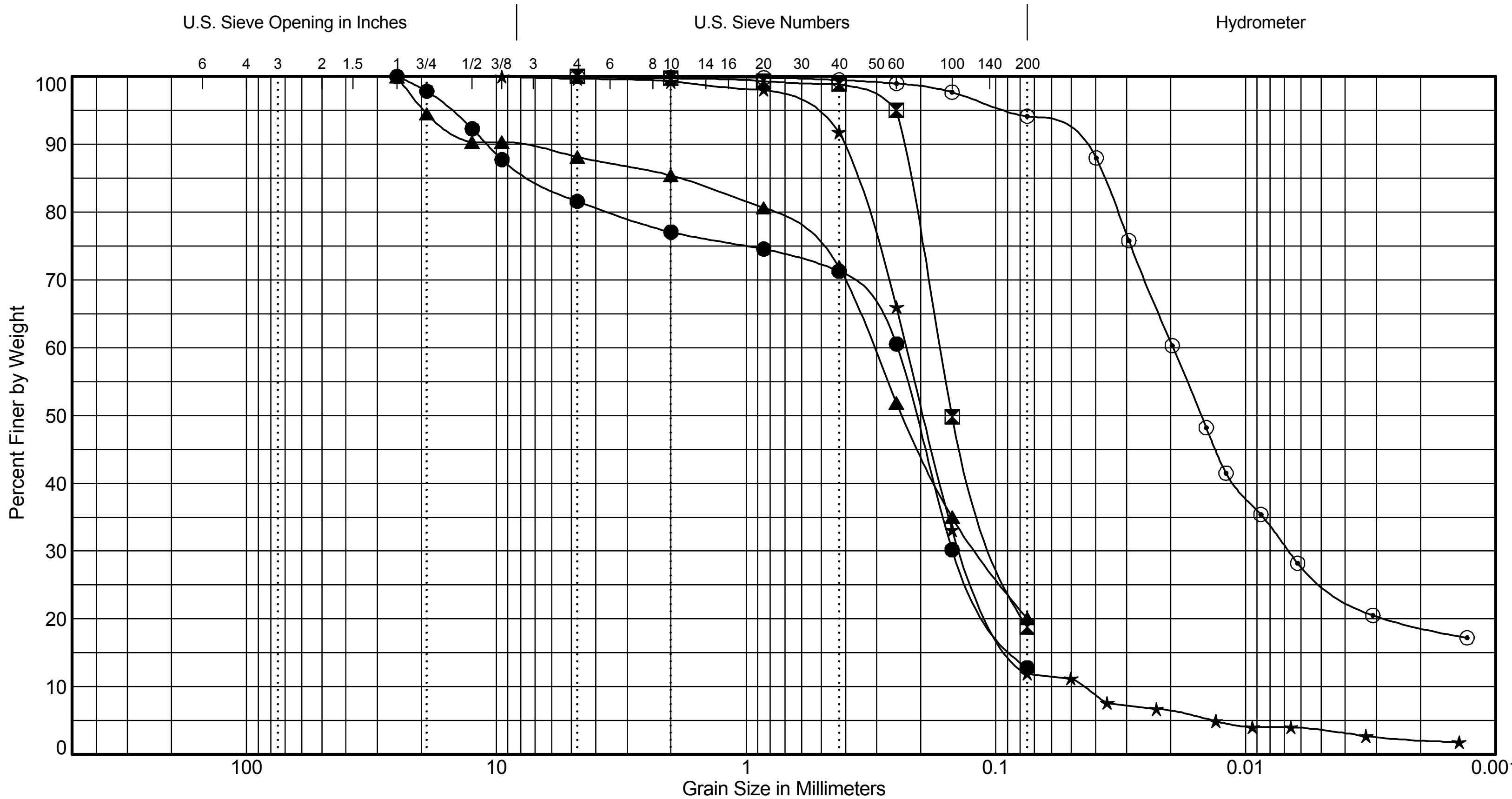
SOIL pH AND RESISTIVITY TESTING

Soil samples were selected from test pit explorations and from previous borings and subjected to pH and resistivity testing at the Soil Technology, Inc. laboratory. pH tests were accomplished in general accordance with ASTM D4972. Resistivity tests were accomplished in general accordance with ASTM G57. A tabular summary of these results is presented in reports by Soil Technology, Inc., included in this appendix.

REFERENCES

Landau Associates. 2007. Report: *Geotechnical Design Study WSDOT Special Projects Construction Site, Grays Harbor, Washington*. Prepared for WSDOT. March 29.

Landau Associates. 2006. *Geotechnical and Hydrogeologic Study, Bridge Pontoon Construction Facility, Grays Harbor, Washington.* Prepared for WSDOT. May 31.



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-37-08	S-1	4.0	34	Gravelly, fine SAND with silt	SP-SM
⧗	TH-40-08	S-1	0.5	38	Silty, fine SAND	SM
▲	TH-42P-08	S-1	0.5	15	Silty, fine to medium SAND with fine gravel	SM
★	TH-43P-08	S-2	4.0	30	Fine SAND with silt	SP-SM
⊙	TH-43P-08	S-4	9.0	73	SILT with sand	ML/MH

