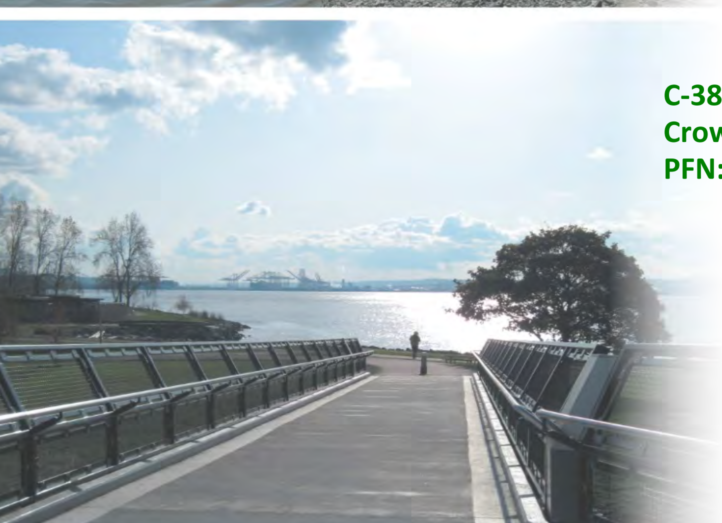

DRAFT

Subsurface Conditions Report

# Point Wells Redevelopment

Richmond Beach, Washington

**Prepared for**

BSRE Point Wells, LP

**June 11, 2015**
**17203-54**

**C-38 SUPERSEDED Draft Subsurface Conditions Report by Hart Crowser June 11 2015**
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DRAFT

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Richmond Beach, Washington

**Prepared for**

BSRE Point Wells, LP

**17203-54**
**June 11, 2015**

**Prepared by**

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Subsurface Conditions Report

# Point Wells Redevelopment

Richmond Beach, Washington

## 1.0 EXECUTIVE SUMMARY

This report presents our geotechnical engineering study for the environmental impact analysis for the proposed mixed-use redevelopment at Point Wells in Richmond Beach, Snohomish County, Washington. An environmental impact statement is being prepared for three alternatives. Alternative 1 is the Urban Center Alternative; it would include multiple mid- and high-rise buildings, supporting infrastructure, and open space. Alternative 2, the Urban Village Alternative, is similar to Alternative 1 but with shorter buildings for fewer residential units. Alternatives 1 and 2 would also include a potential Secondary Access Road from the east. There are also two No Action alternatives: Alternative 3a would continue existing industrial use, and Alternative 3b would continue existing industrial use but expand industrial operations.

The site consists of a 56-acre “Lower Bench” adjacent to Puget Sound and a 5-acre “Upper Bench” to the east. The Upper and Lower Benches are split by the BNSF railroad tracks that run along Puget Sound. East of the site is an ascending slope about 150 to 200 feet high with average overall slope gradient ranging from about 18 to 50 percent (or about 3H:1V to 2H:1V). The slope gradient varies locally, maximizing at about 100 percent (1H:1V).

Soils at the site and in the adjacent eastern slope include Fill, Colluvium, Vashon Till, Advance Outwash, Lawton Clay, and Pre-Fraser Deposits. Shallow groundwater is present below the Upper and Lower Benches, and groundwater is also present at varying levels in the eastern slope. Areas of localized slope instability were observed in the field and reported historically along similar slopes on Puget Sound.

Geologically hazardous areas at the site and in the eastern slope include erosion, landslide, seismic, and tsunami. The impacts of the proposed alternatives on these hazards areas, as well as the potential impacts of the hazardous areas on the proposed alternatives, can be mitigated during design. There is essentially no difference between Alternatives 1 and 2 relative to these geologic hazards.

## 2.0 INTRODUCTION

This report presents our geotechnical engineering study for the environmental impact analysis for the proposed mixed-use redevelopment at the Point Wells asphalt plant and marine fuel terminal in Richmond Beach, Washington (the Project). We understand an environmental impact statement (EIS) is being prepared for the proposed development. The EIS describes two redevelopment alternatives. Alternative 1 is the Urban Center Alternative, with 3,081 residential units. Alternative 2 is the Urban Village Alternative, with approximately 2,600 residential units. There are also two No Action alternatives: Alternative 3a would continue existing industrial use, and Alternative 3b would continue existing industrial use but expand industrial operations. This report provides our findings on geotechnical aspects of the proposed development of the site and supplements our previous preliminary geotechnical engineering study (Hart Crowser 2010).

This report contains several sections. The main body of the report presents our findings and is organized as follows:

- Introduction
- Site and Project Descriptions
- Field Activities
- Site Geology and Subsurface Conditions
- Geologic Hazards
- Hazard Mitigation and Geotechnical Design and Construction Considerations for the Project

Tables are in the text following their initial reference, and figures are at the end of the text. The field exploration procedures and logs are in Appendix A. The laboratory procedures and test results are in Appendix B. Appendix C presents vibrating wire piezometer (VWP) data and groundwater measurements Hart Crowser collected at the site. Appendix D presents logs of field exploration performed by Hart Crowser and others previously at this site. This report presents the results of our geotechnical assessment for the EIS; additional supporting information is provided in our previous study (Hart Crowser 2010).

## 2.1 Purpose

The purpose of our work is to assess geotechnical conditions (i.e., geology, soils, and groundwater and seismic conditions) at the site to support preparation of the EIS for the Project. This includes assessing potential impacts of geologic hazards that may impact the proposed development, and assessing how the proposed development would impact the surrounding environment considering these potential geologic hazards. This report provides geotechnical engineering findings to support planning-level decisions, but is not intended to be sufficient for final design.

## 2.2 Scope

The scope of our work was based on “Summary of the Public EIS Scoping Process” from the Snohomish County Planning and Development Services (PDS), dated August 8, 2014; the detailed EIS scope (Draft 8.27.14) provided by EA Engineering, Science, and Technology, Inc.; and Exhibit A of “Point Wells Mixed Use Redevelopment EIS, EIS Preparation Protocols and Guidance,” dated September 17, 2014.

Our scope of work to address the geotechnical engineering aspects at this phase of the Project includes:

- Describe existing soils and geologic/topographic conditions on and in the vicinity of the site, including the adjacent hillside area to the east (Section 5);

- Describe geologically hazardous areas on and adjacent to the site, including the relationship of the proposed development to identified geologic hazard areas (Sections 5 and 6);

- Evaluate anticipated earthwork associated with construction of the proposed redevelopment (Sections 6.4, 7.1.4, and 7.2);
- Describe proposed grading activities and construction techniques required or recommended for consideration for development, including sources of any fill (Section 7.2);
- Analyze the potential for geotechnical impacts with development and for the No Action alternatives (Section 6);
- Assess potential for erosion during construction (Sections 6.4 and 7.1.4);
- Discuss potential vibration impacts to existing structures on and immediately adjacent to the site resulting from redevelopment activities including construction and truck traffic (Section 7.6.2);
- Discuss potential for vibration from the adjacent railroad operations to impact proposed development (Section 7.6.2);
- Analyze overall suitability of soils to accommodate redevelopment (Section 7);
- Discuss geotechnical impacts associated with development of the Secondary Access Road (Section 6);
- Identify mitigation measures necessary to minimize impacts on earth (Section 7); and
- Present the results of our study in this report.

We developed our geotechnical engineering findings considering the combined geotechnical data from previous and current explorations, as well as our experience with the local geology. This study focuses on the proposed development alternatives described in the following section.

Description of contaminated soils and discussions related to Model Toxics Control Act cleanup/remediation processes were excluded from our scope; we understand these topics will be addressed by others in a separate report.

## 2.3 The Use of This Report

We completed this work in general accordance with our proposal dated October 30, 2014. We received written authorization to proceed on March 3, 2015. This report is for the exclusive use of BSRE Point Wells, LP, and its consultants for specific application to the Project and site. We completed this design study in accordance with generally accepted geotechnical practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. We make no other warranty, express or implied.

The explorations performed for this study represent subsurface conditions only at discrete locations across the Project site and that actual conditions in other areas could vary.

# 3.0 SITE AND PROJECT DESCRIPTIONS

## 3.1 Site Description

The Point Wells facility is in Snohomish County, Washington, on Puget Sound near the border of King County with Snohomish County (Figure 1). Figure 2 shows the existing site topography, which was provided by the Project team. The elevations in this report correspond to NAVD88, unless specified otherwise. Figure 3 is an aerial photo that shows existing site features and the location of soil borings used in our evaluation of the Project site.

The west side of the site consists of a semicircular area of about 56 acres adjacent to Puget Sound, referred to as the "Lower Bench" because it is at a lower elevation than the rest of the site. The southeast portion of the site is a more or less rectangular area of about 5 acres, referred to as the "Upper Bench" because it is at a higher elevation. The two areas are separated by the approximately north–south Burlington Northern Santa Fe (BNSF) railroad tracks. On the east side of the proposed development, across the railroad tracks, is an ascending slope. The slope is approximately 150 to 200 feet high and is covered with vegetation. The average overall slope gradient ranges from about 18 to 50 percent (or about 3H:1V to 2H:1V), with gradients generally increasing from the south end to the north end of the site (Figure 4). The slope gradient varies locally, maximizing at 100 percent (1H:1V).

Several buildings and a retention pond are on the Upper Bench. The Upper Bench is relatively flat, with a steep ascending slope along its eastern perimeter having an average gradient of about 50 percent and locally steeper sections approaching 100 percent. A short concrete block retaining wall is located on the east portion of the Upper Bench, adjacent to the toe of the existing slope. The western boundary of the Upper Bench descends on a short steep slope to the BNSF railroad tracks.

The Lower Bench contains an asphalt plant and marine fuel terminal. The Lower Bench is generally flat with less than 10 feet of elevation change across the site. The Lower Bench is protected from the adjacent Puget Sound by a concrete seawall, sheet pile wall, and/or riprap.

Figure 3 is an aerial photograph of the site and shows impervious surfaces and roads. Over 200 borings and/or monitoring wells have been advanced at the site. Hart Crowser's report titled "2008 Remediation System and Groundwater Quality Evaluation, Richmond Beach Asphalt and Marine Fuels Terminal" contains information on our most recent groundwater study. Because site use dates back to the early 20th century, there may be existing drain fields or other subsurface constructed features on the site. Utility and easement information is not part of our scope of work.

## 3.2 Project Description

We understand the site is being considered for development of a waterfront community of mixed use (office, retail, and residential). Potential development plans call for multiple mid- and high-rise buildings, supporting infrastructure, and open space.

Once specific building layout and structural loads are available, design-level geotechnical explorations and engineering analyses will be necessary to develop specific design criteria and recommendations for the Project.

**Alternative 1.** The Urban Center Alternative includes construction of approximately 3.081 million square feet ($ft^2$) of residential space (3,081 units), 32,262 $ft^2$ of commercial/office space, and 94,300 $ft^2$ of retail space. The Project would also provide passive recreational activity areas, open space, a public dock, and associated infrastructure. Alternative 1 is anticipated to support approximately 6,200 residents and approximately 500 on-site employees.

As part of this alternative, an Urban Plaza would be developed on the Upper Bench and would include 254 residential units and all of the proposal's commercial floor space. It would consist of three low-rise buildings (2 to 4 stories), one mid-rise building (10 stories), and four tower buildings (12 to 18 stories). The development would include one level below grade over the majority of the Upper Bench for parking and service and transportation access. The bottom level of the development would be about 10 feet below the existing grade of the Upper Bench.

The South, Central, and North Villages described below would all be constructed on the Lower Bench. In general, the final grades in the South, Central, and North Villages would be raised about 15 to 30 feet above the existing grade of the Lower Bench over the majority of the development, with less grade change at the Puget Sound edge. The bottom of the lowest levels of the planned structures would be about 0 to 5 feet below the existing grades of the Lower Bench.

The South Village would include 24,000 $ft^2$ of retail space and 653 residential units. It would consist of eight low-rise buildings (of one to four stories), six mid-rise buildings (eight to 10 stories) and three residential towers (12 to 16 stories). The South Village would have one to three levels of below-grade parking, depending on varying final site grades.

The Central Village would include 44,000 $ft^2$ of retail space and 1,271 residential units. It would consist of 11 low-rise buildings (one to four stories), five mid-rise buildings (six to 10 stories) and five residential towers (12 to 16 stories). The South Village would have one to three levels of below-grade parking, depending on varying final site grades.

The North Village would include 903 residential units. It would consist of three low-rise buildings (two to four stories), one mid-rise building (10 stories), and four residential towers (12 to 17 stories). The North Village would have one level of below-grade parking.

The site has an existing seawall approximately 3,300 feet long that is a combination of concrete, timber sheet pile, and rip-rap rock seawall on the Lower Bench. This wall would be totally removed and reconstructed. Most of the new seawall would be located 40 to more than 100 feet landward of its existing location. The primary purpose of this realignment would be to create approximately 5.7 acres of new intertidal habitat area.

**Alternative 2**. The Urban Village Alternative would have the site redeveloped as a mixed-use urban village, with the same general site plan as Alternative 1. However, the maximum building height would be less. Approximately 2.6 million $ft^2$ of residential uses (2,600 units) would be provided under Alternative 2. The same amounts of commercial/office uses with space for on-site police and fire facilities (32,262 $ft^2$), retail uses (94,300 $ft^2$), and open space as Alternative 1 is assumed for Alternative 2. Alternative 2 is anticipated to support approximately 5,232 residents and approximately 500 employees.

As we understand the Project, Alternatives 1 and 2 are essentially the same from a geotechnical perspective.

**Secondary Access Road.** As part of the proposed redevelopment under either Alternative 1 or Alternative 2, the Secondary Access Road is proposed. At the time of this writing, the alignment alternatives were not yet available. Our understanding from discussions with the EIS team is that two alignments are being considered (see Figure 2):

1. Along the narrow strip of property extending upslope to the east from the south end of the Upper Bench; and
2. Along the general alignment of the abandoned access road north of the Upper Bench and east of the Lower Bench.

**Alternative 3.** The no action alternatives are: Alternative 3a, which would involve continuation of existing industrial use, and Alternative 3b, which is a continuation of existing industrial use with increased industrial operations through renovation and reuse of existing underutilized facilities.

Alternatives 3a and 3b are essentially the same from a geotechnical perspective.

# 4.0 FIELD ACTIVITIES

To assess soil conditions and potential geologic hazards, we completed a 250-foot soil boring at the top of the eastern slope and installed VWPs to monitor groundwater levels in different stratigraphic units. Field reconnaissance was performed on the eastern slope to document slope conditions and evaluate potential landslide features identified on laser imaging, detection, and ranging (LiDAR) imagery of the site with respect to the proposed development alternatives. LiDAR imagery was collected in April 2013 and provided by the Washington State Department of Transportation (WSDOT 2013). As part of the reconnaissance, five hand-auger soil borings were advanced on the slope. Details of these activities are in the following section, and exploration locations are shown on Figures 2 and 3.

## 4.1 Soil Boring

From April 16 to 21, 2015, soil boring HC-1 was advanced to 250 feet below ground surface (bgs) by Gregory Drilling of Redmond, Washington. A Hart Crowser geologist logged soil samples collected at 5-foot intervals. Following completion of the soil boring, four VWPs were installed at depths of 14, 58.5, 114, and 154 feet bgs to record groundwater pore pressures in different geologic units. Site geology and groundwater measurements are discussed in Section 5, below. A detailed boring log is in Appendix A, and VWP calibrations and readings are in Appendix C.

## 4.2 Slope Reconnaissance

On April 21 and 22, and on May 26, 2015, two Hart Crowser geologists traversed the slope east of the BNSF railroad tracks. The primary focus of the reconnaissance was to document surface features on the steep slopes, identify potential geologic hazards, and evaluate potential landslide features identified on LiDAR imagery. This reconnaissance was limited to areas that were readily accessible and did not include a detailed survey of the slope. Observations made during the reconnaissance included identification of geologic contacts (interface of one predominant soil type with another), landslides, and other features related to downslope soil movement; springs, seeps, or other expressions of groundwater at the surface; location or evidence of surface water; and the extent and type of vegetative cover. Details of the reconnaissance are discussed in Section 5.1.5, and a summary field observation is on Figure 5.

### *4.2.1 Hand Auger Borings*

During the field reconnaissance, five hand auger borings were advanced to approximately 3 to 8.5 feet bgs. Soil conditions encountered in these shallow borings are shown in Table 1. Hand auger locations are on Figures 2 and 3.

Table 1 – Hand Auger Details

| Hand Auger ID | Depth in Feet | Depth in Feet – Soil Description | Depth to Water |
|---|---|---|---|
| HA-1 | 3 | 0 to 1 – Moist to wet , gray, silty, clayey Sand (Colluvium)<br>1 to 3 – Wet, gray SAND (Lawton Formation?) | 1 feet bgs |
| HA-2 | 5 | 0 to 4 – Moist gray silty Sand and sand SILT (Colluvium)<br>4 to 5 – Wet, gray, Sand | 4 feet bgs |
| HA-3 | 4 | 0 to 5 - Wet, gray, silt, clayey, SAND | At surface |
| HA-4 | 8.5 | 0 to 1 – Moist, gray, Silt and Sand (Colluvium)<br>1 to 2 – Moist, gray with orange mottled, Silt<br>2 to 7.5 – Moist, gray, clayey Silt<br>7.5 – 8 - Wet, gray, Sand trace silt | 7 feet bgs, rising to 2.5 feet bgs prior to backfill |
| HA-5 | 8 | 0 to 7 – Wet, gray, Sand (Outwash)<br>7 to 8 – Moist, gray silty Clay (Lawton Formation) | 0 feet; water is at surface |

Terms such as Colluvium, Outwash, and the Lawton Formation refer to soil units at the site that are described below in Section 5.1.2.

# 5.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

The following sections describe surface and subsurface conditions at the site.

## 5.1 Subsurface and Topographic Conditions

### *5.1.1 Site Geology*

A geologic map of the site and surrounding vicinity based on the work by Booth et al. (2004) is shown on Figure 6. The surficial soils of the Lower and Upper Benches consist of artificial fill (af) and pre-Fraser deposits (Qpf), respectively. The pre-Fraser deposits are sedimentary deposits typically consisting of poorly to well-sorted gravel, sand, silt, and clay. The original ground surface of the Lower Bench was modified and fill was placed to raise grade for construction of the existing facility. The artificial fill consists of loose to dense, trace to silty, gravelly Sand.

The surficial geologic units decrease in age to the east of the site. On the hillside east of the site, the pre-Fraser deposits are overlain by Lawton Clay (Qvlc), Advance Outwash (Qva), Vashon Till (Qvt), and Recessional Outwash (Qvr). The geologic map does not indicate the presence of a significant amount of colluvium on the slope. The colluvium that is present was deposited from ongoing erosion and historical landslides. In addition to these natural processes, the slope was likely graded to facilitate construction of the now-abandoned access road shown on Figure 3, as well as other structures built on the hillside. During our field reconnaissance, neighborhood residents reported observing fill material being deposited on the hillside during historical operation of the Point Wells facilities.

### *5.1.2 Soil Conditions*

Soil conditions at the site and on the eastern hillsides are discussed in the follow sections. Subsurface contamination during past use of the site is discussed separately for the EIS, and so is omitted from this discussion.

The soils on the eastern hillside and the Upper and Lower Benches fall into six basic soil units, as indicated by our recent boring and historical borings. These soil units reflect the geologic depositional history at the site, and are, in order of increasing age, fill, colluvium, Vashon Till, Advance Outwash, Lawton Clay, and alternating pre-Fraser nonglacial fluvial and lacustrine deposits. Figures 7 and 8 are generalized subsurface cross sections of the site and eastern hillside based on subsurface conditions encountered in the explorations. Descriptions of these soils are presented in detail below.

**Fill.** This layer was observed underlying the Upper and Lower Benches and consists of loose to medium dense, gray brown to brown to dark gray, moist to wet, none to silty, none to gravelly, Sand and sandy Gravel. The Fill layer extends to a depth of up to 5 feet bgs where observed in the borings and may be deeper at other locations. This Fill unit is below asphalt and concrete in the Upper Bench, and below a layer of surface Gravel on the Lower Bench. The fill may contain cobbles and possibly boulders or debris.

**Colluvium.** This material consists of very soft, moist to wet, gray, none to sandy, Silt and loose to medium dense, very moist, gray silty Sand as indicated in some borings and observed on the eastern hillside. Scattered zones of gravelly Sand were observed as well as scattered wood fragments and organic material.

**Vashon Till.** This layer consists of an unsorted mixture of silts, clays, gravel, cobbles, and occasional scattered boulders. The unit is compact and very hard or dense because of loading of as much as 3,000 feet of overriding ice during the last glaciation. This unit was generally at the surface in explorations at the top of the slope and was up to 56.5 feet thick, as observed in HC-1. The upper 10 to 15 feet of the till appeared weathered.

**Advance Outwash.** This unit generally underlies the Vashon Till and consists of dense sand, gravelly sand, and slightly silty, gravelly sand. The sand is compact and less cohesive because it lacks fines. This material varied from about 0 to 30 feet thick in explorations at the top of the slope. In general the unit appears to be thicker to the north and may have been completely eroded by the Vashon Till in areas to the south. Perched water is frequently encountered in this material overlying fine-grained Layton Clay below.

**Lawton Clay.** This unit underlies the Advance Outwash and generally consists of massive, hard clay and silt, with scattered silty sand and sand layers. The fine-grained materials (silts and clays) are less permeable, resulting in perched groundwater at its contact with the overlying Advance Outwash. This unit was 116 feet thick in HC-1, which was the only boring at the top of the slope deep enough to drill through the unit. While known to be relatively strong, Lawton Clay can weaken when exposed to water. Slickensides were observed on exposed outcrops during the field reconnaissance and in samples collected from exploration HC-1.

**Pre-Fraser Nonglacial Fluvial Deposits**. Pre-Fraser nonglacial fluvial deposits underlie the Lawton Clay on the eastern slope, the Colluvium in the Upper Bench and the Fill in the Lower Bench. This unit was observed in the borings in the Lower Bench and HC-1. Underlying the Colluvium on the Upper Bench and Fill on the Lower Bench, this unit consists of loose to very dense, moist to wet, gray to dark gray, none to gravelly, none to silty Sand and none to silty, sandy Gravel. Scattered shell fragments and trace scattered organic material were observed in this unit in the Lower Bench explorations. In HC-1, located on top of the east hillside, the fluvial deposits consisted of layers of very dense silty sand, clayey sand, and sand that alternated with lacustrine deposits (described in the next section) from 175 feet bgs to the bottom of boring HC-1 at 248.5 feet bgs.

**Pre-Fraser Nonglacial Lacustrine Deposits**. This unit was observed to alternate with fluvial deposits (described in the previous section) within the borings located in the Lower Bench. This unit consists of medium dense, wet, olive gray, silty Sand to stiff to very stiff, sandy Silt. Traces of scattered shell, gravel, and wood fragments were observed. In HC-1, located on top of the east hillside, nonglacial lacustrine layers of hard silt and clay alternated with fluvial deposits from 175 feet to the bottom of the boring at 248.5 feet bgs.

### *5.1.3 Groundwater*

Our understanding of groundwater conditions at the site is based on field reconnaissance, observations reported during drilling, and VWP and water level measurements completed by Hart Crowser and others at the site. Groundwater conditions on the Upper and Lower Benches and the eastern slope are described in the following sections. The focus of our reconnaissance and VWP measurements was on the eastern slope. Our understanding of the groundwater conditions below the Upper and Lower Benches is from our 2010 analysis (Hart Crowser 2010). Note that measured groundwater levels are representative for the times indicated. Fluctuations in groundwater levels may occur because of variations in rainfall, temperature, seasons, and other factors.

Perched groundwater can result from infiltrating groundwater encountering a low-permeability soil layer and building up as groundwater slowly flows laterally on top of the low-permeability layer. Soil layers below the low-permeability layer may not be saturated.

Confined groundwater conditions result when groundwater in a high-permeability soil layer wants to rise above the bottom of an overlying low-permeability layer. Groundwater pressures build up in the high-permeability layer because vertical flow is impeded. Soil layers above the confining low-permeability layer may not be saturated. Groundwater head is a measurement used to represent the groundwater pressure measured in soil pores, often referred to as pore pressure. Groundwater head is the height the groundwater would rise to in an open standpipe above the point at which the groundwater pore pressure is measured.

#### 5.1.3.1 Upper Bench

Exploration B09-1 was advanced in December 2009. At the time of drilling, groundwater was encountered at a depth of 2.5 feet. This corresponds to an elevation of 44.5 feet.

As shown on Figure 3, several monitoring wells were previously advanced on the Upper Bench. The explorations shown on Figure 3 are 20 feet deep or greater. Water level was measured at the site on October 5, 2009, in monitoring wells MW-95 and MW-122. At that time, the groundwater in MW-95 was observed at an elevation of about 40 feet. Artesian flowing conditions were observed at MW-122, as indicated by water flowing from the top of the monitoring well. Artesian flowing conditions occur when groundwater is confined and groundwater pressures increase enough to cause groundwater to rise through the well and flow at ground surface. The ground surface elevation in MW-122 is approximately 48 feet.

#### 5.1.3.2 Lower Bench

In Lower Bench explorations B09-2 and B09-3, groundwater was observed in B09-2 only, at a depth of 1.5 feet bgs in December 2009. This corresponds to an elevation of 5.5 feet. The soil was wet in B09-3 starting at a depth of 7.5 feet bgs, which corresponds to an elevation of approximately 3.5 feet.

In the vicinity of B09-2, several monitoring wells were previously advanced at the site, as shown on Figure 3. The explorations shown are 20 feet deep or greater. Hart Crowser measured water levels between October 5 and 7, 2009, for MW-42, MW-103, and MW-110. At that time, the groundwater elevation was between about 5 to 8 feet bgs.

### 5.1.3.3 Eastern Slope

**Soil Boring Measurements.** In exploration HC-1, located at the top of the eastern slope, perched groundwater was encountered at 186 feet elevation at the time of drilling. Upon completion of drilling, four VWPs were installed on April 22, 2015, using the grout-in method. The VWPs were placed to monitor groundwater conditions at the contact between the weathered and unweathered Vashon Till (229-foot elevation), within the Advance Outwash overlying the Lawton Clay (184-foot elevation), and in water-bearing silty sand and sand layers within the Lawton Clay (129- and 89-foot elevations). Measurements made on May 6, 21, and 26 in 2015 are shown in Table 2, and are the groundwater levels shown on Figure 8. Because of the relative permeability of the soil layers, groundwater measurements indicate perched and/or confined conditions, and not all layers below the reported groundwater depth or elevation are saturated.

Table 2 – Vibrating Wire Piezometer Measurements, Boring HC-1 – Ground Surface Elevation 243 Feet

| VWP Elevation in Feet | Measurement Date | Measured Head in Feet | Groundwater Depth in Feet | Groundwater Elevation in Feet |
|---|---|---|---|---|
| 229 | 5/6/2015 | 7.6 | 6.4 | 236.6 |
| | 5/21/2015 | 6.9 | 7.1 | 235.9 |
| | 5/26/2015 | 6.9 | 7.1 | 235.9 |
| 184 | 5/6/2015 | 39.0 | 19.8 | 223.2 |
| | 5/21/2015 | 40.0 | 18.7 | 224.3 |
| | 5/26/2015 | 40.5 | 18.3 | 224.7 |
| 129 | 5/6/2015 | 55.3 | 58.7 | 184.3 |
| | 5/21/2015 | 57.2 | 56.8 | 186.2 |
| | 5/26/2015 | 58.0 | 56.0 | 187.0 |
| 189 | 5/6/2015 | 38.4 | 115.6 | 127.4 |
| | 5/21/2015 | 38.2 | 115.8 | 127.2 |
| | 5/26/2015 | 38.4 | 115.6 | 127.4 |

Groundwater heads measured at the VWP elevations were higher than anticipated based on piezometer measurements at the Woodway Landslide, which were typically about 8 feet or less as measured near the top of the Lawton Clay (Savage et al. 2000) and about 18 feet in a sand layer underlying the Lawton Clay (Landau 1998). Before installing the VWPs, we took measurements from each VWP in a 5-gallon bucket of water, which confirmed the VWPs were functioning properly. We also allowed sufficient time for the grout to set, as indicated by VWP temperature readings, and the readings have been fairly consistent over time, as shown in Table 2. More detailed VWP information, including raw data and VWP calibration certifications, are in Appendix D.

**Slope Reconnaissance Observations.** Numerous seeps, springs, and areas of wet soil were observed on the slope during our reconnaissance. The locations of surface water observed on the slope are shown on Figure 5. Surface water was generally observed at contacts above and below the Lawton Clay, as well as at sand layers and interbeds within the formation. The Vashon Till and the Lawton Clay are known to have relatively low permeability, resulting in confined and/or perched groundwater; however, pore pressure measurements from the VWPs and observations of seeps and springs along the slope indicate the presence of these water-bearing zones within these units. Our groundwater measurements and field observations suggest that multiple groundwater zones are present on the hillside.

We observed numerous streams that may be seasonal on the hillside above the site. Because of dense vegetation on the slope, the origin of most of the small streams was not determined, so it is unclear how much flow is due to stormwater runoff and how much is due to groundwater flow from seeps and springs. Stream discharge near the bottom of the hillside was generally approximately 5 to 10 gallons per minute or higher in the larger creeks at the time of our observations in April and May. The larger drainages, Drainages 1 and 2 (Figure 2), started at the top of the slope and were primarily fed by runoff.

A relatively large, roughly contiguous area of wet soil and scattered ponded surface water was observed on the eastern slope near the abandoned access road (Figure 5). The access road fill and compacted base material appear to be damming surface water on the slope, creating small ponds and large areas of wet soil. Surface water in this area likely originates from the Advance Outwash and from sandy layers and joints within the Lawton Formation.

Water-bearing sand layers and joints were observed in the Lawton Formation, as confirmed by the pore pressure readings from VWPs placed in HC-1 (Table 2) within sandy zones of the formation. Field observations of exposed Lawton Formation confirmed the presence of joints and thin sand layers. Similar observations were made during investigations of the Woodway Landslide to the north (Landau 1998); however, the post-landslide groundwater pore pressures were lower at the Woodway Landslide than those recorded at HC-1 in the eastern slope above the site.

Near the bottom of the slope, approximately 150 feet east of the railway at an elevation of roughly 65 feet, a confined layer of wet sand was observed in hand auger boring HA-4. The water was initially observed at 7.5 feet bgs within a sand unit and quickly rose to apparent equilibrium at 2.5 feet bgs, indicating pore pressures in the sand were confined by the overlying silty clay.

Near the bottom of the slope, a retaining wall extends along a portion of the BNSF tracks and intercepts the creeks that drain the hillside, channeling the water into a culvert east of the railway.

### 5.1.4 Site Topography

The Upper and Lower Benches are generally flat, but the slope east of the railway rises approximately 150 to 200 feet. Site topography is shown on Figure 2 and LiDAR imagery is shown on Figure 5. The majority of the slope is steeper than 33 percent (3H:1V), and is designated a landslide hazard area under the Snohomish County Code (SCC), as shown on Figure 9. However, the steepness of the slope varies considerably. LiDAR-derived slope calculations for the site and the east hillside are shown on Figure 10. Slope profiles through representative sections of the site and slopes to the east are shown on Figure 4. The overall slopes are less steep moving from north to south.

In general, steeper slopes and vertical scarps were encountered in the northern portion of the slope, adjacent to Drainages 2, 3, and 4, which are located in the middle and northern portion of the slope (Figure 2). A near-vertical, approximately 50-foot-high bluff is at the top of the northwest slope, just west of residential homes. Throughout the site, the steepest slopes were generally adjacent to drainages or along the upper 1/5 of the slope of the bluffs.

The main portion of the Lower Bench is generally flat, with approximately 10 feet of elevation change across the area. The Upper Bench is also generally flat with only a few feet of elevation change across the area.

### 5.1.5 Slope Reconnaissance

We conducted field reconnaissance of the site with a primary focus on the condition of the steep slopes east of the BNSF railroad tracks. No significant rainfall had occurred in the previous week. The SCC, Section 30.62B, requires the geotechnical study to include specific information relevant to the geologic hazards. The following section provides relevant information for landslide hazards based on our field reconnaissance. Figure 5 shows LiDAR-derived surface topography and important features observed during our reconnaissance. In Figure 5, “recent” landslide activity refers to observed evidence of slope movement interpreted to have occurred within the last 20 years, and “historical” refers to observed evidence of older landslide activity.

**Observed Landslides or Downslope Soil Movement.** Evidence of historical landslide activity was observed during our field reconnaissance of the steep slope east of the BNSF railroad tracks. Above the site, between Drainages 1 and 2, evidence of slope movement was observed, as indicated by pistol-butted leaning or dead trees and hummocky topography. It is unclear whether activity in this area is related to a deep rotational slide as described in a 2004 geotechnical report (Earth Consultants 2004) or a result of ponded surface water and highly saturated soils resulting in localized shallow rotational slides, sloughing, and small debris flows. Shallow landslides are more typical in Puget Sound bluffs and generally do not travel as far as deep-seated slides (see Potential Landslide Travel Distance/Runout in Section 5.1.6.1). Additional explorations and slope instrumentation could be used to better characterize this area during design.

The abandoned asphalt access road connecting historical Chevron operations on top of the hillside to the terminal below may be contributing to the extremely wet soil conditions generally observed in the area. The roadway and compacted base material appear to be damming surface water on the slope, creating small ponds and large areas of wet soil. It is not clear whether the road was abandoned because of landslide activity. The road is now barely recognizable because portions have been transported down the slope by erosion and localized instability, and the road is covered by dense vegetation.

As documented in our preliminary geotechnical engineering study (Hart Crowser 2010), a clearly defined head scarp or crest was observed on the slope east of the Upper Bench. Immediately below the scarp, an oversteepened slope was observed, followed by hummocky terrain to the toe of the slope. We observed trees of similar ages grouped together, trees leaning downslope (indicating downslope soil movement), and trees tilted upslope (indicating potential soil block rotation as part of landslide activity). These observations are consistent with the landslide descriptions from the coastal atlas of the area (Ecology 2004), as shown on Figure 11.

Our observations found recent landslide activity to be primarily confined to the immediate vicinity of the drainages and likely the result of erosion at the toe of the slope and saturated soil conditions resulting from seeps and springs on the hillside. Examples of these slides are shown in Photographs 1 and 2.

*Photographs 1 (top) and 2 (bottom): Localized small landslides near Drainage 1.*

Evidence of larger block slides and bluff erosion was observed along the northern portion of the upper bluff. At the base of the upper bluff, where the Advance Outwash-Lawton Clay contact could be observed, seeps within the Advance Outwash formed a small creek (Photograph 3).

*Photograph 3: Creek forming from seepage at the Advance Outwash-Lawton Clay contact.*

Evidence of older, large rotation and block failure landslides were observed adjacent to drainages in the northern and southern portions of the hillside, but none appeared to have been large enough for landslide debris to reach the site. In general, as indicated in cross section B-B' (Figure 8), colluvium was widespread on the slope, indicating relatively frequent historical landslide activity.

Along the toe of the slope and at a wood retaining wall, evidence of surficial, slow downslope movement (i.e., creep) was observed east of the BNSF railroad tracks, as shown on Figure 2. In some locations, a small amount of soil had eroded from behind the wall. In some areas, the wall itself appeared to bulge out slightly because of soil movement.

A concrete ecology block wall was observed at the toe of the slope in the Upper Bench area during our 2010 reconnaissance. Its presence suggests that soil needed to be retained in this area because of cutting of the toe of the slope and/or past landslide activity. The slope in this area was not explored during the site visit because of access limitations.

**Significant Geologic Contacts**. Because of slope vegetation, observation of significant geologic contacts was limited. As mentioned above, Vashon Till, Advance Outwash, and Lawton Clay were observed in the upper portion of the hillside and generally correlated with drilling observations.

In the lower third of the slope, a contact was observed between the pre-Fraser Formation and the overlying Lawton Clay during the 2010 reconnaissance. Hand auger boring HA-4 appeared to encounter Pre-Fraser or Whidbey Formation sands underlying the Lawton Clay.

In other areas of the slope, exposed soil appeared consistent with expected geology, as shown on Figure 6. On the slope between the Upper Bench and the BNSF railroad tracks and south of the abandoned bridge, an exposed colluvium face was observed. The presence of the colluvium is consistent with the area being the site of past landslide activity. In Drainage 2 (Figure 2), a near-vertical exposure of Lawton Clay was observed at approximately elevation 150 to 170 feet. Overlying this unit, wet sand and seeps were observed within the Advance Outwash. These exposures are consistent with the geologic map of the area.

**Location or Evidence of Any Springs, Seeps, or Other Surface Expressions of Groundwater.** As discussed Section 5.1.3, numerous springs and seeps were identified on the eastern hillside. Large areas of wet soil and surface water were observed in several areas on the slope, near the abandoned Chevron access road. The observed seeps and springs appear to be primarily flowing from Advance Outwash sand overlying the Lawton Clay and from sand layers and joints within the Lawton Formation. Pooled water was observed at the toe of the slope located along the east side of the BNSF railroad tracks.

During our field reconnaissance, we identified two primary drainages (Drainages 1 and 2) extending from the top to the toe of the slope, as shown on Figure 2. Two additional drainages (Drainages 3 and 4) were located north of the primary drainages and did not appear to extend to the top of the slope, although this was not verified in the field because of dense vegetation and steep slopes. The estimated extent of the creeks is shown on Figure 10. Seeps and springs appear to account for a large portion of the water in all the drainages, particularly in the northern portion of the hillside.

**Location or Evidence of Any Surface Water.** Streams in Drainages 1 and 2 were observed to originate from upslope runoff. Drainage 1 originates from a retention pond at approximately elevation 175 feet. Immediately below the retention pond, a 6-inch-diameter pipe was observed to be leaking into the stream at a rate in excess of roughly 10 gallons per minute. Drainage 1 empties into a 6-foot-deep retention pond on the northeastern part of the Upper Bench. At the time of the field visit, the retention pond was full and water was continuously flowing through it, despite the lack of recent rainfall.

Drainage 2 begins at approximately elevation 235 feet, where a storm drain discharges to the surface near the private property gate at the end of 238th Street Southeast, as shown in Photograph 4.

*Photograph 4: Surface runoff at gate to the private property at the top of the slope, above Drainage 2.*

Surface water was observed west of the existing detention pond on the Upper Bench during our 2010 investigation. The water was observed to have migrated to the surface from below existing asphalt. We understand previous test results indicated the water was most likely linked to a water pipe in the perimeter of the Upper Bench.

During our 2010 investigation, an unidentified pipe was observed on the slope between the Upper Bench and the railroad tracks. At the time, water was visible flowing from the pipe and ice was present on the ground below the discharge.

Numerous pipes that are mostly buried and likely related to historical Chevron activities at the top of the slope were observed near Drainage 1. As mentioned above, one of these was leaking near the upper retention pond, as shown in Photograph 5. It is unclear whether water is conveyed through the other pipes.

*Photograph 5: Leaking pipes below retention pond in Drainage 1.*

**Extent and Type of Vegetative Cover.** The vegetation on the slope generally consisted of mature deciduous trees and second-growth conifers. The understory is heavily vegetated with brush and small trees. In areas near seeps, hydrophytic plants such as horsetail, cattail, and watercress were observed.

### *5.1.6 Steep Slope Assessment*

In general, landslides on steep slopes adjacent to Puget Sound are common. Coastal bluff erosion is an ongoing, natural process. Our investigation and numerous previous geotechnical and slope assessments have been completed in the vicinity of the site and along other coastal bluffs in the region. Landslides of varying sizes have occurred on the slope above the site and will continue to occur unless engineering controls are put in place to stabilize the slope.

Our field reconnaissance identified many areas where landsliding has occurred or is ongoing. In general, most of the recent slope movement appears to be related to wet surface soil, seeps, and surface water erosion, which causes small block failures, localized rotational slides, and surface sloughing, as shown in Photographs 1 and 2. However, evidence of larger landslides was observed on the steeper bluffs located northwest of the site and above the Upper Bench. It is unknown whether runout from these larger slides reached the site.

Wet weather and similar subsurface conditions likely triggered these larger slides. In both areas, sand with a relatively high hydraulic conductivity underlies the relatively impermeable Vashon Till and the fine-grained layers within the Lawton Clay. It appears likely that increased pore pressures in these sand layers resulted in increased groundwater flow from the formation to the surface as springs or seeps and decreased soil strength. Under these conditions, increased rates of erosion undermine the overlying material, generally causing surface sloughing or localized shallow landslides. If the erosion becomes severe enough, block failure landslides can occur if a large section of the overlying material becomes undermined. If pore pressures build up high enough behind the face of the bluff, deep-seated landslides may be triggered.

Large, deep-seated landslides have occurred in the vicinity of the site. The well-documented Woodway Landslide, approximately 1,500 feet north of the site and shown in Photograph 6, is an example of the type of large, deep-seated landslides that occur on Puget Sound coastal bluffs. The Woodway slide followed a prolonged period of heavy precipitation, which resulted in increased water infiltration into the subsurface, increased groundwater pore pressures, and reduced soil strength; these combined factors are believed to have triggered the landslide (Landau 1998 and Savage et al. 2000). Based on finite element slope stability modeling, Savage et al. estimated the slide was triggered when the accumulation of perched groundwater above the Lawton Clay increased to about 16.5 feet from its typical 8 feet measured over a period of 2.5 years after the slide occurred.


*Photograph 6: 1997 Woodway Landslide in 2000 (Ecology 2002).*

### 5.1.6.1 Slope Stability Analysis

We performed a slope stability analysis on a tall, steep section of the bluff adjacent to the site at the north end to provide a preliminary assessment of the risk and impact of a potential deep-seated landslide similar to the Woodway Landslide to the north of the site. Additional slope stability evaluations will be needed to assess other areas of proposed development during design.

We performed limit equilibrium stability analysis using the computer program SLOPE/W Version 8.11.1 (Geo-Slope International 2013). The Morgenstern-Price method for slope stability analysis was used to search for rotational circular surface failure mechanisms.

We used the soil properties summarized in Figure 12. These properties were estimated based on our field observations, typical soil properties for the same or similar geologic units in the Puget Sound region, and our local experience with similar soil types.

The slope stability section, stratigraphy, and soil properties are shown on Figure 12. The stratigraphy for the slope stability section includes the assumed presence of sand layers within the Lawton Clay to model the influence of the measured groundwater pore pressures. Because these sandy, higher-permeability layers are perched and/or confined layers with little evidence of static groundwater in the lower-permeability Vashon Till and massive clays in the Lawton Clay, pore pressures were only applied to the higher-permeability layers in which the pore pressures were measured. The four piezometric lines shown on Figure 12 were only applied to the adjacent sandy layers in the model. The piezometric heads, or pore pressures, are based on the measurements in HC-1, which is set back about 400 to 600 feet from where seeps or springs in these layers would occur at the slope face and where potential failure surfaces are likely to occur. While we anticipate that piezometric heads would decrease toward the face of the slope where groundwater emerges as seeps and springs at atmospheric pressure, we conservatively assumed the piezometric lines were approximately horizontal until reaching the slope face.

We evaluated two cases for a deep-seated landslide for both static and seismic conditions: (1) a shallower failure of the steepest portion of the profile and (2) a deeper failure of a large portion of the bluff. For seismic stability evaluations we used a pseudostatic horizontal acceleration coefficient of one-half the design peak ground acceleration (PGA; see Section 6.2.2). A pseudostatic horizontal acceleration coefficient of 0.168 g was used in the seismic slope stability analysis.

The slope stability analysis results are shown on Figures 13 through 16, and summarized in Table 3. Also provided in Table 3 are slope stability analysis results assuming no groundwater was present. These “dry case” stability analyses are intended to provide a frame of reference for the influence of groundwater conditions on slope stability.

### Table 3 – Summary of Slope Stability Factors of Safety

| Failure Surface | Piezometric Surface Estimated from VWPs | | No Groundwater / Dry Case | |
|---|---|---|---|---|
| | Static | Seismic | Static | Seismic |
| Shallower | 1.11 | 0.82 | 1.40 | 1.11 |
| Deeper | 1.29 | 0.87 | 1.68 | 1.19 |

The factors of safety estimated from the slope stability analysis indicate the slope is marginally stable to stable under current conditions and the estimated groundwater heads. However, the estimated seismic factors of safety are less than 1, indicating a slope failure would occur for the assumed ground acceleration and groundwater conditions.

**Potential Landslide Travel Distance/Runout**. Models are available to estimate landslide travel distance, or runout, but they do not account for trees and vegetation, which may become entrained in the debris flow (Harp et al. 2006). The best available information on runout lengths is measured data from actual debris flows. The USGS evaluated Puget Sound coastal bluffs from Seattle to Everett following the significant landslide events of the 1996 to 1997 rainy season, as reported by Baum et al. (2000).

Baum et al. mapped 326 landslides in their study, and Harp et al. evaluated the landslide runout data from Baum et al. The mapped landslides included three shallow earth slides or debris flows on the slope east of the site and the Woodway Landslide about 1,500 feet to the north of the site. Runout lengths were measured from the landslide headscarp to the furthest edge of the mapped debris downslope. The three mapped landslides adjacent to the site were of similar size, had a runout length of about 155 feet, and did not reach the toe of the slope. The Woodway Landslide had a runout length of about 770 feet, and the landslide debris extended about 425 feet from the toe of the slope across the BNSF railroad tracks and into Puget Sound. The Woodway Landslide was one of two landslides in the study with a runout length greater than 650 feet. The average (50th percentile) runout length of the landslides studied was about 200 feet, and the 90th percentile runout length was about 330 feet or less. The Baum et al. study represents a small sample size, because it primarily includes landslides occurring over a single rainy season during which landslide activity was primarily associated with two significant rain events, one in January and one in March (Harp et al. 2006). However, the study provides some of the most valuable information on landslide runout for the coastal bluffs in this stretch of Puget Sound.

While subsurface conditions in the slope east of the site appear similar to those at the Woodway Landslide, the overall slopes adjacent to the site appear flatter than the Woodway Landslide site was estimated to be prior to sliding. As shown on Figure 4, the average slope gradient of Section B-B’ is about 40 percent east on the hillside at the north end of the site, and slopes generally appear to flatten moving south. Savage et al. (2000) estimated the pre-failure slope gradient at the Woodway Landslide was about 70 percent, and we estimated similar pre-failure slope gradients of about 60 to 80 percent from the USGS Edmonds West Quadrangle Map. Using the same map, we checked the slope of Section B-B’; our results using the map are similar to slopes described in the profile from the site survey.

# 6.0 GEOLOGIC HAZARDS

The SCC includes requirements for the protection of critical areas according to the Growth Management Act (RCW 36.70A.060 and 36.70A.170). Our geotechnical study addresses critical areas that are geologic hazards. Specific standards are provided in Critical Area Regulations (CAR) Section 30.62B.300 for treatment of erosion, landslide, seismic, mine, volcanic, and tsunami hazard areas. The following sections describe applicable hazards and their potential impacts to the proposed development. Figure 9 shows the geologic hazard areas relevant to the site.

Because of the distance between the site and known mine and volcanic hazards, the risk for these particular hazards is low for the Project site.

The following section describes the impacts of the proposed development on geologic hazard areas, as well as the potential impacts of the geologic hazard areas on the proposed development. Preliminary considerations for mitigating these impacts are discussed in Section 7.

## 6.1 Landslide Hazard Areas

SCC 30.62B defines landslide hazard areas as "areas potentially subject to mass earth movement based on a combination of geologic, topographic, and hydrologic factors, with a vertical height of 10 feet or more." This includes areas with slopes that are steeper than 33 percent, where the geologic contacts are susceptible to landslide activity, and where springs or groundwater seeps are present. Landslide hazard areas also include areas of historical landslide activity and areas susceptible to undercutting by waves.

According to the SCC, a structural setback is required from the top and bottom of the slope unless the County approves a deviation. The toe of the slope is defined by SCC 30.91S.390 as the lowest first significant and regular break in the slope. The top of the slope is defined by SCC 30.91S.400 as the top of the first significant and regular break in a slope. The minimum top of slope setback is 50 feet, or the height of the slope divided by three. The minimum toe of slope setback is 50 feet, or the height of the slope divided by two.

**Impact**

The impact of the development to the site can be mitigated, provided that appropriate setbacks (which may be greater than the code minimum) or engineering solutions are used. Slope stabilization measures to minimize impact to the slope are described in Section 7.

***Alternatives 1 and 2***

**Lower Bench.** Development of the Lower Bench under Alternatives 1 or 2 would have minimal impact to the existing slope conditions. The proposed development generally appears to be outside the standard code setback distance. Based on the estimated landslide runout (distance traveled) lengths measured from the landslide scarp in Harp et al. (2006) for the 50th percentile (average) and 90th percentile, it is not anticipated landslide runout would reach the Lower Bench if a static slope failure occurred. However, if a landslide on the scale of the Woodway Landslide were to occur (greater than 99th percentile), the landslide runout would reach the proposed development. In general, as the slopes become less steep overall from north to south, the potential impact from the landslide hazard area likely decreases. Additional evaluations would be needed during design to better assess potential landslide runout and design mitigation for the different areas of the slope and development.

For the seismic case, the anticipated runout is less clear because Harp et al. (2006) is based on extreme weather events rather than on a seismic event, and these two events would typically not be combined for design given the low probability of the two events occurring at the same time. Additional investigation and analyses would be needed during design to better define groundwater conditions and better assess the likelihood of a seismic failure and anticipated seismic slope displacement.

**Upper Bench.** Development of the Upper Bench under Alternatives 1 or 2 would impact the existing slope conditions. Portions of the proposed development would be inside the standard code setback distance. Because the Upper Bench is directly at the base of a section of shorter steep slopes that have slid in the past, slope failures above the Upper Bench would likely result in potential landslide debris runout reaching the proposed development for Alternatives 1 and 2. Additionally, Alternatives 1 and 2 likely would include excavating the Upper Bench at the toe of the adjacent steep slopes for below-grade structures. The temporary shoring for excavation and permanent retaining structures would be designed to accommodate the proposed development and mitigate landslide hazards.

**Secondary Access Road.** Development of the Secondary Access Road on the slope face would affect the existing slope conditions. Grading would be performed on or adjacent to steep slopes and observed recent landslides. Field observations indicate the old access road alignment has moved downslope, and it is within a mapped and observed recently unstable area (Figure 11). Areas of cut and fill may be necessary, and drainage along the alignments would likely be impacted and require mitigation.

***Alternative 3***

Alternative 3 would not impact the landslide hazard areas. The landslide hazard areas' impacts on Alternative 3 would be similar to the areas' impacts on Alternatives 1 and 2, and could result in significant environmental impacts to Puget Sound if above-ground tanks or piping containing petroleum products were to rupture following a large landslide.

## 6.2 Seismic Hazard Areas

The site is in a seismically active area. In this section, we describe the seismic setting at the Project site, discuss potential development of a code-based design response spectrum, and discuss seismically induced geological hazards.

### 6.2.1 Seismic Setting

The seismicity of Western Washington is dominated by the Cascadia Subduction Zone (CSZ), in which the offshore Juan de Fuca plate is subducting beneath the continental North American plate. Three main types of earthquakes are typically associated with subduction zone environments—crustal, intraplate, and interplate. Seismic records in the Puget Sound area clearly indicate the existence of a distinct shallow zone of crustal seismicity (e.g., the Seattle Fault) that may have surficial expressions and can extend to depths of up to 25 to 30 kilometers (km; 15 to 18 miles). A deeper zone is associated with the subducting Juan de Fuca plate and produces intraplate earthquakes at depths of 40 to 70 km (24 to 42 miles) beneath the Puget Sound region (e.g., the 1949, 1965, and 2001 earthquakes) and interplate earthquakes at shallow depths near the Washington coast (e.g., the 1700 earthquake, with an approximate magnitude of 9.0).

### *6.2.2 Seismic Design*

At this time we assume that seismic design of the proposed development would be in accordance with the 2012 International Building Code (IBC). The basis of design for this code is two-thirds of the hazard associated with an earthquake with 2 percent probability of exceedance in a 50-year time period, which corresponds to an average return period of 2,475 years. We obtained the seismic hazard from the United States Geologic Survey 2008 National Seismic Hazard Maps (USGS 2008) for latitude 47.781 and longitude −122.395. This location corresponds most closely with the middle of the Lower Bench. Parameters for a code-based seismic design are:

- Risk-targeted maximum considered earthquake ($MCE_R$) seismic parameters for structural design and slope stability
  - Spectral response acceleration at short periods ($S_S$) = 1.262 g
  - Spectral response acceleration at 1-second period ($S_1$) = 0.495 g
- Maximum considered earthquake geometric mean ($MCE_G$) seismic parameters for liquefaction evaluation
  - PGA = 0.500 g
  - Magnitude = 7.0

#### 6.2.2.1 Upper and Lower Benches

Without consideration of liquefaction-susceptibility, the soil site class was determined for the current explorations advanced in this study. Based on B09-1, the Upper Bench soils were determined to be Site Class E. However, soil conditions varied across the Upper Bench, and previous borings suggest these soils may be classified as Site Class D. Based on B09-2 and B09-3, the Lower Bench soils were determined to be Site Class D. However, soil conditions varied across the Lower Bench, and some of the previous borings suggest these soils may be classified as Site Class E. After the building locations are determined, we recommend advancing location-specific borings to better characterize the soil site class.

We performed liquefaction analyses for the three explorations advanced at the site as part of our geotechnical study in 2010. We checked our analysis based on the updated 2012 IBC liquefaction evaluation criteria, and found the results were similar.

The factor of safety against liquefaction in the loose to medium-dense, saturated soil layers was less than 1.2 in the Upper Bench and Lower Bench locations. In the Upper Bench, layers in the fill and colluvium were estimated to be liquefiable. One existing exploration (MW-95) on the Upper Bench suggests low liquefaction potential, but the other exploration (MW-122) suggests high liquefaction potential. This dichotomy reflects variability in soil conditions observed at the site.

In the Lower Bench, layers in the lacustrine deposit (up to 47 feet bgs) were estimated to be liquefiable in B09-2. Isolated layers in the upper 23 feet of B09-3 have the potential to liquefy. The amount of liquefaction depends on the soil density, type, and saturation. Because the site area is large, there is significant variability in the amount of liquefaction expected. After the building locations are determined, we recommend advancing location-specific borings to better characterize the liquefaction hazard.

Because the site is potentially liquefiable, the soil is Site Class F. A site-specific site response analysis is required by code for Site Class F sites with building periods of more than 0.5 second. Based on the proposed building heights, we expect that some or all of the proposed mid-rise buildings and residential towers for Alternatives 1 and 2 are likely to have a fundamental period greater than 0.5 second; therefore, a site response analysis would need to be performed at a later stage of design.

#### 6.2.2.2 Slope

Based on HC-1 (drilled for this study), the slope soils classify as Site Class C, and no potentially liquefiable soils were encountered.

Borings completed by Earth Consultants (2004) along the top of the slope appear to indicate the slope soils classify as Site Class C or D. Three borings advanced in the slope above the Upper Bench (B-3, B-9, and B-10) appear to indicate that there are some potentially liquefiable sand and silt layers, depending on groundwater conditions. The potentially liquefiable soils were identified as wet with zones of seepage or possible seepage. Groundwater conditions in this area should be confirmed during design to assess potential for liquefaction in these layers.

The CDM (2006) borings to the south but further upslope of the Earth Consultants borings may have encountered potentially liquefiable layers, based on soil descriptions (medium dense, wet, flowing/caving). However, only E-102 included standard penetration test (SPT) data, which did not start until 20 feet deep.

The design PGA based on the 2012 IBC mapped parameters is 0.366 g, and the seismic (pseudo-static) horizontal acceleration coefficient for evaluating slope stability is 0.168 g.

### *6.2.3 Seismically Induced Hazards*

Development in Snohomish County must meet applicable standards of the IBC and SCC Chapter 30.51A. Potential seismically induced geotechnical hazards at the proposed site include surface rupture, liquefaction and subsidence, lateral spread, and seismically induced landslides. Our review of these hazards is based on the existing soil explorations presented in this report and our limited preliminary evaluations, as well as on our regional experience and knowledge of local seismicity.

### 6.2.3.1 Surface Rupture

As measured from the middle of the Lower Bench, the site is approximately 12 km (about 7.5 miles) south of the Southern Whidbey Island Fault, and approximately 20 km (about 12.5 miles) north of the northern trace of the Seattle Fault (USGS 2006).

**Impact**

***Alternatives 1, 2, and 3***

The probability that these faults would produce surface rupture that would affect the site is low, so impacts to any of the alternatives from surface rupture are unlikely.

### 6.2.3.2 Liquefaction and Subsidence

When cyclic loading occurs during a seismic event, the shaking can increase the pore pressure in loose to medium-dense saturated sands and cause liquefaction, or temporary loss of soil strength. This can lead to surface settlement and lateral spreading (discussed in the following section).

Our liquefaction potential assessment for site-specific borings was discussed in Section 6.2.2.

**Lower Bench.** We encountered saturated soils in a loose to medium-dense condition in the borings conducted for this Project. We estimate a high likelihood of widespread liquefaction capable of causing damage to the Lower Bench. The Palmer et al. (2004) map of liquefaction susceptibility in Snohomish County indicates high susceptibility for the Lower Bench (Figure 9). This conclusion is in agreement with our preliminary analysis of the soil characteristics for the Lower Bench.

**Upper Bench.** The soils observed on the Upper Bench are potentially liquefiable. As Figure 9 shows, Palmer et al. (2004) indicate this location does not have high liquefaction potential. The discrepancy may be attributed to the scale at the Palmer et al. study was performed, as well as the variability in the soil conditions on the Upper Bench; specifically, whether the location was in the colluvium deposit (MW-122 and B09-1) or in the native soils (MW-95).

**Slope.** Only limited soil layers in the slopes east of the site appear to be potentially liquefiable (B-3, B-9, and B-10), depending on groundwater conditions, as previously discussed in Section 6.2.2.2. These soils are in the slopes above the Upper Bench and adjacent to the potential Secondary Access Road alignment at the south end of the Upper Bench.

Palmer et al. (2004) show the area of the slope with the abandoned road as having a high liquefaction susceptibility (Figure 9). This mapped area appears to coincide with a zone Minard (1983) mapped as landslide deposits, and Palmer et al. may have interpreted this area as having high liquefaction susceptibility based on the landslide deposits mapped by Minard. However, site observations and the coastal atlas (Ecology 2004), as shown in Figure 11, did not agree that the unstable areas extended all the way to the existing road between the top of the slope and residences to the east as mapped by Minard. Borings at the top of the slope in this area (B-4, B-6, and B-7) do not indicate a high liquefaction susceptibility. Based on our hand auger exploration (HA-1) in the middle of this area, we observed about 1 foot of colluvium over native sand. Our qualitative assessment in the field was that the colluvium was loose and the native soil was dense, consistent with information from borings drilled at the top of the slope. From this exploration we interpret the thin layer of surficial colluvium may be potentially liquefiable, but the underlying native soil did not appear to be susceptible to liquefaction. Additional borings would need to be drilled in this area during design to assess the potential for liquefaction, since liquefaction on the slope could lead to a slope failure and significant runout.

**Impact**

***Alternatives 1 and 2***

Potential significant liquefaction-induced settlement or bearing capacity failure of buildings and infrastructure may occur, if not mitigated; however, mitigation as part of design would be relatively straightforward and similar to liquefaction mitigation at other sites around the Puget Sound region. Potential post-earthquake loss of soil strength on the east slope due to liquefaction could result in a landslide/debris flow of significant runout that could impact development on the Upper and Lower Benches.

Developing on a site that is potentially liquefiable will require engineering solutions to minimize the impacts of liquefaction. Several alternatives would be feasible, including ground improvement or pile-supported structures.

The Secondary Access Road could also be severely damaged or destroyed by liquefaction-induced settlement or lateral movement, if the alignment goes through or is adjacent to areas with potentially liquefiable soils. Along the southern potential alignment (the narrow strip of property extending upslope to the east from the south end of the Upper Bench), existing explorations indicate there may be potentially liquefiable soils, depending on groundwater conditions. For the alignment along the abandoned access road, the liquefaction hazard map (Palmer et al. 2004) indicates potentially liquefiable soils. Both alignments are shown on Figure 2. Additional explorations during design would be needed to better assess potential for liquefaction, impacts, and mitigation. Potential drainage impacts of developing the Secondary Access Road would need to be addressed during design to keep from increasing soil saturation and thereby potentially increasing liquefaction susceptibility.

***Alternative 3***

Impacts to Alternative 3 from liquefaction would be similar to impacts to Alternatives 1 and 2. Alternative 3 will not impact liquefaction susceptibility.

### 6.2.3.3 Lateral Spreading

Lateral spreading is typically associated with slope movement caused by the liquefaction of underlying soils. The site perimeter of the Lower Bench is currently constructed of retaining walls and shoring. The depth of these elements is reported to extend up to 25 feet bgs. However, as-built plans or further reconnaissance would be required to accurately determine the shoring depth. There is no retaining wall around the Upper Bench. Without considering retaining structures, we estimate lateral spread to be approximately several feet near the existing shoreline, decreasing closer inland. This estimate may be refined using more sophisticated analysis tools, but a refined estimate is not needed for an EIS.

**Impact**

***Alternatives 1 and 2***

Both action alternatives include re-establishing the beach for intertidal habitat and replacing the existing retaining walls landward of their current location as part of re-establishing the beach for intertidal habitat and redeveloping the waterfront area for recreational access. Lateral spread can affect the stability of the overlying structures. Appropriate engineering solutions will be needed to mitigate lateral spread for structure design, or foundations will need to be designed for the influence of lateral spread. Non-building elements (e.g., walkway, beach, utilities) may be affected by lateral spread, and maintenance of these elements will be required. Alternatives 1 and 2 would not increase the likelihood of lateral spread occurring.

***Alternative 3***

The impacts of lateral spread on Alternative 3 would be similar to its impacts on Alternatives 1 and 2. The existing retaining walls and adjacent facilities may be damaged by potential lateral spreading. Since little or no available design and construction data are available for the existing retaining wall, the extent to which Alternative 3 may be at risk because of lateral spreading is unknown. Alternative 3 will not impact the likelihood of lateral spread occurring.

### 6.2.3.4 Seismically Induced Landslides

Landslides can be triggered by the increase in load from an earthquake or potential weakening of soils due to liquefaction. Preliminary stability analysis based on estimated groundwater conditions at the northern third of the Lower Bench indicates a landslide would likely occur during a design seismic event. Additional analysis would be needed to assess potential for seismically induced landslides at other locations during design.

**Impact**

***Alternatives 1, 2, and 3***

Landslide impacts were discussed in Section 6.1.

## 6.3 Tsunami Hazard Areas

Tsunami flooding hazards are possible at the site because of the close proximity of Puget Sound. Tsunami inundation hazard maps are not available for the Project area. We reviewed an available inundation model for the entire Puget Sound (Koshimura and Mofjeld 2001) and a recently published tsunami hazard map for Everett, Washington, (Walsh et al. 2014) to provide a general idea of potential site risks from tsunamis.

From the models we reviewed, we estimate increases in water levels near the site due to a magnitude 7.2 to 7.3 earthquake on the Seattle Fault (maximum credible event/credible worst-case scenario) to be on the order of 1.5 feet to 5 feet, based on the Edmonds location in Koshimura and Mofjeld and the Central Puget Sound location in Walsh et al., respectively. The estimated recurrence interval for this event is thousands of years.

Walsh et al. (2014) also evaluated a less severe but more likely 6.7 Seattle Fault earthquake; the estimated increase in water level was about 4 inches. This less-severe event is estimated to have 5 percent probability of exceedance in a 50-year time period, which corresponds to an average return period of 975 years.

The SCC (1) requires that development activities comply with associated tsunami disclosure and recording requirements, and (2) encourages developers to follow the recommendations in “Designing for Tsunamis” (National Tsunami Hazard Mitigation Program 2001).

**Impact**

***Alternatives 1 and 2***

Based on the proposed changes in grade for Alternatives 1 and 2, it appears the overall site grades would be above the estimated increase in water level. Some erosion to beaches may occur, which could be addressed through maintenance, if necessary. The new seawall will need to be designed to resist the impacts and potential erosion related to a tsunami, or potential damage to the seawall could be addressed through maintenance or reconstruction, if necessary.

**Alternative 3**

Based on the existing grade to remain for Alternative 3, it is possible a tsunami based on the worst-case scenario and the highest water level increase modeled could overtop the existing seawall, depending on the tides at the time of the tsunami. The seawall and structures on land could be damaged, which could be addressed through maintenance or reconstruction, if necessary. The modeling indicates the tsunami would arrive about 10 minutes after the earthquake.

## 6.4 Erosion Hazard Areas

In SCC 30.91E.160, erosion hazard areas include areas at high risk of water erosion according to the mapped description units of the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), river-channel migration zones and shorelines of other waterbodies subject to wind and wave erosion.

**Lower Bench.** The USDA NRCS maps the Lower Bench soils as “Urban Land” and does not indicate a high risk of water erosion. In general, increased silt content increases the risk of water erosion. Lower Bench soils are generally sand and gravel; silt content varies. Soils appear to be generally non-silty to slightly silty (typically less than 12 percent silt) and do not appear to have a significant water erosion risk, though more silty zones are present.

The site is not adjacent to any of the rivers listed in the SCC; however, it is adjacent to a shoreline. The current influence of wave erosion on the site and adjacent slopes is likely low because of the presence of a series of steel sheet pile seawalls, concrete seawalls, and/or riprap adjacent to Puget Sound along the shoreline.

**Upper Bench.** The USDA NRCS maps the Upper Bench soils as "Urban Land" and does not indicate a high risk of water erosion. Upper Bench soils are generally silty sand and silt and appear susceptible to erosion.

The proposed development site is not adjacent to any of the rivers listed in the SCC. Although the Upper Bench is isolated from Puget Sound shoreline, appropriate runoff management will be needed during construction to prevent turbid stormwater from entering the Sound.

**Slope.** The USDA NRCS maps the slope soils as gravelly sandy loam (till and outwash) and does not indicate a high risk of water erosion. In general, increased silt content increases the risk of water erosion. Borings at the top of the slope and on the face of the slope encountered till, outwash, and lacustrine clay and silt. These soil units included silty sand and silt layers that are susceptible to erosion.

**Impact**

***Alternatives 1 and 2***

**Lower Bench.** Both action alternatives involve re-establishing the beach and seawall protecting the Lower Bench from erosion. Protection of the beach and seawall from wave erosion will be addressed during design.

Soil erosion during construction will need be addressed through erosion and sediment control best management practices (BMPs).

**Upper Bench.** The Upper Bench will remain protected by the riprap adjacent to Puget Sound, protecting the site from wave erosion. Soil erosion due to stormwater runoff during construction will need to be addressed through erosion and sediment control best management practices (BMPs).

Both action alternatives include excavation of about 15 feet of soil from the Upper Bench for construction of the below-grade structures. These excavations will encounter silty sands and silts that are susceptible to erosion. Soil erosion during construction will need be addressed through erosion and sediment control BMPs.

**Secondary Access Road.** Grading for either of the potential Secondary Access Road alignments on the slope will likely encounter silty sands and silts that are susceptible to erosion. Because of site grades along the potential secondary access alignments, this grading would present a higher erosion risk than grading in other areas. Soil erosion during construction will need be addressed through erosion and sediment control BMPs. Surface water management will be critical for Secondary Access Road grading activities, especially if they are performed during the rainy season.

***Alternative 3***

Based on the existing grade and surfaces to remain for Alternative 3, the potential for soil erosion is minimal.

# 7.0 HAZARD MITIGATION AND PRELIMINARY GEOTECHNICAL DESIGN AND CONSTRUCTION CONSIDERATIONS FOR THE PROJECT

In the following sections we describe potential mitigation strategies for proposed development on or adjacent to the geologically hazardous areas for Alternatives 1 and 2. Alternative 3 has two No Action alternative components: (a) continued industrial use as-is and (b) expanded industrial use. From a geotechnical perspective, mitigation similar to that discussed for Alternatives 1 and 2 may apply to Alternative 3b.

## 7.1 Geotechnical Hazard Area Design Considerations and Mitigation

### *7.1.1 Landslide Hazard Areas*

The slope reconnaissance, existing historical data, and preliminary slope stability analysis suggest that additional slope stability analyses would need to be performed during design. Groundwater pore pressures are a key factor in estimating slope stability. Additional investigations or analyses should be performed to estimate how groundwater pore pressures vary perpendicular to the bluff face and along its length. The results of the stability analyses would be used to design engineering solutions to mitigate slope instability and/or minimize impact to structures if the slope fails.

Engineering solutions to mitigate the existing landslide hazards may include:

- Improving slope vegetation; this could help reduce surface water infiltration, erosion, and shallow sloughing.

- Reducing surface water discharge and/or infiltration onto and above the slope. This could be accomplished by diverting surface water flow away from landslide hazard areas or piping water to the bottom of and away from landslide hazard areas.

- Reducing groundwater pore pressures in slope soils. This could be accomplished using horizontal drains, interceptor trenches, or pumped wells.

- Stabilizing slopes using piles, drilled shafts, tiebacks, soil nails, spiral nails, or other appropriate technologies, depending on the depth of potential instability. Retaining walls near or at the toe of the slope could be used to stabilize slopes, and the height of the wall could be increased, with the top designed as a catchment for shallow, surficial slide debris. Considering the proposed development geometry for the Upper Bench and subsurface conditions, a soldier pile and lagging or secant pile wall with tiebacks may be efficient options.

Implementing some of these potential landslide hazard area mitigation strategies effectively may require easements and coordination with neighboring properties and municipalities. Drainage improvements may require regular operations and maintenance (O&M), especially for active pumping systems, to keep them functional. Slope stabilization measures would be designed considering the design life of proposed structures and would not require regular O&M except for drain line cleaning.

Grading in or adjacent to landslide hazard areas for either of the potential Secondary Access Road alignments should be minimized as much as possible. Drainage will need to be designed to minimize or mitigate potential effects on slope stability. The potential need for slope stabilization measures or use of deep foundations to support portions of the Secondary Access Road will need to be addressed during design.

### *7.1.2 Seismic Hazard Areas*

Mitigation of seismic hazards is generally focused on reducing the risk and potential impact of liquefaction at the site, which appears to be the most significant seismic hazard. The extent to which mitigation of liquefaction may be mitigated will be determined during design. According to the 2012 IBC, seismic design of buildings is generally based on life safety/no collapse performance criteria. However, essential facilities (e.g., fire, rescue, ambulance and police stations, and emergency vehicle garages) are intended to remain operational after an earthquake.

During design it will be necessary to advance location-specific borings to better characterize the liquefaction hazard for proposed buildings and infrastructure during design. This should include additional explorations and testing to assess the presence and extent of the potentially liquefiable soils for the mapped high liquefaction susceptibility in the recent slide area of the abandoned access road and slopes above the Upper Bench.

#### 7.1.2.1 Ground Improvement

Ground improvement is the modification of in situ soils to achieve desirable soil characteristics. In this case, loose, liquefiable soils can be modified to increase the soil's resistance to liquefaction to mitigate liquefaction induced settlement, loss of strength, and lateral spreading. Several ground improvement options are described below.

**Stone Columns.** The stone columns ground improvement technique involves using either an electrically or hydraulically actuated cylindrical-shaped vibrating probe to make stones displace or replace weak soils. In applications related to liquefaction mitigation, stone columns are typically 30 to 42 inches in diameter and spaced 6 to 10 feet on center. Installation of stone columns typically densifies liquefaction-susceptible granular soils surrounding the stone columns. It has been our experience that stone columns installed within shallow depths can cause ground heave (thereby loosening rather than densifying surrounding soils) if the fines content of the soils exceeds 15 to

35 percent. If this option is considered, we recommend completing more sampling and laboratory testing to evaluate the feasibility of stone columns.

**Geopiers or Rammed Aggregate Piers.** The geopier system consists of augering out undesirable soils to a depth that reaches underlying, more competent material and then filling the augered hole with compacted aggregate. For the Project, geopiers should extend at least 2 feet into the bearing soils. A contractor who specializes in geopiers should design the geopier system. The spacing and distribution of geopiers depends on the settlement requirements. Typically, geopiers are 24 to 30 inches in diameter and are spaced 6 to 10 feet on center, depending on loading, settlement, and liquefaction mitigation requirements.

**Grouting.** Grouting is a ground improvement procedure used to create in situ soil-cement formations. In compaction grouting, the surrounding soil is displaced and bulbs of cementatious grout are formed. The result is a soil-cement "column" or, using several grouting locations, a soil-cement mass of variable geometry. The geometry and physical properties of the soil-cement are engineered. Typically the grouting should be contracted as design-build to allow the contractor to optimize the installation method.

#### 7.1.2.2 Overexcavation

The unsuitable soils may also be excavated and replaced by compact structural fill. Because of the depth of the unsuitable soils, existing contamination, and high groundwater table, this option may not be economical and will generate potentially contaminated soil and groundwater that requires disposal.

#### 7.1.2.3 Deep Foundations

As an alternative to ground improvement or overexcavation and replacement, deep foundations can be used to mitigate seismic hazards. Deep foundation options are discussed in Section 7.4.

#### 7.1.2.4 Groundwater Drainage

As discussed in Section 7.1.1 for landslide hazard areas, drainage of groundwater in slopes with potentially liquefiable soils could potentially be used to mitigate liquefaction because liquefaction will not occur if the soil is not saturated. The effectiveness of this potential mitigation would need to be address during design.

### *7.1.3 Tsunami Hazard Areas*

The proposed increase in grade and reconstruction of the seawall appear to be effective mitigation of potential tsunami impacts.

### *7.1.4 Erosion Hazard Areas*

Construction and long-term impacts to erosion can be mitigated through application of erosion and sediment control BMPs including limiting soil exposure time, limiting disturbance to vegetation, covering exposed soils with plastic sheeting, and managing surface water.

Permanent landscaping, surface water management, and re-vegetation plans for areas disturbed will be developed during design.

## 7.2 Proposed Earthwork

Alternatives 1 and 2 include a significant amount of earthwork for excavating the Upper Bench for below-grade structures and raising grade on the Lower Bench. Our understanding is about 600,000 cubic yards of material would be imported and about 100,000 cubic yards of native material would be re-used.

The suitability of excavated site soil for compacted structural fill depends on the gradation and moisture content of the soil when it is placed. As the amount of fines (that portion passing the No. 200 sieve) increases, the soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve. Soil containing more than about 5 percent fines cannot be consistently compacted to a dense, non-yielding condition when the water content is greater than about 2 percent above or below optimum. Reusable soil must also be free of organic and other unsuitable material.

Explorations indicate that the site soils contain variable percent fines. The excavation of the Upper Bench, where the most significant excavation is anticipated for below-grade structures, appears likely to encounter moist to wet silty sand and gravel and silt. Grading for the secondary access on the slope is likely to encounter moist to wet silty sand and silt. In general, site soils do not appear suitable for structural fill because of their composition and gradation; however, soils will need to be evaluated at the time of construction. Site soils can be used for non-structural purposes such as in landscaped areas. Another consideration for the potential re-use of on-site soils is potential contamination that may be encountered, which will be addressed in other Project documents.

Earthwork will likely be performed with standard excavation, grading, and compaction equipment. While all earthwork activities benefit from dry weather, timing of the earthwork for the Upper Bench and Secondary Access Road to coincide with drier periods may greatly facilitate these efforts, due to the potential for high groundwater below the Upper Bench and significant springs and seeps on slopes.

BMPs will need to be used to manage surface water and control erosion during earthwork. Managing surface water and controlling erosion will be critical for any earthwork on slopes associated with the Secondary Access Road.

## 7.3 Temporary Shoring

The proposed development under Alternatives 1 and 2 for the Upper Bench will require temporary shoring for construction of basement levels below existing grade. The proposed development in these alternatives on the Lower Bench may also require shoring, though excavations of limited depth could be accomplished with cut slopes.

Because of the high water table observed in the explorations, a temporary dewatering system would typically be required in the excavation, or a “water tight” shoring system could be used with the wall designed to resist hydrostatic groundwater pressures. Potential alternatives would include a soldier pile with tiebacks or a cement-soil-mix (CSM) or slurry wall.

The type of shoring system would depend on the depth of the excavation as well as the possibility of obtaining permits to discharge the collected water. Foundation types would be determined based on the depth of the excavation and building loads, as discussed below.

Lateral earth pressures on the Upper Bench shoring system will be significant because of the presence of the slopes above, which have overall slope gradients ranging from about 30 to 45 percent.

## 7.4 Foundation Considerations

The types of foundations that may be recommended for the proposed site development depends on the nature of the underlying soils and the depth below grade of the structures. General comments are provided in the following sections.

Alternatives 1 and 2 generally have the lowest level near the existing grade on the Lower Bench. Because the subsurface soils are potentially liquefiable, shallow foundations are not recommended to support the building loads without first performing ground improvement or overexcavation and replacement. Deep foundations that extend to and are supported by the dense to very dense pre-Fraser Nonglacial Fluvial soils are likely the preferred approach.

Where retaining walls are used to support grade changes, the foundation type would be similar to that required for structures developed on the ground surface.

Contaminated soils could be encountered during overexcavation or construction of drilled foundations; disposal would incur additional costs. These issues will be addressed in other Project documentation.

## 7.5 Foundation Types

### *7.5.1 Shallow Foundations*

We do not recommend the use of shallow foundations in areas where there are potentially liquefiable soils, unless the soils are treated with ground improvement or overexcavated and replaced. These methods were discussed in Section 7.1.

### *7.5.2 Deep Foundations*

A variety of deep foundation types will most likely be required to support the proposed development. Vertical compressive loads can be resisted by friction along the pile sides and by end bearing at the tip. Therefore, it is critical to embed piles sufficiently into competent soils. We define competent soil (or bearing stratum) as the dense to very dense, pre-Fraser Nonglacial Fluvial Deposits. The depth to the competent soils may vary across the site. The explorations from the current study indicate these soils begin at a depth of 47 to 50 feet bgs. To determine pile tip depths, additional subsurface explorations will be needed once the building locations are determined.

Several pile types are described in the following sections. The type of pile that would be considered suitable for this Project depends on the loads and locations of the proposed structures. In addition, concerns about vibration or noise during installation should factor into pile type selection.

#### 7.5.2.1 Drilled Shafts

A drilled shaft is a drilled, cast-in-place concrete-reinforced pile. It is installed by augering down to the pile depth, lowering a reinforced steel cage into the bored hole, and using a tremie pipe to pump concrete to the base of the hole. Drilled shafts are typically larger in diameter (3 to 10 feet), which may allow penetration through cobbles and boulders where smaller-diameter holes may not succeed. Drilled shaft installation is a low-vibration and relatively quiet process. However, due to the generally large diameter of drilled shafts, a significant amount of cuttings may be generated.

#### 7.5.2.2 Augercast Piles

An augercast pile is a mid-sized (14 to 24 inches in diameter), drilled and grouted replacement pile that is typically reinforced. Augercast piles are a good alternative to driven piles because of their lower vibration and noise. Augercast piles are installed by continuously auguring down to the pile depth with a plug in the auger tip. When the pile depth is reached, the plug is removed and grout flows out of the auger under pressure as the auger is extracted from the hole. To increase the uplift pile capacity, a steel bar is usually placed in the center of the pile and a steel cage is placed in the upper portion to provide increased lateral resistance. Augercast piles can be a cost-effective foundation system; however, cuttings will be generated.

#### 7.5.2.3 Micropiles

A micropile is a small-diameter (6 to 12 inches in diameter), drilled and grouted replacement pile that is typically reinforced. A micropile is installed by rotary drilling a borehole, placing reinforcement, and grouting from the bottom up. The end-bearing capacity of micropiles is typically neglected because it is minor compared with the grout-to-ground capacity along the pile’s perimeter. The soil conditions and installation procedure strongly influence the grout-to-ground strength. Micropiles, like augercast piles, are bored piles that generate cuttings. Micropiles are typically used when overhead room is limited or when the loads are light.

#### 7.5.2.4 Driven Piles

Driven piles include prefabricated steel and concrete piles that are installed into the ground using a pile-driving rig equipped with a vibratory or impact hammer. H-piles and pipe piles are examples of steel piles. Concrete piles typically include octagonal or square precast reinforced concrete members. Noise and vibration are generated during installation. Ground heave may occur surrounding the driven piles, which displaces and densifies soil immediately adjacent to the piles. In loose soils, ground settlement may also result at distance from the piles because of ground vibration from driving the piles. The benefits of using driven piles are that cuttings are not generated, installation is relatively quick compared with installation of bored piles, and pile capacities can be verified during installation.

## 7.6 Vibration Considerations

### *7.6.1 Construction Vibrations*

We performed a screening-analysis-level review of the potential construction vibration impacts on existing structures and future development. Our review focused on potential damage to structures and did not include human annoyance vibration levels.

Vibration sources during construction include truck traffic, heavy on-site equipment, vibratory compaction equipment, and impact or vibratory installation methods associated with foundations (e.g., piles) or ground improvement (e.g., stone columns, geopiers).

Typical vibration source levels for construction equipment are provided in Table 4; these source levels are based on measured data as reported in FTA (2006).

Table 4 – Vibration Source Level for Construction Equipment

| Equipment | | Peak Particle Velocity at 25 Feet (inches/second) |
|---|---|---|
| Pile driver (impact) | Upper range | 1.518 |
| | Typical | 0.644 |
| Pile driver (sonic) | Upper range | 0.734 |
| | Typical | 0.170 |
| Clam shovel drop (slurry wall) | | 0.202 |
| Hydromill (slurry wall) | In soil | 0.008 |
| | In rock | 0.017 |
| Vibratory roller | | 0.210 |
| Hoe ram | | 0.089 |
| Large bulldozer | | 0.089 |
| Caisson drilling | | 0.089 |
| Loaded trucks | | 0.076 |
| Jackhammer | | 0.035 |
| Small bulldozer | | 0.003 |

Recommended threshold vibration criteria for structures are provided in Table 5. These criteria are based on recommendations in FTA (2006) and are generally considered conservative for structures. The criteria in Table 5 may also be applied to tracks and utilities.

Table 5 – Construction Vibration Damage Criteria

| Structure Category | Peak Particle Velocity in inches/second |
|---|---|
| Reinforced concrete, steel or timber (no plaster) | 0.5 |
| Engineered concrete and masonry (no plaster) | 0.3 |
| Non-engineered timber and masonry structures | 0.2 |
| Structures extremely susceptible to vibration damage | 0.12 |

#### 7.6.1.1 Off-Site Structures

In general, we do not anticipate that the effects of construction vibration on off-site structures will be significant.

The BNSF railroad tracks adjacent to the proposed development regularly experience more significant vibrations from the freight trains than are anticipated to result from construction.

Residences are within about 100 feet of the proposed development at the south end of the Upper Bench. These residences appear to have been above the approximate path of the Brightwater Conveyance Tunnel. They are as close as 200 feet from the tunnel receiving pit at the south end of the Lower Bench, 150 feet from the BNSF railroad tracks, and 50 feet from the existing industrial access road to the site. Vibrations at these residences during Project construction are not anticipated to be damaging to the structures.

Residences are within about 50 feet of the potential secondary access alignment at the southern third of the Upper Bench. Vibrations at these locations will be similar to vibrations from standard road construction (e.g., graders, vibratory compactors); we do not anticipate they will damage structures.

Vibrations from construction traffic should be similar to those from the current industrial truck traffic and Brightwater construction traffic. If the frequency of truck traffic increases, we do not anticipate they will damage structures. We understand some construction materials (e.g., import fill) will likely be barged in, which would significantly reduce potential construction traffic.

#### 7.6.1.2 On-Site Structures

Construction vibration impacts to existing structures, utilities, and slopes near the proposed construction activity will depend on their condition at the time of construction and their distance from the construction activity. Tables 4 and 5 summarize vibration source levels for construction equipment and construction vibration damage criteria, respectively. As noted, the data in Table 4 are for a reference distance of 25 feet. Typically vibration magnitude diminishes rapidly with increasing distance from the source of vibration.

Pile-driving and vibratory ground improvement methods would have the most significant potential impacts, because of both potential vibration levels and local vibration-induced settlement. Potential effects of construction activity on existing structures will depend on phasing/demolition and construction methods that will be determined during design. These impacts may be mitigated through logistical and scheduling consideration or selection of appropriate construction methods.

#### 7.6.1.3 Vibration Monitoring

A geotechnical instrumentation program should be used to document and monitor work performed near settlement- and vibration-sensitive areas, structures, and/or utilities. This program would include preconstruction surveys, frequent monitoring, and an alert system during construction.

### *7.6.2 Railroad*

We performed a screening-analysis-level review of the potential railroad vibration impacts on existing structures and future development of Alternatives 1, 2, and 3b. Our review focused on potential damage to structures and did not include human annoyance vibration levels.

Based on screening criteria in FTA (2006), we do not anticipate that vibrations from the railroad tracks will damage the existing structures or proposed development structures. No additional soil settlement related to railroad operations are anticipated, as the railroad has operated in this location historically. Also, potential issues related to settlement will be addressed during design of specific structures (e.g., deep foundations, ground improvement).

As part of completing the Seattle to Everett Commuter Rail EIS for the BNSF corridor adjacent to the site, Sound Transit and its consultants assessed the potential influence of railroad vibrations on stability of the adjacent slopes (Sound Transit 1999). Sound Transit concluded vibrations from commuter rail traffic would not contribute significantly to overall slope instability and were unlikely to increase the potential for landslides or create new landslides, but they could affect the timing of landslides. In other words, railroad vibrations could trigger an imminent landslide on the verge of failing to slide sooner rather than later. Sound Transit (1999) focused on commuter trains and indicated longer, heavier freight trains produce greater vibrations and would be more likely to trigger an imminent landslide than would a commuter train.

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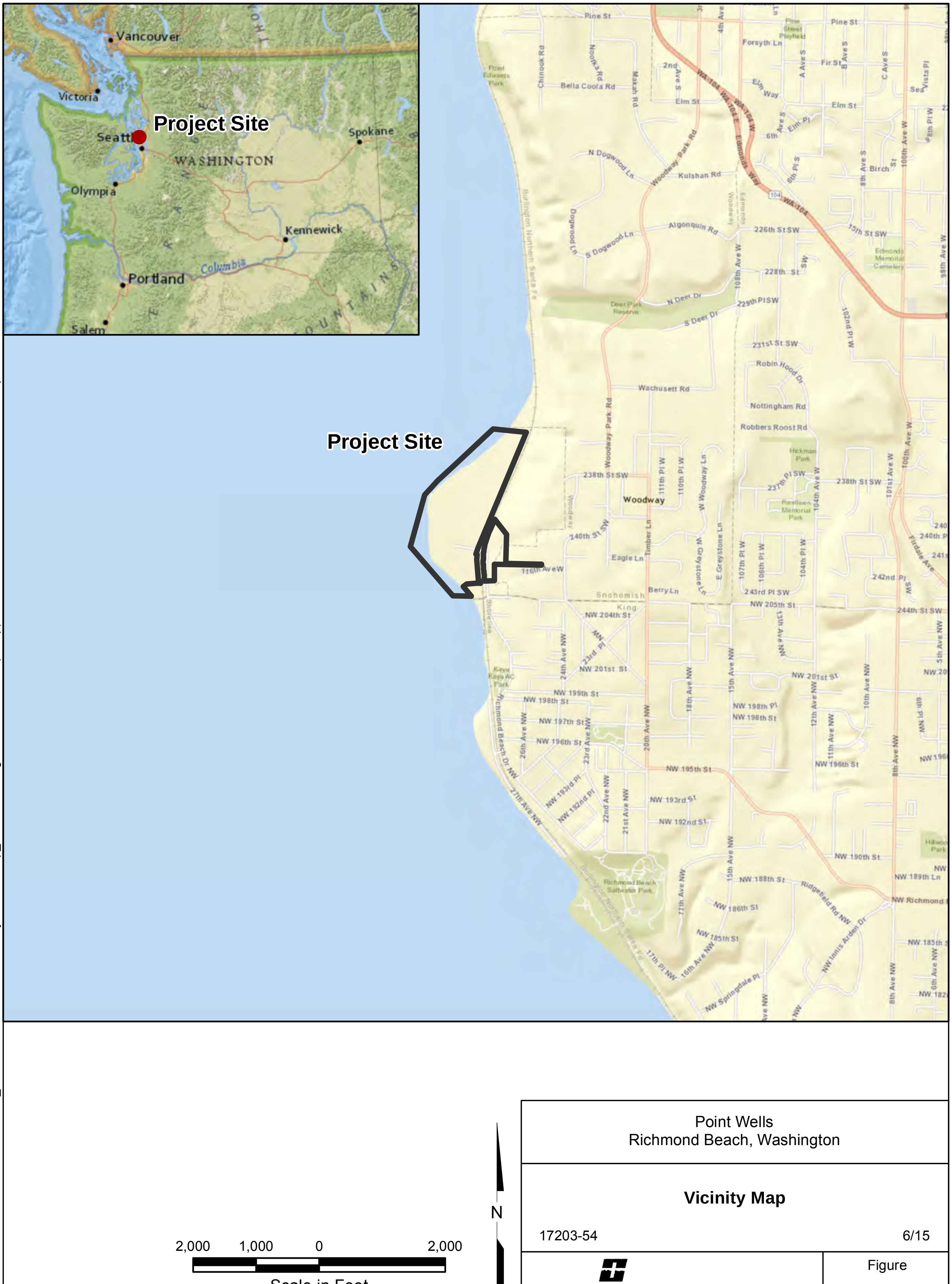


Point Wells
Richmond Beach, Washington

**Vicinity Map**

17203-54 6/15

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Figure 1

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Legend

- HC-1 ◆ Hart Crowser boring (2015)
- HA-1 ⊠ Hart Crowser hand auger (2015)
- B09-1 ● Hart Crowser boring (2009)
- MW-110 Hart Crowser monitoring well (2008)
- B-483+00 ■ HWA boring (2007)
- B-1 ▲ ECI boring (2004)
- P19-03 □ CDM boring (2003)
- AP-39 ⊙ KHM boring/well (2001)
- MW-99 ○ KHM monitoring well (2001)
- MW-95 ⊕ Pacific Environmental Group monitoring well (1998)
- MW-79 ◑ Convers NW monitoring well (1991-1992)
- A A' Cross section/slope profile designation
- — — Abandoned access road

***Note:*** Explorations shown are 20 feet or deeper. Previous shallower explorations are not shown.

N

0 300 600

Scale in Feet

Point Wells
Richmond Beach, Washington

**Site Topography**

17203-54 6/15

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Figure **2**

EAL 06/10/15 1720354-001 (STopo).dwg


Legend

- HC-1 ◆ Hart Crowser boring (2015)
- HA-1 Hart Crowser hand auger (2015)
- B09-1 ● Hart Crowser boring (2009)
- MW-110 Hart Crowser monitoring well (2008)
- B-483+00 ■ HWA boring (2007)
- B-1 ▲ ECI boring (2004)
- P19-03 □ CDM boring (2003)
- AP-39 ⊙ KHM boring/well (2001)
- MW-99 ○ KHM monitoring well (2001)
- MW-95 ⊕ Pacific Environmental Group monitoring well (1998)
- MW-79 ◑ Convers NW monitoring well (1991-1992)
- A A' Cross section/slope profile designation
- — — — Abandoned access road

***Note:*** Explorations shown are 20 feet or deeper. Previous shallower explorations are not shown.

N

0 300 600

Scale in Feet

Point Wells
Richmond Beach, Washington

**Site and Exploration Plan**

17203-54 6/15

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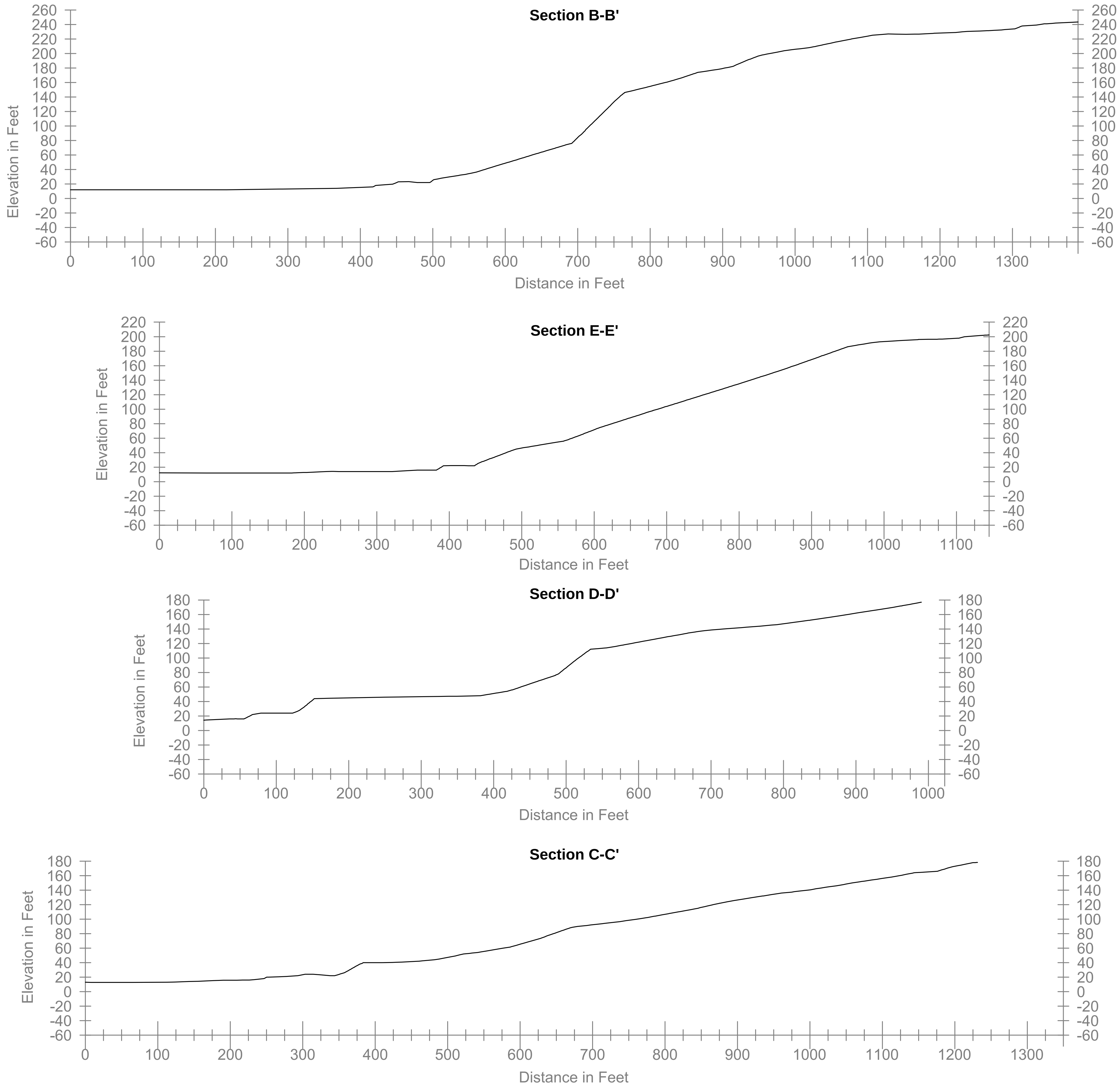
Figure **3**

EAL 06/10/15 1720354-002 (SPlan).dwg




***Note:*** Profiles are arranged from south to north, bottom to top (see Figure 2).

0 150 300
Scale in Feet

Point Wells
Richmond Beach, Washington

**Slope Profile Comparison**

17203-54 6/15

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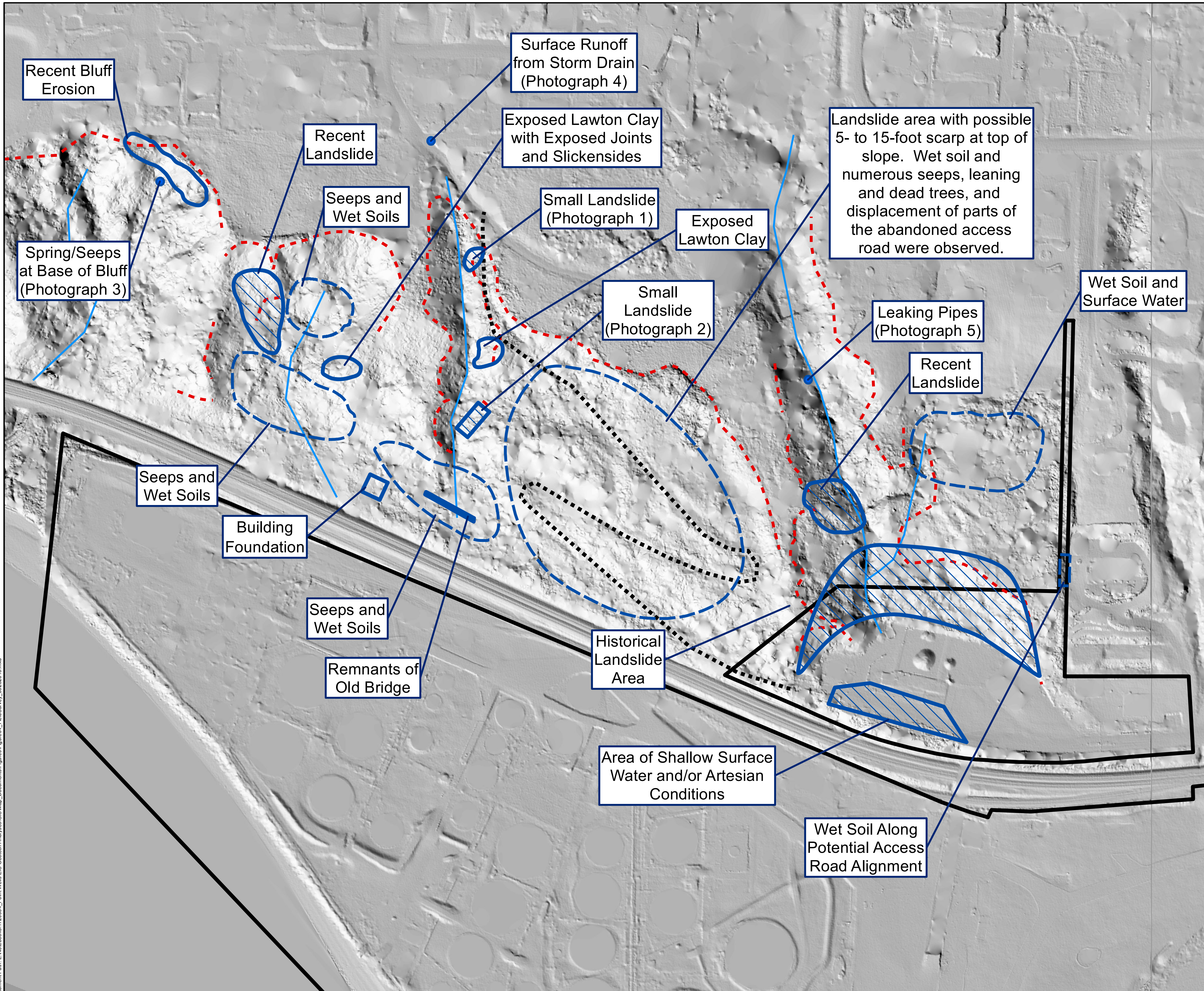
Figure
**4**

EAL 06/11/15 1720354-009 (XSecComp).dwg




Legend

- Abandoned Access
- Possible Scarps
- Approximate Location of Seasonal Streams
- Project Boundary
- Field Reconnisance Observations

Note: LiDAR source Washington State Department of Transportation Rail Division, 2013.