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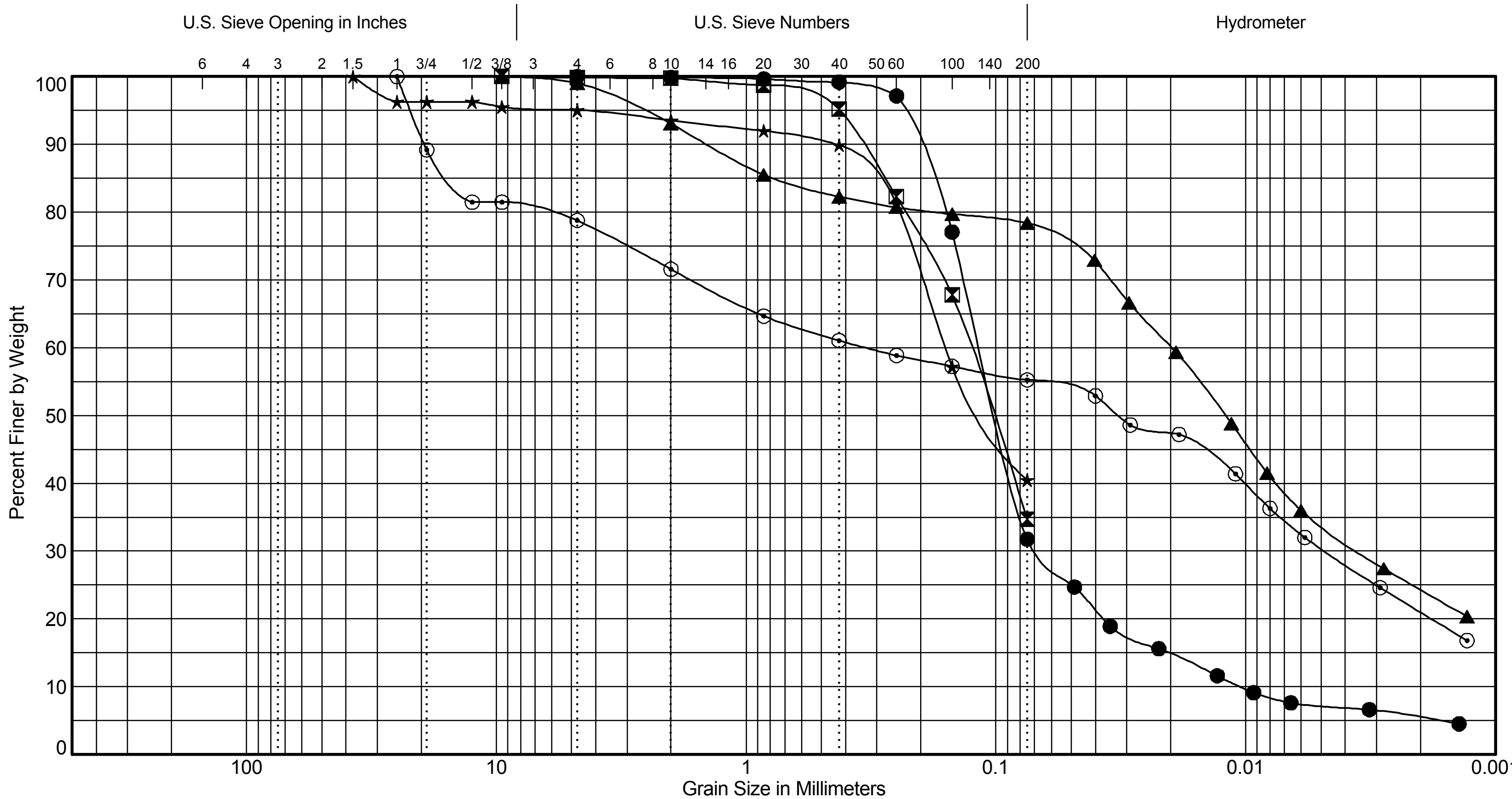
SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Grain Size Distribution Soil Unit 1	Figure B-4



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-44P-08	S-2	4.0	43	Very silty, fine SAND	SM
⧗	TH-46P-08	S-3	6.5	46	Very silty, fine SAND	SM
▲	TH-47P-08	S-3	6.5	70	Sandy, clayey SILT with trace fine gravel	ML
★	TH-48-08	S-1	4.0	61	Very silty, fine SAND	SM
⊙	TH-49P-08	S-1	0.5	48	Sandy and gravelly, clayey SILT	ML

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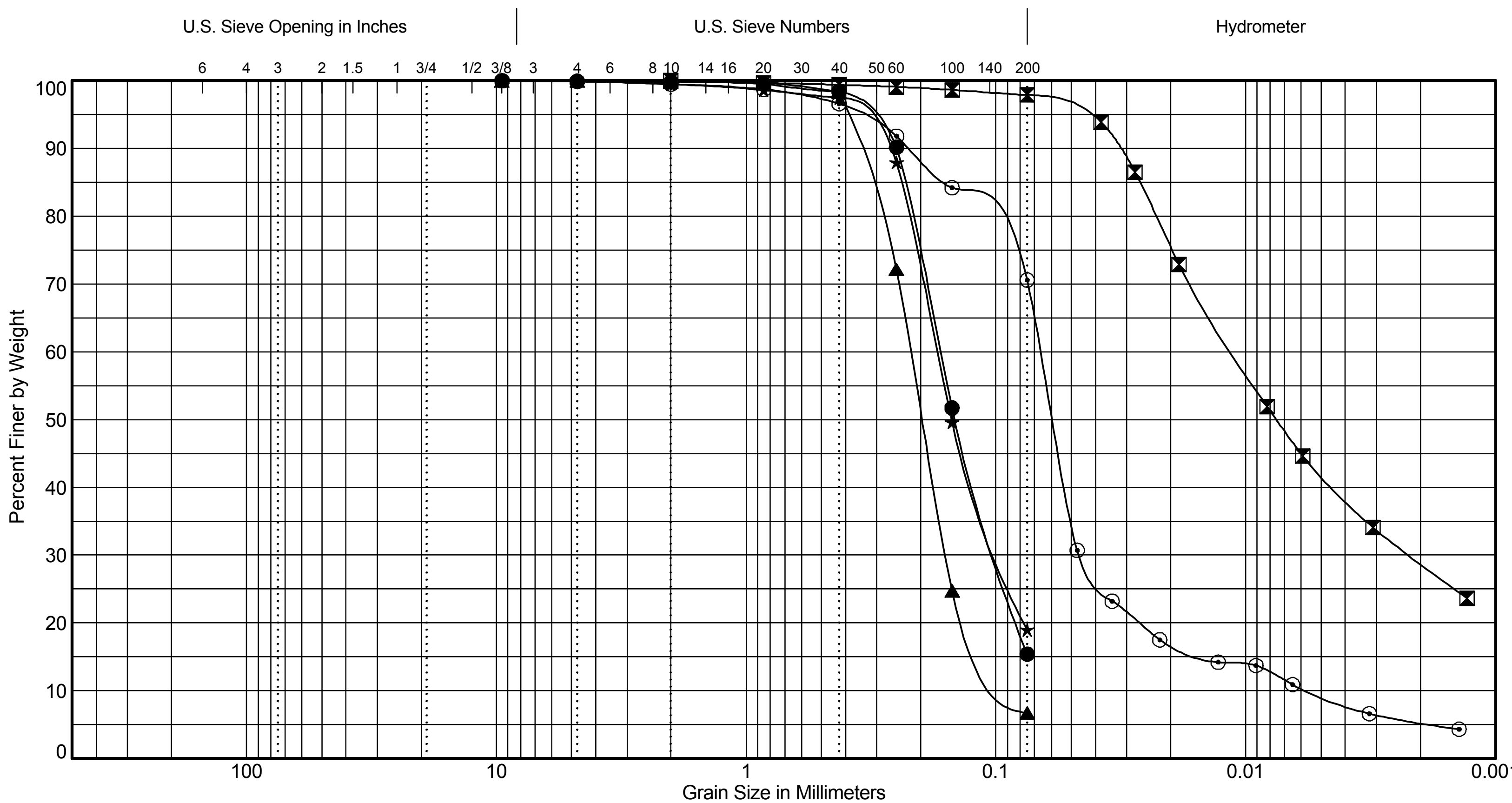
SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Grain Size Distribution
Soil Unit 1