N

0 100 200 400 Feet

1 inch = 200 feet

Point Wells
Richmond Beach, WA

**LiDAR Topography and Field Survey**

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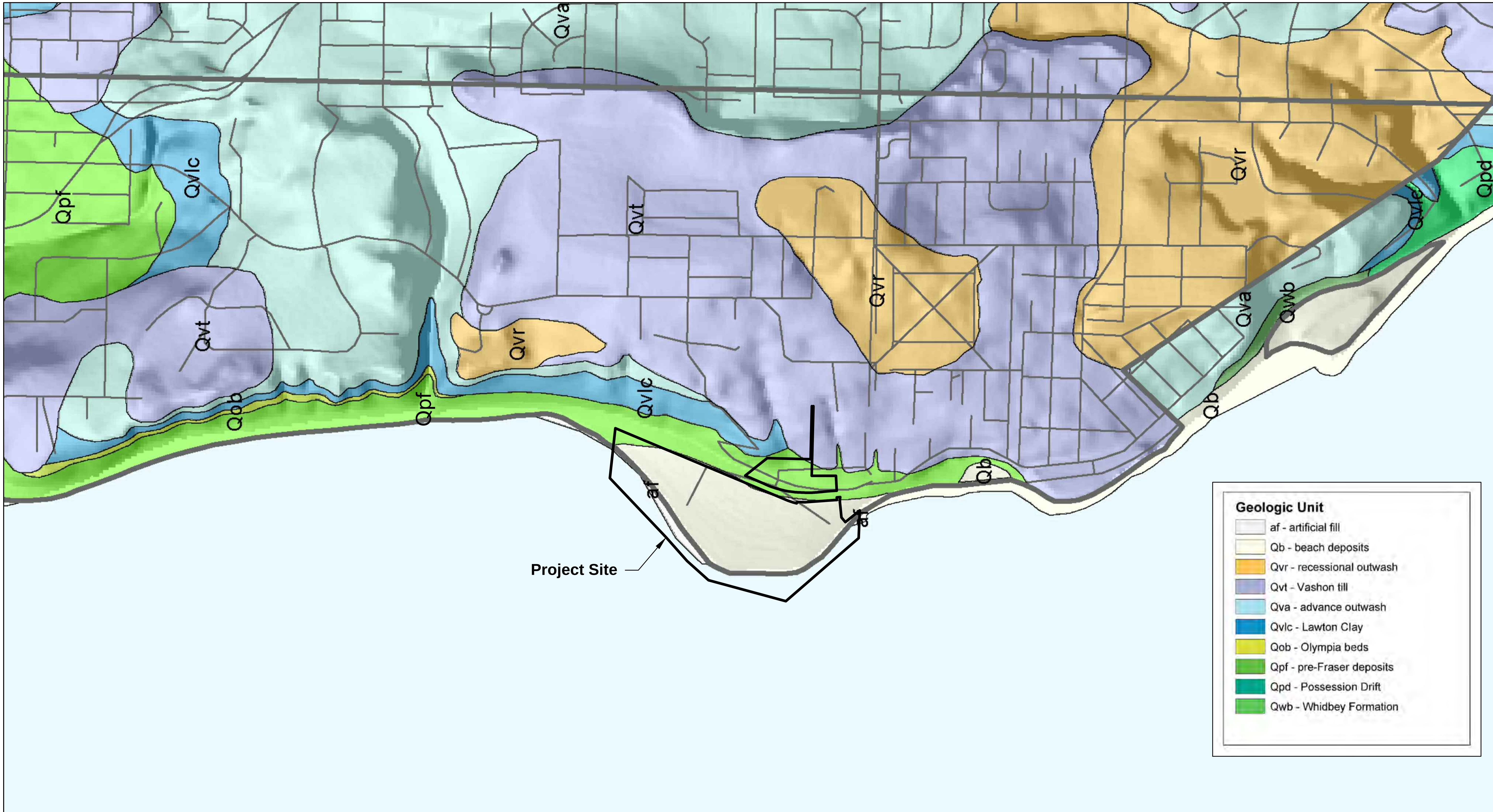
Figure 5




***Source:*** "Composite Geologic Map of the Sno-King Area," Central Puget Lowland, Washington, by Derek Booth, Brett Cox, Kathy Troost, and Scott Shimel. Seattle-Area Geologic Mapping Project (SGMP), University of Washington, and the United States Geological Survey (USGS) January 5, 2004. Map scale 1:24,000.

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**Geologic Map**

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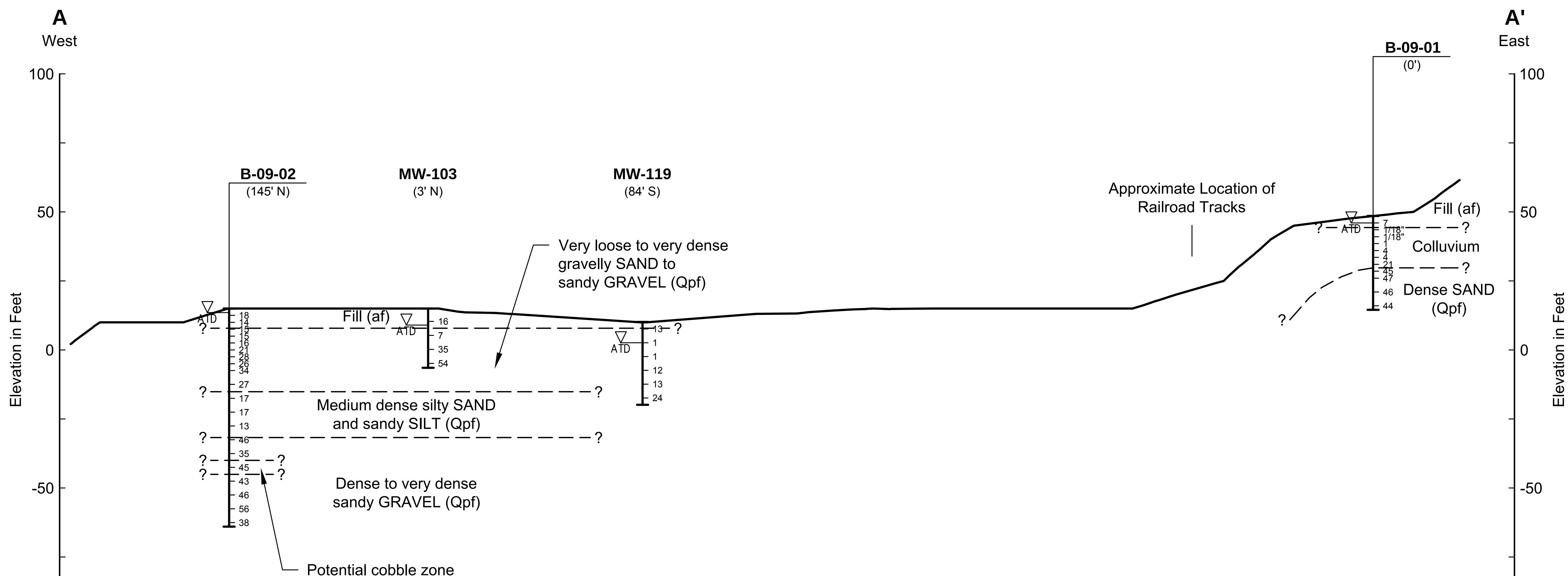
Figure
6

EAL 06/11/15 1720354-003 (Geol).dwg




Legend

**HC-102** (34.5' E) Exploration Number (Offset Distance and Direction)

Exploration Location

ATD Water Level

9 Standard Penetration Resistance in Blows per Foot

Horizontal Scale in Feet
0 100 200

0 40 80
Vertical Scale in Feet
Vertical Exaggeration x 2.5

Point Wells
Richmond Beach, Washington

**Generalized Subsurface Cross Section A-A'**

17203-54 6/15

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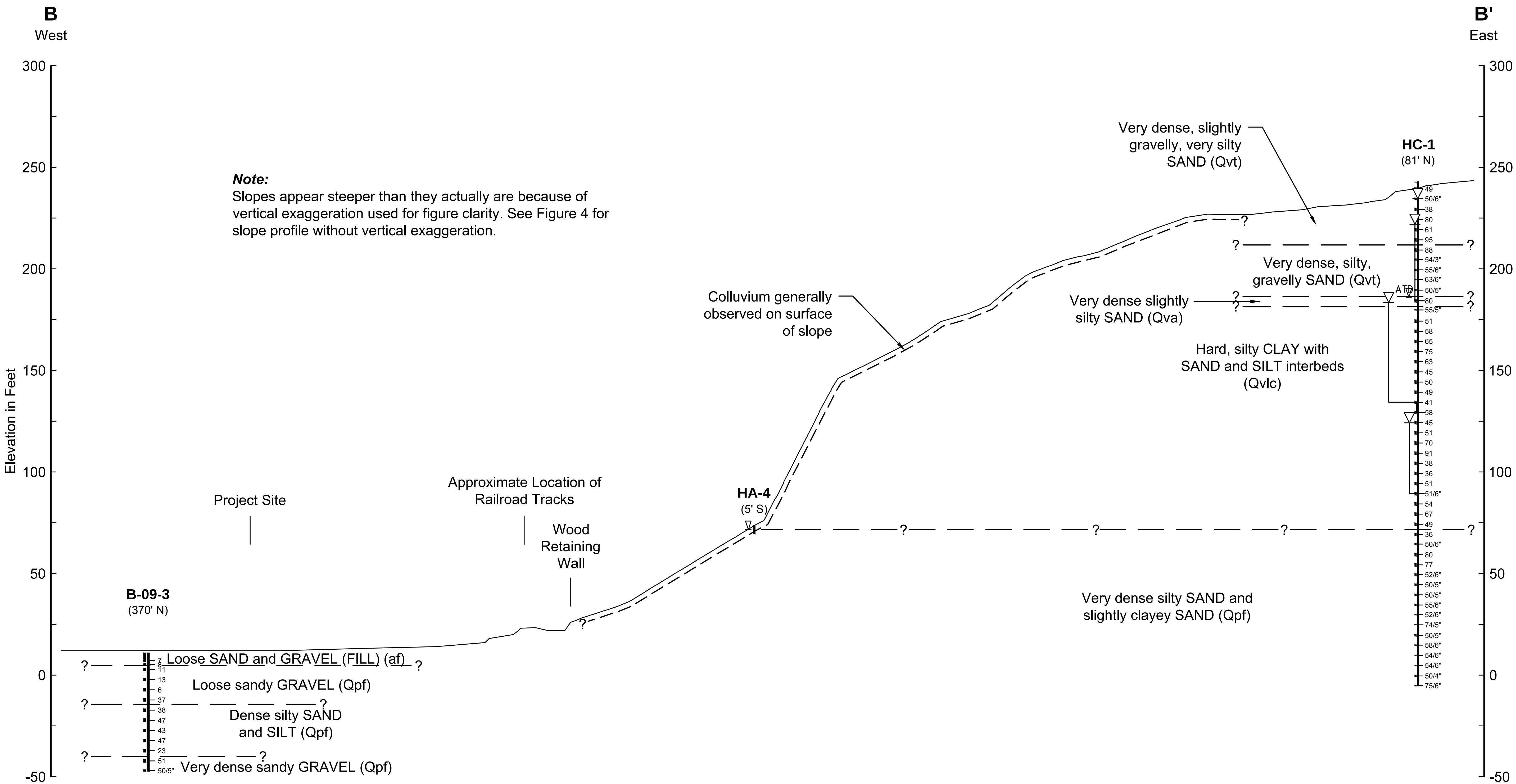
Figure **7**

EAL 06/11/15 1720354-007 (XSecA).dwg




Legend

**HC-1** (81' N) Exploration Number (Offset Distance and Direction)

Exploration Location

Water Level

Standard Penetration Resistance in Blows per Foot

Vibrating Wire Piezometer and Measured Groundwater Head

Horizontal Scale in Feet
0 100 200

0 50 100
Vertical Scale in Feet
Vertical Exaggeration x 2

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**Generalized Subsurface Cross Section B-B'**

17203-54 6/15

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Figure **8**

EAL 06/11/15 1720354-008 (XSecB).dwg


Legend

- Landslide hazard area (>33% slopes and ≥10-foot elevation change)
- Modified land
- High liquefaction susceptibility

***Note:***
This map is for information purposes. Data were compiled from multiple sources as listed on this map. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since publication of this map. Locations of all features shown are approximate.

***Source:***
1. Slope data based on LiDAR from Washington State Department of Transportation Rail Division, 2013. Slope data were calculated using GIS tools.
2. Modified land data from Washington State Department of Ecology Coastal Atlas.
3. Liquefaction Susceptibility Map of Snohomish County from Washington State Department of Natural Resources.

N

0 300 600
Scale in Feet

Point Wells
Richmond Beach, Washington

**Geologic Hazard Areas**

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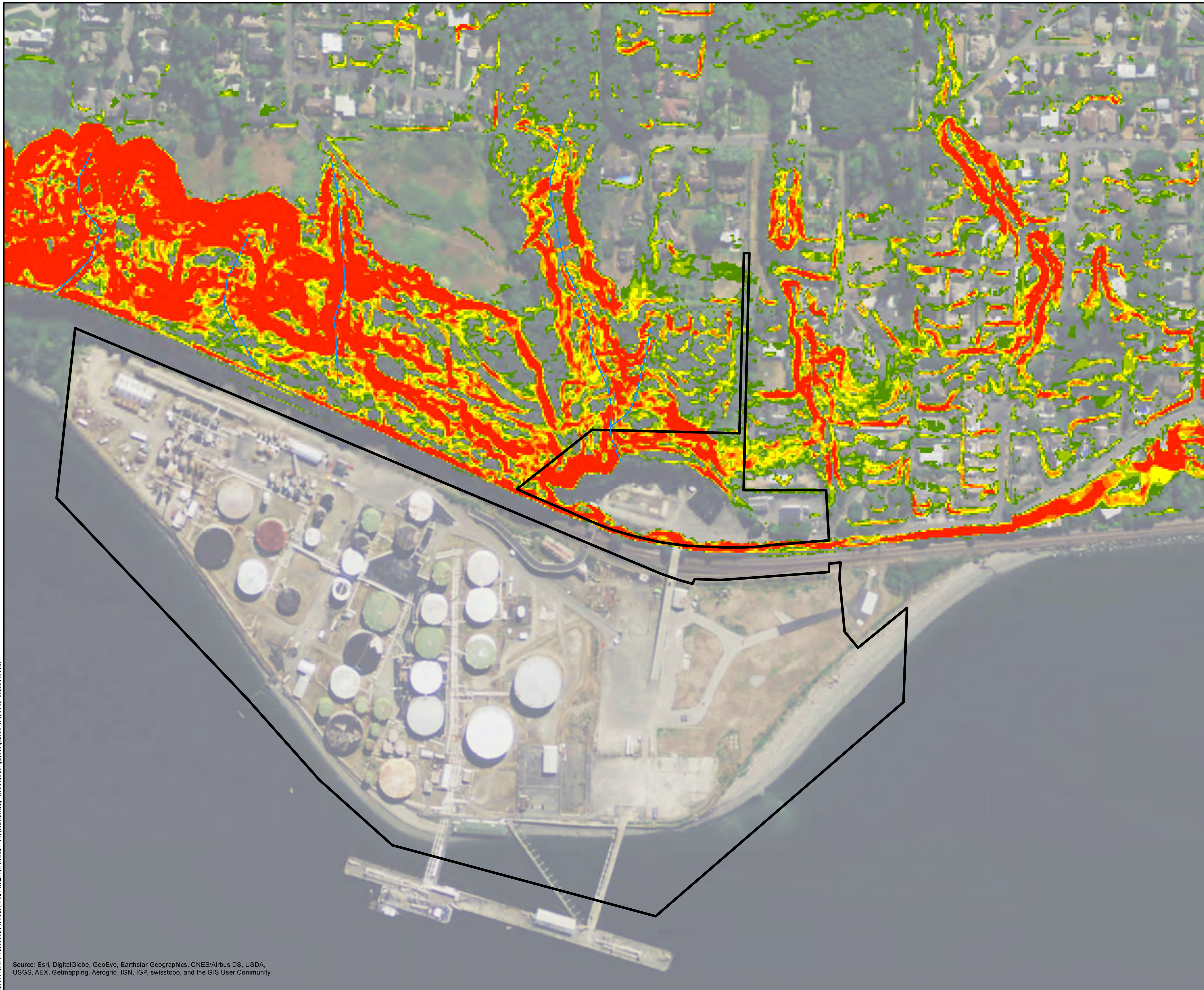
Figure
9

EAL 06/11/15 1720354-004 (Haz).dwg




**Slope**

- < 20%
- 21% - 25%
- 26% - 30%
- 31% - 35%
- 36% - 40%
- 41% - 45%
- >45%
- Approximate Location of Seasonal Streams
- Project Boundary

Note: Slope data based on LiDAR from Washington State Department of Transportation Rail Division, 2013. Slope data were calculated using GIS tools.

N

0 300 600 Feet

1 inch = 300 feet

Point Wells
Richmond Beach, WA

**LiDAR-Derived Slopes**

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Figure 10

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Coastal Atlas Mapped Unstable Areas (Ecology 2004)

Recent unstable area

Unstable area

0 500 1000

Scale in Feet

N

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**Mapped and Observed Unstable Areas**

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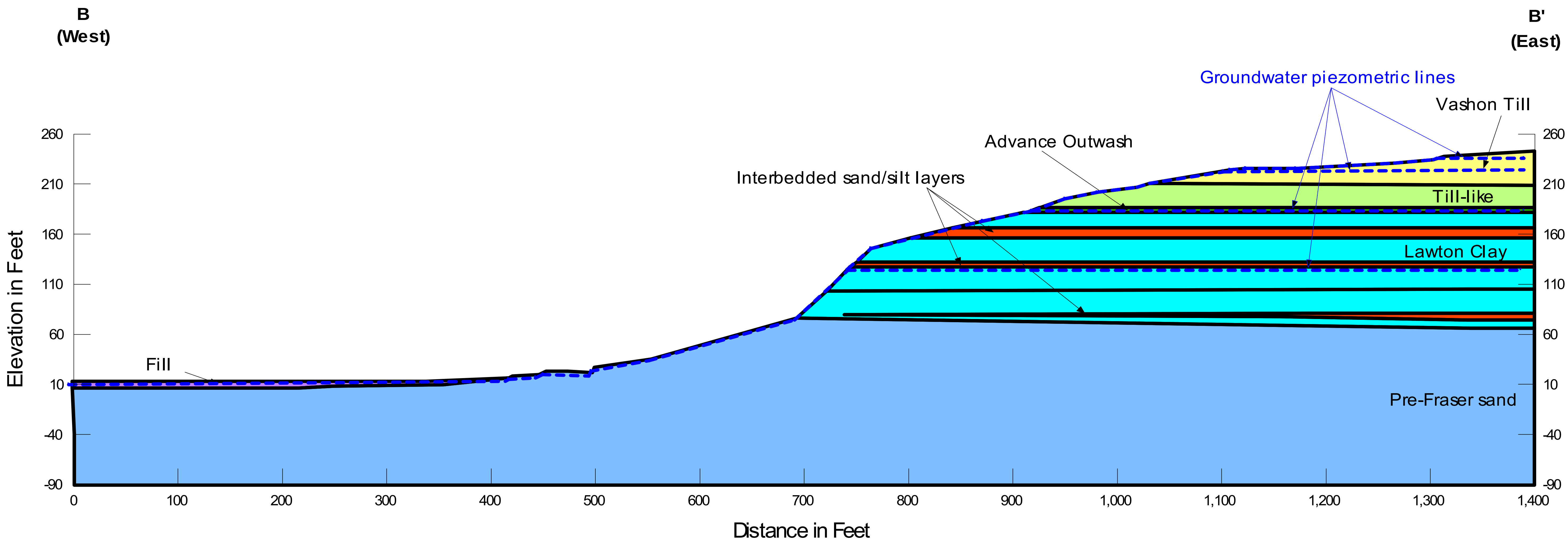
Figure **11**

EAL 06/11/15 1720354-005 (Geol).dwg




Stratigraphy inferred from available subsurface explorations and field reconnaissance observations for stability analysis.

| Material Properties | | | |
|---|---|---|---|
| Name | Unit Weight in pcf | Friction Angle in degrees | Cohesion in psf |
| Vashon Till | 140 | 40 | 2,000 |
| Till-like | 140 | 40 | 0 |
| Advance Outwash | 135 | 38 | 0 |
| Lawton Clay | 120 | 25 | 1,000 |
| Interbedded sand/silt layers | 135 | 38 | 0 |
| Pre-Fraser sand | 135 | 38 | 0 |
| Fill | 110 | 32 | 0 |

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Richmond Beach, Washington

**Slope Stability Stratigraphy - Cross Section B-B'**

17203-54 06/15

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Figure 12

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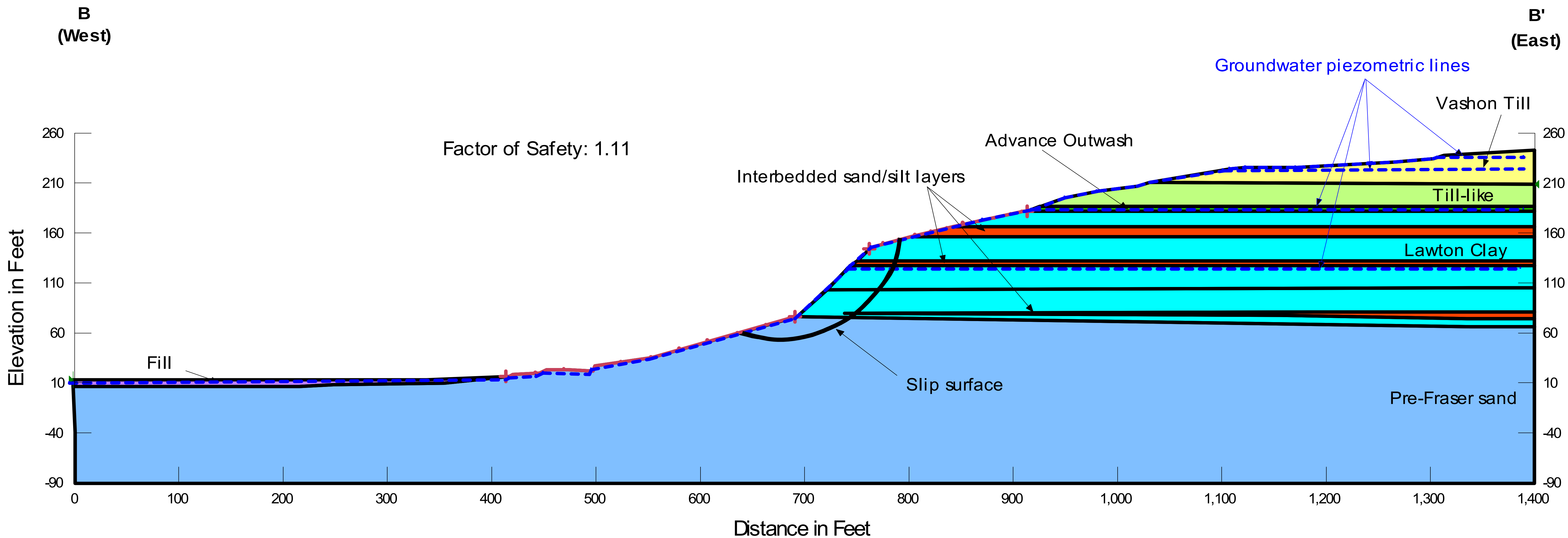




Point Wells
Richmond Beach, Washington

**Static, Shallower Failure Slope Stability Model - Cross Section B-B'**

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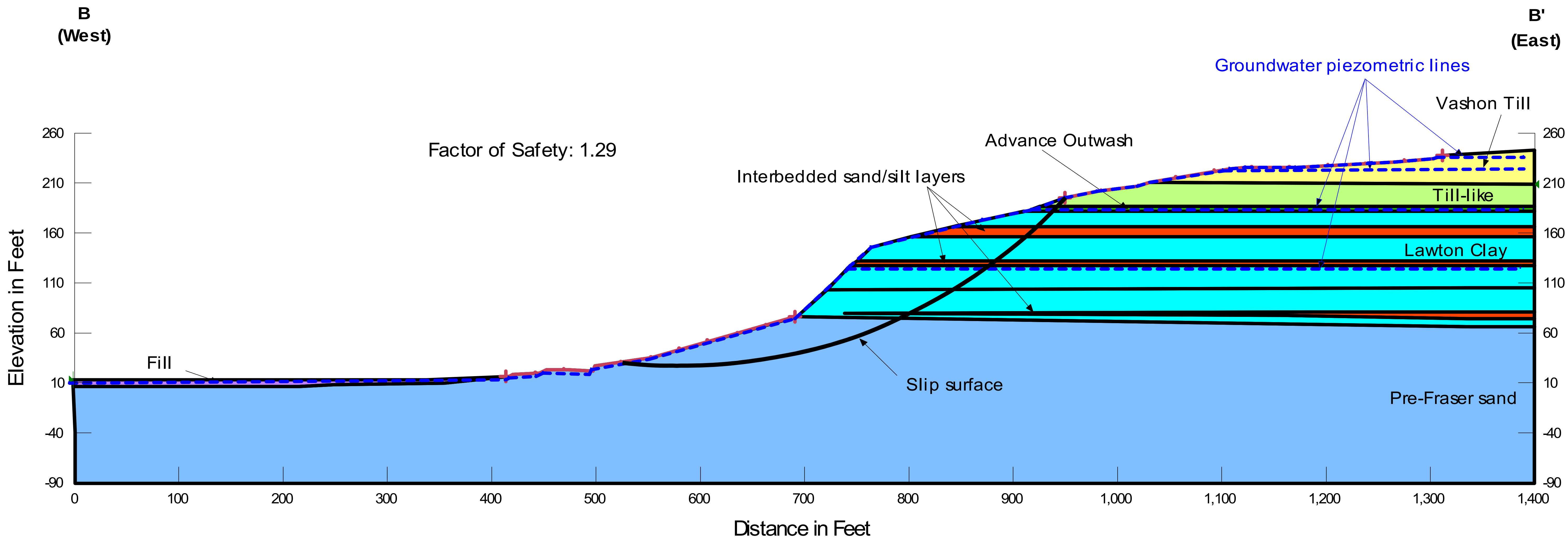
Figure
**13**




Point Wells
Richmond Beach, Washington

**Static, Deeper Failure Slope Stability Model - Cross Section B-B'**

17203-54

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Figure

**14**

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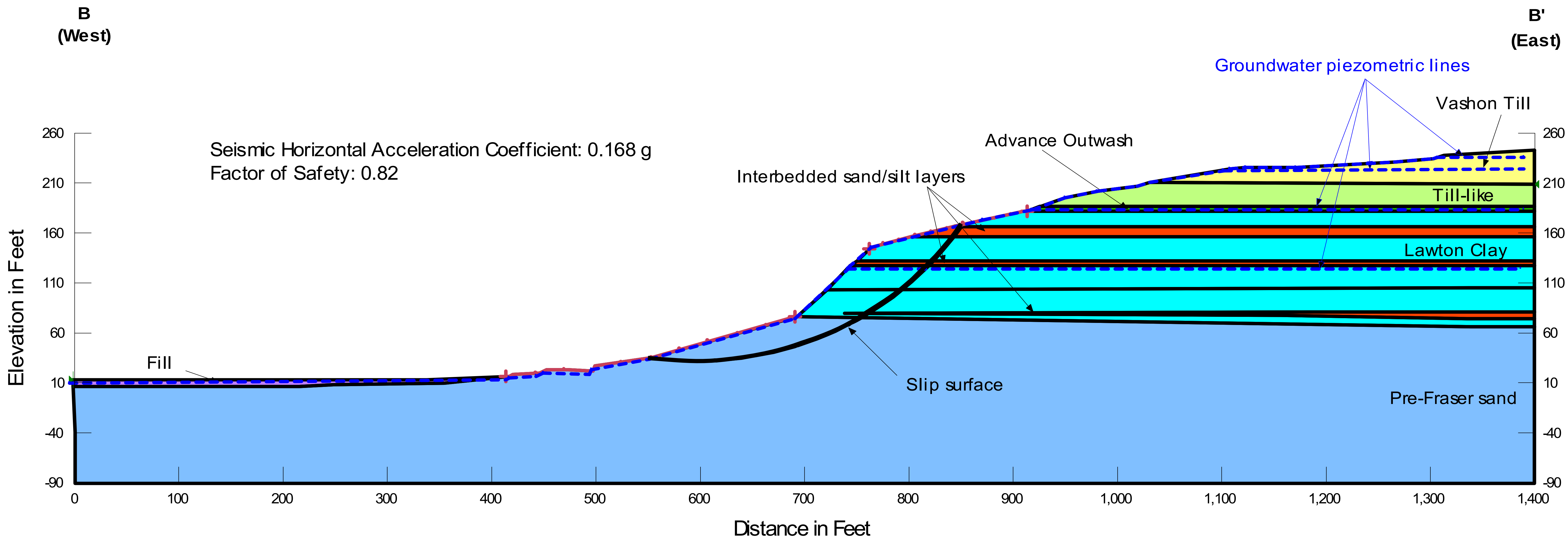


Point Wells
Richmond Beach, Washington

**Seismic, Shallower Failure Slope Stability Model - Cross Section B-B'**

17203-54 06/15

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Figure
**15**

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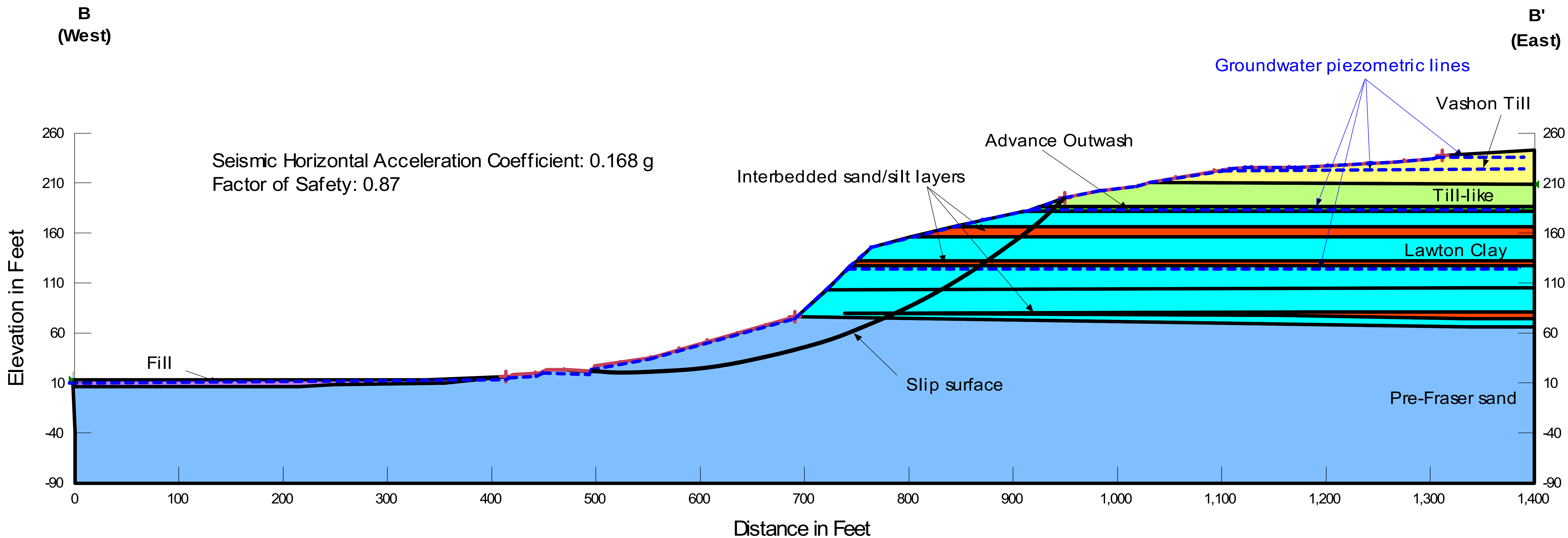


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Richmond Beach, Washington

**Seismic, Deeper Failure Slope Stability Model - Cross Section B-B'**

17203-54 06/15

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Figure
**16**

# APPENDIX A
# Field Exploration Methods and Analysis

# APPENDIX A
# FIELD EXPLORATIONS METHODS AND ANALYSIS

This appendix documents the processes Hart Crowser used to determine the nature (and quality) of the soil and groundwater underlying the Project site addressed by this report. The sections are:

- Exploration and Its Location;
- Mud Rotary Borings;
- Standard Penetration Test (SPT) Procedures;
- Vibrating Wire Piezometer Installation; and
- Groundwater Level Measurements.

## Exploration and Its Location

The subsurface exploration for this Project was HC-1. The exploration log in this appendix shows our interpretation of the drilling, sampling, and testing data. The logs indicate the depth at which the soils change. The change may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on Figure A-1 – Key to Exploration Logs. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

The location of the exploration is based on GPS measurements referenced to Washington State Plane North coordinates. The ground surface elevation was determined by an available digital survey map of the area. The method used determines the accuracy of the information given on the exploration's location and elevation.

## Mud Rotary Borings

A 250-foot-deep mud rotary boring, designated HC-1, was drilled from April 16 to April 22, 2015. The boring used an approximately 4-inch-diameter tri-cone bit and was advanced with a truck-mounted drill rig subcontracted by Hart Crowser. A geologist from Hart Crowser observed the drilling continuously. Detailed field logs were prepared of each boring. Using the standard penetration test (SPT), we obtained samples at 5-foot depth intervals.

The boring logs are on Figure A-2 at the end of this appendix.

## Standard Penetration Test Procedures

The SPT (as described in ASTM D1586) provides an approximate measure of soil density and consistency. The results must be used in conjunction with other tests and according to engineering judgment. To obtain disturbed samples, a standard 2-inch-outside-diameter split-spoon sampler is driven into the soil for 18 inches using a 140-pound autohammer, free-falling 30 inches. The number of blows required to drive the sampler the last 12 inches only is the standard penetration resistance. This resistance, or blow count, measures the relative density of granular soils and the consistency of cohesive soils. The blow counts are plotted on the boring logs at their respective sample depths.

Soil samples are recovered from the split-barrel sampler, field classified, placed into water-tight jars, and taken to Hart Crowser's laboratory for further testing.

### *In the Event of Hard Driving*

Occasionally, very dense materials preclude driving the total 18-inch sample. When this happens, the penetration resistance is entered on logs as described below.

**Penetration Less than 6 Inches.** The blow count is noted on the boring log as 100 blows per foot.

**Penetration Greater than 6 Inches.** The number of blows completed after the first 6 inches of penetration is divided by the total number of blows and multiplied by 12 inches to determine the blow count in blows per foot. For example, a blow count series of 12 blows for 6 inches, 20 blows for 6 inches, and 50 (the maximum number of blows counted within a 6-inch increment for SPT) for 4 inches would be recorded as 84 blows per foot. The blow count is noted on the log and limited to 100 blows per foot.

## Vibrating Wire Piezometer Installation

Vibrating wire piezometers (VWPs) were installed in HC-1 on April 22, 2015, in accordance with Washington State Department of Ecology regulations to allow for long-term groundwater level monitoring at the site. The VWPs were installed to the desired depth with the readout wires extending to the ground surface and encased in the grout backfill. The VWP construction details are illustrated on the boring log on Figure A-2.

## Groundwater Level Measurements

VWPs were used to determine groundwater pressure at the depth of the VWP instruments. Groundwater pressure is measured using a data readout connected to the VWP wires at the ground surface. The measured groundwater pressure is then converted to a groundwater elevation or depth. The calibration data for converting the electronic VWP signal to groundwater pressure as well as our field VWP measurements are provided in Appendix C.

# Key to Exploration Logs

## Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

## Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits and probes is estimated based on visual observation and is presented parenthetically on the logs.

| SAND or GRAVEL Density | Standard Penetration Resistance (N) in Blows/Foot | SILT or CLAY Consistency | Standard Penetration Resistance (N) in Blows/Foot | Approximate Shear Strength in TSF |
|---|---|---|---|---|
| Very loose | 0 to 4 | Very soft | 0 to 2 | <0.125 |
| Loose | 4 to 10 | Soft | 2 to 4 | 0.125 to 0.25 |
| Medium dense | 10 to 30 | Medium stiff | 4 to 8 | 0.25 to 0.5 |
| Dense | 30 to 50 | Stiff | 8 to 15 | 0.5 to 1.0 |
| Very dense | >50 | Very stiff | 15 to 30 | 1.0 to 2.0 |
| | | Hard | >30 | >2.0 |

## Sampling Test Symbols

- ☒ 1.5" I.D. Split Spoon
- Grab (Jar)
- 3.0" I.D. Split Spoon
- Shelby Tube (Pushed)
- Bag
- Cuttings
- Core Run

## Moisture

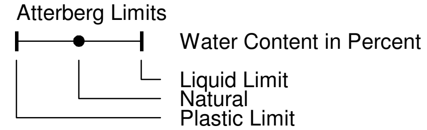
| | |
|---|---|
| Dry | Little perceptible moisture |
| Damp | Some perceptible moisture, likely below optimum |
| Moist | Likely near optimum moisture content |
| Wet | Much perceptible moisture, likely above optimum |

## Minor Constituents

| Minor Constituents | Estimated Percentage |
|---|---|
| Trace | <5 |
| Slightly (clayey, silty, etc.) | 5 - 12 |
| Clayey, silty, sandy, gravelly | 12 - 30 |
| Very (clayey, silty, etc.) | 30 - 50 |

## Laboratory Test Symbols

| | |
|---|---|
| GS | Grain Size Classification |
| CN | Consolidation |
| UU | Unconsolidated Undrained Triaxial |
| CU | Consolidated Undrained Triaxial |
| CD | Consolidated Drained Triaxial |
| QU | Unconfined Compression |
| DS | Direct Shear |
| K | Permeability |
| PP | Pocket Penetrometer<br>Approximate Compressive Strength in TSF |
| TV | Torvane<br>Approximate Shear Strength in TSF |
| CBR | California Bearing Ratio |
| MD | Moisture Density Relationship |
| AL | Atterberg Limits |




| | |
|---|---|
| PID | Photoionization Detector Reading |
| CA | Chemical Analysis |
| DT | In Situ Density in PCF |
| OT | Tests by Others |

## SOIL CLASSIFICATION CHART

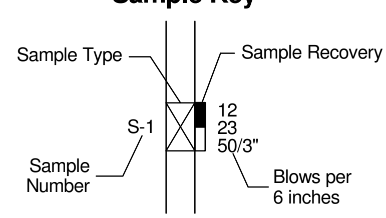
| MAJOR DIVISIONS | | | SYMBOLS GRAPH | SYMBOLS LETTER | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|---|
| COARSE GRAINED SOILS | GRAVEL AND GRAVELLY SOILS | CLEAN GRAVELS | | GW | WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES |
| | | (LITTLE OR NO FINES) | | GP | POORLY-GRADED GRAVELS,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

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

## Groundwater Indicators

- Groundwater Level on Date or (ATD) At Time of Drilling
- Groundwater Seepage (Test Pits)

## Sample Key

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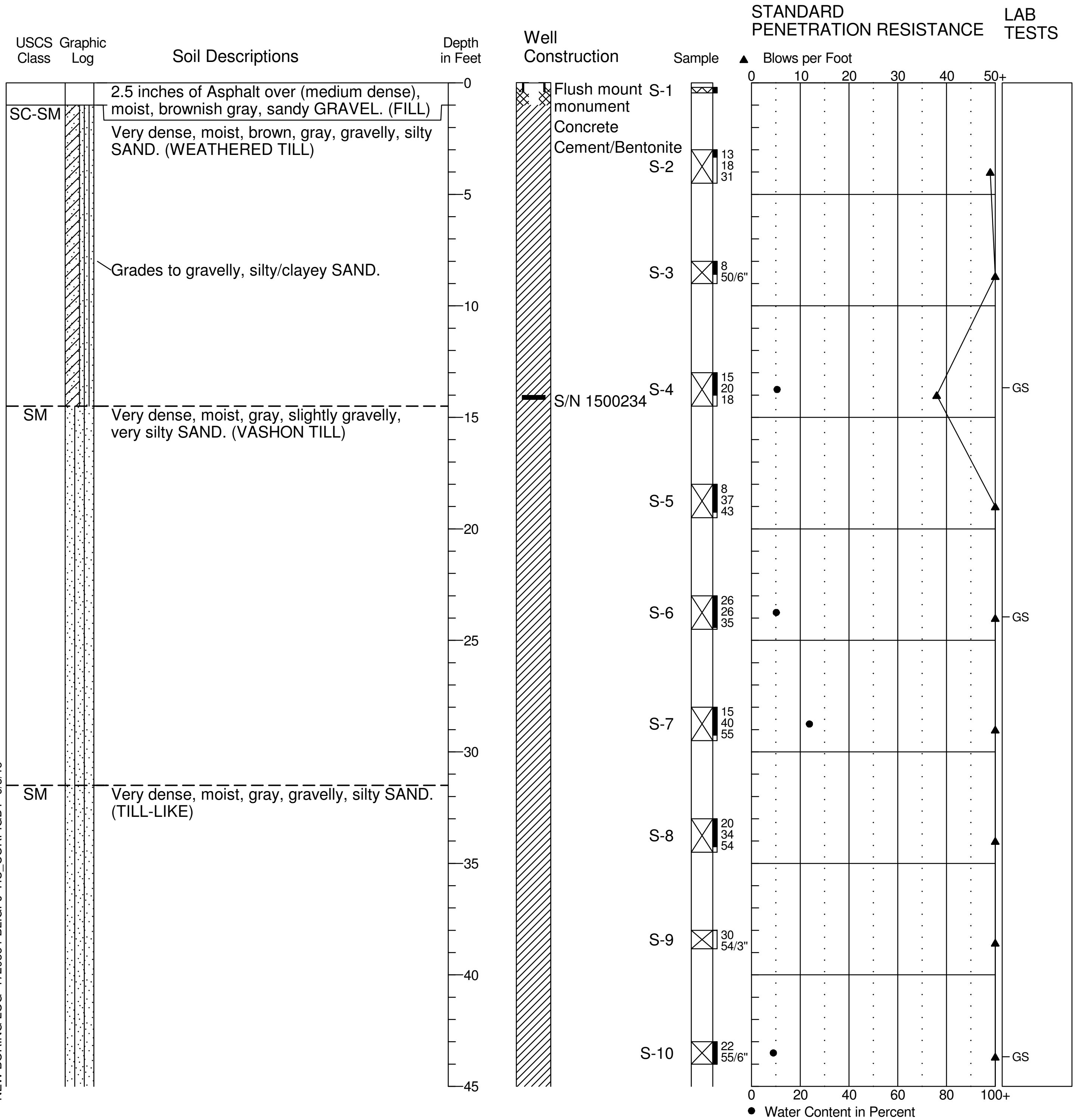
*17203-54* *4/15*

*Figure A-1*

# Boring Log HC-1

Location: N 289560 E 1258161
Approximate Ground Surface Elevation: 243 Feet
Horizontal Datum: NAD 83, WA State Plane N, US Feet
Vertical Datum: NAVD88