Figure
B-5

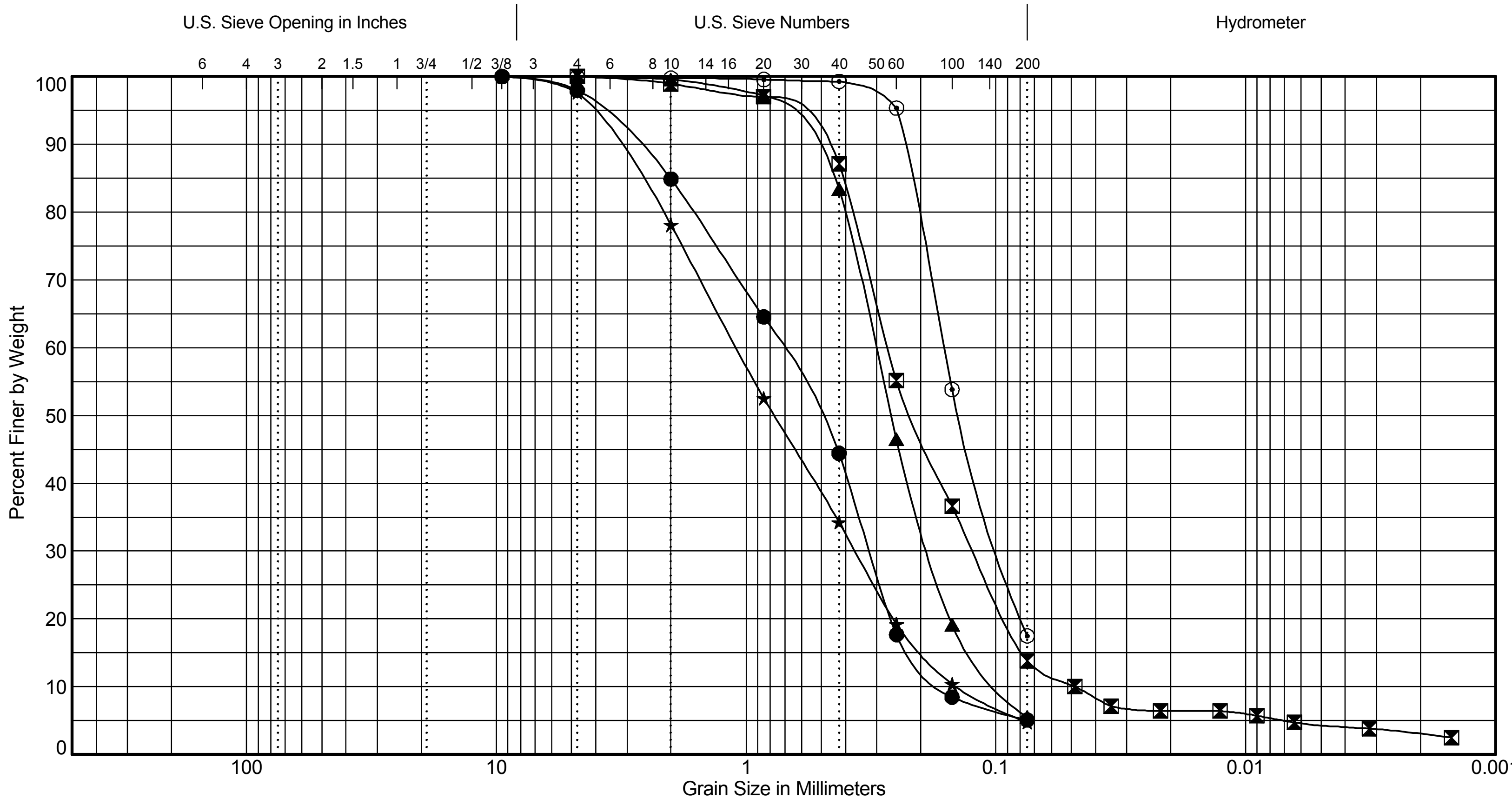


Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-53-08	S-1	0.5	31	Silty, fine SAND	SM
⧗	TH-54-08	S-3	6.5	97	Clayey SILT with trace sand	MH
▲	TH-55-08	S-1	0.5	26	Fine SAND with silt	SP-SM
★	TH-56-08	S-2	4.0	33	Silty, fine SAND	SM
⊙	TH-56-08	S-4	9.0	39	Sandy SILT with trace clay	ML

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Grain Size Distribution Soil Unit 1	Figure B-6



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

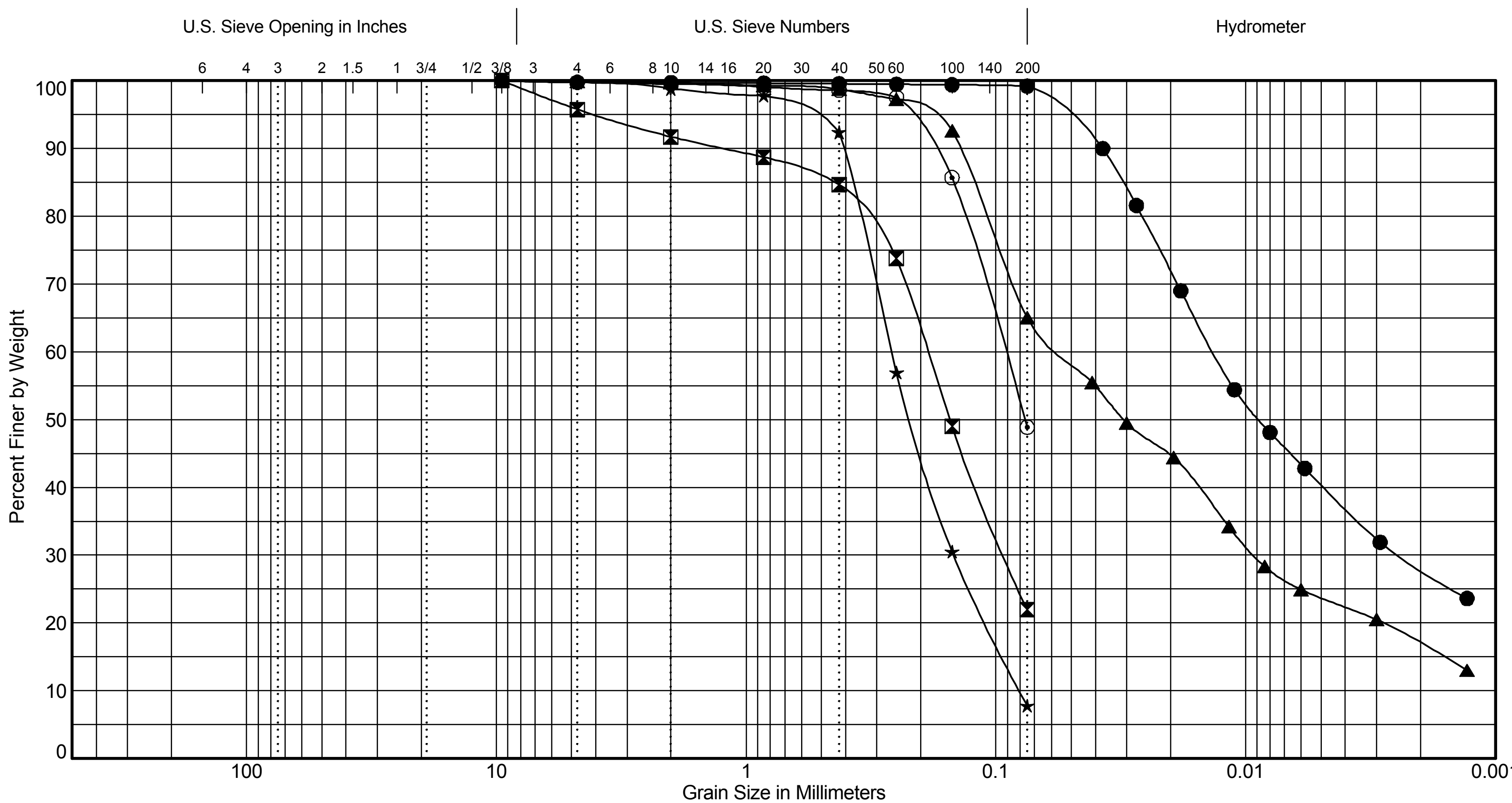
Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-57-08	S-1	0.5	9	Fine to coarse SAND with silt and trace gravel	SM
⧗	TH-57-08	S-3	6.5	35	Fine to medium SAND with silt	SP-SM
▲	TH-58-08	S-1A	0.5	23	Fine to medium SAND with silt	SP-SM
★	TH-58-08	S-1B	1.5	16	Fine to coarse SAND with trace silt and gravel	SP
⊙	TH-59-08	S-1	0.5	33	Silty, fine SAND	SM

LANDAU ASSOCIATES

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Grain Size Distribution
Soil Unit 1

Figure
B-7

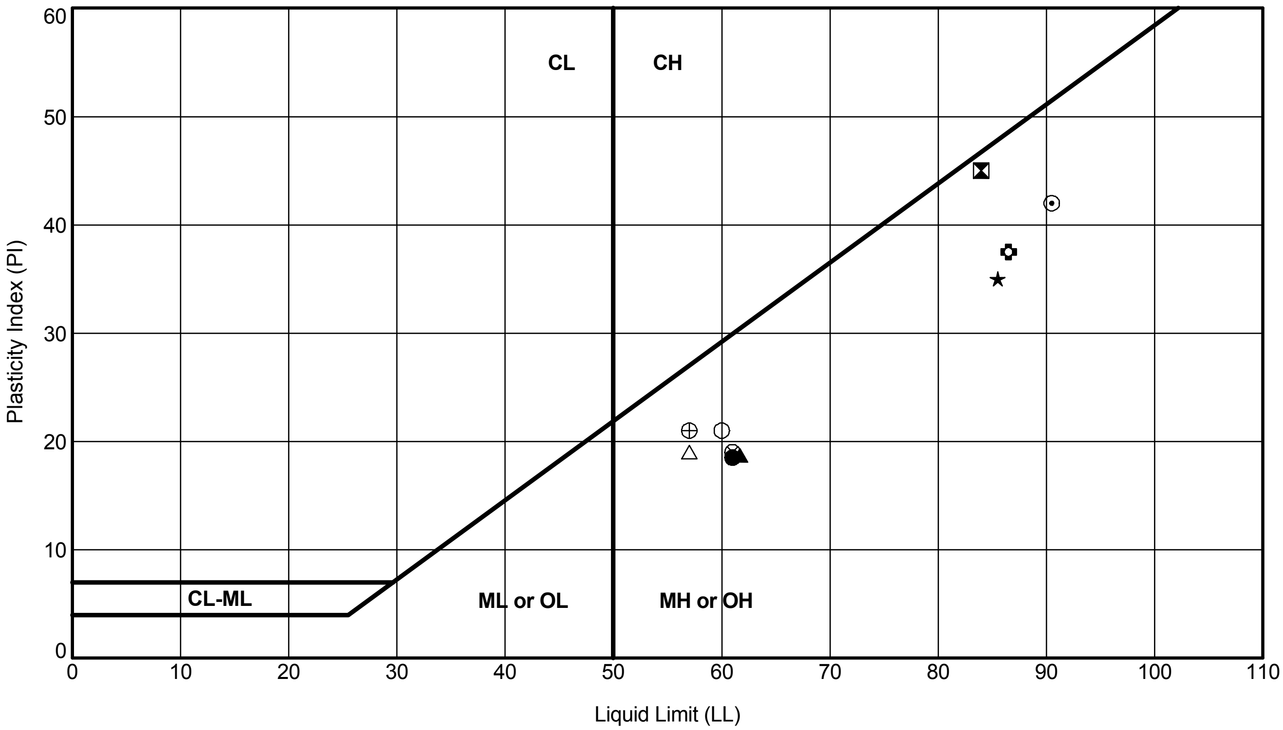


Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-62-08	S-2	4.0	72	Clayey SILT with trace sand	MH
⧗	TH-63-08	S-1	0.5	24	Silty, fine SAND with trace gravel	SM
▲	TH-63-08	S-2	4.0	44	Very sandy SILT	ML
★	TP-04-08	S-1	6.0	31	Fine SAND with silt	SP-SM
⊙	TP-05-08	S-2	3.5	40	Very silty, fine SAND	SM