Drill Equipment: CME 85/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 4 inches
Logged By: B. McDonald    Reviewed By: N. Campbell






1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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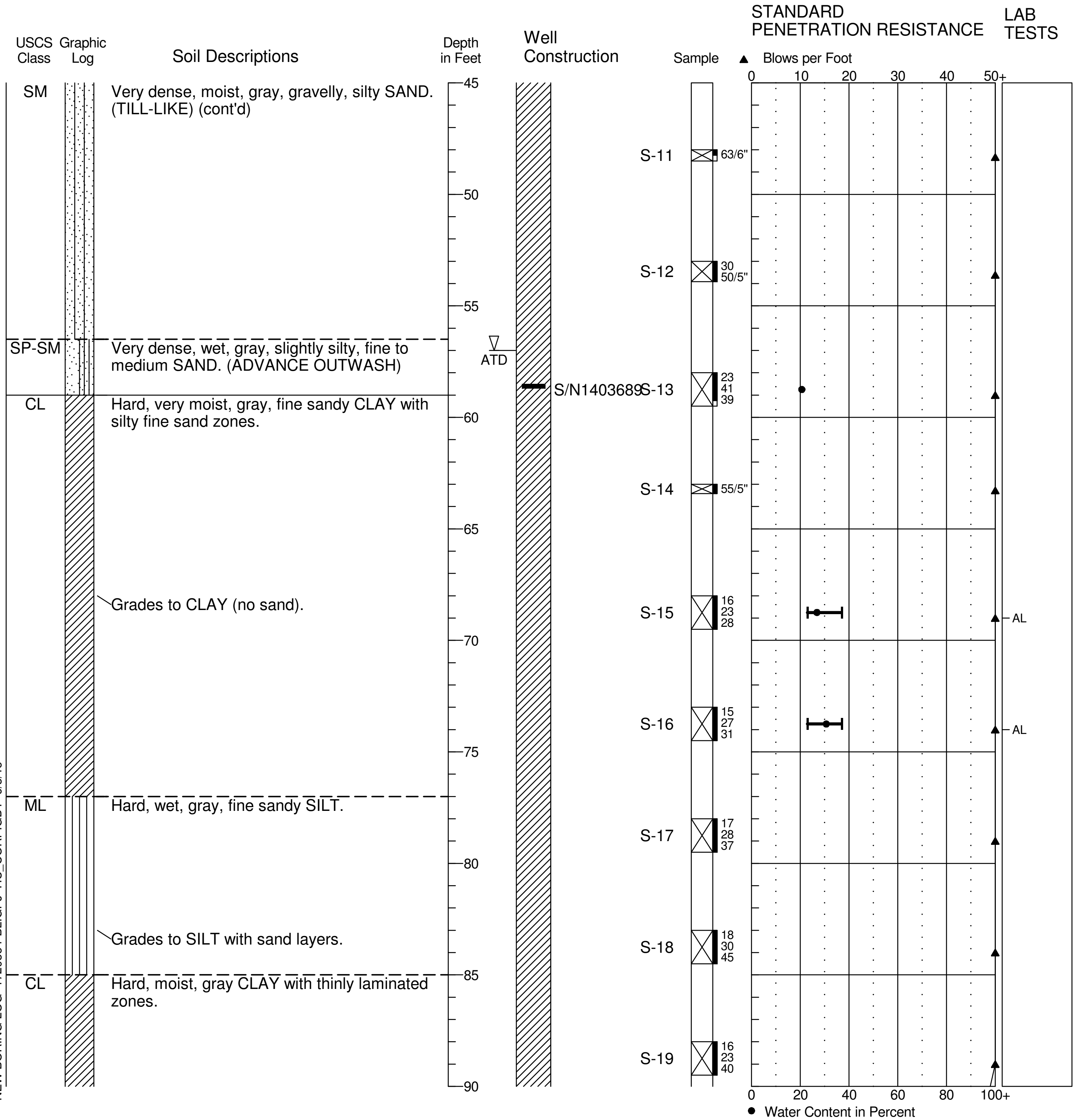
*17203-54* *4/15*

*Figure A-2* *1/6*

# Boring Log HC-1

Location: N 289560 E 1258161
Approximate Ground Surface Elevation: 243 Feet
Horizontal Datum: NAD 83, WA State Plane N, US Feet
Vertical Datum: NAVD88

Drill Equipment: CME 85/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 4 inches
Logged By: B. McDonald  Reviewed By: N. Campbell






1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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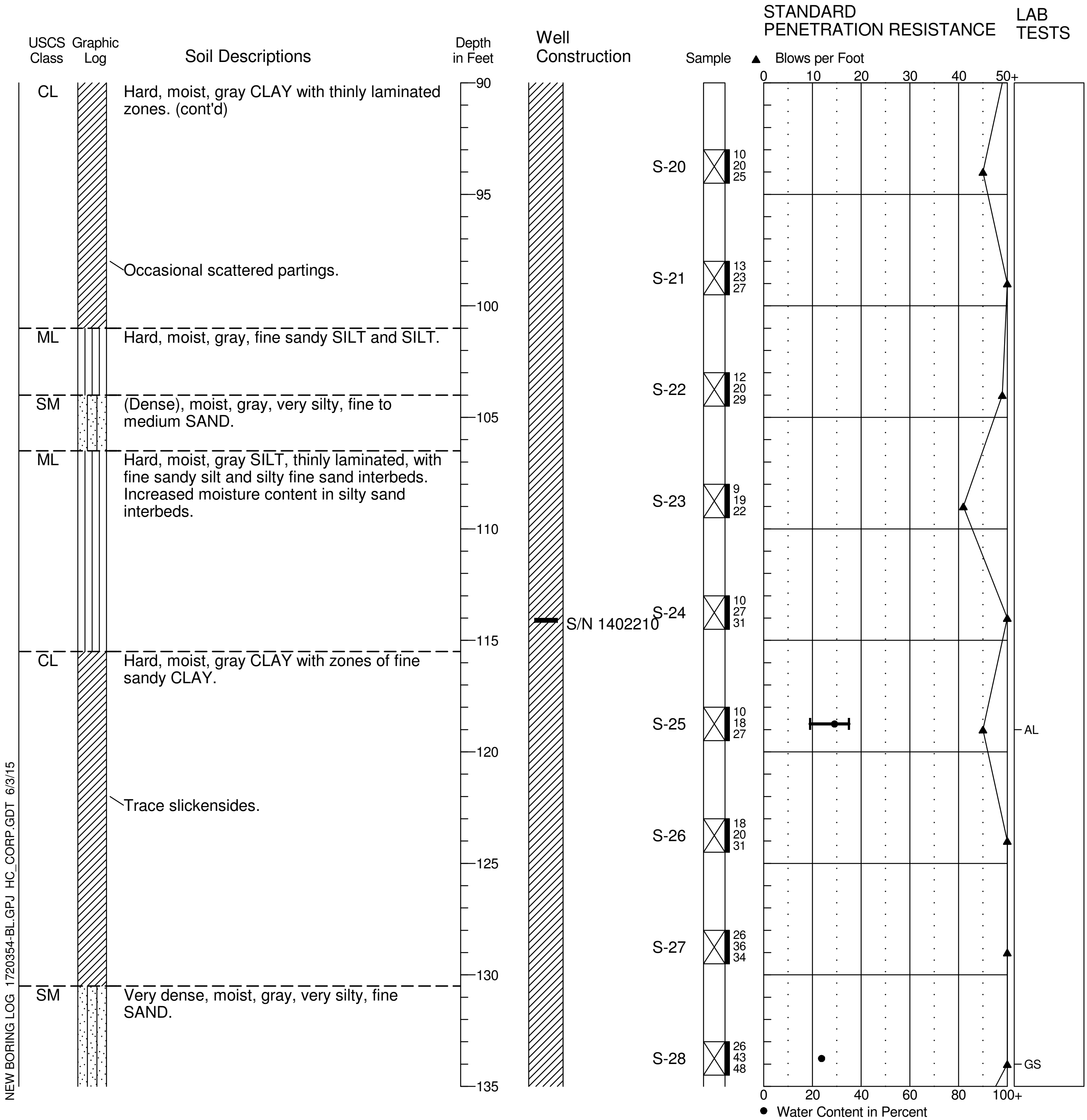
# Boring Log HC-1

Location: N 289560 E 1258161
Approximate Ground Surface Elevation: 243 Feet
Horizontal Datum: NAD 83, WA State Plane N, US Feet
Vertical Datum: NAVD88

Drill Equipment: CME 85/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 4 inches
Logged By: B. McDonald    Reviewed By: N. Campbell




1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

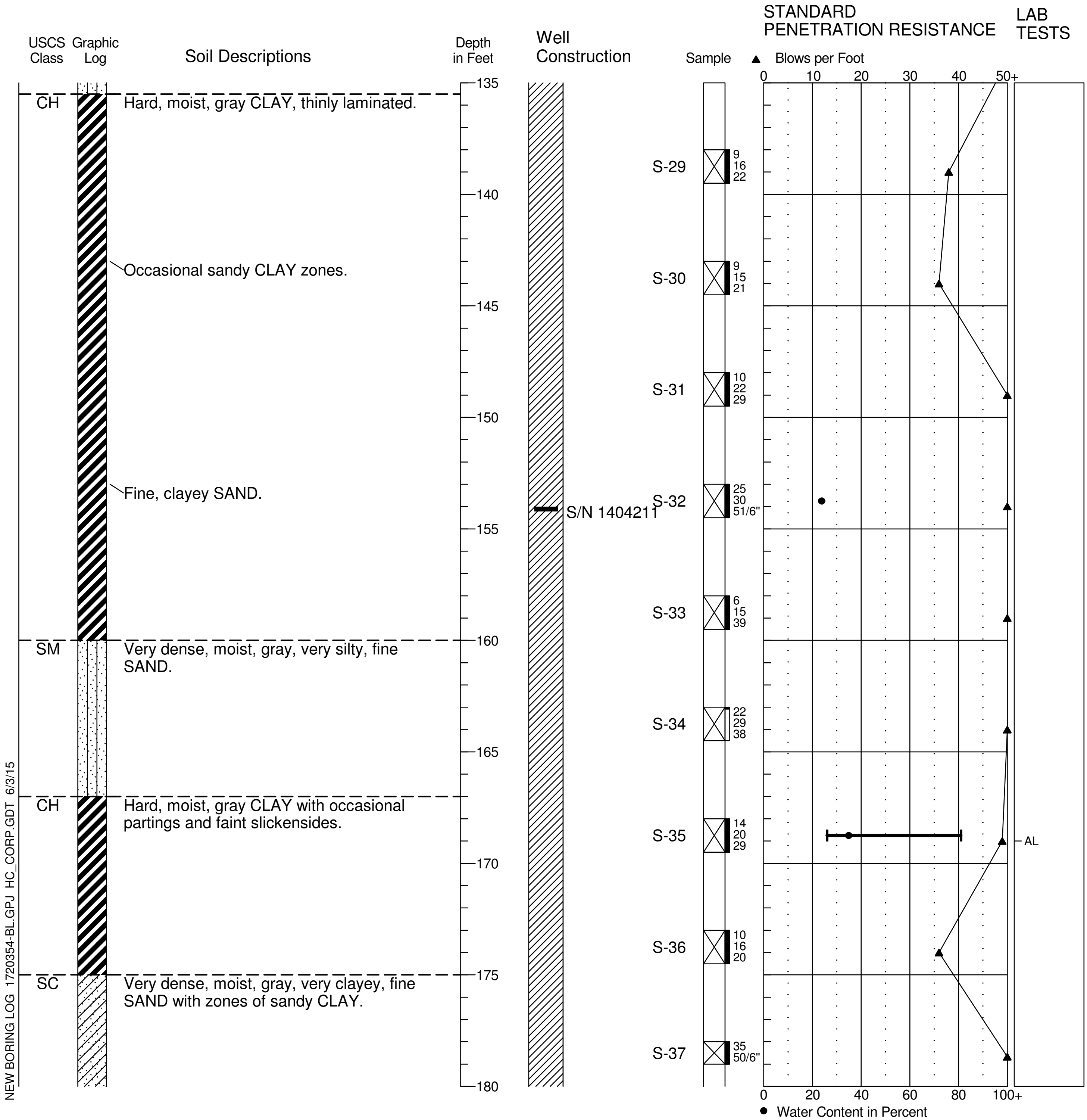
*17203-54* *4/15*

*Figure A-2* *3/6*

# Boring Log HC-1

Location: N 289560 E 1258161
Approximate Ground Surface Elevation: 243 Feet
Horizontal Datum: NAD 83, WA State Plane N, US Feet
Vertical Datum: NAVD88

Drill Equipment: CME 85/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 4 inches
Logged By: B. McDonald Reviewed By: N. Campbell



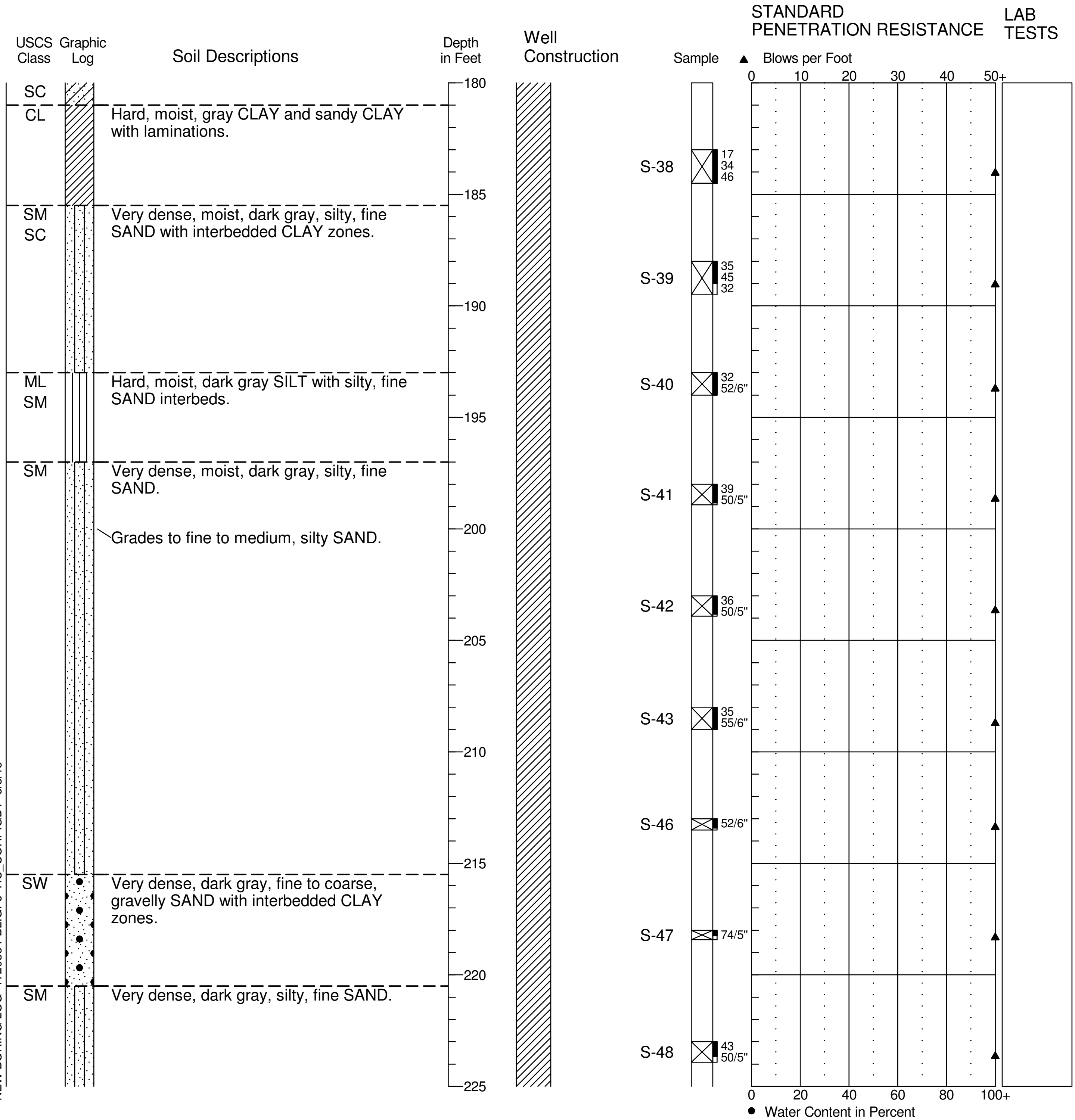

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

# Boring Log HC-1

Location: N 289560 E 1258161
Approximate Ground Surface Elevation: 243 Feet
Horizontal Datum: NAD 83, WA State Plane N, US Feet
Vertical Datum: NAVD88

Drill Equipment: CME 85/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 4 inches
Logged By: B. McDonald    Reviewed By: N. Campbell




NEW BORING LOG 1720354-BL.GPJ HC_CORP.GDT 6/3/15

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

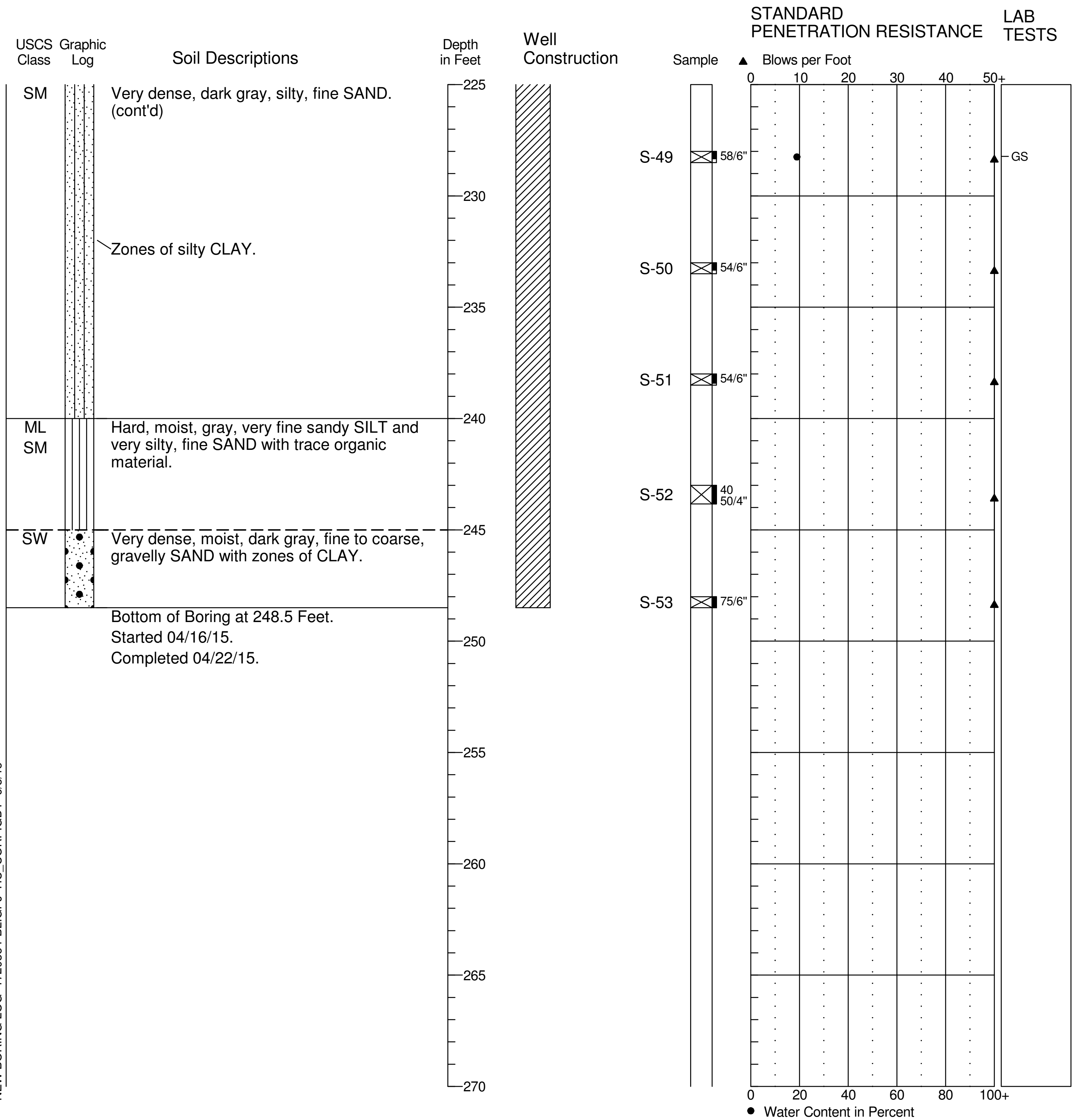
*17203-54* *4/15*

*Figure A-2* *5/6*

# Boring Log HC-1

Location: N 289560 E 1258161
Approximate Ground Surface Elevation: 243 Feet
Horizontal Datum: NAD 83, WA State Plane N, US Feet
Vertical Datum: NAVD88

Drill Equipment: CME 85/Mud Rotary
Hammer Type: SPT w/140 lb. Automatic hammer
Hole Diameter: 4 inches
Logged By: B. McDonald    Reviewed By: N. Campbell






1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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# APPENDIX B
# Laboratory Testing Program

# APPENDIX B
# LABORATORY TESTING PROGRAM

Laboratory tests were run for this study to evaluate the basic index and geotechnical engineering properties of the site soils. The tests performed and the procedures followed are outlined below.

## Soil Classification

**Field Observation and Laboratory Analysis**. Soil samples from the explorations were visually classified in the field and then taken to our laboratory where the classifications were verified in a relatively controlled laboratory environment. Field observations and laboratory tests included density/consistency, moisture condition, and grain size and plasticity estimates.

The classifications of selected samples were checked by laboratory tests such as Atterberg limits determinations and grain size analyses. Classifications were made in general accordance with the Unified Soil Classification (USC) System, ASTM D2487, as presented on Figure B-1.

## Water Content Determinations

Water content was determined for most samples recovered in the explorations in general accordance with ASTM D2216 as soon as possible following the samples' arrival in our laboratory. Water content was not determined for very small samples or for samples whose large gravel content would result in unrepresentative values. The test results are plotted on the exploration log at the depth from which each sample was taken. In addition, water content is routinely determined for samples subjected to other testing. These results are also presented on the exploration logs.

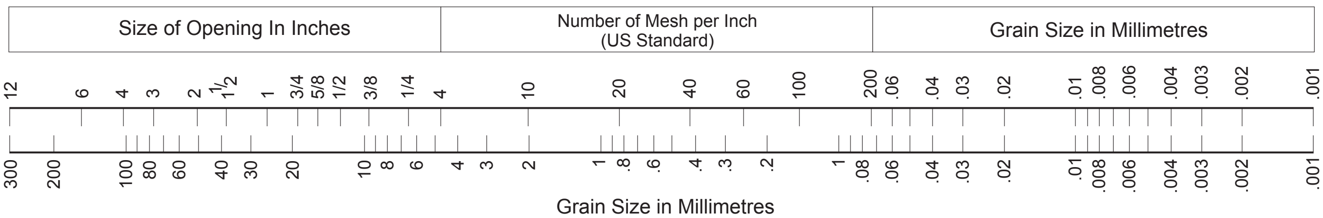
## Grain Size Analysis

Grain size distribution was analyzed on representative samples in general accordance with ASTM D422. Wet sieve analysis was used to determine the size distribution greater than the U.S. No. 200 mesh sieve. The results of the tests are presented as curves plotting percent finer by weight versus grain size on Figures B-2 and B-3.

## Atterberg Limits (AL)

We determined Atterberg limits for selected fine-grained soil samples. The liquid limit and plastic limit were determined in general accordance with ASTM D4318-84. The results of the Atterberg limit analyses and the plasticity characteristics are summarized in Figure B-4, Liquid and Plastic Limits Test Report. This relates the plasticity index (liquid limit minus the plastic limit) to the liquid limit. The results of the Atterberg limits tests are shown graphically on the boring log.

# *Unified Soil Classification (USC) System*
## *Soil Grain Size*




| COBBLES | GRAVEL | SAND | SILT and CLAY |
|---|---|---|---|
| Coarse-Grained Soils | | | Fine-Grained Soils |

### *Coarse-Grained Soils*

| G W | G P | G M | G C | S W | S P | S M | S C |
|---|---|---|---|---|---|---|---|
| Clean GRAVEL <5% fines | | * GRAVEL with >12% fines | | Clean SAND <5% fines | | * SAND with >12% fines | |
| GRAVEL >50% coarse fraction larger than No. 4 | | | | SAND >50% coarse fraction smaller than No. 4 | | | |
| Coarse-Grained Soils >50% larger than No. 200 sieve | | | | | | | |

G W and S W $\left(\frac{D_{60}}{D_{10}}\right)$ >4 for G W, >6 for S W & $1 \leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right) \leq 3$

G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A line with PI <4

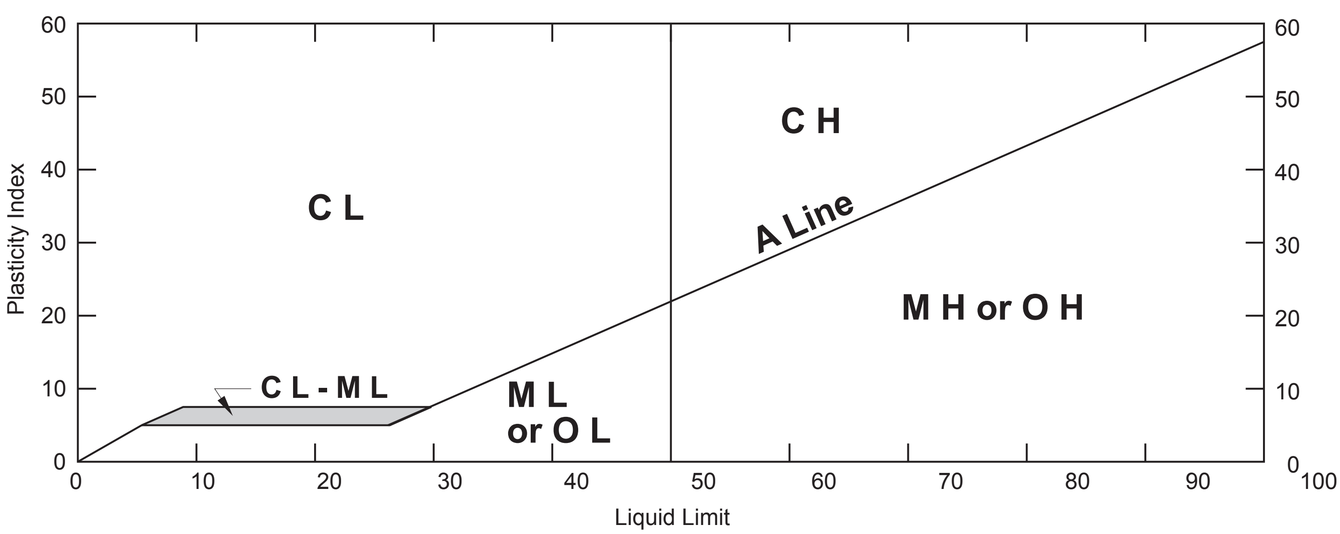
G C and S C Atterberg limits above A Line with PI >7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases requiring use of dual symbols.

$D_{10}$, $D_{30}$, and $D_{60}$ are the particles diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

### *Fine-Grained Soils*

| M L | C L | O L | M H | C H | O H | Pt |
|---|---|---|---|---|---|---|
| SILT | CLAY | Organic | SILT | CLAY | Organic | Highly Organic Soils |
| Soils with Liquid Limit <50% | | | Soils with Liquid Limit >50% | | | |
| Fine-Grained Soils >50% smaller than No. 200 sieve | | | | | | |




SRF Grain Size (B-1).cdr 3/06

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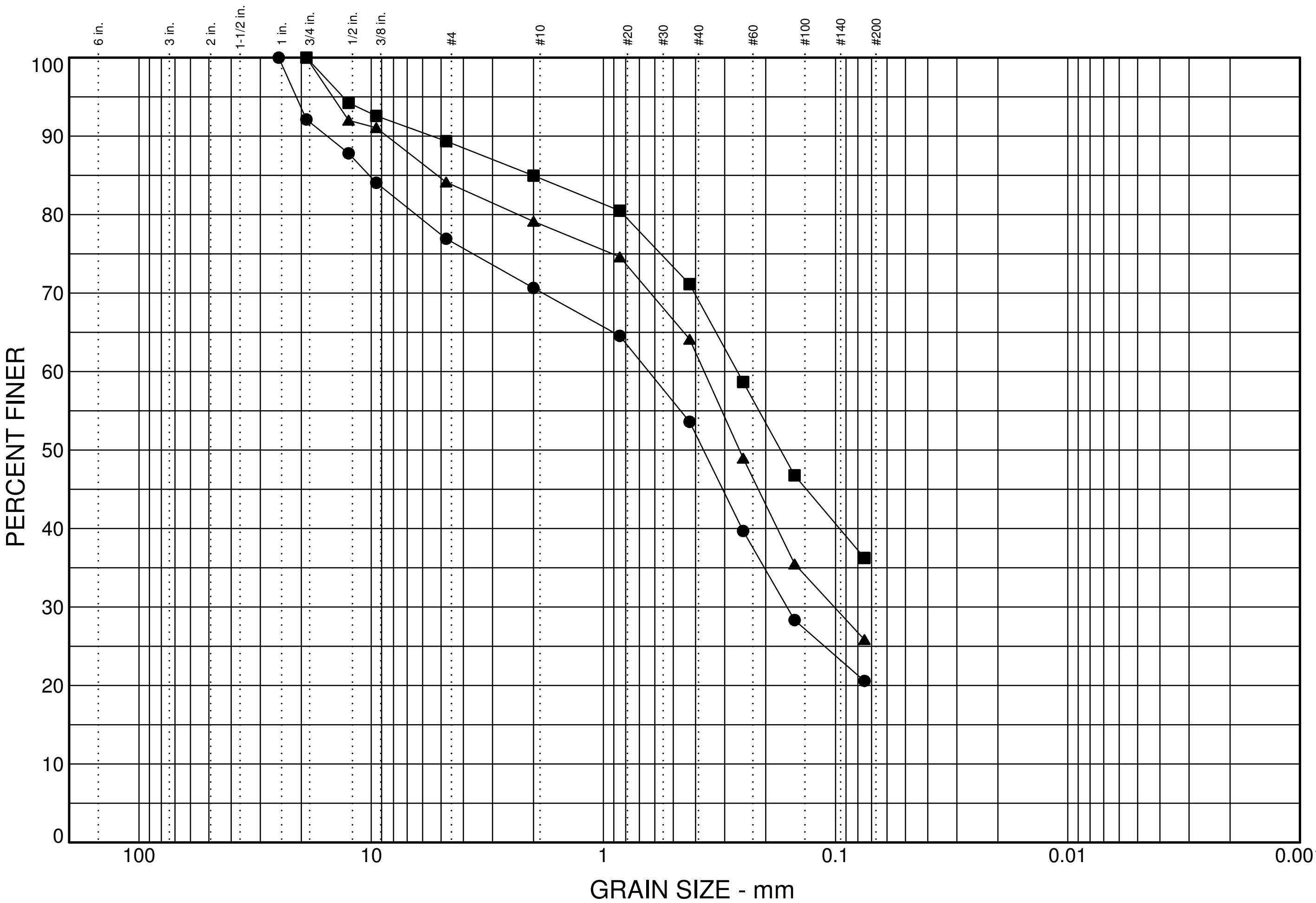
Figure B-1

# *Particle Size Distribution Test Report*




| | % COBBLES | % GRAVEL | % SAND | % SILT | % CLAY |
|---|---|---|---|---|---|
| ● | 0.0 | 23.1 | 56.3 | 20.6 | |
| ■ | 0.0 | 10.6 | 53.1 | 36.3 | |
| ▲ | 0.0 | 15.9 | 58.3 | 25.9 | |

| | LL | PI | $D_{85}$ | $D_{60}$ | $D_{50}$ | $D_{30}$ | $D_{15}$ | $D_{10}$ | $C_c$ | $C_u$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | | | 10.174 | 0.637 | 0.37 | 0.162 | | | | |
| ■ | | | 2.015 | 0.265 | 0.172 | | | | | |
| ▲ | | | 5.173 | 0.368 | 0.259 | 0.101 | | | | |

| MATERIAL DESCRIPTION | USCS | NAT. MOIST. |
|---|---|---|
| ● silty gravelly SAND | SM | 10.5% |
| ■ slightly gravelly, very silty SAND | SM | 10.2% |
| ▲ gravelly, silty SAND | SM | 9.0% |

**Remarks:**
●

■

▲

**Project:** Richmond Beach

**Client:**

● Source: HC-1 Sample No.: S-4 Depth: 13.0 to 14.0
■ Source: HC-1 Sample No.: S-6 Depth: 23.0 to 24.0
▲ Source: HC-1 Sample No.: S-10 Depth: 43.0 to 44.0

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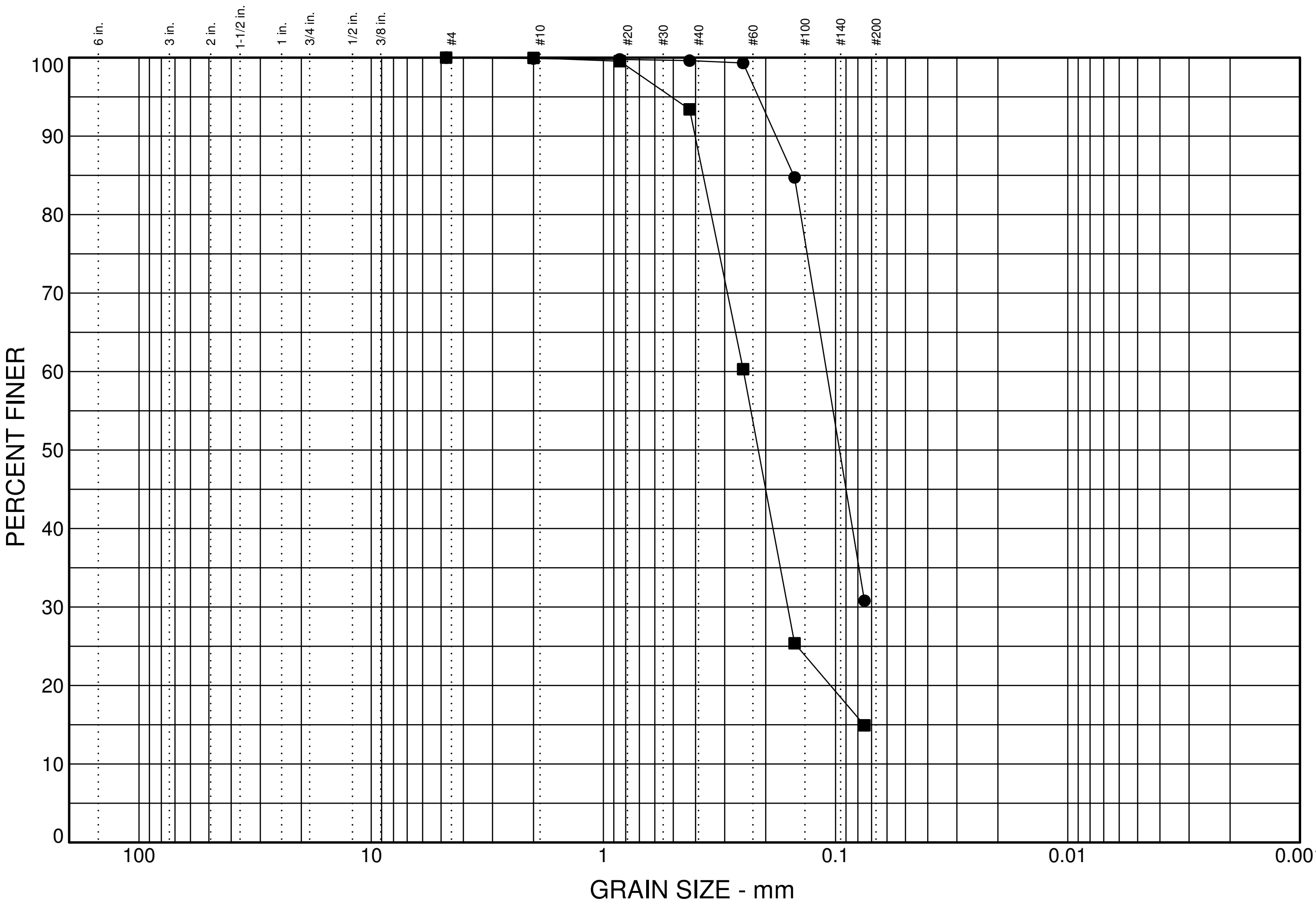
*17203-54* *4/15*

*Figure B-2*

GRAIN SIZE 1720354-BL.GPJ HC_CORP.GDT 6/3/15

# *Particle Size Distribution Test Report*




| | % COBBLES | % GRAVEL | % SAND | % SILT | % CLAY |
|---|---|---|---|---|---|
| ● | 0.0 | 0.0 | 69.2 | 30.8 | |
| ■ | 0.0 | 0.0 | 85.1 | 14.9 | |
| | | | | | |

| | LL | PI | $D_{85}$ | $D_{60}$ | $D_{50}$ | $D_{30}$ | $D_{15}$ | $D_{10}$ | $C_c$ | $C_u$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | | | 0.151 | 0.109 | 0.096 | | | | | |
| ■ | | | 0.371 | 0.249 | 0.215 | 0.16 | 0.075 | | | |
| | | | | | | | | | | |

| MATERIAL DESCRIPTION | USCS | NAT. MOIST. |
|---|---|---|
| ● very silty SAND | SM | 23.8% |
| ■ silty SAND | SM | 18.9% |

**Remarks:**
●

■

**Project:** Richmond Beach

**Client:**

● Source: HC-1 Sample No.: S-28 Depth: 133.0 to 133.5
■ Source: HC-1 Sample No.: S-49 Depth: 228.0 to 228.5

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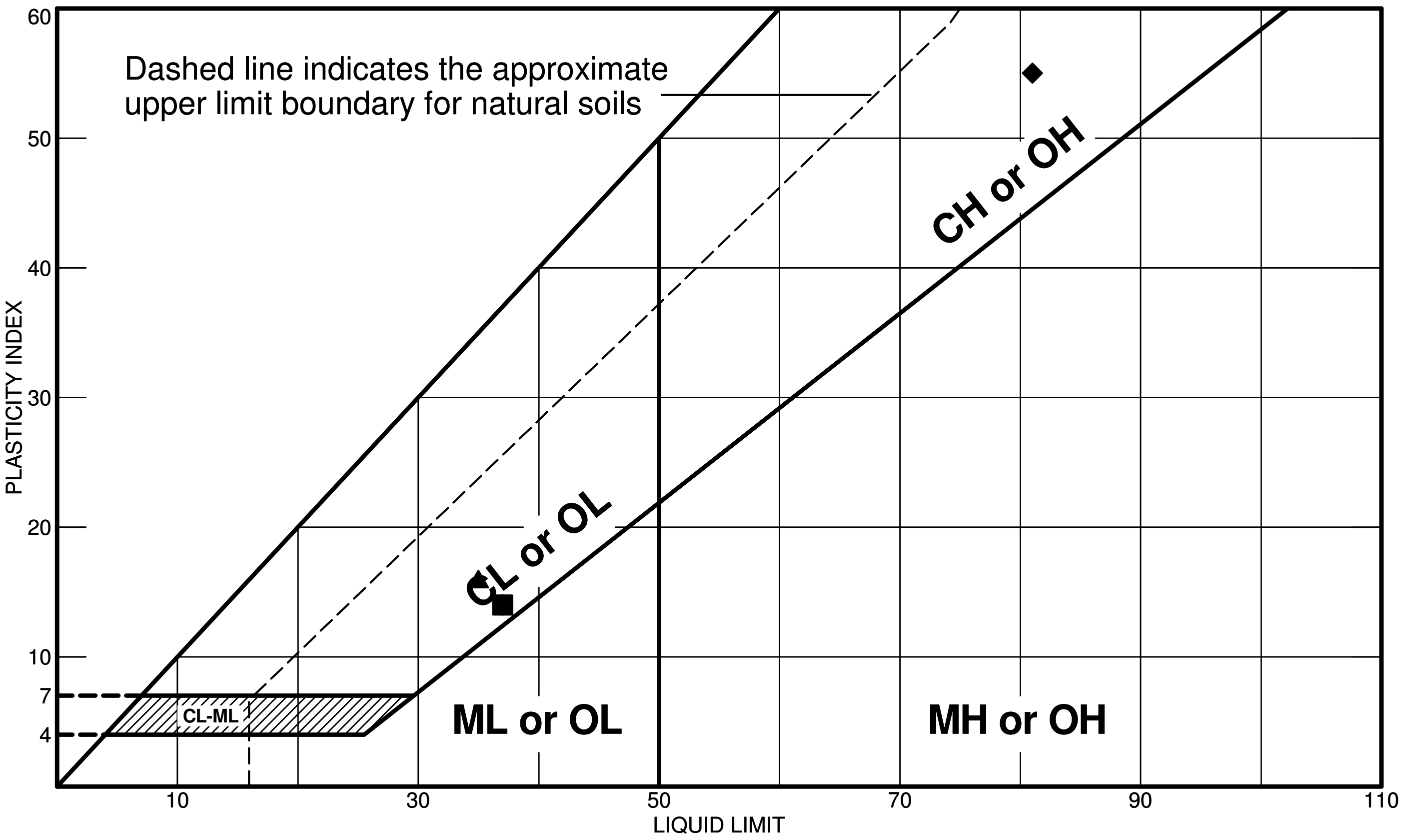
*Figure B-3*

# Liquid and Plastic Limits Test Report




| Location + Description | LL | PL | PI | -200 | USCS |
|---|---|---|---|---|---|
| ● Source: HC-1 Sample No.: S-15 Depth: 68<br>CLAY | 37 | 23 | 14 | | CL |
| ■ Source: HC-1 Sample No.: S-16 Depth: 73<br>CLAY | 37 | 23 | 14 | | CL |
| ▲ Source: HC-1 Sample No.: S-25 Depth: 118<br>CLAY | 35 | 19 | 16 | | CL |
| ◆ Source: HC-1 Sample No.: S-35 Depth: 168<br>CLAY | 81 | 26 | 55 | | CH |
| | | | | | |

**Remarks:**

●

■

▲

◆

**Project:** Richmond Beach

**Client:**

**Location:**

HARTCROWSER

*17203-54* *4/15*

*Figure B- 4*

# APPENDIX C
# VIBRATING WIRE PIEZOMETER MEASUREMENTS AND CALIBRATION CERTIFICATES

# APPENDIX C
# VIBRATING WIRE PIEZOMETER MEASUREMENTS AND CALIBRATION CERTIFICATES

Vibrating wire piezometer measurement data are summarized in Table C-1, and vibrating wire piezometer calibration certificates for the vibrating wire are attached.

**Table C1 - Vibrating Wire Piezometer (VWP) Meaurements Boring HC-1**

| VWP Information[1] | | | Date | VWP Measurements | | Groundwater | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth in Feet | Elevation in Feet | Serial No. | | Reading in Hz | Temperature in Celsius | Pressure in psi | Head in Feet | Depth in Feet | Elevation in Feet |
| 14 | 229 | 1500234 | 4/22/2015 | 2730.7 | 9.2 | 0.28 | 0.6 | N/A[1] | N/A[1] |
| | | | 5/6/2015 | 2700.5 | 12.3 | 3.27 | 7.6 | 6.4 | 236.6 |
| | | | 5/21/2015 | 2703.5 | 12.4 | 2.99 | 6.9 | 7.1 | 235.9 |
| | | | 5/26/2015 | 2703.5 | 12.5 | 2.99 | 6.9 | 7.1 | 235.9 |
| 58.75 | 184.25 | 1403689 | 4/22/2015 | 2756.2 | 8.9 | 0.31 | 0.7 | N/A[1] | N/A[1] |
| | | | 5/6/2015 | 2645.2 | 12.4 | 16.89 | 39.0 | 19.8 | 223.2 |
| | | | 5/21/2015 | 2642 | 12.3 | 17.35 | 40.0 | 18.7 | 224.3 |
| | | | 5/26/2015 | 2640.7 | 12.2 | 17.54 | 40.5 | 18.3 | 224.7 |
| 114 | 129 | 1402210 | 4/22/2015 | 2839.6 | 9.1 | 0.30 | 0.7 | N/A[1] | N/A[1] |
| | | | 5/6/2015 | 2678.9 | 11.0 | 23.97 | 55.3 | 58.7 | 184.3 |
| | | | 5/21/2015 | 2673.1 | 10.8 | 24.79 | 57.2 | 56.8 | 186.2 |
| | | | 5/26/2015 | 2670.6 | 10.7 | 25.14 | 58.0 | 56.0 | 187.0 |
| 154 | 89 | 1404211 | 4/22/2015 | 2872.2 | 8.8 | 0.33 | 0.8 | N/A[1] | N/A[1] |
| | | | 5/6/2015 | 2766.7 | 10.5 | 16.65 | 38.4 | 115.6 | 127.4 |
| | | | 5/21/2015 | 2767.3 | 10.2 | 16.55 | 38.2 | 115.8 | 127.2 |
| | | | 5/26/2015 | 2766.7 | 10.2 | 16.64 | 38.4 | 115.6 | 127.4 |

Notes:

[1]All VWPs installed on 4/22/15. Measurements shown for 4/22/2015 are prior to installation with all VWPs in a 5-gallon bucket of water with about 1-foot of water above piezometer tips.

# VW Piezometer Calibration Certificate

Serial #: 1500234
Range : 350 kPa
Cable Length: 15 m
Date of Calibration: 1/27/2015

Part #: 52611028
Cable Part # : 50613524
Calibrated by: AM
Note:

## ABC Calibration Factors

| | A | B | C |
|---|---|---|---|
| kPa | -1.252835E-4 | 1.821970E-2 | 8.875334E+2 |
| psi | -1.817084E-5 | 2.642544E-3 | 1.287258E+2 |

Pressure in kPa/psi = $(A \times Hz^2) + (B \times Hz) + C$, where Hz is frequency in Hertz.

## TI Calibration Factors

| | C0 | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|
| kPa | 8.863479E+2 | 1.714305E-2 | 1.542821E-1 | -1.251720E-4 | 3.211352E-5 | -1.254770E-3 |
| psi | 1.285494E+2 | 2.486302E-3 | 2.237594E-2 | -1.815402E-5 | 4.657508E-6 | -1.819826E-4 |

Pressure in kPa/psi = $C0 + (C1 \times Hz) + (C2 \times T) + (C3 \times Hz^2) + (C4 \times Hz \times T) + (C5 \times T^2)$

Where Hz is the frequency reading in Hertz and T is the Thermistor reading in degrees C.
TI factors are calculated from temperatures at 5.0, 15.0 and 25.0 degrees C.
Applied pressure and temperature are NIST traceable.

## Summary of Test Results at 15°C

Thermistor reading is 14.7 °C.