LANDAU ASSOCIATES

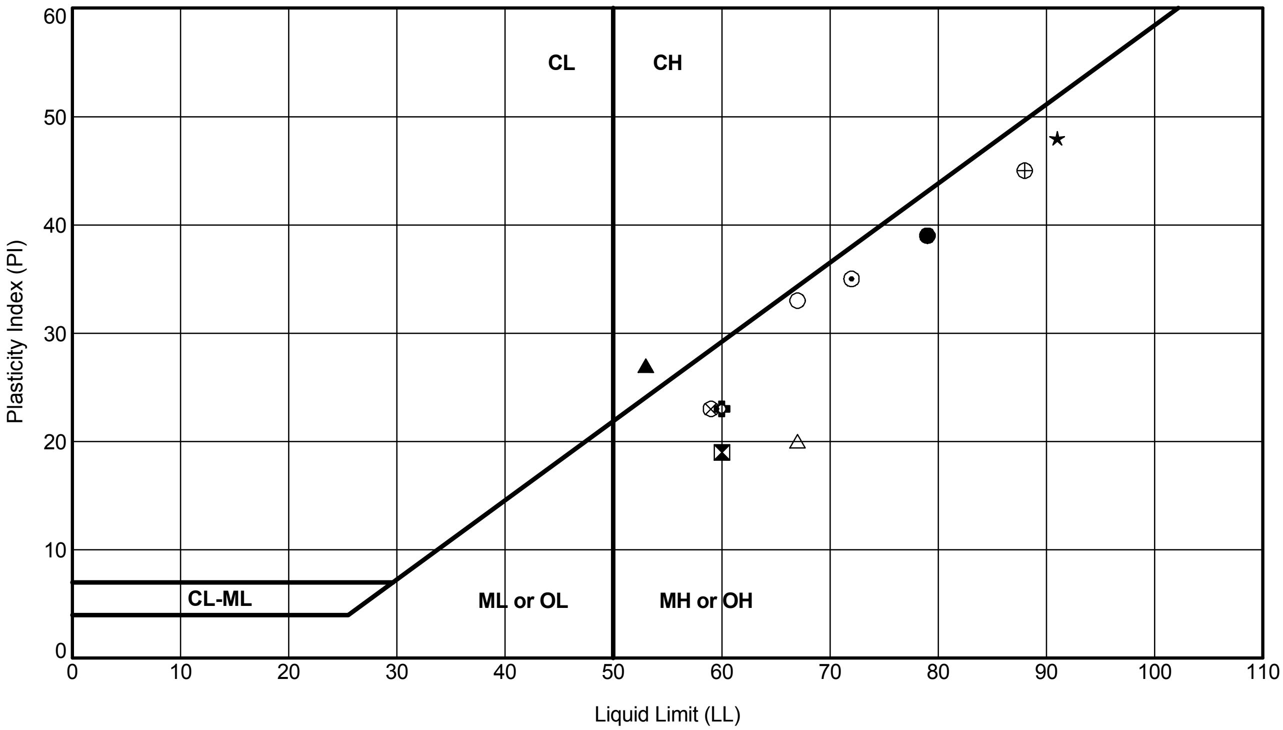
SR 520 Pontoon Construction Project Port of Grays Harbor, Washington	Grain Size Distribution Soil Unit 1	Figure B-8



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-17	S-5	14.0	61	43	19	61	SILT with fine sand trace fine organics	MH
⧗	B-17	S-8	23.0	84	39	45	66	Clayey SILT	MH
▲	B-18	S-1	2.5	62	43	19	64	Clayey SILT	MH
★	B-18	S-7	15.0	86	51	36	76	Clayey SILT	MH
⊙	B-18	S-10	22.5	91	49	42	82	Clayey SILT	MH
✿	B-19	S4	7.5	87	49	37	88	Clayey SILT	MH
○	TH-27-08	S-3	14.1	60	39	21	61	High plasticity SILT with organics	MH
△	TH-27-08	S-3	14.6	57	38	19	65	High plasticity SILT	MH
⊗	TH-27-08	S-3	15.1	61	42	19	62	High plasticity, SILT with organics	MH
⊕	TH-28-SW-08	S-2	13.0	57	36	21	84	High plasticity SILT	MH

ASTM D 4318 Test Method



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-29-SW-08	S-1	15.9	79	40	39	84	High plasticity, SILT with organics	MH
⧗	TH-30-SW-08	S-1	14.7	60	41	19	63	High plasticity SILT	MH
▲	TH-31-SW-08	S-3	15.7	53	26	27	72	High plasticity CLAY	CH
★	TH-32-08	S-4	13.2	91	43	48	86	High plasticity SILT	MH
⊙	TH-32-08	S-8	24.0	72	37	35	69	High plasticity SILT	MH
✿	TH-34-08	S-5	11.5	60	37	23	58	High plasticity SILT	MH
○	TH-36-08	S-4	12.0	67	34	33	58	High plasticity SILT	MH
△	TH-36-08	S-7	20.4	67	47	20	65	High plasticity, SILT with organics	MH
⊗	TH-37-08	S-6	12.0	59	36	23	71	High plasticity SILT	MH
⊕	TH-39-08	S-5	11.5	88	43	45	57	High plasticity SILT	MH

ASTM D 4318 Test Method

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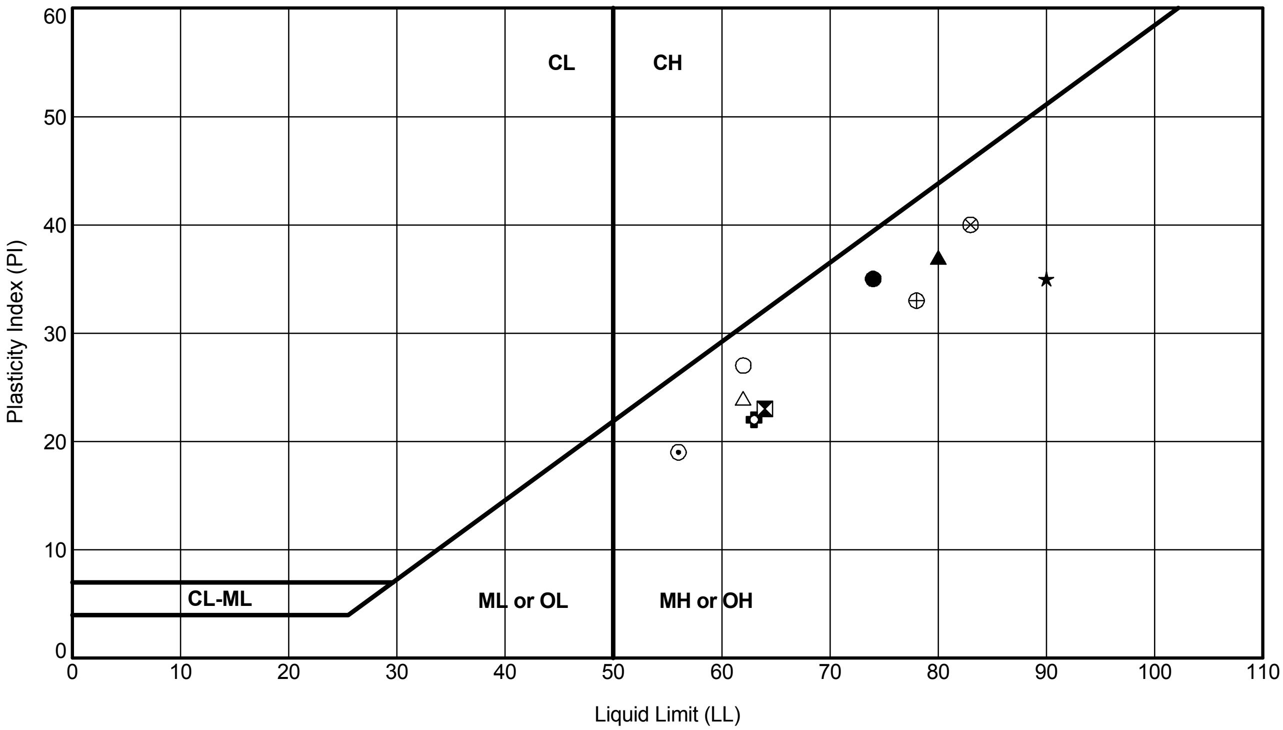
SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Plasticity Chart
Soil Unit 1