Applied Pressure is referenced to 1 atm. Calculated Pressure uses ABC Calibration factors.

| Applied (kPa) | Equivalent (psi) | Frequency (Hz) | Calculated (kPa) | Calculated (psi) | Error (%FS) |
|---|---|---|---|---|---|
| 0.0 | 0.00 | 2735.2 | 0.1 | 0.01 | -0.02 |
| 35.0 | 5.08 | 2682.4 | 35.0 | 5.07 | 0.01 |
| 70.0 | 10.15 | 2628.5 | 69.8 | 10.13 | 0.05 |
| 105.0 | 15.23 | 2573.0 | 105.0 | 15.23 | 0.00 |
| 140.0 | 20.31 | 2516.4 | 140.1 | 20.31 | -0.01 |
| 175.0 | 25.38 | 2458.6 | 175.0 | 25.39 | -0.01 |
| 210.0 | 30.46 | 2399.3 | 210.0 | 30.46 | -0.01 |
| 245.0 | 35.53 | 2338.5 | 245.0 | 35.54 | 0.00 |
| 280.0 | 40.61 | 2276.0 | 280.0 | 40.61 | 0.00 |
| 315.0 | 45.69 | 2211.7 | 315.0 | 45.69 | 0.00 |
| 350.0 | 50.76 | 2145.3 | 350.0 | 50.77 | -0.01 |

12123 Harbour Reach Drive Suite 106, Mukilteo, WA 98275 USA
www.slopeindicator.com

# VW Piezometer Calibration Certificate

Serial #: 1403689
Range : 700 kPa
Cable Length: 30 m
Date of Calibration: 11/5/2014

Part #: 52611033
Cable Part # : 50613524
Calibrated by: KB
Note:

## ABC Calibration Factors

| | A | B | C |
|---|---|---|---|
| kPa | -1.682822E-4 | -1.122758E-1 | 1.591547E+3 |
| psi | -2.440727E-5 | -1.628423E-2 | 2.308344E+2 |

Pressure in kPa/psi $= (A \times Hz^2) + (B \times Hz) + C$, where Hz is frequency in Hertz.

## TI Calibration Factors

| | C0 | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|
| kPa | 1.588037E+3 | -1.114441E-1 | 1.168997E-1 | -1.686665E-4 | 6.713741E-5 | -1.672841E-3 |
| psi | 2.303172E+2 | -1.616303E-2 | 1.695427E-2 | -2.446215E-5 | 9.737115E-6 | -2.426165E-4 |

Pressure in kPa/psi $= C0 + (C1 \times Hz) + (C2 \times T) + (C3 \times Hz^2) + (C4 \times Hz \times T) + (C5 \times T^2)$

Where Hz is the frequency reading in Hertz and T is the Thermistor reading in degrees C.
TI factors are calculated from temperatures at 5.0, 15.0 and 25.0 degrees C.
Applied pressure and temperature are NIST traceable.

## Summary of Test Results at 15°C

Thermistor reading is 14.8 °C.

Applied Pressure is referenced to 1 atm. Calculated Pressure uses ABC Calibration factors.

| Applied (kPa) | Equivalent (psi) | Frequency (Hz) | Calculated (kPa) | Calculated (psi) | Error (%FS) |
|---|---|---|---|---|---|
| 0.0 | 0.00 | 2759.4 | 0.4 | 0.06 | -0.05 |
| 70.0 | 10.15 | 2691.9 | 69.9 | 10.14 | 0.02 |
| 140.0 | 20.31 | 2622.6 | 139.6 | 20.25 | 0.05 |
| 210.0 | 30.46 | 2551.1 | 209.9 | 30.45 | 0.01 |
| 280.0 | 40.61 | 2477.9 | 280.1 | 40.62 | -0.01 |
| 350.0 | 50.76 | 2403.0 | 350.0 | 50.77 | 0.00 |
| 420.0 | 60.92 | 2325.9 | 420.0 | 60.92 | 0.00 |
| 490.0 | 71.07 | 2246.4 | 490.1 | 71.09 | -0.02 |
| 560.0 | 81.22 | 2164.5 | 560.1 | 81.24 | -0.02 |
| 630.0 | 91.37 | 2079.9 | 630.0 | 91.38 | -0.01 |
| 700.0 | 101.53 | 1992.4 | 699.8 | 101.50 | 0.02 |

# VW Piezometer Calibration Certificate

Serial #: 1402210
Range : 700 kPa
Cable Length: 45 m
Date of Calibration: 7/8/2014

Part #: 52611034
Cable Part # : 50613524
Calibrated by: KB
Note:

## ABC Calibration Factors

| | A | B | C |
|---|---|---|---|
| kPa | -1.885533E-4 | 2.856795E-2 | 1.443441E+3 |
| psi | -2.734735E-5 | 4.143431E-3 | 2.093534E+2 |

Pressure in kPa/psi $= (A \times Hz^2) + (B \times Hz) + C$, where Hz is frequency in Hertz.

## TI Calibration Factors

| | C0 | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|
| kPa | 1.440101E+3 | 2.806768E-2 | 2.117773E-1 | -1.885909E-4 | 4.307205E-5 | -1.609062E-3 |
| psi | 2.088616E+2 | 4.070730E-3 | 3.071462E-2 | -2.735183E-5 | 6.246853E-6 | -2.333665E-4 |

Pressure in kPa/psi $= C0 + (C1 \times Hz) + (C2 \times T) + (C3 \times Hz^2) + (C4 \times Hz \times T) + (C5 \times T^2)$

Where Hz is the frequency reading in Hertz and T is the Thermistor reading in degrees C.
TI factors are calculated from temperatures at 5.0, 15.0 and 25.0 degrees C.
Applied pressure and temperature are NIST traceable.

## Summary of Test Results at 15°C

Thermistor reading is 16.5 °C.

Applied Pressure is referenced to 1 atm. Calculated Pressure uses ABC Calibration factors.

| Applied (kPa) | Equivalent (psi) | Frequency (Hz) | Calculated (kPa) | Calculated (psi) | Error (%FS) |
|---|---|---|---|---|---|
| 0.0 | 0.00 | 2843.5 | 0.1 | 0.02 | -0.02 |
| 70.0 | 10.15 | 2775.8 | 69.9 | 10.14 | 0.01 |
| 140.0 | 20.31 | 2706.2 | 139.9 | 20.29 | 0.02 |
| 210.0 | 30.46 | 2634.6 | 209.9 | 30.45 | 0.01 |
| 280.0 | 40.61 | 2560.9 | 280.0 | 40.61 | 0.00 |
| 350.0 | 50.76 | 2485.1 | 350.0 | 50.76 | 0.00 |
| 420.0 | 60.92 | 2406.7 | 420.1 | 60.92 | -0.01 |
| 490.0 | 71.07 | 2325.7 | 490.0 | 71.07 | 0.00 |
| 560.0 | 81.22 | 2241.6 | 560.0 | 81.23 | -0.01 |
| 630.0 | 91.37 | 2154.2 | 630.0 | 91.37 | 0.00 |
| 700.0 | 101.53 | 2063.0 | 699.9 | 101.51 | 0.01 |

# VW Piezometer Calibration Certificate

Serial #: 1404211
Range : 700 kPa
Cable Length: 60 m
Date of Calibration: 12/6/2014

Part #: 52611035
Cable Part # : 50613524
Calibrated by: KB
Note:

## ABC Calibration Factors

| | A | B | C |
|---|---|---|---|
| kPa | -1.907203E-4 | 1.371290E-2 | 1.537918E+3 |
| psi | -2.766164E-5 | 1.988888E-3 | 2.230562E+2 |

Pressure in kPa/psi $= (A \times Hz^2) + (B \times Hz) + C$, where Hz is frequency in Hertz.

## TI Calibration Factors

| | C0 | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|---|
| kPa | 1.534389E+3 | 1.389239E-2 | 2.046774E-1 | -1.908957E-4 | 4.733165E-5 | -2.816794E-3 |
| psi | 2.225365E+2 | 2.014850E-3 | 2.968490E-2 | -2.768611E-5 | 6.864634E-6 | -4.085270E-4 |

Pressure in kPa/psi $= C0 + (C1 \times Hz) + (C2 \times T) + (C3 \times Hz^2) + (C4 \times Hz \times T) + (C5 \times T^2)$

Where Hz is the frequency reading in Hertz and T is the Thermistor reading in degrees C.
TI factors are calculated from temperatures at 5.0, 15.0 and 25.0 degrees C.
Applied pressure and temperature are NIST traceable.

## Summary of Test Results at 15°C

Thermistor reading is 14.9 °C.

Applied Pressure is referenced to 1 atm. Calculated Pressure uses ABC Calibration factors.

| Applied (kPa) | Equivalent (psi) | Frequency (Hz) | Calculated (kPa) | Calculated (psi) | Error (%FS) |
|---|---|---|---|---|---|
| 0.0 | 0.00 | 2875.7 | 0.2 | 0.02 | -0.02 |
| 70.0 | 10.15 | 2810.6 | 69.9 | 10.13 | 0.02 |
| 140.0 | 20.31 | 2743.8 | 139.7 | 20.26 | 0.04 |
| 210.0 | 30.46 | 2674.9 | 210.0 | 30.46 | 0.00 |
| 280.0 | 40.61 | 2604.3 | 280.1 | 40.62 | -0.01 |
| 350.0 | 50.76 | 2531.9 | 350.0 | 50.77 | 0.00 |
| 420.0 | 60.92 | 2457.3 | 420.0 | 60.91 | 0.00 |
| 490.0 | 71.07 | 2380.3 | 490.0 | 71.06 | 0.00 |
| 560.0 | 81.22 | 2300.6 | 560.0 | 81.23 | 0.00 |
| 630.0 | 91.37 | 2218.1 | 630.0 | 91.37 | 0.00 |
| 700.0 | 101.53 | 2132.4 | 699.9 | 101.52 | 0.01 |

# APPENDIX D
# EXISTING EXPLORATIONS
# BY HART CROWSER AND OTHERS

# APPENDIX D
# EXISTING EXPLORATIONS BY HART CROWSER AND OTHERS

In addition to the explorations and laboratory test results presented in Appendices A and B, respectively, previous soil explorations by Hart Crowser and others were used to gain an understanding of the subsurface conditions at the proposed development at Point Wells.

Borings previously performed by Hart Crowser and others at the Project site were consulted for the current report. These logs are included in this appendix, separated by location (slope, Upper Bench, and Lower Bench). Logs produced by others are presented for reference only and Hart Crowser is not responsible for the accuracy or completeness of the information presented in the logs. Approximate locations of these borings are shown on Figures 2 and 3; actual locations may differ from those shown.

SLOPE

# Boring Log

| Project Name: Point Wells | | | | Sheet 1 of 3 |
|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-1 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±236' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Surface Conditions: Depth of Topsoil 6": grass |
|---|---|---|---|---|---|---|---|
| | | | | | | SM | Brown silty fine to medium SAND with gravel, medium dense, moist |
| | | | | 1 | | | |
| | | | | 2 | | | |
| | | | | 3 | | | |
| | | | | 4 | | | |
| | 8.9 | 38 | | 5 | | | -variable silt content |
| | | | | 6 | | | |
| | | | | 7 | | | |
| | | | | 8 | | | |
| | | | | 9 | | | |
| | 18.9 | 19 | | 10 | | | -moist to wet<br>-6" silt layer<br>-wet<br>-possible seepage at 10.5' |
| | | | | 11 | | | |
| | | | | 12 | | | |
| | | | | 13 | | | |
| | | | | 14 | | | |
| | 8.3 | 57 | | 15 | | SP-SM | Brown poorly graded SAND with silt, very dense, moist to wet<br><br>-10.2% fines |
| | | | | 16 | | | |
| | | | | 17 | | | |
| | | | | 18 | | | |
| | | | | 19 | | | |

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A2 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

RB-8-00010283

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# Boring Log

| Project Name: Point Wells | | | | Sheet 2 of 3 |
|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-1 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±236' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 12.8 | 55 | | 21–24 | | SP-SM | Brown poorly graded SAND with silt, very dense, moist to wet |
| | 10.3 | 48 | | 25–29 | | SM | Bray silty fine to medium SAND with gravel, dense, moist |
| | 7.6 | 45 | | 30–34 | | SP-SM | Gray poorly graded fine SAND with silt, dense, moist |
| | 4.7 | 64 | | 35–39 | | | -very dense |

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A3 |
|---|---|---|---|---|---|

BORING LOG 10903.GPJ ECI.GDT 3/4/04

# Boring Log

| Project Name: Point Wells | | | | Sheet 3 of 3 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-1 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±236' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | 17.7 | 49 | 41–44 | SP-SM | Gray poorly graded SAND with silt, dense, wet<br>-seepage at 40' |
| | 21.0 | 41 | 45–49 | CL | Gray lean CLAY, very stiff, moist<br>LL=34 PL=22 PI=12 |
| | 28.8 | 70 | 50–54 | | |
| | 31.9 | 62 | 55–56 | | |
| | | | | | Boring terminated at 56.5 feet below existing grade. Groundwater seepage encountered at 10.5 and 40.0 feet during drilling. Boring backfilled with bentonite and cuttings. |

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A4 |
|---|---|---|---|---|---|

# Boring Log

| Project Name: Point Wells | | | | Sheet 1 of 2 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-2 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±246' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

Surface Conditions: Depth of Topsoil 6": grass

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | | | | 0 | | SM | Brown silty SAND with gravel, medium dense, moist |
| | | | | 1 | | | |
| | | | | 2 | | | |
| | | | | 3 | | | |
| | | | | 4 | | | |
| | 10.9 | 34 | | 5 | X | | |
| | | | | 6 | | | |
| | | | | 7 | | | |
| | | | | 8 | | | |
| | | | | 9 | | | |
| | 11.9 | 30 | | 10 | X | | |
| | | | | 11 | | | -seepage at 11.5' |
| | | | | 12 | | | |
| | | | | 13 | | | |
| | | | | 14 | | | |
| | 12.6 | 50/4" | | 15 | X | | |
| | | | | 16 | | | |
| | | | | 17 | | | |
| | | | | 18 | | | |
| | | | | 19 | | | |

RB-8-00010287

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A5 |
|---|---|---|---|---|---|

# Boring Log

| Project Name: Point Wells | | | | Sheet 2 of 2 |
|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-2 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±246' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | |
|---|---|---|---|---|---|---|---|
| | 7.4 | 50/5" | | | | SM | Gray silty SAND with gravel, very dense, moist |
| | | | | 21 | | | Boring terminated at 21.0 feet below existing grade. Groundwater seepage encountered at 11.5 feet during drilling. Boring backfilled with bentonite and cuttings. |

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A6 |
|---|---|---|---|---|---|

BORING 10903.GPJ ECI.GDT 3/4/04

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

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## Boring Log

| Project Name: Point Wells | | | | Sheet 1 of 4 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-3 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±160' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

Surface Conditions: Depth of Forest Duff 6"

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | | | | 0 | | SM | Brown silty SAND with gravel, loose to medium dense, moist (Possible Fill) |
| | 5.7 | 20 | | 5 | | | -iron oxide staining<br>-variable silt content |
| | | | | 9 | | SM | Brown silty SAND with gravel, dense, moist |
| | 13.2 | 44 | | 10 | | | |
| | 22.2 | 73 | | 15 | | | -becomes wet, possible seepage |

RB-8-00010289

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A7 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | Sheet 2 of 4 |
|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 |
| Boring No.: B-3 | Drilling Contactor: Boretec | Drilling Method: HSA | Sampling Method: SPT |

Ground Surface Elevation: ±160'

Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | 13.7 | 50/5" | 20–26 | SM | Gray silty SAND with gravel, very dense, moist<br>-contains thin layer of organic matter<br>-iron oxide staining<br>-becomes wet, possible seepage |
| | 27.3 | 21 | | | |
| | | | 26–31 | CL | Gray lean CLAY, stiff, moist |
| | 24.7 | 20 | | | |
| | | | 31–36 | ML | Gray fine sandy SILT, medium dense, wet<br>-possible seepage at 31'<br>-wet<br>-seepage at 35.5' |
| | 31.4 | 16 | | | |
| | | | 36– | SM | Gray silty fine SAND, medium dense, moist |

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A8 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | | Sheet 3 of 4 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-3 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±160' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | 30.3 | 13 | | SM | Gray silty fine SAND, medium dense, moist |
| | | | 41 | ML | Gray SILT, medium dense, moist |
| | | | 42 | | |
| | | | 43 | | |
| | | | 44 | | |
| | 26.9 | 21 | 45 | SM | Gray silty fine SAND, medium dense, moist to wet |
| | | | 46 | | -possible seepage zone |
| | | | 47 | | |
| | | | 48 | | |
| | | | 49 | | |
| | 34.7 | 39 | 50 | | |
| | | | 51 | CL | Gray lean CLAY, stiff, moist |
| | | | 52 | | |
| | | | 53 | | LL=50 PL=23 PI=27 |
| | | | 54 | SM | Gray silty fine SAND, medium dense, wet |
| | 25.7 | 28 | 55 | | |
| | | | | CL | Gray silty CLAY, stiff, moist |
| | | | 56 | ML | Gray SILT, stiff, wet |
| | | | 57 | | |
| | | | 58 | | |
| | | | 59 | | |

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BORING LOG 10903.GPJ ECI.GDT 3/4/04

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A9 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

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# Boring Log

| Project Name: Point Wells | | | | Sheet 4 of 4 |
|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-3 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±160' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | |
|---|---|---|---|---|---|---|---|
| | 33.7 | 59 | | 61 | | ML | Gray SILT, very stiff / hard, moist |
| | | | | | | | Boring terminated at 61.5 feet below existing grade. Groundwater seepage encountered at 15.0, 26.0, 35.5, 46.0 and 55.0 feet during drilling. Boring backfilled with bentonite and cuttings. |

RB-8-00010292

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A10 |
|---|---|---|---|---|---|

BORING LOG 10903.GPJ ECI.GDT 3/4/04

## Boring Log

| Project Name: Point Wells | | | Sheet 1 of 2 |
|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | 
| Boring No.: B-4 | | | |
| Drilling Contactor: Boretec | Drilling Method: HSA | Sampling Method: SPT | |
| Ground Surface Elevation: ±206' | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

Surface Conditions: Depth of Topsoil 6": grass

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | | | 0 | SM | Brown silty SAND with gravel, medium dense, moist |
| | 16.4 | 12 | 5–6 | | -becomes wet, possible seepage |
| | | | 7 | | -gray |
| | 28.2 | 30 | 10–11 | | -wet |
| | 28.6 | 33 | 15–16 | ML | Gray SILT, stiff, moist |
| | | | 17 | | -sand layers |

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A11 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | | Sheet 2 of 2 |
|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-4 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±206' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 28.3 | 39 | | 21, 22, 23, 24 | | CL | Gray lean CLAY, very stiff, moist |
| | 27.0 | 32 | | 25, 26, 27, 28, 29 | | ML | Gray SILT, stiff, moist<br>-wet sand layers |
| | 23.5 | | | 30 | | SP-SM | Gray poorly graded fine SAND with silt, very dense, wet |
| | | 61 | | 31 | | ML | Gray SILT, hard, wet, possible seepage zone |
| | | | | | | | Boring terminated at 31.5 feet below existing grade. Groundwater seepage encountered at 5.0 and 30.0 feet during drilling. Boring backfilled with bentonite and cuttings. |

RB-8-00010294

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A12 |
|---|---|---|---|---|---|

## Boring Log

| Project Name: Point Wells | | | | Sheet 1 of 2 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-5 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±218' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

Surface Conditions: Depth of Topsoil 6": grass

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | | | 0 | SM | Brown silty SAND with gravel, medium dense, moist to wet |
| | 9.8 | 50/5" | 5 | | -very dense |
| | | | 8 | | -gray |
| | 10.6 | 50/5" | 10 | | |
| | 26.5 | 71 | 15 | SP-SM | Brown poorly graded SAND with silt, very dense, wet |
| | | | 15.5 | | -seepage zone |

RB-8-00010295

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A13 |
|---|---|---|---|---|---|

## Boring Log

| Project Name: Point Wells | | | | | Sheet 2 of 2 |
|---|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/9/04 | Completion Date: 2/9/04 | Boring No.: B-5 | |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT | |
| Ground Surface Elevation: ±218' | | Hole Completion: ☐ Monitoring Well | ☐ Piezometer | ☒ Abandoned, sealed with bentonite | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | |
|---|---|---|---|---|---|---|---|
| | 20.9 | 45 | | 21 | | SP-SM | Brown poorly graded SAND with silt, dense, water bearing |
| | | | | | | | Boring terminated at 21.5 feet below existing grade. Groundwater seepage encountered at 15.0 and 20.0 feet during drilling. Boring backfilled with bentonite and cuttings. |

RB-8-00010296

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A14 |
|---|---|---|---|---|---|

# Boring Log

| Project Name: Point Wells | | | | Sheet 1 of 3 |
|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/10/04 | Completion Date: 2/10/04 | Boring No.: B-6 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±186' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Surface Conditions: Depth of Topsoil 6": grass |
|---|---|---|---|---|---|---|---|
| | | | | | | SM | Brown silty fine to medium SAND, medium dense, moist |
| | | | | 1 | | | |
| | | | | 2 | | | |
| | | | | 3 | | | |
| | | | | 4 | | | -contains gravel |
| | 14.3 | 28 | | 5 | | | |
| | | | | 6 | | | |
| | | | | 7 | | | |
| | | | | 8 | | | -variable silt content |
| | | | | 9 | | | |
| | 21.0 | 12 | | 10 | | | -wet<br>-possible seepage zone<br>-17.1% fines |
| | | | | 11 | | | |
| | | | | 12 | | | |
| | | | | 13 | | | |
| | | | | 14 | | | -gray |
| | 27.5 | 14 | | 15 | | CL | Gray lean CLAY, stiff, moist |
| | | | | 16 | | | -sand lenses<br>LL=33 PL=23 PI=10 |
| | | | | 17 | | | |
| | | | | 18 | | | |
| | | | | 19 | | | |

RB-8-00010297

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A15 |
|---|---|---|---|---|---|

BORING LOG 10903.GPJ ECI.GDT 3/4/04

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

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# Boring Log

| Project Name: Point Wells | | | | Sheet 2 of 3 |
|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/10/04 | Completion Date: 2/10/04 | Boring No.: B-6 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±186' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|---|
| | 28.8 | 21 | | 21–24 | ML | Gray SILT, stiff, moist |
| | 28.5 | 29 | | 25–29 | CL | Gray lean CLAY, very stiff, moist<br>-silt lenses |
| | 27.8 | 44 | | 30–34 | ML | Gray SILT, very stiff / hard, wet<br>-seepage zone |
| | 32.0 | 25 | | 35–39 | CL | Gray lean CLAY, stiff, moist |

RB-8-00010298

Earth Consultants Inc.
Geotechnical Engineers, Geologists & Environmental Scientists

**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A16 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | | Sheet 3 of 3 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/10/04 | Completion Date: 2/10/04 | Boring No.: B-6 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±186' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 28.0 | 23 | | 41 | | CL | Gray lean CLAY, stiff, moist |
| | | | | | | | Boring terminated at 41.5 feet below existing grade. Groundwater seepage encountered at 11.0 and 31.0 feet during drilling. 1" PVC Standpipe installed to 41.5 feet. Lower 30.0 - 40.0 feet slotted. Boring backfilled with sand and bentonite. Concrete well cap. |

RB-8-00010299

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A17 |
|---|---|---|---|---|---|

BORING L. 10903.GPJ ECI.GDT 3/4/04

# Boring Log

| Project Name: Point Wells | | | | Sheet 1 of 3 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/10/04 | Completion Date: 2/10/04 | Boring No.: B-7 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±200' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

Surface Conditions: Depth of Topsoil 6": grass

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | | | | | | SM | Brown silty fine to medium SAND. medium dense, moist |
| | | | | 1 | | | |
| | | | | 2 | | | -contains gravel |
| | | | | 3 | | | |
| | | | | 4 | | | |
| | 26.5 | | | 5 | | | |
| | | 14 | | 6 | | ML | Gray brown SILT, stiff, moist |
| | | | | 7 | | | -iron oxide staining |
| | | | | 8 | | | |
| | | | | 9 | | | |
| | 27.4 | | | 10 | | | |
| | | 22 | | 11 | | | -possible seepage zone at 11' |
| | | | | 12 | | | |
| | | | | 13 | | | LL=29 PL=24 PI=5 |
| | | | | 14 | | | |
| | 31.0 | | | 15 | | | |
| | | 25 | | 16 | | | -poorly graded wet sand layer, 4" thick |
| | | | | 17 | | | |
| | | | | 18 | | | RB-8-00010300 |
| | | | | 19 | | | |

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A18 |
|---|---|---|---|---|---|

BORING L 10903.GPJ ECI.GDT 3/4/04

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

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# Boring Log

| Project Name: Point Wells | | | | Sheet 2 of 3 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/10/04 | Completion Date: 2/10/04 | Boring No.: B-7 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±200' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 28.0 | 23 | | 21 | | ML | Gray SILT, stiff, moist |
| | | | | 22 | | | |
| | | | | 23 | | | |
| | | | | 24 | | | |
| | 27.5 | 41 | | 25 | | | |
| | | | | 26 | | | |
| | | | | 27 | | | |
| | | | | 28 | | | |
| | | | | 29 | | | |
| | 29.6 | 35 | | 30 | | | -wet<br>-seepage zone |
| | | | | 31 | | | |
| | | | | 32 | | | |
| | | | | 33 | | | |
| | | | | 34 | | | |
| | 27.6 | 39 | | 35 | | | -wet<br>-with fine sand |
| | | | | 36 | | | |
| | | | | 37 | | | |
| | | | | 38 | | | |
| | | | | 39 | | | |

RB-8-00010301

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A19 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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## Boring Log

| | | | | | |
|---|---|---|---|---|---|
| Project Name: Point Wells | | | | | Sheet 3 of 3 |
| Job No. 10903 | Logged by: SSR | Start Date: 2/10/04 | Completion Date: 2/10/04 | Boring No.: B-7 | |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT | |
| Ground Surface Elevation: ±200' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 29.1 | 28 | | 41 | | CL | Gray lean CLAY, stiff, moist |
| | | | | 42 | | | |
| | | | | 43 | | | |
| | | | | 44 | | | |
| | 26.0 | 28 | | 45 | | | -massive texture |
| | | | | 46 | | | |
| | | | | 47 | | | |
| | | | | 48 | | | |
| | | | | 49 | | | |
| | 28.2 | 25 | | 50 | | | |
| | | | | 51 | | | |
| | | | | | | | Boring terminated at 51.5 feet below existing grade. Groundwater seepage encountered at 11.0 and 30.0 feet during drilling. 1" PVC standpipe installed to 51.5 feet. Lower 30.0 - 40.0 feet slotted. Boring backfilled with sand, bentonite. Concrete well cap. |

RB-8-00010302

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**Boring Log**
Point Wells
Snohomish County, Washington

| | | | | | |
|---|---|---|---|---|---|
| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A20 |

BORING LOG 10903.GPJ ECI.GDT 3/4/04

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

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# Boring Log

| Project Name: Point Wells | | | | Sheet 1 of 2 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/10/04 | Completion Date: 2/10/04 | Boring No.: B-8 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±242' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

Surface Conditions: Depth of Topsoil 6": grass

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | | | 0 | SM | Brown silty fine to medium SAND with gravel, medium dense, moist |
| | 11.8 | 21 | 5 | | -moist to wet |
| | 9.0 | 27 | 10 | SP-SM | Brown poorly graded SAND with silt, medium dense, moist |
| | | | 11 | | -7.3% fines |
| | 11.6 | 50/5" | 15 | SM | Brown silty SAND with gravel, very dense, moist |

RB-8-00010303

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A21 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING_ 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | | | Sheet 2 of 2 |
|---|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/10/04 | Completion Date: 2/10/04 | Boring No.: B-8 | |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT | |
| Ground Surface Elevation: ±242' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 2.0 | 50/5" | | 21 | | SP-SM | Brown poorly graded SAND with silt, very dense, moist |
| | | | | 22 | | | |
| | | | | 23 | | | |
| | | | | 24 | | | |
| | 4.7 | 50/4" | | 25 | | SM | Brown silty SAND with gravel, very dense, moist |
| | | | | 26 | | | |
| | | | | 27 | | | |
| | | | | 28 | | | |
| | | | | 29 | | | |
| | 17.8 | 60 | | 30 | | SP-SM | Brown poorly graded SAND with silt, very dense, wet |
| | | | | 31 | | | -seepage at 30' |
| | | | | | | | Boring terminated at 31.5 feet below existing grade. Groundwater seepage encountered at 30.0 feet during excavation. 1" PVC standpipe installed to 31.5 feet. Lower 10.0 feet slotted. Boring backfilled with sand and bentonite. Concrete well cap. |

RB-8-00010304

BORING 10903.GPJ ECI.GDT 3/4/04

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A22 |
|---|---|---|---|---|---|

## Boring Log

| Project Name: Point Wells | | | | | Sheet 1 of 4 |
|---|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/11/04 | Completion Date: 2/11/04 | Boring No.: B-9 | |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT | |
| Ground Surface Elevation: ±132' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | | |

Surface Conditions: Heavy brush, saplings and blackberry brambles

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | | | 0 | SM | Brown silty SAND with gravel, loose to medium dense, moist |
| | 21.4 | 18 | 5–6.5 | | -gray<br>~wet |
| | 31.3 | 13 | 10–11.5 | ML | Gray SILT, stiff, moist, with sand lenses |
| | | | 11 | CH | Gray fat CLAY, stiff, moist |
| | 40.4 | 11 | 15–16.5 | | LL=64 PL=29 PI=35 |

RB-8-00010305

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A23 |
|---|---|---|---|---|---|



Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

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# Boring Log

| Project Name: Point Wells | | | | Sheet 2 of 4 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/11/04 | Completion Date: 2/11/04 | Boring No.: B-9 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±132' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | 30.4 | 10 | | ML | Gray SILT, stiff, wet |
| | | | 21 | SP-SM | Gray poorly graded very fine SAND with silt, medium dense, wet<br>-seepage at 21' |
| | 28.6 | 20 | 25 | | |
| | 29.0 | 22 | 30 | | |
| | | | 31 | ML | Gray fine sandy SILT, medium dense, moist to wet |
| | 29.8 | 20 | 35 | CL | Gray lean CLAY, stiff, moist |
| | | | 36 | SP-SM | Gray poorly graded fine SAND with silt, medium dense, wet<br>-seepage at 36' |

RB-8-00010306

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A24 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | | Sheet 3 of 4 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/11/04 | Completion Date: 2/11/04 | Boring No.: B-9 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±132' | | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 33.0 | 19 | | | | SM | Gray silty fine SAND, medium dense, wet |
| | | | | 41 | | | |
| | | | | 42 | | | -seepage zone, 62.2% fines |
| | | | | 43 | | | |
| | | | | 44 | | | |
| | 30.4 | 24 | | 45 | | | -silt and clay layers |
| | | | | 46 | | | -wet |
| | | | | 47 | | | |
| | | | | 48 | | | |
| | | | | 49 | | | |
| | 30.1 | 14 | | 50 | | | -wet |
| | | | | 51 | | | -clay layer |
| | | | | 52 | | | |
| | | | | 53 | | | |
| | | | | 54 | | | |
| | 38.2 | 26 | | 55 | | | |
| | | | | 56 | | CL | Gray lean CLAY, stiff, moist, with silt and sand lenses |
| | | | | 57 | | | |
| | | | | 58 | | | |
| | | | | 59 | | | |

RB-8-00010307

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A25 |
|---|---|---|---|---|---|



BORING LOG 10903.GPJ ECI.GDT 3/4/04

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## Boring Log

| Project Name: Point Wells | | | Sheet 4 of 4 |
|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/11/04 | Completion Date: 2/11/04 |
| Boring No.: B-9 | Drilling Contactor: Boretec | Drilling Method: HSA | Sampling Method: SPT |
| Ground Surface Elevation: ±132' | Hole Completion: ☐ Monitoring Well ☐ Piezometer ☒ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 30.5 | 24 | | 61 | | CL | Gray lean CLAY, stiff, moist, with sand lenses |
| | | | | | | | Boring terminated at 61.5 feet below existing grade. Groundwater seepage encountered at 21.0, 36.0 and 40.0 feet during drilling. Boring backfilled with bentonite and cuttings. |

RB-8-00010308

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A26 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | Sheet 1 of 3 |
|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/11/04 | Completion Date: 2/11/04 | Boring No.: B-10 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±142' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

Surface Conditions: Heavy brush, saplings and blackberry brambles

| General Notes | W (%) | No. Blows Ft. | Depth Ft. | USCS Symbol | Description |
|---|---|---|---|---|---|
| | | | 0 | SM | Brown silty fine SAND with gravel, medium dense, wet |
| | 23.0 | 16 | 5–6 | | -gray<br>-wet, seepage zone, 17.8% fines |
| | 23.5 | 16 | 10–11 | ML | Gray fine sandy SILT, medium dense, moist<br><br>-sand lenses |
| | 39.4 | 12 | 15–16 | CL | Gray lean CLAY, stiff, moist<br><br>-massive texture<br><br>LL=35 PL=22 PI=13 |

RB-8-00010309

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A27 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | | Sheet 1 of 3 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/11/04 | Completion Date: 2/11/04 | Boring No.: B-10 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±142' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

Surface Conditions: Heavy brush, saplings and blackberry brambles

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | | | | 0 | | SM | Brown silty fine SAND with gravel, medium dense, wet |
| | 23.0 | 16 | | 5 | X | | -gray<br>-wet, seepage zone, 17.8% fines |
| | 23.5 | 16 | | 10 | X | | |
| | | | | 11 | | ML | Gray fine sandy SILT, medium dense, moist<br><br>-sand lenses |
| | 39.4 | 12 | | 15 | X | CL | Gray lean CLAY, stiff, moist<br><br>-massive texture<br><br>LL=35 PL=22 PI=13 |

RB-8-00010309

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A27 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING LOG 10903.GPJ ECI.GDT 3/4/04

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# Boring Log

| Project Name: Point Wells | | | | Sheet 2 of 3 |
|---|---|---|---|---|
| Job No.: 10903 | Logged by: SSR | Start Date: 2/11/04 | Completion Date: 2/11/04 | Boring No.: B-10 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±142' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | Description |
|---|---|---|---|---|---|---|---|
| | 41.1 | 11 | | 21 | | ML | Gray fine sandy SILT, medium dense, moist |
| | | | | 22 | | | |
| | | | | 23 | | | |
| | | | | 24 | | | |
| | 31.5 | 31 | | 25 | | SM | Gray silty fine SAND, dense, wet |
| | | | | 26 | | | -seepage zone |
| | | | | 27 | | | |
| | | | | 28 | | | |
| | | | | 29 | | | |
| | 31.9 | 25 | | 30 | | | -wet |
| | | | | 31 | | | |
| | | | | 32 | | | |
| | | | | 33 | | | |
| | | | | 34 | | | |
| | 23.8 | 50/6" | | 35 | | | |
| | | | | 36 | | | |
| | | | | 37 | | | |
| | | | | 38 | | | |
| | | | | 39 | | | |

RB-8-00010310

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A28 |
|---|---|---|---|---|---|

BORING 10903.GPJ ECI.GDT 3/4/04

# Boring Log

| Project Name: Point Wells | | | | Sheet 3 of 3 |
|---|---|---|---|---|
| Job No. 10903 | Logged by: SSR | Start Date: 2/11/04 | Completion Date: 2/11/04 | Boring No.: B-10 |
| Drilling Contactor: Boretec | | Drilling Method: HSA | | Sampling Method: SPT |
| Ground Surface Elevation: ±142' | | Hole Completion: ☐ Monitoring Well ☒ Piezometer ☐ Abandoned, sealed with bentonite | | |

| General Notes | W (%) | No. Blows Ft. | Graphic Symbol | Depth Ft. | Sample | USCS Symbol | |
|---|---|---|---|---|---|---|---|
| | 38.1 | 20 | | 41 | | CL | Gray lean CLAY, stiff, moist, massive, occasional sand lens |
| | | | | | | | Boring terminated at 41.5 feet below existing grade. Groundwater seepage encountered at 5.0 and 26.0 feet during drilling. 1" PVC standpipe installed to 41.5 feet. Lower 20.0 - 30.0 feet slotted. Boring backfilled with sand and bentonite. Concrete well cap. |

RB-8-00010311

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**Boring Log**
Point Wells
Snohomish County, Washington

| Proj. No. 10903 | Dwn. GLS | Date Mar. 2004 | Checked RAC | Date 3/4/04 | Plate A29 |
|---|---|---|---|---|---|

Subsurface conditions depicted represent our observations at the time and location of this exploratory hole, modified by engineering tests, analysis and judgment. They are not necessarily representative of other times and locations. We cannot accept responsibility for the use or interpretation by others of information presented on this log.

BORING 10903.GPJ ECI.GDT 3/4/04

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| | |
|---|---|
| **Project: King County WTD / Brightwater Conveyance System**<br>**Project Location: King & Snohomish Counties, Washington**<br>**Contract Number: E23007E** | **Log of Boring E-101**<br>Sheet 1 of 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date(s) Drilled | **3/19/03 - 3/20/03** | Geotechnical Consultant | **Camp Dresser & McKee Inc.** | Logged By | **SHE/TCB** | Checked By | **VJP 02-03-04** |
| Drilling Method/Rig Type | **Roto-Sonic/Mud Rotary/ T3** | Drilling Contractor | **Cascade Drilling, Inc.** | Total Depth of Borehole | **140.0 feet** | | |
| Casing Size/Type | **6"/4"** | Hammer Weight/Drop (lbs/in.) | **300# / 30"** | Ground Surface Elevation/Datum | **131.2 feet / Metro** | | |
| Location | **NW Richmond Beach Dr and 205th St** | Coordinates | **N 287747 E 1256907** | Elevation Source | **Survey** | | |

| Elevation, feet | Depth, feet | SAMPLES Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | NA | 10 Inches Asphaltic Concrete Pavement | | | | |
| 130 | | | | | | | GW | Sandy GRAVEL (GW) and cobbles **(af)** | | | | |
| 125 | 5 | | | | | | | | | | | |
| | | | | | | | SP-SM | Medium dense, olive gray, wet, slightly silty SAND (SP-SM), trace rounded gravel, poorly-graded, homogeneous **(Qpfnf)** | | | | Logged from cuttings to 20 ft bgs |
| 120 | 10 | | | | | | | | | | | |
| 115 | 15 | | | | | | | | | | | |
| 110 | 20 | ■ | 1 | 10 - 17 - 19 (36) | 67 | | | | | M,SA | | |
| | 25 | | | | | | | | | | | |

**Groundwater Observation Data:**

OW (FT BGS): 34.0 (Low) 26.8 (High)

**Remarks:** Negative Groundwater Data indicates measurements above Ground Surface

Recovery values > 100 indicate sample expansion during sampling.



CDM

| Project: King County WTD / Brightwater Conveyance System<br>Project Location: King & Snohomish Counties, Washington<br>Contract Number: E23007E | Log of Boring E-101<br>Sheet 2 of 5 |
|---|---|

| Elevation, feet | Depth, feet | Samples: Type | Samples: Number | Samples: Blows / 6 in. (N) | Samples: Recovery, % | Samples: Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | | | | | | | | | | | |
| 105 | | | | | | | | | | | | |
| | 30 | | | | | | | | | | | |
| 100 | | | | | | | | | | | | |
| | 35 | | | | | | | | | | | |
| 95 | | | | | | | | | | | | |
| | 40 | | 2 | 7 - 24 - 30 (54) | 78 | | | | | | | |
| 90 | | | | | | | | | | | | |
| | 45 | | | | | | | | | | | |
| 85 | | | | | | | | | | | | |
| | | | | | | | | Layers of brown, silty sand, occasional organics | | | | |
| | 50 | | | | | | | | | | | |
| 80 | | | | | | | | | | | | |
| | | | | | | | SM | Medium dense, olive gray, wet, very silty SAND (SM), fine sand, occasional organics **(Qpfnf)** | | | | |
| | 55 | | 3 | 3 - 5 - 15 (20) | 28 | | | | | M,SA | | |
| 75 | | | | | | | | | | | | |
| | | | | | | | | Scattered strata of dense sand and sandy silt up to 2 feet thick | | | | |
| | 60 | | | | | | | | | | | |

| Project: King County WTD / Brightwater Conveyance System<br>Project Location: King & Snohomish Counties, Washington<br>Contract Number: E23007E | **Log of Boring E-101**<br>Sheet 3 of 5 |
|---|---|

| Elevation, feet | Depth, feet | Sample Type | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 60 | | 4 | 10 - 22 - 30 (52) | 67 | | | M,SA DD | | |
| 65 | 65 | | 5 | 25 - 18 - 24 (42) | 89 | ML | Hard, olive gray, moist, SILT (ML), nonplastic to low plasticity, rapid dilatancy, occasional organics as partings **(Qpfnl)** | | | Sample has organic odor |
| 60 | 70 | | 6 | 12 - 19 - 36 (55) | 89 | SM | Very dense, olive gray, wet, silty SAND (SM), fine sand, scattered organics **(Qpfnf)** | M,SA | | Slight organic odor |
| 55 | 75 | | 7 | 9 - 15 - 20 (35) | 100 | ML | Hard, olive gray, moist to wet, SILT (ML), trace clay, low plasticity, slow dilatancy, laminated to stratified, scattered organics **(Qpfnl)** | MP | | |
| 50 | 80 | | 8 | 17 - 50 50 | 50 | GW | Very dense, gray green, wet, very sandy GRAVEL (GW), well-graded fine to coarse gravel, subangular to rounded **(Qpfnf)** | M,SA | | |
| 45 | 85 | | 9 | 4 - 21 - 50/4" (100+) | 50 | | Scattered cobbles | | | Rough drilling; based on drilling behavior, cobble zone from 84 to 93 ft bgs |
| 40 | 90 | | 10 | 5 - 38 - 50/5" (100+) | 36 | | | | | |
| | 95 | | | | | | Transitions trace fine sand, trace silt, rounded | | | |

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CDM

**Project:** King County WTD / Brightwater Conveyance System
**Project Location:** King & Snohomish Counties, Washington
**Contract Number:** E23007E

# Log of Boring E-101



| Elevation, feet | Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|
| | 95 | 11 | 11 - 50/6" (100+) | 50 | | gravel | | |
| -35 | | | | | | | | |
| -30 | 100 | | | | | | | |
| | | | | | | Scattered cobbles and occasional thin sand layers | | Cobble zone from 102 to 105 feet bgs |
| | 105 | | | | SP-SM | Dense, gray green, moist, very gravelly SAND (SP-SM), trace silt, poorly-graded fine to coarse gravel, angular to subangular **(Qpfnf)** | | |
| -25 | | | | | | Transitions very sandy grvel | M,SA | Switch to Roto-Sonic drilling at 107 ft bgs due to loss of circulation in mud rotary |
| | 110 | | | | SW | Dense, gray green, moist, very gravelly SAND (SW), well-graded fine to coarse sand **(Qpfnf)** | | |
| -20 | | 12 | | 80 | | | | |
| -15 | 115 | | | | | | | |
| | | | | | | Transitions slightly gravelly sand | | |
| | 120 | | | | | Transitions fine gravelly sand, trace coarse gravel | | |
| -10 | | 13 | | 50 | | | | |
| | | | | | | Transitions very gravelly sand<br>Transitions very fine to coarse sandy, fine gravel | BG | |
| | 125 | | | | | | | Drilling action indicates heave below 125 ft bgs, possibly due to tidal influences |
| -5 | | | | | | Layer fine to medium sand | | |
| | 130 | | | | | | | |



CDM

| Project: King County WTD / Brightwater Conveyance System | Log of Boring E-101 |
|---|---|
| Project Location: King & Snohomish Counties, Washington | Sheet 5 of 5 |
| Contract Number: E23007E | |

| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 130 | | 14 | | 75 | | | | | | | |
| 0 | | | | | | | | Interbed of coarse gravel | | | | |
| | | | | | | | SW-SM | Dense, gray green, moist, sightly gravelly SAND (SW-SM), trace silt, trace coarse sand, well-graded fine to medium sand **(Qpfnf)** | | | | |
| | 135 | | | | | | | Transistions gravelly to very gravelly | | | | |
| -5 | | | | | | | | Transitions trace gravel, occasional fine organics | | | | |
| | | | 15 | | 98 | | | | | | | |
| | | | | | | | | | | M,SA | | |
| | 140 | | | | | | | Terminated boring at 140 feet below ground surface | | | | |
| -10 | | | | | | | | | | | | |
| | 145 | | | | | | | | | | | |
| -15 | | | | | | | | | | | | |
| | 150 | | | | | | | | | | | |
| -20 | | | | | | | | | | | | |
| | 155 | | | | | | | | | | | |
| -25 | | | | | | | | | | | | |
| | 160 | | | | | | | | | | | |
| -30 | | | | | | | | | | | | |
| | 165 | | | | | | | | | | | |



CDM

| Project: King County WTD / Brightwater Conveyance System<br>Project Location: King & Snohomish Counties, Washington<br>Contract Number: E23007E | **Log of Boring E-102**<br>Sheet 1 of 8 |
|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date(s) Drilled | 3/3/03 - 3/6/03 | Geotechnical Consultant | Camp Dresser & McKee Inc. | Logged By | SHE | Checked By | VJP 02-03-04 |
| Drilling Method/Rig Type | Mud Roatry/ Porta-drill | Drilling Contractor | Gregory Drilling, Inc. | Total Depth of Borehole | 270.0 feet | | |
| Casing Size/Type | PQ (7"O.D.) | Hammer Weight/Drop (lbs/in.) | 300# / 30" | Ground Surface Elevation/Datum | 291.2 feet / Metro | | |
| Location | NE 205th St/50' W of 26th Ave W | Coordinates | N 287608 E 1258098 | Elevation Source | Survey | | |

| Elevation, feet | Depth, feet | SAMPLES Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | NA | Crushed rock | | | | |
| 290 | | | | | | | SM | Medium dense, brown, wet, silty SAND (SM), trace fine to coarse rounded gravel, fine to medium sand, homogeneous with gravel scattered at random **(Qvt)** | | | | Soil description inferred from drill action and cuttings |
| | | | | | | | SP-SM | Medium dense, brown, saturated slightly silty SAND (SP-SM), poorly-graded trace gravel **(Qva)** | | | | Flowing and caving sand |
| 285 | 5 | | | | | | | | | | | |
| 280 | 10 | | | | | | | Transitions to gravelly sand, fine to coarse grained, subrounded to rounded | | | | |
| 275 | 15 | | | | | | GW | Dense, brown, wet GRAVEL (GW), trace clay (most matrix washed out), trace sand, well-graded medium plasticity, clay gravel fine to coarse, rounded to subangular, varied lithology-mostly volcanics and quartz **(Qva)** | | | | Gravelly drilling last 5 to 7 feet |
| 270 | 20 | | 1 | 1 - 7 - 23 (30) | 67 | | | | | | | |
| | 25 | | | | | | | | | | | |

**Groundwater Observation Data:**

| | Low | High |
|---|---|---|
| OW (FT BGS): | 135.8 (Low) | 134.6 (High) |
| VWP 1 (FT BGS): | 189.5 (Low) | 185.2 (High) |

**Remarks:** Negative Groundwater Data indicates measurements above Ground Surface
Recovery values > 100 indicate sample expansion during sampling.

| Project: King County WTD / Brightwater Conveyance System | **Log of Boring E-102** |
|---|---|
| Project Location: King & Snohomish Counties, Washington | Sheet 2 of 8 |
| Contract Number: E23007E | |

| Elevation, feet | Depth, feet | Sample Type | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|
| 265 | 25 | | | | | | | | | |
| | ~27.5 | | | | | SP | Dense dark gray, wet, SAND (SP), fine beds laminated (<1 mm), coarser thin beds (1-3 mm), laminated beds folded-interbeds 3-5 cm **(Qva)** | | | Inferred from drill action and cuttings |
| 260 | 30 | | | | | | | | | |
| | ~33 | | | | | | | | | Quiet, rapid drilling |
| | 35 | | | | | SM | Silty SAND (SM), fine sand **(Qva)** | | | |
| 255 | | | | | | | | | | Washing hole for extended period-abundant silty fine sand |
| | ~39 | | | | | ML | Very stiff to hard, dark gray, wet, SILT (ML), low plasticity, rapid dilatancy, laminated beds (1-3 mm), folded-interbeds 1 to 2 inch thick **(Qvlc)** | | | |
| 250 | 40 | ■ | 2 | 8 - 13 - 25 (38) | 72 | | | MP | | |
| 245 | 45 | | | | | | | | | |
| 240 | 50 | | | | | | | | | |
| | ~51.5 | | | | | CL | Hard, olive gray, dry to moist, silty CLAY (CL), medium plasticity, laminated (<1 mm) to layered (10 mm), interbedded strata of silt to 2 feet thick **(Qvlc)** | | | Driller reports clayey bed from 52 to 57 feet |
| 235 | 55 | | | | | | | | | |
| | 60 | | | | | | | | | |

| Elevation, feet | Depth, feet | SAMPLES Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 | | 3 | 11 - 13 - 19 (32) | 78 | | | Slickensides, sand folds | | | | |
| 230 | | | | | | | | | | | | |
| | 65 | | | | | | | | | | | |
| 225 | | | | | | | SP | Dense, dark gray, wet SAND (SP), trace silt, poorly-graded indistinctly bedded to massive **(Qpfnf)** | | | | Even, rapid to medium drilling, driller reports silty |
| | 70 | | | | | | | | | | | |
| 220 | | | | | | | | | | | | |
| | 75 | | | - | | | | | | | | |
| 215 | | | | | | | | | | | | |
| | 80 | | 4 | 13 - 18 - 19 (37) | 78 | | | | | BG | | Soil resistance to drilling is consistent |
| 210 | | | | | | | | | | | | |
| | 85 | | | | | | | | | | | |
| 205 | | | | | | | | | | | | |
| | 90 | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| | 95 | | | | | | | | | | | |

| Elevation, feet | Depth, feet | Samples: Type | Samples: Number | Samples: Blows / 6 in. (N) | Samples: Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 95 | | | | | | | | | | | |
| 195 | | | | | | | | | | | | |
| | | | | | | | | Transitions to gray purple | | | | |
| | 100 | | 5 | 13 - 13 - 14 (27) | | | CL | Very stiff, olive gray and gray purple, dry to moist, silty CLAY (CL), medium plasticity, no dilatancy, laminated and layered, with silt and silty sand **(Qpfnl)** | | MP | | |
| 190 | | | | | | | | | | | | |
| | 105 | | | | | | | | | | | |
| 185 | | | | | | | | | | | | |
| | 110 | | | | | | | | | | | |
| 180 | | | | | | | | | | | | |
| | 115 | | | | | | SP | Very dense, olive gray, moist SAND (SP), trace silt, poorly-graded fine sand, homogeneous, subangular to subround **(Qpfnf)** | | | | 30% quartz, 70% green and dark gray volcanics |
| 175 | | | | | | | | | | | | |
| | 120 | | 6 | 21 - 33 - 44 (77) | 100 | | | | | BG | | |
| 170 | | | | | | | | | | | | |
| | 125 | | | | | | | | | | | |
| 165 | | | | | | | | | | | | |
| | 130 | | | | | | | | | | | |

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

# Log of Boring E-102



| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|
| 160 | 130 | | | | | | | | | Smooth, quiet, firm drilling, driller reports sandy |
| 155 | 135 | | | | | SM | Very dense, olive gray, dry to moist, SILTY SAND (SM) **(Qpfnf)** | | | |
| 150 | 140 | | 7 | 17 - 26 - 34 (60) | 100 | | | BG | | Quartz to 60 to 70% |
| 145 | 145 | | | | | | | | | Consistant soil resistance to drilling |
| 140 | 150 | | | | | | | | | No sample taken, drilling action suggests sand |
| 135 | 155 | | | | | ML | Hard, olive gray, moist, sandy SILT (ML), fine sand **(Qpfnf)** | | | |
| 130 | 160 | | 8 | 21 - 32 - 40 (72) | 100 | | | M,SA DD | | Consistent soil resistance to drilling |
| | 165 | | | | | | | | | |



CDM

| Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|
| 170 | 9 | 11 - 20 - 39 (59) | 89 | ML | Hard, gray olive, dry to moist, slightly clayey SILT (ML), medium plasticity, no dilatancy, homogeneous, with possible occasional parting along bedding, occasional small organics especially at top - one reed blade **(Qpfnl)** | AD,MP | 170 ft bgs, conventional radiocarbon date 19,310 +/- 100 years B.P. |
| | | | | SW-SM | Very dense, olive gray to gray purple, moist, slightly silty SAND (SW-SM), well-graded fine to medium sand, with occasional clear laminate, grains dark gray volcanics and quartz, silt interbeds as partings to layers from 183 to 187 feet bgs, silt with greenish tint **(Qpfnf)** | | |
| 175 | 10 | 30 - 41 - 50/5" (100+) | 100 | | | M,SA DD | |
| 180 | 11 | 50/6" | 83 | | Gray purple, clean, subrounded | M,SA | Irregular drilling resistance due to gravel |
| | | | | | Occasional organics | | |
| 185 | 12 | 25 - 36 - 34 (70) | 100 | | | | |
| | | | | SP-SM | Very dense, gray purple, moist slightly silty SAND (SP-SM), poorly-graded fine to coarse, homogeneous, subangular to subrounded **(Qpfnf)** | | Quartz 60%, volcanics 40% |
| 190 | 13 | 30 - 40 - 50 (90) | 89 | | | M,SA DD | Consistant soil resistance to drilling |
| | | | | | Trace fine gravel | | |
| 195 | 14 | 50/6" | 100 | | | M,DD BG | |
| | | | | SP | Very dense, olive gray, moist SAND (SP), trace silt, fine to medium, indistinctly laminated, trace fine rounded gravel in layers **(Qpfnf)** | | |

Elevation scale: 125 (at ~166 ft depth), 120, 115, 110, 105, 100, 95. Depth 165 to 200.

| Project: King County WTD / Brightwater Conveyance System | Log of Boring E-102 |
|---|---|
| Project Location: King & Snohomish Counties, Washington |  |
| Contract Number: E23007E | |

| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 200 | | 15 | 50/6" | 100 | | | | | | |
| 90 | | | | | | | | | | | |
| | 205 | | 16 | 29 - 23 - 34 (57) | 100 | | | | | | |
| 85 | | | | | | | 6-Inch layer of gray olive, moist silt at 206 feet bgs, contact sharp, with fibrous organics along contact | | | | |
| | | | | | | SW | Very dense, olive gray to gray purple, wet, gravelly SAND (SW), well-graded fine to coarse grained, subangular to subrounded, gravel fine, rounded, tabular, well graded **(Qpfnf)** | | | | |
| | 210 | | 17 | 50/5" (100+) | 67 | | | | | | |
| 80 | | | | | | | | | | | |
| | | | | | | GW | Very dense, olive gray, wet, sandy GRAVEL (GW), well-graded fine to coarse gravel , subrounded **(Qpfnf)** | | | | Gravel predominantly fine grained volcanics |
| | 215 | | 18 | 50/3" (100+) | 67 | | | | | | |
| 75 | | | | | | | | | | | |
| | | | | | | | | | | | Irregular drilling resistance due to gravel |
| | 220 | | 19 | 30/0" | | | | | | | No penetration - 30-plus blows, stopped drive to save sampler |
| 70 | | | | | | | | | | | |
| | | | | | | SP-SM | Very dense, gray green, moist, slightly silty SAND (SP-SM), poorly-graded fine to medium sand, trace gravels, parting along indistinct bedding planes **(Qpfnf)** | | | | 70% white to green subangular to subround quartz, 30% dark gray subrounded volcanics. |
| | 225 | | 20 | 50/6" | 100 | | | | M,SA | | |
| 65 | | | | | | | | | | | |
| | | | | | | CL | Hard, olive gray, moist, silty CLAY (CL), medium plasticity, slow dilatancy, scattered fibrous organics **(Qpfnl)** | | | | Inferred from drill action and cuttings |
| | 230 | | 21 | 20 - 38 - 50/4" (100+) | 81 | ML | Hard, gray green, moist, sandy SILT (ML), nonplastic, rapid dilatancy, laminated at contact, scattered organics **(Qpfnl)** | | | | |
| 60 | | | | | | | | | | | |
| | 235 | | | | | | | | | | |



CDM

**Project:** King County WTD / Brightwater Conveyance System
**Project Location:** King & Snohomish Counties, Washington
**Contract Number:** E23007E

# Log of Boring E-102



| Depth, feet | Elevation, feet | Sample Type | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|
| 235 | | | 22 | 50/6" | 100 | | | M,SA MP | | |
| | 55 | | | | | | | | | |
| 240 | | | 23 | 20 - 21 - 31 (52) | 89 | | | | | |
| | 50 | | | | | | Scattered fibrous organics in fine beds, abundant peaty organics in tip, trace clay | | | |
| 245 | | | 24 | 15 - 27 - 30 (57) | 89 | | Red brown | MP,BG | | |
| | 45 | | | | | | | | | Gravel causing sampler bounce |
| 250 | | | 25 | 50/3" (100+) | 100 | | | | | At 250 ft bgs; Sharp oil layer contact, sandy silty, over gravel in smpler shoe |
| | 40 | | | | | GW | Very dense, gray green, wet GRAVEL (GW), trace silt/sand matrix, well-graded clast supported fine to coarse gravel, rounded to subrounded, clay coating on clasts **(Qpfnf)** | | | Drilling resistance due to gravel |
| 255 | | | 26 | | 0 | | | | | 6 inches of slough in ring |
| | 35 | | | | | | | | | |
| 260 | | | 27 | 50/1" (100+) | 104 | | | | | Boirng sloughed approximately 9 inches |
| | 30 | | | | | | | | | Continued drilling resistance to gravel |
| 265 | | | | | | | | | | |
| | 25 | | | | | | Boring terminated at 270 feet below ground surface | | | Hole stopped at 270 feet due to gravel slough and mud loss |
| 270 | | | | | | | | | | |

CDM

**Project:** King County WTD / Brightwater Conveyance System
**Project Location:** King & Snohomish Counties, Washington
**Contract Number:** E23007E

# Log of Boring E-201



| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | 4/17/03 - 4/22/03 | Geotechnical Consultant | Camp Dresser & McKee Inc. | Logged By: JAP | Checked By: VJP 02-03-04 |
| Drilling Method/Rig Type | Roto-Sonic/ | Drilling Contractor | Cascade/Boart-Longyear | Total Depth of Borehole | 242.0 feet |
| Casing Size/Type | 9"/6"/4"/Telescoping | Hammer Weight/Drop (lbs/in.) | N/A | Ground Surface Elevation/Datum | 260.6 feet / Metro |
| Location | 20425 25th Ave NW | Coordinates | N 287564 E 1257757 | Elevation Source | Survey |

| Elevation, feet | Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|
| 260 | 0 | | | | | | | | 0 to 6 ft bgs excavated with vacuum truck, not sampled |
| 255 | 5–9 | | | | GM | Loose, brown, wet, silty, slightly sand GRAVEL (GM) poorly-graded **(af)** | | | |
| 250 | 10 | 1 | | 52 | SP | Medium dense, olive gray, wet SAND (SP), trace gravel, trace silt, poorly-graded fine to medium sand **(Qva)** | | | |
| 245 | 15 | | | | | 4-Inch thick silty sand layer | | | |
| 240 | 20 | 2 | | 95 | | | | | |
| | 22 | | | | ML | Very stiff, gray, moist SILT (ML), trace sand, trace organics, frequent partings, sandy seams **(Qvlc)** | M | | |
| | 25 | | | | | | | | |

**Groundwater Observation Data:**

OW (FT BGS): 159.1 (Low) 155.9 (High)

**Remarks:** Negative Groundwater Data indicates measurements above Ground Surface
Recovery values > 100 indicate sample expansion during sampling.



CDM

| Project: King County WTD / Brightwater Conveyance System<br>Project Location: King & Snohomish Counties, Washington<br>Contract Number: E23007E | **Log of Boring E-201**<br>Sheet 2 of 8 |
|---|---|

| Elevation, feet | Depth, feet | Samples: Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|
| 235 | 25 | | | | | Sand-filled vertical fractures 26 to 27.5 ft bgs, trace brown organics in sand seams | M | | |
| 230 | 30 | 3 | | 105 | ML | Hard, gray, moist SILT (ML), trace sand, horizontal laminations **(Qpfnl)** | | | |
| 225 | 35 | | | | | Grades very stiff, slickensides | M | | |
| | | 4 | | 73 | | | M | | |
| 220 | 40 | | | | | Grades hard | | | |
| 215 | 45 | 5 | | 99 | | | M | | |
| | | | | | | Grades to clayey | | | |
| 210 | 50 | | | | CL | Hard, gray, moist CLAY (CL), silt layers up to 3 inches thick, slickensides **(Qpfnl)** | | | |
| | | 6 | | 105 | | | M | | |
| 205 | 55 | | | | ML | Soft to very stiff, gray, wet, very sandy SILT (ML), trace clay, occasional organics, layered silty, fine sand layers **(Qpfnl)** | | | Sample disturbed |
| | 60 | | | | | | | | |

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CDM

| Project: King County WTD / Brightwater Conveyance System<br>Project Location: King & Snohomish Counties, Washington<br>Contract Number: E23007E | **Log of Boring E-201**<br>Sheet 3 of 8 |
|---|---|

| Elevation, feet | Depth, feet | SAMPLES: Type | SAMPLES: Number | SAMPLES: Blows / 6 in. (N) | SAMPLES: Recovery, % | SAMPLES: Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| | 65 | | | | | | | | | | | |
| 195 | | | 7 | | 102 | | | Interbedded silt and clay 66 to 68 ft bgs with slickensides at boundaries | | | | |
| | | | | | | | | 3-inch layer silty clay | | | | |
| | 70 | | | | | | | Grades hard, moist, slightly clayey | | | | |
| 190 | | | | | | | | | | | | |
| | | | | | | | | 7-inch thick layer fine sand | | | | |
| | 75 | | | | | | | | | M | | |
| 185 | | | | | | | SM | Dense, gray, wet, silty SAND (SM), trace clay, fine sand **(Qpfnf)** | | | | |
| | | | 8 | | 98 | | CL | Hard, gray, moist, silty CLAY (CL), trace sand, slickensides **(Qpfnl)** | | | | |
| | 80 | | | | | | | Frequent slickensides 80 to 90 ft bgs | | | | |
| 180 | | | | | | | | | | | | |
| | 85 | | 9 | | 92 | | | | | | | |
| 175 | | | | | | | | | | | | |
| | 90 | | | | | | | | | | | |
| 170 | | | | | | | ML | Very stiff, olive gray, wet, very sandy SILT (ML), rapid dilatancy, scattered organics **(Qpfnl)** | | | | |
| | | | 10 | | 42 | | | | | M | | |
| | 95 | | | | | | | | | | | |

| Project: King County WTD / Brightwater Conveyance System | **Log of Boring E-201** |
|---|---|
| Project Location: King & Snohomish Counties, Washington | Sheet 4 of 8 |
| Contract Number: E23007E | |

| Elevation, feet | Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|
| 165 | 95 | | | | CL | Hard, gray, moist, silty CLAY (CL), trace sand, slickensides **(Qpfnl)** | M | | |
| 160 | 100 | 11 | | 88 | SM | Dense, gray, wet, silty SAND (SM), trace clay, scattered organics **(Qpfnf)** | | | |
| 155 | 105 | | | | CL | Hard, gray, moist, slightly silty CLAY (CL), slickensides **(Qpfnl)** | M | | |
| | | | | | | Grades silty clay | | | |
| 150 | 110 | 12 | | 110 | SP-SM | Dense, gray, wet, slightly silty SAND (SP-SM), trace clay, poorly-graded fine to medium sand, micaceous **(Qpfnf)** | | | |
| 145 | 115 | | | | | 1-foot layer of silty clay | | | |
| | | | | | | Organic odor, trace organics | | | |
| 140 | 120 | 13 | | 112 | CL | Hard, gray, moist, silty CLAY (CL) **(Qpfnl)** | M | | |
| | | | | | SP | Dense, gray, moist SAND (SP), trace silt, poorly-graded fine to medium sand **(Qpfnf)** | | | |
| 135 | 125 | | | | | Trace fine gravel, subangular to subrounded | | | |
| | | | | | | Trace clay, clay has black organic streaks, organic smell | | | |
| | 130 | | | | | | | | |

| Elevation, feet | Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|
| 130 | 130 | 14 | | 89 | | | | | |
| 125 | 135 | | | | | 136 to 146 ft bgs, sand cleaner, trace silt, fine to coarse gravel content increasing, gravel subrounded | | | |
| 120 | 140 | 15 | | 89 | | | M,SA | | |
| 115 | 145 | | | | | Grades gravelly sand 147 to 152 ft bgs, gravel subangular to subrounded, granitic matrix | M,SA | | |
| 110 | 150 | 16 | | 96 | | Grades to trace gravel, 152 to 156 ft bgs | | | |
| 105 | 155 | | | | SW-SM | Dense, gray, moist, gravelly, slightly silty to silty SAMD (SW-SM), well-graded fine to coarse sand **(Qpfnf)** | M,SA | | |
| 100 | 160 | 17 | | 80 | | | | | |
| | 165 | | | | | | | | |

| Elevation, feet | Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|
| 95 | 165 | | | | | | M,SA | | |
| | | | | | | Grades to gravelly, wet | | | |
| 90 | 170 | 18 | | 34 | | | | | |
| | | | | | | Layers of brown, sandy silt up to 4 inches thick 173 to 176 ft bgs | | | |
| 85 | 175 | | | | GP | Dense, gray, wet, very sandy GRAVEL (GP), trace silt, poorly-graded, fine to coarse gravel, fine to coarse sand **(Qpfnf)** | | | |
| | | | | | SP | Dense, gray, wet, slightly gravelly SAND (SP), trace silt, poorly-graded fine to medium sand **(Qpfnf)** | | | |
| 80 | 180 | | | | | Grades to slightly silty | | | |
| 75 | 185 | 19 | | 71 | | 4-inch peat layer | | | |
| 70 | 190 | | | | | Sand grades finer, siltier | | | |
| | | | | | SM | Dense, gray, wet, silty SAND (SM), trace fine gravel, frequent organics **(Qpfnf)** | M | | |
| | | | | | PT | Hard, dark brown, moist PEAT (PT), layers of hard, gray olive, moist, clayey SILT (ML) **(Qpfnw)** | | | |
| 65 | 195 | | | | | | M,OC | | |
| | | | | | ML | Very stiff, gray olive, wet, sandy, slightly clayey SILT (ML), nonplastic, fine sand, homogeneous, scattered organics **(Qpfnl)** | | | |
| | 200 | | | | | | M | | |

| Elevation, feet | Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|
| 60 | 200 | | | | | | | | |
| | | 20 | | 104 | PT | Hard, brown, moist PEAT (PT) **(Qpfnw)** | | | |
| | | | | | ML | Stiff, brown, moist, slightly sandy SILT (ML), fine sand, homogeneous **(Qpfnl)** | M | | |
| 55 | 205 | | | | SM | Dense, gray, moist, silty SAND (SM), fine to medium sand, faint laminations of sand **(Qpfnf)** | | | |
| | | | | | PT | Hard, brown, moist PEAT (PT) **(Qpfnw)** | | | |
| | | 21 | | 122 | ML | Stiff, gray, moist, slightly sandy SILT (ML), scattered black and brown organics **(Qpfnl)** | M | | |
| 50 | 210 | | | | | Grades to very sandy | | | |
| | | | | | | Grades to wet | | | |
| 45 | 215 | | | | | 1-foot hard, brown peat layer | M | | |
| | | 22 | | 83 | | | | | |
| 40 | 220 | | | | SP-SM | Dense, gray, moist, gravelly, slightly silty SAND (SP-SM), poorly-graded, fine to coarse sand, fine to coarse gravel **(Qpfnf)** | | | |
| | | | | | GP-GM | Dense, gray, wet, slightly silty, very sandy GRAVEL (GP-GM), subangular to subrounded gravel, fine to coarse sand, poorly-graded, clay coating gravel **(Qpfnf)** | | | |
| 35 | 225 | | | | | Grades to sandy, coarser gravel | | | |
| 30 | 230 | 23 | | 90 | | | M,SA | | |
| | | | | | | Grades to trace silt | | | |
| | 235 | | | | | | | | |

| Elevation, feet | Depth, feet | SAMPLES Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 235 | | | | | | | Clayey organics on gravel | | | | |
| | | | 24 | | 90 | | | | | | | |
| 20 | 240 | | | | | | | | | | | |
| | | | | | | | | Terminated boring at 242 feet below ground surface | | | | |
| 15 | 245 | | | | | | | | | | | |
| 10 | 250 | | | | | | | | | | | |
| 5 | 255 | | | | | | | | | | | |
| 0 | 260 | | | | | | | | | | | |
| -5 | 265 | | | | | | | | | | | |
| | 270 | | | | | | | | | | | |

**Project: King County WTD / Brightwater Conveyance System**
**Project Location: King & Snohomish Counties, Washington**
**Contract Number: E23007E**

# Log of Boring E-401



| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | **10/16/03 - 10/17/03** | Geotechnical Consultant | **Camp Dresser & McKee Inc.** | Logged By **TCB** | Checked By **RWS 2/2/04** |
| Drilling Method/Rig Type | **Wireline Core/ Portadrill** | Drilling Contractor | **Gregory Drilling, Inc.** | Total Depth of Borehole | **121.0 feet** |
| Casing Size/Type | **PQ (7" OD)** | Hammer Weight/Drop (lbs/in.) | **N/A** | Ground Surface Elevation/Datum | **211.8 feet / Metro** |
| Location | **2621 NW 205th** | Coordinates | **N 287641 E 1257412** | Elevation Source | **Survey** |

| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | | | | | | 0 to 6 feet excavated with vacuum truck, not sampled |
| 210 | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | |
| | | | | | | | ML | Very stiff to hard, gray, moist, slightly clayey to clayey SILT (ML), low plasticity, frequent horizontal lamination **(Qpfnl)** | | | 2.5 | |
| 205 | | | | | | | | | | | 4.5 | |
| | | | 1 | | 18 | | | | | | | |
| | | | | | | | | Grades silty, occasional organics, mica | | | | |
| | 10 | | | | | | | | | | | |
| | | | | | | | | Frequent partings of light gray, silt | | | | |
| 200 | | | | | | | | | | | | |
| | | | 2 | | 62 | | | | | | | |
| | 15 | | | | | | | | | | | |
| | | | | | | | | 2-inch layer of brown silt with red brown partings and seams | | | | |
| 195 | | | | | | | | Clayey SILT, gray, slow dilatancy | | | | |
| | | | 3 | | 50 | | | | | | | |
| | 20 | | | | | | | 6-inch layer of silt, low plasticity, rapid dilatancy | | | | 6-inch layer of blocky fractures |
| 190 | | | | | | | | | | | | |
| | | | | | | | | Decreasing clay, no plasticity, trace fine sand, rapid dilatancy | | | | |
| | 25 | | | | | | | | | | | |

**Groundwater Observation Data:**

VWP 1 (FT BGS): 56.3 (Low) 49.2 (High)

**Remarks:** Negative Groundwater Data indicates measurements above Ground Surface

Recovery values > 100 indicate sample expansion during sampling.

Pocket Penetrometer shown as 4.6 indicates unconfined compressive strength > 4.5 tsf (penetrometer upper limit).

| Elevation, feet | Depth, feet | Sample Type | Sample Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | | | | | | | | | | | |
| | | | 4 | | 30 | | | | | | | |
| 185 | | | | | | | | Pockets of dark gray SILT | | | | 45 to 60 degree inclined bedding, jumbled texture |
| | 30 | | | | | | | | | | | |
| 180 | | | | | | | | Interbedded layers of clayey SILT and slightly sandy SILT, fine sand | | | | 3-inch layer of highly fractured, gray clay |
| | 35 | | 5 | | 67 | | | | | | | |
| 175 | | | | | | | | | | | | |
| | | | | | | | | Pockets of silty, fine sand | | | | |
| | 40 | | | | | | | | | | | |
| 170 | | | 6 | | 67 | | | | | | | 4-inch layer highly fractured blocky texture and slickensides |
| | 45 | | | | | | | Bedding inclined 30 degrees | | | | |
| 165 | | | | | | | CL | Hard, olive gray, moist, slightly silty to silty CLAY (CL-CH), medium to high plasticity, frequent silty SAND, fine sand layers, with mica **(Qpfnl)** | | | | Frequent fractures and slickensides inclined 30 to 45 degrees |
| | 50 | | 7 | | 67 | | | | | | | |
| 160 | | | | | | | | | | | | |
| | | | | | | | | Grades back and forth between clayey silt and clay | | | | |
| | 55 | | | | | | | | | | | |
| 155 | | | 8 | | 67 | | | | | | 4 | |
| | 60 | | | | | | | | | | | |

| Project: King County WTD / Brightwater Conveyance System | **Log of Boring E-401** |
|---|---|
| Project Location: King & Snohomish Counties, Washington |  |
| Contract Number: E23007E | |

| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 | | | | | | | | | | | |
| 150 | | | | | | | | Sandy SILT layer, rapid dilatancy | | | | |
| | | | | | | | SP-SM | Very dense, olive gray, moist, silty SAND (SM) grading to slightly silty SAND (SP-SM), fine to medium sand, poorly-graded, occasional organics, mica, homogeneous, with occasional interbedded layers of silty CLAY and clayey SILT **(Qpfnf)** | | | | |
| | 65 | | 9 | | 67 | | | | | | | |
| 145 | | | | | | | | | | | | |
| | | | | | | | | Clay seam with blocky fractures and slickensides | | | | Flows at 1 to 2 gpm |
| | 70 | | | | | | | | | M,SA | | |
| 140 | | | 10 | | 67 | | | | | | | |
| | | | | | | | | Scattered pockets of laminated silty clay | | | | |
| | 75 | | | | | | | | | | | Angular clasts of clay within sand matrix |
| 135 | | | | | | | | | | | | |
| | | | 11 | | 66 | | | | | | | |
| | 80 | | | | | | | | | | | |
| 130 | | | | | | | | Hard, gray olive to gray green, moist | | | | Irregular bedding, dipping 30 to 45 degrees, sand-filled fractures, blocky fracture, |
| | | | | | | | | 3-foot stratum of slightly clayey SILT, occasional organics | | | 3.75 | |
| | 85 | | 12 | | 67 | | | | | | | |
| 125 | | | | | | | | | | | | |
| | | | | | | | | Very heterogeneous silt rip-ups in clean sand and wavy irregular interbedded clay, silt, and sand seams | | | | Very heterogeneous silt rip-ups in clean sand and wavy irregular interbedded clay, silt, and sand seams |
| | 90 | | | | | | | | | M,SA | | |
| 120 | | | 13 | | 29 | | | Irregular texture throughout, no structure | | | | Irregular texture throughout, no structure |
| | 95 | | | | | | | | | | | |



CDM

| Project: King County WTD / Brightwater Conveyance System | **Log of Boring E-401** |
|---|---|
| Project Location: King & Snohomish Counties, Washington | Sheet 4 of 4 |
| Contract Number: E23007E | |

| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|
| 115 | 95 | | | | | | | | | |
| 110 | 100 | | 14 | | 0 | | | | | |
| | | | | | | SP | Very dense, gray, moist SAND (SP), fine to medium sand, trace coarse sand, trace silt, poorly-graded, scattered fine gravelly layer **(Qpfnf)** | | | 102 to 114 ft bgs, sand has quartz and feldspar content estimated at 75% |
| 105 | 105 | | | | | | | | | Driller report: soils are medium dense, fine to coarse sand, with scattered fine gravel layers |
| 100 | 110 | | 15 | | 0 | | | | | |
| | | | | | | | Fine to medium sand, no gravel | | | |
| | 115 | | 16 | | 60 | | | M,SA | | |
| 95 | | | | | | ML | Hard, gray green, moist SILT (ML), nonplastic, interbedded with frequent brown organic silt seams, 1-inch red brown, moist organic SILT and fibrous PEAT (OL) layer at top of contact **(Qpfnl)** | | | SILT rip-ups |
| | | | 17 | | 38 | SM | Very dense, gray, moist, silty SAND (SM), fine to medium sand **(Qpfnf)** | | 4.6 | |
| 90 | 120 | | | | | | Terminated boring at 121 feet below ground surface | | | |
| 85 | 125 | | | | | | | | | |
| | 130 | | | | | | | | | |

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CDM

| Project: King County WTD / Brightwater Conveyance System<br>Project Location: King & Snohomish Counties, Washington<br>Contract Number: E23007E | **Log of Boring E-402**<br>Sheet 1 of 7 |
|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date(s) Drilled | 9/30/03 - 10/7/03 | Geotechnical Consultant | Camp Dresser & McKee Inc. | Logged By | MJB | Checked By | RWS 2/02/04 |
| Drilling Method/Rig Type | Wireline/ CME 45C | Drilling Contractor | Gregory Drilling, Inc. | Total Depth of Borehole | 206.5 feet | | |
| Casing Size/Type | PQ (7"O.D.) | Hammer Weight/Drop (lbs/in.) | Canterra | Ground Surface Elevation/Datum | 304.4 feet / Metro | | |
| Location | 2162 NW 204th St | Coordinates | N 287489 E 1258407 | Elevation Source | Survey | | |

| Elevation, feet | Depth, feet | SAMPLES Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | | Vegetation (sod), topsoil | | | | |
| 300 | 5 | | | | | | | | | | | |
| | | | | | | | SP-SM | Medium dense to dense, gray, moist to wet, slightly silty, gravelly SAND (SP-SM), poorly-graded fine to coarse sand, fine to coarse subrounded to subangular gravel **(Qva)** | | | | |
| 295 | | | 1 | | 0 | | | | | | | |
| | 10 | | | | | | | | | | | Sand with scattered gravels inferred from drill action and cuttings |
| | | | 2 | | 17 | | | | | | | |
| 290 | | | | | | | ML | Very stiff, dark gray, moist, slightly gravelly, slightly sandy to sandy SILT (ML), fine to medium sand, trace coarse sand, fine to coarse subrounded to subangular gravel, homogeneous **(Qvlc)**<br>Grades wet, slightly sandy, clayey silt, scattered layers of fine sandy silt | | | | |
| | 15 | | 3 | | 0 | | | | | | | |
| 285 | | | 4 | | 40 | | | | | | | |
| | 20 | | | | | | | | | | 3.2 | |
| | | | 5 | | 50 | | | | | | | |
| 280 | | | 6 | | 100 | | | | | | 4.5 | |
| | 25 | | | | | | | | | | | |

**Groundwater Observation Data:**

VWP 1 (FT BGS): 149.2 (Low) 147.7 (High)

**Remarks:** Negative Groundwater Data indicates measurements above Ground Surface

Recovery values > 100 indicate sample expansion during sampling.

| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | | | | | | | | | | | |
| | | | 7 | | 30 | | | | | | | Sand inferred from drill action and cuttings |
| 275 | | | | | | | | Rapid dilatancy | | | | |
| | 30 | | | | | | | | | | | |
| | | | 8 | | 36 | | | | | | | Sand inferred from drill action and cuttings |
| 270 | | | | | | | | | | | | |
| | 35 | | | | | | | | | | | |
| | | | 9 | | 70 | | ML | Hard, dark gray, moist to wet, slightly sandy, clayey SILT (ML), fine to medium sand, laminations of gray silt **(Qpfnl)** | | | | |
| 265 | | | | | | | | | | | 4 | |
| | 40 | | | | | | SM | Medium dense, dark gray, wet, very silty SAND (SM), rapid dilatancy, scattered organics **(Qpfnf)** | | | | |
| | | | 10 | | 40 | | | | | | | |
| 260 | | | | | | | | | | | | |
| | 45 | | | | | | | | | | | |
| | | | 11 | | 54 | | | | | | | blocky structure |
| 255 | | | | | | | | | | | | |
| | 50 | | | | | | | | | | | |
| | | | 12 | | 0 | | | | | | | |
| 250 | | | | | | | | | | | | |
| | 55 | | | | | | | | | | | |
| | | | | | | | ML | Hard, dark gray, moist, clayey SILT (ML), trace fine sand, medium plasticity, slow dilatancy **(Qpfnl)** | | | | |
| | | | 13 | | 100 | | | | | | 4.5 | |
| 245 | | | | | | | | | | | | |
| | 60 | | | | | | | | | | | |

| Elevation, feet | Depth, feet | Samples: Type | Samples: Number | Samples: Blows / 6 in. (N) | Samples: Recovery, % | Samples: Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 | | | | | | | | | | | |
| | | | | | | | | Scattered silty clay seams, silty sand layers with scattered organics | | | | |
| | | | 14 | | 64 | | | Grades wet, low plasticity, | | | | |
| 240 | 65 | | | | | | | | | | | Blocky structure, bedding 0 to 5 degrees, high angle slickensides 60 degrees |
| | | | 15 | | 100 | | | | | | | |
| 235 | 70 | | | | | | | | | | | Blocky structure |
| | | | 16 | | 50 | | | | | | | |
| 230 | 75 | | | | | | | | | | | Paleosol |
| | | | | | | | | | | | 3 | Blocky structure, bedding 0 to 5 degrees, slickensides - high angle 45 degrees, slow HCl reaction |
| | | | 17 | | 60 | | SP-SM | Dense, dark gray, wet, slightly silty to silty SAND (SP-SM), poorly-graded fine to medium sand, frequent layers of medium plasticity clayey silt, scattered partings of organics **(Qpfnf)** | | | | |
| 225 | 80 | | | | | | | | | | | |
| | | | 18 | | 56 | | | | | | | |
| 220 | 85 | | | | | | | | | | 2 | |
| | | | 19 | | 64 | | | | | | | |
| 215 | 90 | | | | | | SP | Dense, dark gray, wet SAND (SP) trace silt, poorly graded fine to medium sand, numerous organics **(Qpfnf)** | | | | |
| | | | 20 | | 60 | | | | | | | |
| 210 | 95 | | | | | | | | | | | |

| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|
| | 95 | | | | | | | | Slight groundwater flowing conditions (1 to 2 gpm) through drill pipe |
| | | | | | | ML | Hard, dark gray, wet, clayey SILT (ML), low plasticity, frequent seams of silty clay and sandy silt **(Qpfnl)** | | Bedding 0 degrees, blocky structure and slickensides |
| 205 | 100 | | 21 | | 60 | | | 3.5 | PP for clay layers |
| | | | | | | SP | Dense, dark gray, wet SAND (SP), trace silt, poorly-graded fine sand **(Qpfnf)** | | Groundwater flowing approximately 2 gpm |
| 200 | 105 | | 22 | | 50 | | | | |
| | | | | | | CH | Hard, dark gray, moist CLAY (CH), trace fine subrounded to subangular gravel, high plasticity, high dry strength **(Qpfnl)** | 3.2 | |
| | | | | | | ML | Hard, dark gray, wet, sandy SILT (ML), low plasticity, well-graded fine sand, scattered organics **(Qpfnl)** | | |
| 195 | 110 | | 23 | | 30 | | | | |
| | | | | | | SM | Dense, dark gray, wet, silty SAND (SM), fine sand, scattered organics **(Qpfnf)** | | |
| 190 | 115 | | 24 | | 52 | | | | |
| 185 | 120 | | | | | CH | Very stiff, green gray to dark gray, moist CLAY (CH), medium to high plasticity, laminated **(Qpfnl)** | | Blocky structue, numerous slickensides high angle 40 degrees, Paleosol? |
| | | | | | | SM | Dense, green gray to dark gray, wet, very silty SAND (SM), trace fine gravel, fine sand, rapid dilatancy, seams of silty clay and layers of clayeysilt **(Qpfnf)** | | |
| 180 | 125 | | 25 | | 60 | | | | |
| 175 | 130 | | 26 | | 2 | | | | |

| Project: King County WTD / Brightwater Conveyance System<br>Project Location: King & Snohomish Counties, Washington<br>Contract Number: E23007E | **Log of Boring E-402**<br>Sheet 5 of 7 |
|---|---|

| Elevation, feet | Depth, feet | Samples: Type | Samples: Number | Samples: Blows / 6 in. (N) | Samples: Recovery, % | Samples: Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 130 | | | | | | | | | | | |
| | | | | | | | | 12-inch silty clay layer, medium plasticity | | | 4.5 | PP for clay layer |
| 170 | | | 27 | | 60 | | | | | | | |
| | 135 | | | | | | | Grades coarser sand | | | | Very blocky structure, stiff, 6-inch slickensided layer |
| | | | | | | | SM | Dense, dark gray, wet, silty SAND (SM), fine sand, scattered seams and layers of medium to high plasticity clay **(Qpfnf)** | | | | |
| 165 | | | 28 | | 20 | | | | | | | |
| | 140 | | | | | | | | | | | |
| | | | | | | | | Grades very silty | | | | |
| 160 | | | 29 | | 5 | | | | | | | |
| | 145 | | | | | | | | | | | |
| 155 | | | 30 | | 50 | | | | | | | Organic odor |
| | 150 | | | | | | | Grades very dense, silty, fine to medium sand, scattered mica | | | | Trace weathered andesite, medium sand grains |
| 150 | | | 31 | | 0 | | | | | | | |
| | 155 | | | | | | | | | | | |
| 145 | | | 32 | | 100 | | | | | | | |
| | 160 | | | | | | | | | | | |
| 140 | | | 33 | | 100 | | | | | | | |
| | 165 | | | | | | | | | | | |



CDM

# Log of Boring E-402



| Elevation, feet | Depth, feet | Type | Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | 165 | | | | | | | M,SA | | |
| -135 | | | 34 | | 100 | | | | | |
| | 170 | | | | | | | | | |
| -130 | | | 35 | | 100 | | | | | |
| | 175 | | | | | | | | | |
| -125 | | | 36 | | 90 | | | | | |
| | 180 | | | | | ML | Hard, dark gray to green gray, moist, slightly gravelly SILT (ML), trace sand, fine subrounded gravel, scattered organics **(Qpfnl)** | | | Paleosol<br>Organic odor ($CH_4$) |
| | | | | | | SM | Dense, light gray, wet, silty SAND (SM), well-graded fine to medium sand **(Qpfnf)** | | | |
| -120 | | | 37 | | 50 | | | | | |
| | 185 | | | | | | | M,SA | | |
| | | | | | | | Gravelly organic silt layer | | | |
| -115 | | | 38 | | 60 | | Scattered layers of hard, green gray, moist, Organic clayey, to clay, medium to high plasticity, high to very high dry strength, | | | |
| | 190 | | | | | | | | | Sand was observed to have high quartz content (est. 80% quartz) |
| -110 | | | 39 | | 100 | | | | | |
| | 195 | | | | | | | | | |
| | | | | | | SP | Very dense, dark gray, wet, SAND (SP) poorly-graded fine to medium sand, **(Qpfnf)** | | | Organic odor |
| -105 | | | 40 | | 70 | | | | | |
| | 200 | | | | | | | | | |

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

# Log of Boring E-402



| Elevation, feet | Depth, feet | SAMPLES Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 200 | | | | | | | | | M,SA | | Gravel inferred from drill action and cuttings |
| 100 | | | 41 | | 50 | | | | | | | |
| | 205 | | | | | | | 1-foot hard, green gray, organic silt, abundant wood particles and organics | | | 4.25 | Paleosol |
| | | | | | | | | Terminated boring at 206.5 feet below ground surface | | | | |
| 95 | 210 | | | | | | | | | | | |
| 90 | 215 | | | | | | | | | | | |
| 85 | 220 | | | | | | | | | | | |
| 80 | 225 | | | | | | | | | | | |
| 75 | 230 | | | | | | | | | | | |
| 70 | 235 | | | | | | | | | | | |



CDM

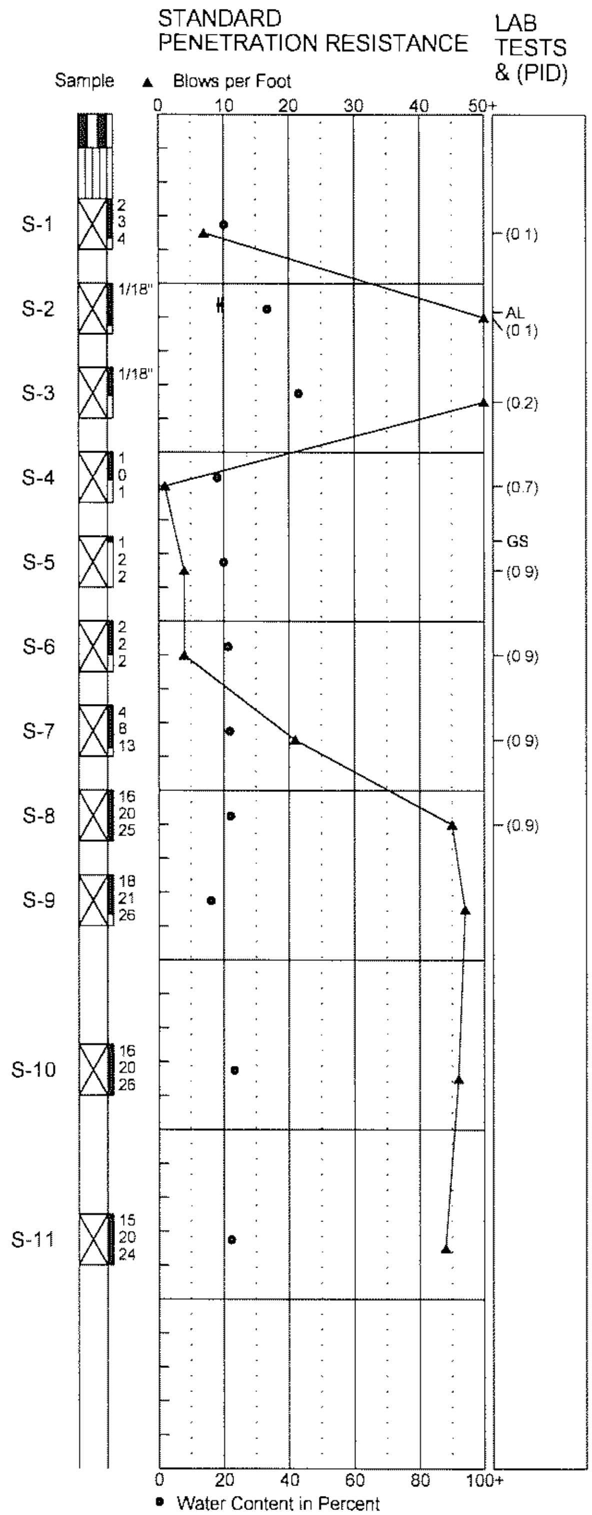
# UPPER BENCH

# Boring Log B-09-1

Location: See Figure 3.
Approximate Ground Surface Elevation: 47 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: K. Shah

| USCS Class | Soil Descriptions | Depth in Feet |
|---|---|---|
| | 2 inches of Asphalt over 10 inches of Sand over 3 inches of Concrete. | 0 |
| SM | Loose, wet, gray-brown, silty SAND with scattered gravel. (FILL) | ATD (groundwater) |
| | Brown discharge with abundant gravel observed. | 5 |
| ML | Very soft, wet, gray SILT and sandy SILT. (Colluvium) | |
| | Trace of wood fragments observed to 11.5 feet. | |
| | Scattered organic material and zones of silty gravel observed. | 10 |
| SM/GM | Loose, wet, gray, slightly silty, very sandy GRAVEL with trace organic material to 15 feet. (Colluvium) | |
| | Grades to silty SAND with zones of sandy SILT and scattered gravel to 17.5 feet. | 15 |
| | Medium dense, with gravelly SAND zones. | |
| SP | Dense, wet, gray SAND. (Fluvial) | 20 |
| | Gravelly. | |
| | Slightly silty. | 25 |
| | Occasional silty SAND partings. | 30 |
| | Bottom of Boring at 34.0 Feet. Started 01/05/10. Completed 01/05/10. | 35 |
| | | 40 |




1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
17203-38 1/10
Figure A-2

SEE SITE MAP FIGURE 2

**PACIFIC ENVIRONMENTAL GROUP, INC.**

WELL NO. MW-95
PAGE 1 OF 1

| | |
|---|---|
| PROJECT NO: 520-133.1G | CLIENT: CHEVRON |
| LOGGED BY: B.A. | DATE DRILLED: 10-9-98 |
| DRILLER: HAYES DRILLING | LOCATION: Point Wells, Richmond Beach |
| DRILLING METHOD: HSA | HOLE DIAMETER: 6" |
| SAMPLING METHOD: SPLIT SPOON | HOLE DEPTH: 21.5' |
| CASING TYPE: SCHD. 40 PVC | WELL DIAMETER: 2" |
| SLOT SIZE: 0.020" | WELL DEPTH: 19.8' |
| GRAVEL PACK: 2 x 12 SAND | CASING STICKUP: NA |

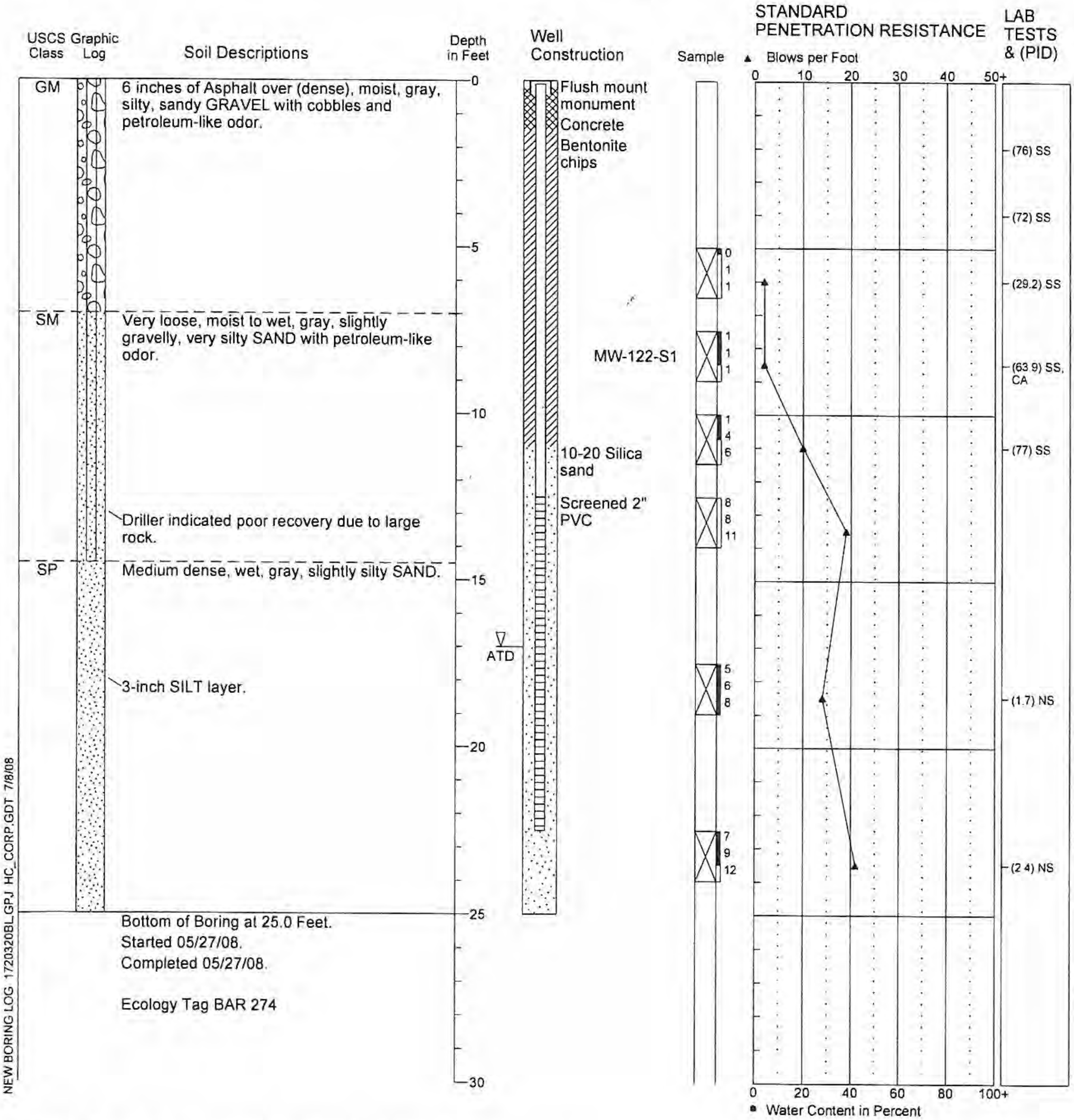
WELL COMPLETION: CEMENT, BENTONITE, SAND

| MOISTURE CONTENT | PID (ppm) | PENETRATION (BLOWS/ 6") | DEPTH (FEET) | SOIL TYPE | LITHOLOGY/REMARKS |
|---|---|---|---|---|---|
| | | | 0 | | GRAVEL COVER. |
| | | | 1 | SM | SILTY SAND: light olive brown; 20% fines; 80% very fine to fine sand. |
| Dp | - | | 3 | | |
| Dp | | 67 | 5 | | |
| | | | 8 | CL-ML | INTERBEDDED CLAY/SILT: dark olive brown to dark gray; low plasticity; 50% clay; 50% silt. |
| Dp | | 42 | 10 | | |
| ▽ | 0 | | 10.5 | | |
| | | | 11 | SM | SILTY SAND: dark gray; 15% fines; 85% fine to medium sand. |
| Wt | | | 12 | | |
| | | | 14 | | @14': as above; 15% fines; 60% very fine to medium sand; 25% coarse sand; trace subangular gravel. |
| Wt | | 53 | 16 | ML | SANDY SILT: dark gray; 80% silt; 20% very fine sand. |
| Mst | | | 18 | | |
| Wt Sat | | 45 | 21 | SM | SILTY SAND: 10 to 40% fines; 40 to 60% fine to medium sand. |
| | | | 22 | | BOTTOM OF BORING 21.5' |

# Boring Log & Construction Data for Monitoring Well MW-122

Location: See Figure 2.
Approximate Ground Surface Elevation: Feet
Horizontal Datum: Field located
Vertical Datum: NA

Drill Equipment: Hollow stem auger
Hammer Type: 140 lb. Auto hammer with 30" drop
Hole Diameter: 10 inches
Logged By: A. Inglish/A. Goodwin Reviewed By: A. Goodwin




1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
5. SS = Slight Sheen, NS = No Sheen, MS = Moderate Sheen, HS = Heavy Sheen
6. While trying to set well, hole was heaving and was unable to reach a depth of 25' (closest was 21'). Moved north 3' and drilled new borehole. Abandoned borehole's water level is 2 - 2.5' bgs showing confined conditions.
7. Analytical water content tabulated in Table 2.