Figure
B-31



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-40-08	S-5	11.5	74	39	35	70	High plasticity SILT	MH
⧗	TH-42P-08	S-7	16.5	64	41	23	68	High plasticity SILT	MH
▲	TH-44P-08	S-4	9.0	80	43	37	83	High plasticity SILT	MH
★	TH-46P-08	S-1A	0.5	90	55	35	45	High plasticity SILT	MH
⊙	TH-48-08	S-7	14.9	56	37	19	56	High plasticity, SILT with organics	MH
✿	TH-49P-08	S-5	11.5	63	41	22	71	High plasticity SILT	MH
○	TH-50-08	S-5	10.5	62	35	27	67	High plasticity SILT	MH
△	TH-51-08	S-1	0.5	62	38	24	57	High plasticity SILT	MH
⊗	TH-53-08	S-4	9.0	83	43	40	73	High plasticity SILT	MH
⊕	TH-54-08	S-2	4.0	78	45	33	85	High plasticity SILT	MH

ASTM D 4318 Test Method

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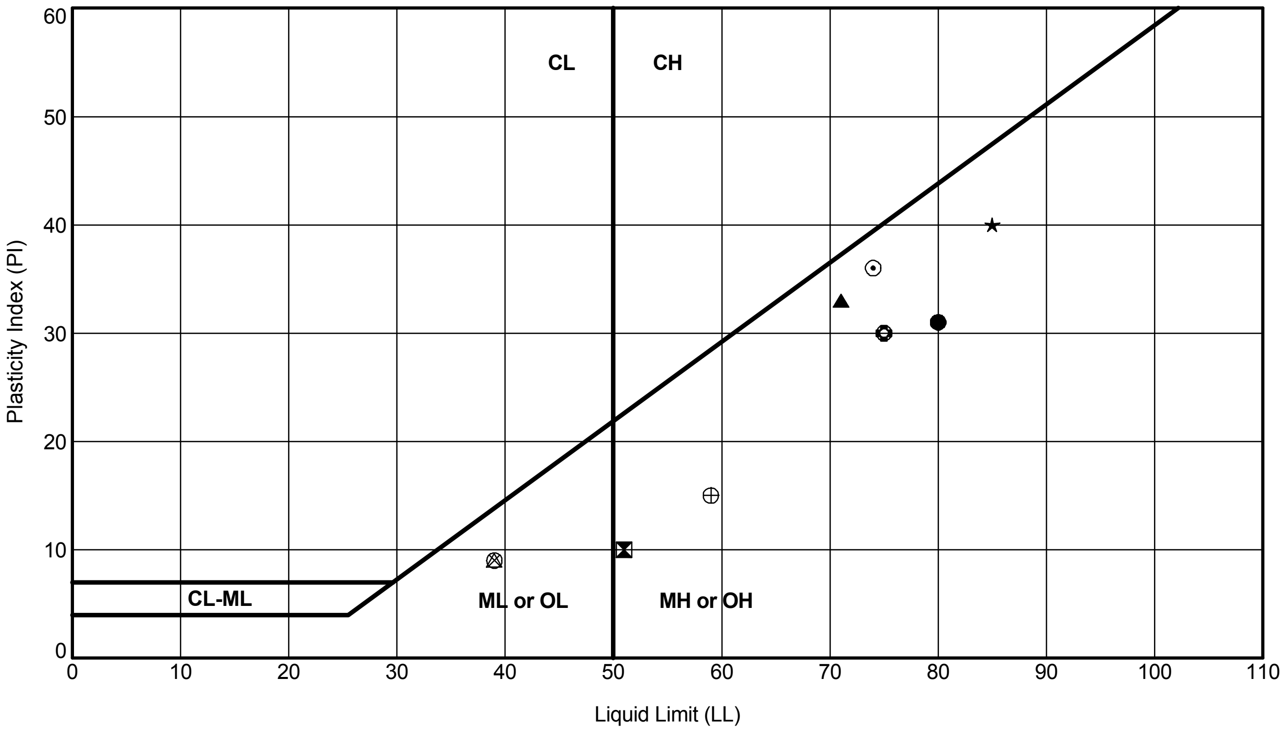

ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-55-08	S-5	11.5	80	49	31	67	High plasticity SILT	MH
⧗	TH-56-08	S-7	16.5	51	41	10	54	High plasticity SILT	MH
▲	TH-58-08	S-7	16.5	71	38	33	64	High plasticity SILT	MH
★	TH-59-08	S-2	4.0	85	45	40	54	High plasticity SILT	MH
⊙	TH-60-08	S-6	14.0	74	38	36	82	High plasticity SILT	MH
✿	TH-61-08	S-1B	1.0	75	45	30	66	High plasticity SILT	MH
○	TH-61-08	S-1B	1.0	75	45	30	66	High plasticity SILT	MH
△	TH-62-08	S-1B	1.0	39	30	9	40	Low plasticity SILT	ML
⊗	TH-62-08	S-1B	1.0	39	30	9	40	Low plasticity SILT	ML
⊕	TH-62-08	S-4	9.0	59	44	15	60	High plasticity SILT	MH