NEW BORING LOG 1720320BL.GPJ HC_CORP.GDT 7/8/08

HARTCROWSER

17203-20 5/08

Figure A-93

# LOWER BENCH

# Boring Log B-09-2

Location: See Figure 3.
Approximate Ground Surface Elevation: 7 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

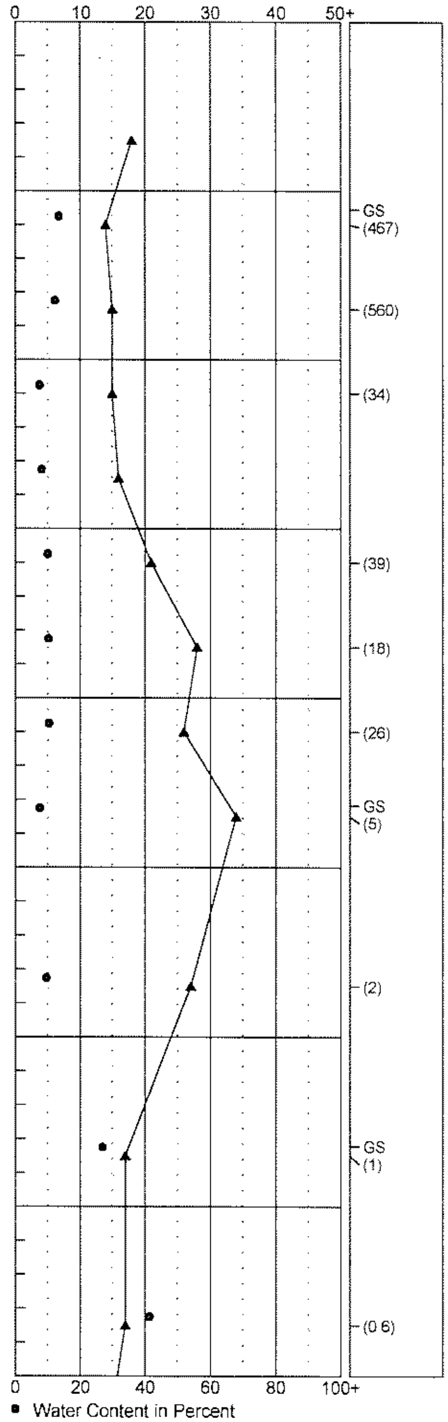
Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: K. Shah

| USCS Class | Depth in Feet | Soil Descriptions |
|---|---|---|
| SM/GM | 0–5 | Crushed GRAVEL over (medium dense), moist, brown, gravelly SAND to (medium dense), wet, gray, sandy GRAVEL. (FILL)<br>Large gravel/cobbles observed with petroleum hydrocarbon-like odor to 5 feet. |
| SP | 5–10 | Medium dense, wet, dark gray, very gravelly SAND to silty, gravelly SAND (TPH impacted). (Fluvial) |
| GP | 10–22 | Medium dense, wet, gray to dark gray, slightly silty, sandy GRAVEL. (Fluvial)<br>12 inches of slough observed.<br>Slight petroleum hydrocarbon-like odor to 20 feet.<br>Very sandy.<br>Slightly silty, gravelly SAND to sandy GRAVEL. |
| SM/GM | 22–30 | Dense, wet, gray, slightly silty, very gravelly SAND to medium dense, sandy GRAVEL. (Fluvial) |
| SM | 30–40 | Medium dense, wet, olive-gray, silty SAND with wood fragments. (Lacustrine)<br>Grades to very silty SAND to sandy SILT with scattered gravel and shells. |

∇ ATD

STANDARD PENETRATION RESISTANCE

| Sample | Blows | LAB TESTS & (PID) |
|---|---|---|
| S-1 | 6, 10, 8 | |
| S-2 | 4, 6, 8 | GS (467) |
| S-3 | 5, 7, 8 | (560) |
| S-4 | 5, 7, 8 | (34) |
| S-5 | 5, 7, 9 | |
| S-6 | 7, 10, 11 | (39) |
| S-7 | 10, 12, 16 | (18) |
| S-8 | 10, 11, 15 | (26) |
| S-9 | 18, 19, 15 | GS (5) |
| S-10 | 10, 14, 13 | (2) |
| S-11 | 7, 7, 10 | GS (1) |
| S-12 | 4, 7, 10 | (0.6) |




1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

NEW BORING LOG 172033B-BL.GPJ HC_CORP.GDT 1/22/10

HARTCROWSER

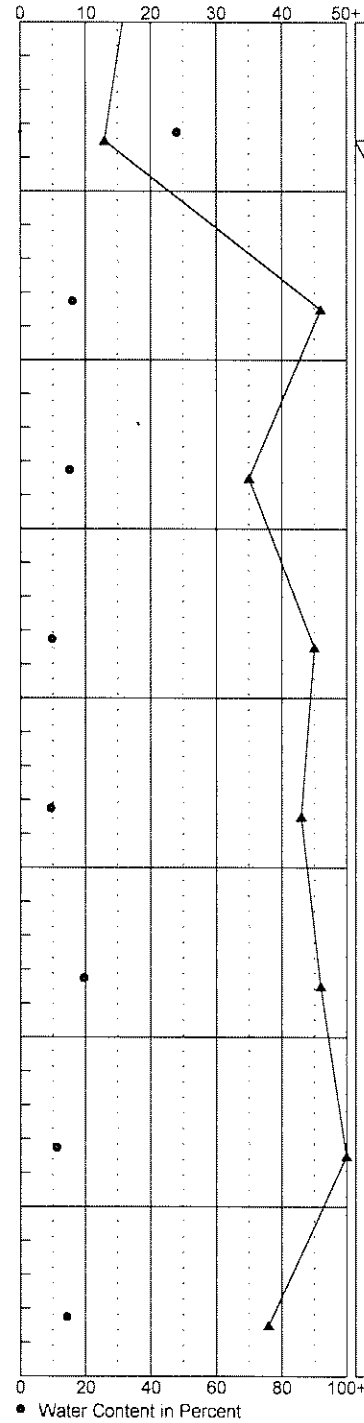
# Boring Log B-09-2

Location: See Figure 3.
Approximate Ground Surface Elevation: 7 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald    Reviewed By: K. Shah

| USCS Class | Soil Descriptions | Depth in Feet |
|---|---|---|
| SM | Medium dense, wet, olive-gray, silty SAND with wood fragments. (Lacustrine) (cont'd) | 40 |
| | Grades to stiff, wet, olive-gray, sandy SILT with scattered wood fragments, trace of shell, and hydrogen sulfide odor. (Non-plastic) | |
| | Abundant wood fragments observed to 47 feet. | 45 |
| GP | Dense, wet, gray to dark gray, sandy GRAVEL with shell fragments to 59 feet. | |
| | Silty. (Fluvial) | 50 |
| | Gravelly SAND. | |
| | Drill action indicates possible large gravel/cobbles. | 55 |
| | | 60 |
| | | 65 |
| | Slightly silty, gravelly SAND. | |
| | | 70 |
| | No recovery with 2-inch diameter SPT. Resampled with 3-inch diameter SPT. | |
| | Abundant shell fragments to bottom of boring. | 75 |
| | Bottom of Boring at 79.0 Feet. Started 12/28/09. Completed 12/30/09. | 80 |

| Sample | Blows | Lab Tests & (PID) |
|---|---|---|
| S-13 | 4, 8, 5 | (<0.1) AL |
| S-14 | 10, 21, 25 | |
| S-15 | 6, 12, 23 | |
| S-16 | 18, 20, 25 | |
| S-17 | 9, 21, 22 | |
| S-18 | 21, 20, 26 | |
| S-19 | 22, 26, 30 | |
| S-20 | 18, 18, 20 | |





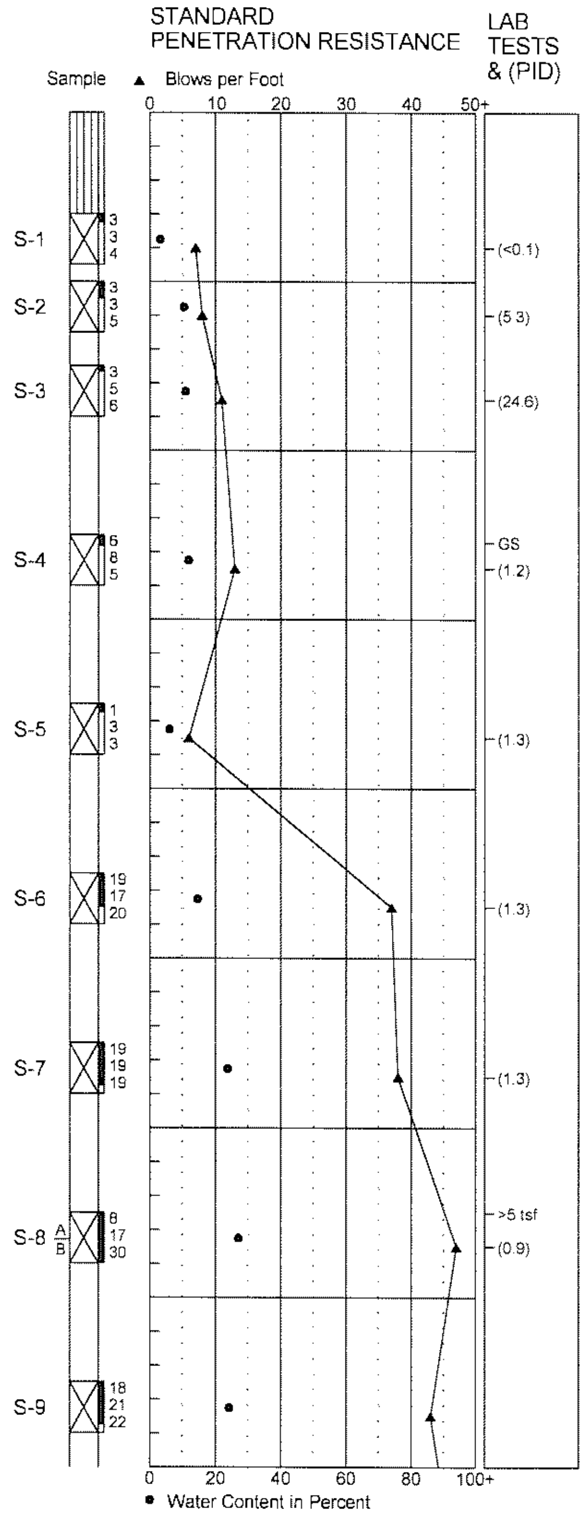

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

# Boring Log B-09-3

Location: See Figure 3.
Approximate Ground Surface Elevation: 11 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: K. Shah

| USCS Class | Soil Descriptions | Depth in Feet |
|---|---|---|
| SP | (Loose), moist, brown to dark gray, silty, gravelly SAND to sandy GRAVEL. (FILL) | 0 |
| GW | Loose, moist to wet, gray to dark gray, sandy GRAVEL (TPH impacted). (Fluvial) | 5 |
| | Medium dense. | |
| | Drill action indicates possible scattered cobble. | 10 |
| | Abundant gravel to 17.5 feet. | 15 |
| | Slightly sandy GRAVEL. | |
| | Dense, gravelly SAND with scattered shell fragments. | 20 |
| SM | Dense, wet, gray, slightly silty SAND with scattered shell fragments. (Fluvial) | 25 |
| ML | Very stiff, wet, gray SILT. (Lacustrine) | 30 |
| SM | Dense, wet, gray, silty SAND with laminations. (Fluvial) | |
| | Trace organic material. | 35 |
| | Slightly silty. | 40 |




NEW BORING LOG 172033B-BL.GPJ HC_CORP.GDT 1/22/10

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

*17203-38* *12/09*

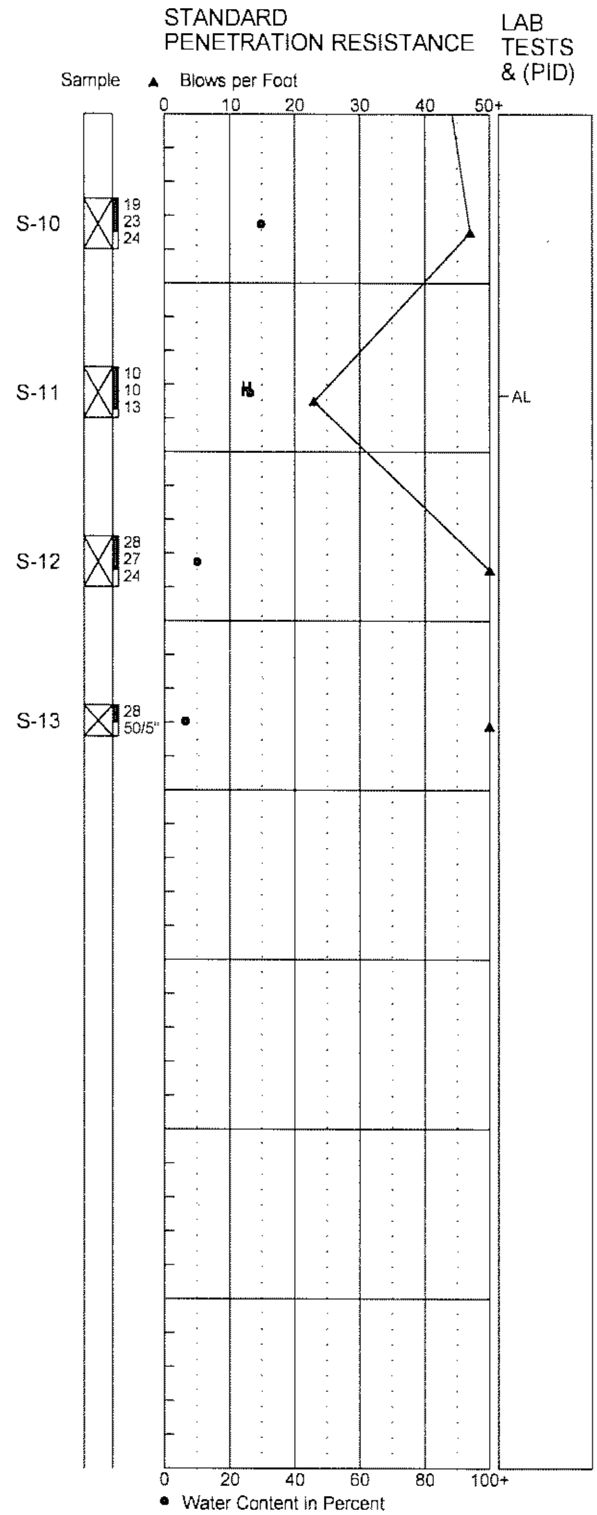
*Figure A-4* *1/2*

# Boring Log B-09-3

Location: See Figure 3.
Approximate Ground Surface Elevation: 11 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald    Reviewed By: K. Shah

| USCS Class | Graphic Log | Soil Descriptions | Depth in Feet |
|---|---|---|---|
| SM | | Dense, wet, gray, silty SAND with laminations. (Fluvial) (cont'd) | 40 |
| SM/ML | | Very stiff, wet, gray, sandy SILT and SILT with thin laminations. (Lacustrine) | 45 |
| GP | | Very dense, wet, gray, sandy to slightly sandy GRAVEL. (Fluvial) | 50 |
| | | Bottom of Boring at 58.4 Feet.<br>Started 12/30/09.<br>Completed 12/30/09. | |




NEW BORING LOG 1720338-BL.GPJ HC_CORP.GDT 1/22/10

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

**HARTCROWSER**

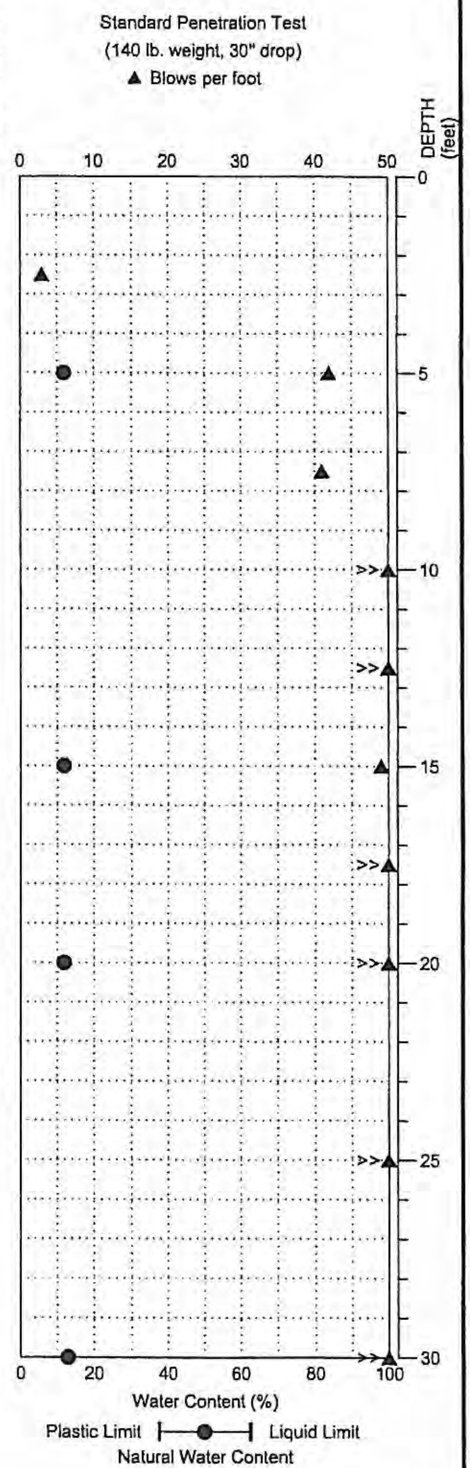
*17203-38* *12/09*

*Figure A-4* *2/2*

DRILLING COMPANY: Subterranean
DRILLING METHOD: Mud Rotary
SAMPLING METHOD: SPT w/safety hammer
SURFACE ELEVATION: 3 ± feet

LOCATION: N 288249.6, 1255930.7
DATE STARTED: 10/29/2007
DATE COMPLETED: 11/1/2007
LOGGED BY: D. Maloney + J. Gillie

| DEPTH (feet) | USCS SOIL CLASS | DESCRIPTION | SAMPLE NUMBER | PEN. RESISTANCE (blows/6 inches) | OTHER TESTS | GROUNDWATER |
|---|---|---|---|---|---|---|
| 0 | GP | Very loose to dense, dark gray, slightly silty, sandy, fine to coarse GRAVEL, moist. | | | | |
| | | Low recovery in S-1 at 2.5 feet. Gravel lodged in tip. | S-1 | 3-2-1 | | |
| 5 | SP SM | Dense, dark gray to dark olive gray, slightly silty to silty, fine gravelly, fine to coarse SAND, moist. **(PRE-FRASER NON-GLACIOFLUVIAL DEPOSITS)** | S-2 | 20-20-22 | GS | |
| | | | S-3 | 23-21-20 | | |
| 10 | GW | Very dense to dense, dark gray, slightly silty, sandy, well graded GRAVEL, moist. Low recovery in S-4. High blow count probably a result of pounding on a cobble or coarse gravel particle. Driller notes rough, cobbly drilling action. | S-4 | 27-32-48 | | |
| | | | S-5 | 32-50/5" | | |
| 15 | | | S-6 | 39-27-22 | GS | |
| | | | S-7 | 38-37-42 | | |
| | SP | Very dense, dark gray, slightly silty, fine to coarse SAND, moist. | | | | |
| 20 | GW GM | Very dense, dark gray, slightly silty to silty, sandy, well graded GRAVEL, moist. | S-8 | 39-37-45 | GS | |
| 25 | GP | Very dense, dark gray, medium to coarse sandy, fine to coarse GRAVEL, moist. | S-9 | 31-50-39 | | |
| 30 | | | | | | |




For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-490+36

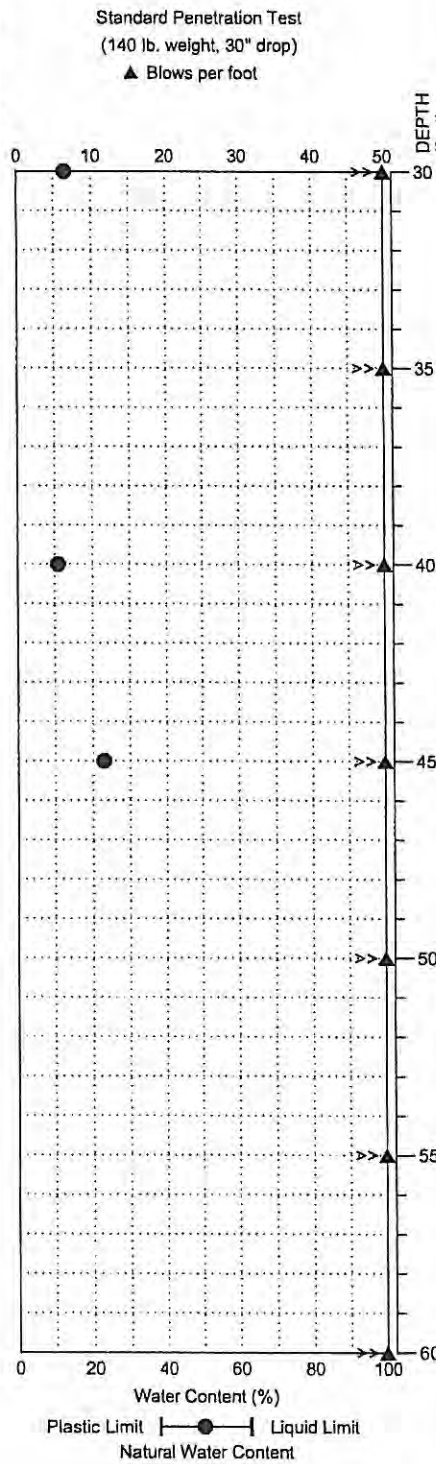


PROJECT NO.: 2007-007-21 FIGURE: 12

DRILLING COMPANY: Subterranean
DRILLING METHOD: Mud Rotary
SAMPLING METHOD: SPT w/safety hammer
SURFACE ELEVATION: 3 ± feet

LOCATION: N 288249.6, 1255930.7
DATE STARTED: 10/29/2007
DATE COMPLETED: 11/1/2007
LOGGED BY: D. Maloney + J. Gillie

| DEPTH (feet) | USCS SOIL CLASS | DESCRIPTION | SAMPLE NUMBER | PEN. RESISTANCE (blows/6 inches) | OTHER TESTS | GROUNDWATER |
|---|---|---|---|---|---|---|
| 30 | SM | Very dense, dark gray, fine to coarse gravelly, silty, fine to coarse SAND, moist. | S-10 | 45-47-50 | GS | |
| | | Driller notes sandy drilling, but very dense, slow, constant drilling. | | | | |
| | | Driller notes sandy drilling, but faster. | | | | |
| 35 | | Drilling and blows are consistent. | S-11 | 58-50/6" | | |
| | | Driller notes off and on gravelly drilling, mostly sand, slow. | | | | |
| 40 | GW GM | Very dense, dark gray to dark olive gray, slightly silty, fine to coarse sandy, well-graded GRAVEL, moist. | S-12 | 38-36-31 | GS | |
| | | Driller notes constant, smooth, faster drilling. | | | | |
| 45 | SM | Very dense, dark gray to dark olive gray, slightly fine gravelly, silty, fine SAND, moist. | S-13 | 36-48-43 | GS | |
| 50 | GP | Very dense, dark gray, slightly silty, slightly sandy, fine to coarse GRAVEL, moist. | S-14 | 64-50/5" | | |
| 55 | | Very dense, dark gray, medium to coarse sandy GRAVEL, wet. | S-15 | 45-40-50/5.5" | | |
| 60 | | | | | | |




For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-490+36



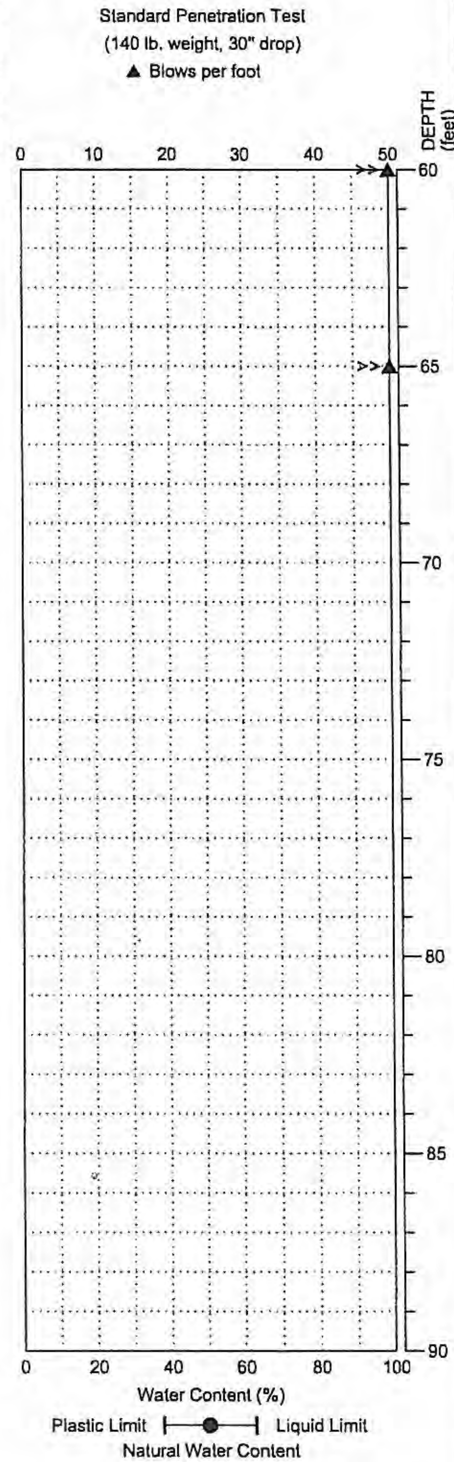
PROJECT NO.: 2007-007-21 FIGURE: 12

DRILLING COMPANY: Subterranean
DRILLING METHOD: Mud Rotary
SAMPLING METHOD: SPT w/safety hammer
SURFACE ELEVATION: 3 ± feet

LOCATION: N 288249.6, 1255930.7
DATE STARTED: 10/29/2007
DATE COMPLETED: 11/1/2007
LOGGED BY: D. Maloney + J. Gillie

| DEPTH (feet) | SYMBOL | USCS SOIL CLASS | DESCRIPTION | SAMPLE TYPE | SAMPLE NUMBER | PEN. RESISTANCE (blows/6 inches) | OTHER TESTS | GROUNDWATER |
|---|---|---|---|---|---|---|---|---|
| 60 | | SP | Very dense, dark gray, gravelly, medium to coarse SAND, wet. | ☒ | S-16 | 55-50/6" | | |
| 65 | | GP | Very dense, dark gray, medium to coarse sandy GRAVEL, wet. Some gravel particles fracturing like soft rock. | ☒ | S-17 | 46-50/5.5" | | |

Borehole terminated at 66.0 feet below the existing ground surface.




For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-490+36

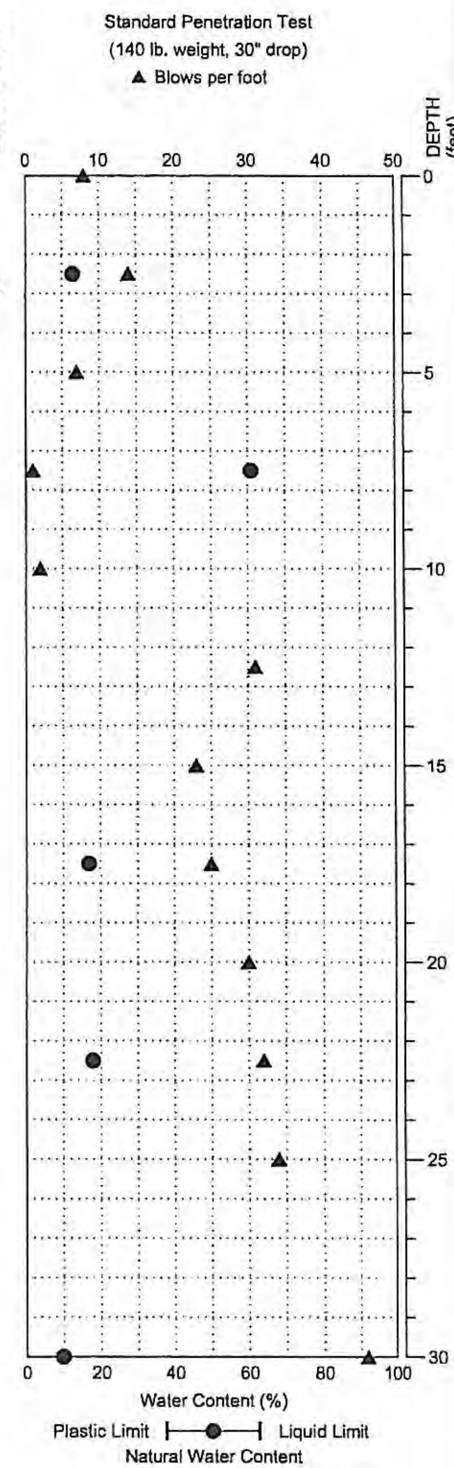
PAGE: 3 of 3

PROJECT NO.: 2007-007-21 FIGURE: 12

DRILLING COMPANY: Gregory Drilling Inc.
DRILLING METHOD: HSA
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 8 ± feet

LOCATION: N 288202.2, E 1256046.4
DATE STARTED: 10/8/2007
DATE COMPLETED: 10/8/2007
LOGGED BY: J. Speck

| DEPTH (feet) | SYMBOL | USCS SOIL CLASS | DESCRIPTION | SAMPLE TYPE | SAMPLE NUMBER | PEN. RESISTANCE (blows/6 inches) | OTHER TESTS | GROUNDWATER |
|---|---|---|---|---|---|---|---|---|
| 0 | | SP | Loose, gray, fine to medium SAND, trace coarse sand and shell fragments, wet. | ⊠ | S-1 | 2-3-5 | | |
| | | | As above, brownish gray, medium dense, trace coarse sand, fine gravel, shell fragments. | ⊠ | S-2 | 4-8-6 | GS | ∇ |
| 5 | | | | ⊠ | S-3 | 3-5-2 | | |
| | | | Loose, olive gray, fine to coarse SAND, trace silt. | | | | | |
| | | OL | Soft, olive brown to very dark brown, organic SILT, with decomposing wood, trace sand, hydrogen sulfide odor. | ⊠ | S-4 | 0-0-1 | GS | |
| | | SP | Loose, olive gray, fine to medium SAND, trace gravel and silt, wet. | | | | | |
| 10 | | | | ⊠ | S-5 | 1-1-1 | | |
| | | | No recovery - coarse gravel or cobbles. | ⊠ | S-6 | 11-15-16 | | |
| 15 | | SP | Medium dense, gray to dark gray, fine to medium SAND, with fine to coarse gravel, wet. | ⊠ | S-7 | 8-12-11 | | |
| | | | | ⊠ | S-8 | 4-10-15 | GS | |
| 20 | | | As above, dense. | ⊠ | S-9 | 11-13-17 | | |
| | | | | ⊠ | S-10 | 14-13-19 | GS | |
| 25 | | | | ⊠ | S-11 | 12-14-20 | | |
| 30 | | | | | | | | |

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HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-491+63

PAGE: 1 of 2

PROJECT NO.: 2007-007-21 FIGURE: 13

DRILLING COMPANY: Gregory Drilling Inc.
DRILLING METHOD: HSA
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 8 ± feet

LOCATION: N 288202.2, E 1256046.4
DATE STARTED: 10/8/2007
DATE COMPLETED: 10/8/2007
LOGGED BY: J. Speck

| DEPTH (feet) | SYMBOL | USCS SOIL CLASS | DESCRIPTION | SAMPLE TYPE | SAMPLE NUMBER | PEN. RESISTANCE (blows/6 inches) | OTHER TESTS | GROUNDWATER |
|---|---|---|---|---|---|---|---|---|
| 30 | | SW SM | Dense, gray to dark gray, well-graded SAND with silt and gravel, wet. | | S-12 | 21-25-21 | GS | |

Boring terminated at 31.5 feet below surface.

Ground water observed at 3 feet at time of exploration (ground water tidally influenced).

Standard Penetration Test (140 lb. weight, 30" drop)
▲ Blows per foot

Depth scale: 30, 35, 40, 45, 50, 55, 60
Blows per foot scale: 0, 10, 20, 30, 40, 50
Water Content (%) scale: 0, 20, 40, 60, 80, 100

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

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HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-491+63



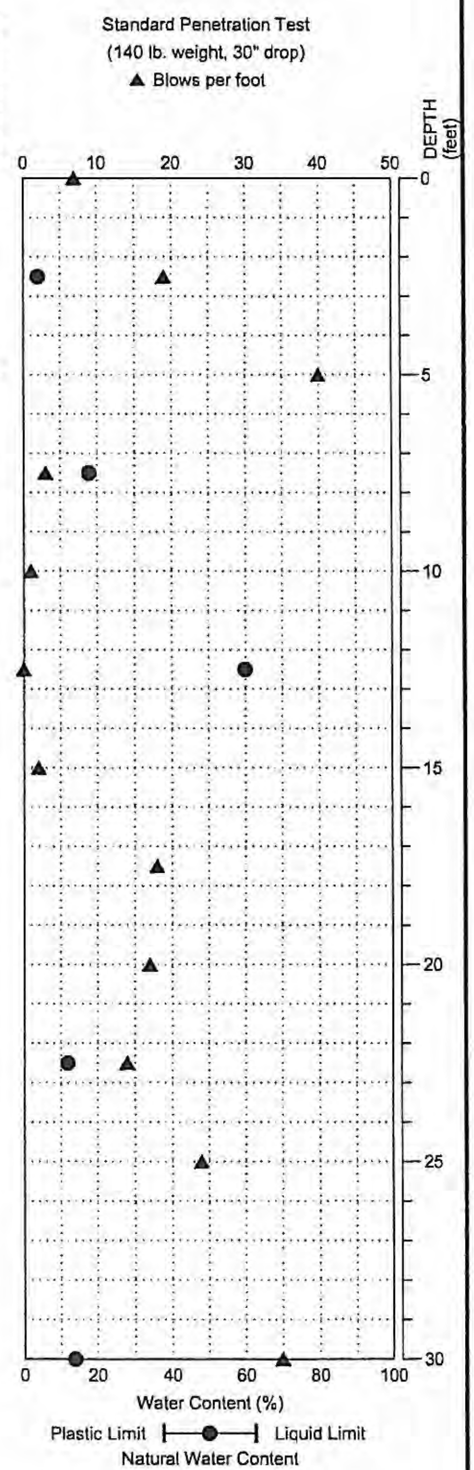
PROJECT NO.: 2007-007-21 FIGURE: 13

BORING 2007-007.GPJ 3/6/08

DRILLING COMPANY: Gregory Drilling Inc.
DRILLING METHOD: HSA
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 13 ± feet

LOCATION: N 288151.9, E 1256169.5
DATE STARTED: 10/8/2007
DATE COMPLETED: 10/8/2007
LOGGED BY: J. Speck

| DEPTH (feet) | USCS SOIL CLASS | DESCRIPTION | SAMPLE NUMBER | PEN. RESISTANCE (blows/6 inches) | OTHER TESTS | GROUNDWATER |
|---|---|---|---|---|---|---|
| 0 | SP | Loose, olive gray, slightly fine to coarse gravelly, fine to medium SAND, with trace coarse sand, trace silt, moist. | S-1 | 2-2-5 | | |
| | | | S-2 | 6-8-11 | GS | |
| 5 | | As above, grayish brown, medium dense, trace shell fragments. | S-3 | 20-19-21 | | ∇ |
| | SP SM | Loose to dense, olive gray to dark olive gray, slightly silty to silty, fine to medium SAND, with trace coarse sand and gravel, wet. | S-4 | 5-2-1 | GS | |
| | PT | Soft PEAT with sand interbeds, wet, hydrogen sulfide odor. | | | | |
| 10 | OL | Soft, light yellow brown, SILT, decomposed wood fragments, fine to medium sand interbeds, moist. | S-5 | 0-0-1 | | |
| | | Dark gray to black, wood and sand interbed, faint hydrocarbon odor. | S-6 | 0-0-0 | GS | |
| 15 | | Soft, olive gray SILT, decomposed wood fragments, fine to medium sand interbeds, moist, hydrogen sulfide odor. | S-7 | 0-0-2 | | |
| | SP | Medium dense, olive gray to dark gray, fine to medium, gravelly, SAND, trace silt, wet. Gravel is fine to coarse. Decreasing hydrogen sulfide odor. | S-8 | 6-8-10 | | |
| 20 | | As above decreasing odor. | S-9 | 7-7-10 | | |
| | SP | Medium dense, dark gray, fine to medium SAND with fine to coarse gravel, trace coarse sand, wet. No hydrogen sulfide odor. | S-10 | 5-5-9 | GS | |
| 25 | | As above with increasing fine sands. | S-11 | 5-10-14 | | |
| 30 | | | | | | |

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NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING: B-492+94

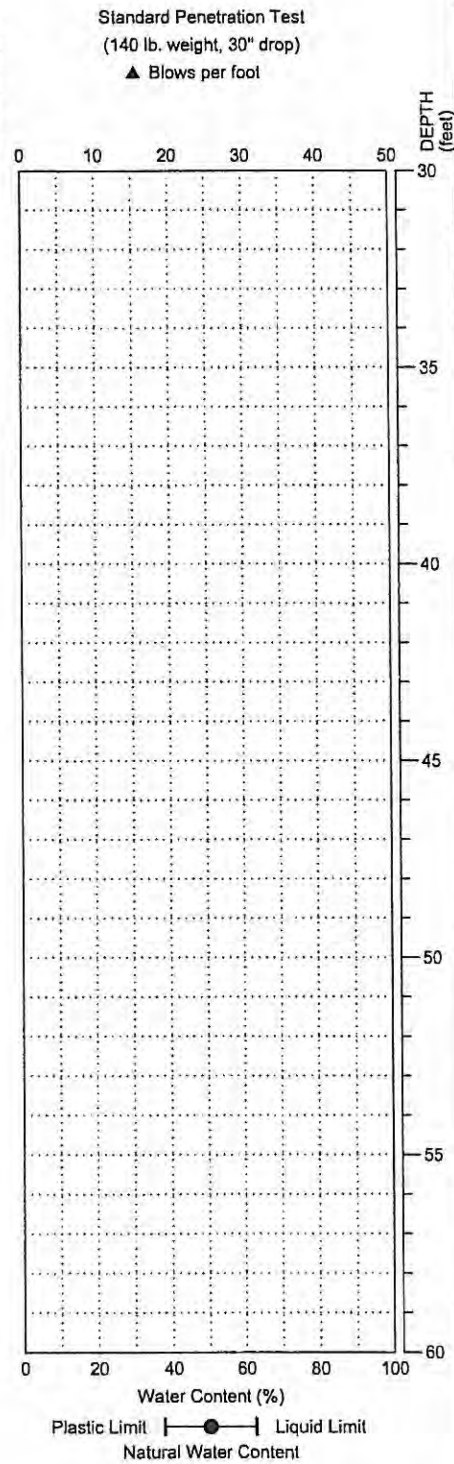


PROJECT NO.: 2007-007-21 FIGURE: 14

DRILLING COMPANY: Gregory Drilling Inc.
DRILLING METHOD: HSA
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 13 ± feet

LOCATION: N 288151.9, E 1256169.5
DATE STARTED: 10/8/2007
DATE COMPLETED: 10/8/2007
LOGGED BY: J. Speck

| DEPTH (feet) | SYMBOL | USCS SOIL CLASS | DESCRIPTION | SAMPLE TYPE | SAMPLE NUMBER | PEN. RESISTANCE (blows/6 inches) | OTHER TESTS | GROUNDWATER |
|---|---|---|---|---|---|---|---|---|
| 30 | | | As above, dense. | | S-12 | 8-19-16 | GS | |
| | | | Boring terminated at 31.5 feet below surface. | | | | | |
| | | | Ground water observed at 5 feet at time of exploration (ground water tidally influenced). | | | | | |




For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-492+94



PROJECT NO.: 2007-007-21 FIGURE: 14

KHM
ENVIRONMENTAL MANAGEMENT INCORPORATED

| | | | |
|---|---|---|---|
| PROJECT NO: | CG29291A | CLIENT: | Chevron |
| LOGGED BY: | E. Larsen | LOCATION: | Pt. Wells Terminal |
| DRILLER: | Cascade | DATE DRILLED: | 10/31/01 |
| DRILLING METHOD: | HS | HOLE DIAMETER: | 12-Inches |
| SAMPLING METHOD: | D&M | HOLE DEPTH: | 21.5 Feet |
| CASING TYPE: | Sch. 40 PVC | WELL DIAMETER: | 8 Inches |
| SLOT SIZE: | 0.040" | WELL DEPTH: | 20 Feet |
| GRAVEL PACK: | Pea Gravel | CASING STICKUP: | N/A |

BORING/WELL NO: AP-36
PAGE 1 OF 1

LOCATION MAP
SEE FIGURE 3

| ELEVATION | NORTHING | EASTING |
|---|---|---|
| | | |

Well Completion: Backfill — BENT (0–4 ft, above bentonite fill), PEA GRAVEL (4–21.5 ft); Casing (blank to ~5 ft, screen ~5–20 ft). Static Water Level ▼ at ~7.2 ft.

| Moisture Content | PID Reading (ppm) | Penetration (blows/6") | Depth (feet) | Soil Type | LITHOLOGY / DESCRIPTION |
|---|---|---|---|---|---|
| | | | 0 | | SAND & GRAVEL - FILL |
| | | | 2 | SW | SAND: grayish brown; 5% fines; fine to coarse grained; 20-30% gravel; loose; no odor. |
| Dp | 2.6 | 10, 14, 20 | 5 | | @ 5 Feet: as above; dense; faint hydrocarbon odor. |
| Wet | 16 | 2, 2, 1 | 10 | | @ 10 feet: as above; increasing gravel; hydrocarbon odor (oil); medium dense; sheen. |
| Wet | 8 | 7, 14, 20 | 15 | | @15 Feet: as above; 10-20% gravel; hydrocarbon odor; sheen. |
| | | | 18 | SM | SILTY SAND: gray; 10-20% fines; fine to medium grained; medium dense; faint hydrocarbon odor. |
| Wet | 4.1 | 9, 10, 17 | 20 | | |
| | | | 21.5 | | BOTTOM OF BORING AT 21.5 FEET |

| | | | |
|---|---|---|---|
| PROJECT NO: | CG29291A | CLIENT: | Chevron |
| LOGGED BY: | E. Larsen | LOCATION: | Pt. Wells Terminal |
| DRILLER: | Cascade | DATE DRILLED: | 11/8/01 |
| DRILLING METHOD: | HS | HOLE DIAMETER: | 12-Inches |
| SAMPLING METHOD: | D&M | HOLE DEPTH: | 21.5 Feet |
| CASING TYPE: | Sch. 40 PVC | WELL DIAMETER: | 8 Inches |
| SLOT SIZE: | 0.040" | WELL DEPTH: | 20 Feet |
| GRAVEL PACK: | Pea Gravel | CASING STICKUP: | N/A |

KHM ENVIRONMENTAL MANAGEMENT INCORPORATED

BORING/WELL NO: AP-39

PAGE 1 OF 1

LOCATION MAP: SEE FIGURE 3

| ELEVATION | NORTHING | EASTING |
|---|---|---|
| | | |

# LITHOLOGY / DESCRIPTION

| Well Completion (Backfill / Casing) | Static Water Level | Moisture Content | PID Reading (ppm) | Penetration (blows/6") | Depth (feet) | Sample (Recovery / Interval) | Soil Type | Lithology / Description |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0–4 | | | SAND & GRAVEL - FILL |
| BENT (approx. 1.5–4 ft) | | | | | | | | |
| PEA GRAVEL (approx. 4–21.5 ft); screen approx. 5–20 ft | | | | | | | GW | Sandy GRAVEL: dark gray; 5% fines; 20-30% sand; fine to medium gravel; medium dense; strong hydrocarbon odor; sheen. |
| | | Mst | 39 | 5 7 6 | 5–6.5 | Sample | | |
| | ▼ (approx. 7.5 ft) | | | | | | | |
| | | Wet | 8.9 | 2 2 1 | 10–11.5 | Sample | | @ 10 feet: as above; very loose; strong hydrocarbon odor; sheen. |
| | | | | | | | SW | SAND: dark gray; 5% fines; fine to coarse grained; 10-20% gravel; loose; hydrocarbon odor; sheen. |
| | | Wet | 12.1 | 2 3 4 | 15–16.5 | Sample | | |
| | | | | | | | GW | Sandy GRAVEL: dark gray; 5% fines; 20-30% sand; fine to medium gravel; medium dense; hydrocarbon odor. |
| | | Wet | 5.8 | 8 12 15 | 20–21.5 | Sample | | BOTTOM OF BORING AT 21.5 FEET |

# Converse NW

## Monitoring Well Geologic & Construction Log

Project Number: 91-35101-06

Well Number: MW-42

Sheet 1 of 1

Project: Pt. Wells Monitoring Well Installations

Elevation (Top of Well Casing): 11.94

Water Level Elev.: 4.94

Drilling Contractor: McDonald Holt, Inc.