ASTM D 4318 Test Method

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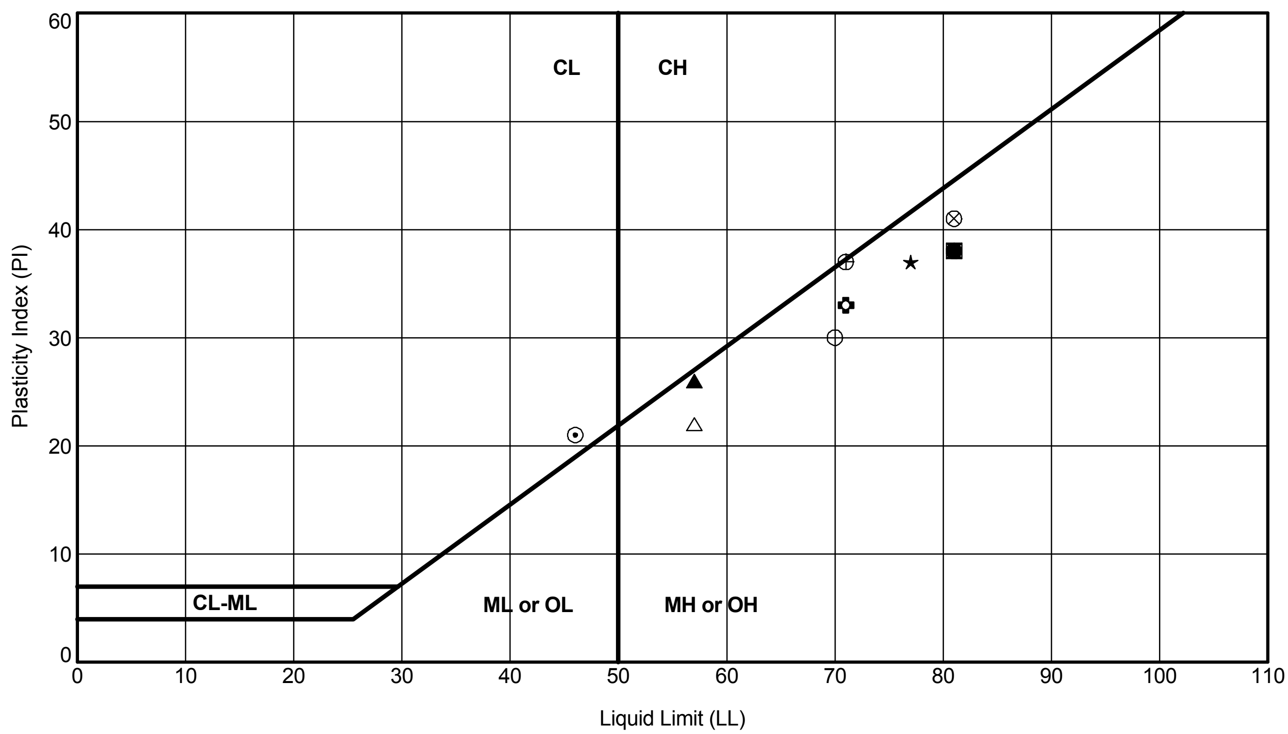
Landau Associates

SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Plasticity Chart
Soil Unit 1

Figure
B-33



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TH-63-08	S-5	11.5	81	43	38	80	High plasticity SILT	MH
⧗	TH-63-08	S-5	11.5	81	43	38	80	High plasticity SILT	MH
▲	TH-67P-08	S-2	17.3	57	31	26	64	High plasticity, SILT with organics	MH
★	TH-67P-08	S-2	17.8	77	40	37	65	High plasticity, SILT with organics	MH
⊙	TH-67P-08	S-5A	29.0	46	25	21	56	Low plasticity CLAY	CL
✿	TP-16-08	S-3	12.0	71	38	33	66	High plasticity SILT	MH
○	TP-17-08	S-3	17.0	70	40	30	64	High plasticity SILT	MH
△	TP-19-08	S-3	10.0	57	35	22	58	High plasticity SILT	MH
⊗	TP-20-08	S-1	7.0	81	40	41	72	High plasticity SILT	MH
⊕	TP-22-08	S-1	1.0	71	34	37	64	High plasticity SILT	MH

ASTM D 4318 Test Method

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SR 520 Pontoon Construction Project
Port of Grays Harbor, Washington

Plasticity Chart
Soil Unit 1

Figure
B-34

APPENDIX C
Settlement Calculations

Settle3 Analysis Information
Hoquiam - North Shore Levee, West Segment

Project Settings

Document Name	Hoquiam-NSL, West - Typical Embankment Section.s3z
Project Title	Hoquiam - North Shore Levee, West Segment
Analysis	Settlement of Typical Levee Embankment
Author	CAH
Company	GeoEngineers
Date Created	1/27/2020, 8:13:05 AM
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	months
Permeability Units	feet/day
Minimum settlement ratio for subgrade modulus	0.9

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [months]
1	Stage 3	2
2	Stage 4	12
3	Stage 5	120
4	Stage 6	1200

Results

Time taken to compute: 0.143049 seconds

Stage: Stage 3 = 2 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.0604059	0.48
Loading Stress XX [ksf]	0.224851	0.488593
Loading Stress YY [ksf]	0.447149	0.794545
Effective Stress ZZ [ksf]	0	2.95
Effective Stress XX [ksf]	0.224851	3.38132
Effective Stress YY [ksf]	0.447149	3.58434
Total Stress ZZ [ksf]	0.48	7.37841
Total Stress XX [ksf]	0.704851	7.80972
Total Stress YY [ksf]	0.927149	8.01274
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0	0
Pore Water Pressure [ksf]	0.48	4.42841
Excess Pore Water Pressure [ksf]	0.0604059	0.48
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0.00338024	3.37263
Over-consolidation Ratio	1	2.9
Void Ratio	0.78	1.62
Permeability [ft/d]	1.88776e-005	0.043709
Coefficient of Consolidation [ft^2/d]	0.04	0.9
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	0	0
Undrained Shear Strength	0	0

Stage: Stage 4 = 12 mon

Data Type	Minimum	Maximum
Total Settlement [in]	-0.00746094	8.70592
Total Consolidation Settlement [in]	-0.00746094	8.70592
Virgin Consolidation Settlement [in]	0	6.62812
Recompression Consolidation Settlement [in]	-0.0411578	2.0778
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.0604059	0.48
Loading Stress XX [ksf]	0.224851	0.488593
Loading Stress YY [ksf]	0.447149	0.794545
Effective Stress ZZ [ksf]	0.448173	2.92078
Effective Stress XX [ksf]	0.704851	3.3521
Effective Stress YY [ksf]	0.927149	3.55512
Total Stress ZZ [ksf]	0.48	7.37841
Total Stress XX [ksf]	0.704851	7.80972
Total Stress YY [ksf]	0.927149	8.01274
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	-0.000219192	0.585522
Pore Water Pressure [ksf]	0	4.45762
Excess Pore Water Pressure [ksf]	0	0.291882
Degree of Consolidation [%]	0	74.019
Pre-consolidation Stress [ksf]	0.481158	3.37263
Over-consolidation Ratio	1	2.93135
Void Ratio	0.0859336	1.62057
Permeability [ft/d]	1.88776e-005	0.243775
Coefficient of Consolidation [ft^2/d]	0.04	0.9
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	4.53784	21.9583
Undrained Shear Strength	0	0.0220705

Stage: Stage 5 = 120 mon

Data Type	Minimum	Maximum
Total Settlement [in]	-0.0157998	10.3333
Total Consolidation Settlement [in]	-0.0157998	10.3333
Virgin Consolidation Settlement [in]	0	6.86719
Recompression Consolidation Settlement [in]	-0.0199713	3.46613
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.0604059	0.48
Loading Stress XX [ksf]	0.224851	0.488593
Loading Stress YY [ksf]	0.447149	0.794545
Effective Stress ZZ [ksf]	0.48	2.9053
Effective Stress XX [ksf]	0.704851	3.33662
Effective Stress YY [ksf]	0.927149	3.53964
Total Stress ZZ [ksf]	0.48	7.37841
Total Stress XX [ksf]	0.704851	7.80972
Total Stress YY [ksf]	0.927149	8.01274
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	-8.56504e-005	0.585523
Pore Water Pressure [ksf]	0	4.47311
Excess Pore Water Pressure [ksf]	0	0.13437
Degree of Consolidation [%]	0	87.8553
Pre-consolidation Stress [ksf]	0.481165	3.37263
Over-consolidation Ratio	1	2.83079
Void Ratio	0.0859291	1.61964
Permeability [ft/d]	1.88776e-005	0.243775
Coefficient of Consolidation [ft^2/d]	0.04	0.9
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	1.55311	68.893
Undrained Shear Strength	-0.000303149	0.023842

Stage: Stage 6 = 1200 mon

Data Type	Minimum	Maximum
Total Settlement [in]	0	11.1878
Total Consolidation Settlement [in]	0	11.1878
Virgin Consolidation Settlement [in]	0	7.16441
Recompression Consolidation Settlement [in]	0	4.02338
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.0604059	0.48
Loading Stress XX [ksf]	0.224851	0.488593
Loading Stress YY [ksf]	0.447149	0.794545
Effective Stress ZZ [ksf]	0.48	2.95753
Effective Stress XX [ksf]	0.704851	3.38885
Effective Stress YY [ksf]	0.927149	3.59187
Total Stress ZZ [ksf]	0.48	7.37841
Total Stress XX [ksf]	0.704851	7.80972
Total Stress YY [ksf]	0.927149	8.01274
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	0
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	0.000145121	0.585523
Pore Water Pressure [ksf]	0	4.42087
Excess Pore Water Pressure [ksf]	0	0.0528754
Degree of Consolidation [%]	0	95.1202
Pre-consolidation Stress [ksf]	0.481166	3.37263
Over-consolidation Ratio	1	2.59298
Void Ratio	0.085929	1.61858
Permeability [ft/d]	1.88776e-005	0.243775
Coefficient of Consolidation [ft^2/d]	0.04	0.9
Hydroconsolidation Settlement [in]	0	0
Average Degree of Consolidation [%]	51.5099	95.904
Undrained Shear Strength	0	0.0238863

Embankments

1. Embankment: "Typical Earthen Levee Section (El +16 to +12 FT)"

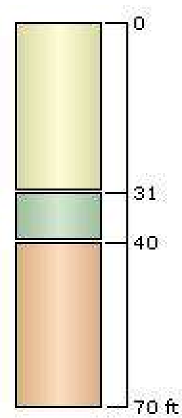
Label	Typical Earthen Levee Section (El +16 to +12 FT)
Center Line	(0, 0) to (100.012, 0)
Near End Angle	90 degrees
Far End Angle	90 degrees
Number of Layers	1
Base Width	26

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft^3)	Right Angle (deg)	Right Bench Width (ft)
1	Stage 3 = 2 mon	0	27	4	0.12	27	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Upper Alluvial Silt (El. 12 to -19 FT)	31	0	No
2	Lower Silt Interbed (El. -19 to -28 FT)	9	31	No
3	Lower Silty Sand Alluvium (El -28 to -58 FT)	30	40	No



Soil Properties

Property	Upper Alluvial Silt (El. 12 to -19 FT)	Lower Silt Interbed (El. -19 to -28 FT)	Lower Silty Sand Alluvium (El -28 to -58 FT)
Color			
Unit Weight [kips/ft^3]	0.1	0.102	0.11
Saturated Unit Weight [kips/ft^3]	0.1	0.102	0.11
K0	1	1	1
Primary Consolidation	Enabled	Enabled	Enabled
Material Type	Non-Linear	Non-Linear	Non-Linear
Cc	0.686	0.686	0.232
Cr	0.123	0.069	0.023
e0	1.62	1.62	0.78
OCR	2.9	1.9	1
Cv [ft^2/d]	0.04	0.04	0.9
Cvr [ft^2/d]	0.04	0.04	0.9
B-bar	1	1	1
Undrained Su A [kips/ft2]	0	0	0
Undrained Su S	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8
Piezo Line ID	1	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft^3

Piezometric Line Entities

ID	Depth (ft)
1	0 ft

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	50, 0	Auto: 47

APPENDIX D
Report Limitations and Guidelines for Use

APPENDIX D
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical Services are Performed for Specific Purposes, Persons and Projects

This report has been prepared for KPFF Consulting Engineers, Inc. and for the Project(s) specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our Agreement with KPFF Consulting Engineers, Inc. dated September 16, 2019 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Geotechnical Engineering or Geologic Report is based on a Unique Set of Project-Specific Factors

This report has been prepared for the North Shore Levee West Segment in Hoquiam, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Environmental Concerns are Not Covered

Unless environmental services were specifically included in our scope of services, this report does not provide any environmental findings, conclusions, or recommendations, including but not limited to, the likelihood of encountering underground storage tanks or regulated contaminants.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical and Geologic Findings are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted, or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

Geotechnical Engineering Report Recommendations are Not Final

We have developed the following recommendations based on data gathered from subsurface investigation(s). These investigations sample just a small percentage of a site to create a snapshot of the subsurface conditions elsewhere on the site. Such sampling on its own cannot provide a complete and accurate view of subsurface conditions for the entire site. Therefore, the recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions. If another party performs field observation and confirms our expectations, the other party must take full responsibility for both the observations and recommendations. Please note, however, that another party would lack our project-specific knowledge and resources.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.