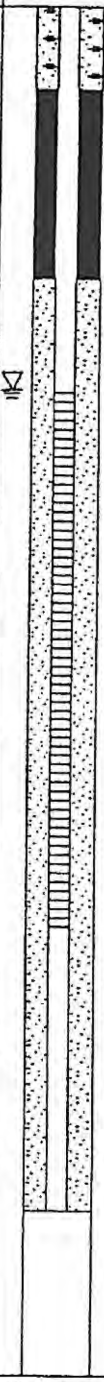
Drilling Method: B-61/HSA

Location: Pt. Wells Distribution Center

Surface Elevation:

Start Date: April 16, 1991

Finish Date: April 16, 1991



| Depth feet | Well Construction | Lab Tests | ST | Blows/ 6" | OVM Reading | Description |
|---|---|---|---|---|---|---|
| 0 | locking flush-mounted aluminum monument; concrete | | | | | SILTY SAND (Fill); brown, some fine to coarse gravel; medium dense, very moist |
| 1–2 | bentonite seal | C | Drive Barrel | 9, 8, 9 | | |
| 5–7 | 10/20 silica sand filter pack; ATD 4/16/91 (water level) | | Drive Barrel | 2, 3, 2 | | grades to gray; loose, very moist |
| 8 | | | Drive Barrel | 3, 5, 6 | | grades to black, hydrocarbon like staining and odor |
| 10–12 | well screen, 4.0" ID schedule 40 PVC with 0.010" slots | | Drive Barrel | 7, 10, 15 | | |
| 15 | | | Drive Barrel | 3, 5, 12 | | SAND (Fill); gray, fine to medium, trace gravel; medium dense, wet; hydrocarbon like odor with sheen |
| 20 | | | Drive Barrel | 5, 11, 12 | | little fine to medium gravel, trace shell fragments; medium dense, wet; hydrocarbon like odor and sheen |
| 22 | | | | | | Bottom of boring at depth 22.0 feet. Soil sampler driven using a 300-pound hammer falling 30 inches. |

ST - Sampler Type:
- | 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- ∇ Water Level

Logged by: BCP

Approved by: RAL

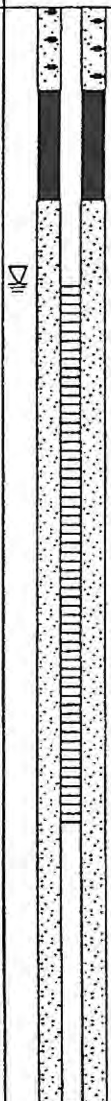
Figure No. A-10

**Converse NW**

# Monitoring Well Geologic & Construction Log

| Project Number | Well Number | Sheet |
|---|---|---|
| 91-35101-06 | MW-43 | 1 of 1 |

Project: Pt. Wells Monitoring Well Installations
Location: Pt. Wells Distribution Center
Elevation (Top of Well Casing): 10.04
Surface Elevation:
Water Level Elev.: 5.04
Start Date: April 16, 1991
Drilling Contractor: McDonald Holt, Inc.
Finish Date: April 16, 1991
Drilling Method: B-61/HSA



| Depth feet | Well Construction | Lab Tests | Blows/6" | OVM Reading | Description |
|---|---|---|---|---|---|
| 0 | locking flush-mounted aluminum monument; concrete | | | | SILTY SAND (Fill); gray to brown, fine sand, trace fine to medium gravel, wood fragments; medium dense, wet; hydrocarbon like odor |
| 2.5 | bentonite seal | C | 3 5 7 | | |
| 5 | ATD 4/16/91; 10/20 silica sand filter pack | | 5 9 6 | | increasing silt content, decreasing gravel content |
| 7.5 | | | 3 8 12 | | |
| 10 | well screen, 4.0" ID schedule 40 PVC with 0.010" slots | | 3 5 7 | | grades to gray, fine to coarse sand, some fine to medium gravel |
| 15 | | | 1 2 2 | | SILT (Fill); dark brown, trace sand, peat and wood fragments; very loose, very moist; hydrocarbon like odor and visible liquid hydrocarbons in sample |
| 20 | | | 5 9 14 | | SILTY SAND (Fill); gray, fine to coarse, some fine to coarse gravel; medium dense, wet; hydrocarbon like odor |
| 21.5 | | | | | Bottom of boring at depth 21.5 feet. Soil sampler driven using a 300-pound hammer falling 30 inches. |

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- ∇ Water Level

Logged by: BCP
Approved by: RAL

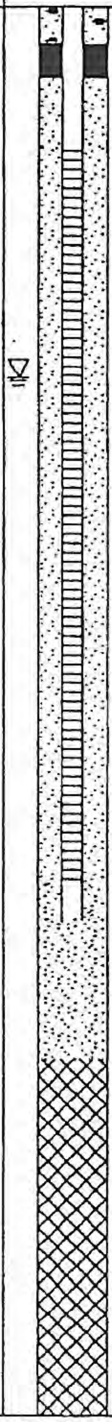
Figure No. A-11

# Converse NW

## Monitoring Well Geologic & Construction Log

| Project Number | Well Number | Sheet |
|---|---|---|
| 91-35101-11 | MW-79 | 1 of 2 |

Project: South Warehouse-Barrel Facility Environmental Assessment
Location: Chevron Point Wells Distribution Fa
Elevation (Top of Well Casing): 11.16
Surface Elevation: 11.50
Water Level Elev.: 6.25
Start Date: January 21, 1992
Drilling Contractor: Geoboring & Dev. Co.
Finish Date: January 22, 1992
Drilling Method: Skid Mounted / HSA



| Depth feet | Well Construction | Lab Tests | ST | Blows/ 6" | OVM Reading | Description |
|---|---|---|---|---|---|---|
| | locking flush-mounted steel monument | | | | ppm | 6 inches thick CONCRETE SLAB |
| | concrete annular seal | | | | | FILL |
| | bentonite seal | C | | 15 23 20 | 11 | SAND; gray, fine to medium, little coarse sand, trace fine gravel; medium dense, moist unidentified odor |
| | 10/20 silica sand filter pack | | | | | |
| | ATD 1/22/92 | | | 21 26 28 | 560 | SILTY SAND; gray-brown, fine to medium, some lumps of hard yellow-brown silt, trace coarse sand and mica, trace fine gravel; dense, very moist; hydrocarbon-like odor |
| | | C | | 22 25 21 | 600 | |
| 5 | 1/23/92 | | | | | SANDY SILT; gray, fine sand, little coarse sand, trace wood fragments; very stiff, moist; hydrocarbon-like odor |
| | | | | 1 7 10 | 500 | ESTUARINE DEPOSITS<br>SAND; gray, some silt, medium to coarse, few fine gravel, trace plant fragments; medium dense, wet; hydrocarbon-like odor |
| | well screen, 2" ID schedule 40 PVC with 0.010" slots | | | | | |
| 10 | | | | | | |
| | threaded end cap | | | 1 2 2 | 30 | ORGANIC SILT; yellow-brown to gray-brown, few plant fibers and fragments; soft, moist; organic-like odor |
| 15 | | | | | | |
| | backfilled with bentonite chips | | | 9 10 10 | 20 | |
| | | | | | | SAND; gray, medium to coarse, some fine sand and silt, trace fine gravel; medium dense, wet; organic-like odor |

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- ∇ Water Level

Logged by: ECR
Approved by: RAL

Figure No.

# Converse NW

## Monitoring Well Geologic & Construction Log

| Project Number | Well Number | Sheet |
|---|---|---|
| 91-35101-11 | MW-79 | 2 of 2 |

Project: South Warehouse-Barrel Facility Environmental Assessment
Location: Chevron Point Wells Distribution Fa
Elevation (Top of Well Casing): 11.16
Surface Elevation: 11.50
Water Level Elev.: 6.25
Start Date: January 21, 1992
Drilling Contractor: Geoboring & Dev. Co.
Finish Date: January 22, 1992
Drilling Method: Skid Mounted / HSA

| Depth feet | Well Construction | Lab Tests | ST | Blows/ 6" | OVM Reading | Description |
|---|---|---|---|---|---|---|
| | | | | | | trace wood fragments and lumps of organic silt |
| | | | | 1<br>9<br>19 | 15 | |
| | backfilled with bentonite chips | | | | | grades coarser across sample with depth |
| 25 | | | | | | |
| | | | | 12<br>15<br>22 | 45 | |
| | | | | | | Bottom of boring at depth 29.0 feet<br>Bore hole allowed to cave in to 15 feet<br>Monitoring well installed to depth 12.5 feet<br>Soil sampler driven using a 140-pound hammer falling 30 inches |
| 30 | | | | | | |
| 35 | | | | | | |

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: ECR
Approved by: RAL
Figure No.

# Converse NW

## Monitoring Well Geologic & Construction Log

| Project Number | Well Number | Sheet |
|---|---|---|
| 91-35101-11 | MW-83 | 1 of 2 |

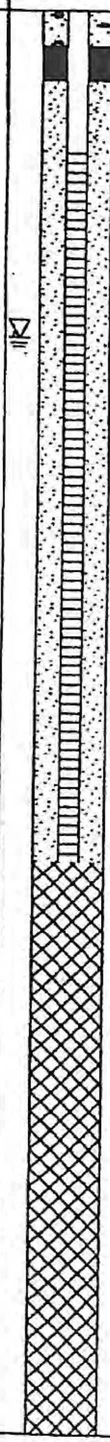
**Project** South Warehouse-Barrel Facility Environmental Assessment  **Location** Chevron Point Wells Distribution Fa

**Elevation (Top of Well Casing)** 11.45  **Surface Elevation** 11.66

**Water Level Elev.** 7.04  **Start Date** January 27, 1992

**Drilling Contractor** Geoboring & Dev. Co.  **Finish Date** January 27, 1992

**Drilling Method** Skid Mounted / HSA



| Depth feet | Well Construction | Lab Tests | ST | Blows/ 6" | OVM Reading | Description |
|---|---|---|---|---|---|---|
| | locking flush-mounted steel monument<br>concrete annular seal<br>bentonite seal | | | | ppm | 6 inches thick CONCRETE SLAB |
| | riser, 2" ID schedule 40 PVC | C | | 11<br>16<br>23 | 8 | FILL<br>SAND; brown, fine to coarse, little fine gravel, trace silt; medium dense, moist |
| | 10/20 silica sand filter pack | C | | 14<br>20<br>18 | 14 | SILTY SAND WITH GRAVEL; brown, fine to coarse sand, fine gravel; medium dense, moist<br>hydrocarbon-like odor and staining |
| 5 | 2/13/92<br>well screen, 2" ID schedule 40 PVC, 0.010" slot size | | | 10<br>11<br>13 | 45 | SAND; brown to gray, fine to medium, trace silt; medium dense, wet; hydrocarbon-like odor, sheen on sampler |
| | | | | 1<br>0<br>0 | 120 | BEACH DEPOSITS<br>SAND; gray, fine to medium, trace silt and shell fragments; very loose, wet; hydrocarbon-like odor |
| 10 | | | | | | |
| | threaded end cap | | | 3<br>6<br>9 | | ESTUARINE DEPOSITS<br>ORGANIC SILT; brown, fibrous, few fine to medium sand, trace shell fragments; stiff, moist; hydrocarbon-like odor |
| 15 | mixture of soil and bentonite chips | | | | | |
| | | | | 7<br>11<br>18 | | few plant fibers; soft, moist; hydrocarbon-like odor<br>BEACH DEPOSITS<br>SAND WITH GRAVEL; gray-brown, fine to coarse sand, fine gravel; medium dense, wet; hydrocarbon-like odor |

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- ∇ Water Level

Logged by: ECR

Approved by: RAL

Figure No.

Converse NW

# Monitoring Well Geologic & Construction Log

| Project Number | Well Number | Sheet |
|---|---|---|
| 91-35101-11 | MW-83 | 2 of 2 |

Project: South Warehouse-Barrel Facility Environmental Assessment
Location: Chevron Point Wells Distribution Fa
Elevation (Top of Well Casing): 11.45
Surface Elevation: 11.66
Water Level Elev.: 7.04
Start Date: January 27, 1992
Drilling Contractor: Geoboring & Dev. Co.
Finish Date: January 27, 1992
Drilling Method: Skid Mounted / HSA

| Depth feet | Well Construction | Lab Tests | ST | Blows/ 6" | OVM Reading | Description |
|---|---|---|---|---|---|---|
| | | | | | | **ESTUARINE DEPOSITS** ORGANIC SILT; brown, few fibers; soft, moist |
| | | | Drive Barrel | 8 21 31 | | **BEACH DEPOSITS** SAND WITH GRAVEL; gray, fine to coarse sand, fine gravel, abundant quartz sand, trace silt; dense, wet |
| 25 | | | | | | |
| | | | Drive Barrel | 13 27 43 | | |
| 30 | | | | | | Bottom of boring at 29.0 feet<br>Boring backfilled with bentonite chips<br>Soil sampler driven using a 140-pound hammer falling 30 inches |
| 35 | | | | | | |

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: ECR
Approved by: RAL

Figure No.

KHM ENVIRONMENTAL MANAGEMENT INCORPORATED

| | | | | |
|---|---|---|---|---|
| PROJECT NO: CG29291A | CLIENT: Chevron | | BORING/WELL NO: MW-97 | |
| LOGGED BY: E. Larsen | LOCATION: Pt. Wells Terminal | | PAGE 1 OF 1 | |
| DRILLER: Cascade | DATE DRILLED: 10/29/01 | LOCATION MAP | | |
| DRILLING METHOD: HS | HOLE DIAMETER: 12-Inches | SEE FIGURE 2 | | |
| SAMPLING METHOD: D&M | HOLE DEPTH: 21.5 Feet | | | |
| CASING TYPE: Sch. 40 PVC | WELL DIAMETER: 8 Inches | | | |
| SLOT SIZE: 0.040" | WELL DEPTH: 20 Feet | | | |
| GRAVEL PACK: Pea Gravel | CASING STICKUP: N/A | | | |
| ELEVATION | NORTHING | EASTING | | |

Well Completion: Backfill / Casing — BENT (0–~4 ft below concrete); PEA GRAVEL (~4–21.5 ft). Static Water Level ▼ at ~7.7 ft.

| Moisture Content | PID Reading (ppm) | Penetration (blows/6") | Depth (feet) | Soil Type | LITHOLOGY / DESCRIPTION |
|---|---|---|---|---|---|
| | | | 0 | | CONCRETE SLAB |
| | | | 1 | SW | SAND: brown; trace fines; fine to coarse grained; 10-20% fine gravel; dense; damp; no hydrocarbon odor. |
| Mst | 21 | 15 18 30 | 5–6.5 | ML | SILT: gray; 15-20% fine sand; hard; organic odor. |
| | | | 8.5 | SW | SAND: gray; 5% fines; fine to coarse grained; 20-30% gravel; cobbles; very dense; strong hydrocarbon odor; sheen. |
| Wet | 647 | 50 (6) | 10 | | |
| | | | 14 | PT | PEAT: brown; damp; strong hydrogen sulfide odor. |
| Dp | 227 | 5 6 7 | 15–16.5 | OL | ORGANIC CLAY: dark gray; stiff; strong hydrogen sulfide odor. |
| | | | 17.5 | SW | SAND: dark gray; 5% fines; medium to coarse grained; 10-20% gravel; dense; hydrogen sulfide odor. |
| Wet | 217 | 6 17 30 | 20–21.5 | | BOTTOM OF BORING AT 21.5 FEET |

**KHM**
ENVIRONMENTAL MANAGEMENT INCORPORATED

| | | | | |
|---|---|---|---|---|
| PROJECT NO: | CG29291A | CLIENT: | Chevron | BORING/WELL NO: MW-98 |
| LOGGED BY: | E. Larsen | LOCATION: | Pt. Wells Terminal | PAGE 1 OF 1 |
| DRILLER: | Cascade | DATE DRILLED: | 10/29/01 | LOCATION MAP |
| DRILLING METHOD: HS | | HOLE DIAMETER: | 12-Inches | |
| SAMPLING METHOD: D&M | | HOLE DEPTH: | 21.5 Feet | |
| CASING TYPE: | Sch. 40 PVC | WELL DIAMETER: | 8 Inches | SEE FIGURE 2 |
| SLOT SIZE: | 0.040" | WELL DEPTH: | 20 Feet | |
| GRAVEL PACK: | Pea Gravel | CASING STICKUP: | N/A | |
| ELEVATION | | NORTHING | EASTING | |

| Well Completion (Backfill / Casing) | Static Water Level | Moisture Content | PID Reading (ppm) | Penetration (blows/6") | Depth (feet) | Sample (Recovery / Interval) | Soil Type | LITHOLOGY / DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0 | | | CONCRETE SLAB |
| BENT | | | | | 1–2 | | SW | SAND: brown; trace fines; fine to coarse grained; 10-20% gravel; medium dense; damp; faint hydrocarbon odor. |
| PEA GRAVEL | ▼ | Dp | 77 | 8 14 17 | 5–6.5 | ■ | ML | SILT: gray; 20-30% fine sand; hard; hydrocarbon odor. |
| | | Wet | 202 | 8 12 7 | 10–11.5 | ■ | GW | GRAVEL: dark gray; trace fines; 10-20% fine to coarse sand; fine to coarse gravel; wood fragments; medium dense; strong hydrocarbon odor; sheen. |
| | | Wet | 170 | 16 9 8 | 15–16.5 | ■ | SW | SAND: brown; trace fines; fine to coarse grained; 10% gravel; thin peat/organic clay interbed; medium dense; hydrocarbon odor. |
| | | Wet | 95 | 16 18 24 | 20–21.5 | ■ | | @20 Feet: dark gray; wood fragments; anoxic; dense; hydrocarbon odor. |
| | | | | | 21.5 | | | BOTTOM OF BORING AT 21.5 FEET |

| | | | | | |
|---|---|---|---|---|---|
| **KHM** ENVIRONMENTAL MANAGEMENT INCORPORATED | PROJECT NO: CG29291A | CLIENT: Chevron | BORING/WELL NO: MW-99 | | |
| | LOGGED BY: E. Larsen | LOCATION: Pt. Wells Terminal | PAGE 1 OF 1 | | |
| | DRILLER: Cascade | DATE DRILLED: 10/29/01 | LOCATION MAP | | |
| | DRILLING METHOD: HS | HOLE DIAMETER: 12-Inches | SEE FIGURE 2 | | |
| | SAMPLING METHOD: D&M | HOLE DEPTH: 21.5 Feet | | | |
| | CASING TYPE: Sch. 40 PVC | WELL DIAMETER: 8 Inches | | | |
| | SLOT SIZE: 0.040" | WELL DEPTH: 20 Feet | | | |
| | GRAVEL PACK: Pea Gravel | CASING STICKUP: N/A | | | |
| | ELEVATION | NORTHING | EASTING | | |

| Well Completion (Backfill / Casing) | Static Water Level | Moisture Content | PID Reading (ppm) | Penetration (blows/6") | Depth (feet) | Sample (Recovery / Interval) | Soil Type | LITHOLOGY / DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0 | | | CONCRETE SLAB |
| BENT | | | | | 1 | | SW | SAND: brown; trace fines; fine to coarse grained; 10-20% gravel; dense; damp; no odor. |
| PEA GRAVEL | ▼ | Dp | 146 | 9<br>18<br>25 | 5–6.5 | ■ | ML | SILT: gray; 20-30% fine sand; trace gravel; hard; hydrocarbon odor. |
| | | | | | 8.5 | | GW | GRAVEL: gray; 5% fines; 20-30% fine to coarse sand; fine to medium gravel; medium dense; hydrocarbon odor; sheen; thin peat interbed. |
| | | Wet | 311 | 6<br>6<br>10 | 10–11.5 | ■ | | |
| | | Wet | NR | 3<br>3<br>4 | 15–16.5 | ■ | | @15 Feet: no recovery. |
| | | | | | 18.5 | | SW | SAND: dark gray; trace fines; fine to coarse grained; 10% gravel; very dense; hydrogen sulfide odor. |
| | | Wet | 0 | 5<br>17<br>21 | 20–21.5 | ■ | | |
| | | | | | 21.5 | | | BOTTOM OF BORING AT 21.5 FEET |

**KHM**
ENVIRONMENTAL MANAGEMENT INCORPORATED

| | | | |
|---|---|---|---|
| PROJECT NO: | CG29291A | CLIENT: | Chevron |
| LOGGED BY: | E. Larsen | LOCATION: | Pt. Wells Terminal |
| DRILLER: | Cascade | DATE DRILLED: | 10/30/01 |
| DRILLING METHOD: | HS | HOLE DIAMETER: | 8-Inches |
| SAMPLING METHOD: | D&M | HOLE DEPTH: | 21.5 Feet |
| CASING TYPE: | Sch. 40 PVC | WELL DIAMETER: | 4 Inches |
| SLOT SIZE: | 0.020" | WELL DEPTH: | 19 Feet |
| GRAVEL PACK: | 2X12 Sand | CASING STICKUP: | N/A |

BORING/WELL NO: MW-103
PAGE 1 OF 1

ELEVATION | NORTHING | EASTING

LOCATION MAP

SEE FIGURE 2

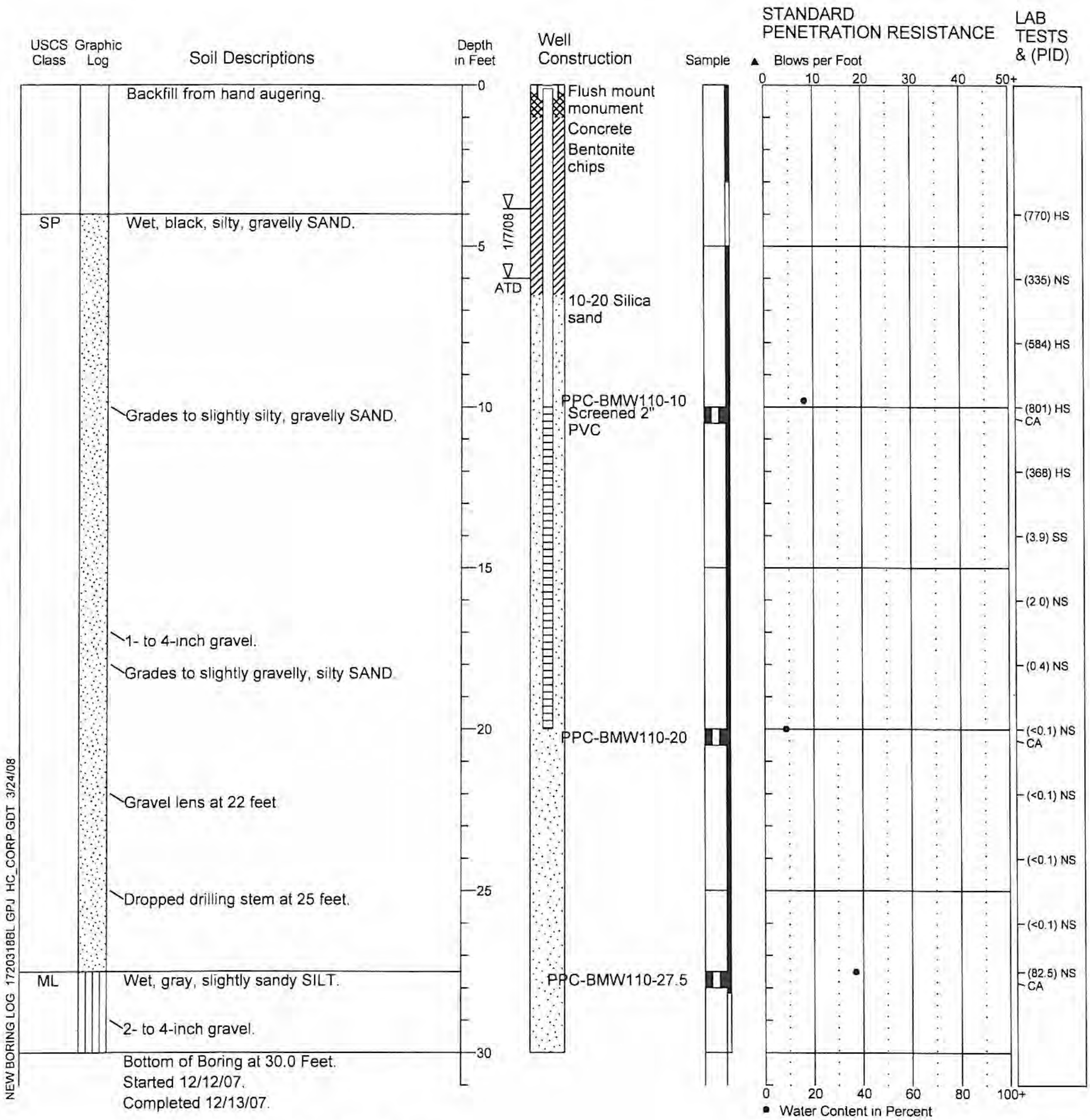
Well Completion: Backfill / Casing (B T; 2 X 1 2 S A N D)

| Static Water Level | Moisture Content | PID Reading (ppm) | Penetration (blows/6") | Depth (feet) | Soil Type | LITHOLOGY / DESCRIPTION |
|---|---|---|---|---|---|---|
| | | | | 0 | | CONCRETE SLAB |
| | | | | 1–2 | SW | SAND - FILL: trace fines; fine to coarse grained; 20-30% gravel; cobbles; loose; damp; no odor. |
| ▼ | Wet | 312 | 5<br>6<br>10 | 5–6.5 | | @ 5 Feet: native sand; gray; 5% fines; fine to coarse grained; 5-10% gravel; medium dense; saturated with product (diesel odor). |
| | | | | 8.5–9 | SP | SAND: gray; 5% fines; fine grained; loose; micaceous; hydrocarbon odor |
| | Wet | 0 | 2<br>3<br>4 | 10–11.5 | | |
| | Wet | 0 | 6<br>17<br>18 | 15–16.5 | | @15 Feet: as above; dense; hydrocarbon odor; |
| | | | | 18.5–19 | GW | Sandy GRAVEL: dark gray; 5% fines; 20-30% fine to coarse sand; fine to coarse gravel; very dense; no odor. |
| | Wet | 0 | 12<br>30<br>24 | 20–21.5 | | BOTTOM OF BORING AT 21.5 FEET |

# Boring Log & Construction Data for Monitoring Well MW-110

Location: See Figure 1.
Approximate Ground Surface Elevation: 7.96 Feet
Horizontal Datum: Field Located
Vertical Datum: NA

Drill Equipment: Sonic Drill
Hammer Type: Plastic sleeve
Hole Diameter: 6 inches
Logged By: C. Rust   Reviewed By: G. Both




SS = Slight Sheen, MS = Moderate Sheen,
HS = Heavy Sheen, NS = No Sheen

1. Refer to Figure B-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
5. Water Content was not determined by Hart Crowser.

HARTCROWSER

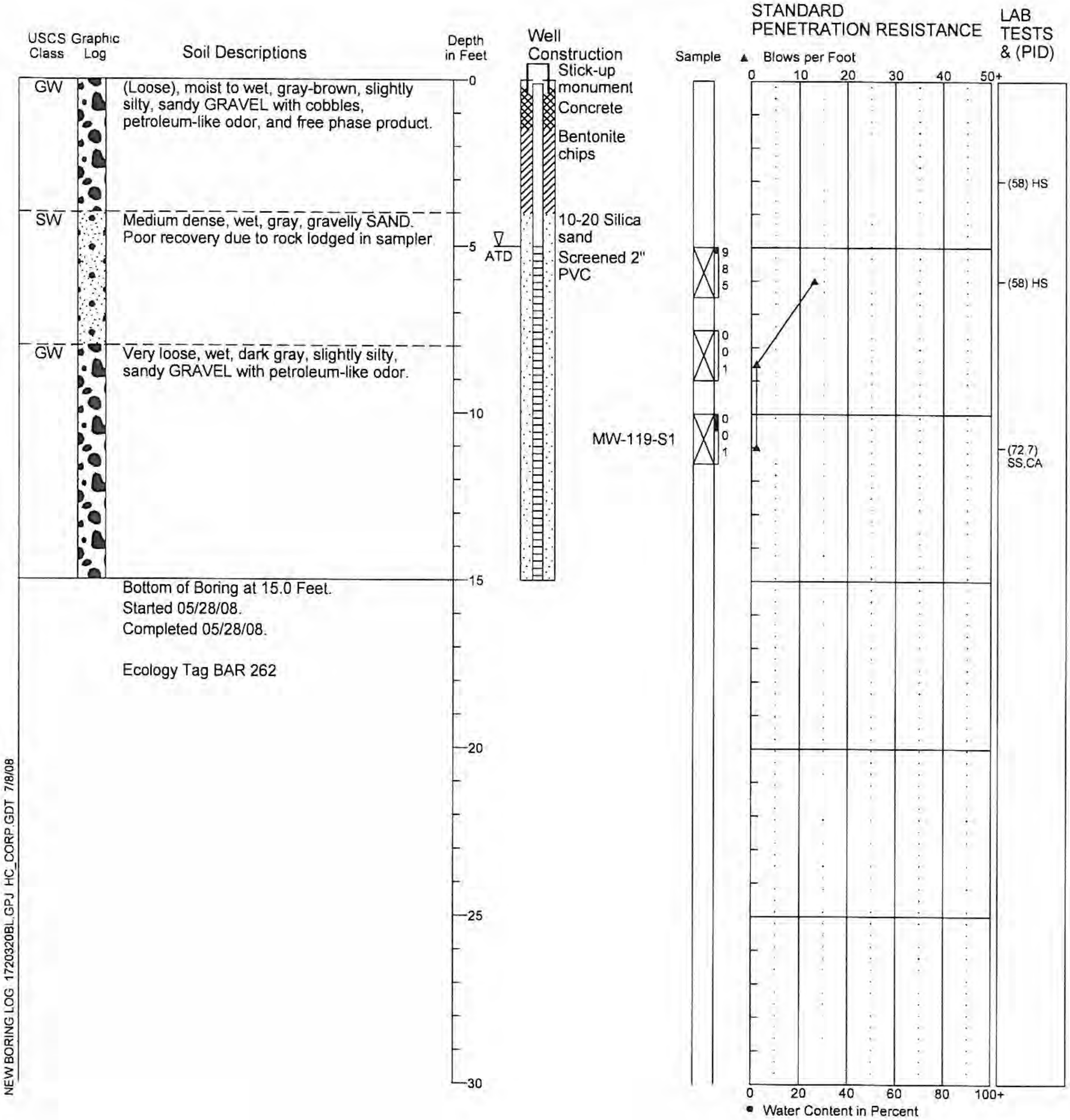
*17203-16* *12/07*

*Figure B-3*

# Boring Log & Construction Data for Monitoring Well MW-119

Location: See Figure 2.
Approximate Ground Surface Elevation: Feet
Horizontal Datum: Field located
Vertical Datum: NA

Drill Equipment: Hollow stem auger
Hammer Type: 140 lb. Auto hammer with 30" drop
Hole Diameter: 10 inches
Logged By: A. Inglish Reviewed By: A. Goodwin




1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
5. SS = Slight Sheen, NS = No Sheen, MS = Moderate Sheen, HS = Heavy Sheen
6. Analytical water content tabulated in Table 2.

HARTCROWSER

17203-20 5/08

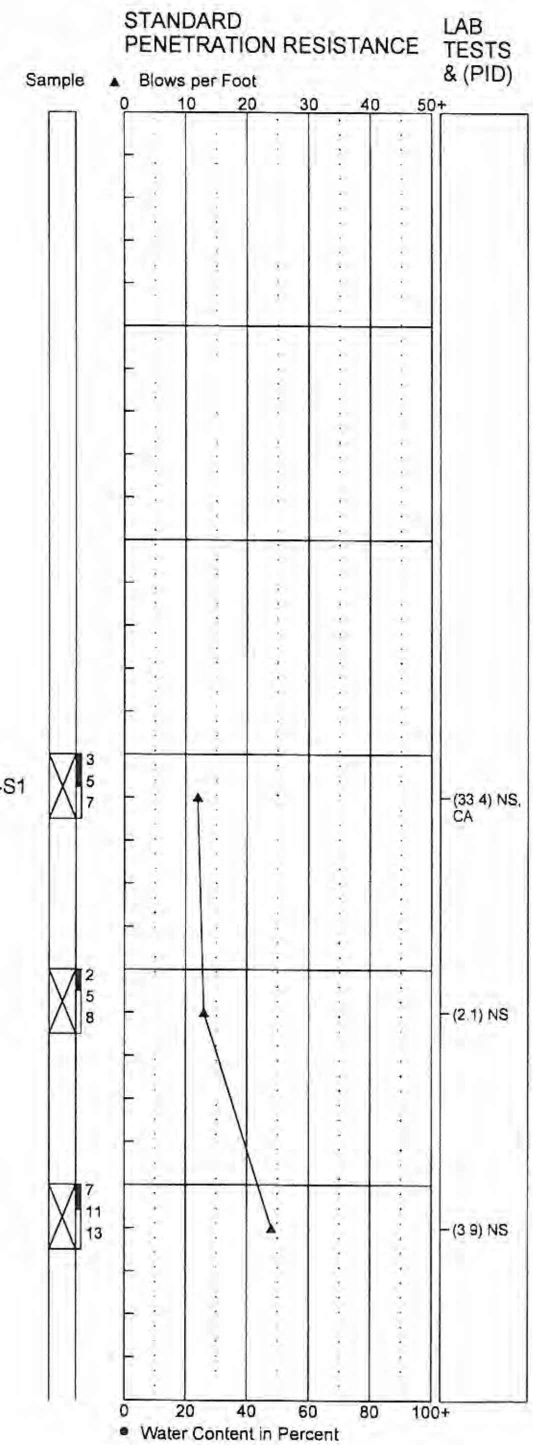
Figure A-89

# Boring Log B-119A

Location: See Figure 2.
Approximate Ground Surface Elevation: Feet
Horizontal Datum: Field located
Vertical Datum: NA

Drill Equipment: Hollow stem auger
Sample Type: 140 lb. Auto hammer with 30" drop
Hole Diameter: 10 inches
Logged By: A. Inglish Reviewed By: A. Goodwin

| USCS Class | Graphic Log | Soil Descriptions | Depth in Feet |
|---|---|---|---|
| | | Drilled unsampled to 15 feet. Refer to Boring Log MW-119 for soil classification. | 0 |
| | | (Groundwater ∇ ATD) | |
| SW | | Medium dense, wet, gray, slightly gravelly, coarse SAND. | 15 |
| | | Grading very gravelly | 20 |
| | | Bottom of Boring at 30.0 Feet. Started 05/30/08. Completed 05/30/08. | 30 |




B-119A was originally named MW-119A.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
5. SS = Slight Sheen, NS = No Sheen, MS = Moderate Sheen, HS = Heavy Sheen
6. Analytical water content tabulated in Table 2

| | |
|---|---|
| **Project:** King County WTD / Brightwater Conveyance System<br>**Project Location:** King & Snohomish Counties, Washington<br>**Contract Number:** E23007E | # Log of Boring P19-02<br>Sheet 1 of 4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date(s) Drilled | **8/18/03 - 8/25/03** | Geotechnical Consultant | **Camp Dresser & McKee Inc.** | Logged By | **MJB** | Checked By | **VJP 02-03-04** |
| Drilling Method/Rig Type | **Wireline/ CME 85** | Drilling Contractor | **Cascade Drilling, Inc.** | Total Depth of Borehole | **107.0 feet** | | |
| Casing Size/Type | **PQ (7"O.D.)** | Hammer Weight/Drop (lbs/in.) | **300# / 30"** | Ground Surface Elevation/Datum | **109.0 feet / Metro** | | |
| Location | **Pt. Wells** | Coordinates | **N 288005 E 1256501** | Elevation Source | **Survey** | | |

| Elevation, feet | Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|
| | 0 | | | | SP-SM | Medium dense to dense, dark gray to light brown, dry to moist, slightly silty, gravelly SAND (SP-SM), poorly-graded, fine to coarse sand, fine to coarse gravel, subrounded to subangular, slight odor **(af)** | |
| | | 1 | 10 - 11 - 11 (22) | 100 | | | |
| 105 | | 2 | 12 - 19 - 19 (38) | 100 | | | |
| | 5 | | | | | | |
| | | 3 | 10 - 13 - 20 (33) | 67 | SP | Dense, dark gray and black, wet, trace silt to slightly silty SAND (SP), trace gravel, poorly-graded, fine to coarse sand, fine to coarse gravel, subrounded and wood debris **(Qb)** | |
| | | | | | PT | Medium stiff, brown, moist PEAT,(PT), wood debris **(Qw)** | |
| 100 | 10 | 4 | 3 - 2 - 3 (5) | | | | |
| | | 5 | 1 - 2 - 3 (5) | 100 | | | |
| 95 | 15 | 6 | 1 - 3 - 2 (5) | 100 | OL | Medium stiff, gray, moist ot wet, slightly sandy, organic SILT (OL), low plasticity, scattered to abundant organics/woody material, layers of peat, sandy silt, silty sand **(Qw)** | |
| | | 7 | 17 - 10 - 7 (17) | 100 | SM | Dense, brown, wet, silty to very silty SAND (SM), trace fine gravel, fine to coarse sand, numerous organics, organic odor **(Qpfnf)** | |
| | | 8 | 9 - 14 - 24 (38) | | | | |
| 90 | 20 | | | | GP | Very dense, dark gray, wet, very sandy GRAVEL (GP), trace silt, poorly-graded fine to coarse sand, fine to coarse gravel, angular to subrounded **(Qpfnf)** | |
| | | 9 | 75/6" (100+) | 4 | | | |
| 85 | 25 | | | | | | |

**Groundwater Observation Data:**

| | | |
|---|---|---|
| OW (FT BGS): | 11.4 (Low) | 3.5 (High) |
| VWP 1 (FT BGS): | 7.7 (Low) | -4.9 (High) |

**Remarks:** Negative Groundwater Data indicates measurements above Ground Surface
Recovery values > 100 indicate sample expansion during sampling.

| Project: King County WTD / Brightwater Conveyance System<br>Project Location: King & Snohomish Counties, Washington<br>Contract Number: E23007E | Log of Boring P19-02<br>Sheet 2 of 4 |
|---|---|

| Elevation, feet | Depth, feet | Sample Number | Blows / 6 in. (N) | Recovery, % | USCS | MATERIAL DESCRIPTION | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|
| | 25 | | | | ML | Very dense, gray green, moist, slightly gravelly, sandy SILT (ML), fine to coarse sand, fine gravel, subrounded to subangular, homogeneous **(Qpfnl)** | |
| | | 10 | 50/6" (100+) | 3 | | | |
| 80 | | | | | GP | Very dense, gray, wet, sandy GRAVEL to gravelly SAND (GP-SP) **(Qpfnf)** | Soil description inferred from drill action and cuttings |
| | 30 | | | | | | |
| | | 11 | 70/6" (100+) | 0 | | | |
| 75 | | | | | | | Gravelly drilling, sand in cuttings |
| | 35 | | | | | | |
| | | 12 | 100/4" (100+) | 0 | | | |
| 70 | | | | | | | |
| | 40 | | | | | | Gravelly drilling (4-inch gravels/cobbles), sand in cuttings |
| | | 13 | 100/3" (100+) | 0 | | | |
| 65 | | | | | | | |
| | 45 | | | | | | |
| | | 14 | 100/4" (100+) | 49 | | | Coarse gravel in sampling shoe |
| 60 | | | | | | | |
| | 50 | | | | ML | Hard, dark brown, moist, gravelly SILT (ML), laminated, numerous organics **(Qpfnl)** | |
| | | 15 | 100/6" (100+) | 17 | | | |
| 55 | | | | | | | |
| | 55 | | | | GM | Very dense, dark gray, wet, silty to very silty, sandy GRAVEL (GM), fine to coarse sand, fine to coarse gravel, subrounded, occasional organics **(Qpfnf)** | Most fines washed from sample |
| | | 16 | 100/5" (100+) | 60 | | | |
| 50 | | | | | | | |
| | 60 | | | | | | |

# Log of Boring P19-02



| Elevation, feet | Depth, feet | Samples: Type | Samples: Number | Samples: Blows / 6 in. (N) | Samples: Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 | | | | | | | | | | | |
| | | ■ | 17 | 100/5" (100+) | 40 | | | | | | | Coarse gravel/cobble in shoe, 14 ft of heave, hole cave overnight 65 to 51 ft, case to 53 ft |
| 45 | | | | | | | | | | | | |
| | 65 | | | | | | GW | Dense, green gray, wet, sandy, GRAVEL (GW), well-graded, fine to coarse sand, subangular to subrounded fine to coarse gravel, with cobbles, possible boulders **(Qpfnf)** | | | | Gravelly drilling, sand in cuttings |
| | | | | | | | | | | | | Wood in cuttiings |
| 40 | | | | | | | | | | | | |
| | 70 | | | | | | | | | | | |
| | | | | | | | | | | | | 4-inch cobbles, clean SW in cuttings, wood fragments |
| 35 | | | | | | | | | | | | |
| | 75 | | | | | | | | | | | Cobbles, medium sand, cuttings - cobble/boulder |
| | | | | | | | | Layer of fine to coarse sand, well-graded | | | | 12 feet of heave to 66 ft |
| 30 | | | | | | | | | | | | |
| | 80 | | | | | | | | | | | |
| | | | | | | | | | | | | High tide, mud mix thinning |
| 25 | | | | | | | | | | | | |
| | 85 | | | | | | | | | | | |
| | | | | | | | | Grades green gray, fine to coarse sand, gravel with cobbles | | | | |
| 20 | | | | | | | | | | | | |
| | 90 | | | | | | | | | | | |
| | | | | | | | | Grades coarser, gravel/cobble/boulder | | | | |
| | | | | | | | | Medium to coarse sand | | | | Cuttings from cobble/boulder |
| 15 | | | | | | | | | | | | |
| | 95 | | | | | | | | | | | |

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

# Log of Boring P19-02



| Elevation, feet | Depth, feet | Samples: Type | Samples: Number | Samples: Blows / 6 in. (N) | Samples: Recovery, % | Samples: Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 95 | | | | | | | | | | | Organics in cuttings |
| 10 | | | | | | | | | | | | 16 ft of heave |
| | 100 | | | | | | | | | | | |
| 5 | | | | | | | | Green gray, fine to coarse sand and fine gravel, angular to subangular | | | | |
| | 105 | | | | | | | | | | | Shell fragments |
| | | | | | | | | Terminated boring at 107 feet below ground surface | | | | |
| 0 | | | | | | | | | | | | |
| | 110 | | | | | | | | | | | |
| -5 | | | | | | | | | | | | |
| | 115 | | | | | | | | | | | |
| -10 | | | | | | | | | | | | |
| | 120 | | | | | | | | | | | |
| -15 | | | | | | | | | | | | |
| | 125 | | | | | | | | | | | |
| -20 | | | | | | | | | | | | |
| | 130 | | | | | | | | | | | |



CDM

**Project:** King County WTD / Brightwater Conveyance System
**Project Location:** King & Snohomish Counties, Washington
**Contract Number:** E23007E

# Log of Boring P19-03



| | | | | | |
|---|---|---|---|---|---|
| Date(s) Drilled | 8/26/03 - 8/29/03 | Geotechnical Consultant | Camp Dresser & McKee Inc. | Logged By | SWC/MJB |
| Checked By | VJP 02-03-04 | Drilling Method/Rig Type | Wireline/ CME 85 | Drilling Contractor | Cascade Drilling, Inc. |
| Total Depth of Borehole | 76.0 feet | Casing Size/Type | PQ (7"O.D.) | Hammer Weight/Drop (lbs/in.) | 300# / 30" |
| Ground Surface Elevation/Datum | 108.8 feet / Metro | Location | Pt. Wells | Coordinates | N 288365 E 1256276 |
| Elevation Source | Survey | | | | |

| Elevation, feet | Depth, feet | Samples: Type | Number | Blows / 6 in. (N) | Recovery, % | Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | SM | Medium dense, gray, moist, silty SAND (SM), trace fine gravel, fine to medium sand **(af)** | | | | |
| | | ■ | 1 | 6 - 9 - 12 (21) | 100 | | | | | | | |
| 105 | | ■ | 2 | 6 - 6 - 5 (11) | 100 | | | | | | | |
| | 5 | | | | | | | | | | | |
| | | ■ | 3 | 6 - 5 - 5 (10) | 100 | | | | | | | |
| | | | | | | | PT | Medium stiff, brown, moist PEAT (PT), fibrous, and gray olive SILT (ML), low plasticity, slow dilatancy **(Qw)** | | | | |
| 100 | | ■ | 4 | 1 - 2 - 2 (4) | 100 | | | | | | | |
| | 10 | | | | | | | | | | | |
| | | ■ | 5 | 1 - 2 - 2 (4) | 100 | | OL | Soft to medium stiff, brown to dark gray, moist, organic SILT (OL), low to medium plasticity varying to slightly clayey SILT (MH), numerous organics, medium to high plasticity, slow dilatancy **(Qw)** | | | | |
| 95 | | ■ | 6 | 1 - 2 - 2 (4) | 100 | | | | | | | |
| | 15 | | | | | | | | | | | |
| | | ■ | 7 | 4 - 4 - 8 (12) | 100 | | SP-SM | Medium dense, dark gray, wet, slightly silty SAND (SP-SM), poorly-graded fine to medium sand **(Qb)** | | | | |
| 90 | | | | | | | | | | | | |
| | 20 | | | | | | | | | | | |
| 85 | | | | | | | | | | | | |
| | 25 | | | | | | | | | | | |

**Groundwater Observation Data:**

| | Low | High |
|---|---|---|
| OW (FT BGS): | 7.9 (Low) | 4.3 (High) |
| VWP 1 (FT BGS): | 16.0 (Low) | 5.6 (High) |

**Remarks:** Negative Groundwater Data indicates measurements above Ground Surface
Recovery values > 100 indicate sample expansion during sampling.



CDM

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

# Log of Boring P19-03



| Elevation, feet | Depth, feet | Samples: Type | Samples: Number | Samples: Blows / 6 in. (N) | Samples: Recovery, % | Samples: Graphic Log | USCS | MATERIAL DESCRIPTION | Piezometer Schematic | Lab Tests | Pocket Penetrometer (tsf) | REMARKS AND OTHER TESTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 | | 15 | 50/4" (100+) | 0 | | | | | | | Fine to coarse sand in cuttings, gravelly drilling |
| -45 | 65 | | 16 | 44 - 50/6" (100+) | 25 | | | | | | | |
| -40 | 70 | | 14 | 12 - 14 - 19 (33) | 11 | | | | | | | Fine to coarse sand in cuttings, gravelly drilling, coarse gravel in sampler tip |
| -35 | 75 | | | | | | | | | | | |
| | | | | | | | | Terminated boring at 76 feet below ground surface. | | | | |
| -30 | 80 | | | | | | | | | | | |
| -25 | 85 | | | | | | | | | | | |
| -20 | 90 | | | | | | | | | | | |
| -15 | 95 | | | | | | | | | | | |



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